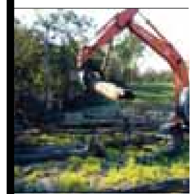
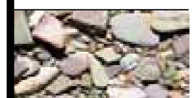
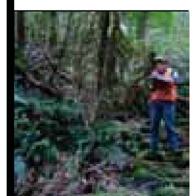
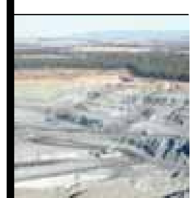
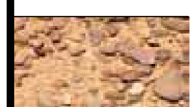


Letter of Application

APPENDIX 1

Centennial Newstan
(wholly owned subsidiary of Centennial Coal)

Fassifern Road
Fassifern NSW 2283
PO Box 1000
Toronto NSW 2283 Australia

T 02 4956 0200
F 02 4950 4230

www.centennialcoal.com.au

23rd August, 2012,

Director of Environment and Sustainability
NSW Department of Trade, Investment, Regional Infrastructure and Services – Division of Resources and Energy (DTIRIS-DRE)

Dear Sir,

RE: NEWSTAN COLLIERY SUBSIDENCE MANAGEMENT PLAN (SMP) APPLICATION – LONGWALL PANELS LW101-103

Newstan Colliery (Newstan) is an underground coal mine which is owned and operated by Centennial Newstan Pty Limited (Centennial Newstan), part of Centennial Coal (Centennial), a wholly owned subsidiary of Banpu Public Company Limited. Underground mining at Newstan first commenced some 125 years ago and is currently undertaken utilising both bord and pillar, and longwall mining methods. The long history of mining in the area provides a substantial basis for ongoing subsidence management and associated stakeholder engagement. Newstan is regionally located approximately 25 kilometres south-west of Newcastle and approximately 140 kilometres north of Sydney within the Lake Macquarie Local Government Area (LGA). The proposed mining area (SMP Application Area) is located within the *West Lakes Mine Subsidence District*. The Newstan pit top and surface facilities are located approximately four kilometres north of the township of Toronto.

The SMP Application Area (herein referred to as the *SMP Study Area*) has been conservatively established for the development and extraction of **three (3) longwall panels (LW101-103)** located wholly within Mining Lease ML1452, Consolidated Coal Lease CCL746, and existing Development Consent DA73-11-98. The proposed mining will target the combined Young Wallsend seam and part Yard seam using longwall mining methods.

In accordance with the requirements of the *Guidelines for Applications for Subsidence Management Approvals* (*the 'SMP Guidelines'*, DTIRIS-DRE 2003), please find enclosed an application from Centennial Newstan for development and extraction of longwall panels LW101-103. The application includes detailed subsidence assessments by MSEC and various specialist environmental impact assessments (including ecology, surface water, groundwater, and Aboriginal Cultural Heritage).

These followed a conservative risk-based approach and ongoing consultation with potentially affected stakeholders. Consultation will continue to progress during completion of specific management plans for surface features ahead of potential mining impact as outlined further below. The SMP Application consists of three (3) separate volumes as follows:

- **Volume 1:** **SMP Written Report & Appendices** (including risk assessment, subsidence assessment and various specialist reports)
- **Volume 2:** **Management Plans** (SMP, Subsidence Monitoring Plan, Public Safety MP)
- **Volume 3 :** **SMP A0 Plans**

Specifically, Centennial Newstan seeks conditional subsidence management approval from DTIRIS-DRE for the following:

- Development of main headings and gateroads for panel LW101 and the stubs (first 300m) of the northern ends of maingates for panels LW102 and LW103 (in order to facilitate safe mining conditions and effective mine development of the Main East headings). As outlined below, this is sought before January 2013 under the current mine schedule, and accordingly is the priority timing need for the SMP Application;
- Secondary extraction (longwall mining) within panel LW101, following finalisation of related management plans (prior to commencement of LW101);
- Conditional/deferred approval for the development of gateroads for LW102 and LW103 subject to successful completion of related studies for those panels (including, in particular, the Action Plan for the Awaba Waste Management Facility (AWMF));
- Conditional/deferred approval for secondary extraction of panels LW102 and LW103 subject to completion of related management plans for those panels (including, in particular, for the AWMF, as per timings presented within the SMP Written Report and the Subsidence Management Plan).

First workings within the SMP Area are scheduled to begin in **Q1 2013** (including development of Main East headings and panel stubs), with secondary extraction of LW101 currently scheduled to begin in **Q4 2014** under the 2012 business plan.

Secondary extraction is scheduled to begin in **LW102 in Q3 2015** and in **LW103 Q1 2016** under the 2012 business plan. This schedule takes into account various aspects including development, access, coal clearance, ventilation and equipment requirements to provide the safest and most economical means of recovering the coal.

As requested during consultation with DTIRIS-DRE, the application includes draft versions of the following plans of management that are central to the proposed subsidence management framework:

- *Subsidence Management Plan,*
- *Subsidence Monitoring Program and*
- *Public Safety Management Plan.*

The above draft plans will be finalised in consultation with stakeholders **prior to commencement of LW101**. Additionally, the following management plans for surface features will be developed in consultation with stakeholders prior to undermining:

- *Water Management Plan;*
- *Aboriginal Cultural Heritage Management Plan;*
- *Flora and Fauna Management Plan;*
- *Watercourse Management Plan;*
- *Powerlines Management Plan;*
- *AAPT Infrastructure Management Plan;*
- *Telstra Infrastructure Management Plan*
- *Awaba Waste Management Facility (AWMF) Management Plan;*
- *Public Roads Management Plan;*
- *Private Roads Management Plan;* and

- *Private Property Management Plans (PPMP)* – proposed for Newcastle & Lake Macquarie Clay Target Club, West Lakes Auto Club, Toronto Adventist Centre, and Toronto Country Club;

Specific timing requirements for completion of these plans are described within the SMP Written Report.

Should you require any further information or have any queries please do not hesitate to contact the undersigned on (02) 4956 0200 or Jason Boersma, Technical Services Manager on (02) 4956 0215.

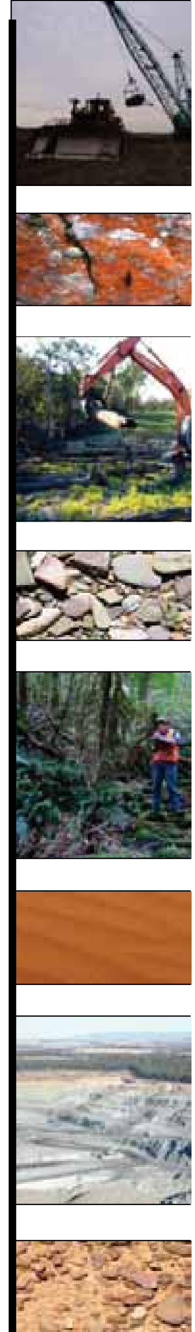
Yours faithfully,

Grant Watson
Mine Manager
NEWSTAN COLLIERY

Government Agency Distribution List

Government Agency	Contact	Details of Submission Documents				Comments
		Hardcopy of SMP Application	Hardcopy of SMP Plans		Electronic Copies of Entire SMP Application (Application & Plans)	
			A0	A3		
Department of Trade and Investment – Resources and Energy	Mr Paul Langley	**3**	3 (incl. 3 Signed Approved Plans)		3	
Department of Planning and Infrastructure	Mr Howard Reed	**1**	1		1	
Sydney Catchment Authority	Mr Ian Landon-Jones	**-**	-	-	1	SCA advised that electronic copy only required as outside SCA area.
Mine Subsidence Board	Mr Greg Cole-Clark	**-**	-	1	1	
Environmental Protection Authority	Mr William Dove	**-**	-	1	1	
Department of Trade and Investment – Fisheries	Mr Scott Carter	**-**	-	1	1	
Dams Safety Committee	Mr Bill Ziegler	**-**	-	-	1	
NSW Office of Water	Mr Mark Mignanelli	**1**	1	-	1	
	Total	**5**	**5**	**3**	**10**	

Development Consent



APPENDIX 2

ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979

INTEGRATED STATE SIGNIFICANT DEVELOPMENT

DETERMINATION OF DEVELOPMENT APPLICATION PURSUANT TO SECTIONS 76(A)9 & 80

I, the Minister for Urban Affairs and Planning, pursuant to Sections 76(A)9 & 80 of the Environmental Planning and Assessment Act, 1979 ("the Act) determine the development application ("the application") referred to in Schedule 1 by granting consent to the application subject to the conditions set out in Schedule 2.

The reasons for the imposition of the conditions are to:

(i) minimise the adverse impact the development may cause through water and air pollution, noise and visual disturbance;

(ii) provide for environmental monitoring and reporting; and

(iii) set requirements for infrastructure provision.

Andrew Refshauge
Minister for Urban Affairs and Planning

ORIGINAL CONSENT SIGNED BY MINISTER REFSHAUGE 14 MAY 1999.

Sydney, 1999 File No. N91/00544

Schedule 1

Application made by:	Powercoal Pty Ltd (ACN 052 533 070) ("the Applicant").
To:	The Minister for Urban Affairs and Planning (DA 73-11-98)
In respect of:	The area of land as shown in red edge and orange hatch in Figure 1 of Appendix 1.
For the following:	Extension of an underground coal mine, and upgrade of associated surface facilities ("the Development").
BCA Classification:	Class 10(a) (conveyor coal reclaim system, train loading bin (Newstan Colliery); ventilation shaft, men and materials access shaft and winder housing (Awaba Colliery)).
NOTE:	1) To ascertain the date upon which the consent becomes effective, refer to section 83 of the Act. 2) To ascertain the date upon which the consent is liable to lapse, refer to section 95 of the Act.

3) Section 97 of the Act confers on an Applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within 12 months after receipt of notice.

23 September 2007 modification (DA73-11-98 MOD 1) shown in red type.

27 November 2009 modification (DA73-11-98 MOD 2) shown in blue type.

26 November 2010 modification (DA73-11-98 MOD 3) shown in green type.

16 March 2012 modification (DA 73-11-98 MOD 4) shown in pink type (Newstan Main West)

SCHEDULE 2

INDEX

DEFINITIONS:

AEMR - *Annual Environmental Management Report*
CCC - *Community Consultative Committee*
DA - *Development Application*
DA Area – *the area of land to which this consent applies, as shown in red edge and orange hatch in Figure 1 of Appendix 1*
Department – *Department of Planning and Infrastructure*
Director-General - *Director-General of the Department of Planning and Infrastructure or delegate*
Development Consent Area – *the area of the development as shown in the figure in Appendix 1*
EIS - *Environmental Impact Statement*
Executive Director, Mineral Resources – *the Executive Director of the Mineral Resources within DRE*
LEA – *Lease Extension Area as shown in blue broken line in Figure 1 of Appendix 1*
Main West Mining Area – *the area shown in orange hatch in Figure1 of Appendix1*
Minister – *Minister for Planning and Infrastructure, or delegate*
SEE – *Statement of Environmental Effects*
SMP – *Subsidence Management Plan*
Surface facilities – *Northern Reject Emplacement Area, Southern Reject Emplacement Area, new coal stockpile areas and Rail Loading Facilities (Newstan Colliery), and Ventilation and Men and Materials Access Shafts (Awaba Colliery).*
Section 138 – *section 138 of the Coal Mine Regulation Act, 1982*
Relevant Area – *relevant area of* **surface facilities**
Safe, serviceable and repairable criteria – *Category 3 to 5 for strain and/or category C or D for tilt, in accordance with Australian Standard AS2870-1996*

Government Authorities

EPA – *Environment Protection Authority*
DRE – *Division of Resources and Energy, within the Department* of *Trade and Investment, Regional Infrastructure and Services*
LMCC - *Lake Macquarie City Council*
MSB - *Mine Subsidence Board*
NOW – *NSW Office of Water*
OEH – *Office of Environment and Heritage*
RMS – *Roads and Maritime Services*

1. General

There is an obligation on the Applicant to prevent and minimise harm to the environment throughout the life of the project. This requires that all practicable measures are to be taken to prevent and minimise harm that may result from the construction, operation and, where relevant, decommissioning of the development.

1.1 Terms of Approval

The Applicant shall carry out the development generally in accordance with the:

(a) DA 73-11-98;

(b) EIS titled *"Newstan Colliery Life Extension Project"*, dated November 1998;

(c) SEE titled *"Newstan Colliery Modifications to Development Consent",* dated April 2007;

(d) the modification application DA 73-11-98 – MOD 2 and accompanying Environmental Assessment entitled *Washing of Mandalong Coal at Newstan Section 96(1A) Application Statement of Environmental Effects,* dated October 2009;

(e) the modification application DA 73-11-98 – MOD 3 and accompanying Environmental Assessment entitled *Washing of Awaba Coal at Newstan Section 75W Application Statement of Environmental Effects,* dated September 2010;

(f) the modification application DA 73-11-98 – MOD 4 and accompanying Environmental Assessment entitled *Centennial Coal Newstan Colliery Main West Mining Project Section 75W Modification Environmental Assessment,* dated June 2011; and the Response to Submissions document entitled *Centennial Coal Newstan Colliery Main West Mining Project Response to Submissions,* dated December 2011; and

(g) the conditions of this consent.

If there is any inconsistency between the above documents, the latter document shall prevail to the extent of the inconsistency. However, the conditions of this consent shall prevail to the extent of any inconsistency.

1.2 Period of Approval/Project Commencement

(i) The approval for mining is for a period of 21 years from the date of granting of a mining lease pursuant to this consent. If, at any time, the Director-General is aware of environmental impacts from the proposal that pose serious environmental concerns due to the failure of existing environmental management measures to ameliorate the impacts, the Director-General may order the Applicant to cease the activities causing those impacts until those concerns have been addressed to the satisfaction of the Director-General.

(ii) At least one month prior to the commencement of: construction of each of the surface facilities; and secondary workings within the LEA, or within such period as agreed by the Director-General, the Applicant shall submit for the approval of the Director-General a compliance report detailing compliance with all the relevant conditions that apply prior to the commencement: of construction of each of the surface facilities; and secondary workings within the LEA.

(iii) Date of commencement of construction of each of the surface facilities and date of commencement of first and secondary workings in the LEA is to be notified in writing to the Director-General and LMCC, at least two weeks prior to commencement of the surface construction works, and underground mining in the LEA respectively.

1.3 Dispute Resolution

In the event that the Applicant and the LMCC or a Government agency, other than the Department, cannot agree on the specification or requirements applicable under this consent, the matter shall be referred by either party to the Director-General or if not resolved, to the Minister, whose determination of the disagreement shall be final and binding on the parties.

1.4 Security Deposits and Bonds

Security deposits and bonds will be paid as required by DRE under mining lease approval conditions.

2. Mine Management

2.1 Deleted

2.2 Limits on Production or Hours of Operation

The operation of bulldozers on the northern and southern reject emplacement areas shall occur only during daylight hours.

3. Land and Site Environmental Management

3.1 Appointment of Environmental Officer

(i) The Applicant shall employ a suitably qualified Environmental Officer throughout the life of the mine, whose qualifications are acceptable to the Director-General and who shall report to the Mine Manager. The Officer will:
- (a) be responsible for the preparation of the environmental management plans (refer condition 3.2);
- (b) be responsible for considering and advising on matters specified in the conditions of this consent and compliance with such matters;
- (c) be responsible responding to complaints in accordance with condition 10.2(a);
- (d) facilitate an induction and training program for all persons involved with construction activities, mining and remedial activities; and
- (e) have the authority and independence to require reasonable steps to be taken to avoid or minimise unintended or adverse environmental impacts and failing the effectiveness of such steps, to stop work immediately if an adverse impact on the environment is likely to occur.

(ii) The Applicant shall notify the Director-General, DRE, EPA, NOW, LMCC and the CCC (refer condition 8.8) of the name and contact details of the Environmental Officer upon appointment and any changes to that appointment.

3.2 Environmental Management Strategies and Plans

(a) The Applicant shall prepare an Environmental Management Strategy as a continuation of the existing Newstan Colliery Environmental Management System for the DA area including within the LEA and all proposed surface facilities. The Environmental Management Strategy shall be prepared in consultation with the relevant authorities and the Community Consultative Committee and to the satisfaction of the Director-General, prior to commencement of construction of surface facilities or secondary workings, whichever is the sooner.

(b) The Environmental Management Strategy shall include:
- (i) statutory and other obligations which the Applicant is required to fulfill during construction and mining, including all approvals and consultations and agreements required from authorities and other stakeholders, and key legislation and policies;
- (ii) definition of the role, responsibility, authority, accountability and reporting of personnel relevant to environmental management, including the Environmental Officer;
- (iii) overall environmental management objectives and performance outcomes, during construction, mining and decommissioning of the mine, for each of the key environmental elements for which management plans are required under this consent;
- (iv) overall ecological and community objectives for the water catchment, and a strategy for the restoration and management of the areas of the catchment affected by mining operations, including elements such as

(v) identification of cumulative environmental impacts and procedures for dealing with these at each stage of the development;

(vi) overall objectives and strategies to protect existing economic productivity within the area affected by mining, including agricultural productivity and other businesses;

(vii) steps to be taken to ensure that all approvals, plans, and procedures are being complied with;

(viii) processes for conflict resolution in relation to the environmental management of the project; and

(ix) documentation of the results of consultations undertaken in the development of the Environmental Management Strategy.

(c) The Applicant shall make copies of the Environmental Management Strategy available to LMCC, EPA, NOW, DRE, MSB and the Community Consultative Committee within fourteen days of approval by the Director-General.

(d) The Applicant shall also prepare the following environmental management plans:

- Archaeology and cultural management plan (refer condition 3.3)
- Flora and fauna management plan (refer condition 3.4)
- Erosion and sediment control plan (refer condition 3.5(a))
- Soil stripping management plan (refer condition 3.5(c))
- Landscape management plan (refer condition 3.7)
- Bushfire management plan (refer condition 3.8)
- Land management plan (refer condition 3.9(a))
- Wetland management plan (refer condition 3.9 (c))
- Site water management plan (refer condition 4.1)
- Dust management plan (refer condition 6.1)
- Noise management plan (refer condition 6.4(d))

(e) The management plans are to be revised/updated at least every 5 years or as otherwise directed by the Director-General in consultation with the relevant government agencies. They will reflect changing environmental requirements or changes in technology/operational practices. Changes shall be made and approved in the same manner as the initial environmental management plan. The plans shall also be made publicly available at LMCC within two weeks of approval of the relevant government authority.

(f) If the applicant is unable to prepare the relevant environmental strategies and plans within the period required by these conditions of consent, prior to commencing relevant works within the area of LW15A, the applicant shall prepare specific management strategies and plans for the area of LW 15A prior to commencement of those works. The preparation, content and approval of the plans for the area of LW15A shall not otherwise be inconsistent with the requirements for the management strategies and plans set out in this consent.

3.3 Heritage Assessment and Management

(A) The Applicant shall prior to construction of surface facilities or secondary workings within identified areas of archaeological sensitivity within the LEA:

(i) Prepare an archaeology and cultural management plan which shall include, but not be limited to:

(a) identification of any future salvage, excavation, monitoring, and protection of any heritage and archaeological items, within the area of the surface facilities, particularly the waste emplacement and coal stockpile areas, Awaba Colliery, and the area within the LEA prior to and during development;

(b) measures to undertake test excavations along Lords Creek to verify the archaeological potential of those areas identified as having low archaeological sensitivity at least one year prior to finalisation of the route of channelisation or other proposed works along Lords Creek;

(c) details of proposed investigations of rockshelters and grinding groove sites identified as having potential to contain archaeological deposit to be undertaken prior to mining being undertaken in the vicinity of the identified sites. The investigation will include test excavations undertaken in accordance with a permit issued under section 87 of the National Parks and Wildlife Act 1974, under a research design which is acceptable to the Aboriginal community and OEH;

(d) measures to protect Aboriginal sites from subsidence and mine working impacts, in consultation with OEH, the Aboriginal community and local residents to ensure integration of measures to protect Aboriginal sites.

(e) identification and documentation of Aboriginal cultural heritage issues;

(f) details of a monitoring program to document the effects of subsidence and mining works on Aboriginal sites and areas of archaeological sensitivity.

The plan shall be prepared in consultation with OEH, the Local Aboriginal Land Council, LMCC, and to the satisfaction of the Director-General, and shall be considered by the Applicant when completing the final underground mine layout;

(B) The Applicant shall:

(i) submit to and have approved by the Director-General of OEH, a Consent to Destroy application under section 90 of the National Parks and Wildlife Act 1974 for Aboriginal archaeological sites that have been identified to be damaged or destroyed as a result of the development prior to this consent and/or by the archaeology and cultural management plan, prior to any disturbance of the identified sites by mining activity; and

(ii) not undertake surface development works within the area of high archaeological sensitivity identified as the alluvial terrace along Lords Creek (within proposed Long Wall 42).

(C) If, during the course of construction of any surface facilities, or mining in the LEA, the Applicant becomes aware of any heritage or archaeological material not previously identified, all work likely to affect the material shall cease immediately and the relevant authorities consulted about an appropriate course of action prior to recommencement of work. The relevant authorities may include OEH, the NSW Heritage Office, and the Local Aboriginal Land Council. Any necessary permits or consents shall be obtained and complied with prior to recommencement of work.

(D) General Terms of Approval - OEH

The Applicant shall invite the Koompahtoo Local Aboriginal Land Council to collect the identified isolated artefacts within the area of the proposed surface facilities prior to construction within the relevant area.

3.4 Flora and Fauna Assessment and Management

(a) The Applicant shall prior to commencement of any construction works for surface facilities in the relevant area or secondary workings within the LEA, prepare and implement a Flora and Fauna Management Plan for the management of flora and fauna issues for the areas of the proposed surface facilities and LEA. The Plan shall be prepared in consultation with OEH and LMCC, and to the satisfaction of the Director-General, and shall include but not be limited to:

(i) a detailed assessment of the current characteristics and ecological values of existing ecosystems likely to be affected by the development;

(ii) strategies to minimise the net loss of ecologically significant vegetation communities within DA area as a result of the development, including the provision of compensatory areas of equivalent ecological and habitat value where necessary;

(iii) strategies to provide increased security for existing habitats and communities (including the strengthening of riparian communities, the management of *Tetratheca juncea* plants in the vicinity of the proposed surface facilities, particularly in and around the northern and southern reject emplacement areas), and LEA, and habitats of other threatened species such as the Squirrel Glider and Threatened Bat Species identified in the species impact statement;

(iv) strategies to manage the impact of surface water management, erosion and sediment control measures, and flooding mitigation measures on flora and fauna, including the impact of heavy machinery;

(v) details of monitoring the mine's impacts on native vegetation and threatened fauna and flora, and outline contingency measures should impacts be identified as occurring (refer also condition 8.5);

(vi) measures to monitor the impacts on threatened species populations shall address:

1. methods of clearing near existing vegetation and measures to protect exisiting vegetation from the edge affects. Consideration of buffers is essential, especially near drainage lines.
2. measures to reduce sediment into drainage lines.

3. subsidence impacts on *Tetratheca juncea* through a monitoring program. This program will be co-ordinated with a surveyed and levelled line to determine drops in the terrain, following mine subsidence;
4. development of a program to specifically monitor the success or otherwise of proposed ameliorative measures in relation to the threatened flora and fauna species over five years from the commencement of construction in the relevant area. The monitoring is to be undertaken by experienced Botanist(s)/ Zoologist(s). Annual progress reports and a final report outlining the implementation and success or otherwise of the ameliorative measures shall be included in the AEMR during the monitoring period.

(vii) measures to maintain trees with denning hollows for the protection of threatened arboreal fauna species such as the Squirrel Glider and small Bats. In the event that trees and/or nesting value relevant to these species are felled and tree hollows relocated to augment habitat, and/or in the event that individual animals are captured and relocated during construction, this work shall be undertaken by a Zoologist with knowledge and experience in the implementation of such ameliorative techniques for these species;

(viii) a large scale plan showing quadrat number locations for *Tetratheca juncea* together with a table showing sub-population sizes and their relevant co-ordinates. In particular, this information is required where populations will be lost by the Northern and Southern Reject Emplacement Areas;

(ix) strategies to maintain and enhance wildlife corridors around and through the site for the movement of fauna particularly for arboreal mammals, small birds, and squirrel gliders.

(x) development of a protocol for identifying and managing significant impacts on any threatened flora and fauna species not identified in the EIS, during development through construction or operation of the coal mine.

(b) Deleted.

(c) The Applicant shall not disturb the *Tetratheca juncea* population within the area identified as "common" in figure 7 of the species impact statement, which is close to the northern reject emplacement area boundary.

(d) The Applicant shall implement the ameliorative measures for *Tetratheca juncea,* Squirrel Glider, and Threatened Bat Species identified in sections 11.1 and 11.2 of the species impact statement.

(e) Any fencing of native vegetation which is to be retained shall not consist of barbed wire fencing.

3.5 Prevention of Soil Erosion

(a) The Applicant shall prepare Erosion and Sediment Control Plans for the surface facilities, particularly the waste reject emplacement areas, and the LEA in consultation with LMCC and to the satisfaction of NOW and Director-

General, and submit these Plans to the EPA as part of applications for a licence under the Protection of the Environment Act. The Plans shall be prepared and implemented prior to the commencement of work in the relevant areas.

(b) The Erosion and Sediment Control Plans shall include:

(i) consideration and management of erosion and sedimentation of surface watercourses/waterbodies, including LT Creek and all creeks within the LEA; and

(ii) consideration of LMCC's Erosion and Sediment Control Policy and Code of Practice.

(iii) a program for reporting on the effectiveness of the sediment and erosion control systems and performance against objectives contained in the approved erosion and sediment control management plans, and EIS. (refer also condition (d) (i) below)

(c) The Applicant shall also prepare a soil stripping management plan for the northern waste emplacement extension area and southern waste emplacement area to the requirements of DRE which shall include, but not be limited to:

(i) details of the management of soil stockpiles, soil stripping techniques and scheduling; and

(ii) a program for reporting on the effectiveness of the soil stripping methods and performance against objectives contained in the soil stripping management plan, and EIS.

(d) <u>General Terms of Approval - EPA</u>

(i) *Stormwater/sediment Control - Construction Phase*

The Erosion and Sediment Control Plan (ESCP) in sub clause (a) above must also be prepared to describe the measures that will be employed to minimise soil erosion and the discharge of sediment and other pollutants to lands and/or waters during construction activities. The ESCP should be consistent with the requirements for such plans outlined in *Managing Urban Stormwater: Soils and Construction,* (Landcom), or most recent version of these guidelines.

(ii) *Stormwater/sediment Control- Operation Phase*

A Stormwater Management Scheme must be developed and implemented to mitigate the impacts of stormwater runoff from the site following the completion of construction activities. The Scheme should be consistent with the Stormwater Management Plan for the catchment and the Water Management Plans in condition 4.1. Where a Stormwater Management Plan has not yet been prepared, the Scheme should be consistent with the guidance contained in Managing Urban Stormwater: Council Handbook (available from the EPA). The Scheme shall be prepared at the same time as the Water

Management Plans in condition 4.1.

3.6 Site Rehabilitation Management

The Applicant shall carry out rehabilitation of all mine areas in accordance with the requirements of any Mining Lease.

3.7 Visual Amenity and Landscaping

a) The Applicant shall, prior to the commencement of construction works in the relevant area, submit for the approval of LMCC a detailed landscape and revegetation management plan for the surface facility sites prepared by a suitably qualified person. The plan shall include, but not be limited to:

(i) details of the establishment of vegetation and the construction of mounding or bunding, for the purposes of maintaining satisfactory visual amenity, ecological functioning and habitat provision;

(ii) consideration of revegetation works along creeklines;

(iii) use of indigenous species;

(iv) details of the visual appearance of all buildings, structures, facilities or works (including paint colours and specifications). Buildings and structures shall be designed and constructed so as to blend as far as possible with the surrounding landscape;

(v) details, specifications and staged work programs to be undertaken, including a maintenance program of all landscape works, building materials and cladding.

The landscaping and revegetation plan must be consistent with the Environmental Management Strategy (condition 3.2).

b) The Applicant shall ensure that an undisturbed barrier of 50 metres be maintained between the eastern boundary of the property at 1 Fassifern Road, Wakefield, and the toe of the proposed Northern Reject Emplacement Area.

3.8 Bushfire and other Fire Controls

The Applicant shall:

(a) provide adequate fire protection works on the sites of surface works in accordance with the Coal Mine Regulation Act, 1982; and

(b) prior to commencement of construction of surface facilities/works prepare a bushfire management plan for all its holdings contained in the DA, particularly the southern waste emplacement area to the satisfaction of the LMCC.

3.9 Land Management

The Applicant shall:

(a) prior to commencement of construction works in the relevant area prepare a Land Management Plan for the areas of the proposed surface facilities, and its holdings in the LEA, to provide for proper land management in consultation with OEH, DRE, and LMCC, and to the satisfaction of the Director-General . The plan shall include, but not be limited to:

(i) pastures and remnant vegetation management;

(ii) prevention and rehabilitation of land degradation;

(iii) eradication of vermin and noxious weeds as required by the Rural Lands Protection Authority, the Prickly Pear Authority and other relevant authorities;

(iv) feral animal control.

(b) minimise the removal of trees and other vegetation from the proposed surface facilities, particularly the waste emplacement areas and proposed new coal stockpile areas, and restrict any clearance to the areas occupied by mine activity, buildings and paved surfaces, and those areas necessary for fire control in accordance with LMCC's requirements.

(c) prepare and implement a Wetland Management Plan for all wetland areas affected by the surface facilities, particularly within the proposed southern reject emplacement area. The Plans shall be prepared in consultation with OEH, DRE and affected landowners, and to the satisfaction of LMCC, prior to surface construction works in the relevant area. The plan shall include, but not limited to, replacement of habitat and in creek storages for water flows as part of the restoration of the emplacement areas.

3.10 Subsidence Management Plan

Prior to carrying out any underground mining operations that could cause subsidence, the Applicant shall prepare a Subsidence Management Plan (SMP) to the satisfaction of the Executive Director, Mineral Resources. This plan must be prepared in accordance with the:

(a) *New Approval Process for Management of Coal Mining Subsidence - Policy*; and

(b) *Guideline for Applications for Subsidence Management Approvals* (or the latest versions or replacements of these documents).

3.11 Subsidence Protection

In preparing the SMP, the Applicant shall pay particular attention to assessing and managing the potential surface impacts on all areas of the proposed underground mining area where:

(a) cover depths are less than 100 metres (not including any depth of alluvium);

(b) overlying mine workings occur; or

(c) surface infrastructure such as power line towers and Hawkmount Road occurs.

3.12 Subsidence Management in the Main West Mining Area

The Applicant shall:

(a) not conduct mining operations within 100 metres of pointsin the seam directly below Tension Tower # 18;

(b) ensure that underground mining in the Main West Mining Area does not cause more than 20 mm of vertical subsidence at the surface in any location; and

(c) remediate any unpredicted subsidence impacts on the 330 kV power transmission lines and towers in the Main West Mining Area, to the satisfaction of TransGrid.

4. Water Management

4.1 Surface & Ground Water Management

The Applicant shall:

(a) prior to the commencement of construction of each of the new surface facilities at Newstan Colliery, and prior to first workings within the LEA , prepare water management plans for the relevant developments, in consultation with NOW, EPA, LMCC, and DRE and to the satisfaction of the Director-General, which shall include, but not be limited to, the following matters:

(i) management of the quality and quantity of surface and ground water within the areas covered by the water management plans, which shall include preparation of monitoring programs as provided by condition 8.2.;

(ii) management of stormwater and general surface runoff diversion to ensure separate effective management of clean and dirty water; (refer also condition 3.5 (d) (ii)).

(iii) measures to prevent the quality of any surface waters being degraded below the relevant water quality prior to construction, particularly in LT Creek and all creeks within the LEA due to the operation of the mine workings;

(iv) investigation into opportunities to reduce the minewater discharge into LT Creek in consultation with the EPA and include the results of such investigations in the Annual Environmental Management Report;

(v) identification of any possible adverse effects on water supply sources of surrounding land holders, as a result of the underground mining operations in the LEA and surface mine works, and implementation of mitigation measures as necessary;

(vi) identification of changes in flow of surface waters including all creeks within the LEA, particularly in Lord's Creek, due to subsidence, and LT Creek particularly due to the southern and northern waste emplacement areas and coal stockpiling areas;

(vii) identification of any stream rehabilitation works required to ameliorate subsidence effects on stream flows within Lords Creek;

(viii) contingency plans for managing adverse impacts of the development on surface and groundwater quality, including the matter in condition 4.1(d)(iv);

(ix) identification of the fresh quality groundwater resources within the project area, including the development of appropriate protection strategies;

(x) projection of potential groundwater changes during mining (short term) and post-mining (long term) with particular attention given to the affectof changes to groundwater quality and mobilisation of salts;

(xi) a monitoring and remediation strategy for all streams which may be adversely affected by subsidence including bed fracturing and/or degradation of the stream channel. Where the monitoring indicates any adverse impacts due to mining, the company shall implement the remediation strategy to the satisfaction of NOW.

(xii) consideration of the State Wetlands Management Policy for all significant downstream wetlands that may be effected by mining activity within the LEA or the relevant area.

(xiii) a program for reporting on the effectiveness of the water management systems and performance against objectives contained in the approved site water management plans, and EIS;

(b) implement remediation measures, to the satisfaction of NOW, where the development is responsible for the loss of groundwater quality or quantity below its current beneficial use;

(c) obtain a license with NOW under part 5 of the Water Act (1912) prior to construction of all new excavations, test bores and production bores (including dewatering bores) that intersect the groundwater.

(d) General Terms of Approval - NOW

Pursuant to Part 2 of the Water Act, 1912:

(i) the licensed works shall:
  (a) be constructed in accordance with plans and specifications approved by NOW;
  (b) be constructed and maintained in a safe and proper manner;
  (c) not impede or capture floodwater;
  (d) not cause erosion or sedimentation of adjacent and downstream watercourses shall;

(ii) Deleted;

(iii) an appropriate vegetative buffer zone shall be installed between the licensed works and any adjacent mining activities;

(iv) groundwater and surface water quality monitoring shall be conducted, to the satisfaction of NOW, in the vicinity of the licensed works. The monitoring program is to identify any degradation in water quality as a result of the works (also refer to condition 8.2(ii)). A contingency plan shall be developed, to the satisfaction of NOW, to remediate any such degradation (also refer to condition 4.1(a)(ix)). A copy of the finding shall be submitted to LMCC.

(e) General Terms of Approval - EPA

(i) Pollution of Waters

The licensee must design construct and operate all plant and equipment and any other facilities on the premises so as to minimise the pollution of waters.

(ii) Discharge Concentration Limits

The Applicant shall only discharge water from the development in accordance with the provisions of a current Environmental Protection Licence.

(iii) Wastewater Utilisation Areas

Spray from the application of wastewater must not drift beyond the boundary of the waste water utilisation area to which it is applied.

(iv) Maintaining Waste Water Utilisation Areas

Waste water utilisation areas must effectively utilise the waste water applied to those areas. This includes the use for pasture or crop production, as well as ensuring the soil is able to absorb the nutrients, salts, hydraulic load and organic materials in the solids or liquids. Monitoring of land and receiving waters to determine the impact of waste water application may be required by the EPA.

4.2 Assessment of LT Creek and Water Re-use Options

The Applicant shall undertake an assessment of water quality and stream health in LT Creek and minewater re-use options to the satisfaction of the Director-General. This assessment must:

(a) be prepared in consultation with the CCC, EPA, NOW and LMCC and be submitted to the Director-General by the end of March 2013 for approval;
(b) review the history of operations at Newstan Colliery and describe any historical impacts from discharges from the Colliery on water quality and stream health in LT Creek;
(c) identify the source(s) of exceedances of ANZECC water quality criteria for waters discharged from the site;
(d) establish appropriate water quality criteria for water discharged from the site;
(e) identify any reasonable and feasible options for the improvement of water management at Newstan Colliery including water treatment, re-use or transfer; and
(f) provide a proposed timetable for the implementation of reasonable and feasible measures identified in (d) above.

4.3 Groundwater Monitoring Program – Main West Mining Area

The Applicant shall prepare a Groundwater Monitoring Program for the Main West Mining Area. This program must:

(a) be prepared in consultation with NOW, and be submitted to the Director-General by the end of August 2012 for approval;
(b) include:

- baseline data of groundwater levels (including alluvial and weathered rock aquifers), yield and quality in the region, and any privately owned groundwater bores that may be affected by mining operations;
- groundwater assessment criteria based upon analysis of baseline data for groundwater, surface water, including trigger levels for investigating any potentially adverse groundwater impacts; and
- a program to monitor and/or validate the impacts of mining in Main West on alluvial and coal seam aquifers, and any groundwater bores.

5. Hazardous Materials and Tailings Management

5.1 Waste Rock Emplacement and Management

The Applicant shall construct and manage the waste emplacements as set out in the EIS, and to the approval of the DRE.

5.2 Fine Rejects/Tailings Emplacement and Management

The Applicant shall prepare a Fine Rejects Management Plan for the placement of fine rejects in the Southern Waste Emplacement area to the satisfaction of the DRE prior to any placement of fine rejects in the emplacement areas.

5.3 Waste

General Terms of Approvals - EPA

(a) Receiving or Disposing of Waste

Except as expressly permitted in a licence, waste must not be:

- received at the premises for storage, treatment, processing, reprocessing or disposal; or
- disposed of at the premises.

(b) Hazardous and industrial waste

Hazardous or industrial waste must be stored and disposed of in a manner that will minimise the wastes impact on the environment including appropriate segregation for storage or disposal and transportation by a waste transporter licensed by theEPA.

6. Air Quality, Blast, Noise and Light Management

6.1 Air Quality and Greenhouse Gas

Odour

6.1A The Applicant shall ensure that no offensive odours, as defined under the POEO Act, are emitted from the site.

Greenhouse Gas Emissions

6.1B The Applicant shall implement all reasonable and feasible measures to minimise the release of greenhouse gas emissions from the site to the satisfaction of the Director-General.

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Air Quality Criteria

6.1C The Applicant shall ensure that all reasonable and feasible avoidance and mitigation measures are employed so that particulate matter emissions generated by the development do not exceed the criteria listed in Tables 1, 2 and 3 at any residence on privately owned land, or on more than 25 percent of any privately owned land.

Table 1: Long term impact assessment criteria for particulate matter

Pollutant	***Averaging period***	***[d] Criterion***
Total suspended particulate (TSP) matter	Annual	[a] 90 µg/m^3
Particulate matter < 10 µm (PM_{10})	Annual	[a] 30 µg/m^3

Table 2: Short term impact assessment criterion for particulate matter

Pollutant	***Averaging period***	***[d]Criterion***
Particulate matter < 10 µm (PM_{10})	24 hour	[a] 50 µg/m^3

Table 3: Long term impact assessment criteria for deposited dust

Pollutant	***Averaging period***	***Maximum increase[2] in deposited dust level***	***Maximum total[1] deposited dust level***
[c]Deposited dust	Annual	[b] 2 g/m^2/month	[a] 4 g/m^2/month

Notes to Tables 1-3

[a] Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources);

[b] Incremental impact (i.e. incremental increase in concentrations due to the development on its own);

[c] Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method; and

[d] Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed by the Director-General.

Operating Conditions

6.1D The Applicant shall:

(a) implement best management practice to minimise the off-site odour and dust emissions of the development;

(b) operate a comprehensive air quality management system on site that uses a combination of predictive meteorological forecasting and real-time air quality monitoring data to guide the day to day planning of surface activities and the implementation of both proactive and reactive air quality mitigation measures to ensure compliance with the relevant conditions of this consent;

(c) minimise the air quality impacts of the development during adverse meteorological conditions and extraordinary events (see Note d to Tables 1-3);

(d) minimise any visible off-site air pollution; and

(e) minimise the surface disturbance of the site generated by the development,

to the satisfaction of the Director-General.

Air Quality and Greenhouse Gas Management Plan

6.1E The Applicant shall prepare and implement an Air Quality and Greenhouse Gas Management Plan for the development to the satisfaction of the Director-General. This plan must:

(a) be prepared in consultation with the EPA, and be submitted to the Director-General for approval by the end of September 2012;

(b) describe the measures that would be implemented to ensure:
- best management practice is being employed;
- the air quality impacts of the development are minimised during adverse meteorological conditions and extraordinary events; and
- compliance with the relevant conditions of this consent;

(c) describe the proposed air quality management system;

(d) include an air quality monitoring program that:
- uses a combination of real-time monitors and supplementary monitors to evaluate the performance of the development;
- adequately supports the proactive and reactive air quality management system;
- includes $PM_{2.5}$ monitoring;
- evaluates and reports on the effectiveness of the air quality management system;
- includes a protocol for determining any exceedances of the relevant conditions of this consent.

6.3 Blast Management

(a) The Applicant shall only blast for the purposes of underground mining or constructing the vent shaft at the Awaba Colliery. (refer to condition 8.4 (b) for blast monitoring)

General Terms of Approval - OEH

(b) Overpressure

The overpressure level from blasting operations on the premises must not:

(i) exceed 115dB (Lin Peak) for more than 5% of the total number of blasts over a period of 12 months; and
(ii) exceed 120dB (Lin Peak) at any time,

when measured or computed at a free field location within 30 metres of any potentially affected residential building or other noise sensitive location such as a school or hospital unless otherwise approved in writing by the OEH.

(c) Ground Vibration (ppv)

Ground vibration peak particle velocity from the blasting operations on the premises must not:

(i) exceed 5mm/s for more than 5% of the total number of blasts over a period of 12 months; and
(ii) exceed 10mm/s at any time,

when measured or computed at a free field location within 30 metres of any potentially affected residential boundary or other noise sensitive location such as a school or hospital.

(d) Time of Blasting

(i) Blasting operations associated with surface construction works may only take place between the hours of *9am and 5pm Monday to Saturday inclusive.*

(ii) Deleted.

(e) Blast Management Protocol

A Blasting/Vibration Management Protocol must be prepared and implemented which will include details on:

- Compliance standards;
- Mitigation measures;
- Remedial action;
- Monitoring methods and program;
- Monitoring program for flyrock distribution;

- Measures to protect underground utilities (eg: rising mains, subsurface telecommunication and electric cables), and livestock nearby;
- Notification of procedures for neighbours prior to detonation of each blast;
- Measures to ensure no damage by flyrock to people, property, livestock and powerlines.

6.4 Noise Control Newstan Surface Facilities

Operational Noise Criteria

6.4A The Applicant shall ensure that noise from the development (excepting the Newstan ventilation shaft site at Awaba) does not exceed the noise criteria in Table 4.

Table 4: *Noise criteria*

Location	Shoulder dB(A) $L_{Aeq(15\ min)}$	Day dB(A) $L_{Aeq(15\ min)}$	Evening dB(A) $L_{Aeq(15\ min)}$	Night dB(A) $L_{Aeq(15\ min)}$	Night dB(A) $L_{A1\ (1\ min)}$
NC1 -Davis	35	35	35	35	45
NC2 – Culgan	38	38	35	35	45
NC3 – Orrock	39	39	37	37	45
NC4 – Phelps	35	35	35	35	45
NC5 - Parnell	35	35	35	35	45
NC6 – Fassifern Primary School	N/A	35	N/A	N/A	N/A
All other privately-owned land	N/A	35	N/A	N/A	n/A

Notes:

- *To interpret the locations referred to in Table 4, see Figure1 in Appendix2;*
- *Noise generated by the development is to be measured in accordance with the relevant requirements and exemptions (including certain meteorological conditions) of the NSW Industrial Noise Policy.*
- *Day is defined as the period from 7am to 6pm;*
- *Evening is defined as the period from 6pm to 10pm;*
- *Night is defined as the period from 10pm to 6am; and*
- *Shoulder is defined as the period from 6 am to 7am.*

However, these criteria do not apply if the Applicant has an agreement with the relevant owner/s of these residences/land to generate higher noise levels, and the Applicant has advised the Department in writing of the terms of this agreement.

Operating Conditions

6.4B The Applicant shall:

(i) implement best practice noise management to minimise the operational, low frequency, rail and road traffic noise of the development

(ii) regularly assess the real-time noise monitoring and meteorological forecasting data and relocate, modify, and/or stop operations on site to ensure compliance with the relevant conditions of this consent;

(iii) minimise the noise impacts of the development during temperature inversions;

(iv) use its best endeavours to achieve the long-term noise goals in Table 5, where this is reasonable and feasible, and report on the progress towards achieving these goals in the Annual Environmental Management Report; and

(v) carry out a comprehensive noise audit of the development in conjunction with each independent environmental audit,

to the satisfaction of the Director-General.

Table 5: Long-term noise goal

Location	Day/Evening/Night/Shoulder dB(A) $L_{Aeq\ (15min)}$
All privately-owned land	35

Note: Noise generated by the development is to be measured in accordance with the relevant requirements and exemptions (including certain meteorological conditions) of the NSW Industrial Noise Policy.

Noise Management Plan

6.4C The Applicant shall revise the Noise Management Plan for the development to the satisfaction of the Director-General. This revised plan must:

(i) be prepared by a suitably qualified expert whose appointment has been approved by the Director-General;

(ii) be submitted to the Director-General by the end of September 2012 for approval;

(iii) describe the measures that would be implemented to ensure compliance with the relevant conditions of this consent, including a real-time noise management system that employs both reactive and proactive mitigation measures; and

(iv) include a Noise Monitoring Program that:

- uses a combination of real-time and supplementary attended noise monitoring measures to evaluate the performance of the development;
- is capable of monitoring temperature inversion strengths at an appropriate sampling rate;

- evaluates and reports on the effectiveness of the real-time noise management system; and
- includes a protocol for determining exceedances of the relevant conditions of this consent.

6.4D Noise Control – Newstan Ventilation Shaft Site at Awaba

Operational Noise Criteria

The Applicant shall ensure that the noise generated at the Newstan ventilation shaft site at Awaba does not exceed the noise impact assessment criteria in Table 3A for any privately owned residence.

Table 3A: Noise impact assessment criteria dB(A)

Location	Day $L_{Aeq(15\ minute)}$	Evening $L_{Aeq(15\ minute)}$	Night $L_{Aeq(15\ minute)}$
All privately owned residences	38	40	36

Notes:

a) Noise from the development is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 metres of a dwelling (rural situations) where the dwelling is more than 30 metres from the boundary, to determine compliance with the $L_{Aeq(15\ minute)}$ noise limits in the above table. The modification factors in Section 4 of the NSW Industrial Noise Policy shall also be applied to the measured noise levels where applicable.

b) Where it can be demonstrated that direct measurement of noise from the development is impractical, the OEH may accept alternative means of determining compliance (see Chapter 11 of the NSW Industrial Noise Policy).

c) The noise emission limits identified in the above table apply under meteorological conditions of:
- *wind speeds of up to 3 m/s at 10 metres above ground level; or*
- *temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level.*

d) In this condition:
- *Day is defined as the period from 7am to 6pm on Monday to Saturday, and 8am to 6pm on Sundays and Public Holidays;*
- *Evening is defined as the period from 6pm to 10pm; and*
- *Night is defined as the period from 10pm to 7am on Monday to Saturday, and 10pm to 8am on Sundays and Public Holidays.*

Construction Activities

The Applicant shall ensure that noise caused by construction activities at the Newstan ventilation shaft site at Awaba outside of the hours 7am to 6pm Monday to Friday and 8am to 1pm Saturdays does not exceed the operational noise criteria in Table 3A.

Noise Monitoring

Prior to the commencement of construction activities at the Newstan ventilation shaft site at Awaba the Applicant shall prepare and implement a Noise Monitoring Program for the Awaba surface facilities and ventilation shaft site to the satisfaction of the Director-General. This program must:

(a) be submitted to the Director-General for approval; and

(b) provide for the monitoring of both construction and operational activities.

6.5 Light Emissions

The Applicant shall screen or direct all onsite lighting away from residences and roadways to the satisfaction of LMCC.

7. Transport and Utilities

7.1 Road Transport

(a) No approval is granted for the haulage of coal on public roads.

(b) Deleted.

(c) The Applicant, in consultation with MSB, shall ensure that access within the DA area, to properties and within properties, is maintained at no less than the existing standard during the period in which mining occurs under the land and for a period of at least five years thereafter, in relation to condition, flood liability, public safety and flood hazard. The Applicant shall carry out any roadworks considered necessary by LMCC or the RMS to ensure compliance with this condition insofar as any works to maintain the existing standard at the time of mining are directly attributable to the operation of the mine, particularly on the F3 Sydney-Newcastle Freeway, Main Road 220 – Toronto to Freemans Waterholes and Main Road 217 – Toronto to Morisset.

(d) The Applicant shall ensure that the efficiency and effectiveness of all drainage, culverts and watercourses affecting roadways within the DA area must be maintained in so far as any works to maintain the existing standard.at the time of mining are directly attributable to the operation of the mine.

(e) Pre-surveys of existing public road formations, roadways structures and drainage structures must be conducted prior to the commencement of mining activity and every year subsequent year until the possibility of potential subsidence has ceded. All datum collected must be submitted to the RMS Hunter Region and LMCC for review.

(f) All mining activities and works related to mining in the LEA must be conducted in such a fashion as to ensure that there will be no subsidence within the F3 Sydney-Newcastle Freeway corridor.

(g) The Applicant shall notify the RMS and LMCC of imminent mining operations at least 12 months prior to mining under any section of Main Road 217 and/or Main Road 220.

7.2 Deleted.

8. Monitoring/Auditing

(a) In addition to the requirements contained elsewhere in this consent, the Director-General may, at any time in consultation with the relevant government authorities and Applicant, require the monitoring programs in conditions 8.1 - 8.7 below to be revised/updated to reflect changing environmental requirements or changes in technology/operational practices. Changes shall be made and approved in the same manner as the initial monitoring programs. All monitoring programs shall also be made publicly available at LMCC within two weeks of approval of the relevant government authority.

(b) All sampling strategies and protocols undertaken as part of any monitoring program shall include a quality assurance/quality control plan and shall require approval from the relevant regulatory agencies to ensure the effectiveness and quality of the monitoring program. Only accredited laboratories shall be used for laboratory analysis.

8.1 Meteorological

For the life of the development, the Applicant shall ensure that there is a meteorological station in the vicinity of the site that:

(i) complies with the requirements in the *Approved Methods for Sampling of Air Pollutants in New South Wales* guideline; and

(ii) is capable of continuous real-time measurement of temperature lapse rate in accordance with the *NSW Industrial Noise Policy,* unless a suitable alternative is approved by the Director-General following consultation with the EPA

8.2 Surface and Ground Water

(a)

(i) The Applicant shall construct and locate surface and ground water monitoring positions, as identified in the site water management plan (condition 4.1 (a)), in consultation with NOW, LMCC and EPA, and to the satisfaction of the Director-General , at least three months prior to the commencement of construction works in the relevant area and first workings in the LEA;

(ii) The Applicant shall prepare a detailed monitoring program in respect of ground and surface water quality and quantity, including water in and around the Newstan mine site, Northern and Southern Emplacements, and LEA, and also consistent with condition 4.1(b)(iv), during construction works, mine operations and post mine operations in consultation with NOW, EPA, and to the satisfaction of the Director-General. The monitoring program shall also include surveys of drainage channels within the LEA to update information obtained in the preparation of Property Subsidence Management Plans. The monitoring program shall be prepared prior to commencement of construction in the relevant area.

(iii) The results and interpretation of surface and ground water monitoring are to be provided by the Applicant in an approved form to the NOW, LMCC and EPAon a six monthly basis, unless otherwise directed by the Director-General. The results are also to be contained and analysed in the Annual Environmental Management Report (Condition 9.1).

(b) The Applicant must conduct water quality monitoring for pollutants in accordance with any current Environment Protection Licence under the *Protection of the Environment Operations Act 1997* for the site.

8.3 Deleted

8.4 Noise and Blast

(a) Noise Investigations and Management-Newstan Surface Facilities

The Applicant shall:

(i) prior to commencement of construction in the relevant area, develop a plan to conduct noise investigation*s* at three monthly intervals to evaluate, assess and report the LA_{10} (15 minute) noise emission levels due to normal operations of the mine under prevailing weather conditions, or as otherwise determined by the EPA**.** The methodologies, including establishing the mine's operating configuration, determining survey intervals, weather conditions, seasonal variations, selecting variations, selecting locations, periods and times of measurements, the design of any noise modelling or other studies, including the means for determining the noise levels emitted by the mining operations, shall be in accordance with the requirements of the EPA;

(ii) survey and investigate noise reduction measures from plant and equipment at the conclusion of the first 12 months.

(iii) arrange independent noise emission investigations as provided in Condition 11.2.

A summary of noise monitoring results shall be included in the AEMR.

(b) Blasting-Newstan Surface Facilities and Newstan Ventilation Shaft Site at Awaba

The Applicant shall:

(i) monitor any blasts and record the overpressure and peak particle velocity as agreed by the EPA, including details of monitoring locations; and

(ii) include the results of the monitoring information as required by the EPA and in the Annual Environmental Management Report (Condition 9.2).

8.5 Fauna and Flora Monitoring

The Applicant shall prepare a detailed monitoring program of habitat areas, including any wetlands and aquatic habitats, during the development and for a period after the completion of the development to be determined by the Director-General in consultation with LMCC, OEH and DRE. The program shall monitor impacts attributable to the development and include monitoring of the success of any restoration or reconstruction works. The Applicant shall include the monitoring program in the Flora and Fauna Management Plan (condition 3.4). The Applicant shall carry out any further works required by the Director-General as a result of the monitoring. A summary of monitoring results shall be included in the AEMR.

8.6 Cultural Heritage Monitoring

The Applicant shall monitor the effectiveness of measures outlined in the archaeology and heritage management plan (condition 3.3). A summary of monitoring results shall be included in the AEMR.

8.7 Subsidence Monitoring

The Applicant shall undertake a detailed and ongoing monitoring program of subsidence resulting from mining to the satisfaction of the Director-General and in consultation with NOW, DRE and MSB throughout the life of the mine and for a period of at least five years after the completion of mining, or other such period as determined by the Director-General in consultation with NOW and DRE. Monitoring shall include the following:

(i) a survey of watercourses within areas mined within the DA Area;
(ii) monitoring of groundwater levels and quality;
(iii) monitoring of impacts on any buildings, structures and roads within areas mined within the DA Area;
(iv) a monitoring program to identify any subsidence impacts on the 330kV power transmission lines and towers in the Main West Mining Area, developed in consultation with DRE and TransGrid;
(v) monitoring of remedial measures; and
(vi) a comparison of predicted impacts with actual impacts, including mapping of subsidence profiles within areas mined within the DA Area.

The Applicant shall include information on monitoring conducted and the interpreted results in the Annual Environmental Management Report (condition 9.2).

8.8 Community Consultative Committee

(i) The Applicant shall maintain a Community Consultative Committee (CCC) for the development. This committee shall:
   (a) comprise:
      - 2 representatives from the Applicant, including the person responsible for environmental management at the mine;
      - at least 1 representative from Council (if available); and
      - at least 3 representatives (or as otherwise agreed by the Director-General) from the local community whose appointment has been approved by the Director-General;

(b) be chaired by an independent chairperson, whose appointment has been approved by the Director-General;
(c) meet at least twice per year;
(d) review the Applicant's performance with respect to environmental management and community relations;
(e) undertake regular inspections of the mining operations;
(f) review community concerns or complaints about the mine operations, and the Applicant's complaints handling procedures;
(g) provide advice to:
- the Applicant on improved environmental management and community relations, including the provision of information to the community and the identification of community initiatives to which the Applicant could contribute;
- the Department regarding the conditions of this consent; and
- the general community on the performance of the mine with respect to environmental management and community relations; and

(h) be operated generally in accordance with any guidelines the Department may publish in regard to the operation of Community Consultative Committees for mining projects.

Notes:
1) *Guidelines were published by the Department in June 2007.*
2) *The CCC is an advisory committee. The Department and other relevant agencies are responsible for ensuring that the Applicant complies with this consent.*

(ii) The Applicant shall, at its own expense:
(a) ensure that 2 of its representatives attend CCC meetings;
(b) provide the CCC with regular information on the environmental performance of the development;
(c) provide meeting facilities for the CCC;
(d) arrange site inspections for the CCC, if necessary;
(e) respond to any advice or recommendations the CCC may have in relation to environmental management or community relations;
(f) take minutes of the CCC meetings;
(g) forward a copy of these minutes to the Director-General; and
(h) put a copy these minutes on its website.

8.9 Independent Environmental Audit

(i) Prior to 14 May 2009, and every 3 years thereafter, unless the Director-General directs otherwise, the Applicant shall commission and pay the full cost of an Independent Environmental Audit of the development. This audit must:
(a) be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Director-General;
(b) include consultation with the relevant agencies
(c) assess the environmental performance of the project and assess whether it is complying with the relevant requirements of this approval and any relevant mining lease or EPL (including any strategy, plan or program required under these approvals);

(d) review the adequacy of strategies, plans or programs required under these approvals; and, if appropriate,

(e) recommend measures or actions to improve the environmental performance of the project, and/or any strategy, plan or program required under these approvals.

Note: This audit team must be led by a suitably qualified auditor.

(ii) Within 6 weeks of the completion of this audit, or as otherwise agreed by the Director-General, the Applicant shall submit a copy of the audit report to the Director-General, together with its response to any recommendations contained in the audit report.

(iii) Within 3 months of submitting the audit report to the Director-General, the Applicant shall review, and if necessary revise the strategies/plans/programs required under this consent to the satisfaction of the Director-General.

9. Reporting

9.1 Annual Environmental Management Report

Each year the Applicant shall submit an AEMR to the Director-General and to all relevant agencies. This report must:

(a) identify the standards and performance measures that apply to the development;

(b) describe the works carried out in the last 12 months;

(c) describe the works that will be carried out in the next 12 months;

(d) include a summary of the complaints received during the past year, and compare this to the complaints received in the previous 5 years;

(e) include a summary of the monitoring results on the development during the past year;

(f) include an analysis of these monitoring results against the relevant:
- impact assessment criteria/limits;
- monitoring results from previous years; and
- predictions in the EIS and SEE noted in condition 1.1;

(g) identify any trends in the monitoring results over the life of the development;

(h) identify any non-compliance during the previous year; and

(i) describe what actions were, or are being, taken to ensure compliance.

9.2 Access to Information

(a) Within 3 months of the approval of any plan/strategy/program required under this consent (or any subsequent revision of these plans/strategies/programs), or the completion of the audits or AEMRs required under this consent, the Applicant shall:
- provide a copy of the relevant document/s to the relevant agencies;
- ensure that a copy of the relevant document/s is made publicly available at the mine; and
- put a copy of the relevant document/s on its website.

(b) During the development, the Applicant shall:
- make a summary of monitoring results required under this consent publicly available at the mine and on its website; and
- update these results on a regular basis (at least every three months).

9.3 Recording and Reporting Requirements

General Terms of Approval – EPA

(i) Recording of Monitoring

The results of any monitoring required must be recorded and retained as set out in the licence.

(ii) Reporting Requirements

The EPA will require reporting on the environmental performance of the proposal as set out in the licence. The timing of reporting shall be consistent with the environmental reporting required by this consent, as far as practical.

10. Community Consultation/Obligations

10.1 Deleted

10.2 Community Consultation

(a) Complaints

The Environmental Officer (refer condition 3.1) shall be responsible:

(i) for responding to complaints with respect to construction works and mine operations on a dedicated and publicly advertised telephone line, 24 hours per day 7 days per week, entering complaints or comments in an up to date system, and ensuring that a response is provided to the complainant within 24 hours; and

(ii) providing a report of complaints in the AEMR throughout the life of the project to the Director-General, LMCC, EPA, DRE, and CCC.

(b) Other community consultation required by this consent

Refer condition 8.8 - Community Consultative Committee
Refer condition 3.3 - Heritage Assessment and Management

11. Land Acquisition and Compensation

11.1 Land Acquisition as a Result of Subsidence

Initial Valuation and Options Agreement

(a) The Applicant shall compensate landowners for compensable loss in accordance with the provisions of the Mining Act, 1992. Compensable loss is defined in that Act.

(b) Within six months of the date of this consent, any landowner within the Development Consent Area may request in writing a valuation of their property from the Applicant. Upon receipt of the request, the Applicant shall:

- (i) obtain a valuation within one month of receipt of the request, which includes proper consideration of a sum not less than the current market value of the owner's interest in the land as if the land was unaffected by the development proposal, whosoever is the occupier, having regard to:
  - the existing use and permissible use of the land in accordance with the applicable planning instruments at the date of the written request; and
  - the presence of improvements on the land and/or any Council approved building or structure which although substantially commenced at the date of the request is completed subsequent to that date ; and
- (ii) within 14 days of receipt of the valuation, offer in writing to enter into an options agreement with the landowner to acquire the land when notification is received if the mine plan submitted with an application for approval under s138 of the Coal Mine Regulation Act, 1982 indicates that the landowner is entitled to acquisition under Conditions 11.1(B) and (C).

(c) The valuation and options agreement shall also be available to any landowner who may be affected by noise and/or dust impacts from the surface facilities as proposed in the EIS. The options agreement shall be based on an option to sell if and when the landowner is entitled to acquisition under Condition 11.2.

(B) Acquisition and Compensation – Significant Structural Damage to Dwellings

(a) Where a dwelling within the DA area is, or is likely to be, subject to damage beyond the safe, serviceable and repairable criteria as a result of the development, the landowner, after receiving notification from the Applicant, may request the Applicant in writing to:

- (i) carry out such works as agreed by the landowner to remedy or mitigate any damage; or
- (ii) compensate the landowner for such effects; or
- (iii) acquire the whole of the property, or such part of the property requested by the landowner where subdivision is approved.

(b) The Applicant shall comply with any such request for acquisition or compensation in accordance with Conditions 11.1(D) and (E). If necessary to confirm the impact, the Applicant shall, at the request of the landowner in writing, conduct a structural inspection.

(C) Acquisition and Compensation – Land Use Impacts

(a) Where a landowner suffers a loss of agricultural productivity or other adverse impact on the use of land as a result of the development, the landowner, may request the Applicant in writing to:
   (i) carry out such works as agreed by the landowner to rectify the problem; or
   (ii) compensate the landowner for such effects; or
   (iii) acquire the whole of the property, or such part of the property requested by the landowner where subdivision is approved.

(b) The Applicant shall comply with any such request for acquisition or compensation in accordance with Conditions 11.1(D)-(E). If necessary to confirm the impact, the Applicant shall, at the request of the landowner in writing, conduct a structural inspection.

(c) Where the landowner requests acquisition, significant adverse impact to agricultural productivity or the use of the land or an enterprise must be demonstrated.

Note: The Independent Panel may be requested to advise on whether significant adverse impact has been demonstrated.

(D) Acquisition and Compensation – Procedure

(a) Any disputes relating to land acquisition or compensation (except those relating to valuation matters) may be referred by either party to the Independent Panel for consideration and advice if no agreement is reached within three months of receipt by the Applicant of the written request, or to the Mining Warden at any time in accordance with the provisions of the Mining Act.

(b) Upon receipt of a written request to purchase property in accordance with any conditions of this consent, the Applicant shall negotiate and purchase the whole of the property (unless the request specifically requests acquisition of only part of the property and subdivision has already been approved) within six months of receipt of the request. The Applicant shall pay the landowners an acquisition price resulting from proper consideration of:
   (i) a sum not less than the current market value of the owner's interest in the land as if the land was unaffected by the development proposal, whosoever is the occupier, having regard to:
      - the existing use and permissible use of the land in accordance with the applicable planning instruments at the date of the written request; and
      - the presence of improvements on the land and/or any Council approved building or structure which although substantially commenced at the date of the request is completed subsequent

(ii) the owner's reasonable compensation for disturbance allowance and relocation within the Lake Macquarie or Wyong local government areas, or within such other location as may be determined by the Director-General in exceptional circumstances;(iii) the owner's reasonable costs for obtaining legal advice and expert witnesses for the purposes of determining the acquisition price for the land and the terms upon which it is to be acquired; and (iv) the purchase price determined by reference to points (i), (ii) and (iii) shall be reduced by the amount of any compensation awarded to a landowner pursuant to the Mining Act, 1992 or other legislation providing for compensation in relation to coal mining but limited to compensation for dwellings, structures and other fixed improvements on the land, unless otherwise determined by the Director-General in consultation with the DRE or MSB.

(c) An offer by the Applicant to purchase a property under the conditions of this consent shall remain open to the landowner for the following periods from the date of the offer:
(i) for damage to a dwelling beyond the safe, serviceable and repairable criteria (Condition 11.1(B)), three years after completion of mining of longwall panels that affect the property;
(ii) for land use impacts (Condition 11.1(C)), five years after completion of mining of longwall panels that affect the property; and
(iii) for noise or dust impacts (Condition 11.2), for the life of the mine.

(d) Notwithstanding any other Condition of this consent, the landowner and the Applicant may enter into any other agreed arrangement regarding compensation; or the Applicant may, upon request of the landowner, acquire any property affected by the project during the course of this consent on terms agreed to between the Applicant and the landowner.

(E) Independent Valuation

(a) In the event that the Applicant and the landowner cannot agree within three months upon the acquisition price of the land and/or the terms upon which it is to be acquired under the terms of this consent, then either party may refer the matter to the Director-General who shall request an independent valuation to determine the acquisition price. The independent valuer shall consider any submissions from the landowner and the Applicant in determining the acquisition price.

(b) If the independent valuer requires guidance on any contentious legal, planning or other issues, the independent valuer shall refer the matter to the Director-General, who, if satisfied that there is a need for a qualified panel, shall arrange for the constitution of the panel. The panel shall consist of:
(i) the appointed independent valuer;

(ii) the Director-General; and/or
(iii) the President of the Law Society of NSW or nominee.
The qualified panel shall, on the advice of the valuer, determine the issue referred to it and advise the valuer.

(c) The Applicant shall bear the costs of any independent valuation or survey assessment requested by the Director-General.

(d) The Applicant shall, within fourteen days of receipt of a valuation by the independent valuer, offer in writing to acquire the relevant land at a price not less than the said valuation.

(F) Independent Panel

(a) The Director-General shall establish an Independent Panel to assist in the implementation of conditions of this consent relating to subsidence impacts, including remedial work, compensation, acquisition and decisions about impacts on agriculture and other land uses. The Panel shall be chaired by an independent mediator appointed by the Director-General, and comprise representatives, as required, from Lake Macquarie City Council and government agencies and/or technical experts. The Applicant shall contribute reasonable funds to facilitate functioning of the Panel, at amounts determined by the Director-General, for payment of the mediator and technical experts.

(b) The purpose of the Panel will be to assist in the resolution of disputes and provide technical advice on matters relating to subsidence impacts, but not those relating to valuation of property. If matters cannot be resolved by the Panel, they shall then be referred to the appropriate statutory body (such as the MSB or the Mining Warden). The Panel shall report annually to the Director-General on its considerations. If at any time the Chairperson of the Panel considers it necessary, the Panel may refer a matter to the Director-General for advice or determination.

(c) In considering matters referred to it, the Panel shall seek and consider submissions from all relevant parties.

(d) Before considering any matters relating to the impact of the development on agricultural productivity or other land uses, the Panel shall prepare guidelines setting out the criteria on which it will base such advice. The Guidelines shall be prepared within two months of receipt of the first request for advice and be made available to any enquirer upon request.

11.2 Land Acquisition as a Result of Excessive Noise and/or Dust

Note: In Condition 11.2 (a)-(e) "land" means the whole of a lot in a current plan registered at the Land Titles Office as at the date of this consent.

(a) (i) In the event that landowners consider that noise and/or dust from the Newstan mining operations, including surface facilities at their dwelling(s) is in excess of the noise levels set out in this consent or the relevant EPA amenity criteria for dust levels, and the Director-General, in consultation with the EPA, is satisfied that an investigation is required, the Applicant shall upon receipt of a written request:

- appoint a qualified independent person to undertake direct discussions with the landowners affected to ascertain their concerns and to plan and implement an investigation to quantify the impact and determine the sources of the effect, and
- bear the cost of the independent investigation and make available plans, programmes and other information necessary for the independent person to form an appreciation of the past, present and future mining operations and their effects on noise and/or dust emissions.

(ii) The investigation is to be carried out by a qualified independent person in accordance with a documented Plan. The Plan shall be designed and implemented to measure and/or compute (with appropriate calibration by measurement) the relevant noise and/or dust levels at the complainant's residence emitted by the current normal mining operations.

(iii) The independent person, the Plan and the timing of its implementation shall be approved by the Director-General, in consultation with LMCC, the EPA, the affected landowner and the Applicant. A report of the investigation shall be provided to the Director-General, the EPA the Applicant and the affected landowner.

(iv) The results of the investigation shall be assessed and reported by the independent person in the light of the mine's current operations and proposed short, medium and long term development plans.

(v) If the independent noise and/or dust investigation finds that the relevant criteria are being exceeded by noise and/or dust emission from normal mining operations, the Applicant shall:

- modify those areas of the mining operation which are causing the exceedances; or
- undertake other measures, as agreed with the affected landowner, to ameliorate the effects of the impact, within three (3) months or as otherwise directed by the Director General in consultation with the EPA.

(vi) Within two (2) months after the expiry of the three (3) month period in sub-clause (v) above, and upon written request from the landowner, the Applicant shall arrange for a further independent noise and/or dust investigation to be completed.

(vii) If the investigation in sub-clause (vi) above finds that the relevant noise and/or dust emission levels from normal mine operations exceed relevant amenity criteria or consent conditions, the Applicant shall purchase the property within six months of receipt of a written request from the owner of the affected property.

(viii) Further independent investigations shall cease if the Director-General, in consultation with the EPAis satisfied that the relevant consent limits or EPA amenity criteria are not being exceeded and are unlikely to be exceeded in the future.

(b) In respect of a request to purchase land arising under Condition 11.2(a), the Applicant shall pay the owner the acquisition price which shall take into account and provide payment for:

(i) a sum not less than the current market value of the owner's interest in the land used for its existing use at the date of this consent who is the occupier and all improvements thereon at this date as if the land was unaffected by the development proposal.

(ii) the owner's reasonable compensation for disturbance allowance and relocation costs within the Lake Macquarie City or Wyong Local Government Areas.

(iii) the owner's reasonable costs for obtaining legal advice and expert witnesses for the purposes of determining the acquisition price of the land and the terms upon which it is to be acquired.

(c) In the event that the Applicant and any owner referred to in Condition 11.2(a) cannot agree within the time limit upon the acquisition price of the land and/or the terms upon which it is to be acquired, then:

(i) either party may refer the matter to the Director-General, who shall request the President of the Australian Institute of Valuers and Land Economists to appoint a qualified independent valuer, suitably qualified in compensation issues, who shall determine, after consideration of any submissions from the land owner and the Applicant, the acquisition price.

(ii) in the event that the independent valuer requires guidance on any contentious legal, planning or other issues, the independent valuer shall refer the matter to the Director-General, who if satisfied that there is need for a qualified panel, shall arrange for the constitution of the panel. The panel shall consist of:

1) the appointed independent valuer,
2) the Director-General,
and/or
3) the President of the Law Society of NSW or his/her nominee.

The qualified panel shall, on the advice of the valuer, determine the issue referred to it and advise the valuer.

(d) The Applicant shall bear the costs of any valuation or survey assessment requested by the Director-General in accordance with Conditions 11.2(a) - 11.2(c).

(e) Upon receipt of a valuation, the Applicant shall offer to acquire the relevant land at a price not less than the said valuation. Should the Applicant's offer to acquire not be accepted by the owner within six (6) months of the date of such offer, the Applicant's obligations to such owner and in respect of that property under Conditions 11.2(a) - 11.2(e) above shall cease.

12. Structural Adequacy

12.1 Structural Adequacy

The Applicant shall ensure that all new buildings and structures, and any alterations or additions to existing buildings and structures, are constructed in accordance with the relevant requirements of the Building Code of Australia.

Notes:

- *Under Part 4A of the EP&A Act, the Applicant is required to obtain construction and occupation certificates for the proposed building works.*
- *Part 8 of the EP&A Regulation sets out the requirements for the certification of the development.*

12.2 Demolition

The Applicant shall ensure that all demolition work is carried out in accordance with *Australian Standard AS 2601-2001: The Demolition of Structures*, or its latest version.

APPENDIX 1
DA AREA

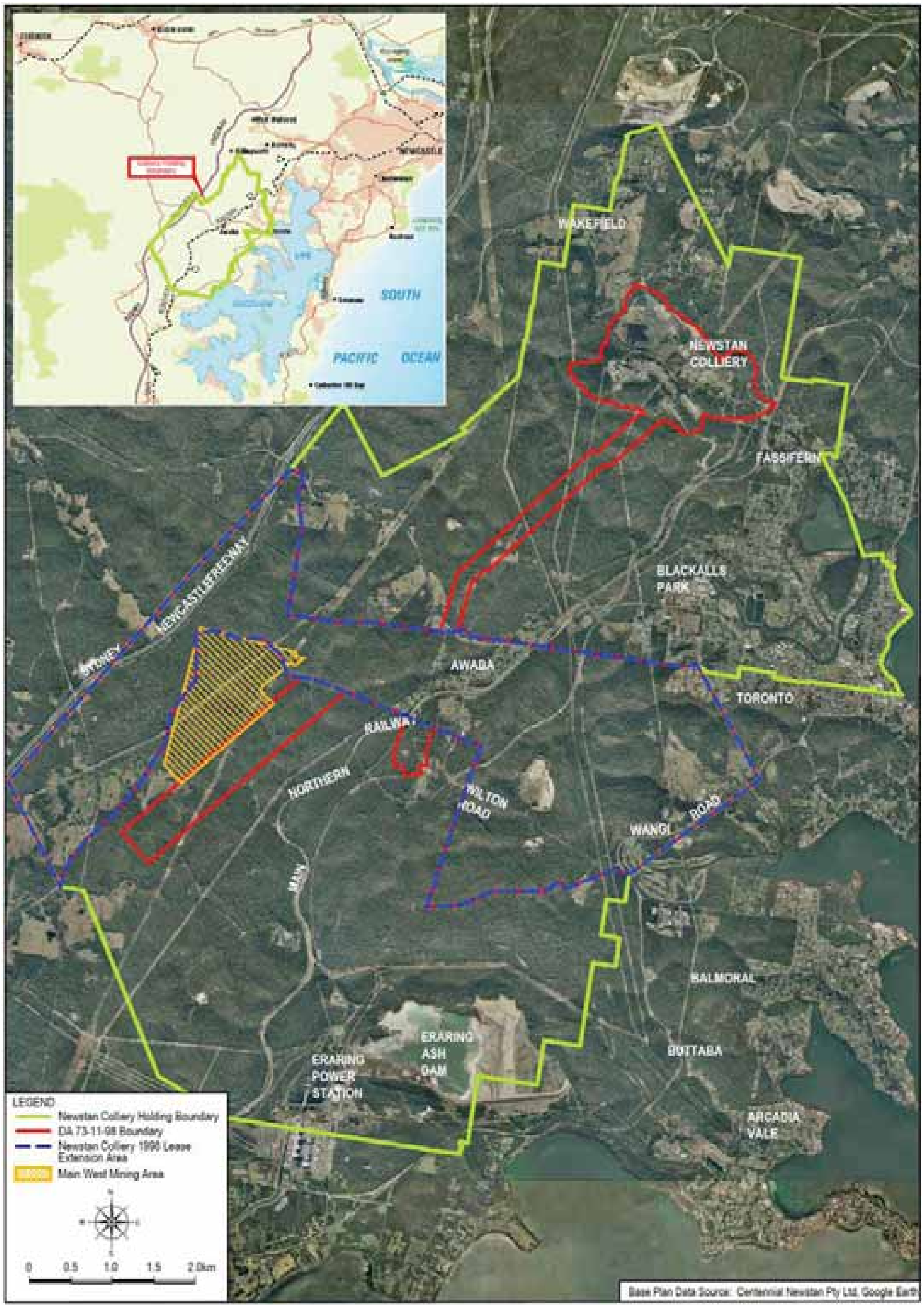


***Figure 1:** DA Area (combination of all areas within the red boundary of DA 73-11-98 and the orange hatched area of Main West Mining Area)*

APPENDIX 2
NOISE ASSESSMENT LOCATIONS

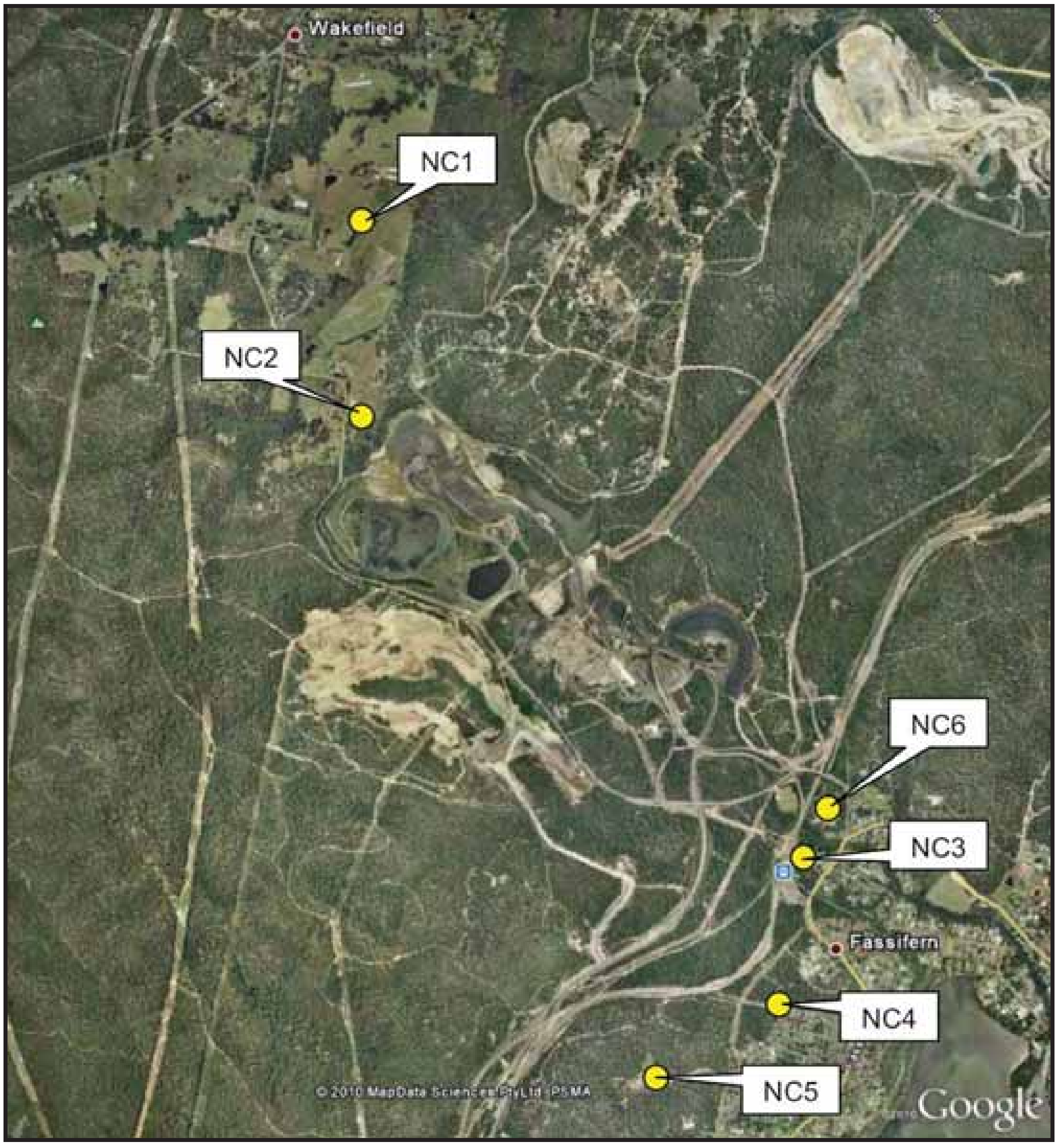
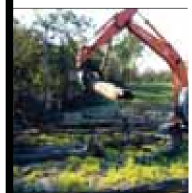
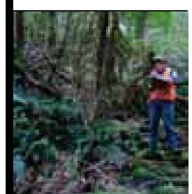
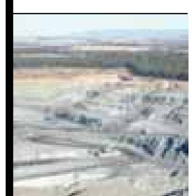
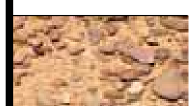


Figure 1: *Noise assessment locations*







Mining Leases

APPENDIX 3

N.S.W. STAMP DUTY
CL No. 1846308 COAL MINING LEASE
1997 ··· 1998 ··· 1999 [signature] 13/7/99

MINING LEASE

MINING ACT 1992

NO. 1452

DATED 6th JULY A.D. 1999

THE MINISTER FOR MINERAL RESOURCES
OF THE STATE
OF NEW SOUTH WALES
TO

POWERCOAL PTY LTD
ACN 052 533 070

RECORDED in the Department of Mineral Resources at Sydney, this 13th day of July A.D. 1999 at the hour of 12 o'clock in the noon.

J Beattie
for Director-General

Mining Lease Application No. 97

MINING ACT 1992

MINING LEASE

THIS DEED made 6th JULY One thousand nine hundred and ninety nine in pursuance of the provisions of the Mining Act 1992 (hereinafter called "the Act") BETWEEN THE HONOURABLE **EDWARD OBEID**, Minister for Mineral Resources of the State of New South Wales (hereinafter called "the Minister" which expression shall where the context admits or requires include the successors in office of the Minister and the person acting as such Minister for the time being) AND **POWERCOAL PTY LTD ACN 052 533 070** (which with its successors and transferees is hereinafter called "the lease holder").

WHEREAS

(a) in conformity with the Act application was made for a mining lease over the lands hereinafter described; and

(b) all conditions and things required to be done and performed before granting a mining lease under the Act have been done and performed NOW THIS DEED WITNESSETH that in consideration of the observance and performance of the covenants contained in this Deed and the payment of royalty by the lease holder, the Minister in pursuance of the provisions of the Act DOES HEREBY demise and lease to the lease holder ALL THAT piece or parcel of land containing by admeasurement an area of about **1587 hectares** and more particularly described and delineated in the plan **Catalogue No. M 26880** attached for the purpose of prospecting and mining for **coal**.

TO HOLD the said land together with any appurtenances thereon subject to:

(a) such rights and interests as may be lawfully subsisting therein or which may be reserved by the Act at the date of this Deed; and

(b) such conditions, provisos and stipulations as are contained in this Deed UNTO the lease holder from and including the date of this Deed for the period of **twenty one years** for the purpose as stated and for no other purpose.

1. THAT in this lease except insofar as the context otherwise indicates or requires:

    (a) any reference to an Act includes that Act and any Act amending or in substitution for the same; "Director-General" means the person for the time being holding office or acting as Director-General, Department of Mineral Resources, Sydney;

the word "mine" has the meaning assigned to it by the Act; words importing the singular number shall include the plural, the masculine gender the feminine or neuter gender and vice versa; and

(b) any covenant on the part of two or more persons shall be deemed to bind them jointly and severally.

2. THAT the lease holder shall during the said term pay to the Minister in Sydney in respect of all such minerals as stated, recovered from the land hereby demised, royalty at the rate or rates prescribed by the Act and the Regulations thereunder at the time the minerals are recovered, or at the rate or rates fixed by the Minister from time to time during the term of this demise in exercise of the power in that behalf conferred upon him by the Act.

3. THAT the lease holder shall at all times during the term of this lease keep and preserve the said mine from all avoidable injury or damage and also the levels, drifts, shafts, watercourses, roadways, works, erections and fixtures therein and thereon in good repair and condition and in such state and condition shall on the expiration or sooner determination of the said term or any renewal thereof deliver possession of the land and the premises hereby demised to the Minister or other persons authorised to receive possession thereof.

4. THAT the conditions and provisions set forth in the Schedule of Conditions of Authority herein and numbered:- **1 to 3 (inclusive), 9, 11, 19, 20, 23, 25, 27, 31, 32, 33, 37, 41 & 44 to 56 (inclusive).** inclusive are embodied and incorporated within this Deed as conditions and provisions of the lease hereby granted AND that the lease holder shall observe fulfil and perform the same.

PROVIDED always and it is hereby declared as follows:

(a) THAT this lease is granted subject to amendment as provided under Section 79 of the Act.

(b) THAT if the lease holder at any time during the term of this demise -

(i) fails to fulfil or contravenes the covenants and conditions herein contained; or

(ii) fails to comply with any provision of the Act or the Regulations with which the lease holder is required to comply; or

(iii) fails to comply with the requirements of any agreement or assessment in relation to the payment of compensation, this lease may be cancelled by the Minister by instrument in writing and the cancellation shall have effect from and including the date on which notice of the cancellation is served on the lease holder or on such later date as is specified in the notice; and any liability incurred by the lease holder before the cancellation took effect shall not be affected.

(c) THAT no implied covenant for title or for quiet enjoyment shall be contained herein.

(d) THAT all the conditions and provisions contained in the Mining Act 1992 and the Regulations thereunder, the Mines Inspection Act 1901 and the Coal Mines Regulation Act 1982 or any other law hereafter to be passed or prescribed shall be incorporated within this Deed as conditions and provisions of the lease granted. The lease holder hereby covenants to observe, fulfil and perform the same.

(e) THAT such of the provisions and conditions declared and contained in this Deed as requiring anything to be done or not to be done by the lease holder, shall be read and construed as covenants by the lease holder with the Minister which are to be observed and performed.

IN WITNESS WHEREOF the parties hereto have executed this Deed the day and year first abovewritten.

SIGNED AND DELIVERED
BY THE HONOURABLE **EDWARD OBEID**,
Minister for Mineral Resources in the State
of New South Wales

....

....
WITNESS

SIGNED SEALED AND DELIVERED
by the said

POWERCOAL PTY LTD
ACN 052 533 070

POWERCOAL PTY. LTD.
ACN
052 533 070
Common
Seal

....

....
WITNESS

SCHEDULE OF CONDITIONS OF AUTHORITY - 1998
(COAL)

EXTRACTION OF COAL

1 The lease holder shall extract as large a percentage of the coal in the subject area as is practicable consistent with the provisions of the Coal Mines Regulations Act 1982 and the Regulations thereunder and shall comply with any direction given or which may be given in this regard by the Minister.

MINING, REHABILITATION, ENVIRONMENTAL MANAGEMENT PROCESS (MREMP)

Mining Operations Plan (MOP)

2 (1) Mining operations, including mining purposes, must be conducted in accordance with a Mining Operations Plan (the Plan) satisfactory to the Director-General. The Plan together with environmental conditions of development consent and other approvals will form the basis for:-

(a) ongoing mining operations and environmental management; and

(b) ongoing monitoring of the project.

(2) The Plan must be prepared in accordance with the Director-General's guidelines current at the time of lodgement.

(3) A Plan must be lodged with the Director-General:-

(a) prior to the commencement of operations;

(b) subsequently as appropriate prior to the expiry of any current Plan; and

(c) in accordance with any direction issued by the Director-General.

(4) The Plan must present a schedule of proposed mine development for a period of up to seven (7) years and contain diagrams and documentation which identify:-

(a) area(s) proposed to be disturbed under the Plan;

(b) mining and rehabilitation method(s) to be used and their sequence;

(c) areas to be used for disposal of tailings/waste;

(d) existing and proposed surface infrastructure;

(e) progressive rehabilitation schedules;

(f) areas of particular environmental sensitivity;

(g) water management systems (including erosion and sediment controls);

(h) proposed resource recovery; and

(i) where the mine will cease extraction during the term of the Plan, a closure plan including final rehabilitation objectives/methods and post mining landuse/vegetation

(5) The Plan when lodged will be reviewed by the Department of Mineral Resources.

(6) The Director-General may within two (2) months of the lodgement of a Plan, require modification and relodgement.

(7) If a requirement in accordance with clause (6) is not issued within two months of the lodgement of a Plan, the lease holder may proceed with implementation of the Plan submitted subject to the lodgement of the required security deposit within the specified time.

(8) During the life of the Mining Operations Plan, proposed modifications to the Plan must be lodged with the Director-General and will be subject to the review process outlined in (5) - (7) above.

3 **Annual Environmental Management Report (AEMR)**

(1) Within 12 months of the commencement of mining operations and thereafter annually or, at such other times as may be allowed by the Director-General, the lease holder must lodge an Annual Environmental Management Report (AEMR) with the Director-General.

(2) The AEMR must be prepared in accordance with the Director-General's guidelines current at the time of reporting and contain a review and forecast of performance for the preceding and ensuing twelve months in terms of:-

(a) the accepted Mining Operations Plan;

(b) development consent requirements and conditions;
(c) Environment Protection Authority and Department of Land and Water Conservation licences and approvals;

(d) any other statutory environmental requirements;

(e) details of any variations to environmental approvals applicable to the lease area; and

(f) where relevant, progress towards final rehabilitation objectives.

(3) After considering an AEMR the Director-General may, by notice in writing, direct the lease holder to undertake operations, remedial actions or

supplementary studies in the manner and within the period specified in the notice to ensure that operations on the lease area are conducted in accordance with sound mining and environmental practice.

(4) The lease holder shall, as and when directed by the Minister, co-operate with the Director-General to conduct and facilitate review of the AEMR involving other government agencies.

BARRIERS

9 The lease holder shall not work or cause to be worked any seam of coal within the subject area without leaving, if the Minister, so directs, a barrier of such width or a protective pillar or pillars of such size or sizes against any surface improvements of any feature whether natural or artificial.

11 The lease holder unless with the consent of the Minister and subject to such conditions as the Minister may impose shall not work or cause to be worked any seam of coal by underground methods within the subject area within the barrier defined as follows:

The land within the zone beneath and adjacent to the **Main Northern Railway** enclosed by an angle of draw of 35° from either side of the railway lands excluding lands not related to railway operations such as carparks or quarries, such angle of draw being measured outwards from the point on the vertical plane of the said boundary at the surface or at the level of the horizontal plane of the railway track, whichever may be the higher, to the floor of the coal seam in which mining operations are to be carried out.

MANAGEMENT AND REHABILITATION OF LANDS (GENERAL)

19 The lease holder shall observe any instruction given or which may be given by the Minister with a view to minimising or preventing public inconvenience or damage to public or private property.

20 If required to do so by the Minister and within such time as may be stipulated by the Minister the lease holder shall carry out to the satisfaction of the Minister surveys of structures, buildings and pipelines on adjacent landholdings to determine the effect of operations on any such structures, buildings and pipelines.

23 If so directed by the Minister the lease holder shall rehabilitate to the satisfaction of the Minister and within such time as may be allowed by the Minister any lands within the subject area which may have been disturbed by mining or prospecting operations whether such operations were or were not carried out by the lease holder.

25 The lease holder shall provide and maintain to the satisfaction of the Minister efficient means to prevent contamination, pollution, erosion or siltation of any river, stream, creek, tributary, lake, dam, reservoir, watercourse, groundwater or catchment area or any undue interference to fish or their environment and shall observe any instruction given or which may be given by the Minister with a view to preventing or minimising the contamination, pollution, erosion or siltation of any river, stream, creek, tributary, lake, dam, reservoir, watercourse, groundwater or catchment area or any undue interference to fish or their environment.

TREES (PLANTING AND PROTECTION OF) FLORA AND FAUNA AND ARBOREAL SCREENS

27 If so directed by the Minister, the lease holder shall ensure that operations are carried out in such manner so as to minimise disturbance to flora and fauna within the subject area.

ROADS

31 The lease holder shall pay to **Lake Macquarie City Council**, Department of Land and Water Conservation or the Chief Executive, Roads and Traffic Authority or the Executive Officer, State Forests of NSW the cost incurred by such Council or Department or Chief Executive or Executive Officer of making good any damage caused by operations carried on by or under the authority of the lease holder to any road adjoining or traversing the surface or the excepted surface or the excepted surface, as the case may be of the subject area.

PROVIDED HOWEVER that the amount to be paid by the lease holder as aforesaid shall be reduced by such sum of money if any as may be paid to the said Council the Department of Conservation and Land Management or the Chief Executive, Roads and Traffic Authority as the case may be from the Mine Subsidence Compensation Fund constituted under the Mine Subsidence Compensation Act, 1961, in settlement of a claim for compensation for the same damage, and provided any approval required to be obtained from the Mine Subsidence Board at the time of construction of any road had been obtained by Lake Macquarie City Council, Department of Land and Water Conservation or the Executive Officer, State Forests of NSW, Roads and Traffic Authority or Chief Executive or Executive Officer.

32 In the event of operations being conducted on the surface of any road, track or firetrail traversing the subject area or in the event of such operations causing damage to or interference with any such road, track or firetrail the lease holder, at his own expense, shall if directed to do so by the Minister provide to the satisfaction of the Minister an alternate road, track or firetrail in a position as required by the Minister and shall allow free and uninterrupted access along such alternate road, track or firetrail and, if required to do so by the Minister, the lease holder shall upon completion of operations rehabilitate the surface of the original road, track or firetrail to a condition satisfactory to the Minister.

CATCHMENT AREAS

33 (a) Operations shall be carried out in such a way as not to cause any pollution of the **Lake Macquarie** Catchment Area.

(b) If the lease holder is using or about to use any process which in the opinion of the Minister is likely to cause contamination of the waters of the said Catchment Area the lease holder shall refrain from using or cease using as the case may require such process within twenty four (24) hours of the receipt by the lease holder of a notice in writing under the hand of the Minister requiring the lease holder to do so.

(c) The lease holder shall comply with any regulations now in force or hereafter to be in force for the protection from pollution of the said Catchment Area.

TRIG. STATIONS AND SURVEY MARKS

37 (a) The lease holder shall contact the Newcastle Surveyor-General's office prior to the mining of each section to ascertain which marks will be disturbed.

(b) In the event of operations being likely to interfere with or damage any Trigonometrical Station, Permanent Mark or State Survey Mark (under the Survey Co-ordination Act 1949) erected on or near the subject area, the lease holder shall inform the Surveyor General's office (Newcastle) and shall comply with any directions given by the Surveyor General with respect to re-establishing any Trigonometrical Station, Permanent Mark or State Survey Mark after mining is completed.

TRANSMISSION LINES, COMMUNICATION LINES AND PIPELINES

41 The lease holder shall as far as is practicable so conduct operations as not to interfere with or impair the stability or efficiency of any transmission line, communication line or pipeline traversing the surface or the excepted surface of the subject area and shall comply with any direction given or which may be given by the Minister in this regard.

LABOUR/EXPENDITURE

44 The lease holder shall during each year of the term of the authority:

(a) ensure that at least **64** workers are efficiently employed on the subject area or

(b) expend on operations carried out in the course of prospecting or mining the subject area, an amount of not less than **$1,120,000.**

ADDITIONAL INFORMATION

45 The lease holder shall if directed by the Minister and within such time as the Minister may stipulate furnish to the Minister:

(a) information regarding the ownership of the land within the subject area;

(b) information regarding the ownership of the coal within the subject area prior to 1st January, 1982;

(c) an indemnity in a form approved by the Minister indemnifying the Crown and the Minister against any wrong payment effected as a result of incorrect information furnished by the lease holder;

(d) information regarding the financial viability of the lease holder and operations within and associated with the subject area; and

(e) information regarding shareholdings in the lease holder.

SERVICE OF NOTICES

46 Within a period of three (3) months from the date of this authority or a period of three (3) months from the date of service of the notice of renewal, or within such further time as the Director General may allow the lease holder shall serve on each owner and occupier of the private land and on each occupier of the Crown land held under a pastoral lease within the subject area a notice in writing indicating that this authority has been granted or renewed and whether the authority includes the surface. The notice shall be accompanied by an adequate plan and description of the subject area.

If there are ten (10) or more owners or occupiers affected the lease holder may serve the notice by publication in a newspaper circulating in the region where the subject area is situated. The notice shall indicate that this authority has been granted or renewed, state whether the authority includes the surface and shall contain an adequate plan and description of the subject area.

INSPECTORS

47 (a) Where the Inspector is of the opinion that any condition of this authority relating to operations within the subject area, or any provision of the Mining Act, 1992, relating to operations within the subject area, are not being complied with by the lease holder, the Inspector may serve on the lease holder a notice stating that and give particulars of the reason why, and may in such notice direct the lease holder:

(i) to cease operations within the subject area in contravention of that condition or Act; and

(ii) to carry out within the specified time works necessary to rectify or remedy the situation.

(b) The lease holder shall comply with the directions contained in any notice served pursuant to sub paragraph (a) of this condition. The Director General may confirm, vary or revoke any such direction.

(c) A notice referred to in his condition may be served on the Colliery Manager.

INDEMNITIES

48 The lease holder shall indemnify and keep indemnified the Crown from and against all actions suits and claims and demands of whatsoever nature and all costs charges and expense which may be brought against the lease holder or which the lease holder may incur in respect of any accident or injury to any person or property which may arise out of the construction maintenance or working of any workings now existing or to be made by the lease holder within the boundaries of the subject area or in connection with any of the operations notwithstanding that all other conditions of this authority shall in all respects have been observed by the lease holder or that any such accident or injury shall arise from any act or thing which the lease holder may be licensed or compelled to do hereunder.

49 The lease holder shall save harmless the Crown from payment of compensation and from and against all claims, actions, suits or demands whatsoever in the event of any damage resulting from mining operations under or near the subject area.

PROSPECTING (GENERAL)

50 (a) Where the lease holder desires to commence prospecting operations in the subject area the lease holder shall notify the Director General in writing and shall comply with such additional conditions as the Minister may impose including any condition requiring the lodgement of an additional bond of other form of security or rehabilitation of the area affected by such operations.

(b) Where the lease holder notifies the Director General pursuant to sub paragraph (a) of this condition the lease holder shall furnish with that notification details of the type of prospecting methods that would be adopted and the extent and location of the area that would be affected by them.

ADDITIONAL CONDITIONS

51. Prior to lodging an application under Section 138 of the Coal Mines Regulation Act, where such application involves mining beneath transmission lines under the control of Transgrid, the lease holder as far as practicable adopt the procedures outlined in the Mines Subsidence Board's "Guidelines for Coal Mining & Transmission Lines with respect to Subsidence".

52. The lease holder shall prior to any consent given by the Minister subject to Condition 11 of this lease, consult with the relevant authority in respect to operations on the Main Northern Railway and note their requirements in relation to the use of the line, the loading of trains and subsidence monitoring.

53. The lease holder shall, in accordance with Condition 4 of the Development Consent, consult with the New South Wales Fisheries and note their requirements for mining beneath Lords Creek.

54. Second workings approvals will be consistent with the Conditions of the Development Consent (14 May 1999, Newstan Colliery Life Extension, DA 73-11-98, File N91/00544), safety requirements under the Coal Mines Regulation Act 1982 and the Department of Mineral Resources' subsidence impact criteria.

55. Prior to undertaking second workings where any potential damage to a dwelling fails to meet safe, serviceable and repairable criteria, the leaseholder shall:

(a) demonstrate that works are able to be carried out to mitigate any potential damage and such works are in place; or

(b) have appropriate agreements in place with the landowner; or

(c) have acquisition arrangements in place following an offer to acquire the whole of the property, (or such part of the property requested by the landowner where subdivision is approved) in accordance with the Conditions of Consent.

56. Prior to seeking a second workings approval, the leaseholder shall prepare a Longwall Subsidence Management Plan for the relevant area to the satisfaction of the Director General. Each Longwall Subsidence Management Plan shall be consistent with the Development Consent Conditions and the Environmental Management Strategy developed pursuant to Conditions 3.2 and 3.11 of the Development Consent. The leaseholder shall ensure that the terms and details of each relevant Property Subsidence Management Plan (prepared pursuant to Condition 3.10 of the Development Consent) are incorporated into any Longwall Subsidence Management Plan for that part of the development which may affect the property.

PLAN OF PORTION ML129
(Adopted)

PARISH(S) AWABA & COORUMBUNG

COUNTY NORTHUMBERLAND

MAP SHEET NO(S) 9131-1-N, 9231-4-N; 9232-3-S

REDUCTION RATIO 1: 25000

MINING LEASE APPLICATION No 97

MINING DIVISION SINGLETON

APPLICANT POWERCOAL PTY LTD

APPLICATION DATE 9/10/1997

SURFACE EXCEPTION/DEPTH RESTRICTION

+ + The surface and land to a depth of 5 metres below the floor of the Fassifern Seam is excepted.

Remainder - The surface and land to a depth of 15.24 metres is excepted.

NOTES

Azimuth

Plans used in the course of this survey / compilation M24074, M24075, M23483, M23482, M24024, M24022, M24023, M24600, DP835263, M17877, 3249R.2111, DP841849, 3255.2111, 3259R.2111, 3260.2111, M17928, 4916.2111, M17824, & DP263604. DMR: C95/2224

Survey declared on this plan for lines ....

I, Donald James Wyper, 71 Adams St Heddon Greta, a surveyor registered under the Coal Mines Regulation Act, 1982 hereby certify that the information represented in this plan is accurate and has been compiled in accordance with the Mining Act,1992.

Signature : .... 28/4/99.

Surveyors Reference : CERT No 344 CMRA

M 26880R

Survey Calcs : ....

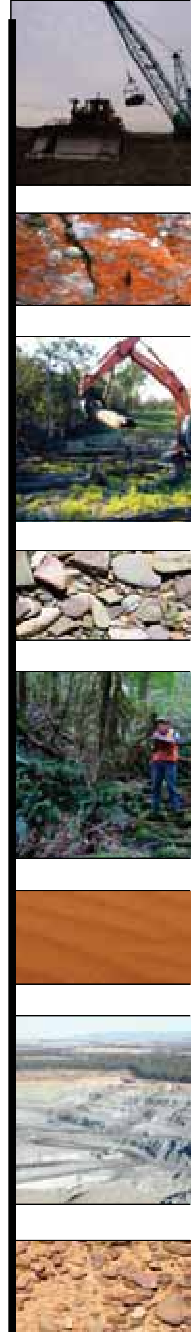
Plan Investigated : 15.6.99

Plan Approved : 15.6.99

Paper No : C94-2228

CO-ORDINATES - ZONE 56/1

CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING	CNR	EASTING	NORTHING
1	348475.6	1348454.4	12	349428.1	1348580.1	23	350579.5	1348455.6	34	352480.1	1343488.5	45	350355.0	1345229.0	56	347538.4	1346613.5	67	348807.9	1345178.5	78	345808.8	1344002.1
2	348500.9	1348411.8	13	349488.2	1348580.7	24	350864.3	1348443.4	35	352280.0	1343541.4	46	348705.3	1345825.2	57	347304.3	1346481.4	68	348865.4	1345148.2	79	345738.2	1343798.0
3	348618.5	1348304.7	14	350292.9	1348455.0	25	350596.4	1348442.0	36	351710.7	1343332.6	47	348570.4	1345934.4	58	347302.5	1346485.5	69	348872.4	1345130.8	80	345628.8	1343545.3
4	348818.2	1348305.2	15	350298.7	1348485.2	26	350622.1	1348400.8	37	351618.0	1343415.7	48	348387.8	1345966.7	59	347281.0	1346136.5	70	348797.7	1345028.1	81	345804.0	1343485.5
5	348509.7	1348178.8	16	350298.7	1348454.5	27	350622.6	1348398.3	38	351450.4	1343306.4	49	348325.2	1346106.3	60	347256.8	1346133.8	71	348728.3	1344910.8	82	345805.2	1343488.7
6	348570.7	1348184.9	17	350316.1	1348508.7	28	351534.2	1348283.4	39	350782.2	1343309.5	50	348322.3	1346210.9	61	347286.7	1345857.2	72	348613.8	1344720.1	83	345030.8	1344750.0
7	348555.9	1348188.6	18	350336.0	1348471.2	29	352483.5	1348098.4	40	350507.4	1343781.1	51	348107.9	1346420.9	62	347171.7	1345784.7	73	348465.5	1344520.7	84	347985.3	1347344.1
8	348602.5	1347776.7	19	350361.8	1348457.8	30	353192.5	1345977.5	41	350354.4	1343142.4	52	347983.1	1346430.6	63	347164.5	1345785.0	74	348387.2	1344487.7	85	348282.9	1347540.0
9	348468.5	1347185.1	20	350397.9	1348458.3	31	353324.9	1348012.6	42	350018.8	1343143.2	53	347677.5	1346422.0	64	347078.8	1345478.0	75	348204.0	1344275.4			
10	349442.5	1346701.2	21	350502.8	1348473.4	32	353556.2	1345904.8	43	350385.6	1344521.0	54	347843.8	1346418.2	65	348075.1	1345311.5	76	348029.0	1344111.2			
11	349603.8	1346604.4	22	350547.6	1348471.6	33	354064.2	1344587.3	44	350712.7	1345082.8	55	347528.1	1346527.6	66	348980.0	1345436.8	77	345920.4	1344025.0			



Subsidence Impact Assessment

APPENDIX 4

mine subsidence ENGINEERING CONSULTANTS

NEWSTAN COAL MINE:

Longwalls 101 to 103

Subsidence Predictions and Impact Assessments for Natural Features and Surface Infrastructure in Support of the SMP Application

Centennial Coal
Newstan

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	JB / DRK	-	24th Feb 12
02	Draft Issue	JB / DRK	AAW	20th Mar 12
A	Final Issue	JB / DRK	AAW	25th May 12
B	Minor Updates	JB / DRK	AAW	13th Jun 12

Report produced to:- Support the SMP Application for Newstan Colliery Longwalls 101 to 103

Background reports available at *www.minesubsidence.com:-*

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

Acknowledgments:- MSEC would like to thank the following companies which assisted in the preparation of this report, including the collection and characterisation of the surface infrastructure and building structures, literature reviews and the specialist impact assessments for some natural features and infrastructure:-

- ACOR Appleyard Consultants,
- Northrop Engineers, and
- Pells Sullivan and Meynink.

Centennial Newstan Pty Limited (Centennial) proposes to extract Longwalls 101 to 103, in the combined Young Wallsend Seam and part Yard Seam, at Newstan Colliery (Newstan), which is located in the Newcastle Coalfield of New South Wales. The layout of the proposed longwalls is shown in Drawing Nos. MSEC537-01 and MSEC537-02, in Appendix F of this report.

In 1998, Powercoal Pty Limited, the (then) owners of Newstan, submitted an Environmental Impact Statement (Umwelt, 1998) to the New South Wales Department of Planning (DoP), seeking approval for the expansion of Newstan, in an area referred to as the Life Extension Area (LEA). On the 14th May 1999, the (then) Minister for Urban Affairs and Planning, granted development consent under Part 4 of the EP&A Act for the Newstan Colliery Life Extension Area pursuant to Development Application 73-11-98 (DA 73-11-98).

Mine Subsidence Engineering Consultants (MSEC) was commissioned by Centennial to:-

- provide subsidence predictions for the proposed Longwalls 101 to 103,
- review the natural features and items of surface infrastructure located in the vicinity of the proposed longwalls, details of which were provided by others,
- provide subsidence predictions for each of these natural features and items of surface infrastructure, and
- provide impact assessments, in conjunction with other specialist consultants, for each of these natural features and items of surface infrastructure.

This report provides information that will support the SMP Application to the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

The predicted subsidence over the proposed longwalls has been determined using the Incremental Profile Method based on the standard IPM prediction curves for the Newcastle Coalfield. No subsidence adjustment factors were adopted for any massive conglomerate units or inferred faulting in the mining area, based on a review of the available geological data and discussions with the Newstan geologist. These conglomerate units lens in and out over the proposed longwalls and were found to be generally less than 10 metres thick. No site specific calibration of the empirical model was carried out, based on the outcomes of the detailed review of the available ground monitoring data at Newstan and other nearby collieries. The maximum predicted subsidence resulting from the extraction of the proposed Longwalls 101 to 103 is 1200 mm.

The SMP Area has been defined as the surface area within the predicted limit of vertical subsidence, determined by the greater of the 26.5 degree angle of draw from the limit of the proposed mining and the predicted 20 mm subsidence contour resulting from the extraction of the proposed longwalls. In this case, the 26.5 degree angle of draw line has been conservatively taken around both the limit of proposed extraction (i.e. second workings) as well as the main headings (i.e. first workings).

The features located outside the SMP Area which could be subjected to far-field or valley related movements and could be sensitive to such movements have also been included in the assessments provided in this report. In this case, features which could be sensitive to far-field or valley related movements, within but not limited to 600 metres from the proposed mining, have been assessed.

A number of natural features and items of surface infrastructure have been identified within or in the vicinity of the SMP Area, including watercourses (1st to 4th order), rock outcrops, steep slopes, local roads, local road bridges, drainage culverts, potable water pipelines, 132 kV transmission lines, low voltage powerlines, optical fibre cables, copper telecommunications cables, a waste management facility, public amenities, farm dams, archaeological sites and survey control marks.

The assessments provided in this report should be read in conjunction with the assessments provided in the reports by other specialist consultants on the project. The main findings from this report are as follows:-

- The watercourses in the mining area are ephemeral, but have ponds in the flatter sections along the lower reaches of the streams. The watercourses typically have shallow incisions into the natural surface soils, but have rock outcropping along the steeper sections. The watercourses are located across the mining area and, therefore, are expected to experience the full range of predicted subsidence movements.

  Increased ponding could develop along the flatter sections of the Schedule 2 streams, as a result of the proposed mining, however, natural ponding was evident along these watercourses due to the relatively flat natural grades. Fracturing of the exposed bedrock along the upper reaches of the watercourses could result in some spalling or dislodgement of lose exposed rocks. Continuous fracturing is not expected between the seam and the surface and, therefore, no loss of water from the catchment is anticipated.

- Rock outcrops and steep slopes are located above the northern ends of the proposed longwalls. Fracturing of the exposed bedrock could result in some minor rockfalls, however, previous experience in the NSW Coalfields indicates that the percentage of rock outcrops impacted is likely to be small. Tensile surface cracking could also occur along the tops of the steep slopes and, in some locations, it may be necessary to remediate the larger cracks.
- Wilton Road and the Mine Haul Road are located directly above the proposed longwalls. These roads could experience cracking and heaving of the bitumen road surfaces. It is expected, that these roads could be maintained in safe and serviceable conditions throughout the mining period using normal road maintenance techniques. Wangi Road is predicted to experience less than 20 mm subsidence and, therefore, no adverse impacts are anticipated along this road.
- The local road bridges are all located well outside the extents of the proposed mining. The closest bridge is WR-BR1, which is a timber structure, where Wilton Road crosses Stony Creek, located 570 metres north-west of the proposed longwalls. The closest concrete bridges are CR-BR1 and CR-BR2, where Cessnock Road crosses over the Main Northern Railway and Awaba Road, which are both located 750 metres north of the proposed longwalls.

  The bridges could experience very small differential horizontal movements. The timber bridge is of flexible construction and would be expected to tolerate these small movements without adverse impacts. The predicted differential horizontal movements at the concrete bridges are expected to be very small and a similar order of magnitude as the thermal movements due to changes in the ambient temperature.
- Box culverts and circular drainage culverts are located where the roads cross the watercourses. Previous experience of mining beneath culverts, at similar depths of cover, indicates that the incidence of impacts is low, generally being limited to cracking in the concrete headwalls which can be readily remediated. In some cases, however, cracking in the culvert pipes have occurred which required the culverts to be replaced.
- A 50 mm diameter polyethylene water pipeline crosses above the maingate of the proposed Longwall 103. This type of pipeline is very flexible and is expected, therefore, to tolerate the predicted curvatures and strains without adverse impact. Other water pipelines are located outside the extents of the proposed longwalls and, therefore, are unlikely to be adversely impacted as a result of the proposed mining.
- The two 132 kV transmission lines and the low voltage powerlines comprise aerial cables supported by timber poles, which are located across the mining area. It is expected that the transmission lines and powerlines could tolerate the predicted movements without adverse impacts. Extensive experience of mining beneath powerlines in the NSW Coalfields, where the depths of cover are similar, indicates that incidences of impacts is very low and of a minor nature.
- The AAPT optical fibre cable is an aerial cable supported by the timber poles along the eastern 132 kV transmission line. It is expected that this optical fibre cable could tolerate the predicted movements without adverse impacts.

  The Telstra optical fibre cable is a direct buried cable which follows Wilton Road to the Awaba Waste Management Facility. Whilst this cable is only partially located above the maingate of the proposed Longwall 103, it could experience elevated compressive strains at the two tributary crossings adjacent to the longwall maingate.

  The strains in the AAPT and Telstra optical fibre cables can be monitored using Optical Time Domain Reflectometry (OTDR). If the measured strains were seen to approach the allowable tolerances, then preventive measures could be implemented, which could include the adjustment of the cable catenaries or the installation of cable sheaves for the AAPT cable, or the Telstra cable could be exposed at the strain concentration and stress relieved.
- The Awaba Waste Management Facility (AWMF) is located directly above the proposed Longwall 103 and comprises a waste emplacement area, leachate and sediment ponds, leachate collection and spray systems, gas drainage and flare infrastructure, a gas powered generator installation, weigh bridges, administration building and storage structures. The facility is also proposing to expand the waste emplacement area and to construct an Alternative Waste Treatment (AWT) facility, which are the subjects of a current development application which was submitted in December 2011.

  The proposed mining beneath the waste emplacement could result in the development of surface cracking and downslope movements which could then increase permeability of the capping layer. The AWMF facility has established procedures to maintain the integrity of the surface capping layer, due to the natural settlement of the waste emplacement, which is estimated to be greater than the subsidence resulting from the proposed mining.

The unlined section of the waste emplacement area uses the natural bedrock levels to funnel leachate downslope to the leachate collection well. The extraction of the proposed longwalls will result in fracturing and dilation of the topmost bedrock layers which will increase permeability of these near surface strata layers. Discussions on the potential changes in permeability of the bedrock are provided in the report by PSM (2012).

It has been observed in the past, that the depth of fracturing and dilation of the uppermost bedrock, as a result of longwall mining, is generally less than 10 metres to 15 metres (Mills 2003, Mills 2007, and Mills and Huuskes 2004). Previous mining experience from the area indicates that continuous cracking would not extend from the seam up to the surface and, therefore, the leachate is expected to be confined to the near surface strata.

The potential impacts on the infrastructure associated with the AWMF, including the leachate and sediment ponds, gas drainage infrastructure, gas powered generation plant, building structures and weigh bridges, could be managed with the implementation of suitable management strategies.

- The public amenities within the SMP Area include the Toronto Adventist Primary School, the Toronto Country Club, the Newcastle Lake Macquarie Clay Target Club and the Westlakes Automobile Club. The building structures and services associated with these properties are all located well outside the proposed longwalls and no adverse impacts are anticipated. The clay target throwers and the target survey markers could be sensitive to small changes in tilt and, therefore, it is recommended that strategies are developed to manage any potential impacts.
- The archaeological sites include a rock shelter and a possible grinding groove site, located directly above the proposed Longwall 101, another grinding groove site located east of the proposed longwalls and scattered artefacts across the mining area.

  The rock shelter could be impacted by fracturing, movement along bedding planes, or rockfalls. Previous experience of mining beneath rock shelters in the Southern Coalfield, where the predicted movements are similar, indicates that approximately 10 % of the shelters have been adversely impacted. This suggests that the likelihood of significant physical impacts on the rock shelter, resulting from the extraction of the proposed longwalls, is relatively low.

  There is a possible grinding groove site located directly above the proposed longwalls which could also be impacted by fracturing of the bedrock. Preventive measures could be implemented at this site, if required, including slotting of the bedrock around the site to isolate it from the ground movements. It is possible, however, that the preventive measures could result in greater impacts on the site than those which would have occurred as a result of mine subsidence movements. Further impact assessments and discussions on the potential mitigation measures are provided in the specialised archaeological report (RPS, 2012b).

  The scattered artefacts are unlikely to be adversely impacted as a result of the proposed mining.
- Three farm dams (excluding the ponds associated with the AWMF) are located outside the extents of the proposed longwalls. It is unlikely that these dams would experience any adverse impacts resulting from the proposed mining.
- The survey control marks within around 3 kilometres of the mining area, could experience small far-field horizontal movements. It will be necessary on the completion of the longwalls, when the ground has stabilised, to re-establish any state survey control marks that are required for future use.

The recommendations provided in this report should be read in conjunction with those provided in the reports by the other specialist consultants on the project. MSEC has recommended that management strategies should be developed, in consultation with the appropriate authorities or infrastructure owners, and that:-

- Ground monitoring lines should be established above the proposed longwalls, so that the observed movements can be compared with those predicted and, hence, the impact assessments reviewed based on the measured data.
- The watercourses should be periodically visually monitored for surface cracking and changes in surface water flows during the active subsidence period.
- The rock outcrops should be periodically visually monitored for fracturing and rockfalls throughout the mining period and for a period after the completion of mining.
- The steep slopes should be periodically visually monitored for surface cracking during the active subsidence period and until any necessary rehabilitation measures have been completed.
- The lose rocks and highly weathered sections of the cuttings along the Mine Haul Road should be removed or stabilised prior to the longwalls mining directly beneath them. Periodic visual inspections of the roads, cuttings and drainage culverts for subsidence impacts should be undertaken during the active subsidence period.

- The predicted movements for the concrete bridges should be provided to the LMCC so that the civil engineers responsible for the bridge designs can review the bridges based on these movements.
- The predicted movements for the 132 kV transmission line should be provided to *Ausgrid* so that any necessary preventive measures can be developed.
- The predicted movements for the optical fibre cables should be provided to *AAPT* and *Telstra* so that any necessary preventive measures can be developed.
- The building structures and associated infrastructure should be periodically visually inspected for subsidence impacts during the active subsidence period.
- Develop management strategies, in consultation with LMCC, for the Awaba Waste Management Facility which could include:-
    - Establish the appropriate monitoring above the earlier proposed Longwalls 101 and 102, which could include extensometers, piezometers and ground monitoring lines, so that the impact assessments for the AWMF can be reviewed, based on the measured data, prior to mining beneath the facility.
    - Develop the appropriate preventive or remediation measures, if the outcomes of the detailed studies or monitoring over earlier longwalls indicate potential impacts, which could include methods to reduce the permeability of the capping layer, upgrades to the existing leachate collection well, or the establishment of additional leachate collection wells.
    - Develop a Trigger Action Response Plan (TARP), in consultation with the LMCC and its consultants, based on the outcomes of the detailed studies, monitoring above earlier longwalls and the established preventive or remediation measures.
    - Install the appropriate monitoring at the AWMF, which could include extensometers, piezometers and ground monitoring.
    - The preventive or remediation measures, TARP and monitoring should be formalised in the agreement Property Subsidence Management Plan for the facility.

The assessments provided in this report indicate that the levels of impact on the natural features and items of surface infrastructure can be managed by the preparation and implementation of the appropriate management strategies. It should be noted, however, that more detailed assessments of some natural features and items of surface infrastructure have been undertaken by other consultants, and the findings in this report should be read in conjunction with the findings in all other relevant reports.

CONTENTS

Tables

Table numbers are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Figures

Figure numbers are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Drawings

Drawings referred to in this report are included in Appendix F at the end of this report.

1.1. Background

Centennial Newstan Pty Limited (Centennial) proposes to extract Longwalls 101 to 103, in the combined Young Wallsend Seam and part Yard Seam, at Newstan Colliery (Newstan), which is located in the Newcastle Coalfield of New South Wales. The layout of the proposed longwalls is shown in Drawing Nos. MSEC537-01 and MSEC537-02, which together with all other drawings, are provided in Appendix F of this report.

Newstan is located within the Lake Macquarie Local Government Area (LGA), around 25 kilometres south-west of Newcastle and around 140 kilometres north of Sydney. The pit top and surface facilities area are located at Fassifern, approximately four kilometres to the north of the township of Toronto. Newstan began mining operations in 1887, prior to the implementation of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act), and operated under continuing use rights pursuant to Section 109 of the EP&A Act.

Underground coal mining at Newstan has been undertaken in the Great Northern Seam, Fassifern Seam, Young Wallsend Seam, (Nobbys Seam and Dudley Seam), Borehole Seam and the West Borehole Seam (Nobbys, Dudley, Yard and Borehole Seams).

In 1998, Powercoal Pty Limited, the (then) owners of Newstan, submitted an Environmental Impact Statement (Umwelt, 1998) to the New South Wales Department of Planning (DoP), seeking approval for the expansion of Newstan in an area referred to as the Life Extension Area (LEA). On the 14th May 1999, the (then) Minister for Urban Affairs and Planning, granted development consent under Part 4 of the EP&A Act for the Newstan Colliery Life Extension Area pursuant to Development Application 73-11-98 (DA 73-11-98).

Mine Subsidence Engineering Consultants Pty Limited (MSEC) was commissioned by Centennial to:-

- provide subsidence predictions for the proposed Longwalls 101 to 103,
- review the natural features and items of surface infrastructure located in the vicinity of the proposed longwalls, details of which are provided by others,
- provide subsidence predictions for each of these natural features and items of surface infrastructure, and
- provide impact assessments, in conjunction with other specialist consultants, for each of these natural features and items of surface infrastructure.

This report provides information that will support the SMP Application to the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), in accordance with the SMP Guideline (DPI, 2003), as summarised in Table 1.1.

Table 1.1 Information Provided in Support of the SMP Application (DPI, 2003)

Information	Section of the Guideline for "Applications for Subsidence Management Approvals"
The SMP Area or Application Area	Section 6.2
Site Conditions of the SMP Area	Section 6.4
Characterisation of Surface and Sub-surface Features within the SMP Area	Section 6.6
Subsidence Prediction	Section 6.7
Subsidence Impacts	Section 6.10.1
Impact Assessment based on Increased Subsidence Predictions	Section 6.10.3

In some cases, the report will refer to other sources for information on specific natural features and items of surface infrastructure. The report will also provide information to assist the risk assessment section for the SMP Application, as outlined in Section 6.10.2 of the SMP Guideline (DPI, 2003).

The appropriate multiplier factors to assess the potential impacts based on increased predictions depend on the subsidence parameter and the location being considered. For locations directly above the proposed longwalls, it has been considered appropriate from our experience that factors of 1.25 for subsidence, 1.5 for tilt and 2.0 for curvature and strain can be used for the assessments based on increased predictions. For simplicity, a factor of 2 has been adopted for subsidence, tilt, curvature and strain, when assessing the potential impacts based on increased predictions in this report.

The proposed Longwalls 101 to 103 and the SMP Area, as defined in Section 2.1, have been overlaid on an orthophoto of the area, which is shown in Fig. 1.1. The major natural features and surface infrastructure in the vicinity of the proposed longwalls are indicated in this figure.

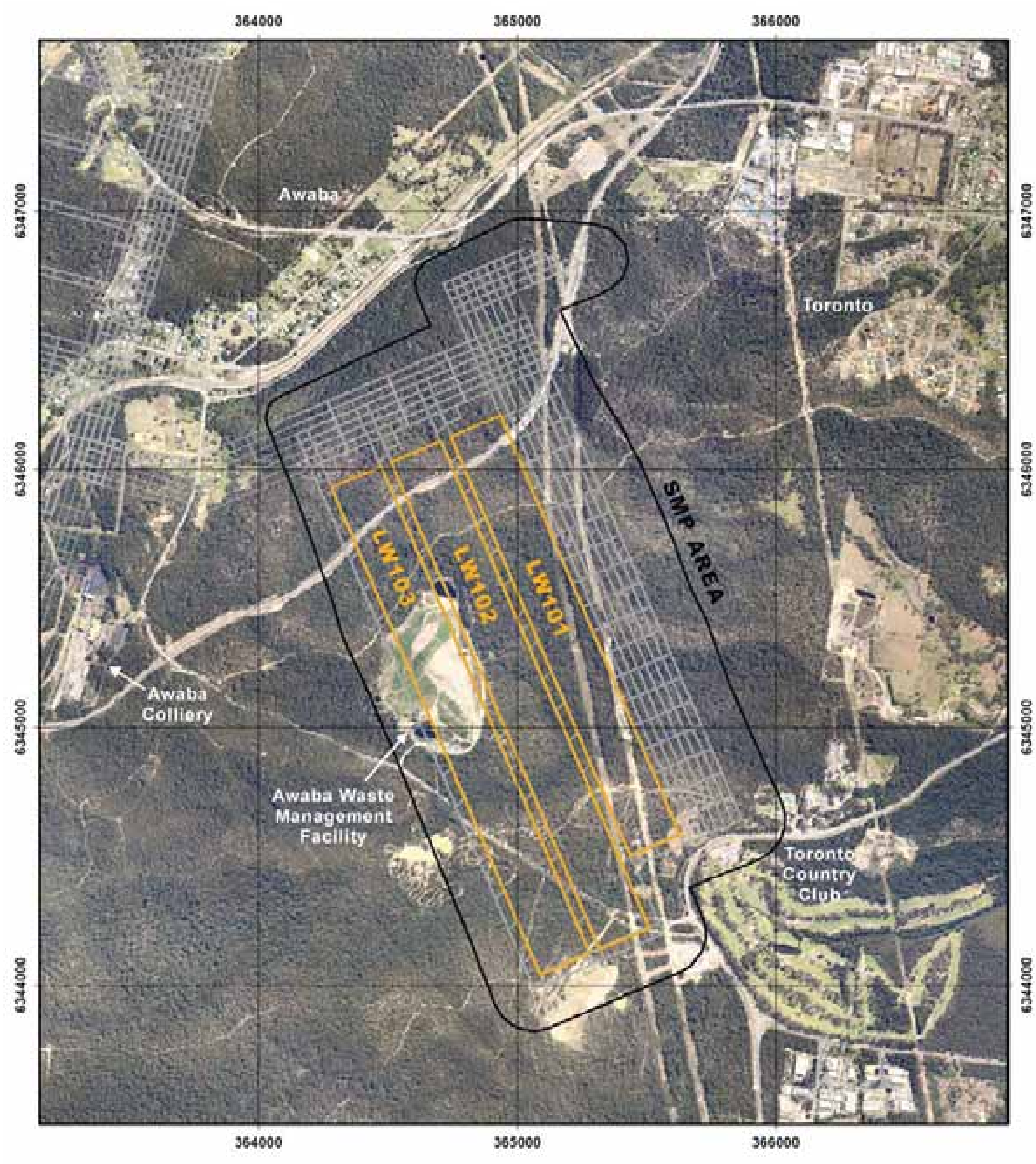


Fig. 1.1 Aerial Photograph Showing Longwalls 101 to 103 and the SMP Area

Chapter 1 of this report provides a general introduction to the study, which also includes a description of the mining geometry and geological details of the area.

Chapter 2 defines the SMP Area and provides a summary of the natural features and items of surface infrastructure within the area.

Chapter 3 includes a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements that are likely to result from the proposed longwalls.

Chapter 4 provides the maximum predicted subsidence parameters due to the extraction of the proposed longwalls.

Chapters 5 and 6 provide the predictions and impact assessments for each of the natural features and items of surface infrastructure that have been identified. Recommendations for each of these features are also provided, which have been based on the predictions and impact assessments.

1.2. Mining Geometry

The proposed layout of Longwalls 101 to 103 is shown in Drawing No. MSEC537-02. A summary of the proposed longwall dimensions is provided in Table 1.2.

Table 1.2 Geometry of the Proposed Longwalls 101 to 103

Longwall	Overall Void Length Including Installation Heading (m)	Overall Void Width Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
LW101	1770	210	-
LW102	2055	210	40
LW103	2055	210	40

The widths of the longwall extraction faces (i.e. excluding the first workings) are 200 metres. The longwalls are proposed to be extracted from the south-east towards the north-west.

1.3. Surface and Seam Levels

The surface level contours in the vicinity of the proposed longwalls, which were generated from an airborne laser scan of the area, are shown in Drawing No. MSEC537-03. The main topographic feature is the hill located above the northern ends of the proposed longwalls.

The surface levels directly above the proposed longwalls vary from a low point of approximately 10 metres AHD, above the southern ends of Longwalls 102 and 103, to a high point of approximately 120 metres AHD, above the northern ends of the proposed longwalls.

The seam floor contours, seam thickness contours and depth of cover contours are shown in Drawing Nos. MSEC537-04, MSEC537-05, and MSEC537-06, respectively. The contours are based on the latest seam information provided by Newstan.

The surface and seam levels vary across the mining area which are illustrated along Cross-Section 1 and Long-Section 1 in Fig. 1.2 and Fig. 1.3, respectively. The locations of these sections are shown in Drawing Nos. MSEC537-03 and MSEC537-04.

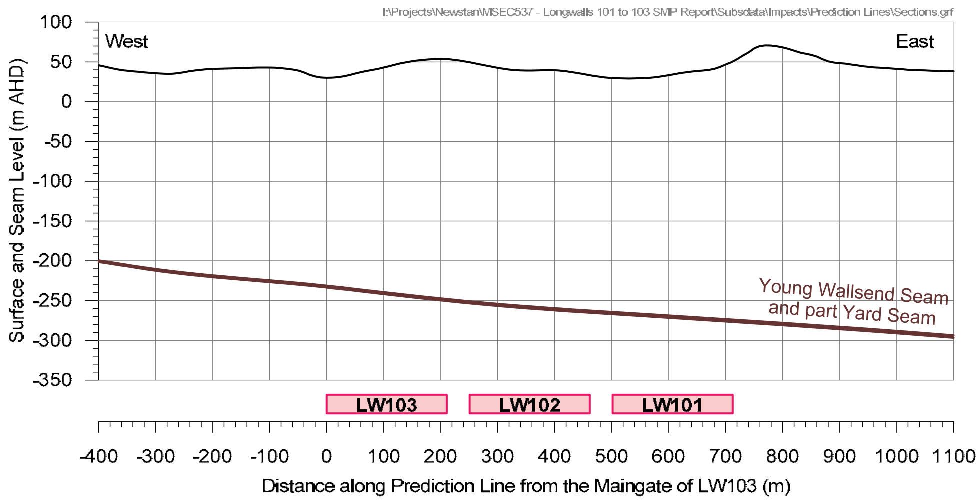


Fig. 1.2 Surface and Seam Levels along Cross-Section 1 through the Middle of the Longwalls

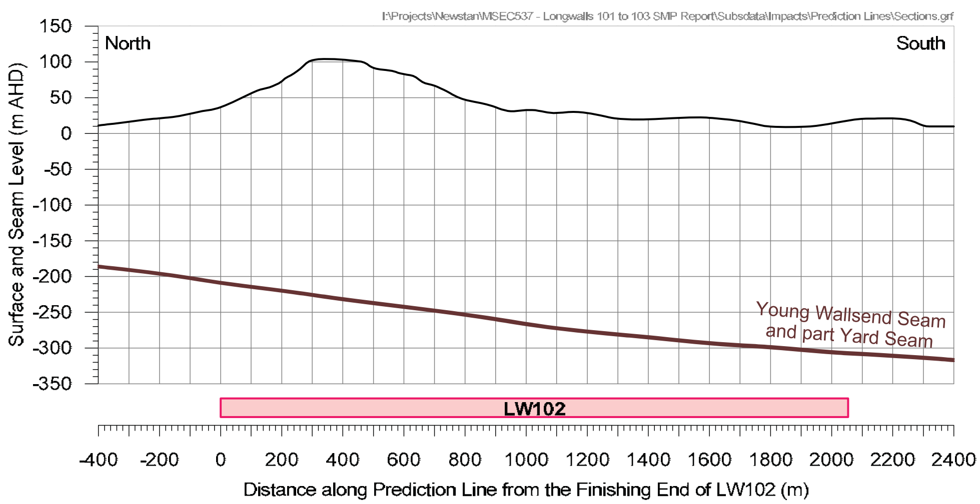


Fig. 1.3 Surface and Seam Levels along Long-Section 1 through the Centreline of Longwall 102

The depth of cover to the combined Young Wallsend Seam and part Yard Seam, directly above the proposed longwalls, varies between a minimum of 210 metres, above the northern end of the proposed Longwall 103, and a maximum of 350 metres, above the tailgate of the proposed Longwall 101.

The seam floor within the mining area generally dips from the north-west to the south-east, having an average dip around 8 %, or 1 in 13. The maximum seam dip within the mining area is around 12 %, or 1 in 8, which occurs in the north-western corner of the mining area.

The thickness of the combined Young Wallsend Seam and part Yard Seam, within the extents of the proposed mining, varies between 2.4 metres and 3.2 metres. The longwall equipment is capable of mining thicknesses between 2.2 metres and 3.6 metres and, therefore, the full combined seam thickness will be extracted.

1.4. Geological Details

The majority of the data presented within this section has been sourced from the geological information provided by Newstan, published geological papers for the region and from the report entitled "*Section 5 - Technical Services - Newstan Colliery Lochiel Project Feasibility Study*" (Newstan, 2011).

The surface lithology within the SMP Area is shown in Fig. 1.4, which shows the proposed longwalls overlaid on Geological Series Sheet 9231, which are published by the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

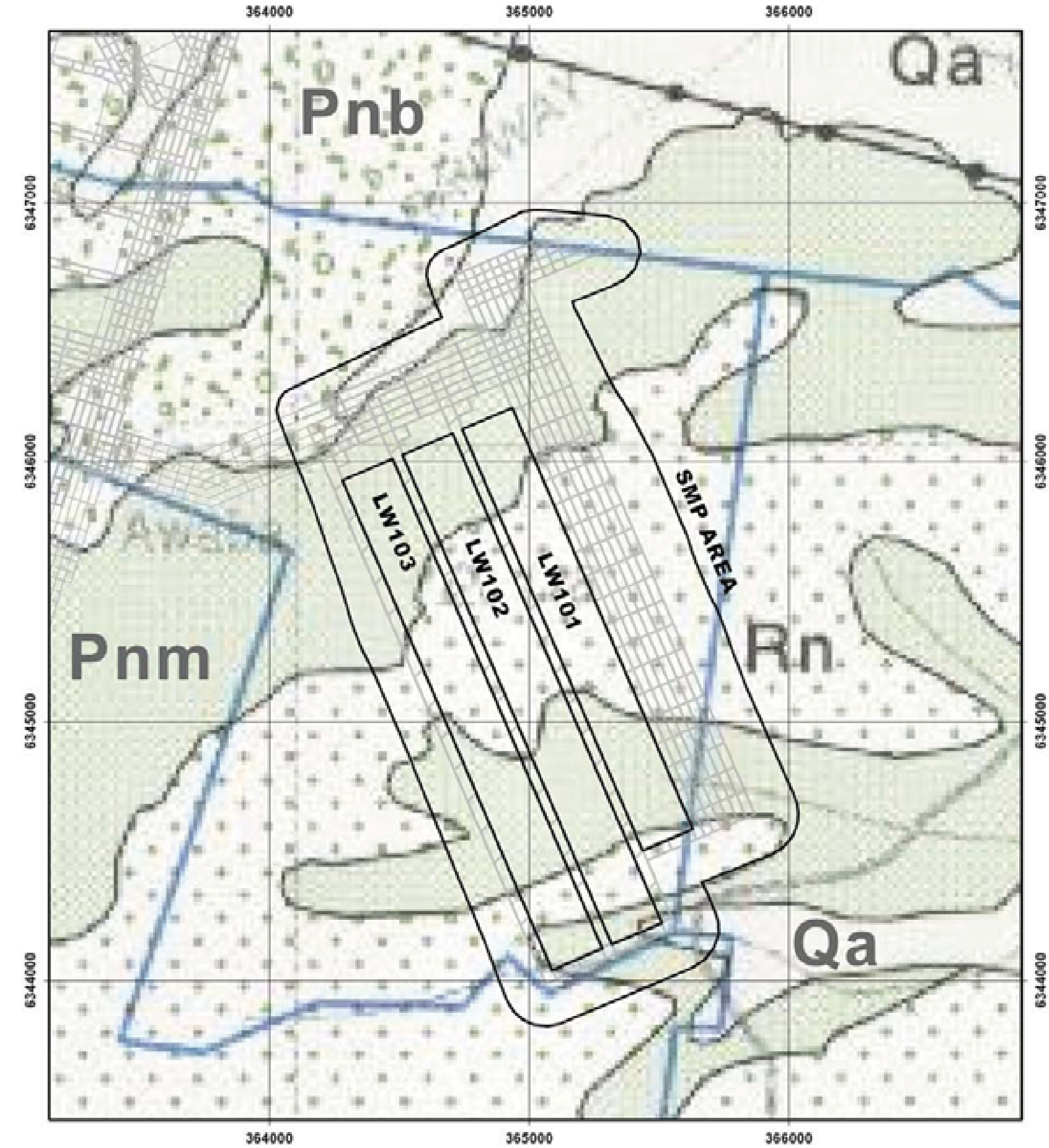


Fig. 1.4 Surface Lithology within the Lease
Geological Series Sheet 9231 (DTIRIS)

It can be seen from the above figure, that the surface lithology within the SMP Area mainly comprises areas with bedrock and surface deposits derived from the Narrabeen Group (Rn) or the Moon Island Beach Formation (Pnm) of the Newcastle Coal Measures. There are also small areas derived from the Boolaroo Formation (Pnb) of the Newcastle Coal Measures and Quaternary Alluvium (Qa) in the lower lying areas.

Newstan lies within the central part of the Newcastle Coal Measures and within the north-east portion of the Sydney Basin. The strata associated with the coal seams were laid down during the Late Permian Period as shown in the stratigraphy of the Newcastle Coalfield, in Table 1.3, which is based on revised Newcastle Coal Measures stratigraphy as ratified in June 1992 by the Standing Committee on Coalfield Geology of NSW (Hawley and Brunton, 1995).

Table 1.3 Permian Stratigraphy of the Newcastle Coalfield (Hawley and Brunton, 1995)

STRATIGRAPHY			LITHOLOGY
Group	**Formation**	**Coal Seams**	
Narrabeen	Clifton Subgroup		Conglomerate, sandstone, siltstone, claystone
Newcastle Coal Measures	Moon Island Beach	Vales Point Wallarah Great Northern	Sandstone, shale, conglomerate, claystone, coal
	Awaba Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Boolaroo	Fassifern Upper Pilot Lower Pilot Hartley Hill	Conglomerate, sandstone, shale, claystone, coal
	Warners Bay Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Adamstown	Australasian Montrose Wave Hill Fern Valley Victoria Tunnel	Conglomerate, sandstone, shale, claystone, coal
	Nobbys Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone chert
	Lambton	Nobbys Dudley } Young Wallsend Yard } West Borehole Borehole	Sandstone, shale, minor conglomerate, claystone, coal
	Waratah Sandstone		Sandstone
Tomago Coal Measures			Shale, siltstone, fine sandstone, coal, and minor tuffaceous claystone

As shown in Table 1.3, the lithology includes sandstone, shale, conglomerate, claystone, tuff, tuffaceous sandstone, tuffaceous siltstone, chert and coal. The upper three formations (Moon Island Beach, Boolaroo and Adamstown) contain many conglomerate and sandstone bands and are interbedded with shale, siltstone, tuffaceous claystone bands and high ash coal seams.

The Newcastle Coal Measures are characterised by a complex geological setting, with a great variety of rock types occurring over short lateral and vertical distances, (Moelle and Dean-Jones, 1995). The Newcastle Coal Measures were formed in a high energy terrestrial setting and contain a high proportion of coarse clastic and volcanogenic sediments, (Lohe and Dean-Jones, 1995).

The Newcastle Coal Measures, in the vicinity of Newstan Colliery, are characterised by complex patterns of splitting and coalescence of the various coal seams that were caused by the localised presence of alluvial paleochannels within the sedimentary sequence. High in-situ horizontal stresses relative to depth have been recorded at the neighbouring colliery, West Wallsend Colliery, with the major horizontal stress typically oriented north to north-north-east, although valley incision has locally reoriented the maximum horizontal stress parallel to the axis of the ridges, which are oriented east-south-east to south-east, (Lohe and Dean-Jones, 1995). Folds, normal faults and dykes dominate the region and generally trend north-west to north-north-west, (Lohe and Dean-Jones, 1995). The major Macquarie Syncline is located to the west of Newstan Colliery.

Newstan Colliery has previously extracted coal from the Great Northern, Fassifern, Young Wallsend, Borehole and West Borehole Seams. The seams of interest, or the target seams, for the proposed Longwalls 101 to 103 are the combined Young Wallsend Seam and part Yard Seam. These seams lie within the Lambton Formation, overlie the Waratah Sandstone and are overlain by the Nobbys Tuff.

A stratigraphic column showing the naming conventions for these seams is included in Fig. 1.5.

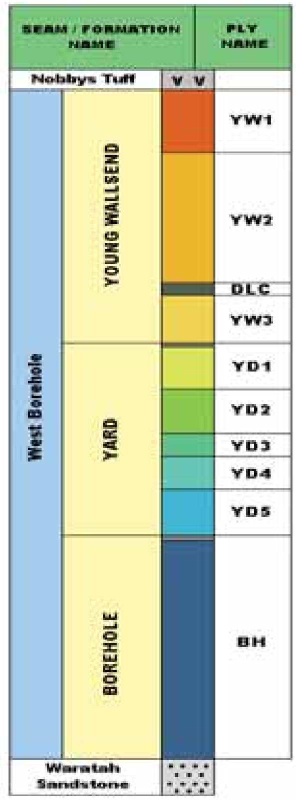


Fig. 1.5 Young Wallsend, Yard and Borehole Seam Naming Conventions (Newstan, 2011)

An exaggerated geological cross-section, that shows the variations in thicknesses of these seams, Nobbys Tuff and two paleochannels that lie above and below the Yard Seam, is provides in Fig. 1.6.

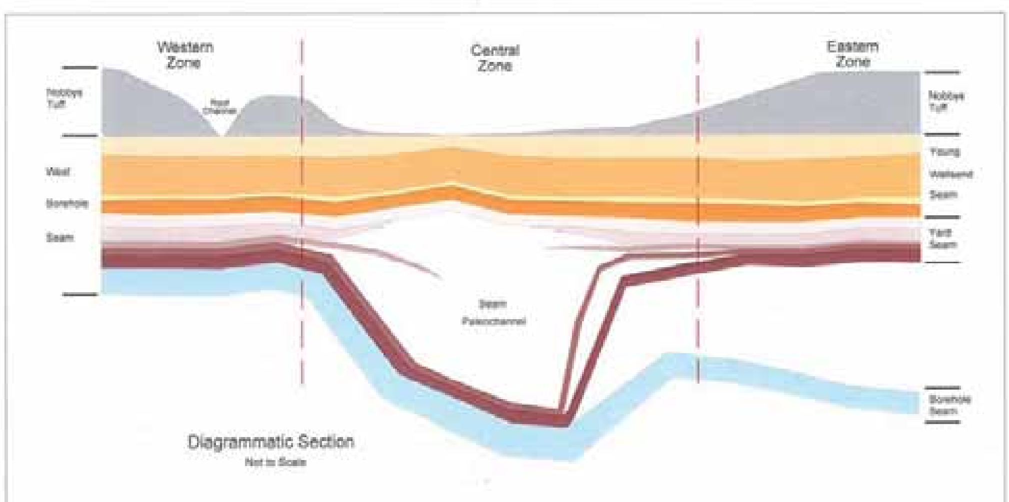


Fig. 1.6 Geological Cross Section showing Variations in Thickness of the Nobbys Tuff, Young Wallsend, Yard and Borehole Seams and Paleochannels (Newstan, 2011)

An east-west geological cross-section relative to surface levels across the SMP Area, which was prepared by a geologist at Newstan to show the stratigraphy of the overburden, is provided in Fig. 1.7. The location of this cross-section is shown as Geological Cross Section A in Drawing No. MSEC537-07.

Another cross-section, Geological Cross Section B, is provided in Fig. 1.8 and its location across the southern areas of the SMP Area is also shown Drawing No. MSEC537-07. This section was also prepared by a Newstan geologist to show the stratigraphy of the overburden that lies 100 metres above the target seams. This Figure also shows the seam paleochannels that are presented in Fig. 1.6.

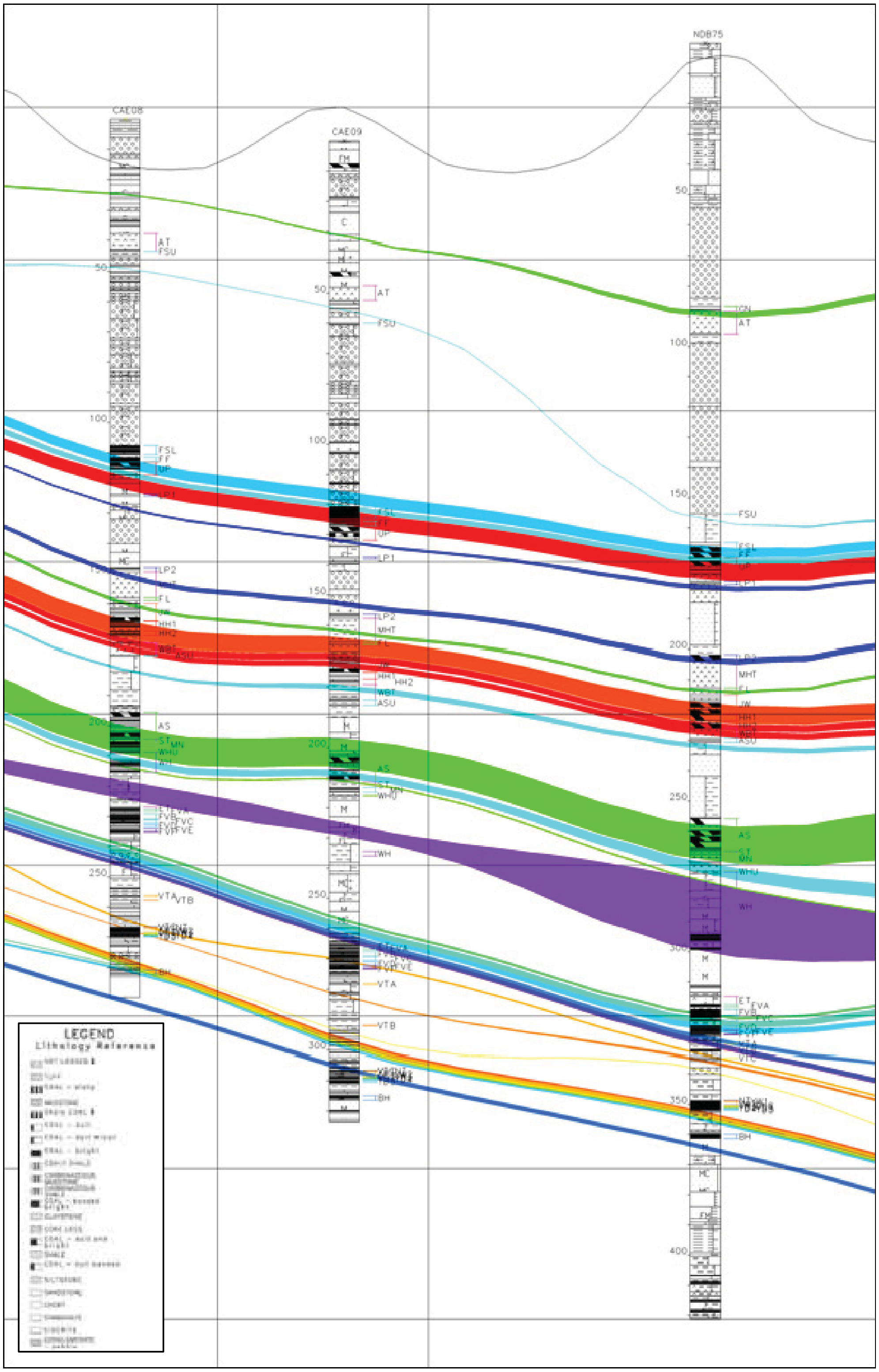


Fig. 1.7 Geological Cross Section A showing the Stratigraphy of the Overburden (Courtesy of Newstan)

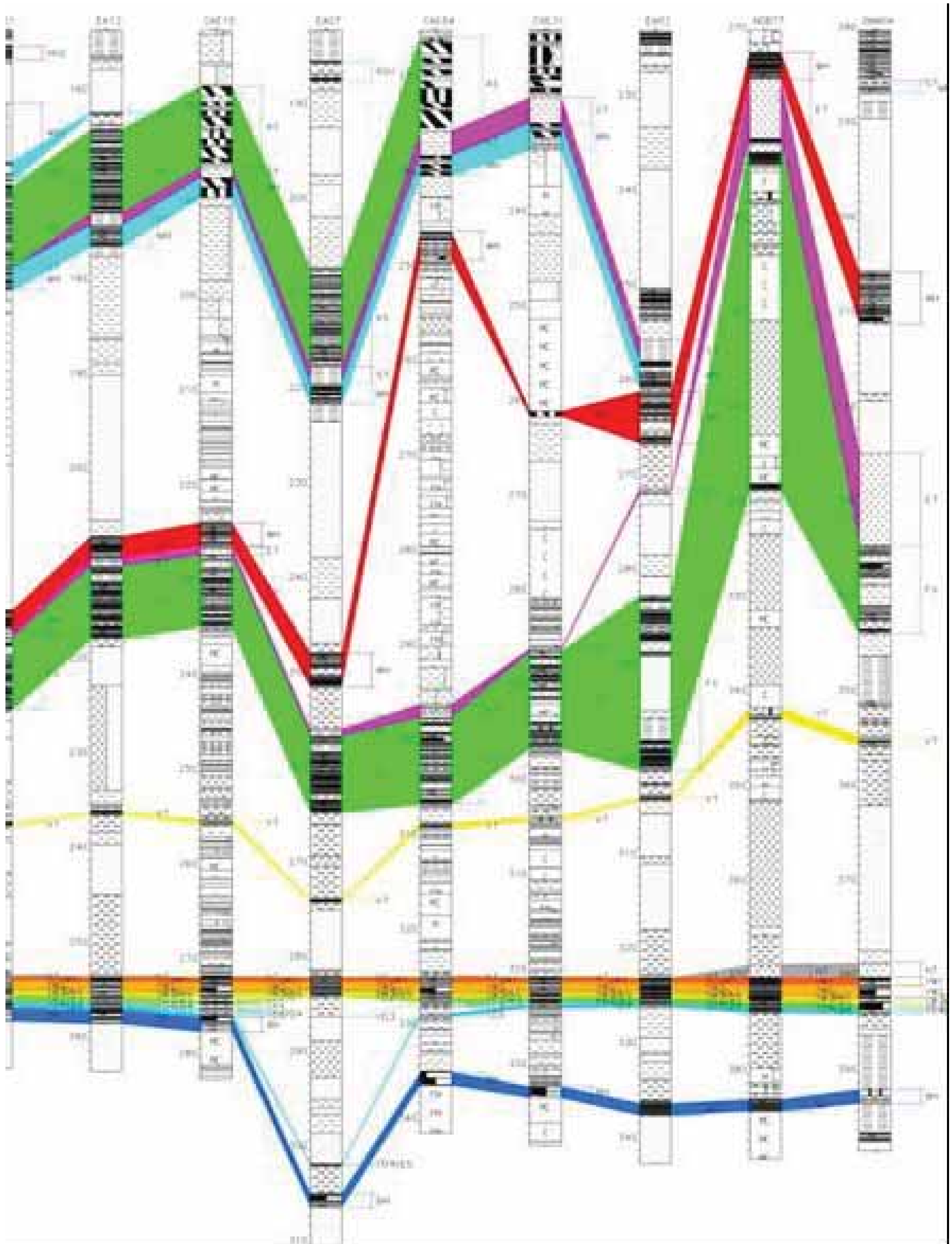


Fig. 1.8 Geological Cross Section B showing the Stratigraphy of the Overburden (Courtesy of Newstan)

The Nobbys Tuff overlies the West Borehole Seam and forms a distinctive marker horizon generally over most of the Newcastle region, although in some local areas, the tuff thins to near-zero thickness. The Adamstown Formation, which overlies the Nobbys Tuff, makes up the bulk of the overburden above the West Borehole Seam within the SMP Area, where it is up to 100 metres thick. This formation contains several coal seams (Australasian, Montrose, Wave Hill, Fern Valley and Victoria Tunnel) that are generally of poor quality. The Warners Bay Tuff lies above the Adamstown Formation and the overlying Boolaroo Formation (Pnb) and is exposed in the northern part of the SMP Area, as shown in Fig. 1.4.

The Boolaroo Formation (Pnb) comprises interbedded sandstone, siltstone and shale, with minor conglomerate bands and thin coal seams (mostly splits of the Pilot Seam). The Awaba Tuff lies over the Boolaroo Formation and the overlying Moon Island Beach Formation (Pnm) and, as shown in Fig. 1.4, is exposed over wide areas of the SMP Area on the sides of the hills. On top of the hills that cross the SMP Area are outcrops of conglomerates and sandstones of the Clifton Sub-Group of the Narrabeen Group (Rn). Quaternary Alluvium (Qa) is also present along some of the watercourses in the lower lying areas.

The seam floor contours of the target seams, in the vicinity of the proposed Longwalls 101 to 103, are shown in the Drawing MSEC537-04, in Appendix F. The seam roof contours of the target seams over a wider area, including the previously mined and future mining areas at Newstan Colliery, are also shown in Fig. 1.9. This figure also shows the location of the central seam paleochannel which is located near the proposed Longwalls 101 to 103. The general dip of the target seams trends towards the east by south-east and towards the axis of the Macquarie Syncline, which is consistent with regional trends.

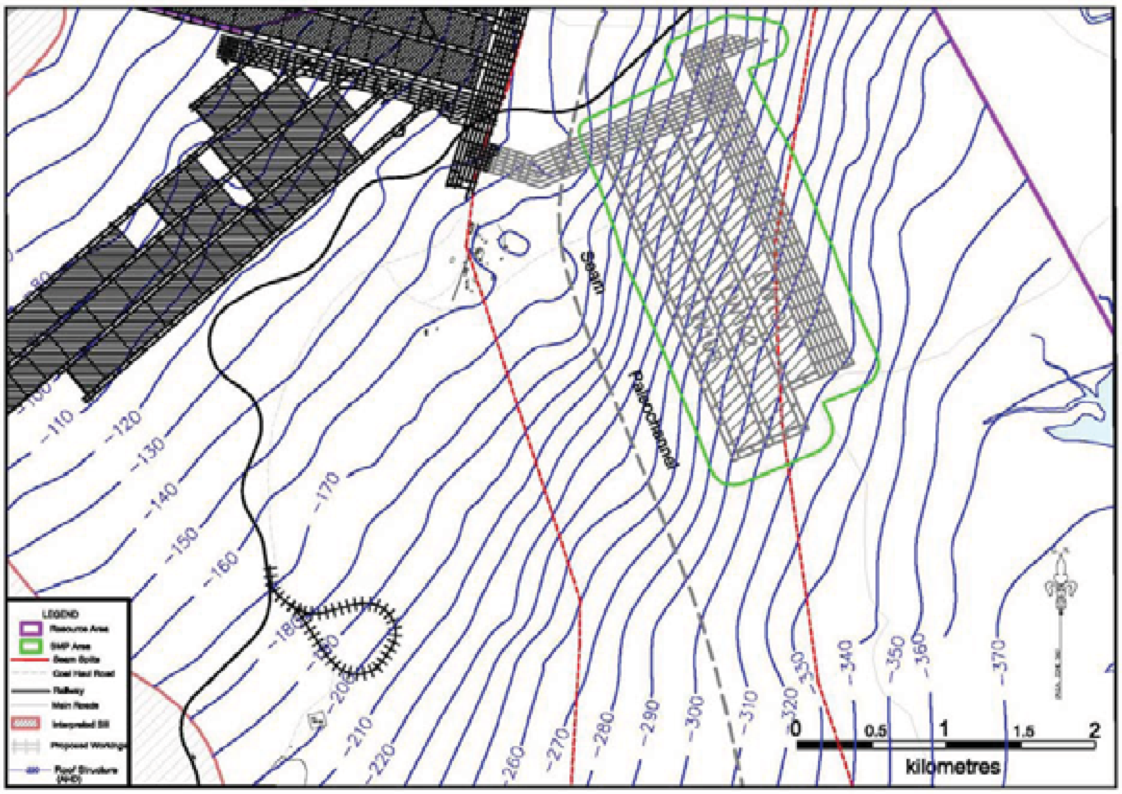


Fig. 1.9 Target Seam Roof Level Contours (Newstan, 2011)

The depth of cover contours of the target seams, in the vicinity of the proposed Longwalls 101 to 103, are shown in Drawing No. MSEC537-06, in Appendix F. The depth of cover contours of the target seams over a wider area, including the previously mined and future mining areas at Newstan Colliery, are also shown in Fig. 1.10 below. This figure shows that the depth of cover increases regionally towards the south-east.

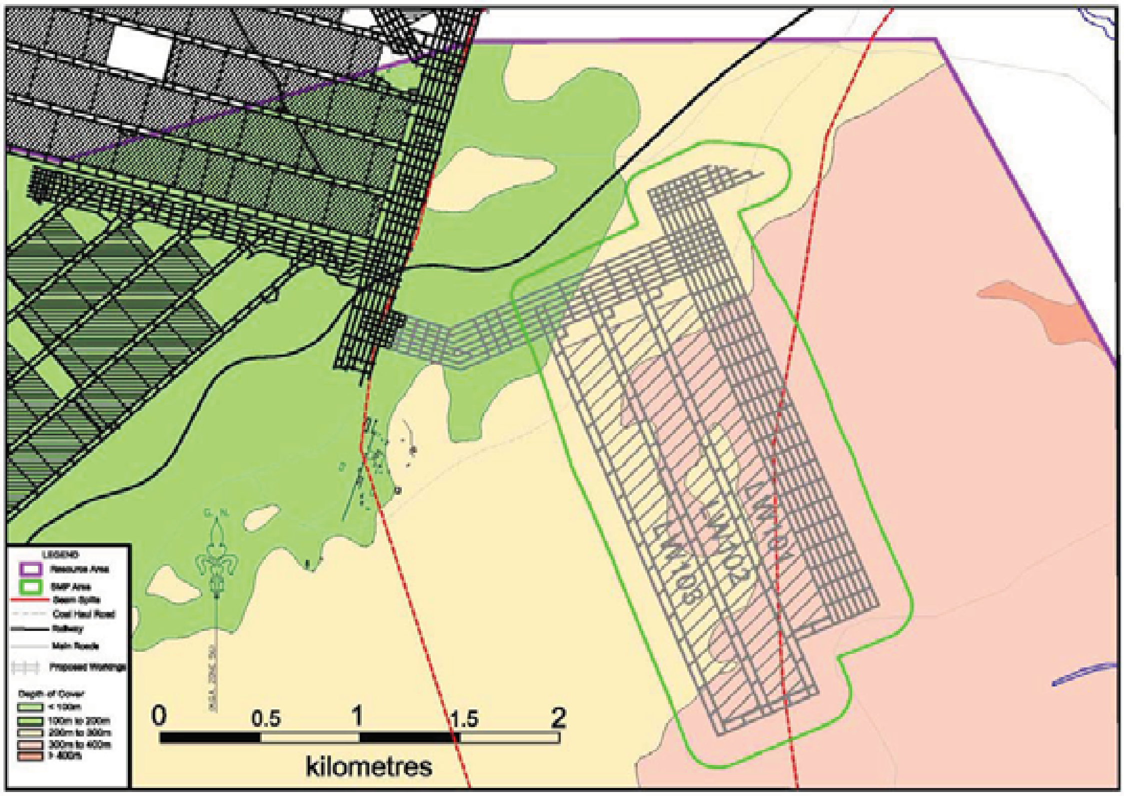


Fig. 1.10 Target Seam Depth of Cover Contours (Newstan, 2011)

The seam thickness contours of the target seams, in the vicinity of the proposed Longwalls 101 to 103, are shown in the Drawing MSEC537-05, in Appendix F. The seam thickness contours of the target seams over a wider area, including the previously mined and future mining areas at Newstan Colliery, are also shown in Fig. 1.11 below.

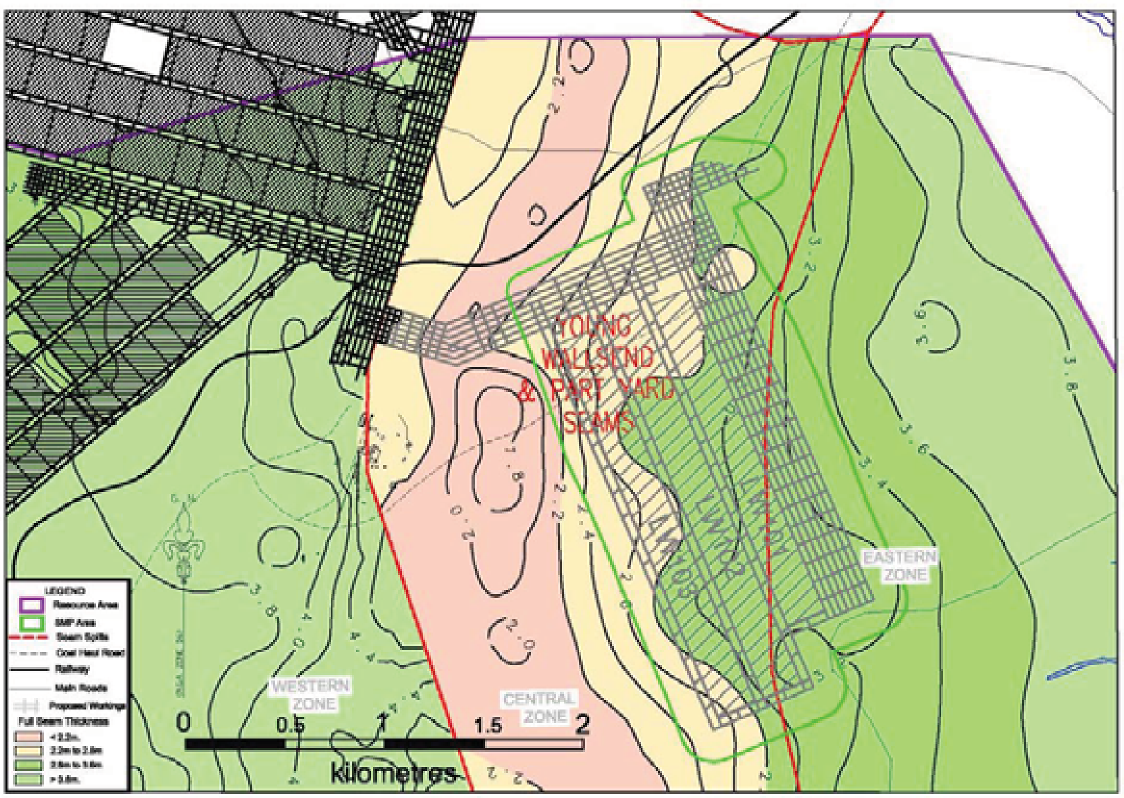


Fig. 1.11 Target Seam Thickness Contours (Newstan, 2011)

The interpreted faults, sills and dykes over the wider area, including the previously mined and future mining areas at Newstan Colliery, are also shown in Fig. 1.12 below.

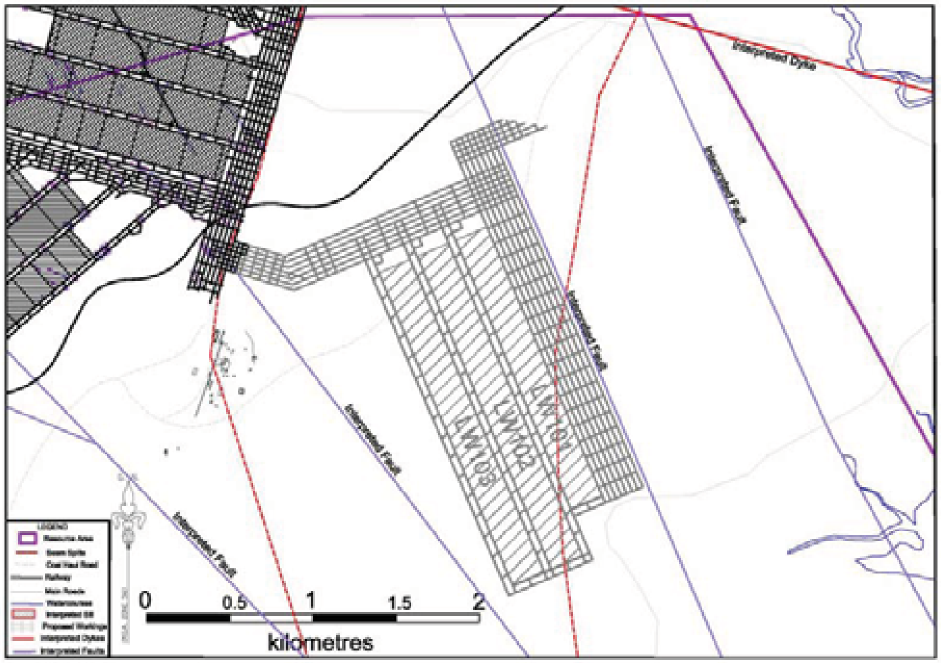


Fig. 1.12 Interpreted Faults, Sills and Dykes (Newstan, 2011)

Irregular patterns in the seam roof structure contours, shown in Fig. 1.9, are evident in the central and northern parts of the area. These anomalies are interpreted by Newstan to be caused by the presence of two localised north-south trending sedimentary seam paleochannels immediately above (roof channel) and below (seam channel) the target seam. The extents of these seam paleochannels are shown in Fig. 1.6, Fig. 1.9 and in Fig. 1.11. The presence of these localised, relatively thick paleochannels within the sedimentary sequence has results in significant "rolling" of the target seams in areas and reduced seam thickness, as shown in Fig. 1.11. These seam paleochannels separate the available seam resources into three zones in the vicinity of the proposed longwalls.

On the western side of the central paleochannel, i.e. west of the proposed Longwalls 101 to 103, all of the Young Wallsend, Yard and Borehole Seams have coalesce forming a single seam that is known as the West Borehole Seam and this seam has been extensively mined in recent years at Newstan Colliery. As shown in Fig. 1.6, the full West Borehole Seam is only available in this western zone, to the west of the proposed Longwalls 101 to 103.

In the central zone, the Borehole Seam is below the paleochannel and the Yard seam is affected by complex splitting and partial deterioration due to the development of the thick paleochannel within the seam horizon. The proposed Longwalls 101 to 103 and located within this central zone and the target seams includes all the Young Wallsend Seam plus what is available of the Yard Seam.

Further to the east, all the Young Wallsend Seam and a thicker Yard Seam section have been defined in an eastern zone where, as shown in Fig. 1.6, the Borehole Seam has been split off by a second seam paleochannel that is below the Yard Seam and above the Borehole Seam.

The projected fault lines that are shown in Fig. 1.12 indicate that no significant faults are anticipated within the extents of the proposed Longwalls 101 to 103. It is not certain, however, that there will be no faults and this will only be confirmed after the development headings have been extracted. If faulting were to be found, they would be expected to be similar to those previously found in the Newstan, Awaba and Myuna Collieries, where approximately 95 % of these faults had vertical throws of less than 3 metres.

Newstan advises that no direct measurements of stress have been undertaken in any of the recent or historic boreholes. High horizontal in-situ stresses and valley bulging have been observed at a number of collieries in the Newcastle Coalfield, on either limb of the Macquarie Syncline, including West Wallsend Colliery, where principal stresses up to 27 MPa have been measured at 200 metres depth (McNally, 1995; Enever et al, 1990). Lohe and Dean-Jones, (1995) advised that underground mining operations in the north eastern part of the region Newcastle Coal Measures (Wallsend Borehole, West Wallsend No. 2, Moonee Collieries), horizontal stress is high to very high with respect to depth and the horizontal stress field is relatively balanced with the ratio of horizontal components 1.3 ~ 1.4 : 1 and that the major stress component is oriented north to north-north-east.

The roof over the target seam for the proposed Longwalls 101 to 103 is typically a thin layer of tuffaceous sandstone (Nobbys Tuff) overlain by bedded, fine grained sediments. The floor is highly variable due to the progressive splitting and coalescence of the Yard Seam plies. The lithology of the floor strata, therefore, varies from coarse grained sandstone to mudstone. Generally, the immediate floor is mudstone or siltstone, which in turn is underlain by fine grained sandstone.

Within each of the stratigraphic conglomerate units that are in the overlying roof strata, there are a number of rock types that include numerous mudstones, sandstones and conglomerates. For the West Borehole Seam to Fern Valley interval, the situation is even more complex with the possibility of a number of sub units or channels. The Merewether Conglomerate is the conglomerate unit that is closest to the West Borehole Seam, but, in this area there is possibly a more complex stratigraphy with several different units present. The thickness of the near seam conglomerate is shown in Fig. 1.13 below.

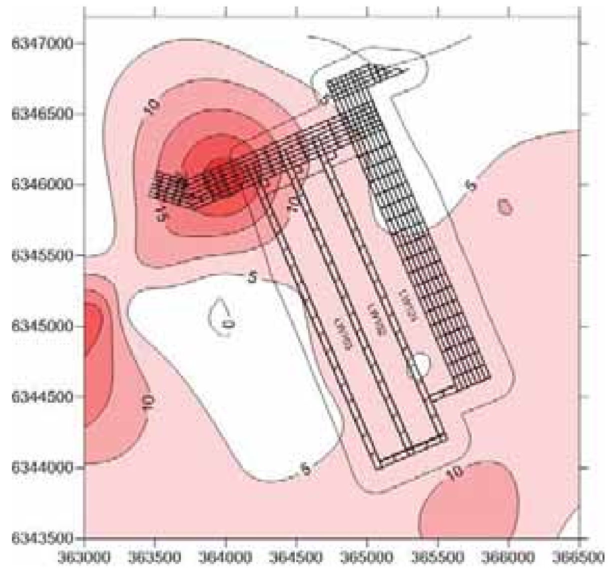


Fig. 1.13 Thickness of Near Seam Conglomerate (Newstan, 2011)

From a geotechnical perspective, the conglomerate channels may include massive units that are thicker than 10 metres and these could affect the longwall mining process. Fortunately the near surface conglomerates, shown in Fig. 1.13, are not adequately developed over the proposed Longwalls 101 to 103 to seriously affect mining, however, these units will marginally reduce the subsidence levels in local areas.

The variations in floor strength in the vicinity of the proposed Longwalls 101 to 103 and across other areas at Newstan are shown in Fig. 1.14. The lower floor strength under the proposed longwalls indicates that these areas are suited to a longwall mining arrangement where a channel of weak floor strength trends north-east to south-west across the workings.

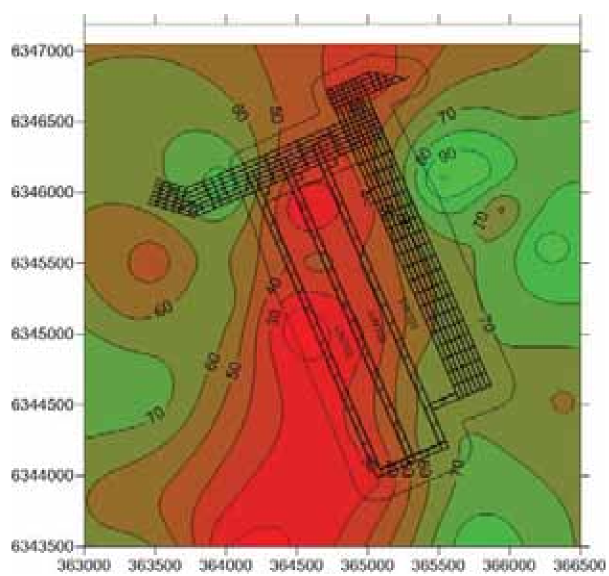


Fig. 1.14 Floor Strength (Newstan, 2011)

2.1. Definition of the SMP Area

The *SMP Area* is defined as the surface area that is likely to be affected by the mining of the proposed Longwalls 101 to 103 in the combined Young Wallsend Seam and part Yard Seam. The extent of the SMP Area has been calculated by combining the areas bounded by the following limits:-

- A 26.5 degree angle of draw from the extents of the proposed Longwalls 101 to 103 and, in this case, also includes the main headings (i.e. first workings) adjacent to the longwalls, and
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour resulting from the extraction of the proposed longwalls.

The 26.5 degree angle of draw line is described as the "*surface area defined by the cover depths, angle of draw of 26.5 degrees and the limit of the proposed extraction area in mining leases for all other NSW Coalfields*" (i.e. other than the Southern Coalfield), as stated in Section 6.2 of the Guideline for Applications for Subsidence Management Approvals (DPI, 2003). In this case, the 26.5 degree angle of draw line has been conservatively taken around both the limit of proposed extraction (i.e. second workings) as well as the main headings (i.e. first workings).

The depth of cover contours are shown in Drawing No. MSEC537-06. It can be seen from this drawing, that the depth of cover directly above the proposed longwalls and main headings varies between a minimum of 175 metres, above the main headings north of the proposed longwalls, and a maximum of 360 metres, above the main headings on the eastern side of the proposed longwalls. The 26.5 degree angle of draw line, therefore, has been determined by drawing a line that is a horizontal distance varying between 88 metres and 180 metres around the extents of the proposed longwalls and main headings.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the Incremental Profile Method, which is described in Chapter 3. The predicted total subsidence contours, resulting from the extraction of the proposed longwalls, are shown in Drawing No. MSEC537-16.

In all locations, the predicted total 20 mm subsidence contour is located inside the 26.5 degree angle of draw line. The SMP Area, therefore, has been defined by the 26.5 degree angle of draw line, which is shown in Drawing No. MSEC537-02.

There are areas that lie outside the SMP Area that are expected to experience either far-field movements, or valley related movements. The surface features which are sensitive to such movements have been identified and have been included in the assessments provided in this report. In this case, features which could be sensitive to far-field or valley related movements, within but not limited to 600 metres from the proposed mining, have been assessed.

2.2. Natural Features and Items of Surface Infrastructure within the SMP Area

The major natural features and items of surface infrastructure within the SMP Area can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), numbered Swansea 9231-4N. The proposed longwalls and the SMP Area have been overlaid on an extract from this CMA map in Fig. 2.1.

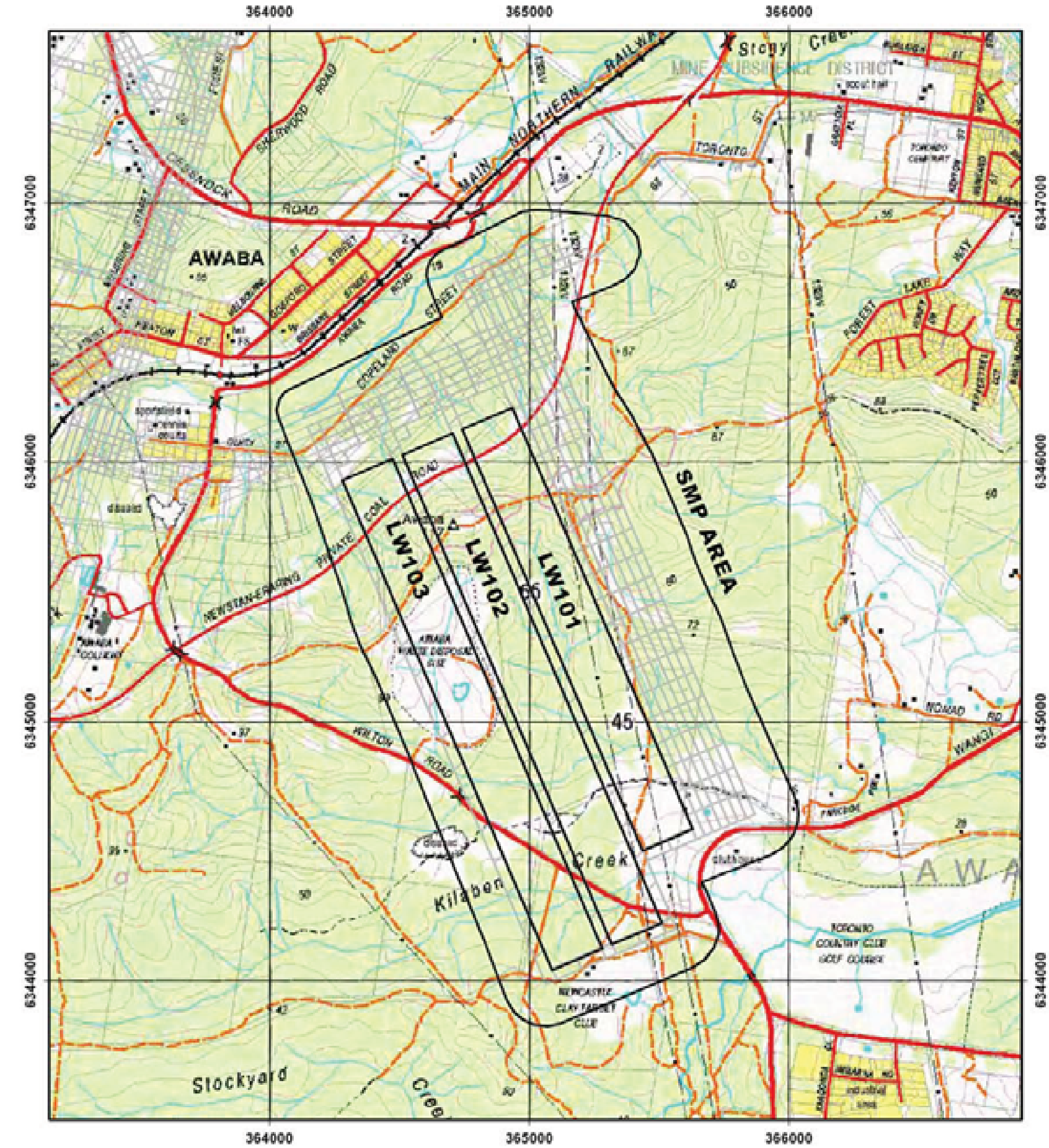


Fig. 2.1 The Proposed Longwalls and the SMP Area Overlaid on CMA Topographic Map No. Swansea 9231-4N

A summary of the natural features and items of surface infrastructure within the SMP Area is provided in Table 2.1. The locations of these features are shown in Drawing Nos. MSEC537-08 to MSEC459-12, in Appendix F.

The descriptions, predictions and impact assessments for the natural features and items of surface infrastructure are provided in Chapters 5 and 6. The section number references are provided in Table 2.1. The characterisation of the surface infrastructure and building structures was based on information provided by *ACOR Appleyard* and *Northrop Engineers*.

Table 2.1 Natural Features and Surface Infrastructure within the SMP Area

Item	Within SMP Area	Section Number Reference
NATURAL FEATURES		
Catchment Areas or Declared Special Areas	×	
Rivers or Creeks	✓	5.2
Aquifers or Known Groundwater Resources	✓	5.3
Springs	×	
Sea or Lake	×	
Shorelines	×	
Natural Dams	×	
Cliffs or Pagodas	×	5.4
Steep Slopes	✓	5.5
Escarpments	×	
Land Prone to Flooding or Inundation	✓	5.7
Swamps, Wetlands or Water Related Ecosystems	✓	5.6
Threatened or Protected Species	✓	5.8
National Parks	×	
State Forests	×	
State Conservation Areas	×	
Natural Vegetation	✓	5.11
Areas of Significant Geological Interest	×	
Any Other Natural Features Considered Significant	×	
PUBLIC UTILITIES		
Railways	×	
Roads (All Types)	✓	6.3
Bridges	✓	6.4
Tunnels	×	
Culverts	✓	6.5
Water, Gas or Sewerage Infrastructure	✓	6.6
Liquid Fuel Pipelines	×	
Electricity Transmission Lines or Associated Plants	✓	6.7
Telecommunication Lines or Associated Plants	✓	6.8
Water Tanks, Water or Sewage Treatment Works	×	
Dams, Reservoirs or Associated Works	×	
Air Strips	×	
Any Other Public Utilities	×	
PUBLIC AMENITIES		
Hospitals	×	
Places of Worship	✓	6.9
Schools	✓	6.9
Shopping Centres	×	
Community Centres	×	
Office Buildings	×	
Swimming Pools	×	
Bowling Greens	×	
Ovals or Cricket Grounds	×	
Race Courses	×	
Golf Courses	✓	6.10
Tennis Courts	×	
Any Other Public Amenities	✓	6.11 & 6.12

Item	Within SMP Area	Section Number Reference
FARM LAND AND FACILITIES		
Agricultural Utilisation or Agricultural Suitability of Farm Land	×	
Farm Buildings or Sheds	×	
Tanks	×	
Gas or Fuel Storages	×	
Poultry Sheds	×	
Glass Houses	×	
Hydroponic Systems	×	
Irrigation Systems	×	
Fences	✓	6.13
Farm Dams	×	
Wells or Bores	✓	6.15
Any Other Farm Features	×	
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS		
Factories	×	
Workshops	×	
Business or Commercial Establishments or Improvements	✓	6.16
Gas or Fuel Storages or Associated Plants	×	
Waste Storages or Associated Plants	✓	6.17
Buildings, Equipment or Operations that are Sensitive to Surface Movements	×	
Surface Mining (Open Cut) Voids or Rehabilitated Areas	×	
Mine Infrastructure Including Tailings Dams or Emplacement Areas	×	
Any Other Industrial, Commercial or Business Features	×	
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓	6.18
ITEMS OF ARCHITECTURAL SIGNIFICANCE	×	
PERMANENT SURVEY CONTROL MARKS	✓	6.20
RESIDENTIAL ESTABLISHMENTS		
Houses	×	
Flats or Units	×	
Caravan Parks	×	
Retirement or Aged Care Villages	×	
Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	✓	6.22
Any Other Residential Features	×	
ANY OTHER ITEM OF SIGNIFICANCE	×	
ANY KNOWN FUTURE DEVELOPMENTS	✓	6.23

2.3. Areas of Environmental Sensitivity

A summary of the features identified as "*Areas of Environmental Sensitivity*" within the SMP Area, as defined in Section 6.6.3 of the SMP Guideline (DPI, 2003), is provided in Table 2.2. The section number references for these features are provided in this table.

Table 2.2 Areas of Environmental Sensitivity within the SMP Area

No.	Description	Within SMP Area	Details	Section Number Reference
1	Land reserved as a State Conservation Area under the *National Parks and Wildlife Act 1974*	×		
2	Land declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*	×		
3	Land identified as Wilderness by the Director, National Parks and Wildlife under the *Wilderness Act 1987*	×		
4	Land subject to a 'conservation agreement' under the *National Parks and Wildlife Act 1974*	×		
5	Land acquired by the Minister for the Environment under Part 11 of the *National Parks and Wildlife Act 1974*	×		
6	Land within State forests mapped as Forestry Management Zone 1, 2 or 3	×		
7	Wetlands mapped under SEPP 14 – Coastal Wetlands	×		
8	Wetlands listed under the Ramsar Wetlands Convention	×		
9	Lands mapped under SEPP 26 – Coastal Rainforests	×		
10	Areas listed on the Register of the National Estate	×		
11	Areas listed under the *Heritage Act 1977* for which a plan of management has been prepared	×		
12	Land declared as critical habitat under the *Threatened Species Conservation Act 1995*	×		
13	Land within a restricted area prescribed by a controlling water authority	×		
14	Land reserved or dedicated under *the Crown Lands Act 1989* for the preservation of flora, fauna, geological formations or other environmental protection purpose	×		
15	Significant surface watercourses and groundwater resources identified through consultation with relevant government agencies	×		
16	Lake foreshores and flood prone areas	×		
17	Cliffs, escarpments and other significant natural features	×		
18	Areas containing significant ecological values	×		
19	Major surface infrastructure	✓	132 kV Transmission Lines Optical Fibre Cables Waste Management Facility	6.7 6.8 6.17
20	Surface features of community significance (including cultural, heritage or archaeological significance)	✓	Archaeological Sites	6.18
21	Any other land identified by the Department to the titleholder	×		

3.1. Introduction

This chapter provides a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed longwalls. Further details are provided in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

3.2. Overview of Longwall Mining

Longwall mining is a method used to extract large rectangular panels (i.e. blocks) of coal, typically 150 metres to 400 metres wide and 1 kilometre to 4 kilometres long. The coal is progressively mined by a shearer that shaves off slices of coal up to 1 metre thick from the longwall face, under the protection of hydraulic supports, until all the panel is fully extracted. While the technology has changed considerably over the years, the basic idea of longwall mining is to maintain a safe working space for the miners along a wide coal face whilst removing all of the coal and allowing the roof and overlying rock to collapse into the void behind.

Firstly a large rectangular panel or pillar is initially formed using continuous miners or road headers. Gate roads are first driven all around the large rectangular pillar before longwall mining begins. The gate road along one long side of the panel is called the maingate where fresh air and mine workers are carried to the face and the extracted coal is conveyed along conveyors. The gate road on the other side of the panel is called the tailgate where air is carried away from the face and also provides a secondary means of egress.

A number of hydraulic jacks, called powered roof supports, chocks or shields, provide support to the roof along the coalface at one end of the longwall panel. Each chock or shield is typically 1.75 metres wide and the supports are placed in a long line, side by side, for the full width of the coal face. An individual support can weigh 30 tonnes to 40 tonnes, extend to a maximum cutting height of up to 6 metres and can support 1,000 tonnes to 1,250 tonnes of the overlying strata weight. Each chock can hydraulically advance itself around 1 metre forward after each slice of coal is extracted.

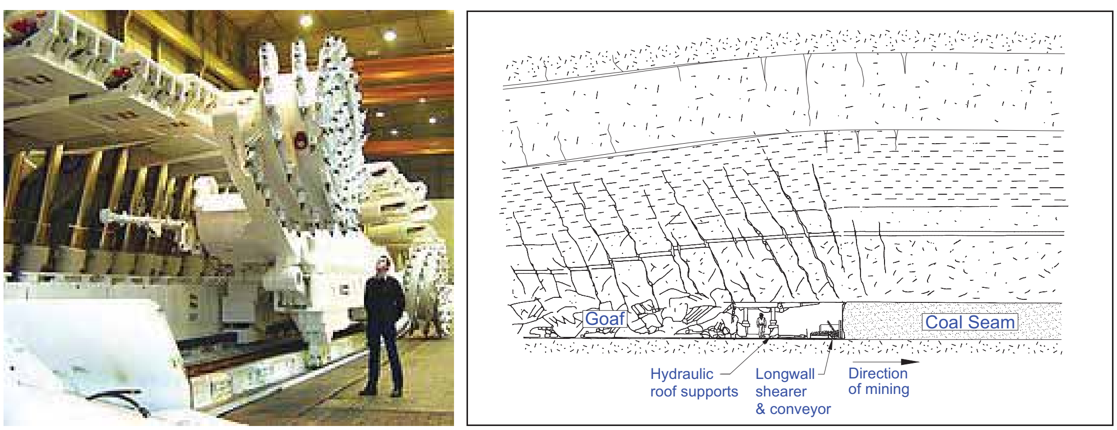


Fig. 3.1 Cross-section along the Length of a Typical Longwall at the Coal Face and a Photograph of a Typical Shearer, Conveyor and Hydraulic Support Chocks

The coal is cut in slices from the coalface by a shearer and the coal falls onto an armoured face conveyor (AFC), which is placed in front of the powered roof supports, and carries the coal from the longwall face to the maingate. From here it is loaded onto a network of conveyor belts for transport to the surface. At the maingate, the coal is often reduced in size in a crusher and loaded onto the first conveyor belt by the beam stage loader (BSL). As the shearer removes the coal, the AFC is snaked over behind the shearer and the powered roof supports move forward into the newly created cavity.

As the longwall face progresses through the seam, the overlying roof strata falls into the mined void (goaf) and the subsidence process of the overburden strata commences. The collapsed roof strata comprises loose blocks and can contain large voids depending on the loading and compaction that follows. Immediately above the mined void and the collapsed zone, the strata can remain relatively intact and bends into the void, resulting in new vertical factures, opening up of existing vertical fractures and bed separation. The strata layers above that bend and shear with the amount of strata sagging, fracturing and bed separation reducing towards the surface.

The basic idea behind longwall mining was developed many years ago, but it has only been in the last thirty years that mining equipment has become powerful and reliable enough to successfully and safely extract large longwall blocks. Safety, productivity and cost considerations dictate that longwall mining is now the major, viable, high production method of coal mining adopted in the majority of Australian underground coal mines that operate at depths greater than about 300 metres.

Longwall mining has a better level of resource recovery when compared to the bord and pillar extraction method, has less need for roof support consumables, has higher volume coal clearance systems and has minimal manual handling. In addition, the safety of the miners is enhanced by the fact that they are always under the hydraulic roof supports when they are extracting coal.

It takes two longwall development heading panels to delineate the first longwall block. Thereafter, only one set of longwall gateroads needs to be driven for each new adjacent longwall panel because the new panel also makes use of one of the gateroads left over from the previous panel. The interpanel pillars that separate each gateroad are known as chain pillars.

Longwall extraction operations effectively result in the formation of very wide and very long excavations separated by a single or double row of relatively narrow chain pillars. Longwall mining therefore involves both first workings and second workings. The mains development and gateroads are first workings, which result in no measurable subsidence at the surface, and the longwall panels are a type of second workings. As with pillar extraction, significant subsidence and resulting disturbance of the subsurface and surface may occur, depending on the mining layout.

Fig. 3.2 An Operating Longwall Face

Note: The following features can be seen: coal seam under extraction, the coal shearer, the face conveyor and system of self-advancing hydraulic roof supports ('chocks' or 'shields').

3.3. Overview of Conventional Subsidence Parameters

The normal ground movements resulting from the extraction of pillars or longwalls are referred to as conventional or systematic subsidence movements. These movements are described by the following parameters:-

- **Subsidence** usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small beyond the longwall goaf edges, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *millimetres (mm)*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres* (km^{-1}), but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
- **Strain** is the relative differential horizontal movements of the ground. **Normal strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strains** occur where the distances between two points increase and **Compressive Strains** occur when the distances between two points decrease. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

  Whilst mining induced normal strains are measured along monitoring lines, ground shearing can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using 3D survey monitoring techniques.
- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. It is not possible, however, to determine the horizontal shear strain across a monitoring line using 2D or 3D monitoring techniques. High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations), and vice versa.

The **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the extraction of each longwall. The **cumulative** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of longwalls. The **total** subsidence, tilts, curvatures and strains are the final parameters at the completion of a series of longwalls. The **travelling** tilts, curvatures and strains are the transient movements as the longwall extraction face mines directly beneath a given point.

3.4. Far-field Movements

The measured horizontal movements at survey marks which are located beyond the longwall goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. These movements are often referred to as *far-field movements*.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural features or surface infrastructure, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

In some cases, higher levels of far-field horizontal movements have been observed where steep slopes or surface incisions exist nearby, as these features influence both the magnitude and the direction of ground movement patterns. Similarly, increased horizontal movements are often observed around sudden changes in geology or where blocks of coal are left between longwalls or near other previously extracted series of longwalls. In these cases, the levels of observed subsidence can be slightly higher than normally predicted, but these increased movements are generally accompanied by very low levels of tilt and strain.

3.5. Overview of Non-Conventional Subsidence Movements

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void and the compression of the pillars and the strata above the pillars. Normal conventional subsidence movements due to longwall extraction are easy to identify where longwalls are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Irregular subsidence movements are generally associated with:-

- shallow depths of cover,
- sudden or abrupt changes in geological conditions,
- steep topography, and
- valley related mechanisms.

Non-conventional movements due to geological conditions and valley related movements are discussed in the following sections.

3.5.1. Non-Conventional Subsidence Movements due to Shallow Depth of Cover

Irregular ground movements are commonly observed in shallow mining situations, where the collapsed zone, which develops above the extracted longwalls, extends near to the surface. These irregular movements appear as localised bumps and steps in the observed subsidence profiles, which are accompanied by elevated tilts, curvatures and ground strains. This type of irregularity is generally only seen where panel widths are supercritical and where the depths of cover less than around 100 metres which, in this case, does not occur above the proposed longwalls.

3.5.2. Non-conventional Subsidence Movements due to Changes in Geological Conditions

It is believed that most non-conventional ground movements are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in a bump in an otherwise smooth subsidence profile and these bumps are usually accompanied by locally increased tilts and strains.

Even though it may be possible to attribute a reason behind most observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term "*anomaly*" is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, non-conventional ground movements are being included statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided in Section 4.3 includes those resulting from both conventional and non-conventional anomalous movements. The impact assessments for the natural features and items of surface infrastructure, which are provided in Chapters 5 and 6, include historical impacts resulting from previous longwall mining which have occurred as the result of both conventional and non-conventional subsidence movements.

3.5.3. Non-conventional Subsidence Movements due to Steep Topography

Non-conventional movements can also result from downslope movements where longwalls are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from downslope movements include the development of tension cracks at the tops and sides of the steep slopes and compression ridges at the bottoms of the steep slopes.

Further discussions on the potential for downslope movements for the steep slopes within the SMP Area are provided in Section 5.5.

3.5.4. Valley Related Movements

The watercourses within the SMP Area may be subjected to valley related movements, which are commonly observed along stream alignments in the Southern Coalfield, but less commonly observed in the Newcastle and Hunter Coalfields. The reason why valley related movements are less commonly observed in the Newcastle and Hunter Coalfields could be that the conventional subsidence movements are typically much larger than those observed in the Southern Coalfield and tend to mask any smaller valley related movements which may occur.

Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 3.3. The potential for these natural movements are influenced by the geomorphology of the valley.

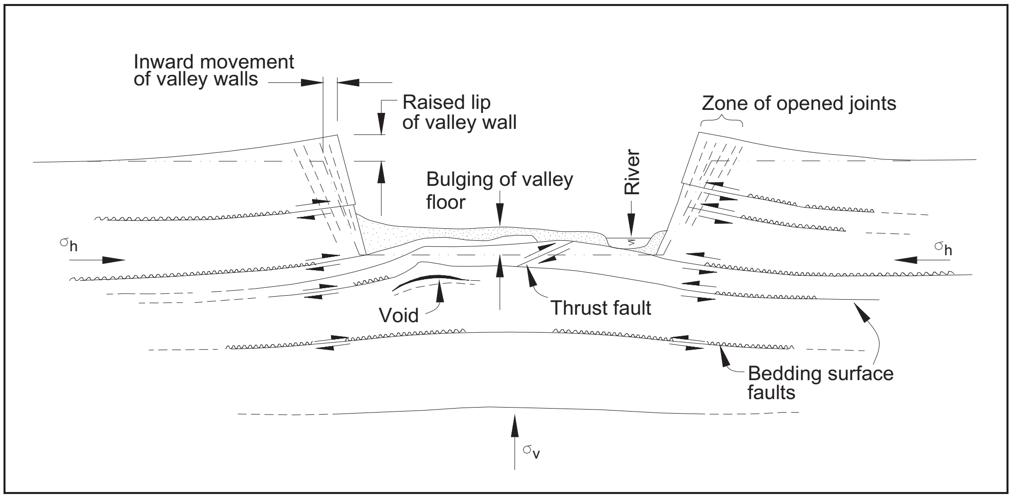


Fig. 3.3 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

Valley related movements can be caused by or accelerated by mine subsidence as the result of a number of factors, including the redistribution of horizontal in-situ stresses and down slope movements. Valley related movements are normally described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.
- **Closure** is the reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides.
- **Compressive Strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile Strains** also occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

The predicted valley related movements resulting from the extraction of the proposed longwalls were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

3.6. The Review of Subsidence Predictions Curves for the Newcastle Coalfield

3.6.1. Background

The geology of the Newcastle Coalfield is considered to be more complex than the geology of the Southern or Hunter Coalfields, due to the greater variations in rock types, strengths and thicknesses occurring over short lateral and vertical distances. There are also a greater number of seams mined, a wider range of extracted seam thicknesses and a greater range of depths of cover.

As a result, it is more difficult to accurately predict mine subsidence ground movements in the Newcastle Coalfield than it is to predict accurately in the Southern or Hunter Coalfields and this is particularly true within the Newstan, Teralba and West Wallsend Collieries, in the southern areas of the Newcastle Coalfield. There have been a number of notable cases where the observed subsidence exceeded the predicted subsidence in this region and, hence, it is important for this SMP Application, to provide an overview of the calibration of the subsidence prediction model used for the proposed longwalls.

The initial subsidence prediction methods for the Newcastle Coalfield were prepared during 1980s and were based on the "Width-to-Depth" (W/H) versus "Subsidence-on-Seam-Thickness" (S_{max}/T) prediction curves that were first developed by NCB subsidence engineers based on experience in the United Kingdom. For example, Fig. 3.4 and Fig. 3.5 below show the Subsidence Prediction Curves that were developed by Kapp (1984) and Holla (1987), respectively, for use for single or first panels in single-seam environments in the Newcastle Coalfield.

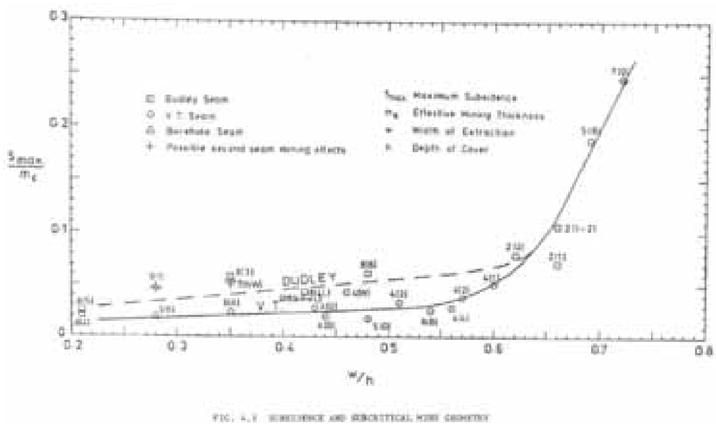


Fig. 3.4 Subsidence Prediction Curve Proposed by Kapp (1984) for the Newcastle Coalfield

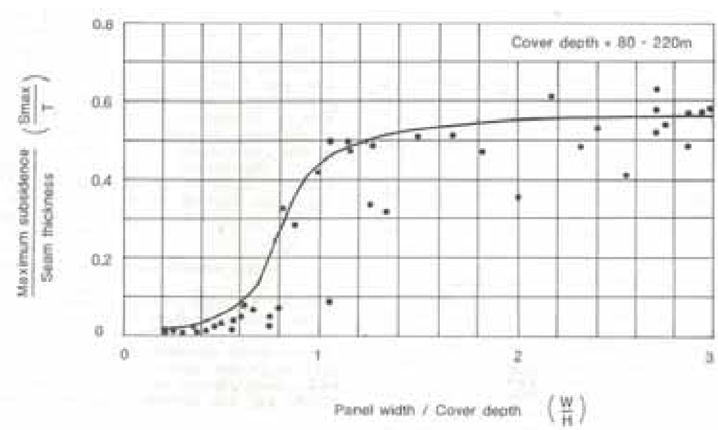


Fig. 3.5 Subsidence Prediction Curve Proposed by Holla (1987) for the Newcastle Coalfield

Holla's prediction curve was prepared based on observed subsidence values over isolated single panels or over the first longwall panels. Where the depths of cover are very low, i.e. less than 200 metres, the magnitudes of the maximum observed subsidence over first panels in a series of longwalls are similar to the magnitudes of the maximum observed subsidence over second and later panels within the series of longwalls. However, at higher depths of cover, the observed subsidence over the second and later panels within a series of longwalls can be several times greater than the magnitude of the maximum observed subsidence over the first panel. Accordingly, these prediction curves should not be used for second or later longwall panels where the depths of cover are greater than 200 metres, such as those being proposed at Newstan Colliery.

Unfortunately, no specific subsidence prediction curves were provided for the maximum subsidence over a series of panels for the Newcastle Coalfield (Holla, 1987). Guidance on predicting total subsidence over a series of longwall panels was provided in a published paper by Holla (1988) when he advised that the total subsidence prediction curves were developed from monitored data from the Southern Coalfield, but, the curves could be used in the Newcastle Coalfield for critical longwall conditions.

Following the experience of extracting Longwalls 9 and 10 at Teralba Colliery, between 1990 and 1992, where the observed subsidence was two to four times greater than those predicted using Kapp's or Holla's Newcastle Subsidence Prediction curves, extensive reviews were undertaken of these early prediction curves and the subsidence monitoring data from the Newcastle Coalfield. At that time the main causes for the increased subsidence were identified to be associated with chain pillar deformation, variations in stratigraphy and geological structures (i.e. faults or dykes).

Over time, the influence multi-seam mining conditions, the presence of several reverse faults and the use of one Subsidence Prediction Curve for all of the Newcastle Coalfield (based on data where the depths were less than 200 metres), appear to be the main factors causing this increased subsidence at Teralba. The use of one Subsidence Prediction Curve for all of the Newcastle Coalfield has proved to be insufficient, as it has been later realised by several researchers that both the depth of cover and the panel width can independently cause different subsidence levels to develop for the same panel width-to-depth (W/H) ratios.

Many authors have reviewed this case and have revealed the following three main factors that are believed to explain the higher than predicted subsidence levels at Teralba Longwalls 9 and 10:-

- the increased ***depth of cover***, which can cause increased compression of the coal chain pillar and the immediate strata above and below the pillar,
- the ***widths of the panels***, which affect the spanning capacity of the overlying strata; i.e. the influence of massive strong conglomerate or sandstone beams, and
- the ***variations in the local geology***; including the thinning of the thicknesses of the strata units and the presence of highly jointed or faulted zones and other geological factors.

The influences of these three factors on the prediction of mine subsidence in the Newcastle Coalfield are discussed in the following sections.

3.6.2. Depth of Cover

The early Newcastle Subsidence Prediction Curves (Holla, 1987) were based on the then available empirical data where the depths of cover did not exceed 220 metres, as shown in the following Table 1.1.

Table 3.1 Empirical Data from the Newcastle Coalfield for Depths of Cover Less than 220 metres used in the Early Newcastle Subsidence Prediction Curves (Holla, 1987)

Colliery	Seam	Width (m)	Cover Depth (m)	Extracted thickness (m)	Extraction type
Burwood	Victoria Tunnel	49-66	107-127	2.0-2.4	short wall
Lambton	Dudley	66-67	102-107	2.1	short wall
Delta	Rathluba	115	100-110	2.24	pillar extraction
Gretley	Dudley	38-360	60-108	2.0	pillar extraction
Munmorah	Great Northern	50-570	183-201	2.1-2.74	pillar extraction
Wyee	Great Northern	139-494	183-197	1.98	pillar extraction
Newvale	Great Northern	43-473	191-197	2.4-2.74	pillar extraction
Newvale 2	Great Northern	141-387	178	2.45	pillar extraction
Wallsend Borehole	Young Wallsend	85-97	98	2.45	pillar extraction
West Wallsend No. 2	Borehole	175	220	2.25	pillar extraction
John Darling	Victoria Tunnel	600	210	2.3	short wall
Wallarah	Wallarah	160-205	80	3.0	pillar extraction
Ellalong	Greta	150	367	3.5	longwall extraction

When additional weight is loaded onto an object, it can be compressed depending on its material properties. Coal pillars can also be compressed by the overburden weight up to a limit where they can fail under excessive loading. At shallow depths of cover, such as those listed in the above table and used to develop the Newcastle Subsidence Prediction Curves (Holla, 1987), the magnitude of the pillar compression is small when compared to the subsidence resulting from the sagging of the strata over the voids. However, as the depth of cover increases, the subsidence resulting from pillar compression and the immediate floor and roof strata can equal and exceed the subsidence resulting from the sagging over the voids. The compression of the pillar is due mostly to the increased overburden weight being supported by the pillar, but, some of the compression is due to the reduction or relaxation of horizontal stresses within the pillars.

At depths of cover around 200 metres, calculations indicate that the compression of 30 metre wide chain pillars can account for up to 250 mm to 400 mm of the observed surface subsidence. At depths of cover around 400 metres, the compression of 30 metre wide chain pillars can account for up to 600 mm to 1000 mm of observed surface subsidence. This additional subsidence due to pillar compression is not allowed for in the Subsidence Prediction Curves (Holla, 1987) as can be shown in a simple example.

Take two cases, both with 30 metre wide chain pillars; the first case having a longwall void width of 100 metres at 200 metres depth of cover, i.e. the W/H ratio is 0.5, and the second case having a longwall void of 200 metres at 400 metres depth of cover, i.e. the same W/H ratio of 0.5. In both these cases, the subsidence predicted using the above Newcastle Subsidence Prediction Curves (Holla, 1987) is 0.08 times the extracted seam thickness, which for a 3 metres thick seam would be 240 mm. However, as discussed above, for the first case the subsidence due to the pillar compression could be up to 250 mm to 400 mm, whilst, in the second case because of the increased depth of cover, the subsidence due to pillar compression could be up to 600 mm to 1000 mm.

3.6.3. Panel Widths and the Spanning Capacity of the Overlying Strata

The types of monitoring lines that clearly reveal the influence of the longwall void widths on the levels of observed subsidence are those that are located over the starting (i.e. commencing) ends of wide longwalls and run longitudinally down the centreline of the longwalls. In one case, a borehole extensometer was installed near the commencing end of the longwall and the resulting data reveals when the various overburden strata layers can span the void and when these strata units fail (Mills, 2000).

As shown in Fig. 3.6, as the length of the longwall void increased, the observed surface subsidence increased up to a maximum of 1400 mm, for a longwall panel that was 260 metres wide, with an extracted seam thickness of 2.55 metres and a depth of cover of 155 metres (Mills, 2000). The observed surface subsidence divided by the extracted seam thickness, for this case, is plotted against the extracted longwall length divided by the depth of cover in Fig. 3.6 below.

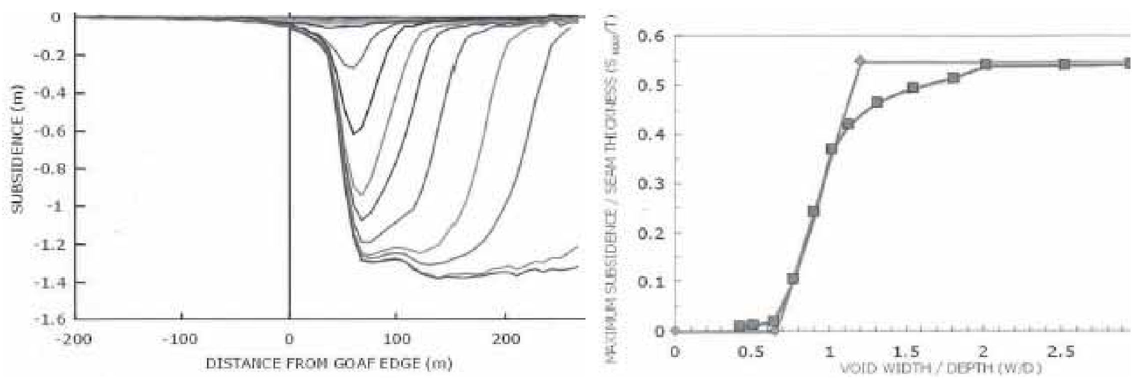


Fig. 3.6 Observed Subsidence near the Commencing End of a Longwall Panel (Mills, 2000)

The second graph in Fig. 3.6 shows three stages of sag subsidence behaviour, i.e. from strata bridging where the layers can span over the void with little observed subsidence, to a geometry dependent stage of subsidence, to the full subsidence stage. Once the bridging width is exceeded, the maximum subsidence becomes a function of the void width until a maximum subsidence is reached, in this case at approximately 55 % of the extracted seam thickness when the void width-to-depth ratio was around 2.0.

For this case, bridging of the overburden strata was observed until the subsidence reached 50 mm, at which time, the spanned width was around 90 metres to 100 metres. This bridging distance is typical of most strata, although weaker strata layers break at narrower spans and wider bridging occurs where there are massive and strong conglomerate units. In this case this 100 metre span equates to a W/H ratio of 0.65 when divided by a cover depth of 155 metres.

The spanning capacity of a strata beam is dependent on the thickness of the strata beam, its homogeneity, its geomechanical properties, its depth of cover (Wilson, 1986) and the height of the beam above the mined seam (Ditton, et al, 2003). However, the spanning capacity of strata beams do not vary linearly with depth of cover. If the failing bridging width was still 100 meters and the depth of cover had been 400 metres, then, the above plot would look entirely different with the bridging point equating to a W/H ratio of 0.25 rather than the W/H ratio of 0.65.

It is understood therefore that the width of extraction can influence the magnitude of subsidence independently of the width-to-depth (W/H) ratio. For example, in the Southern Coalfield, typical longwall panel widths were around 250 metres where the depths of cover were around 500 metres. Also, a few decades ago in the Newcastle Coalfield, typical longwall panel widths were around 120 metres where the depths of cover were in the order of 240 metres. In both these cases, the longwall width-to-depth (W/H) ratios are 0.5, however, typical overburden strata cannot bridge over the 250 metres void widths, whilst overburden strata can typically bridge over 120 metres wide void widths. The result is that, for the same W/H ratio of 0.5, the typical subsidence observed for a longwall in the Southern Coalfield is around 0.28T, or 700 mm for a 2.5 metre extraction height, whilst the typical subsidence observed for a longwall in the Newcastle Coalfield is around 0.04T, or 100 mm for a 2.5 metre extraction height.

3.6.4. Variations in the Local Geology

During the initial reviews, following the experience of Longwalls 9 and 10 at Teralba Colliery, where the observed subsidence was greater than those predicted using the Newcastle Subsidence Prediction Curves (Holla, 1987), the Department of Mineral Resources and various consultants for the colliery investigated the likely causes of the increased levels of subsidence. It was found that the likely causes were associated with increased chain pillar deformations, variations in the stratigraphy, or the possibility of the presence of faults, dykes, or other various geological structures. The published reviews did not indicate that the error was associated with the use of the Newcastle Subsidence Prediction Curves (Holla, 1987), which were based on monitoring data where the depths of cover were all less than 220 metres, whereas the depths of cover at Teralba were greater than 300 metres.

Many reviews also concentrated on the influence of variations in the strength of the overburden. There is a significant body of evidence to show that, the presence or absence of significant massive and competent strata units, or the presence of faults or dykes within the overburden above an extraction panel, can result in varying mining conditions and can cause significant variations in the surface subsidence trough for constant panel widths, depths of cover and extraction thicknesses.

However, with further experience, it became apparent that there were significant shortcomings with predicting the maximum subsidence using a single prediction curve for the Newcastle Coalfield (Holla, 1987), where the depths of cover vary widely between 70 metres to more than 400 metres.

Detailed subsidence monitoring has taken place over mined panels in the West Borehole Seam at Newstan Colliery since the 1970s. Subsidence monitoring data has been gathered over longwalls for different seams having widely varying mining geometries and, hence, there is sufficient subsidence monitoring data to refine the generalised Newcastle Subsidence Prediction Curves (Holla, 1987) and to highlight the influence of panel width (W), depth of cover (H) and the width-to-depth (W/H) ratio on the observed subsidence levels.

In 1995, during the extraction of Newstan Longwall 5, having a void width of 230 metres within the Borehole Seam under massive conglomerate strata, the longwall face experienced aggressive periodic weighting in the process with many major mid-face roof falls. The maximum observed subsidence was 1.5 metres, or 0.35 times the extracted seam thickness. In the light of this experience, the subsequent panel was split longitudinally to form two narrower panels.

When the adjacent Longwalls 6 and 7 were extracted, having void widths of 100 metres and similar depths of cover and extraction heights as the previous panel, the maximum observed subsidence was much lower at only 210 mm, or 0.05 times the extracted seam thickness. The influence of the overlying conglomerate on subsidence observed above Longwall 8, which was 133 metres wide, was even more striking. Where the conglomerate unit spanning the goaf had a thickness more than 35 metres, the observed subsidence was reduced to around 0.2 metres. Where the conglomerate unit had a thickness less than 15 metres and where a highly fractured geological zone was identified, the maximum observed subsidence increased to almost 2 metres, as shown below Fig. 3.7, (Creech, 2001).

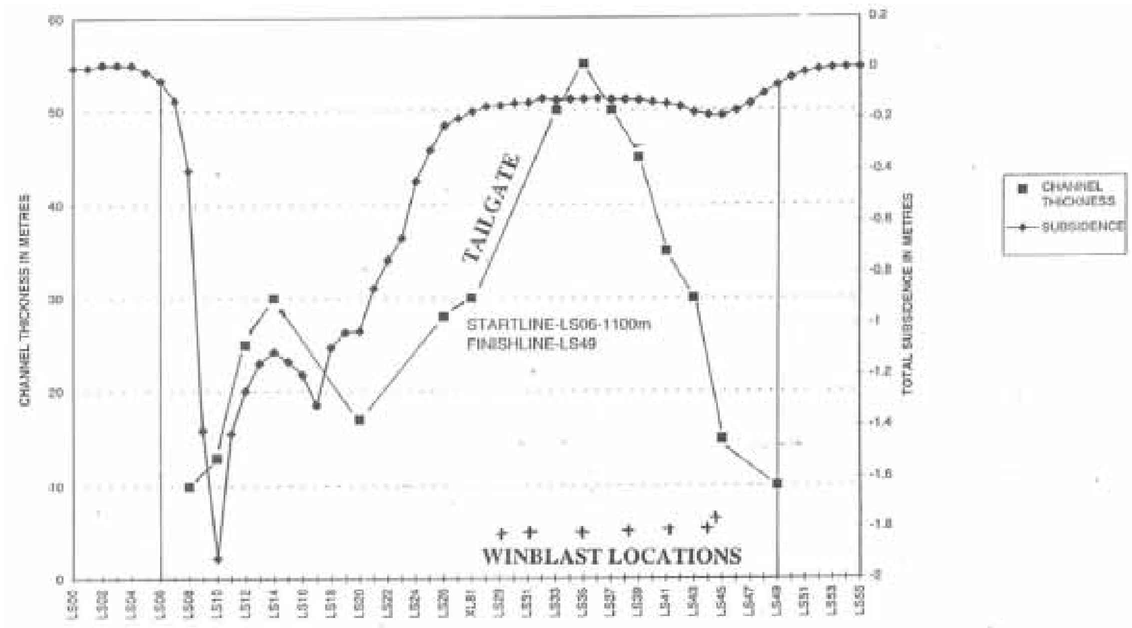


Fig. 3.7 Observed Subsidence and Conglomerate Channel Thicknesses over Newstan Longwall 8 (Creech, 2001)

The main differences between these panels were the void widths and the variations in the thicknesses of the massive conglomerates and sandstones above the workings. These strata were able to bridge over the narrower void widths, in some locations, which limited the surface subsidence. Teralba Colliery and West Wallsend Colliery have also experienced this phenomenon

It is very important to note, for the proposed Newstan Longwalls 101 to 103, that the massive sandstone and conglomerate units do not occur everywhere above the proposed mining area and that their effectiveness to limit subsidence has been reduced by the thinning of units and by the proximity of highly fractured zones, faults and reverse faults. The locations and thicknesses of the strong and massive conglomerate or sandstone channels have been mapped by mine geologists, from borehole information, and methods are now available to allow for the influence of these units on the observed levels of subsidence.

Because of the above discussed limitations in the Newcastle Subsidence Prediction Curves (Holla, 1987), several authors have proposed alternative subsidence prediction curves including Creech, (1995, 1996 and 2001), Tobin (1997) and (Ditton, et al, 2003). These authors have advised that:-

- since 1994 Newstan Colliery has mined under massive conglomerate strata and has suffered severe periodic weighting, windblasts and highly variable surface subsidence, and
- with the increasing widths of extraction and the variable geology, (particularly where there is a lack of overlying massive conglomerate), the Newcastle Subsidence Prediction Curves (Holla, 1987) significantly under predict the actual subsidence and these curves should not be used beyond ranges of the original data on depths of cover, conglomerate geometry and widths of extraction that were available when these curves were developed.

The following plot, Fig. 3.8, shows the various observed subsidence data from the Newcastle Coalfield. The figure also shows the Subsidence Prediction Curves for the Southern Coalfield (Holla, 1985) and for the Newcastle Coalfield (Holla, 1987), as well as an alternative Subsidence Prediction Curve proposed for Newstan Colliery (Tobin, 1997). Tobin advises that the proposed alternative Subsidence Prediction Curve for Newstan was based on local monitoring data that was unaffected by multi-seam extraction and structural anomalies such as dykes and faults.

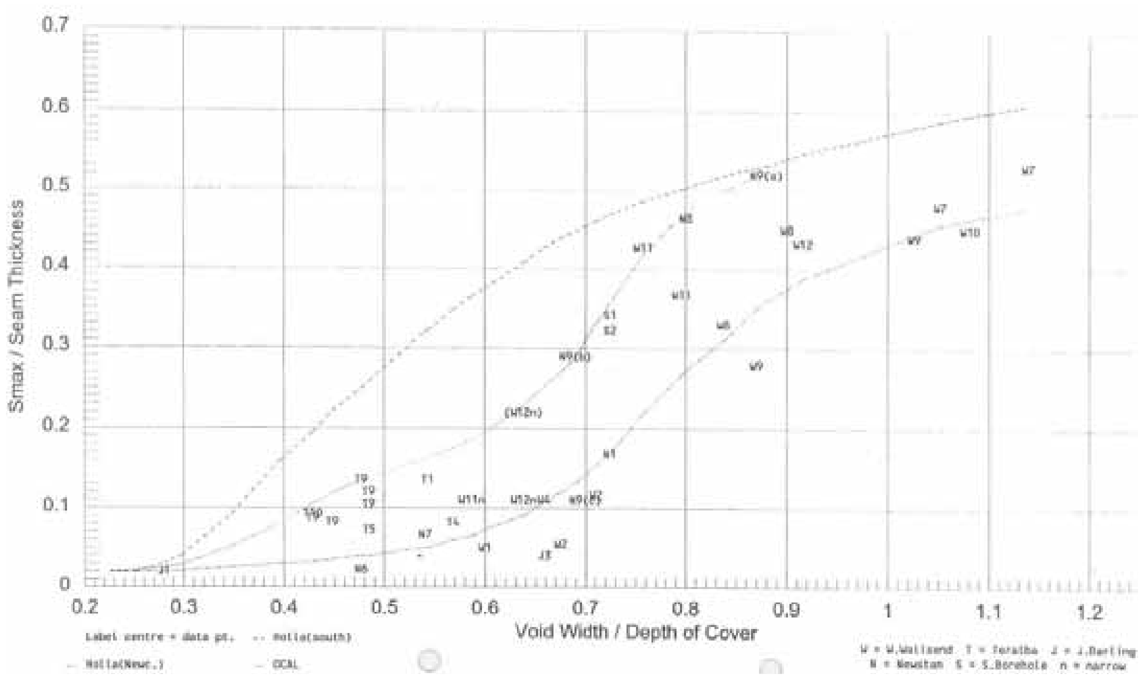


Fig. 3.8 Observed Subsidence in the Newcastle Coalfield, the Southern Coalfield and Newcastle Coalfield Subsidence Prediction Curves (Holla, 1985 and 1987) and the Proposed Newstan Subsidence Prediction Curves (Tobin, 1997)

It can be seen in Fig. 3.8 that for a constant width-to-depth (W/H) ratio of 0.5, there can be three differing maximum subsidence on seam thickness ratios for differing depths of cover; i.e.

- a low value of 0.03 times the extracted seam thickness using the Holla (1987) Newcastle prediction curve where the depths of cover are generally up to 200 metres,
- a higher value of 0.14 times the extracted seam thickness using the Teralba prediction curve where the depths of cover range up to about 330 metres, and
- a much higher value of 0.28 times the extracted seam thickness using the Southern Coalfield where the depths of cover are in excess of 450 metres.

Ditton et al (2003) advised in an ACARP funded report C10023, that it had long been recognised that the massive conglomerate and sandstone channel units in the Newcastle Coalfield had resulted in large differences in the magnitude of surface subsidence (i.e. in the order of metres) along the lengths or centrelines of extracted longwalls. The effect of a strong bridging unit on the overburden behaviour and on surface subsidence was demonstrated in Whittaker and Reddish (1989), based partly on physical modelling techniques, which is illustrated in Fig. 3.9.

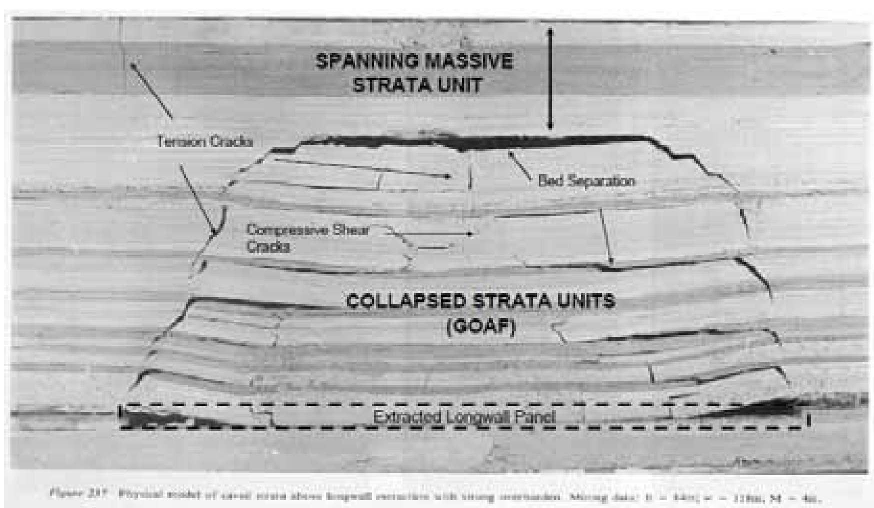


Fig. 3.9 Physical Model Showing the Subsidence Reducing Effect of a Massive Strata Unit (Whittaker and Reddish, 1989)

Ditton et al (2003) collated monitoring data from the Newcastle Coalfield and represented this data using the familiar normalised or dimensionless parameters S_{max}/T versus W/H curves. However, recognition was given to the influence of depth of cover and the influence of massive and strong conglomerate channels. The collated data in this report is shown in Fig. 3.10.

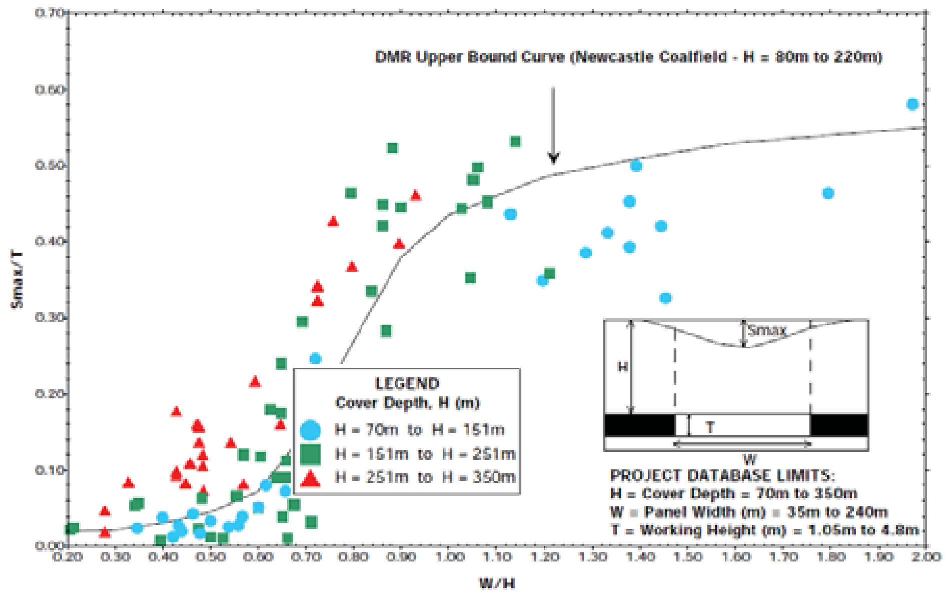


Fig. 3.10 Observed Subsidence Data from the Newcastle Coalfield Based on Depths of Cover between 70m and 350m plus the DMR Subsidence Prediction Curve (Ditton, et al, 2003)

It can be seen in Fig. 3.8 and Fig. 3.10, that the one single Subsidence Prediction Curve is not suitable for predicting subsidence for the Newcastle Coalfield, with such a wide range of depths of cover and panel widths. These figures confirm the understanding that the observed subsidence, as proportions of the extraction thicknesses, can increase from 0.04T to 0.08T to 0.2T for the same width-to-depth (W/H) ratio of 0.5 with increasing depths of cover from 150 metres, to 250 metres, to 350 metres, respectively. For a seam thickness of 3 metres, the range of observed subsidence varies from 120 mm, to 240 mm, to 600 mm.

It should be noted, that the early subsidence prediction methods that used the one Subsidence Prediction Curve (Kapp 1984 or Holla 1987) are only applicable to predicting subsidence over first panels in a series, i.e. single isolated panels that are unaffected by adjacent panels or previous multi-seam mining. No specific guidance was published for predicting the total subsidence over a series of longwalls in the Newcastle Coalfield.

Accordingly a revised subsidence prediction method was required that could be applied for the Newcastle Coalfield to allow for these wide variations in depths of cover, the wide range in overburden geology and the wide range in mining layouts and geometries.

3.6.5. The Incremental Profile Method

The Incremental Profile Method (IPM) was initially developed by Waddington Kay and Associates, now known as MSEC, as part of a study, in 1994 to assess the impacts of subsidence on particular surface infrastructure over a proposed series of longwall panels at Appin Colliery. The method evolved following detailed analyses of subsidence monitoring data from the Southern Coalfield, which was then extended to include detailed subsidence monitoring data from the Newcastle and Hunter Coalfields.

The review of the detailed ground monitoring data from the NSW Coalfields showed that whilst the final subsidence profiles measured over a series of longwalls were irregular, the observed incremental subsidence profiles due to the extraction of individual longwalls were consistent in both magnitude and shape and varied according to local geology, depth of cover, panel width, seam thickness, the extent of adjacent previous mining, the pillar width and stability of the chain pillar and a time-related subsidence component.

MSEC developed a series of subsidence prediction curves for the Newcastle Coalfield, in 1996 to 1998, after receiving extensive subsidence monitoring data from Centennial Coal for the Cooranbong Life Extension Project (Waddington and Kay, 1998). The subsidence monitoring data from many collieries in the Newcastle Coalfield were reviewed and, it was found, that the incremental subsidence profiles resulting from the extraction of individual longwalls were consistent in shape and magnitude where the mining geometries and overburden geologies were similar.

Since this time, extensive monitoring data has been gathered from the Southern, Newcastle and Hunter Coalfields of New South Wales and from the Bowen Basin in Queensland, including: Angus Place, Appin, Awaba, Baal Bone, Bellambi, Beltana, Blakefield South, Bulga, Bulli, Burwood, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Donaldson, Eastern Main, Ellalong, Elouera, Fernbrook, Glennies Creek, Grasstree, Gretley, Invincible, John Darling, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Moranbah North, Mt. Kembla, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, NRE Wongawilli, Oaky Creek, Ravensworth, South Bulga, South Bulli, Springvale, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

Based on the extensive empirical data, MSEC has developed standard subsidence prediction curves for the Southern, Newcastle and Hunter Coalfields. The predictions curves can then be further refined, for the local geology and local conditions, based on the available monitoring data from the area. Discussions on the calibration of the Incremental Profile Method for the proposed Longwalls 101 to 103, at Newstan Colliery, are provided in Sections 3.6.6 and 3.6.7.

The prediction of subsidence is a three stage process where, first, the magnitude of each increment is calculated, then, the shape of each incremental profile is determined and, finally, the total subsidence profile is derived by adding the incremental profiles from each longwall in the series. In this way, subsidence predictions can be made anywhere above or outside the extracted longwalls, based on the local surface and seam information.

For longwalls in the Newcastle Coalfield, the maximum predicted incremental subsidence is initially determined, using the IPM subsidence prediction curves for a single isolated panel, based on the longwall void width (W) and the depth of cover (H). The incremental subsidence is then increased, using the IPM subsidence prediction curves for multiple panels, based on the longwall series, panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H). In this way, the influence of the panel width (W), depth of cover (H), as well as panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H) are each taken into account, so as to avoid the shortcomings of a single subsidence prediction curve based on W/H alone (i.e. Holla, 1987), as described in Sections 3.6.2 and 3.6.3.

The shapes of the incremental subsidence profiles are then determined using the large empirical database of observed incremental subsidence profiles from the Newcastle Coalfield. The profile shapes are derived from the normalised subsidence profiles for monitoring lines where the mining geometry and overburden geology are similar to that for the proposed longwalls. The profile shapes can be further refined, based on local monitoring data, which is discussed further in Sections 3.6.6 and 3.6.7.

Finally, the total subsidence profiles resulting from the series of longwalls are derived by adding the predicted incremental profiles from each of the longwalls. Comparisons of the predicted total subsidence profiles, obtained using the Incremental Profile Method, with observed profiles indicates that the method provides reasonable, if not, slightly conservative predictions where the mining geometry and overburden geology are within the range of the empirical database. The method can also be further tailored to local conditions where observed monitoring data is available close to the mining area.

3.6.6. Calibration of the Incremental Profile Method for Local Geology

Early researchers recognised that there were significant differences in the subsidence behaviour that occurred in the Newcastle Coalfield and in the Southern Coalfield (Kapp, 1984 and Holla, 1987). It was postulated that the presence of massive strata, especially the conglomerate channel units, in the Newcastle Coal Measures resulted in lower than expected subsidence for a given panel width-to-depth (W/H) ratio. It was recognised that the presence of thick and massive conglomerate units in the Newcastle Coalfield, without bedding planes or planes of weaknesses, increased the spaning capacity of the overburden and this reduces the observed surface subsidence movements.

Several massive and strong conglomerate layers have been identified over previously extracted longwalls at Newstan and other nearby collieries. The observed subsidence over these panels was significantly less than the subsidence observed over other longwalls that did not have these massive and strong conglomerate layers.

In the cases where extensive geological investigations have been undertaken, so as to confirm the continuing presence of the massive strong strata layers and to confirm no significant faulting, MSEC has applied various geological factors (or calibration factors) to the standard IPM model to account for the effect of these units on the subsidence predictions.

The geologists at Newstan have advised that there are numerous sandstone, shale, conglomerate, claystone, tuff, tuffaceous sandstone, tuffaceous siltstone, chert and coal layers in the overburden sequence, which is described in Section 1.4. The named conglomerates units (or "stratigraphic units") are not always comprised entirely of conglomeratic rocks, as these Newcastle Coal Measures were formed during a high energy environment and, hence, the measures contain high proportions of coarse clastic and volcanogenic sediments.

As these conglomerate and tuffaceous units can affect the productivity of coal mining and can affect the observed surface subsidence, Newstan undertook a programme of studies to identify any conglomerate channels in the proposed mining area. From a geotechnical perspective, it was determined that conglomerate channels that are thicker than 10 metres could affect the longwall mining process and, hence, contours were prepared showing the thicknesses of each of the potential conglomerate or sandstone layers at Newstan. The *Merewether Conglomerate* is the unit closest to the West Borehole Seam, but, it was found that there was a complex stratigraphy with several different conglomerate units present over the proposed mining area.

Fortunately, the geologists at Newstan found that the near seam conglomerates over the proposed Longwalls 101 to 103 were not adequately developed to seriously affect mining, as shown in Fig. 1.13. The geologists have also advised that these units are not expected to impact on subsidence outcomes due to the relatively small development area.

As a result, no subsidence reduction factors have been applied to the subsidence predictions, based on the geological review of the conglomerates units in the overburden.

3.6.7. Calibration of the Incremental Profile Method Based on Monitoring Data at Newstan, Teralba and West Wallsend Collieries

The Incremental Profile Method (IPM) is an empirical model based on a large database of monitoring data from the Southern, Newcastle and Hunter Coalfields. MSEC developed the IPM subsidence prediction curves for the Newcastle Coalfield, in 1996 to 1998, based on extensive monitoring data from the Newcastle Coalfield. Since this time, additional monitoring data has been collected from the Newcastle and Hunter Coalfields, which further supports the IPM subsidence prediction curves.

MSEC has reviewed the available monitoring data from previously extracted longwalls at Newstan, as well as at other nearby collieries, including Teralba and West Wallsend Collieries, where the regional geology is reasonably similar. The observed movements have been compared with those predicted using the Incremental Profile Method based on the standard IPM subsidence prediction curves for the Newcastle Coalfield.

Monitoring lines were selected for previously extracted longwalls having wide ranges of panel widths, depths of cover and, hence, panel width-to-depth ratios, so that the prediction model could be tested over a wide range of mining geometries. The locations of the monitoring lines at Newstan, Teralba and West Wallsend Collieries, which have been selected, are shown in Fig. C.01, in Appendix C.

The comparisons between the observed and the back-predicted subsidence, tilt and curvature for monitoring lines at Newstan Colliery are shown in Figs. C.02 to C.09, in Appendix C, which are:-

- Fig. C.02 Newstan Colliery (West Borehole Seam) - LW1 Centre Line,
- Fig. C.03 Newstan Colliery (West Borehole Seam) - LW1 and LW2 Cross Line,
- Fig. C.04 Newstan Colliery (West Borehole Seam) - LW2 Centre Line,
- Fig. C.05 Newstan Colliery (West Borehole Seam) - LW3 and LW4 Cross Line,
- Fig. C.06 Newstan Colliery (West Borehole Seam) - LW5 Cross Line,
- Fig. C.07 Newstan Colliery (West Borehole Seam) - LW9 to LW14 Cross Line,
- Fig. C.08 Newstan Colliery (West Borehole Seam) - LW15 Centre Line, and
- Fig. C.09 Newstan Colliery (West Borehole Seam) - LW15 to LW18 Cross Line.

The monitoring lines located above Newstan Longwalls 1 to 4 are shown in Figs. C.02 to C.05. These longwalls have void widths between 210 metres to 225 metres, depths of cover between 290 metres and 330 metres, and extraction heights around 3.3 metres to 3.4 metres, which are similar to those for the proposed Longwalls 101 to 103. It can be seen from these figures, that the maximum observed subsidence and tilt for these monitoring lines were similar to, but slightly less than those predicted. The observed curvatures exceeded those predicted, in some locations, which were very localised and possibly the result of irregular movements or, possibly, disturbed ground marks. Also, the observed profiles of subsidence and tilt reasonably matched those predicted and the observed zones of hogging and sagging curvatures reasonably matched those predicted.

Longwall 5 had a void width of 230 metres and depth of cover around 235 metres, which is similar to the northern end of the proposed Longwall 103. The extraction height for Longwall 5 of 3.6 metres, however, is greater than that for the proposed longwall in this location of 2.6 metres. It can be seen from Fig. C.06, that the profiles of observed subsidence and tilt reasonably matched those predicted. Whilst the observed curvatures exceeded those predicted, in some locations, the observed zones of hogging and sagging reasonably matched those predicted.

Longwalls 6 to 8 have void widths between 100 metres to 135 metres, which are much less than those for the proposed Longwalls 101 to 103 of 210 metres. As described in Section 3.6, the narrower void widths allows greater bridging and, hence, reduced surface subsidence when compared with wider longwalls having similar width-to-depth ratios. It is not unexpected, therefore, that the observed subsidence above these longwalls was much less than predicted.

The monitoring lines located above Newstan Longwalls 9 to 18 are shown in Figs. C.07 to C.09. These longwalls have width-to-depth ratios between 0.8 to 1.9, which are greater than those for the proposed Longwalls 101 to 103. In each case, the profiles of observed subsidence tilt and, to lesser extents curvature, reasonably match those predicted.

The comparisons between the observed and the back-predicted subsidence, tilt and curvature for monitoring lines at Teralba Colliery are shown in Figs. C.10 to C.12, in Appendix C, which are:-

- Fig. C.10 Teralba Colliery (Young Wallsend Seam) - LW9 TA Centre Line,
- Fig. C.11 Teralba Colliery (Young Wallsend Seam) - LW10 TB Centre Line,
- Fig. C.12 Teralba Colliery (Young Wallsend Seam) - LW9 and LW10 TR Cross Line,

Teralba Longwalls 9 and 10 have void widths of 150 metres, which are less than those for the proposed Longwalls 101 to 103 of 210 metres. The chain pillar width of 65 metres is also greater than those for the proposed longwalls of 40 metres. The subsidence observed above these longwalls at Teralba, therefore, is expected to be less than that for the proposed longwalls.

The maximum observed subsidence along the TA Line, shown in Fig. C.10, is greater than the maximum predicted. It is noted, however, that Longwall 9 partially extracted beneath the existing workings in the overlying Great Northern Seam (i.e. multi-seam conditions). Away from this location (i.e. single-seam conditions), the observed subsidence was still greater than that predicted, as was the case for the predictions using the Holla subsidence prediction curves, as described in Section 3.6. As described in that section, the higher than predicted subsidence is believed to be the result of increased chain pillar deformation, variations in stratigraphy and the presence of highly jointed or faulted zones.

The observed profiles of subsidence along the TB and TR Lines, shown in Figs. C.11 and C.12, reasonably matched those predicted. The observed subsidence slightly exceeded that predicted along the TB Line, in the location of multi-seam mining and in the location of identified faulting. The profiles of observed tilt also reasonably matched those predicted, except where there were locally elevated tilts in the vicinity of the identified geological structures at seam level.

The comparisons between the observed and the predicted subsidence, tilt and strain for monitoring lines at West Wallsend Colliery are shown in Figs. C.13 to C.15, in Appendix C, which are:-

- Fig. C.13 West Wallsend Colliery (Young Wallsend Seam) - LW1 TO LW10 Cross Line,
- Fig. C.14 West Wallsend Colliery (Young Wallsend Seam) - LW11 TO LW18 Cross Line, and
- Fig. C.15 West Wallsend Colliery (Young Wallsend Seam) - LW19 TO LW24 Cross Line.

It can be seen from these figures, that the profiles of observed subsidence and tilt reasonably match those predicted. In most locations, the magnitude of the observed subsidence is similar to or less than those predicted. The observed zones of tension and compression reasonably match those predicted, except where localised and elevated strains exceed the predictions, which could be the result of irregular ground movements or, possibly, disturbed survey marks.

Based on these comparisons along the selected monitoring lines at Newstan, Teralba and West Wallsend Collieries, it would appear that the Incremental Profile Method, using the standard IPM subsidence prediction curves for the Newcastle Coalfield, provides reasonable predictions of subsidence, tilt and curvature. It has not been considered necessary, therefore, to provide any site specific calibration of the standard IPM subsidence prediction curves for the proposed Longwalls 101 to 103.

3.7. Reliability of the Predicted Conventional Subsidence Parameters

The Incremental Profile Method is based upon a large database of observed subsidence movements in the NSW Coalfields and has been found, in most cases, to give reasonable, if not slightly conservative, predictions of maximum subsidence, tilt and curvature. The predicted profiles obtained using this method also reflect the way in which each parameter varies over the mined area and indicate the movements that are likely to occur at any point on the surface.

The predictions for the proposed Longwalls 101 to 103 were made using the Incremental Profile Method based on the standard IPM subsidence prediction curves for the Newcastle Coalfield. As described in Section 3.6.7, the standard model provides reasonable predictions when compared with the observed movements along monitoring lines above previously extracted longwalls at Newstan, Teralba and West Wallsend Collieries.

The prediction of the conventional subsidence parameters at specific points is more difficult than the prediction of the maxima anywhere above extracted longwalls. Variations between predicted and observed parameters at a point can occur where there is a lateral shift between the predicted and observed subsidence profiles, which can result from seam dip or variations in topography. In these situations, the lateral shift can result in the observed parameters being greater than those predicted in some locations, whilst the observed parameters are less than those predicted in other locations.

Notwithstanding the above, the Incremental Profile Method provides site specific predictions for each natural feature or item of infrastructure and hence provides a more realistic assessment of the subsidence impacts than by applying the maximum predicted parameters at every point, which would be overly conservative and would yield an excessively overstated assessment of the potential subsidence impacts.

The prediction of strain at a point is even more difficult as there tends to be a large scatter in observed strain profiles. It has been found that measured strains can vary considerably from those predicted at a point, not only in magnitude, but also in sign, that is, the tensile strains have been observed where compressive strains were predicted, and vice versa. For this reason, the prediction of strain in this report has been based on a statistical approach, which is discussed in Section 4.3.

The tilts, curvatures and strains observed at the streams are likely to be greater than the predicted conventional movements, as a result of valley related movements, which is discussed in Section 3.5.4. Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the streams in Sections 5.2. The impact assessments for the streams are based on both the conventional and valley related movements.

It is also likely that some localised irregularities will occur in the subsidence profiles due to near surface geological features. The irregular movements are accompanied by elevated tilts, curvatures and strains, which often exceed the conventional predictions. In most cases, it is not possible to predict the locations or magnitudes of these irregular movements. For this reason, the strain predictions provided in this report are based on a statistical analysis of measured strains, including both conventional and non-conventional anomalous strains, which is discussed in Section 4.3.

3.8. Reliability of the Predicted Upsidence and Closure Movements

The predicted valley related movements resulting from the proposed mining were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

The development of the predictive methods for upsidence and closure are the result of recent and ongoing research and the methods do not, at this stage, have the same confidence level as conventional subsidence prediction techniques. As further case histories are studied, the method will be improved, but it can be used in the meantime, so long as suitable factors of safety are applied. This is particularly important where the predicted levels of movement are small, and the potential errors, expressed as percentages, can be higher.

Whilst the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor that is thought to influence the upsidence and closure movements is the level of in-situ horizontal stress that exists within the strata. In-situ stresses are difficult to obtain and not regularly measured and the limited availability of data makes it impossible to be definitive about the influence of the in-situ stress on the upsidence and closure values. The methods are, however, based predominantly upon the measured data from Tower Colliery in the Southern Coalfield, where the in-situ stresses are high. The methods should, therefore, tend to over-predict the movements in areas of lower stress.

4.1. Introduction

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of the proposed Longwalls 101 to 103 in the combined Young Wallsend Seam and part Yard Seam. The predicted subsidence parameters and the impact assessments for the natural features and items of surface infrastructure are provided in Chapters 5 and 6.

The predicted subsidence, tilt and curvature have been obtained using the Incremental Profile Method, based on the IPM prediction curves for the Newcastle Coalfield, as described in Sections 3.6.5 to 3.6.7. The predicted strains have been determined by analysing the strains measured at other collieries in the Newcastle and Hunter Coalfields, where the longwall width-to-depth ratios and extraction heights are similar to those of the proposed longwalls.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this report describe and show the conventional movements and do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature, which are provided in Chapters 5 and 6.

4.2. Maximum Predicted Subsidence Parameters

The maximum predicted conventional subsidence parameters resulting from the extraction of the proposed longwalls were determined using the Incremental Profile Method, which was described in Chapter 3. A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of each of the proposed longwalls, is provided in Table 4.1.

Table 4.1 Maximum Predicted Incremental Conventional Subsidence, Tilt and Curvature Resulting from the Extraction of Each of the Proposed Longwalls

Longwall	Maximum Predicted Incremental Conventional Subsidence (mm)	Maximum Predicted Incremental Conventional Tilt (mm/m)	Maximum Predicted Incremental Conventional Hogging Curvature (km^{-1})	Maximum Predicted Incremental Conventional Sagging Curvature (km^{-1})
LW101	800	10	0.20	0.20
LW102	1000	13	0.25	0.45
LW103	1100	15	0.35	0.60

The predicted total conventional subsidence contours, resulting from the extraction of the proposed Longwalls 101 to 103 are shown in Drawing Nos. MSEC537-14 to MSEC537-16. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of the proposed longwalls, is provided in Table 4.2. The predicted tilts provided in this table are the maxima after the completion of each of the proposed longwalls. The predicted curvatures provided in the above table are the maxima at any time during or after the extraction of each of the proposed longwalls.

Table 4.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature after the Extraction of Each of the Proposed Longwalls

Longwalls	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
LW101	800	10	0.20	0.20
LW102	1000	13	0.25	0.45
LW103	1200	16	0.40	0.60

The maximum predicted total subsidence, after the completion of the proposed longwalls, is 1200 mm which represents around 47 % of the extraction height. The maximum predicted total conventional tilt is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 65. The maximum predicted total conventional hogging and sagging curvatures are 0.40 km^{-1} and 0.60 km^{-1}, respectively, which represent minimum radii of curvature of 2.5 kilometres and 1.7 kilometres, respectively.

The predicted conventional subsidence parameters vary across the SMP Area as the result of, amongst other factors, variations in the longwall geometry and the depths of cover. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been determined along Prediction Lines 1 and 2, the locations of which are shown in Drawing Nos. MSEC537-14 to MSEC537-16.

The predicted profiles of conventional subsidence, tilt and curvature along Prediction Lines 1 and 2, resulting from the extraction of the proposed longwalls, are shown in Figs. E.01 and E.02, respectively, in Appendix E. The predicted incremental profiles along the prediction lines, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the prediction lines, after the extraction of each of the proposed longwalls, are shown as solid blue lines. The range of predicted curvatures in any direction to the prediction lines, at any time during or after the extraction of the proposed longwalls, is shown by the grey shading.

The reliability of the predictions of subsidence, tilt and curvature, obtained using the Incremental Profile Method, is discussed in Section 3.7.

4.3. Predicted Strains

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the average relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values.

Adopting a linear relationship between curvature and strain provides a reasonable prediction for the conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and the locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones. In the Newcastle Coalfield, it has been found that a factor of 10 provides a reasonable relationship between the predicted maximum curvatures and the predicted maximum conventional strains.

The maximum predicted conventional strains resulting from the extraction of the proposed Longwalls 101 to 103, based on applying a factor of 10 to the maximum predicted curvatures, are 4 mm/m tensile and 6 mm/m compressive.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of potential strains for the proposed Longwalls 101 to 103 has been determined using monitoring data from Newstan, as well as from other nearby collieries including West Wallsend and Teralba, where the local geology and mining geometry were reasonably similar to that for the proposed longwalls. Comparisons of the longwall void widths, depths of cover, longwall W/H ratios and extraction heights are provided in Table 4.3.

Table 4.3 Comparison of the Mine Geometry for Newstan Longwalls 101 to 103 with the Longwalls from the Newcastle Coalfield used in the Strain Analysis

Parameter	Newstan Longwalls 101 to 103		Longwalls Used in Strain Analysis	
	Range	Average	Range	Average
Longwall Width (m)	210	210	130 ~ 230	170
Depth of Cover (m)	210 ~ 350	300	170 ~ 350	190
W/H Ratio	0.6 ~ 1.0	0.7	0.7 ~ 1.0	0.9
Extraction Height (m)	2.4 ~ 3.2	2.9	2.8 ~ 4.8	4.2

It can be seen from the above table, that the range of the longwall width-to-depth ratios used in the strain analysis was similar to but slightly higher, on average, than the width-to-depth ratios of the proposed Newstan Longwalls 101 to 103. The average extraction height for the longwalls used in the strain analysis was greater, on average, than the extraction height for the proposed longwalls. The strain analysis, therefore, should provide a reasonable indication of the range of potential strains resulting from the extraction of the proposed Newstan Longwalls 101 to 103.

The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls in the Newcastle Coalfield, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls. A number of probability distribution functions were fitted to the empirical data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above goaf, for monitoring lines from the Newcastle Coalfield, is provided in Fig. 4.1. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

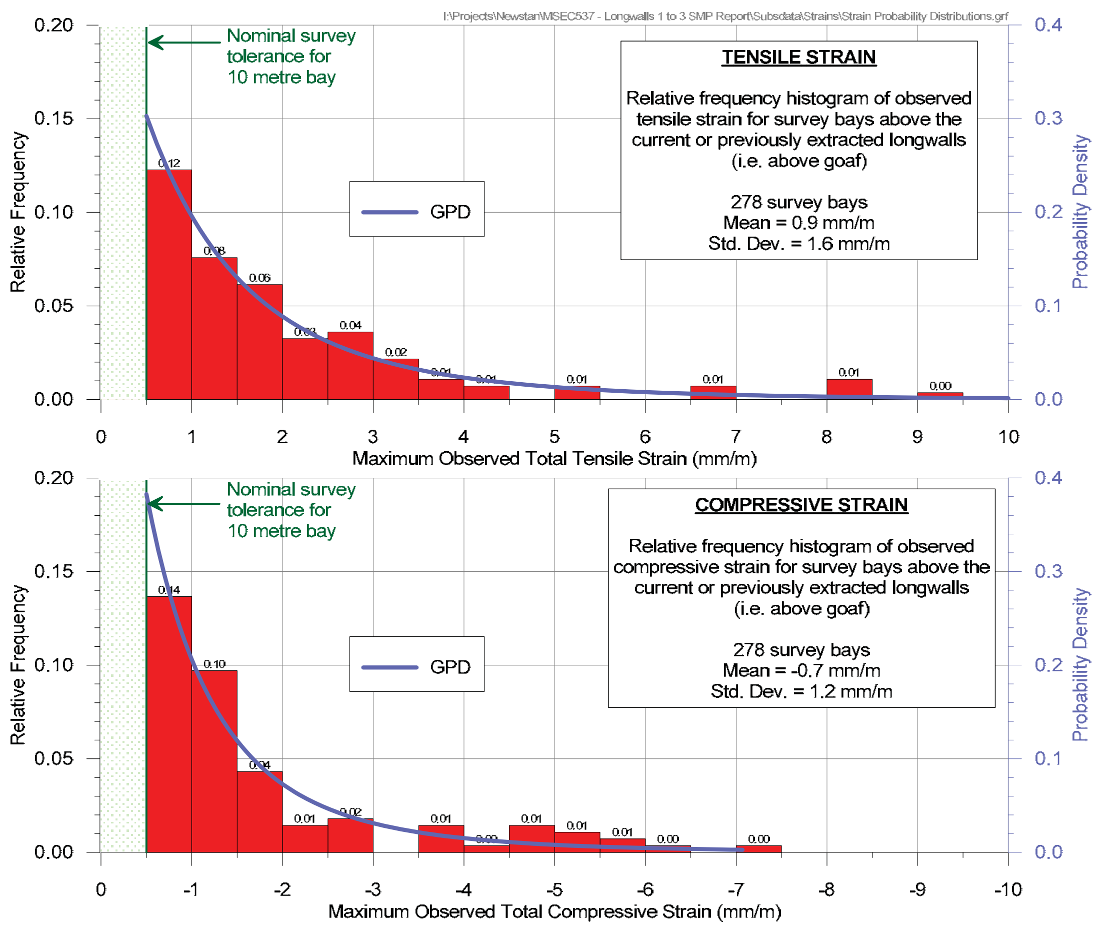


Fig. 4.1 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls in the Newcastle Coalfield for Bays Located Above Goaf

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

The 95 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 4 mm/m tensile and 3 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 8 mm/m tensile and 6 mm/m compressive.

4.4. Comparison of Maximum Predicted Subsidence Parameters

The comparison of the maximum predicted subsidence parameters resulting from the extraction of the proposed Longwalls 101 to 103 with those previously provided in the 1998 EIS is shown in Table 4.4. The predictions for the previous layout adopted in the 1998 EIS are based on those provided in Table 4.3 of the report by Umwelt (1998).

Table 4.4 Comparison of Maximum Predicted Conventional Subsidence Parameters

Layout	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Tensile Strain (mm/m)	Maximum Predicted Total Conventional Comp. Strain (mm/m)
1998 EIS (Table 4.3, Umwelt 1998)	700 ~ 1400	4.0 ~ 10.7	0.8 ~ 2.4	1.2 ~ 3.5
Proposed LW101 to LW103 (Report No. MSEC537)	1200	16 Maximum 12 Typical	4 Maximum 2 Typical	6 Maximum 3 Typical

It is noted, that the maximum predicted tilt and conventional strains for the proposed Longwalls 101 to 103 (MSEC537) occur in the north-western corner of the mining area, where the depth of cover is the shallowest, around 200 metres. Away from this location, the depths of cover are greater than 250 metres and, therefore, the predicted tilts and conventional strains over the majority of the mining area are less than these maxima. For this reason, the maximum as well as the typical predicted tilts and conventional strains have been provided in the above table for the proposed Longwalls 101 to 103 (MSEC537).

It can be seen from Table 4.4, that the maximum predicted subsidence for the proposed Longwalls 101 to 103 is within the range provided in the 1998 EIS. The maximum predicted tilt and the maximum predicted conventional strains for the proposed longwalls, however, are greater than the ranges provided in the 1998 EIS. Whilst these parameters are greater, the maxima occur at the north-western corner of the proposed mining area, where the depth of cover is the shallowest and, elsewhere, the predicted typical tilts and conventional strains are similar to the ranges provided in the 1998 EIS.

Apart from the Mine Haul Road, there are no significant natural features or surface infrastructure located in the north-western corner of the proposed mining area. The predicted tilts and conventional strains for the natural features and surface infrastructure, excluding the Mine Haul Road, therefore, are also similar to the ranges provided in the 1998 EIS.

It is also noted, that the predictions provided in the 1998 EIS were made using the "*generalised multiple panel prediction method of Holla (1988), coupled with the Newcastle Coalfield Guideline (Holla, 1987)*" (Holt, 1998). This method of prediction for maximum subsidence over a series of longwalls is "*strictly applicable to the Southern Coalfield, where overburden strata mainly consist of massive sandstone, but can be extended to the Newcastle Coalfield especially for critical extraction conditions*" (Holla, 1988).

The predictions for the proposed Longwalls 101 to 103 (MSEC537) have been made using the Incremental Profile Method, based on the standard IPM subsidence prediction curves for the Newcastle Coalfield, which uses extensive empirical data from the Newcastle Coalfield. As described in Section 3.7, the comparisons with the subsidence movements previously observed at Newstan, Teralba and West Wallsend Collieries, indicates that the Incremental Profile Method should provide reasonable, if not, slightly conservative predictions for the proposed Longwalls 101 to 103.

4.5. Predicted Far-field Horizontal Movements

In addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed longwalls, it is also likely that far-field horizontal movements will be experienced during the extraction of the proposed longwalls.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominately from the Southern Coalfield. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, are provided in Fig. 4.2. The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in this figure to illustrate the spread of the data.

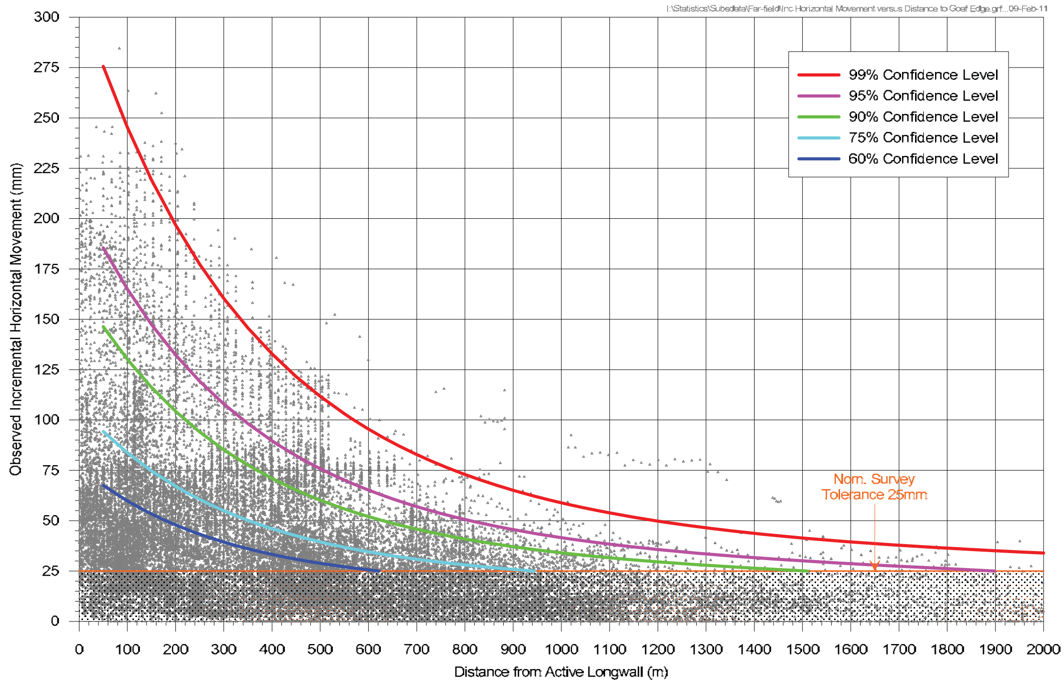


Fig. 4.2 Observed Incremental Far-Field Horizontal Movements

As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in-situ stresses within the strata have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement is not, therefore, the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than the order of survey tolerance (i.e. less than 0.3 mm/m). The impacts of far-field horizontal movements on the natural features and items of surface infrastructure within the vicinity of the proposed longwalls is not expected to be significant, except where they occur at large structures which are sensitive to small differential movements.

4.6. Non-Conventional Ground Movements

It is likely that non-conventional ground movements will occur within the SMP Area, due to near surface geological conditions, steep topography and valley related movements, which were discussed in Section 3.5. These non-conventional movements are often accompanied by elevated tilts, curvatures and strains which are likely to exceed the conventional predictions.

In most cases, it is not possible to predict the exact locations or magnitudes of the non-conventional anomalous movements due to near surface geological conditions. For this reason, the strain predictions provided in this report are based on a statistic analysis of measured strains in the Newcastle Coalfield, including both conventional and non-conventional anomalous strains, which is discussed in Section 4.3.

Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the watercourses in Section 5.2. The impact assessments for the watercourses are based on both the conventional and valley related movements. The potential for non-conventional movements associated with steep topography is discussed in the impact assessments for the steep slopes provided in Section 5.5.

4.7. General Discussion on Mining Induced Ground Deformations

Longwall mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural joints in the bedrock, the presence of near surface geological structures.

Fractures and joints in bedrock occur naturally during the formation of the strata and from subsequent disturbance, tectonic movements, igneous intrusions, erosion and weathering processes. Longwall mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones. The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the bedrock.

As subsidence occurs, surface cracks will generally appear in the tensile zone, i.e. within 0.1 to 0.4 times the depth of cover from the longwall perimeters. Most of the cracks will occur within a radius of approximately 0.1 times the depth of cover from the longwall perimeters. The cracks will generally be parallel to the longitudinal edges or the ends of the longwalls.

At shallower depths of cover, it is also likely that transient surface cracks will occur above and parallel to the moving extraction face, i.e. at right angles to the longitudinal edges of the longwall, as the subsidence trough develops. This cracking, however, tends to be transient, since the tensile phase of the travelling wave, which causes the cracks to open up, is generally followed by a compressive phase, which partially recloses them. It has been observed in the past, however, that surface cracks which occur during the tensile phase of the travelling wave do not fully close during the compressive phase, and tend to form compressive ridges at the surface.

The incidence of surface cracking is dependent on the location relative to the extracted longwall goaf edges, the depth of cover, the extracted seam thickness and the thickness and inherent plasticity of the soils that overlie the bedrock. The widths and frequencies of the cracks are also dependent upon the pre-existing jointing patterns in the bedrock. Large joint spacing can lead to concentrations of strain and possibly the development of fissures at rockhead, which are not necessarily coincident with the joints.

Surface cracks from previous single-seam longwall mining at the colliery have been typically in the order of 25 mm to 50 mm, with surface cracks in some locations greater than 150 mm. Similar surface crack widths have also been previously observed elsewhere in the Newcastle Coalfield at similar depths of cover as the proposed longwalls. The observed step heights at the colliery and elsewhere in the Newcastle Coalfield at similar depths of cover have been typically in the order of 25 mm to 50 mm. Larger crack widths and step heights can also occur due to the concentration of strain at joints or near surface geological structures.

Photographs of typical surface deformations observed from previous single-seam longwall mining at Newstan are provided in Fig. 4.3 and Fig. 4.4.

Fig. 4.3 Photographs of Surface Cracking at Newstan Colliery

Fig. 4.4 Photographs of Surface Cracking and Stepping at Newstan Colliery

Further discussion on surface cracking is provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

4.8. Estimated Height of the Fractured Zone

The extraction of longwalls results in deformation throughout the overburden strata. The terminology used by different authors to describe the strata deformation zones above extracted longwalls varies considerably and care should be taken when comparing the recommendations from differing authors. Forster (1995) noted that most studies have recognised four separate zones, as shown in Fig. 4.5, with some variations in the definitions of each zone.

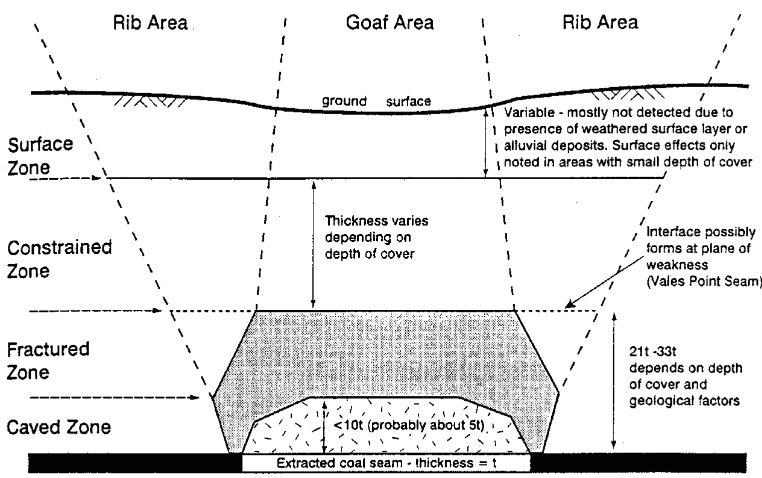


Fig. 4.5 Zones in the Overburden according to Forster (1995)

Peng and Chiang (1984) recognised only three zones as reproduced in Fig. 4.6.

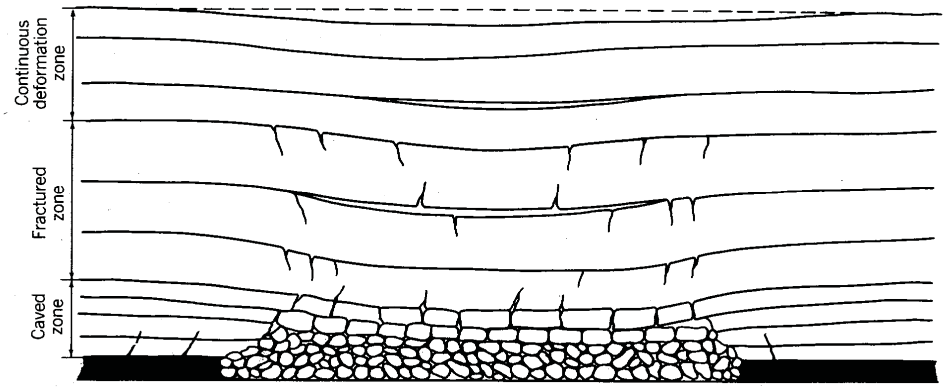


Fig. 4.6 Zones in the Overburden According to Peng and Chiang (1984)

McNally et al (1996) also recognised three zones, which they referred to as the caved zone, the fractured zone and the elastic zone. Kratzsch (1983) identified four zones, but he named them the immediate roof, the main roof, the intermediate zone and the surface zone.

For the purpose of these discussions, the following zones, as described by Singh and Kendorski (1981) and proposed by Forster (1995), as shown in Fig. 4.5, have been adopted:-

- *Caved* or *Collapsed Zone* comprises loose blocks of rock detached from the roof and occupying the cavity formed by mining. This zone can contain large voids. It should be noted, that some authors note primary and secondary caving zones.
- *Disturbed* or *Fractured Zone* comprises in-situ material lying immediately above the caved zone which have sagged downwards and consequently suffered significant bending, fracturing, joint opening and bed separation. It should be noted, that some authors include the secondary caving zone in this zone.
- *Constrained* or *Aquiclude Zone* comprises confined rock strata above the disturbed zone which have sagged slightly but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present as well as some discontinuous vertical cracks, usually on the underside of thick strong beds, but not of a degree or nature which would result in connective cracking or significant increases in vertical permeability. Some increases in horizontal permeability can be found. Weak or soft beds in this zone may suffer plastic deformation.
- *Surface Zone* comprises unconfined strata at the ground surface in which mining induced tensile and compressive strains may result in the formation of surface cracking or ground heaving.

Just as the terminology differs between authors, the means of determining the extents of each of these zones also varies. Some of the difficulties in establishing the heights of the various zones of disturbance above extracted longwalls stem from the imprecise definitions of the fractured and constrained zones, the differing zone names, the use of different groundwater testing methods and differing interpretations of extensometer readings.

Some authors interpret the collapsed and fractured zones to be the zone from which groundwater or water in boreholes could be lost into the mine and, hence, look for the existence of aquiclude layers above this height to confirm whether surface water would or would not be lost into the mine. The heights of the collapsed and fractured zones above extracted longwalls are affected by a number of factors, which include the:-

- widths of extraction,
- heights of extraction,
- depths of cover,
- types and proximity of previous workings, if any, near or above the current extractions,
- interburden thicknesses to previous multi-seam workings,
- presence of pre-existing natural joints within each strata layer,
- thickness, geology, geomechanical properties and permeability of each strata layer,
- angle of break of each strata layer,
- spanning capacity of each strata layer, particularly those layers immediately above the collapsed and fractured zones,
- bulking ratios of each strata layer within the collapsed zone, and the
- presence of adequate tuff, shale, claystone and siltstones which have the ability to act as aquitard or aquiclude zones.

Some authors have suggested simple equations to estimate the heights of the collapsed and fractured zones based solely on the extracted seam height, others have suggested equations based solely on the widths of extraction, whilst others have suggested equations based on the width-to-depth ratios of the extractions. As this is a complex issue, MSEC understand that no simple geometrical equation can properly estimate the heights of the collapsed and fractured zones and a more thorough analysis is required, which should include other properties, such as geology and permeability of the overburden strata.

The following discussions provide background information and an estimation of the height of fracturing that is based on mining geometry only. These estimated heights of fracturing in the overburden for the proposed longwalls have been determined using the method described in the ACARP Research Project C10023 (Ditton et al 2003). This method estimates the heights of fracturing for two zones which are as follows:-

- *A Horizon* - defines the estimated extent of fracturing above a total extraction panel could provide a direct flow-path or hydraulic connection to the workings, if a sub-surface aquifer or coal seam were intersected (i.e. continuous cracking), and
- *B Horizon* - defines the estimated extent above a total extraction panel that could experience a general increase in horizontal and vertical permeability within the rock mass, due to bending or curvature deformation of the overburden. This type of fracturing does not provide a direct flow path or connection to the workings and is more likely to interact with surface cracks or joints (i.e. discontinuous cracking).

The estimated heights continuous and discontinuous fracturing are based on the depth of cover and either the maximum 'smooth profile' (i.e. conventional) tensile strain or the '*overburden curvature index*'. The relationship between the estimated heights of the *A Horizon* and the *B Horizon*, based on the maximum conventional tensile strain, are illustrated in Fig. 4.7.

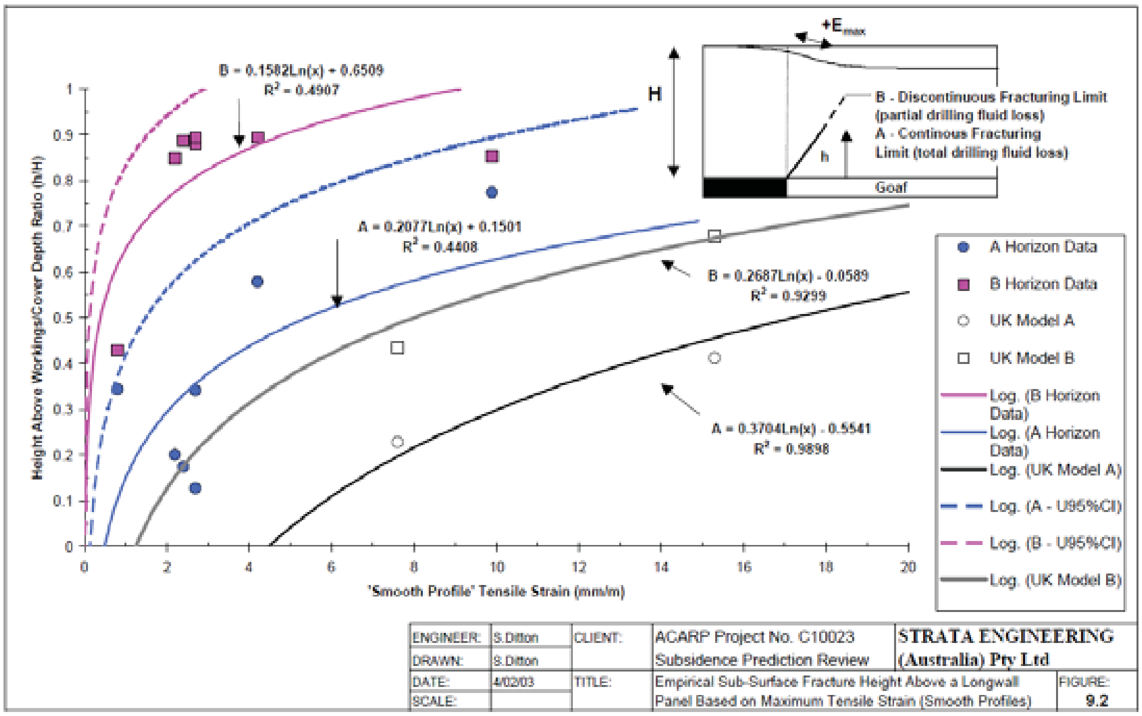


Fig. 4.7 Estimated Heights of the A and B Horizons (Ditton et al 2003)

The estimated heights of continuous and discontinuous fracturing as proportions of the depths of cover, based on the maximum conventional tensile strain, are provided by the following equations (Ditton et al 2003):-

Equation 1 $A = 0.2077 Ln(+E_{max}) + 0.150$ *Height of continuous fracturing divided by cover*

$B = 0.1582 Ln(+E_{max}) + 0.651$ *Height of discontinuous fracturing divided by cover*

where $+E_{max}$ = the maximum conventional tensile strain (mm/m)

The estimated heights of continuous and discontinuous fracturing as proportions of the depths of cover, based on the '*overburden curvature index*', are provided by the following equations (Ditton et al 2003):-

Equation 2 $A = 0.2295Ln\left(S_{max} / W^2\right) + 1.132$ *Height of continuous fracturing divided by cover*

$B = 0.1694Ln\left(S_{max} / W^2\right) + 1.381$ *Height of discontinuous fracturing divided by cover*

where S_{max} = maximum subsidence (mm)

W = width of panel (m)

A summary of the estimated heights of continuous and discontinuous fracturing for the proposed longwalls, based on the Ditton et al (2003) method, is provided in Table 4.5. The heights of fracturing have been based on the greater of those determined using the maximum predicted conventional tensile strain and the maximum predicted subsidence.

Table 4.5 Estimated Heights of Continuous and Discontinuous Cracking based on Ditton et al (2003)

Location	Depth of Cover (m)	Maximum Predicted Conventional Tensile Strain (mm/m)	Maximum Predicted Subsidence (mm)	Estimated Height of the A Horizon (m)	Estimated Height of the B Horizon (m)
Longwalls 101 to 103	230 ~ 320	1 ~ 4	800 ~ 1200	130 ~ 160	220 ~ 280

It can be seen from the above table that, according to the Ditton et al (2003) model, continuous cracking could extend around 130 metres to 160 metres above the seam. The depth of cover directly above the proposed longwalls varies between 210 metres and 350 metres and, on this basis, it is not expected that continuous cracking would extend up to the surface.

It is noted, that the height of continuous fracturing could be less than predicted using the Ditton et al (2003) model, as extensometer measurements at the adjacent West Wallsend Colliery indicate that the caved zone only extended 71 metres above the West Borehole Seam (DoP, 2012).

It is also predicted, based on this Ditton et al (2003) model, discontinuous cracking could extend to around 220 metres to 280 metres above the seam. It is possible, therefore, that discontinuous cracking could extend up to the surface, at the northern ends of the proposed longwalls, where the depth of cover varies down to 210 metres. As described previously, however, discontinuous cracking is not expected to provide a direct flow path or connection to the workings.

Further discussions on the heights of fracturing and specific geology and permeability of the overburden strata are provided in the report by *GHD* (2012b), although they have not undertaken any geomechanical modelling to predict fracture height or changes in permeability.

5.1. Background

The following sections provide the descriptions, predictions and impact assessments for the natural features identified within the SMP Area. All significant natural features located outside the SMP Area, which may be subjected to valley related or far-field horizontal movements and may be sensitive to these movements, have also been included as part of these assessments.

5.2. Watercourses

5.2.1. Description of the Watercourses

There are a number of watercourses within the SMP Area which are shown in Drawing No. MSEC537-08. A summary of the Schedule 2 watercourses (i.e. 3rd order and above) which are located within or immediately adjacent to the SMP Area is provided in Table 5.1.

Table 5.1 Schedule 2 Streams within or Adjacent to the SMP Area

Stream Name	Strahler Stream Order	Description
WC1 (Stony Creek)	4th Order	Located 300 metres north of Longwall 103, at its closest point to the proposed longwalls. Not directly mined beneath.
WC2 (Unnamed)	3rd Order	Located 125 metres west of Longwall 103, at its closest point to the proposed longwalls. Not directly mined beneath.
WC4 (Stockyard Creek)	3rd Order	Located 330 metres south-east of Longwall 102, at its closest point to the proposed longwalls. Not directly mined beneath.
WC10 (Unnamed)	4th Order	Located directly above Longwall 101, downstream of the junction of WC11 and WC12. Approximately 130 metres of 4th order stream located directly above the proposed longwalls.
WC11 (Unnamed)	3rd Order	Located directly above Longwalls 101 and 102. Approximately 520 metres of 3rd order stream located directly above the proposed longwalls.
WC12 (Unnamed)	3rd Order	Located directly above Longwalls 101 to 103. Approximately 650 metres of 3rd order stream located directly above the proposed longwalls.

Kilaben Creek is a 2nd order stream which crosses the southern ends of Longwalls 102 and 103. The total length of creek located directly above the proposed longwalls is approximately 500 metres. There are also other 1st and 2nd order streams within the SMP Area, which are shown in Drawing No. MSEC537-08.

The watercourses within the SMP Area are ephemeral, but have ponds in the flatter sections along the lower reaches of the streams. The stream beds are typically founded in the natural surface soils which, as can be seen from Fig. 1.4, have been derived from the Terrigal Formation and the Clifton Subgroup of the Narrabeen Group (Rn) and the Moon Island Beach Subgroup (Pnm) of the Newcastle Coal Measures. Stony Creek (WC1), the lower reaches of Kilaben Creek (WC5), as well as sections of other watercourses, are also founded in Quaternary Alluvium (Qa).

The lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek) have small incisions into the natural surface soils, however, in some locations, the drainage channels are not well defined due to the thick vegetation growth and soil accumulations. The natural gradients along these sections of the watercourses are very flat, typically less than 10 mm/m (i.e. 1 %, or 1 in 100).

The upper reaches of the watercourses (i.e. 1st and 2nd order, excluding Kilaben Creek) have steeper natural gradients, which are typically greater than 100 mm/m (i.e. 10 %, or 1 in 10). These sections of streams have sandstone outcropping which forms a series of steps or drop downs in the steeper sections. There are also significant debris accumulations which includes boulders and tree branches.

Photographs of the watercourses within the SMP Area are provided in Fig. 5.1 to Fig. 5.4. Further descriptions of the watercourses are provided by the specialist surface water consultant in the report by *GHD* (2012a).

Fig. 5.1 Photographs of WC3 East of Longwall 101

Fig. 5.2 Photographs of WC5 (Kilaben Creek) Upstream (Left) and Downstream (Right) of the Wilton Road Crossing

Fig. 5.3 Photographs of WC12 West of Transmission Line Easement

Fig. 5.4 Photographs of 2nd Order Watercourse above Longwall 101

5.2.2. Predictions for the Watercourses

The predicted profiles of conventional subsidence, tilt and curvature along the alignments of WC3, WC5, WC11 and WC12 (incl. WC6 and WC10) are shown in Figs. E.03, E.04, E.05 and E.06, respectively, in Appendix E. The predicted incremental profiles along the watercourses, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the watercourses, after the extraction of each of the proposed longwalls, are shown as solid blue lines. The range of predicted curvatures in any direction to the watercourses, at any time during or after the extraction of the proposed longwalls, is shown by the grey shading.

A summary of the maximum predicted subsidence, tilts and curvatures for the watercourses, after the extraction of each of the proposed longwalls, is provided in Table 5.2. The predicted tilts are the maxima along the alignments of the watercourses, after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction, at any time during or after the extraction of each of the proposed longwalls.

Table 5.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Watercourses

Watercourse	Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
WC3	After LW101	100	0.5	0.02	0.01
	After LW102	100	0.5	0.02	0.01
	After LW103	100	0.5	0.02	0.01
WC5	After LW101	< 20	< 0.5	< 0.01	< 0.01
	After LW102	750	6.0	0.05	0.15
	After LW103	975	10.0	0.15	0.35
WC11	After LW101	700	4.5	0.05	0.10
	After LW102	825	2.0	0.10	0.10
	After LW103	850	2.0	0.10	0.10
WC12 (incl. WC6 and WC10)	After LW101	750	6.0	0.05	0.15
	After LW102	975	10.5	0.15	0.35
	After LW103	1075	10.5	0.15	0.40

The remaining watercourses and tributaries are located across the SMP Area and, therefore, could experience the full range of predicted movements. A summary of the maximum predicted conventional subsidence movements within the SMP Area is provided in Chapter 4.

The maximum predicted conventional strains for the watercourses, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 4 mm/m tensile and 6 mm/m compressive. The watercourses are also likely to experience elevated compressive strains resulting from the valley related movements.

The valley related upsidence and closure have been determined for the watercourses using the method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). The equivalent valley heights for watercourses have been taken as the heights of the valleys within a half depth of cover of the valley bases.

The upper reaches of the watercourses (i.e. 1st and 2nd order, but excluding Kilaben Creek) have steeper gradients and also have greater equivalent valley heights. The maximum predicted valley related movements for these streams are 300 mm upsidence and 400 mm closure. Compressive strains between 15 mm/m and 20 mm/mm have been observed, in the past, at these magnitudes of upsidence and closure movements.

The lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek) have relatively flat gradients and the valleys and generally comprise shallow incisions into the natural surface soils. The maximum predicted valley related movements for these streams are 150 mm upsidence and 200 mm closure. Compressive strains between 10 mm/m and 15 mm/mm have been observed, in the past, at these magnitudes of upsidence and closure movements.

5.2.3. Impact Assessments for the Watercourses

The impact assessments for the watercourses are provided in the following sections. The assessments provided in this report should be read in conjunction with the assessments provided by the specialist surface water consultant in the report by *GHD* (2012a).

Potential for Increased Levels of Ponding, Flooding and Scouring

Mining can potentially result in increased levels of ponding in locations where the mining induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining induced tilts considerably increase the natural stream gradients that exist before mining.

The maximum predicted tilt within the SMP Area is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 60. The predicted changes in grade are small when compared with the natural gradients along the upper reaches of the streams (i.e. 1st and 2nd order, but excluding Kilaben Creek), which are typically greater than 100 mm/m and, therefore, are unlikely to have a significant impact on the surface water flows.

The predicted changes in grade are similar orders of magnitude to the natural gradients along the lower reaches of the streams (i.e. 3rd and 4th order, but including Kilaben Creek). The natural grades and the predicted post mining grades along Watercourses WC5, WC11 and WC12 are illustrated in Fig. 5.5, Fig. 5.6 and Fig. 5.7, respectively.

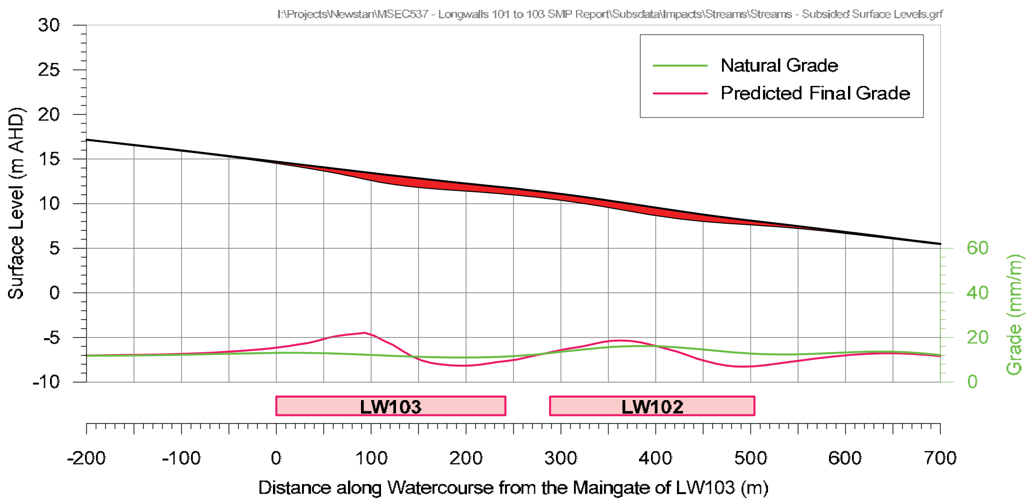


Fig. 5.5 Natural and Predicted Post Mining Surface Levels along Watercourse WC5

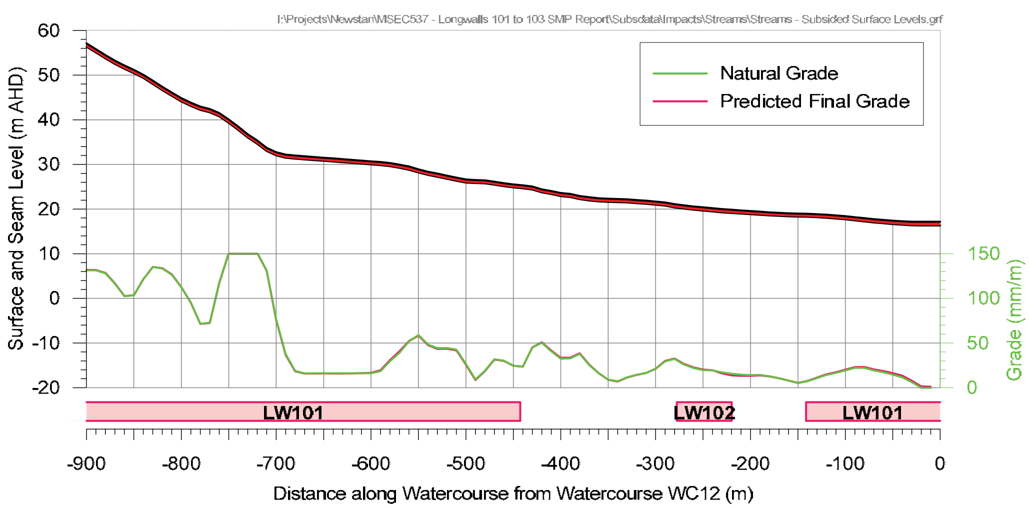


Fig. 5.6 Natural and Predicted Post Mining Surface Levels along Watercourse WC11

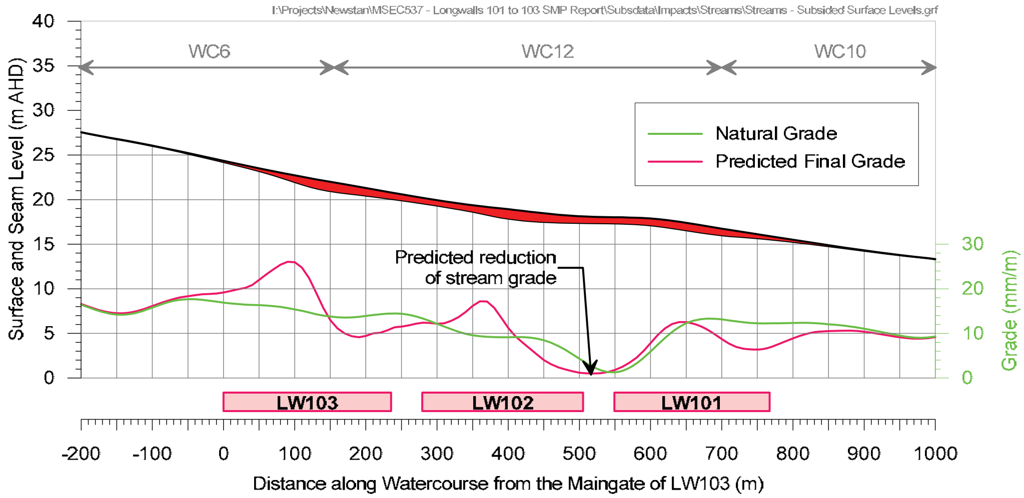


Fig. 5.7 Natural and Predicted Post Mining Surface Levels along Watercourse WC12

It can be seen from the above figures, that there is a predicted reduction of stream grade along Watercourse WC12, above the chain pillar between the proposed Longwalls 101 and 102, and increased ponding could occur upstream of this location. As described previously, natural ponding is evident along the lower reaches of these watercourses due to the relatively flat natural grades.

There are no predicted significant reductions in grade along Watercourses WC5 and WC11 due to the steeper natural gradients and due to the alignments of the watercourses to the proposed longwalls. It is also unlikely that there would be any significant reductions in grade along the upper reaches of the other watercourses (i.e. 1st and 2nd order, but excluding Kilaben Creek) due to the relatively high natural gradients.

It can also be seen from the above figures, that the stream gradients increase along Watercourses WC5 and WC12, immediately downstream of the longwall maingates. The predicted final stream gradients in these locations are similar to the maximum natural gradients along the watercourses and, therefore, the potential for increased scouring is not expected to be significant.

Further discussions and recommendations for the management of the potential changes in ponding and flooding along the watercourses are provided by the specialised surface water consultant in the report by *GHD* (2012a).

Potential for Cracking in the Creek Beds and Fracturing of Bedrock

Fracturing of the uppermost bedrock has been observed in the past, as a result of longwall mining, where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m. It is likely, therefore, that fracturing would occur in the uppermost bedrock based on the predicted maximum strains. It has been observed in the past, that the depth of buckling and dilation of the uppermost bedrock, resulting from longwall mining, is generally less than 10 metres to 15 metres (Mills 2003, Mills 2007, and Mills and Huuskes 2004).

The lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek) have shallow incisions into the surface soils or alluvial deposits. It is unlikely, therefore, that fracturing in the underlying bedrock would be visible at the surface along these sections of the watercourses. In the event that fracturing of the bedrock occurs, in these locations, the fractures are likely to be filled with soil and other materials during subsequent flow events.

The upper reaches of the watercourses (i.e. 1st and 2nd order, but excluding Kilaben Creek) have sandstone outcropping which forms a series of steps or drop downs. Fracturing of the exposed bedrock could result in spalling or dislodgement of rocks from the sandstone outcrops. There could also be some diversion of the surface water flows into the dilated strata beneath the beds, which could drain any ponded surface water upstream of the outcropping. It is unlikely that there would be any net loss of water from the catchment, however, as the depth of dilation and fracturing is expected to be less than 10 metres to 15 metres and, because of the high natural grades, any diverted surface water is expected to re-emerge downstream.

It is not expected that the surface water would be diverted into the mine workings because, as described in Section 4.8, continuous cracking (i.e. the *A Horizon*) is not predicted to extend up to the surface. Vertical fracturing in the upper stratum is expected to be discontinuous and unlikely, therefore, to result in increased hydraulic conductivity. Further discussions on the potential changes in the hydraulic conductivity of the overburden are provided by the specialist groundwater consultant in the report by *GHD* (2012b).

Newstan previously extracted Longwalls 13 and 14 directly beneath Palmers Creek. Whilst cracking was observed in the banks of the creek and in some tributaries, there was no cracking observed within the creek itself and there were no reported adverse impacts on the surface water flows. These longwalls had void widths of 160 metres and were extracted from the West Borehole Seam at depths of cover varying between around 100 metres to 120 metres. The width-to-depth ratios for Longwalls 13 and 14, therefore, varied between 1.3 and 1.6, which are greater than those for the proposed Longwalls 101 to 103.

West Wallsend previously extracted longwalls beneath Diega and Cockle Creeks. Whilst stream bed cracking and loss of surface water flow was initially observed, the ephemeral surface water flows and pools were naturally re-established. This was described by the *Independent Inquiry into the Impacts of Potential Underground Coal Mining in the Wyong Local Government Area* (DoP, 2008) which stated that :-

> "*The best known example of cracking of a stream bed in the southern Newcastle Coalfield is at Diega Creek, a small tributary of Cockle Creek within the Lake Macquarie catchment in Lake Macquarie LGA. Diega Creek was directly undermined by eight longwalls in West Wallsend Colliery between 1999 and 2004. The depth of cover was low (around 200 – 230 m) and the extraction height within the seam was high (4.8 m). However, panel width was low (150 – 175 m). Mine subsidence caused cracking of the stream bed, which in turn was implicated in a complete loss of surface flow in the stream. The mining company (Xstrata Coal) suggested that below-average rainfall during much of the period during which mining took place and following was a likely contributor to the low surface flows, since Diega Creek is recognised as being an ephemeral stream.[74] When the Panel inspected Diega Creek in January 2008, pools contained water and the stream was flowing slowly. Xstrata Coal indicated that groundwater levels near the Creek had risen during 2007, probably due to the above-average rainfall then prevailing*.
>
> [74] Hunter Central Rivers Catchment Management Authority (2003), *Diega Creek Rivercare Plan 2003*."

Previous experience of longwall mining elsewhere in the Newcastle and Hunter Coalfields, where the depths of cover were in the order of 200 metres or greater, also indicates that the impacts on ephemeral streams having shallow incisions into the surface soils are relatively low.

It is not expected, therefore, that there would be any adverse impacts on the surface water flows resulting from the extraction of the proposed Longwalls 101 to 103. It is likely, however, that some fracturing and spalling of the exposed bedrock would occur in the upper reaches of the watercourses.

Further discussions on the potential impacts on the watercourses are provided in the reports by *GHD* (2012a) and *RPS* (2012a).

5.2.4. Impact Assessments for the Watercourses Based on Increased Predictions

If the actual conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilt within the SMP Area would be 32 mm/m (i.e. 3.2 %), which represents a change in grade of 1 in 30. In this case, increased levels of ponding are likely to occur immediately upstream of the longwall tailgates along the lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek). These are illustrated in Fig. 5.8, Fig. 5.9 and Fig. 5.10, which show the natural and predicted final surface levels and grade along Watercourses WC5, WC11 and WC12, respectively, based on the subsidence exceeding the predictions by a factor of 2 times.

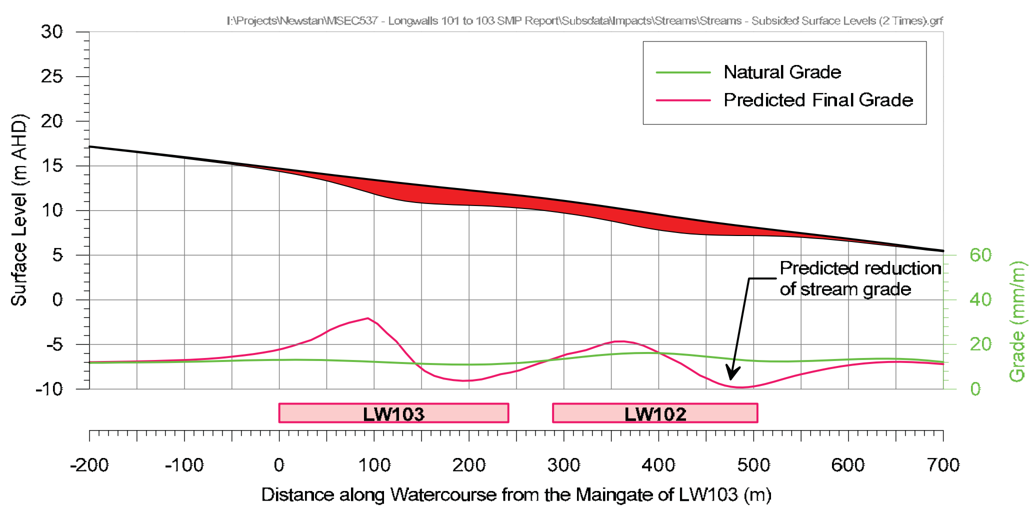


Fig. 5.8 Natural and Predicted Post Mining Surface Levels along Watercourse WC5 Based on Subsidence Exceeding Predictions by a Factor of 2 Times

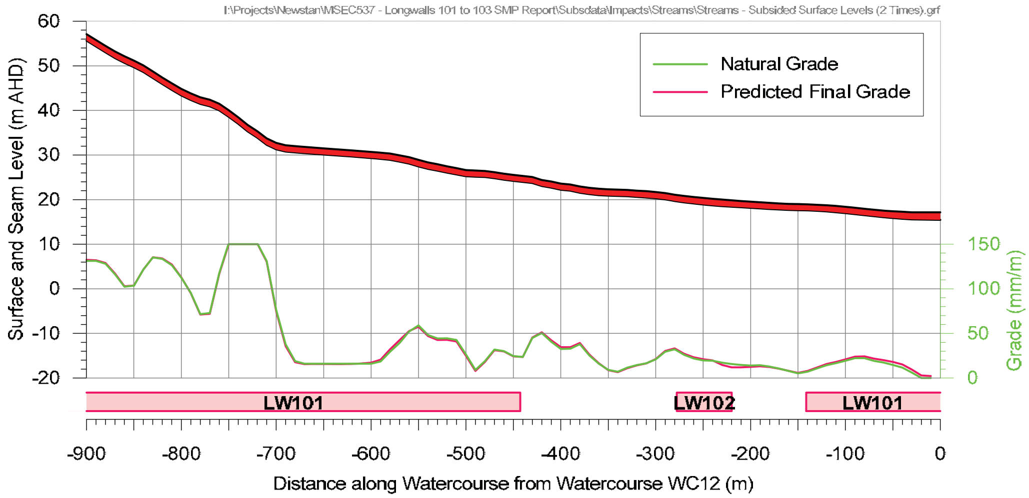


Fig. 5.9 Natural and Predicted Post Mining Surface Levels along Watercourse WC11 Based on Subsidence Exceeding Predictions by a Factor of 2 Times

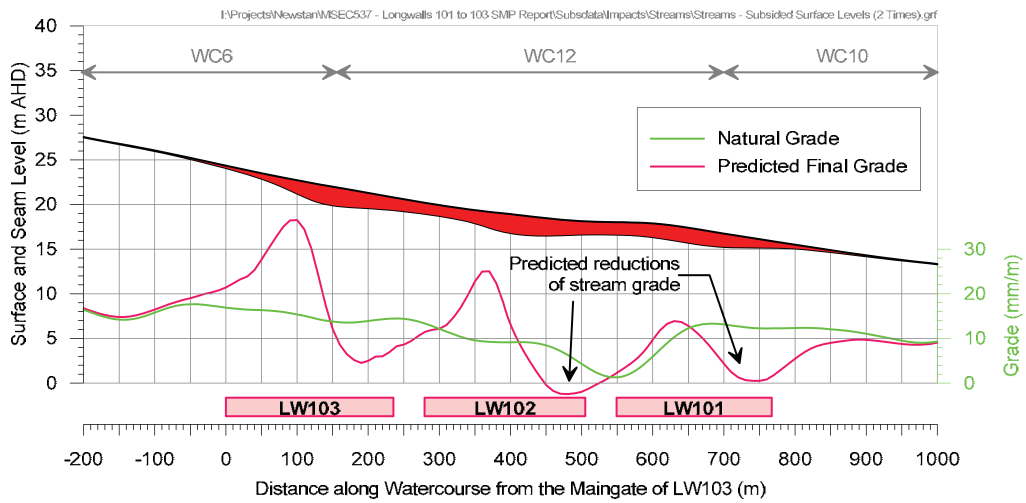


Fig. 5.10 Natural and Predicted Post Mining Surface Levels along Watercourse WC12 Based on Subsidence Exceeding Predictions by a Factor of 2 Times

The increased ponding along Watercourse WC5, upstream of the tailgate of Longwall 102, is estimated to be less than 100 metres long and less than 0.1 metres deep. The increased ponding along Watercourse WC12, upstream of the tailgate of Longwall 102, is estimated to be 150 metres long and up to 0.2 metres deep. The increased ponding elsewhere along Watercourses WC5 and WC12 are estimated to be less than 100 metres long and less than 0.1 metres deep.

If the actual curvatures, strains or valley related movements exceeded those predicted by a factor of 2 times, it would be expected that the extent of fracturing in the uppermost bedrock would increase along the sections of the watercourses located directly above the proposed longwalls. The depth of fracturing and dilation would still be expected to extend no greater than 10 metres to 15 metres and, therefore, no loss of surface water from the catchment would be anticipated.

In this case, the extent of visible fracturing and spalling of the exposed bedrock along the upper reaches of the watercourses (i.e. 1st and 2nd order, but excluding Kilaben Creek) would increase. It would still be unlikely, however, that fracturing in the underlying bedrock would be visible at the surface along the lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek).

5.2.5. Recommendations for the Watercourses

It is recommended that the watercourses are periodically visually monitored during the extraction of the proposed longwalls. The assessed impacts on the watercourses can be managed by the implementation of suitable management strategies. With these strategies in place, it is unlikely that there would be any significant long term impacts on the watercourses resulting from the extraction of the proposed longwalls.

5.3. Aquifers or Known Groundwater Resources

There are no *Ground Water Management Areas*, as defined by the Department of Environment, Climate Change and Water, within the SMP Area. Whilst there are no registered groundwater bores identified within the SMP Area, there are bores located immediately outside this area. The locations of the registered groundwater bores in the vicinity of the proposed longwalls are shown in Drawing No. MSEC537-10 and details are provided in Section 6.15. Further discussions on the groundwater resources are provided by the specialised groundwater consultant in the report by *GHD* (2012b).

5.4. Cliffs and Rock Outcrops

5.4.1. Description of the Cliffs and Rock Outcrops

For the purposes of discussion in this report, a cliff has been defined as a continuous rockface having a minimum height of 10 metres, a minimum length of 20 metres and a minimum slope of 2 to 1, i.e. having a minimum angle to the horizontal of 63°. Rock outcrops have been defined as isolated rockfaces generally having heights less than 10 metres.

The locations of any cliffs were determined using the 1 metre surface level contours which were generated from the Lidar survey dated January 2011. There were no cliffs identified within the SMP Area.

There are, however, rock outcrops located within the SMP Area, which were identified from field investigations. The rock outcropping is predominately located along the hill above the northern ends of the proposed longwalls. A photograph of rock outcropping, located above the chain pillar between the proposed Longwalls 101 and 102, is provided in Fig. 5.11.

Fig. 5.11 Photograph of Rock Outcropping

The rock outcrops are not readily visible from public vantage points due to the heavy vegetation.

5.4.2. Predictions for the Rock Outcrops

The rock outcrops are located across the northern ends of the proposed longwalls and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the SMP Area is provided in Chapter 4.

The maximum predicted conventional tilt within the SMP Area is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 65. The maximum predicted conventional hogging and sagging curvatures are 0.40 km^{-1} and 0.60 km^{-1}, respectively, which represent minimum radii of curvature of 2.5 kilometres and 1.7 kilometres, respectively.

The maximum predicted conventional strains within the SMP Area, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 4 mm/m tensile and 6 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

5.4.3. Impact Assessments for the Rock Outcrops

The extraction of the proposed longwalls is likely to result in fracturing in some of the rock outcrops and, where the rock is marginally stable, could then result in instabilities. Previous experience of mining beneath rock outcrops in the NSW Coalfields indicates that the percentage of rock outcrops that are likely to be impacted by mining is very small.

5.4.4. Impact Assessments for the Rock Outcrops Based on Increased Predictions

If the actual subsidence movements exceeded those predicted by a factor of 2 times, the extent of fracturing and, hence, the incidence of impacts would increase for the rock outcrops located directly above the proposed longwalls. Based on previous experience, however, it would still be expected that the incidence of impacts on the rock outcrops in the SMP Area would be relatively low.

5.4.5. Recommendations for the Rock Outcrops

It is recommended that the conditions of the rock outcrops should be periodically visually monitored throughout the mining period and for a period after the completion of mining.

5.5. Steep Slopes

5.5.1. Descriptions of the Steep Slopes

For the purposes of discussion in this report, a steep slope has been defined as an area of land having a natural gradient greater than 1 in 3 (i.e. a grade of 33 %, or an angle to the horizontal of 18°). The steep slopes were identified from the 1 metre surface level contours which were generated from the Lidar survey dated January 2011. The locations of the steep slopes within the SMP Area are shown in Drawing No. MSEC537-08.

The steep slopes are primarily located along the hill in the northern part of the SMP Area. The natural grades of the steep slopes typically range between 1 in 3 (i.e. 33 % or 18º) and 1 in 2 (i.e. 50 % or 27º), with isolated areas having natural grades up to 1 in 1.5 (i.e. 67 % or 34º).

The surface soils along the steep slopes are derived from weathered sandstone from the Narrabeen Group (Rn), as can be inferred from Fig. 1.4. The majority of the slopes are stabilised by the natural vegetation, which can be seen in Fig. 1.1.

5.5.2. Predictions for the Steep Slopes

The steep slopes are located across the northern ends of the proposed longwalls and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the SMP Area is provided in Chapter 4.

The maximum predicted conventional tilt within the SMP Area is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 65. The maximum predicted conventional hogging and sagging curvatures are 0.40 km^{-1} and 0.60 km^{-1}, respectively, which represent minimum radii of curvature of 2.5 kilometres and 1.7 kilometres, respectively.

The maximum predicted conventional strains within the SMP Area, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 4 mm/m tensile and 6 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

5.5.3. Impact Assessments for the Steep Slopes

The maximum predicted tilt for the steep slopes of 16 mm/m (i.e. 1.6 %, or 1 in 65) is small when compared to the natural grades of the steep slopes, which are greater than 1 in 3. It is unlikely, therefore, that the mining induced tilts themselves would result in any significant impact on the stability of the steep slopes.

The steep slopes are more likely to be impacted by curvature and ground strain, rather than tilt. The potential impacts would generally result from the downslope movement of the soil, resulting in tension cracks appearing at the tops of the steep slopes and compression ridges forming at the bottoms of the steep slopes. Experience of mining in the NSW Coalfields indicates that surface cracking resulting from downslope movements can be the order of 100 mm to 150 mm, with isolated surface cracking greater than 150 mm.

If tension cracks were to develop, as a result of the extraction of the proposed longwalls, it is possible that soil erosion could occur if these cracks were left untreated. It is possible, therefore, that some remediation might be required, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.

5.5.4. Impact Assessments for the Steep Slopes Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the steep slopes would be 32 mm/m (i.e. 3.2 %), which represents a change in grade of 1 in 30. The tilts at the steep slopes would still be small in comparison with the existing natural grades, which exceed 1 in 3.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvature at the steep slopes would be 0.8 km^{-1} hogging and 1.2 km^{-1} sagging, which represent minimum radii of curvature of 1.3 kilometres and 0.8 kilometres, respectively. In this case, more extensive surface cracking would be anticipated, in the order of 150 mm or greater.

Any significant surface cracking could be remediated by infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. In some cases, erosion protection measures may be needed, such as the planting of vegetation in order to stabilise the slopes in the longer term.

5.5.5. Recommendations for the Steep Slopes

It is recommended that the steep slopes are visually monitored throughout the mining period and until any necessary rehabilitation measures are complete. In addition to this, it is recommended that any significant surface cracking which could result in increased erosion or restrict access to areas be remediated by infilling with soil or other suitable materials, or by locally regrading and compacting the surface.

It is also recommended that management strategies be developed to ensure that these measures are implemented. With appropriate management strategies in place, it is unlikely that there would be a significant long term impacts on the steep slopes resulting from the proposed mining.

5.6. Swamps, Wetlands and Water Related Ecosystems

There are no swamps or wetlands identified within the SMP Area. There are, however, water related ecosystems within the SMP Area, which are described in the Report by *RPS* (2012a).

5.7. Land Prone to Flooding or Inundation

The natural grades along the lower reaches of the watercourses (i.e. 3rd and 4th order, but including Kilaben Creek) are relatively flat and natural ponding is evident. It is likely that these areas within the SMP Area would be susceptible to flooding and inundation.

Discussions on the potential for increased ponding along the watercourses were provided in Section 5.2. Further discussions on the potential for increased flooding and inundation are provided by the specialist surface water consultant in the report by *GHD* (2012a).

5.8. Threatened, Protected Species or Critical Habitats

The descriptions and the discussions on the potential impacts on threatened and protected species within the SMP Area are provided by the specialist flora and fauna consultant in the report by *RPS* (2012a).

5.9. National Parks or Wilderness Areas

There are no National Parks nor any land identified as wilderness under the Wilderness Act 1987 within the SMP Area.

5.10. State Recreational or Conservation Areas

There are no State Recreational Areas or Conservation Areas within the SMP Area.

5.11. Natural Vegetation

The vegetation within the SMP Area generally consists of undisturbed native bush. The extent of natural vegetation can be seen from the aerial photograph provided in Fig. 1.1. A survey of the natural vegetation within the SMP Area has been undertaken by the specialist flora and fauna consultant and details are provided in the report by *RPS* (2012a).

6.1. Background

The following sections provide the descriptions, predictions and impact assessments for the surface infrastructure within the SMP Area. The assessments provided in this report should be read in conjunction with the assessments provided by the other specialist consultants on the project.

The locations and details of the surface infrastructure were determined from a *Dial before You Dig* search and field investigations which were undertaken by *ACOR Appleyard*. The details of the building structures were determined from kerbside inspections which were undertaken by *Northrop Engineers.*

6.2. Railways

There are no railways within the SMP Area. The Main Northern Railway is located 500 metres north of Longwall 103, at its closest point to the proposed longwalls. At this distance, the railway and the associated infrastructure are not predicted to experience any significant conventional subsidence movements.

A cross-section through the Main Northern Railway and Longwall 103, where the railway is closest to the proposed longwalls, is provided in Fig. 6.1. It can be seen from this figure, that the railway is located well outside the 35 degree angle of draw from the extent of the proposed second workings.

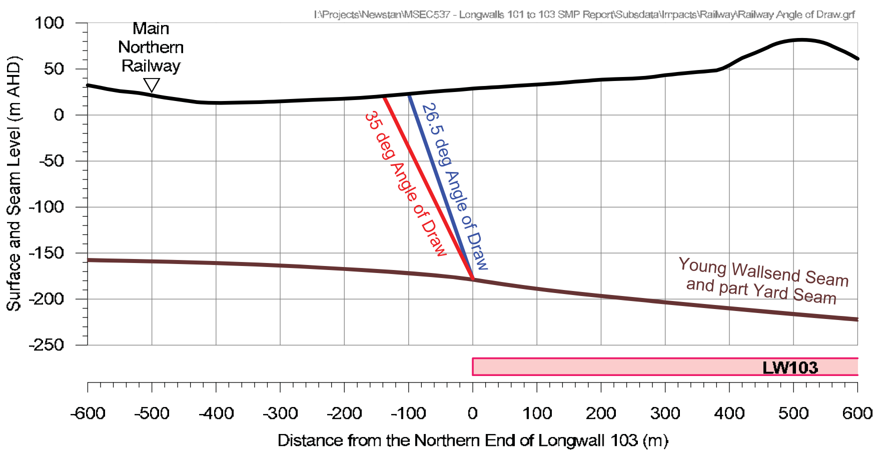


Fig. 6.1 Cross-section through Railway and Proposed Longwalls

The railway and associated infrastructure are likely to experience far-field horizontal movements, which are described in Sections 3.4 and 4.5. It can be seen from Fig. 4.2, that incremental far-field horizontal movements around 100 mm have been observed at distances of 500 metres from previously extracted longwalls. These movements tend to be bodily movements, towards the extracted goaf area, which are accompanied by very low levels of strain, generally less than the order of survey tolerance.

It is unlikely, therefore, that the railway and associated infrastructure would experience any adverse impacts resulting from the proposed mining. The road bridges over the railway, however, could be sensitive to the small differential far-field horizontal movements. The predictions and impact assessments for these road bridges are provided in Section 6.4.

6.3. Roads

The locations of the roads within the SMP Area are shown in Drawing No. MSEC537-09. The descriptions, predictions and impact assessments for the roads are provided in the following sections. The characterisation of the roads is based on the information gathered by *ACOR Appleyard*.

6.3.1. Description of the Roads

Wilton Road crosses the southern ends of Longwalls 102 and 103, with a total length of approximately 0.8 kilometres located directly above the proposed longwalls. The road has a bitumen seal with grass verges and is owned and maintained by the Lake Macquarie City Council (LMCC). A photograph of Wilton Road is provided in Fig. 6.2.

Fig. 6.2 Photograph of Wilton Road

Wangi Road is located to the south and to the east of the proposed longwalls and is not proposed to be directly mined beneath. The road is located approximately 0.1 kilometres south-east of Longwall 101, at its closest point to the proposed longwalls. Wangi Road has a bitumen seal with concrete kerb and guttering and is owned and maintained by the Roads and Maritime Services (RMS) of NSW.

The *Mine Haul Road* crosses the northern ends of Longwalls 101 to 103, with a total length of approximately 0.8 kilometres located directly above the proposed longwalls. The road has a bitumen seal with grass verges and, as indicated in Drawing No. MSEC537-09, there are a number of cuttings and embankments within the SMP Area. Photographs the Mine Haul Road and of a typical cutting are provided in Fig. 6.3 and Fig. 6.4, respectively.

Fig. 6.3 Photograph of the Mine Haul Road (Courtesy of ACOR Appleyard)

Fig. 6.4 Cutting along the Mine Haul Road (Courtesy of ACOR Appleyard)

There are also bridges and drainage culverts along the roads within the SMP Area, which are discussed in Sections 6.4 and 6.5, respectively.

6.3.2. Predictions for the Roads

The predicted profiles of conventional subsidence, tilt and curvature along the alignments of Wilton Road, Wangi Road and the Mine Haul Road are shown in Figs. E.07, E.08 and E.09, respectively, in Appendix E. The predicted incremental profiles along the roads, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the roads, after the extraction of each of the proposed longwalls, are shown as solid blue lines. The range of predicted curvatures in any direction to the roads, at any time during or after the extraction of the proposed longwalls, is shown by the grey shading

Summaries of the maximum predicted subsidence, tilt and curvatures for Wilton Road, Wangi Road and the Mine Haul Road are provided in Table 6.1, Table 6.2, Table 6.3, respectively. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.1 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for Wilton Road

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	650	5.0	0.05	0.10
After LW103	925	6.5	0.15	0.35

Table 6.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for Wangi Road

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	< 20	< 0.5	< 0.01	< 0.01
After LW103	< 20	< 0.5	< 0.01	< 0.01

Table 6.3 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Mine Haul Road

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	775	8.0	0.10	0.20
After LW102	975	11.0	0.15	0.45
After LW103	1175	13.0	0.25	0.55

There are also other roads and tracks which are located across the SMP Area and these could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the SMP Area is provided in Chapter 4.

The maximum predicted conventional curvatures for Wilton Road and the Mine Haul Road are 0.25 km^{-1} hogging and 0.55 km^{-1} sagging, which represent minimum radii of curvature of 4.0 kilometres and 1.8 kilometres, respectively. The maximum predicted conventional curvatures for Wangi Road, which is located outside the extents of the proposed longwalls, are less than 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional curvatures for the other roads and tracks located directly above the proposed longwalls are 0.40 km^{-1} hogging and 0.60 km^{-1} sagging, which represent minimum radii of curvature of 2.5 kilometres and 1.7 kilometres, respectively.

The maximum predicted conventional strains for the roads and tracks located directly above the proposed longwalls, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 4 mm/m tensile and 6 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3. The predicted strains for Wangi Road are less than 0.5 mm/m (i.e. in the order of survey tolerance).

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The cuttings and embankments along the Mine Haul Road are located across the proposed longwalls and, therefore, could experience the full range of movements predicted for the road, which were provided in Table 6.3.

6.3.3. Impact Assessments for the Roads

Wangi Road is predicted to experience less than 20 mm of subsidence resulting from the extraction of the proposed longwalls. Whilst it is still possible that this road could experience subsidence slightly greater than 20 mm, it would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that Wangi Road would experience any adverse impacts resulting from the proposed mining.

Vertical subsidence and tilt can potentially affect the drainage of surface water for roads which are located directly above extracted longwalls. The existing and the predicted post-mining surface levels and grades along Wilton Road and the Mine Haul Road are illustrated in Fig. 6.5 and Fig. 6.6, respectively.

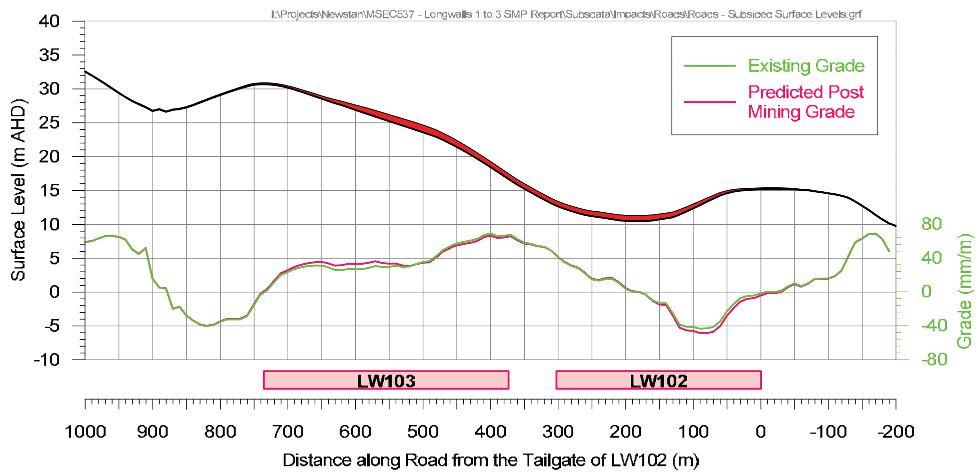


Fig. 6.5 Initial and Predicted Subsided Surface Levels along Wilton Road

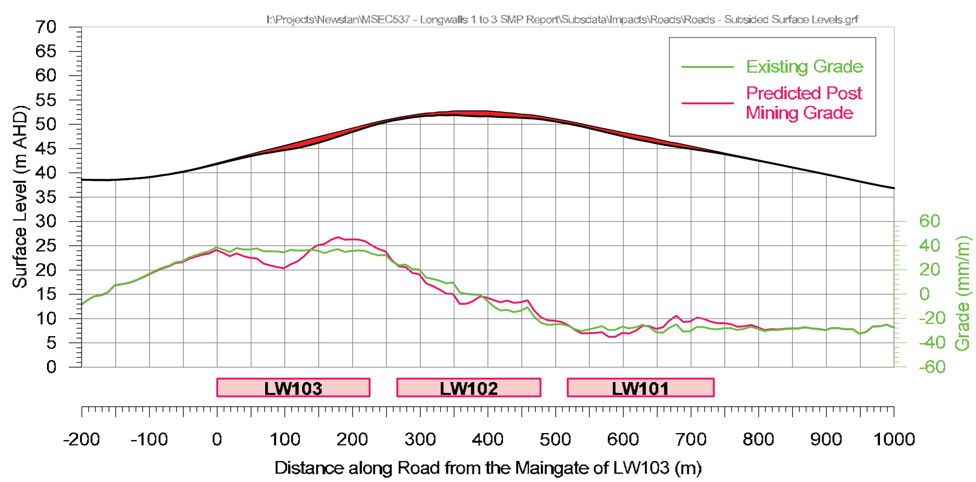


Fig. 6.6 Initial and Predicted Subsided Surface Levels along the Mine Haul Road

It can be seen from the above figures, that the predicted post-mining grades are similar to the existing grades along Wilton Road and the Mine Haul Road. The potential changes in the surface water drainage for these roads are not expected to be significant. Whilst it is possible that localised increased ponding could occur in some locations, directly above the proposed longwalls, it would be expected that this could be remediated using normal road maintenance techniques.

It is expected, at these magnitudes of predicted curvatures and strains, that cracking and rippling of the road surfaces would occur as each of the proposed longwalls mine beneath them. The depths of cover directly above the proposed longwalls typically varies between 210 metres and 350 metres, which equates to panel width-to-depth ratios between 0.6 and 1.0.

Previous experience of mining directly beneath roads in the NSW Coalfields, having similar depths of cover and panel width-to-depth ratios, indicates that crack widths are typically between 10 mm and 25 mm and heaving heights are typically up to 25 mm. It is expected, that the roads located above the proposed longwalls could be maintained in safe and serviceable conditions throughout the mining period using normal road maintenance techniques.

The cuttings along the Mine Haul Road have loose rocks and are highly weathered. The extraction of the proposed longwalls beneath the cuttings could result in marginally stable rocks being dislodged and spilling across the road. It is also recommended, that the lose rocks and highly weathered sections of the cuttings along the Mine Haul Road are removed or stabilised prior to the longwalls mining directly beneath them.

6.3.4. Impact Assessments for the Roads based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be 13 mm/m (i.e. 1.3 %, or 1 in 75) for Wilton Road, 0.5 mm/m (i.e. < 0.1 %, or 1 in 2,000) for Wangi Road and 26 mm/m (i.e. 2.6 %, or 1 in 40) for the Mine Haul Road. In this case, the tilts would still be small when compared with the natural grades along these roads and, therefore, unlikely to adversely impact on the serviceability of the roads and associated surface water drainage.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvatures would be 0.70 km^{-1} for Wilton Road, 0.01 km^{-1} for Wangi Road and 1.1 km^{-1} for the Mine Haul Road. In this case, the incidence of cracking, stepping and heaving along Wilton Road and the Mine Haul Road would increase directly above the proposed longwalls. It would still be expected that these roads could be maintained in safe and serviceable conditions, throughout the mining period, using normal road maintenance techniques.

6.3.5. Recommendations for the Roads

It is recommended, that the loose rocks and highly weathered sections of the cuttings along the Mine Haul Road are removed or stabilised prior to the longwalls mining directly beneath them. It is also recommended that the cuttings are visually monitored, during the active subsidence period, so that any loose rocks or spalling along the cutting faces can be removed.

Management strategies should be developed for Wilton Road, in consultation with the LMCC, so that any impacts can be identified and, as required, remediated so that the roads can be maintained in safe and serviceable conditions throughout the mining period.

6.4. Bridges

The locations of the bridges in the vicinity of the proposed longwalls are shown in Drawing No. MSEC537-09. The descriptions, predictions and impact assessments for the bridges are provided in the following sections. The characterisation of the bridges is based on the information gathered by *ACOR Appleyard*.

6.4.1. Description of the Bridges

There are no bridges located within the SMP Area. There are, however, road bridges in the vicinity of the proposed longwalls, which could experience far-field horizontal movements and could be sensitive to these movements. The locations of the bridges in the vicinity of the proposed longwalls are shown in Drawing No. MSEC537-09.

The bridge closest to the proposed longwalls is WR-BR1, which is located around 570 metres north-west of Longwall 103. This bridge is a timber structure where Wilton Road crosses Stony Creek. A photograph of WR-BR1 is provided in Fig. 6.7.

Fig. 6.7 WR-BR1 where Wilton Road Crosses Stony Creek (Courtesy of ACOR Appleyard)

A second bridge WR-BR2 is located where Wilton Road crosses the Mine Haul Road. The bridge is located approximately 850 metres west of Longwall 103, at its closest point to the proposed longwalls. The bridge comprises a concrete deck supported on concrete abutments with wingwalls and two intermediate concrete headstocks with tri-column supports. A photograph of the Bridge WR-BR2 is provided in Fig. 6.8.

Fig. 6.8 Bridge WR-BR2 where the Wilton Road crosses the Mine Haul Road

There are two bridges CR-BR1 and CR-BR2 where Cessnock Road crosses over the Main Northern Railway and Awaba Road, respectively. These bridges are both located around 750 metres north of Longwall 101, at their closest points to the proposed longwalls. The bridges comprise concrete decks on precast concrete girders which are supported on concrete abutments with wingwalls and intermediate cast insitu concrete headstocks with dual-column supports. A photograph of Bridge CR-BR2 is provided in Fig. 6.9.

Fig. 6.9 Bridge CR-BR2 along Cessnock Road (Courtesy of ACOR Appleyard)

There are also bridges where the Mine Haul Road crosses Awaba Road and the Main Northern Railway at distances around 1.4 kilometres and 1.8 kilometres, respectively, to the north-east of the proposed longwalls.

6.4.2. Predictions for the Bridges

The bridges are located at distances greater than 500 metres from the proposed longwalls, which is well outside the predicted 20 mm subsidence contour (i.e. predicted limit of vertical subsidence). At these distances, the bridges are not expected to experience any measurable conventional tilt, curvatures or strains.

The bridges could experience small far-field horizontal movements resulting from the proposed mining. It can be seen from Fig. 4.2, that incremental far-field horizontal movements between 50 mm and 75 mm (based on a 95 % confidence interval) have been observed at distances between 500 metres and 800 metres from previously extracted longwalls, which are similar to the distances of the bridges from the proposed longwalls.

The potential for impacts on bridges do not result from absolute far-field horizontal movements, but rather from differential horizontal movements over the lengths of the structures. Differential horizontal movements along the alignments of concrete bridges could potentially affect the widths of the expansion joints or the capacities of the support bearings. Differential horizontal movements across the alignments of concrete bridges could potentially induce eccentricities into the structure or affect the capacities of the support bearings.

The potential for differential horizontal movements at the bridges has been assessed by statistically analysing the available 3D monitoring data from the NSW Coalfields. Whilst Bridge WR-BR1 is located closest to the proposed longwalls, it is a timber structure, which is more flexible and tolerant to differential horizontal movements than concrete bridges. The statistical analyses, therefore, have been based on the geometry of Bridges CR-BR1 and CR-BR2, which are the largest and closest concrete bridges to the proposed longwalls.

The intermediate spans (i.e. distances between the supporting headstocks) for Bridges CR-BR1 and CR-BR2 are around 20 metres. The observed incremental differential longitudinal movements for survey marks spaced at 20 metres ±10 metres, relative to the distance from the active longwall, is shown in Fig. 6.10.

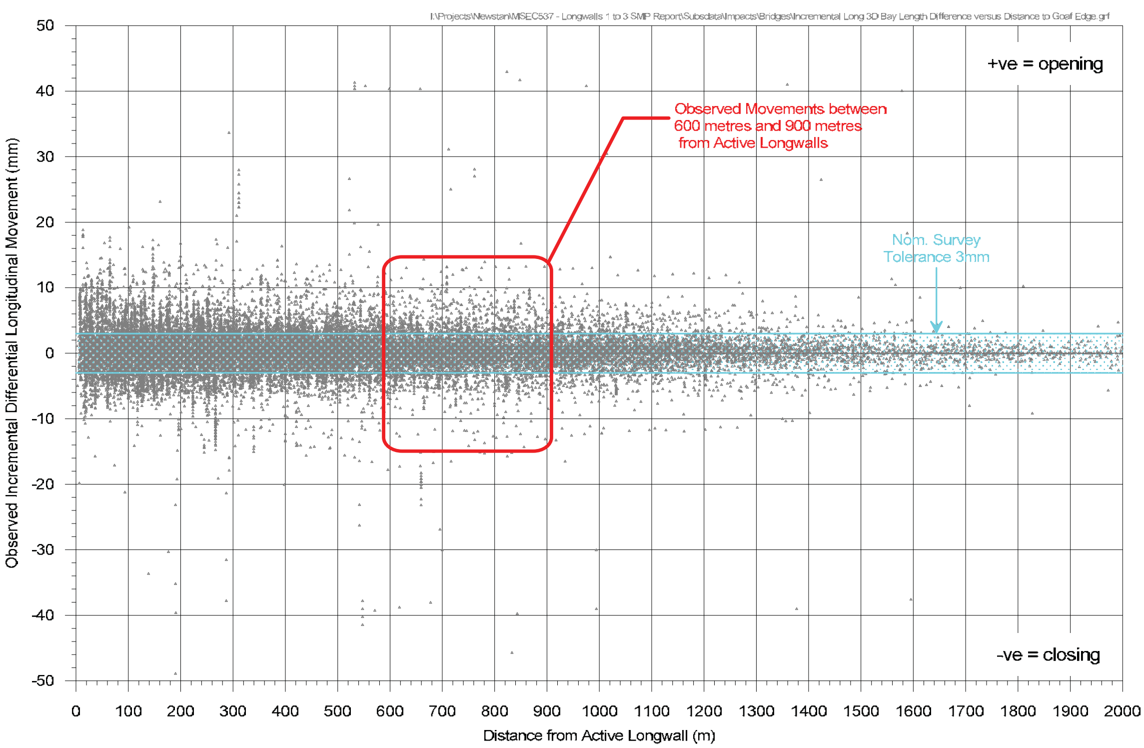


Fig. 6.10 Observed Incremental Differential Horizontal Movements versus Distance from Active Longwall for Marks Spaced at 20 metres ±10 metres

Bridges CR-BR1 and CR-BR2 are located at distances around 750 metres from the proposed longwalls. The distribution of the observed incremental differential longitudinal movements, for survey marks located between 600 metres and 900 metres from active longwalls, is shown in Fig. 6.11. The probability distribution functions, based on the fitted *Generalised Pareto Distributions* (GPDs), have also been shown in this figure.

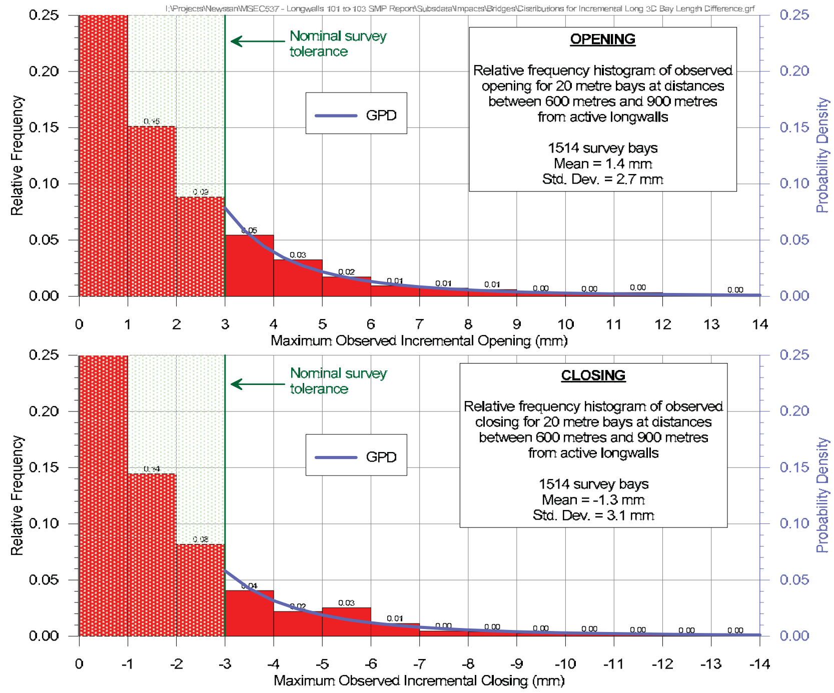


Fig. 6.11 Distribution of Observed Incremental Differential Horizontal Movements for Marks Located between 600 metres and 900 metres from Active Longwalls

Confidence levels have been determined from the empirical data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum opening and the maximum closing movements were used in the analysis (i.e. single opening and single closing measurement per survey bay).

The 95 % confidence levels for the maximum incremental differential longitudinal movements for the survey bays were 5 mm opening and closing. It is noted, that a large proportion of this comprises survey tolerance, which is around ±3 mm.

Mid-ordinate deviation is a measure of differential lateral movement, which is the change in perpendicular horizontal distance from a point to a chord formed by joining points on either side. A schematic sketch showing the mid-ordinate deviation of a peg compared to its adjacent survey pegs between two survey epochs is provided in Fig. 6.12.

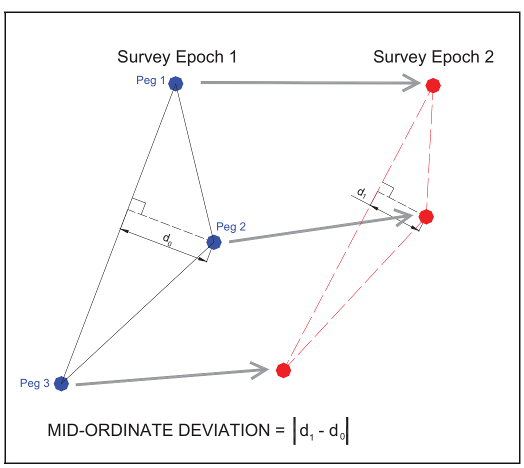


Fig. 6.12 Schematic Representation of Mid-Ordinate Deviation

The distribution of the observed incremental horizontal mid-ordinate deviation for survey marks spaced at 20 metres ±10 metres, relative to the distance from the active longwall, is shown in Fig. 6.13.

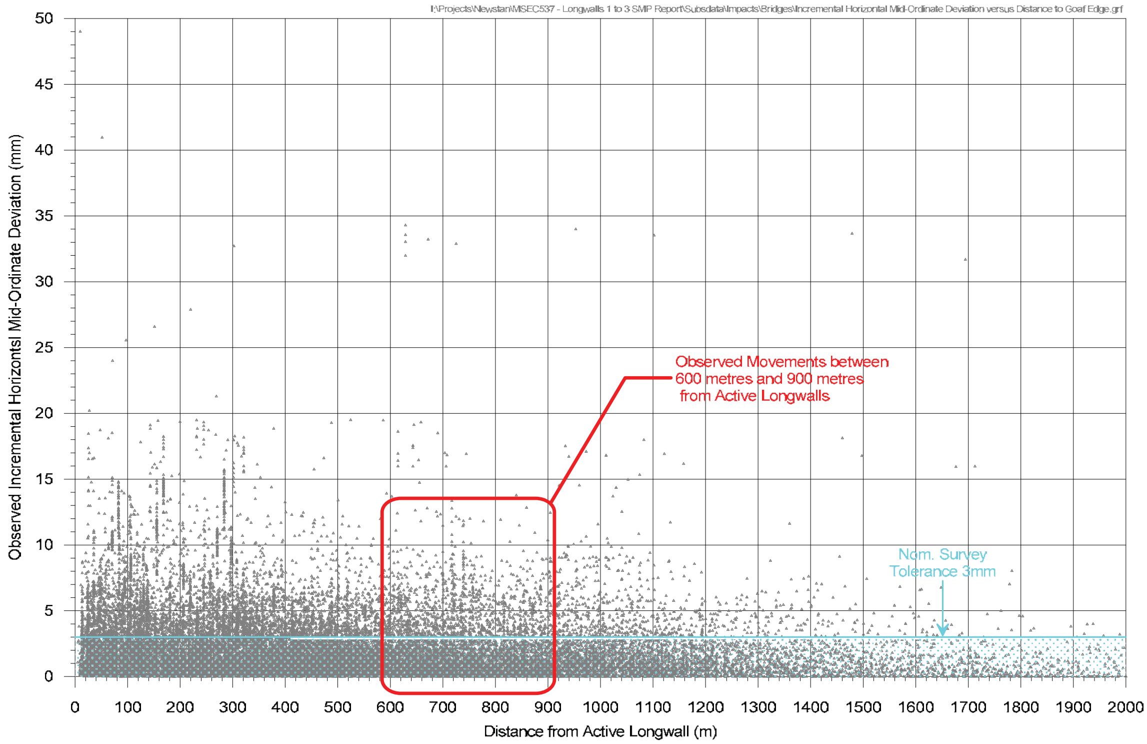


Fig. 6.13 Observed Incremental Horizontal Mid-Ordinate Deviation versus Distance from Active Longwall for Marks Spaced at 20 metres ±10 metres

The distribution of the observed incremental horizontal mid-ordinate deviation, for survey marks located between 600 metres and 900 metres from active longwalls, is shown in Fig. 6.14. The probability distribution function, based on the fitted GPD, has also been shown in this figure.

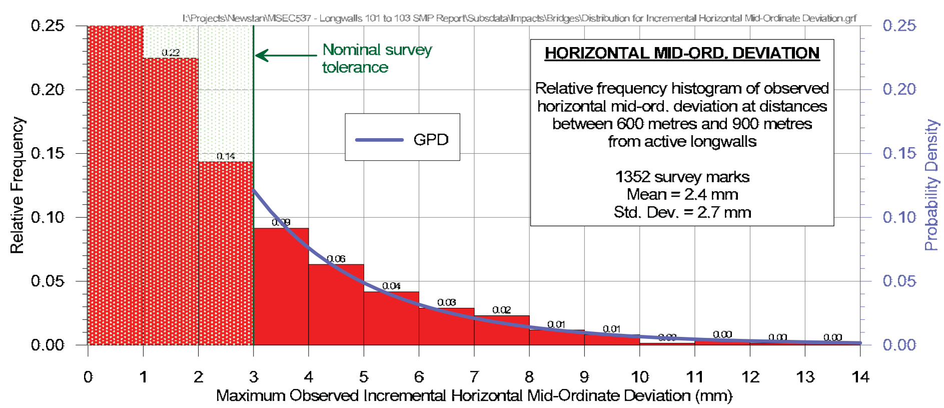


Fig. 6.14 Distribution of Observed Incremental Differential Horizontal Movements for Marks Located between 600 metres and 900 metres from Active Longwalls

Confidence levels have been determined from the empirical data using the fitted GPD. In the cases where survey marks were measured multiple times during a longwall extraction, the maximum horizontal mid-ordinate deviation was used in the analysis (i.e. single measurement per survey mark).

The 95 % confidence level for the maximum incremental horizontal mid-ordinate deviation for the survey marks spaced around 20 metres was ±5 mm. It is noted, that a large proportion of this comprises survey tolerance, which is around ±3 mm.

The maximum predicted differential horizontal movement for the concrete Bridge CR-BR1 and CR-BR2, therefore, is ±5 mm, based on the 95 % confidence interval. The maximum predicted differential horizontal movements for the concrete Bridge WR-BR2, which is located at a distance of 850 metres from the proposed longwalls, is less than ±5 mm, based on the 95 % confidence interval.

Similar statistical analyses for the timber Bridge WC-BR1, based on monitoring data between 400 metres and 700 metres from active longwalls, indicates that the maximum predicted incremental differential horizontal movement for this bridge is ±6 mm, based on the 95 % confidence level.

The predicted differential horizontal movements for the other concrete bridges along the Mine Haul Road, located around 1.4 kilometres and 1.8 kilometres from the proposed longwalls, are in the order of survey tolerance (i.e. not measurable).

6.4.3. Impact Assessments for the Bridges

The maximum predicted differential incremental horizontal movement for the timber Bridge WR-BR1, resulting from the proposed mining, is ±6 mm, based on the 95 % confidence interval. It is noted, that these movements comprise a large proportion of survey tolerance, which is around ±3 mm. The timber bridge is of flexible construction and, therefore, is expected to accommodate these small differential horizontal movements without adverse impacts.

The maximum predicted differential incremental horizontal movements for the concrete Bridges CR-BR1, CR-BR2 and WR-BR2, resulting from the proposed mining, is ±5 mm or less, based on the 95 % confidence interval. Again it is noted, that these movements comprise a large proportion of survey tolerance, which is around ±3 mm. It is likely, therefore, that the differential horizontal movements resulting from mining will not be measurable.

Differential horizontal movements between the concrete decks and supports normally occur as the result of thermal variations. Typical horizontal movements due to temperature, based on a 20 metre deck span (i.e. minimum spacing of expansion joints), a coefficient of thermal expansion of 12×10^{-6}/ºC and a temperature variation of 20ºC, is around 5 mm.

The predicted differential horizontal movements for the concrete Bridges CR-BR1, CR-BR2 and WR-BR2, therefore, are of similar orders of magnitude to the movements which result from normal thermal variations. It is likely, therefore, that these bridges could tolerate the potential movements resulting from mining, without adverse impacts, provided that the expansion joints have sufficient additional capacities. It is recommended, therefore, that the predicted movements are provided to the LMCC so that the bridge engineers can review the bridge designs based on these movements.

The predicted differential horizontal movements for the other concrete bridges in the vicinity of the proposed longwalls are in the order of survey tolerance (i.e. not measurable). It is expected, therefore, that these bridges would not be adversely impacted as a result of the proposed mining.

6.4.4. Impact Assessments for the Bridges Based on Increased Predictions

If the actual movements at the concrete Bridges CR-BR1, CR-BR2 and WR-BR2 exceeded those predicted by a factor of 2 times, the maximum differential horizontal movement would be ±10 mm. It is noted, however, that the prediction was based on observed movements, using a 95 % confidence intervals and, therefore, the application of 2 times factor is overly conservative.

In any case, whilst differential movements of this magnitude could possibly be accommodated by the expansion joints, these movements could reduce the allowable capacities of the joints and bearings. Any potential impacts could be managed by monitoring during active subsidence and, if required, the implementation of remedial measures, which could include the re-alignment of the bridge decks.

If the actual movements at the timber Bridge WR-BR1 exceeded that predicted by a factor of 2 times, the maximum differential horizontal movement would be ±12 mm. The timber bridge is of flexible construction and, therefore, is expected to accommodate these small differential horizontal movements without adverse impacts.

The other concrete bridges in the vicinity of the proposed longwalls are located at distances of 1.4 kilometres, or greater, from the proposed longwalls. At these distances, it is unlikely that there would be any measurable differential movements and, hence, that these bridges would not be adversely impacted as a result of the proposed mining.

6.4.5. Recommendations for the Bridges

It is recommended, that the predicted movements for the concrete Bridges CR-BR1, CR-BR2 and WR-BR2 are provided to the LMCC so that the civil engineers responsible for the bridge designs can review the bridges based on these movements. It is also recommended, that management strategies are developed, in consultation with LMCC, for these bridges.

6.5. Drainage Culverts

The locations of the identified drainage culverts within the SMP Area are shown in Drawing No. MSEC537-09. The descriptions, predictions and impact assessments for the culverts are provided in the following sections. The locations and sizes of the culverts are based on the information gathered by *ACOR Appleyard*.

6.5.1. Description of the Drainage Culverts

Concrete drainage culverts have been constructed where the local roads cross the watercourses. A summary of the culverts identified within the SMP Area is provided in Table 6.4.

Table 6.4 Drainage Culverts Identified within the SMP Area

Road	Culvert Ref.	Type	Location
Wilton Road	WI-C1	3 x ϕ1500 Concrete Culverts	Watercourse WC6
	WI-C2	1 x ϕ600 Concrete Culvert	Tributary to WC5
	WI-C3	3 x 1.8W x 0.9H Box Culverts	Watercourse WC5
	WI-C4	1 x ϕ375 Concrete Culvert	Minor drainage line
Wangi Road	WA-C1	2 x ϕ450 Concrete Culverts	Minor drainage line
	WA-C2	4 x ϕ1200 Concrete Culverts	Watercourse WC5
Mine Haul Road	HR-C1	1 x ϕ1200 Concrete Culvert	Minor drainage line

Photographs of the box culvert WI-C3, where Wilton Road crosses Watercourse WC5 (i.e. Kilaben Creek), are provided in Fig. 6.15. Photographs of the culverts along Wangi Road and along the Mine Haul Road are provided in Fig. 6.16 and Fig. 6.17, respectively.

Fig. 6.15 Photographs of Box Culvert WI-C3 along Wilton Road

Fig. 6.16 Photographs of Concrete Culverts WA-C1 (LHS) and WA-C2 (RHS) along Wangi Road (Courtesy of ACOR Appleyard)

Fig. 6.17 Photograph of Culvert HR-C1 along the Mine Haul Road (Courtesy of ACOR Appleyard)

It is likely that there are other culverts within the SMP Area, on the unsealed roads and tracks and on the private properties, in addition to those identified above.

6.5.2. Predictions for the Drainage Culverts

A summary of the maximum predicted total conventional subsidence parameters for the local road drainage culverts, resulting from the extraction of the proposed longwalls, is provided in Table 6.5. The predicted tilts are the maxima after the completion of any or all of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of the proposed longwalls.

Table 6.5 Maximum Predicted Total Conventional Subsidence Parameters at the Drainage Culverts Resulting from the Extraction of the Proposed Longwalls

Road	Culvert	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt in Any Direction (mm/m)	Maximum Predicted Hogging Curvature in Any Direction (km^{-1})	Maximum Predicted Sagging Curvature in Any Direction (km^{-1})
Wilton Road	WI-C1	75	1.0	0.02	0.01
	WI-C2	800	3.0	0.05	0.09
	WI-C3	775	5.0	0.04	0.12
	WI-C4	< 20	< 0.5	< 0.01	< 0.01
Wangi Road	WA-C1	< 20	< 0.5	< 0.01	< 0.01
	WA-C2	25	< 0.5	< 0.01	< 0.01
Mine Haul Road	HR-C1	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted curvatures at the drainage culverts are 0.05 km^{-1} hogging and 0.12 km^{-1} sagging, which represent minimum radii of curvature of 20 kilometres and 8 kilometres, respectively. The maximum predicted conventional strains for the culverts, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and 1.0 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.5.3. Impact Assessments for the Drainage Culverts

The maximum predicted tilt at the drainage culverts is 5.0 mm/m (i.e. 0.5 %), at Culvert WI-C3, which represents a change in grade of 1 in 200. The maximum predicted change in grade is small, less than 1 % and is in the direction of flow (i.e. slightly increases the grade) and, therefore, unlikely to adversely impact the serviceability of this culvert. It is noted, that scouring of the creek was evident at Culvert WI-C3, which is likely the result of the construction of this culvert. The predicted tilts at the remaining culverts within the SMP are 3.0 mm/m (i.e. 0.3 %), or less, which is very small and unlikely to adversely impact the serviceability of these culverts.

The predicted curvatures and strains at the drainage culverts are small and, in most cases, will not be orientated along the main axes of the culverts. The concrete culverts are expected to tolerate the curvatures and strains, of these magnitudes, without adverse impacts on the stabilities or structural integrities of the culverts.

The drainage culverts are located along drainage lines and could, therefore, experience valley related upsidence and closure movements. The drainage culverts are orientated along the alignments of the drainage lines and, therefore, the upsidence and closure movements are orientated perpendicular the main axes of the culverts and unlikely to result in any adverse impacts.

Previous experience of mining beneath culverts in the NSW Coalfields, at similar depths of cover, indicates that the incidence of impacts is low. Impacts have generally been limited to cracking in the concrete headwalls which can be readily remediated. In some cases, however, cracking in the culvert pipes occurred which required the culverts to be replaced.

6.5.4. Impact Assessments for the Drainage Culverts Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the local road drainage culverts would be 10 mm/m (i.e. 1.0%), or a change in grade of 1 in 100. The potential impacts on the serviceability and surface water drainage through the culverts would not be expected to significantly increase, as the maximum change in grade would still be small, in the order of 1 %. If any ponding or adverse changes in surface water drainage were to occur as a result of mining, the affected culverts could be replaced.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvature at the local road drainage culverts would be 0.24 km^{-1}, which represents a minimum radius of curvature of 4 kilometres. In this case, the incidence of cracking in the culverts would increase, however, it would not be expected to affect the structural capacity or stability of the culverts. If any adverse impacts were to occur as a result of mining, the affected culverts could be replaced.

6.5.5. Recommendations for the Drainage Culverts

It is recommended that the drainage culverts be periodically visually inspected during the active subsidence period. It is also recommended that management strategies be developed, in consultation with the LMCC, so that any impacts on the drainage culverts can be identified and repaired, if required.

6.6. Water Infrastructure

The locations of the water infrastructure within the SMP Area are shown in Drawing No. MSEC537-10. The descriptions, predictions and impact assessments for the water infrastructure are provided in the following sections. The characterisation of the water infrastructure is based on the information gathered by *ACOR Appleyard*.

6.6.1. Description of the Water Infrastructure

The water infrastructure within the SMP Area comprises 50 mm diameter polyethylene pipelines. The pipelines are owned by *Hunter Water* and provide potable water to the Awaba Waste Management Facility, the Toronto Country Club and the Toronto Adventist Primary School.

The section of pipeline located along Copeland Street is located 500 metres north of Longwall 101, at its closest point to the proposed longwalls. The pipeline which services the Awaba Waste Management Facility crosses above the maingate of Longwall 103.

Another section of pipeline follows Wangi Road and services the Toronto Country Club. This pipeline is located 130 metres east of Longwall 101, at its closest point to the proposed longwalls.

6.6.2. Predictions for the Water Infrastructure

The section of pipeline which services the Awaba Waste Management Facility crosses above the maingate of Longwall 103. A summary of the maximum predicted subsidence parameters for this pipeline is provided in Table 6.6. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.6 Maximum Predicted Total Conventional Subsidence Parameters for the Water Pipeline which Services the Awaba Waste Management Facility

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	< 20	< 0.5	< 0.01	< 0.01
After LW103	150	3.5	0.08	0.02

The maximum predicted conventional curvatures for the pipeline are 0.08 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 13 kilometres and 50 kilometres, respectively. The maximum predicted conventional strains for the pipeline, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 1.0 mm/m tensile and less than 0.5 mm/m compressive (i.e. in the order of survey tolerance).

This pipeline crosses three 1st order tributaries adjacent to Longwall 103 and, therefore, could experience valley related movements in these locations. The equivalent valley heights in these locations are small, less than 5 metres and the predicted maximum movements are 20 mm upsidence and 20 mm closure.

The other sections of pipeline along Copeland Street and Wangi Road are located well outside the proposed longwalls and are not expected to experience any significant conventional or valley related movements.

6.6.3. Impact Assessments for the Water Infrastructure

The water pipelines are pressure mains and are unlikely, therefore, to be affected to any great extent by changes in gradient due to vertical subsidence or tilt.

The sections of pipeline along Copeland Street and Wangi Road are located outside the predicted 20 mm subsidence contour. Whilst it is still possible that these pipelines could experience subsidence slightly greater than 20 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that the pipelines along Copeland Street and Wangi Road would experience any adverse impacts resulting from the proposed mining.

Polyethylene pipelines are flexible and expected to tolerate the predicted curvatures and strains without adverse impact. It is possible, although unlikely, that minor impacts could occur to the section of pipeline located above the proposed Longwall 103, if it is anchored to the ground and the strains are fully transferred into the pipeline. Any impacts are expected to be of a minor nature which could be readily remediated. It is unlikely that the other pipelines located outside the extents of the proposed longwalls would be adversely impacted.

6.6.4. Impact Assessments for the Water Infrastructure Based on Increased Predictions

If the actual mine subsidence movements exceeded those predicted by a factor of 2 times, the likelihood of impacts on the pipeline located directly above the proposed longwalls would increase. Based on the previous experience of mining beneath water pipelines in the NSW Coalfields, any impacts would still be expected to be minor and readily remediated. It would still be unlikely that the other pipelines located outside the extents of the proposed longwalls would be adversely impacted.

6.6.5. Recommendations for the Water Infrastructure

It is recommended that management strategies are developed, in consultation with *Hunter Water*, so that any minor impacts on the water pipeline can be repaired, as required.

6.7. Electrical Infrastructure

The locations of the electrical infrastructure within the SMP Area are shown in Drawing No. MSEC537-10. The descriptions, predictions and impact assessments for the electrical infrastructure are provided in the following sections. The characterisation of the electrical infrastructure is based on the information gathered by *ACOR Appleyard*.

6.7.1. Description of the Electrical Infrastructure

There are two parallel 132 kV transmission lines, owned by *Ausgrid*, which cross directly above the proposed Longwalls 101 and 102. The aerial three phase conductors are supported by dual timber poles in the locations indicated on Drawing No. MSEC537-10. A photograph of one of these transmission lines is provided in Fig. 6.18.

Fig. 6.18 Photograph of a 132 kV Transmission Line

There are also high and low voltage powerlines owned by *Ausgrid* which are located within the SMP Area. These powerlines follow the alignments of the roads and service the Awaba Waste Management Facility, the Toronto Country Club and the Toronto Adventist Primary School.

The Rathmines 132/11 kV Substation, which is also owned by *Ausgrid*, is located in the south-eastern corner of the SMP Area. The fenced perimeter of the substation is located 140 metres south-east of Longwall 102, at its closest point to the proposed longwalls. A photograph of the substation is provided in Fig. 6.19.

Fig. 6.19 Photograph of the 132/11 kV Substation

It was recommended by MSEC, that this substation be designed in accordance with the recommendations outlined in the Report No. MSEC423 (MSEC, 2009).

6.7.2. Predictions for the Electrical Infrastructure

The predicted profiles of conventional subsidence, tilt along and tilt across the alignments of the 132 kV transmission lines are shown in Fig. E.10 (western branch) and Fig. E.11 (eastern branch), in Appendix E. The predicted incremental profiles along the transmission lines, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the transmission lines, after the extraction of each of the proposed longwalls, are shown as solid blue lines. The locations of the transmission poles are also indicated in these figures.

Summaries of the maximum predicted subsidence and tilts for the 132 kV transmission lines are provided in Table 6.7 (western branch) Table 6.8 (eastern branch). The tilts are the maximum predicted values which occur anywhere along or across the alignments (i.e. not necessarily at the pole locations), after the completion of each of the proposed longwalls.

Table 6.7 Maximum Predicted Total Conventional Subsidence, Tilts Along and Tilts Across the 132 kV Transmission Line (Western Branch)

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt Along Alignment (mm/m)	Maximum Predicted Total Conventional Tilt Across Alignment (mm/m)	Maximum Predicted Total Conventional Tilt in Any Direction (mm/m)
After LW101	750	2.0	6.0	6.0
After LW102	825	4.5	6.0	6.0
After LW103	825	4.5	6.5	6.5

Table 6.8 Maximum Predicted Total Conventional Subsidence, Tilts Along and Tilts Across the 132 kV Transmission Line (Eastern Branch)

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt Along Alignment (mm/m)	Maximum Predicted Total Conventional Tilt Across Alignment (mm/m)	Maximum Predicted Total Conventional Tilt in Any Direction (mm/m)
After LW101	650	5.5	6.0	6.5
After LW102	725	5.0	6.5	7.0
After LW103	725	5.0	6.5	7.0

The maximum predicted final tilts at the transmission pole locations, after the completion of the proposed longwalls, are 5.0 mm/m (western branch) and 6.5 mm/m (eastern branch). Some poles will experience transient tilts greater than their predicted final tilts, due to the longwall travelling wave, with the maximum predicted transient tilt being 6.5 mm/m.

The high and low voltage powerlines are located across the SMP Area and, therefore, are expected to experience the full range of predicted mine subsidence movements. A summary of the maximum predicted mine subsidence parameters within the SMP Area was provided in Chapter 4.

A summary of the maximum predicted subsidence parameters for the 132/11 kV substation is provided in Table 6.9. The predicted movements are the maxima within a distance of 20 metres of the fenced perimeter of the substation, at any time during or after the extraction of the proposed longwalls.

Table 6.9 Maximum Predicted Total Conventional Subsidence Parameters for the 132/11 kV Substation

Location	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Substation	< 20	< 0.5	< 0.01	< 0.01

It can be seen from the above table, that the substation is predicted to experience less than 20 mm of subsidence resulting from the extraction of the proposed longwalls.

6.7.3. Impact Assessments for the Electrical Infrastructure

The maximum predicted tilt at the transmission pole locations is 6.5 mm/m (i.e. 0.7 %), which represents a change in grade of 1 in 150. The maximum predicted tilt at the high and low voltage powerlines is 16 mm/m (i.e. 1.6 %), which represents a change in grade of 1 in 65.

A rule of thumb used by some electrical engineers is that the tops of the poles may displace up to 2 pole diameters horizontally before remediation works are considered necessary. Based on pole heights of 15 metres and pole diameters of 250 mm, the maximum tolerable tilt at the pole locations is in the order of 33 mm/m. It is unlikely, therefore, that the 132 kV transmission lines, high and low voltage powerlines would experience any adverse impacts resulting from the proposed mining.

Extensive experience of mining beneath powerlines in the NSW Coalfields, where the mine subsidence movements were similar to those predicted for the proposed longwalls, indicates that incidences of impacts are very low and of a minor nature. Some remedial measures have been required, in the past, which included adjustments to cable catenaries, pole tilts and to consumer cables which connect between the powerlines and building structures.

The 132/11 kV substation is predicted to experience less than 20 mm subsidence resulting from the proposed mining. Whilst the substation could experience subsidence slightly greater than 20 mm, it would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that the substation would experience any adverse impacts resulting from the proposed mining.

6.7.4. Impact Assessments for the Electrical Infrastructure Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt along the 132 kV transmission lines would be 13 mm/m (i.e. 1.3 %) and the maximum tilt along the high and low voltage powerlines would be 32 mm/m (i.e. 3.2 %). In this case, the tilts along the transmission line would still be less than the tolerable tilt, which is in the order of 33 mm/m, and the tilt along the powerline would be similar to the tolerable tilt. It is possible, therefore, that some remediation measures would be required, which could include the adjustment of the timber poles or the installation of guy ropes.

If the actual subsidence at the substation exceeded that predicted by a factor of 2 times, the tilts, curvatures and strains would still be small, in the order of survey tolerance. In this case, it would still be unlikely that the substation would experience any adverse impacts resulting from the proposed mining.

6.7.5. Recommendations for the Electrical Infrastructure

It is recommended that the predicted mine subsidence movements for the electrical infrastructure are provided to *Ausgrid*, so that any necessary preventive measures can be developed, which may include the installation of guy wires or cable sheaves. It is also recommended that a Trigger Action Response Plan (TARP) is developed, in consultation with *Ausgrid*.

It is expected, after the implementation of any necessary preventive measures, that the 132 kV transmission lines, the high and low voltage powerlines can be maintained in safe and serviceable conditions throughout the mining period.

6.8. Telecommunications Infrastructure

The locations of the telecommunications infrastructure within the SMP Area are shown in Drawing No. MSEC537-10. The descriptions, predictions and impact assessments for the telecommunications infrastructure are provided in the following sections. The characterisation of the telecommunications infrastructure is based on the information gathered by *ACOR Appleyard*.

6.8.1. Description of the Telecommunications Infrastructure

There is an optical fibre cable, owned by AAPT, which crosses directly above the proposed Longwall 101. The cable is aerial (i.e. not direct buried) which is supported by the transmission poles along the 132 kV transmission line (eastern branch). A photograph of a typical cable connection to the transmission pole is provided in Fig. 6.20.

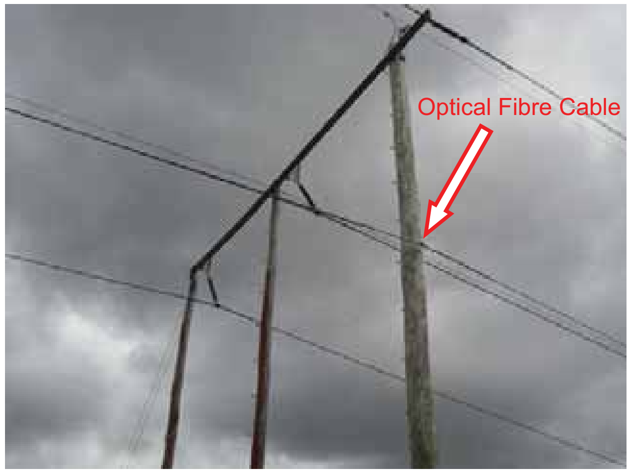


Fig. 6.20 Connection of the AAPT Optical Fibre Cable to a Transmission Pole

A direct buried optical fibre cable, owned by Telstra, follows Wilton Road to the Awaba Waste Management Facility. This cable is only partially located above the maingate of the proposed Longwall 103. There are also direct buried copper telecommunications cables, owned by Telstra, which generally follow the alignments of Wilton and Wangi Roads. The copper cables service the Toronto Country Club and the Toronto Adventist Primary School.

6.8.2. Predictions for the Telecommunications Infrastructure

The AAPT optical fibre cable follows the alignment of the 132 kV transmission line (eastern branch). The predicted profiles of conventional subsidence, tilt along and tilt across the alignment of the transmission line and, hence, the optical fibre cable are shown in Fig. E.11, in Appendix E. The predicted incremental profiles along the alignment, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the alignment, after the extraction of each of the proposed longwalls, are shown as solid blue lines.

A summary of the maximum predicted subsidence and tilts for the AAPT optical fibre cable is provided in Table 6.10. The tilts are the maximum predicted values which occur anywhere along or across the alignment (i.e. not necessarily at the transmission pole locations), after the completion of each of the proposed longwalls.

Table 6.10 Maximum Predicted Total Conventional Subsidence, Tilts Along and Tilts Across the AAPT Optical Fibre Cable

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt Along Alignment (mm/m)	Maximum Predicted Total Conventional Tilt Across Alignment (mm/m)	Maximum Predicted Total Conventional Tilt in Any Direction (mm/m)
After LW101	650	5.5	6.0	6.5
After LW102	725	5.0	6.5	7.0
After LW103	725	5.0	6.5	7.0

The maximum predicted final tilt at the transmission pole locations, after the completion of the proposed longwalls, is 6.5 mm/m. Some poles will experience transient tilts greater than their predicted final tilts, due to the longwall travelling wave, with the maximum predicted transient tilt also being 6.5 mm/m.

Summaries of the maximum predicted subsidence parameters for the Telstra optical fibre cable and copper telecommunications cables, after the extraction of each of the proposed longwalls, are provided in Table 6.11 and Table 6.12, respectively. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.11 Maximum Predicted Total Conventional Subsidence Parameters for the Telstra Optical Fibre Cable

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	< 20	< 0.5	< 0.01	< 0.01
After LW103	200	3.0	0.07	0.01

Table 6.12 Maximum Predicted Total Conventional Subsidence Parameters for the Copper Telecommunications Cables

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	450	6.0	0.10	0.05
After LW103	500	6.5	0.10	0.05

The maximum predicted conventional strains for the Telstra telecommunications cables, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.7 mm/m tensile and less than 0.3 mm/m compressive for the optical fibre cable, and 1 mm/m tensile and 0.5 mm/m compressive for the copper cables.

The Telstra optical fibre cable crosses two 1st order tributaries adjacent to Longwall 103 and, therefore, could experience valley related movements in these locations. The maximum predicted valley related movements in these locations are 50 mm upsidence and 100 mm closure. Compressive strains between 1 mm/m and 3 mm/mm have been observed, in the past, at these magnitudes of upsidence and closure movements outside the extents of extracted longwalls.

The copper telecommunications cables along Wangi Road are located outside the predicted 20 mm subsidence contour. It is unlikely, therefore, that these cables would experience any significant conventional or valley related movements.

6.8.3. Impact Assessments for the Telecommunications Infrastructure

The maximum predicted tilt for the AAPT optical fibre cable, at the supporting pole locations, is 6.5 mm/m (i.e. 0.7 %), which represents a change in grade of 1 in 150. The predicted horizontal movement of the ground, in this location, is around 100 mm. The maximum predicted horizontal movement at the height of the cable, based on a pole height of 15 metres, therefore, is around 200 mm (i.e. 6.5 mm/m * 15 m + 100 mm).

The support poles are separated at distances between 150 metres and 400 metres within the SMP Area. The maximum predicted mining induced tensile strain in the AAPT optical fibre cable, therefore, is around 1.5 mm/m (i.e. 200 mm divided by 150 metres). This strain is additional to the tensile strain in the cable resulting from the cable catenary, which is expected to be greater than the mining induced strain.

Optical fibre cables can typically tolerate tensile strains of 4 mm/m without adverse impacts. It is unlikely, therefore, that this cable would be adversely impacted as a result of the proposed mining. It is recommended, however, that the predicted movements are provided to AAPT, so that the adequacy of the cable can be reviewed based on both the mining induced tensile strain and the existing strains due to the cable catenaries.

The maximum predicted conventional strains for the Telstra optical fibre cable are 0.7 mm/m tensile and less than 0.3 mm/m compressive. This cable could also experience elevated compressive strains at the tributary crossings, located adjacent to the maingate of Longwall 103, which could be in the order of 1 mm/m to 3 mm/m. It is possible, therefore, that the compressive strains at the tributary crossings could be sufficient to result in the reduction in capacity of the cable or transmission loss. It is recommended, that the predicted movements are provided to Telstra, so that the adequacy of the cable can be reviewed based on the predicted ground movements.

The strains in the AAPT and Telstra optical fibre cables can be monitored using Optical Time Domain Reflectometry (OTDR). If the measured strains in the cables were seen to approach the allowable tolerances, then preventive measures could be implemented, which could include the adjustment of the cable catenaries or the installation of cable sheaves for the AAPT cable, or the Telstra cable could be exposed at the strain concentration and stress relieved.

The maximum predicted conventional strains for the copper telecommunications cable along Wilton and Wangi Roads are 1 mm/m and less than 0.5 mm/m, respectively. Copper telecommunications cables can typically tolerance strains of 20 mm/m without adverse impacts. It is unlikely, therefore, that the copper cables would be adversely impacted as the result of the proposed mining.

Extensive experience of mining beneath copper telecommunications cables in the NSW Coalfields, where the mine subsidence movements were greater than those predicted for the proposed mining, indicates that the incidences of impacts are extremely low and of a minor nature.

6.8.4. Impact Assessments for the Telecommunications Infrastructure Based on Increased Predictions

If the actual mine subsidence movements exceeded those predicted by a factor of 2 times, the mining induced tensile strains in the AAPT and Telstra optical fibre cables would be around 3 mm/m and 1.5 mm/m, respectively. In this case, the tensile strains would still be less than those which optical fibre cables can typically tolerate. Whilst the Telstra optical fibre cable could experience elevated compressive strains at the tributary crossings, west of the proposed Longwall 103, it is unlikely that these strains would exceed the predictions by a factor of 2 times, as the crossings are located outside the proposed longwalls. The strains in the AAPT and Telstra optical fibre cables can be monitored using OTDR and, if required, preventive measures can be implemented when the strains approach the allowable tolerances.

If the actual mine subsidence movements exceeded those predicted by a factor of 2 times, the mining induced conventional strains in the copper telecommunications cables along Wilton and Wangi Roads would be 2 mm/m and less than 0.5 mm/m, respectively. In this case, it would still be unlikely that the copper telecommunications cables would be adversely impacted as a result of the proposed mining.

6.8.5. Recommendations for the Telecommunications Infrastructure

It is recommended that the predicted movements for the optical fibre cables are provided to AAPT and Telstra so that the necessary management plans can be developed. It is also recommended that Trigger Action Response Plans (TARPs) are developed for these cables so that, if necessary, preventive measures can be undertaken if the strains in the cables approach the allowable tolerances.

It is also recommended that management strategies are developed, in consultation with Telstra, for the copper telecommunications cables within the SMP Area.

6.9. Schools

The location of the school (Property Ref. TR003) within the SMP Area is shown in Drawing Nos. MSEC537-11 and MSEC537-13. The descriptions, predictions and impact assessments for the school are provided in the following sections. The characterisation of the building structures is based on the information gathered by *Northrop Engineers.*

6.9.1. Description of the School

The *Toronto Adventist Primary School and Church* is located at a distance of 0.3 kilometres east of Longwall 101, at its closest point to the proposed longwalls. The construction drawings for the building structures were approved by the Mine Subsidence Board on the 3rd July 2000. A letter from the MSB dated the 4th April 2000 states that:-

> "*The Mine Subsidence Board would give favourable consideration to the development on the site of a single storey brick veneer church with limited subfloor development not to exceed 30 % of the area.*
>
> *The church is to be erected on strip footings, subject to the following mine subsidence design parameters.*
>
> *Maximum subsidence 1m*
> *Strain 2mm/m*
> *Tilt 6mm/m*"

The main hall (Ref. TR003_pa01) is a single storey building which is elevated above the sloping natural ground. The structure comprises a suspended concrete slab supported on load bearing brickwalls on strip footings. The walls above the concrete slab have light-weight internal frames with brickwork external cladding on the lower part and light-weight cladding on the upper part. Photographs of the main hall are provided in Fig. 6.21.

Fig. 6.21 Photographs of the Main Hall (Ref. TR003_pa01) (Courtesy of Northrop Engineers)

The church (Ref. TR003_pa02) is also constructed on sloping ground with a main floor and a partial subfloor on the downslope side. The structure comprises a suspended concrete slab supported on load bearing brickwalls and brick piers on strip footings. The walls above the concrete slab have light-weight internal frames with brick external cladding on the lower part and light-weight cladding on the upper part. Photographs of the church are provided in Fig. 6.22.

Fig. 6.22 Photographs of the Church (Ref. TR003_pa02) (Courtesy of Northrop Engineers)

The classrooms, administration building and toilet block (Refs. TR003_pa03 to TR003_pa05) are single storey structures with double brick or brick-veneer walls founded on concrete ground slabs and with metal roofs. Photographs of these structure are provided in Fig. 6.23.

Fig. 6.23 Photographs of Classrooms and Administration Building (Courtesy of Northrop Engineers)

The main entry feature wall is a composite double brickwork and blockwork structure, approximately 2.8 metres high, founded on a reinforced concrete strip footing. The main brickwork section contains three reinforced brick piers and the blockwork ends are core filled but unreinforced. Photographs of the feature wall are provided in Fig. 6.24.

Fig. 6.24 Photographs of the Main Entry Feature Wall (Courtesy of Northrop Engineers)

The services and other features on the property include consumer powerlines and telephone lines, above ground water storage tanks, inground septic tanks, retaining walls and external concrete pavements.

6.9.2. Predictions for the School

The predicted conventional subsidence, tilts and curvatures for the building structures within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the building structures associated with the school is provided in Table 6.13. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed longwalls.

Table 6.13 Maximum Predicted Total Conventional Subsidence Parameters for the Building Structures at the Toronto Adventist Primary School and Church

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
TR003_pa01	< 20	< 0.5	< 0.01	< 0.01
TR003_pa02	< 20	< 0.5	< 0.01	< 0.01
TR003_pa03	< 20	< 0.5	< 0.01	< 0.01
TR003_pa04	< 20	< 0.5	< 0.01	< 0.01
TR003_pa05	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional curvatures for the building structures are less than 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional strains for the building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

6.9.3. Impact Assessments for the School

The building structures and associated infrastructure are all predicted to experience less than 20 mm subsidence resulting from the proposed mining. Whilst these features could experience subsidence slightly greater than 20 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that building structures and associated infrastructure would experience any adverse impacts resulting from the proposed mining.

6.9.4. Impact Assessments for the School Based on Increased Predictions

If the actual mine subsidence movements exceeded those predicted by a factor of 2 times, the subsidence at the building structures and infrastructure would still be less than 20 mm. In this case, these features would still not be expected to experience any significant conventional tilts, curvatures or strains and, hence, unlikely to experience any adverse impacts.

6.9.5. Recommendations for the School

There are no specific recommendations for the school.

6.10. Golf Courses

The location of the golf course (Property Ref. TR001) within the SMP Area is shown in Drawing Nos. MSEC537-11 and MSEC537-13. The descriptions, predictions and impact assessments for the golf course are provided in the following sections. The characterisation of the building structures is based on the information gathered by *Northrop Engineers.*

6.10.1. Description of the Toronto Country Club

The *Toronto Country Club* is located at a distance of 120 metres south-east of Longwall 101, at its closest point to the proposed longwalls. The construction drawings for the building structures were approved by the Mine Subsidence Board on the 25th August 2009.

The main club house (Ref. TR001_pa01) is a double storey building structure. The lower storey comprises load bearing brick walls and brick piers supported on a slab on ground. The upper storey comprises a suspended concrete floor with lightweight walls and roof. The structure also includes a porte cochere steel framed awning (Ref. TR001_pa02), at the main entrance, as well as besser block retaining walls, stone clad feature walls and shade sails. Photographs of this building are shown in Fig. 6.25.

Fig. 6.25 Photographs of the Main Club House (Refs. TR001_pa01 and TR001_pa02) (Courtesy of Northrop Engineers)

The property also has a number of metal sheds founded on slabs on ground (Ref. TR001_pa3 to TR001_pa06) which are used for storage and machinery and equipment. Photographs of these building structures are provided Fig. 6.26.

Fig. 6.26 Photographs of the Metal Storage Sheds (Ref. TR001_pa03 to TR001_pa06) (Courtesy of Northrop Engineers)

The club has an 18 hole golf course and, in addition to the fairways, greens, bunkers and water traps, the infrastructure includes pathways, timber pedestrian bridges, concrete drainage culverts and an irrigation system. There is also one registered groundwater bore on the property, which is described in Section 6.15.

6.10.2. Predictions for the Toronto Country Club

The predicted conventional subsidence, tilts and curvatures for the building structures within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the building structures associated with the golf course is provided in Table 6.14. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed longwalls.

Table 6.14 Maximum Predicted Total Conventional Subsidence Parameters for the Building Structures at the Toronto Country Club

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
TR001_pa01	< 20	< 0.5	< 0.01	< 0.01
TR001_pa02	< 20	< 0.5	< 0.01	< 0.01
TR001_pa03	< 20	< 0.5	< 0.01	< 0.01
TR001_pa04	< 20	< 0.5	< 0.01	< 0.01
TR001_pa05	< 20	< 0.5	< 0.01	< 0.01
TR001_pa06	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional curvatures for the building structures are less than 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional strains for the building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

The golf course, itself, is located 150 metres south-east of Longwall 101, at its closest point to the proposed longwalls. At this distance, the golf course is predicted to experience less than 20 mm subsidence and the associated tilts, curvatures and strains are expected to be less than the order of survey tolerance.

6.10.3. Impact Assessments for the Toronto Country Club

The building structures, golf course and associated infrastructure are all predicted to experience less than 20 mm subsidence resulting from the proposed mining. Whilst these features could experience subsidence slightly greater than 20 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that building structures, golf course and associated infrastructure would experience any adverse impacts resulting from the proposed mining.

6.10.4. Impact Assessments for the Toronto Country Club Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the property would be 0.5 mm/m, which represents a change in grade of 1 in 2,000. In this case, the changes in grade would still be extremely small (i.e. less than 0.1 %) and unlikely, therefore, to result in any serviceability impacts on the building structures, golf course or associated infrastructure.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvature at the property would be 0.01 km^{-1} hogging, which represents a minimum radius of curvature of 100 kilometres. In this case, the curvatures and strains would still be in the order of survey tolerance and unlikely, therefore, to result in any adverse impacts on the building structures, golf course or associated infrastructure.

6.10.5. Recommendations for the Toronto Country Club

Whilst no impacts are anticipated, it is recommended that pre-mining visual inspections are undertaken on the building structures at the Toronto Country Club, prior to the extraction of Longwall 101.

6.11. Newcastle Lake Macquarie Clay Target Club

The location of the target club (Property Ref. AW001) within the SMP Area is shown in Drawing Nos. MSEC537-11 and MSEC537-13. The descriptions, predictions and impact assessments for the target club are provided in the following sections. The characterisation of the building structures is based on the information gathered by *Northrop Engineers.*

6.11.1. Descriptions for the Newcastle Lake Macquarie Clay Target Club

The *Newcastle Lake Macquarie Clay Target Club* (Target Club) is partially located above the southern ends of the proposed Longwalls 102 and 103. The property includes a number of building structures and associated infrastructure, which are located immediately to the south of the proposed longwalls.

The main club house (Ref. AW001_pa01) is a single storey mixed brickwork and timber framed structure founded on a slab on ground with a metal roof. This structure is located 50 metres south of the proposed Longwall 103. Photographs of the club house are provided in Fig. 6.27.

Fig. 6.27 Main Club House (Ref. AW001_pa01)
(Courtesy of Northrop Engineers)

Other building structures on the property include a single storey timber cottage on brick piers with a metal roof (AW001_pa02) and demountable structures on mini piers or slab on ground (AW001_pa03, AW001_pa04 and AW001_r15). Photographs of these structures are provided in Fig. 6.28 and Fig. 6.29.

Fig. 6.28 Timber Cottage AW001_pa02 (LHS) and Demountable AW001_pa03 (RHS)
(Courtesy of Northrop Engineers)

Fig. 6.29 Demountable Structures AW001_pa04 (LHS) and AW001_r15 (RHS) (Courtesy of Northrop Engineers)

The trap enclosures (AW001_r01 to AW001_r04) are fabricated steel structures founded on natural ground with timber or concrete retaining walls. The enclosures contain the clay target throwers. Photographs of the enclosures and throwers are provided in Fig. 6.30.

Fig. 6.30 Trap Enclosure AW001_r04 (LHS) and Clay Target Thrower (RHS) (Courtesy of Northrop Engineers)

There are four brick trap houses (AW001_r05 to AW001_r08) which are approximately 2 metre square brick structures, up to approximately 4.5 metres tall , founded on slabs on ground with metal roofs. The taller structures also have steel framed stairs. Photographs of the trap houses are provided in Fig. 6.31.

Fig. 6.31 Trap Houses AW001_r05 (LHS) and AW001_r08 (RHS) (Courtesy of Northrop Engineers)

Other features include free standing roof structures, a playground and other small storage sheds. Photographs of these are provided in Fig. 6.32.

Fig. 6.32 Free Standing Roof Structure (LHS) and Playground (RHS) (Courtesy of Northrop Engineers)

The services on the property include low voltage powerlines, lighting, inground and above ground water storage tanks, and retaining walls.

6.11.2. Predictions for the Newcastle Lake Macquarie Clay Target Club

The predicted conventional subsidence, tilts and curvatures for the building structures within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the building structures associated with the target club is provided in Table 6.15. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed longwalls.

Table 6.15 Maximum Predicted Total Conventional Subsidence Parameters for the Building Structures at the Newcastle Lake Macquarie Clay Target Club

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AW001_pa01	75	1.0	0.01	0.01
AW001_pa02	50	1.0	< 0.01	< 0.01
AW001_pa03	25	< 0.5	< 0.01	< 0.01
AW001_pa04	< 20	< 0.5	< 0.01	< 0.01
AW001_r01	50	0.5	< 0.01	< 0.01
AW001_r02	25	< 0.5	< 0.01	< 0.01
AW001_r03	< 20	< 0.5	< 0.01	< 0.01
AW001_r04	< 20	< 0.5	< 0.01	< 0.01
AW001_r05	75	1.0	0.01	< 0.01
AW001_r06	50	0.5	< 0.01	< 0.01
AW001_r07	50	0.5	< 0.01	< 0.01
AW001_r08	25	< 0.5	< 0.01	< 0.01
AW001_r09	< 20	< 0.5	< 0.01	< 0.01
AW001_r10	50	0.5	< 0.01	< 0.01
AW001_r11	50	0.5	< 0.01	< 0.01
AW001_r12	25	< 0.5	< 0.01	< 0.01
AW001_r13	< 20	< 0.5	< 0.01	< 0.01
AW001_r14	< 20	< 0.5	< 0.01	< 0.01
AW001_r15	75	1.0	0.02	< 0.01

The maximum predicted conventional curvatures for the building structures are 0.02 km^{-1} hogging and 0.01 km^{-1} sagging, which represent minimum radii of curvature of 50 kilometres and 100 kilometres, respectively. The maximum predicted conventional strains for the building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

The predicted conventional subsidence, tilts and curvatures for the dams within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.02, in Appendix D. A summary of the maximum predicted subsidence parameters for the dam associated with the target club is provided in Table 6.16. The predicted movements are the maxima within a distance of 20 metres of the dam, at any time during or after the extraction of the proposed longwalls.

Table 6.16 Maximum Predicted Total Conventional Subsidence Parameters for the Dam at the Newcastle Lake Macquarie Clay Target Club

Dam Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AW001_d01	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional curvatures for the dam are less than 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional strains for the dam, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

6.11.3. Impact Assessments for the Newcastle Lake Macquarie Clay Target Club

The maximum predicted tilt for the main club house (AW001_pa01) and timber cottage (AW001_pa02) is 1.0 mm/m (i.e. 0.1 %), which represents a change in grade of 1 in 1,000. Tilts less than 7 mm/m generally do not result in any significant serviceability issues for building structures. It is unlikely, therefore, that these structures would experience any adverse impacts resulting from the mining induced tilt.

The maximum predicted curvatures for the main club house and timber cottage is 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature of 100 kilometres. The maximum predicted conventional strains for these structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance). The predicted curvatures and strains are very small, in the order of survey tolerance, and unlikely to result in any significant impacts on these structures.

The demountable structures, small storage sheds, trap houses and the trap enclosures, themselves, are founded on small piers, slabs on ground, or the natural ground. The predicted curvatures and strains for these structures are very small, in the order of survey tolerance, and are unlikely to be transferred into these structures and, hence, result in any significant impacts.

The maximum predicted tilt for the clay target throwers is less than 0.5 mm/m (i.e. less than 0.1 %), which represents a change in grade less than 1 in 2,000. Whilst the predicted tilts are extremely small, less than the order of survey tolerance, the clay target throwers and the target survey markers could be sensitive to these small movements. It is understood that the clay target throwers can be adjusted in level. It may be necessary to develop preventive measures, if the predicted tilts exceed the available adjustments to relevel the clay target throwers, or to relocate the target survey markers.

The remaining structures are light-weight and unlikely, therefore, to be adversely impacted by the predicted tilts and curvatures. It is also unlikely that the services would be adversely impacted as a result of the proposed mining.

The dam AW001_d01 is predicted to experience subsidence less than 20 mm. Whilst the dam could experience subsidence slightly greater than 20 mm, it would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that the dam would experience any adverse impacts resulting from the proposed mining.

6.11.4. Impact Assessments for the Newcastle Lake Macquarie Clay Target Club Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the building structures and infrastructure would be 2 mm/m, which represents a change in grade of 1 in 500. In this case, the changes in grade would still be small (i.e. less than 1 %) and unlikely, therefore, to result in any serviceability impacts on the building structures or associated infrastructure. It is possible that the clay throwers and the target survey markers could be sensitive to these small movements and, therefore, it may be necessary to manually adjust this equipment.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvatures at the building structures and infrastructure would be 0.04 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 25 kilometres and 50 kilometres, respectively. It would still be unlikely, at the magnitudes of these curvatures and strains, that they would result in any adverse impacts on the building structures or associated infrastructure.

If the actual subsidence exceeded that predicted by a factor of 2 times, the maximum subsidence at the dam AW001_d01 would be around 20 mm. In this case, the conventional tilts, curvatures and strains would still be very small, in the order of survey tolerance, and unlikely, therefore, to result in any adverse impacts.

6.11.5. Recommendations for the Newcastle Lake Macquarie Clay Target Club

It is recommended that management strategies be developed, in consultation with the target club, so that the clay target throwers can be relevelled or the target survey markers relocated, if required, during the active subsidence period. It may be necessary to develop preventive measures, if the predicted tilts are greater than the adjustments available to relevel the clay target throwers.

6.12. Westlakes Automobile Club

The location of the automobile club within the SMP Area is shown in Drawing Nos. MSEC537-11 and MSEC537-13. The descriptions, predictions and impact assessments for the automobile club are provided in the following sections. The characterisation of the building structures is based on the information gathered by *Northrop Engineers.*

6.12.1. Descriptions for the Westlakes Automobile Club

The *Westlakes Automobile Club* or *AwabaWAC Park* (Automobile Club) is partially located above the southern end of the proposed Longwall 103. The property (Ref. AW003) includes a number of dirt (i.e. unsealed) tracks which are used for various motorsport events.

The building structures on the property (AW003_pa01 to AW003_pa03) are demountable structures founded on concrete pads or besser blocks on natural ground. Photographs of these structures are provided in Fig. 6.33.

Fig. 6.33 Building Structures at AwabaWAC Park (Courtesy of Northrop Engineers)

The services on the property include low voltage powerlines, lighting and a water tank.

6.12.2. Predictions for the Westlakes Automobile Club

The unsealed racing tracks are partially located above the proposed Longwall 103. A summary of the maximum predicted subsidence parameters for this section of track is provided in Table 6.17. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.17 Maximum Predicted Total Conventional Subsidence Parameters for the Section of Track Located Directly Above the Proposed Longwall 103

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	< 0.01	< 0.01
After LW102	< 20	< 0.5	< 0.01	< 0.01
After LW103	800	10	0.15	0.25

The maximum predicted conventional strains for the track, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 1.5 mm/m tensile and 2.5 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements

The predicted conventional subsidence, tilts and curvatures for the building structures within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the building structures associated with the automobile club is provided in Table 6.18. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed longwalls.

Table 6.18 Maximum Predicted Total Conventional Subsidence Parameters for the Building Structures at the Westlakes Automobile Club

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AW003_pa01	< 20	< 0.5	< 0.01	< 0.01
AW003_pa02	< 20	< 0.5	< 0.01	< 0.01
AW003_pa03	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional curvatures for the building structures less than 0.01 km^{-1} hogging and sagging, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional strains for the building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

6.12.3. Impact Assessments for the Westlakes Automobile Club

The maximum predicted tilt for the section of track located directly above the proposed Longwall 103 is 10 mm/m, which represents a change in grade of 1 in 100. The predicted change in grade is extremely small (i.e. 1 %) and unlikely, therefore, to result in any adverse impacts on the surface water drainage.

The predicted curvatures and strains for the section of track located directly above the proposed Longwall 103 could be of sufficient magnitude to result in cracking, heaving, or stepping of the surface. Discussions on the surface deformations resulting from the proposed mining are provided in Section 4.7. It would be expected, that any impacts on the track could be remediated by regrading or recompacting the surface.

The building structures and associated infrastructure are all predicted to experience less than 20 mm subsidence resulting from the proposed mining. Whilst these features could experience subsidence slightly greater than 20 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that building structures and associated infrastructure would experience any adverse impacts resulting from the proposed mining.

6.12.4. Impact Assessments for the Westlakes Automobile Club Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the section of track located directly above the proposed Longwall 103 would be 20 mm/m, which represents a change in grade of 1 in 50. In this case, the changes in grade would still be small when compared with the existing gradients and unlikely, therefore, to result in any adverse impacts on the surface water drainage. The maximum tilt at the building structures would be 0.5 mm/m (i.e. less than 0.1 %) and unlikely, therefore, to result in any serviceability impacts on the building structures or associated infrastructure.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvatures at the section of track located directly above the proposed Longwall 103 would be 0.30 km^{-1} hogging and 0.50 km^{-1} sagging, which represent minimum radii of curvature of 3 kilometres and 2 kilometres, respectively. In this case, the likelihood and extent of surface cracking, heaving and stepping would increase, however, any impacts could be remediated by regrading and recompacting the surface. The curvatures and strains at the building structures and associated infrastructure would still be in the order of survey tolerance and unlikely, therefore, to result in any adverse impacts.

6.12.5. Recommendations for the Westlakes Automobile Club

It is recommended that the section of track located directly above the proposed Longwall 103 is periodically visually inspected during the active subsidence period. Whilst no impacts are anticipated, it is recommended that pre-mining visual inspections are undertaken on the building structures at the AwabaWAC Park, prior to the extraction of Longwall 103.

6.13. Fences

Fences are located across the SMP Area and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence parameters within the SMP Area is provided in Chapter 4.

Wire fences can be affected by tilting of the fence posts and by changes of tension in the fence wires due to strain as mining occurs. These types of fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without significant impacts. Colorbond and timber paling fences are more rigid than wire fences and, therefore, are more susceptible to impacts resulting from mine subsidence movements.

It is expected, at the predicted magnitudes of tilt, curvature and strain, that some sections of the fences within the SMP Area would be impacted as a result of the extraction of the proposed longwalls. Any impacts on the fences could be remediated by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

6.14. Farm Dams

The locations of the farm dams within the SMP Area are shown in Drawing Nos. MSEC537-11 and MSEC537-13. The descriptions, predictions and impact assessments for the dams are provided in the following sections.

The leachate and sediment ponds associated with the Awaba Waste Management Facility are discussed in Section 6.17. The dam associated with the Newcastle Lake Macquarie Clay Target Club is discussed in Section 6.11.

6.14.1. Description of the Farm Dams

There are three farm dams within the SMP Area, excluding the ponds associated with the Awaba Waste Management Facility and the dam associated with the Newcastle Lake Macquarie Clay Target Club. These three dams (TR002_d01 to TR002_d03) are located adjacent to the southern end of the proposed Longwall 101.

The dams are of earthen construction and range in area between 30 m^2 and 300 m^2 and in maximum plan dimension between 5 metres and 25 metres.

6.14.2. Predictions for the Farm Dams

The predicted conventional subsidence, tilts and curvatures for the dams within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.02, in Appendix D. A summary of the maximum predicted subsidence parameters for the farm dams is provided in Table 6.19. The predicted movements are the maxima within a distance of 20 metres of each dam, at any time during or after the extraction of the proposed longwalls.

Table 6.19 Maximum Predicted Total Conventional Subsidence Parameters for the Farm Dams

Dam Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
TR002_d01	75	1.5	0.03	< 0.01
TR002_d02	300	5.0	0.04	0.04
TR002_d03	250	4.0	0.04	0.03

The maximum predicted conventional curvatures for the farm dams are 0.04 km^{-1} hogging and sagging, which represents a minimum radius of curvature of 25 kilometres. The maximum predicted conventional strains for the dams, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.5 mm/m (i.e. in the order of survey tolerance).

6.14.3. Impact Assessments for the Farm Dams

The maximum predicted tilt for the farm dams is 5.0 mm/m (i.e. 0.5 %), which represents a change in grade of 1 in 200. The maximum predicted change in freeboard, based on a maximum plan dimension of 25 metres, is less than ±100 mm. The predicted changes in freeboard are small and, therefore, are unlikely to have any significant impact on the storage capacities of the farm dams.

Surface cracking or heaving is rarely observed, where the ground strains are less than 0.5 mm/m, especially outside the extents of extracted longwalls. Also, it has been found that the incidence of impacts to farm dams in the Newcastle and Hunter Coalfields is extremely low, where the dams are located outside the extents of extracted longwalls and where there is a reasonable depth of cover, in the order of 250 metres or greater, which is the case for the proposed longwalls. Based on this experience, it is unlikely that the farm dams within the SMP Area would be adversely impacted as a result of the proposed mining.

6.14.4. Impact Assessments for the Farm Dams Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the farm dams would be 10 mm/m (i.e. 1.0 %), or a change in grade of 1 in 100. In this case, the maximum change in freeboard would be around 250 mm, which would still be unlikely to have any significant impact on the storage capacities of the farm dams.

If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvature at the farm dams would be 0.08 km^{-1} hogging and the associated conventional strain would be 0.8 mm/m tensile. It is possible, that surface cracking could occur at the farm dam TR002_d02, but at these magnitudes of movement, any surface cracking would still be expected to be of a minor nature and could be easily repaired. It would still be unlikely that there would be any loss of water from the farm dams.

6.14.5. Recommendations for the Farm Dams

There are no specific recommendations for the farm dams.

6.15. Wells and Bores

The locations of the registered groundwater bores in the vicinity of the proposed longwalls are shown in Drawing No. MSEC537-10. The locations and details of these were obtained from the Department of Natural Resources using the *Natural Resource Atlas* website (NRAtlas, 2012).

There were no registered groundwater bores identified within the SMP Area. There was one registered groundwater bore (Ref. GW064214) which is located just outside the SMP Area, on the Toronto Country Club (Property Ref. AW003), approximately 360 metres south-east of the proposed Longwall 101. A summary of this registered groundwater bore is provided in Table 6.20.

Table 6.20 Details of the Registered Groundwater Bores

Ref.	Approximate Easting (m)	Approximate Northing (m)	Depth (m)	Intended Purposes
GW064214	365965	6344430	46	Monitoring

The monitoring bore is located well outside the predicted 20 mm subsidence contour and, therefore, is unlikely to experience any significant conventional subsidence movements. The groundwater table could be affected by the proposed mining and, therefore, could lower piezometric surface at the bore. Further discussions on the potential impacts on the groundwater are provided by the specialised groundwater consultant in the report by *GHD* (2012b).

6.16. Business Establishments

The business establishments within the SMP Area include the Toronto Country Club (refer to Section 6.10), the Newcastle Lake Macquarie Clay Target Club (refer to Section 6.11) and the Awaba Waste Management Facility (refer to Section 6.17).

6.17. Waste Storages

The location of the Awaba Waste Management Facility (Property Ref. AW002) is shown in Drawing Nos. MSEC537-11 and MSEC537-12. The descriptions, predictions and impact assessments for the facility are provided in the following sections. Further characterisation and impact assessments are provided in the reports by *ACOR Appleyard* and *PSM*.

6.17.1. Descriptions of the Awaba Waste Management Facility

The Awaba Waste Management Facility (AWMF) is operated by the Lake Macquarie City Council (LMCC). The facility is a Category 1 landfill site which stores "*household wastes, privately transported residential rubbish, construction and municipal wastes and some industrial wastes*" (LMCC, 2010).

The AWMF (Property Ref. AW002) was commissioned in 1986. The Mine Subsidence Board reviewed the proposal at that time and, in February 1986, wrote a letter to the NSW Department of Health stating that:-

> *"The site of the proposed depot is not likely to be undermined for some 30 to 40 years. It is not within any existing colliery holding."*
>
> *"We presume that the life of the depot would not exceed 20 years and on that basis, we have no objection to the use of the site for solid waste disposal".*

Based on the above statement, it appears that the original facility was not designed for specific mine subsidence parameters or requirements.

The facility was later expanded with the construction of an additional cell in the south-eastern corner of the area. The tender documents for the construction of this cell (RCA, 2005) stated that:-

> *"The cell may be subject to the effects of undermining by Newstan Colliery sometime in the future. Design levels for the base of the cell and proposed liner system have been designed to accommodate the predicted mine subsidence parameters"*

It appears that the new lined cell was designed for mine subsidence, however, the specific mine subsidence parameters could not be found in the available documentation.

The AWMF comprises the waste emplacement area, leachate and sediment ponds, leachate collection and spray systems, gas drainage and flare infrastructure, a gas powered generator installation, weigh bridges, administration building and storage structures. The general layout of the facility is shown in Fig. 6.34.

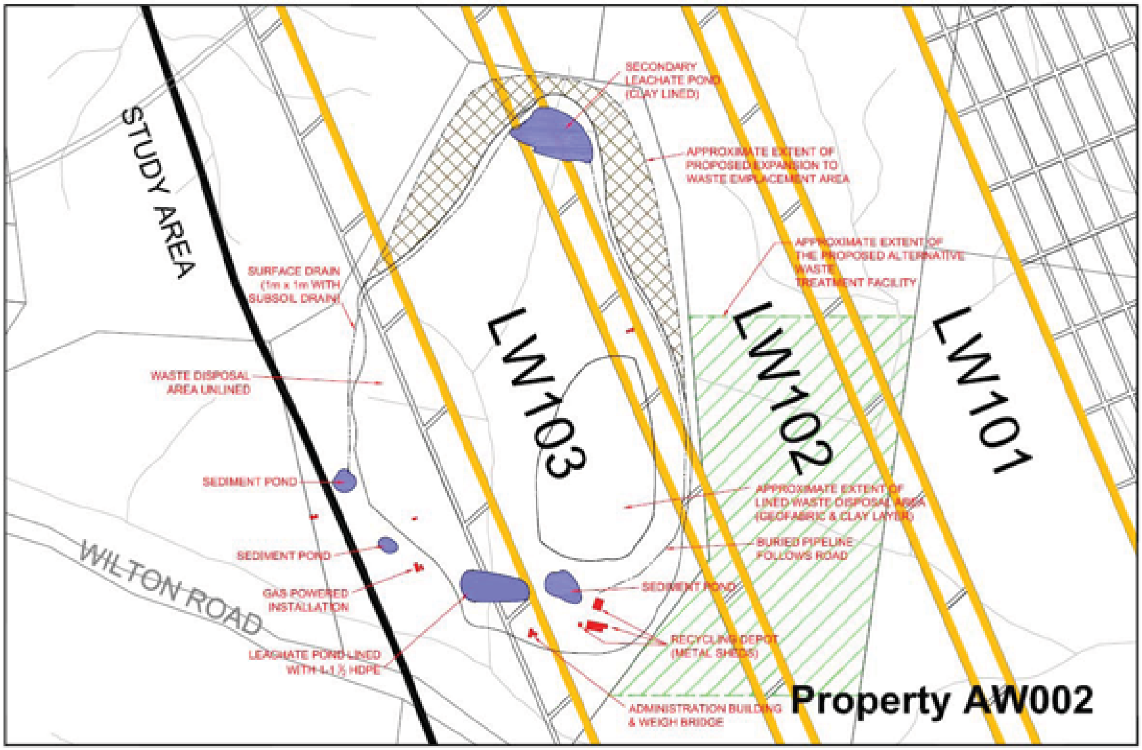


Fig. 6.34 Layout of the Awaba Waste Management Facility

The waste is placed within a natural valley located directly above the proposed Longwall 103. The facility initially had approval for emplacement up to RL 76 m AHD and, in 1995, the allowable emplacement height was increased to 94 m AHD (LMCC, 2010). An east-west cross-section through the valley, showing the natural surface level and the maximum allowable emplacement height, are illustrated in Fig. 6.35.

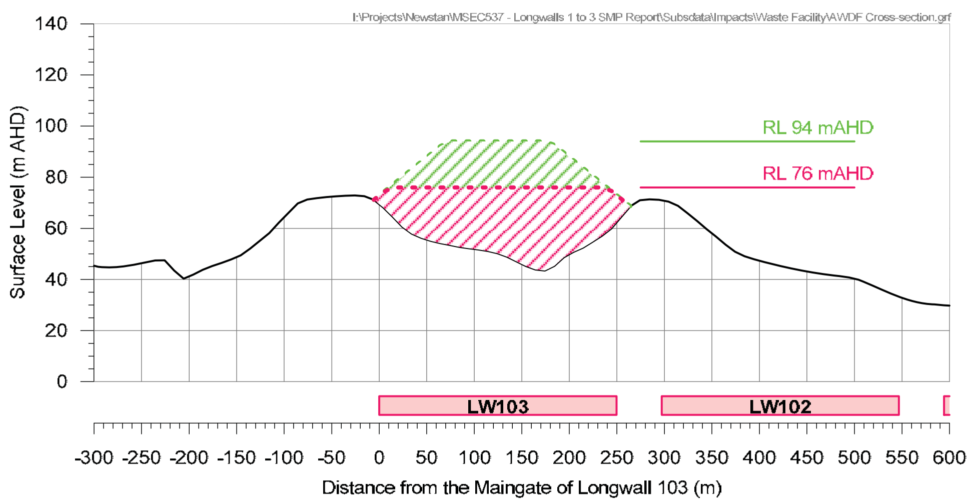


Fig. 6.35 East-West Cross-section through the Waste Emplacement Area

A long-section down the natural drainage line beneath the waste emplacement area is illustrated in Fig. 6.36. The natural surface level and the height of emplacement, based on the Lidar survey dated January 2011, are shown in this figure.

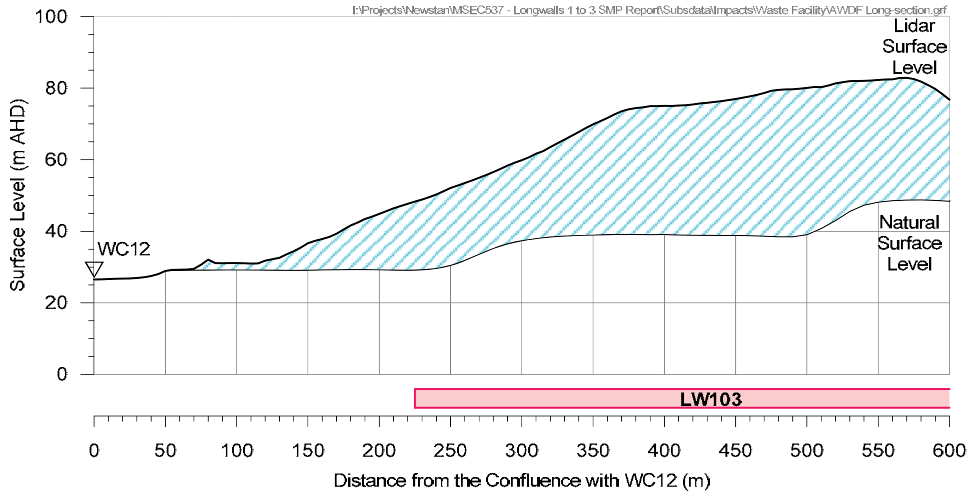


Fig. 6.36 Long-section down the Natural Drainage Line beneath the Waste Emplacement Area

The original waste emplacement area was unlined. The new cell in the south-eastern corner of the area, as indicated in Fig. 6.34, was constructed with a liner. The tender documents for the construction of the new cell (RCA, 2005) provided the following requirements for the liner, from the bottom layer to the top layer, as follows:-

- Geotextile Protection Layer comprising non-woven continuous filament needle punched polyester geotextile with nominal mass of 200 g/m^2 and nominal thickness of 5 mm,
- Geosynthetic Clay Liner (GCL) with dry thickness of 6 mm, Bentonite layer mass of 4500 g/m^2, single non-woven geotextile protection layer with nominal mass of 220 g/m^2, carrier woven mass of 110 g/m^2 and minimum mass per unit area of 4830 g/m^2,
- Geotextile Separation Layer with a nominal mass of 200 g/m^2,
- Compacted Clay Layer (CCL) constructed from ripped and reworked siltstone won from the excavation of the northern end of the quarry. The minimum requirements of the CCL was a thickness of 300 mm ± 25 mm, maximum permeability of 1x10^{-6} m/s, relative density ratio of 95 % (AS1289 5.1.1), less than 20 % particles coarser than 20 mm with no particles coarser than 40 mm and moisture range when compacted 60 % to 95 % of optimum moisture content (AS1289 5.1.1),
- Geotextile Separation Layer with a nominal mass of 200 g/m^2,
- Leachate Collection Layer with minimum thickness of 300 mm, minimum permeability of 1x10^{-3} m/s, sufficiently large pore space > 20 mm to prevent encrustation, uniform, rounded, smooth surfaced with stone size > 20 mm, non-reactive in mildly acidic conditions and free of carbonates, and
- Geotextile Separation Layer with a nominal mass of 200 g/m^2.

A green waste emplacement and processing area is located in the northern part of the facility. Photographs of the waste emplacement and green waste areas are provided in Fig. 6.37.

Fig. 6.37 Waste Emplacement Area (LHS) and Green Waste Area (RHS)

The main leachate pond (Ref. AW002_d01) is located at the base of the natural valley, downslope of the waste emplacement area. The pond has an HDPE lining (estimated 1.5 mm thick) and has a capacity of around 6 ML. A well located at the base of the natural valley collects leachate from the unlined area and a buried 150 mm diameter PN16 PE pipeline (RCA, 2005) within gravel backfill collects leachate from the lined area. Photographs of the main leachate pond and leachate well are provided in Fig. 6.38.

Fig. 6.38 Main Leachate Pond (AW002_d01) and Leachate Well

A secondary leachate pond (AW002_d05) is located in the northern part of the facility. A buried Victaulic pipe at 600 mm cover with bolted connections (RCA, 2005), which follows the unsealed access road, allows leachate to be pumped between the main and secondary leachate ponds. Sediment ponds (AW002_d02 to AW002_d04) are also located at the southern end of the site. These ponds store surface water runoff which is captured using the surface drains around the perimeter of the waste emplacement area.

Gas wells have been established in the waste emplacement area to collect the landfill gas (LFG) generated by the breakdown of organic waste. The gas wells comprise vertical pipes in oversized boreholes within the emplaced waste. The upper sections of the pipes are solid metal casings in soil backfill and the lower sections are perforated PVC casings in gravel backfill. Polyethylene pipelines are connected to the wellheads which transport the captured LFG to the flare installation and the gas powered generation installation. Photographs of a typical gas well and the gas flare installation are provided in Fig. 6.39.

Fig. 6.39 Gas Drainage and Flare

The gas powered generation installation (AW002_pa02 and AW002_pa03) is operated by LMS Energy within the AWMF site. The installation generates around 9,000 MWh of electricity per year using the LFG captured by the gas wells. The plant and building structures are founded on concrete ground slabs or concrete plinths. Other features include the buried gas pipework, lightning protection and fencing. Photographs of the gas powered generation installation are provided in Fig. 6.40.

Fig. 6.40 Gas Powered Generation Plant (AW002_pa02 and AW002_pa03)

There are also a number of building structures and associated infrastructure located near the entry to the AWMF site. The administration building (AW002_pa01) is a single-storey brick structure founded on a slab on ground and with metal roof. Two weigh bridges are also located at the entry, which comprise suspended reinforced concrete slabs, supported by steel beams, sitting between concrete upstands. It is noted, that the weigh bridges are proposed to be replaced prior to the proposed longwalls mining beneath them. The recycling depot has three metal storage sheds (AW002_pa04 to AW002_pa06) which are founded on concrete slabs on ground. Photographs of the administration building, weigh bridges and storage sheds are provided in Fig. 6.41 and Fig. 6.42.

Fig. 6.41 Administration Building and Weigh Bridge (AW002_pa01)

Fig. 6.42 Recycling Depot (AW002_pa04 to AW002_pa06)

The LMCC are proposing to expand the waste emplacement area and to construct an Alternative Waste Treatment (AWT) facility, which are the subjects of a current development application which was submitted in December 2011. The approximate location of the proposed expansion is indicated in Fig. 6.34. The proposed expansion also includes a new green waste processing area east of the current landfill. It has also been proposed to construct a new sewerage pipeline along Wilton Road to connect the AWMF with the pumping station on Dorrington Road.

6.17.2. Predictions for the Awaba Waste Management Facility

The approximate extent of the existing waste emplacement area is indicated in Fig. 6.34 and Drawing No. MSEC537-12. A summary of the maximum predicted subsidence parameters, at the natural ground level, for this area is provided in Table 6.21. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.21 Maximum Predicted Total Conventional Subsidence Parameters at the Natural Ground Level for the Waste Emplacement Area

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	< 20	< 0.5	0.01	< 0.01
After LW102	375	7.5	0.15	0.02
After LW103	1075	12.0	0.20	0.40

The waste emplacement is only partially compacted and, therefore, additional consolidation could occur as a result of mine subsidence movements. Similar behaviour is observed when unconsolidated spoil heaps are directly mined beneath. As there is limited subsidence monitoring data over waste emplacements areas, which were directly mined beneath, the empirical relationships that have been developed for unconsolidated spoil heaps has been used, which is illustrated in Fig. 6.43 (Whittaker and Reddish, 1989).

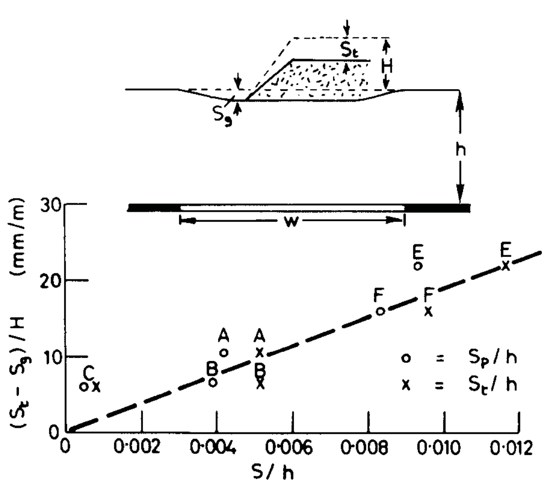


Fig. 6.43 Relationship between Excess Settlement of Mine Spoil Heap and the S/H Ratio (Whittaker and Reddish, 1989)

The maximum predicted subsidence (S) at the natural surface, beneath the waste emplacement area, is 1075 mm and the minimum depth of cover (h) between the seam and natural surface is 270 metres. The ratio of subsidence (S) to depth of cover (h) at the waste emplacement area is 0.004. The predicted additional settlement of the waste emplacement, therefore, is approximately 10 mm/m, or 1 % of the height of the emplacement.

Based on a maximum height of 50 metres, the additional consolidation of the waste emplacement is predicted to be around 0.5 metres. It is noted, that the consolidation due to mine subsidence movements is additional to the natural consolidation of the waste emplacement.

The waste emplacement is located within a natural valley which could also experience valley related movements as the result of mining. The maximum predicted movements for the valley, based on a natural valley height of 30 metres, are 200 mm upsidence and 400 mm closure.

The predicted conventional subsidence, tilts and curvatures for the building structures within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the building structures associated with the AWMF is provided in Table 6.22. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed longwalls.

Table 6.22 Maximum Predicted Total Conventional Subsidence Parameters for the Building Structures at the Awaba Waste Management Facility

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AW002_pa01	100	2.0	0.04	< 0.01
AW002_pa02	25	< 0.5	< 0.01	< 0.01
AW002_pa03	25	< 0.5	< 0.01	< 0.01
AW002_pa04	650	10.5	0.15	0.05
AW002_pa05	350	7.0	0.14	0.03
AW002_pa06	700	10.5	0.15	0.05
AW002_pa07	650	3.5	0.08	0.05
AW002_pa08	700	4.0	0.08	0.05

The maximum predicted conventional curvatures for the building structures are 0.15 km^{-1} hogging and 0.05 km^{-1} sagging, which represent minimum radii of curvature of 7 kilometres and 20 kilometres, respectively. The maximum predicted conventional strains for the building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 1.5 mm/m tensile and 0.5 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The predicted conventional subsidence, tilts and curvatures for the dams within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.02, in Appendix D. A summary of the maximum predicted subsidence parameters for the leachate and sediment ponds associated with the AWMF is provided in Table 6.23. The predicted movements are the maxima within a distance of 20 metres of each pond, at any time during or after the extraction of the proposed longwalls.

Table 6.23 Maximum Predicted Total Conventional Subsidence Parameters for the Ponds at the Awaba Waste Management Facility

Building Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AW002_d01	150	2.5	0.06	0.01
AW002_d02	450	9.0	0.15	0.04
AW002_d03	< 20	< 0.5	< 0.01	< 0.01
AW002_d04	< 20	< 0.5	< 0.01	< 0.01
AW002_d05	850	6.0	0.18	0.06

The maximum predicted conventional curvatures for the ponds are 0.18 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvature of 6 kilometres and 17 kilometres, respectively. The maximum predicted conventional strains for the ponds, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 2.0 mm/m tensile and 0.5 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The approximate locations of the proposed expansion to the waste emplacement area and the proposed AWT facility are indicated in Fig. 6.34. Summaries of the maximum predicted subsidence parameters, at the natural ground level, for these proposed areas are provided in Table 6.24 and Table 6.25. The tilts are the maximum predicted values which occur after the completion of each of the proposed longwalls. The curvatures are the maximum predicted values which occur at any time during or after the extraction of each of the proposed longwalls.

Table 6.24 Maximum Predicted Total Conventional Subsidence Parameters at the Natural Ground Level for the Proposed Expansion to the Waste Emplacement Area

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	30	0.5	0.01	< 0.01
After LW102	600	10	0.15	0.05
After LW103	1000	12.0	0.20	0.40

Table 6.25 Maximum Predicted Total Conventional Subsidence Parameters at the Natural Ground Level for the Proposed AWT Facility

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After LW101	625	6.0	0.05	0.05
After LW102	950	10.5	0.15	0.35
After LW103	1050	11.0	0.20	0.40

The maximum predicted conventional curvatures for both the proposed expansion to the waste emplacement area and the proposed AWT facility are 0.20 km^{-1} hogging and 0.40 km^{-1} sagging, which represent minimum radii of curvature of 5 kilometres and 2.5 kilometres, respectively. The maximum predicted conventional strains for these proposed areas, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 2.0 mm/m tensile and 4.0 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.17.3. Impact Assessments for the Awaba Waste Management Facility

The following sections provide impact assessments for the infrastructure associated with the Awaba Waste Management Facility. These impact assessments should also be read in conjunction with those undertaken by Pells Sullivan and Meynink (PSM, 2012) and ACOR Appleyard (2012).

It has been recognised that the AWMF is one of the most important items of surface infrastructure to be managed during the extraction of the proposed longwalls. The site is extremely complex and, therefore, requires ongoing consultation with the LMCC and its consultants, so that all potential risks are properly identified and that the necessary detailed studies are satisfactorily undertaken to confirm that the appropriate management strategies have been established. The consultation with the LMCC will continue throughout the development of the Subsidence Management Plan, which will allow the ongoing safe operations of the AWMF during and after the extraction of the proposed longwalls.

Waste Emplacement Area

The maximum predicted conventional subsidence at the natural rock surface beneath the waste emplacement area is 1075 mm. It has been estimated, that around 500 mm of additional settlement could occur at the top of the waste emplacement as a result of additional consolidation of the waste material due to the mine subsidence movements.

These subsidence movements are additional to the natural settlement of the waste emplacement which occurs over a long period of time. It has been estimated, that the waste could settle around "*30% or more due to primary and secondary settlement. This corresponds to at least 12 metres of settlement for a waste thickness of up 40 metres*" (PSM, 2012). The predicted mine subsidence movements due to the extraction of the proposed longwalls, therefore, is less than the estimated natural settlement of the waste emplacement.

The natural settlement of the waste emplacement results in differential settlement and cracking of the surface confinement layers over the waste deposits (Jessberger and Stone, 1991). The mining induced subsidence movements could, therefore, result in the development of additional surface cracking and slumping (i.e. downslope movements) which could then increase permeability of the capping layer (Kumar, 1999).

The AWMF facility has established procedures to maintain the integrity of the surface capping layer due to the natural settlement of the waste emplacement. It is recommended, that these procedures are reviewed, so that any potential additional cracking and soil slumping resulting from mine subsidence can be remediated as part of these established procedures.

Further discussions on the potential impacts on the waste emplacement are provided in the report by PSM (2012).

Lining and Leachate Collection System

The original waste emplacement area was unlined. The new cell in the south-eastern corner of the area, as indicated in Fig. 6.34, was constructed with a liner. Discussions on the potential impacts on the liner are provided in the report by PSM (2012).

The unlined section of the waste emplacement area uses the natural bedrock levels to funnel leachate downslope to the leachate collection well. The extraction of the proposed longwalls will result in fracturing and dilation of the topmost bedrock layers which could increase permeability of these near surface strata layers.

It has been observed in the past, that the depth of fracturing and dilation of the uppermost bedrock, resulting from longwall mining, is generally less than 10 metres to 15 metres (Mills 2003, Mills 2007, and Mills and Huuskes 2004). This was also supported by the Independent Inquiry into the Impacts of Potential Underground Coal Mining in the Wyong Local Government Area (DoP, 2008) which stated that "*The main fracture network extends to a depth of about 12 m and bed separation extends to a depth of some 20 m*".

The extent of these mining induced valley related ground movements are dependent on a number of factors, which include the size of the valley, the local geology, the magnitude of mining induced subsidence movements and the proximity of the longwalls to the valley. The method of prediction (ACARP, 2001) has been designed to generally provide conservative predictions and, therefore, it is expected that the actual valley related movements would be less than those predicted.

It is recommended, therefore, that ground monitoring lines are established above the earlier proposed Longwalls 101 and 102. In this way, the observed ground movements can be compared with those predicted and, hence, the impact assessments can be reviewed based on the measured data.

As described in Section 4.8, it is unlikely that continuous fracturing would extend from the seam up to the surface. The estimated height of continuous cracking (i.e. A Horizon) is 130 metres to 160 metres. The minimum depth of cover beneath the AWMF is around 270 metres and, therefore, the thickness of the constrained zone is estimated to be between 110 metres and 140 metres.

It is possible that the height of continuous fracturing could be less than predicted and, hence, the thickness of the constrained zone could be greater than predicted, as extensometer measurements at the adjacent West Wallsend Colliery indicate that the caved zone only extended 71 metres above the West Borehole Seam (DoP, 2012).

It is expected, therefore, that the leachate would remain confined to the near surface strata. It is recommended, however, that further studies are undertaken to better assess the changes in permeability, which could include ground displacement monitoring (above ground and subsurface), and surface and groundwater flow monitoring, above the earlier proposed Longwalls 101 and 102. The outcomes of these studies will better define the potential depth of leachate ingress and, hence, the adequacy of the existing leachate collection system after mining.

Further discussions on the potential impacts on the leachate collection system are provided in the report by PSM (2012) and further discussions on the groundwater system are provided in the report by *GHD* (2012b).

Leachate and Sediment Ponds

The main leachate pond (Ref. AW002_d01) is predicted to experience a maximum subsidence of 150 mm, which occurs along its eastern side. The predicted differential subsidence along the main length of the pond is around 100 mm and, therefore, could result in a reduction in capacity of around 150 m^3, or 150 kL, which could be considered negligible when compared with its capacity of around 6 ML.

The maximum predicted curvatures for the main leachate pond are 0.06 km^{-1} hogging and 0.01 km^{-1} sagging, which represent minimum radii of curvature of 17 kilometres and 100 kilometres, respectively. The maximum predicted conventional strains for the pond, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and less than 0.5 mm/m compressive. The final strain is expected to be uni-axial, along the main axis of the pond, however, some rotation in the direction of strain could occur during mining.

The HDPE liner would be expected to tolerate curvatures and strains of these magnitudes without adverse impacts. Further discussions on the potential impacts on the HDPE liner in the main leachate pond are provided in the report by PSM (2012).

The maximum predicted subsidence at the sediment pond (Ref. AW002_d02) and the secondary leachate pond (Ref. AW002_d05) are 450 mm and 850 mm, respectively. The predicted differential subsidence at these ponds is up to 150 mm which could result in reductions in capacities around 100 m^3 (i.e. 100 kL) for AW002_d02 and 350 m^3 (i.e. 350 kL) for AW002_d05, which are small when compared with the existing capacities.

The maximum predicted curvatures for the sediment pond and the secondary leachate pond are 0.18 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvature of 6 kilometres and 17 kilometres, respectively. The maximum predicted conventional strains for these ponds, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 2 mm/m tensile and 0.5 mm/m compressive.

The predicted strains could be of sufficient magnitudes to result in cracking of the clay linings of AW002_d02 and AW002_d05. There is extensive experience of mining directly beneath dams and ponds in the NSW Coalfields, at similar depths of cover, which indicates that the incidence of impacts on these features is low. Any loss of water from these ponds would be captured by the leachate collection system. Cracking in the ponds could be readily identified and repaired, if required.

The predicted subsidence at the remaining sediment ponds (Refs. AW002_d03 and AW002_d04) are both less than 20 mm. Whilst these ponds could experience subsidence slightly greater than 20 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that these ponds would be adversely impacted as the result of mining.

Further discussions on the potential impacts on the sediment ponds are provided in the report by PSM (2012).

Gas Drainage Infrastructure

The gas drainage infrastructure is established in the top of the waste emplacement. As described previously under the subsection titled "*Waste Emplacement Area*", the predicted subsidence at the top of the emplacement around 1.6 metres (i.e. 1075 mm at the natural surface plus additional settlement around 500 mm) is less than the estimated natural settle of the emplacement of around 12 metres (PSM, 2012).

It is likely, therefore, that the gas drainage infrastructure could tolerate the predicted subsidence resulting from the extraction of the proposed longwalls. It is recommended, however, that management strategies be developed to remediate any impacts on the wells or pipework resulting from the extraction of the proposed longwalls.

Gas Powered Generation Plant

The structures associated with the gas powered generation plant (Refs. AW002_pa02 and AW002_pa03) are predicted to experience around 25 mm of subsidence resulting from the extraction of the proposed longwalls. Whilst it is still possible that these structures could experience subsidence slightly greater than 25 mm, they would not be expected to experience any significant conventional tilts, curvatures or strains. It is unlikely, therefore, that the structures and associated infrastructure at this site would be adversely impacted as the result of mining.

Further discussions and assessments on the potential impacts on the building structures are provided by ACOR Appleyard (2012).

Building Structures

The administration building (Ref. AW002_pa01) is predicted to experience a maximum tilt of 2 mm/m (i.e. 0.2 %), which represents a change in grade of 1 in 500. Tilts less than 7 mm/m generally do not result in any significant impacts on building structures and, therefore, the administration building is unlikely to be adversely impacted by the mining induced tilt in this case.

The maximum predicted curvatures for the administration building are 0.04 km^{-1} hogging and less than 0.01 km^{-1} sagging, which represent minimum radii of curvature of 25 kilometres and greater than 100 kilometres, respectively. The maximum predicted conventional strains for the building, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and less than 0.5 mm/m compressive.

The potential impacts on the administration building have been determined using the method outlined in ACARP Research Project C12015 (ACARP, 2009). The assessed impacts for the administration building are provided in Table 6.26. Further details on the repair categories are provided in ACARP (2009).

Table 6.26 Assessment Impacts for the Administration Building (Ref. AW002_pa01)

Repair Category	Assessed Likelihood	Description of Potential Impacts
Nil or R0	80 %	Door or window jams, or movements at joints in internal finishes
R1 or R2	15 %	Cracks in brick mortar, isolated cracks in brickwork, or cracks or movement in internal finishes, typically less than 5 mm in width.
R3 or greater	5 %	Cracks in external brickwork or internal finishes between 5 mm and 15 mm and, possibly in some locations, greater than 15 mm.

It is expected that any impacts on the administration building could be repaired using normal building maintenance techniques.

The sheds associated with the recycling depot (Refs. AW002_pa04 to AW002_pa06) and the sheds located directly above the proposed longwalls (Refs. AW002_pa07 and AW002_pa08) are predicted to experience tilts up to 10.5 mm/m (i.e. 1.1 %), which represents a change in grade of 1 in 95. It is possible that some of these sheds could experience minor serviceability impacts, including door swings and issues with roof gutter drainage, which could be repaired using normal building maintenance techniques.

The maximum predicted curvatures for these sheds are 0.15 km^{-1} hogging and 0.05 km^{-1} sagging, which represents minimum radii of curvature of 7 kilometres and 20 kilometres, respectively. The maximum predicted conventional strains for these structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 1.5 mm/m tensile and 0.5 mm/m compressive.

The sheds are of flexible construction and it is expected, therefore, that these structures could tolerate curvatures and strains of these magnitudes without significant impacts. There is extensive experience of mining directly beneath steel framed sheds in the NSW Coalfields, at similar depths of cover, which indicates that the incidence of impacts on these structures is very low. It is expected that any impacts on the sheds could be repaired using normal building maintenance techniques.

It is possible, although unlikely (i.e. less than 1 %), that these sheds could experience impacts as the result of irregular ground movements. It is unlikely, that these types of structure would become unstable, in this case, but more extensive repairs may be required.

Further discussions and assessments on the potential impacts on the building structures are provided by ACOR Appleyard (2012).

The Weigh Bridges

It is noted, that whilst the weigh bridges are proposed to be replaced, prior to the proposed longwalls mining beneath them, the following impact assessments have been made based on the existing facility.

The maximum predicted tilt at the weigh bridges is 2.0 mm/m (i.e. 0.2 %), which represents a change in grade of 1 in 500. Tilting, if sufficiently large, can displace the centre of gravity of the vehicle which can then reduce the accuracy of the measurement. In this case, however, the predicted tilt is very small (i.e. less than 1 %) and unlikely, therefore, to result in any adverse impact on the bridges.

The maximum predicted curvature for the weigh bridges is 0.04 km^{-1} hogging, which represent minimum radius of curvature of 25 kilometres. The predicted hogging curvature could result in an uplift of around 2 mm at the expansion joints at the ends of the weigh bridges, based on a bridge length of 20 metres. The predicted differential vertical movement is very small and, if necessary, some adjustment of the weigh bridge structure may be required. If the uplift exceeds the allowable tolerances, it may be necessary to modify the levels of the concrete ramp approach and steel angle.

The maximum predicted conventional strains for the weigh bridges, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and less than 0.5 mm/m compressive. The predicted strains could result in an opening of 10 mm or closure less than 10 mm across the weigh bridges, based on a bridge length of 20 metres. If the opening or closure movements exceed the allowable tolerances, it may be necessary to modify the levels of the concrete ramp approach and steel angle.

Further discussions and assessments on the potential impacts on the building structures are provided by ACOR Appleyard (2012)

6.17.4. Impact Assessments for the Awaba Waste Management Facility Based on Increased Predictions

If the actual subsidence at the waste emplacement exceeded that predicted by a factor of 1.5 times, the maximum subsidence at the natural surface would be 1600 mm. In this case, the estimated settlement at the top of the waste emplacement would be around 2400 mm, which is still less than that estimated for natural settlement. Whilst the potential for cracking and slumping of the capping layer would increase, it would be expected that these impacts could be managed using the established procedures to maintain the integrity of the surface capping layer due to the natural settlement.

If the actual curvatures at the waste emplacement exceeded those predicted by a factor of 2 times, the maximum curvatures would be 0.40 km^{-1} hogging and 0.80 km^{-1} sagging, which represent minimum radii of curvatures of 2.5 kilometres and 1.3 kilometres, respectively. The maximum predicted conventional strains, based on applying a factor of 10 to the maximum predicted conventional curvatures, would be 4 mm/m tensile and 8 mm/m compressive. In this case, the extents and widths of surface cracking would increase, but it would still be expected that the depths of fracturing would be less than 10 metres to 15 metres, as has been observed elsewhere in the NSW Coalfields. It would still be unlikely that continuous fracturing would extend from the seam up to the surface, as the estimated heights have been based on observations from the Newcastle Coalfield.

If the actual tilts at the leachate and sediment ponds exceeded those predicted by a factor of 2 times, the maximum tilt would be 18 mm/m (i.e. 1.8 %, or 1 in 55). In this case, the storage capacities of the ponds located directly above the proposed longwalls (i.e. AW002_d02 and AW002_d05) could be reduced slightly, but it would still be unlikely to result in any instability of the pond walls.

If the actual curvatures at the main leachate pond exceeded those predicted by a factor of 2 times, the maximum curvatures would be 0.12 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 8 kilometres and 50 kilometres, respectively. The maximum predicted conventional strains for the pond, based on applying a factor of 10 to the maximum predicted conventional curvatures, would be 1 mm/m tensile and less than 0.5 mm/m compressive. In this case, the curvatures and strains would still be less than the capacity of the HDPE liner and, therefore, it would still be unlikely that any adverse impacts would occur.

If the actual curvatures at the secondary leachate pond or the sediment ponds exceeded those predicted by a factor of 2 times, the maximum curvatures would be 0.36 km^{-1} hogging and 0.12 km^{-1} sagging, which represent minimum radii of curvature of 3 kilometres and 8 kilometres, respectively. The maximum predicted conventional strains for these ponds, based on applying a factor of 10 to the maximum predicted conventional curvatures, would be 4 mm/m tensile and less than 1 mm/m compressive. In this case, the likelihood and extent of surface cracking at the ponds located above the proposed longwalls (i.e. AW002_d02 and AW002_d05) would increase. Based on previous experience of mining beneath dams in the NSW Coalfields, at similar depths of cover, it would still be unlikely that there would be any loss of stored waters from these ponds.

If the actual tilts at the building structures exceeded those predicted by a factor of 2 times, the maximum tilts would be 4 mm/m (i.e. 0.4 %, or 1 in 250) at the administration building and 21 mm/m (i.e. 2.1 %, or 1 in 45) at the sheds. In this case, serviceability impacts could occur at the sheds located directly above the proposed longwalls, including door swings and issues with roof gutter and pavement drainage, which could be repaired using normal building maintenance techniques.

If the actual curvatures at the building structures exceeded those predicted by a factor of 2 times, the maximum curvatures would be 0.08 km^{-1} hogging and 0.02 km^{-1} sagging, for the administration building, and would be 0.30 km^{-1} hogging and 0.10 km^{-1} sagging, for the sheds. In this case, the sizes and extents of cracking in the brickwalls of the administration building would increase, but it would still be expected that any impacts could be remediated using normal building maintenance techniques. The incidence of impacts on the sheds, which are of flexible construction, would still be expected to be low. It would still be unlikely that any of the building structures would become unsafe, even if the movements exceeded those predicted by a factor of 2 times.

6.17.5. Recommendations for the Awaba Waste Management Facility

The detailed management strategies for the AWMF will be developed, through ongoing consultation with the LMCC and its consultants, as part of the development of the Property Subsidence Management Plan. Based on the outcomes of the studies undertaken, to date, it is recommended that the following are considered as part of these works:-

- Establish the appropriate monitoring above the earlier proposed Longwalls 101 and 102, which could include:-
  - Extensometers and/or piezometers in equivalent locations above the earlier longwalls to confirm the height of fracturing above the seam and the changes in the hydraulic conductivity of the near surface strata, and
  - Ground monitoring lines above the earlier longwalls, so that the observed surface movements can be compared with those predicted and, so that, the impact assessments can be reviewed in light of the measured data.
- Develop the appropriate preventive or remediation measures, if the outcomes of the detailed studies or monitoring over earlier longwalls indicate potential impacts, which could include:-
  - Methods of reducing the permeability of the capping layer over the waste emplacement area and, hence, to reduce the ingress of water and production of leachate, and/or
  - Upgrade the existing leachate collection well, if required, or the establishment of additional leachate collection wells downslope of the waste emplacement area.
- Develop a Trigger Action Response Plan (TARP), in consultation with the LMCC and its consultants, based on the outcomes of the detailed studies, monitoring above earlier longwalls and the established preventive or remediation measures.
- Install the appropriate monitoring at the AWMF site to measure the subsidence movements resulting from mining, which could include:-
  - Extensometers or/and piezometers to monitor the heights of fracturing and changes in hydraulic conductivity,
  - Ground monitoring line along the access road to measure the movements at the natural surface level, and/or
  - Ground monitoring line over the completed area of waste emplacement to measure the movements resulting from both mine subsidence and immediate settlement.
- The preventive or remediation measures, TARP and monitoring should be formalised in the agreement Property Subsidence Management Plan for the facility.

6.18. Archaeological Sites

The locations of the archaeological sites within the SMP Area are shown in Drawing No. MSEC537-10. The descriptions, predictions and impact assessments for these sites are provided in the following sections. The locations of types of archaeological sites are based on the information gathered by *RPS* (2012b).

6.18.1. Descriptions of the Archaeological Sites

There are no lands within the SMP Area declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*. There are nine archaeological sites which have been identified within the SMP Area. A summary of these sites is provided in Table 6.27 (RPS, 2012b).

Table 6.27 Archaeological Sites Identified within the SMP Area (RPS, 2012b)

Recording Code	Site Name	Site Type
45-7-0260	LEA10	Axe Grinding Grooves
45-7-0295	RPS Newst 2	Isolated Find
45-7-0296	RPS Newst 3	Isolated Find
45-7-0297	RPS Newst 4	Isolated Find
45-7-0298	RPS Newst 5	Isolated Find
45-7-0299	RPS Newst 6	Artefact Scatter
45-7-0303	RPS Newst 10	Isolated Find
45-7-0309	RPS Newst 16	Isolated Find
45-7-0005 / 45-7-0310	RPS Newst 17	Rock Shelter, possible grinding grooves

Detailed descriptions of the archaeological sites within the SMP Area are provided by *RPS* (2012b).

6.18.2. Predictions for the Archaeological Sites

The predicted conventional subsidence, tilts and curvatures for the archaeological sites within the SMP Area, after the extraction of each of the proposed longwalls, are provided in Table D.03, in Appendix D. A summary of the maximum predicted conventional subsidence parameters for the archaeological sites is provided in Table 6.28. The predicted tilts are the maxima after the completion of any or all of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of the proposed longwalls.

Table 6.28 Maximum Predicted Total Conventional Subsidence Parameters for the Archaeological Sites Resulting from the Extraction of the Proposed Longwalls

Location	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
45-7-0260	50	0.5	0.01	< 0.01
45-7-0295	100	1.5	0.02	< 0.01
45-7-0296	200	2.0	0.04	< 0.01
45-7-0297	200	2.0	0.03	< 0.01
45-7-0298	150	2.0	0.03	< 0.01
45-7-0299	800	6.0	0.07	0.12
45-7-0303	50	0.5	< 0.01	< 0.01
45-7-0309	850	10.0	0.17	0.09
45-7-0005 / 45-7-0310	650	1.0	0.06	0.02

The maximum predicted conventional strains for the archaeological sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 2 mm/m tensile and 1 mm/m compressive. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.18.3. Impact Assessments for the Open Sites

There are seven sites comprising artefact scatters or isolated finds within the SMP Area, being Sites 45-7-0295, 45-7-0296, 45-7-0297, 45-7-0298, 45-7-0299, 45-7-0303 and 45-7-0309.

The maximum predicted tilt for the open sites is 10 mm/m (i.e. 1.0 %), which represents a change in grade of 1 in 100. It is unlikely that these sites would experience any adverse impacts resulting from the mining induced tilts.

The maximum predicted curvature for the open sites are 0.17 km^{-1} hogging and 0.12 km^{-1} sagging, which represent minimum radii of curvature of 6 kilometres and 8 kilometres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 2 mm/m tensile and 1 mm/m compressive.

These open sites can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that the scattered artefacts or isolated finds themselves would be impacted by surface cracking. It is possible, however, that if remediation of the surface was required after mining, that these works could potentially impact the open sites.

It is recommended that Newstan seek the required approvals from the appropriate authorities, in the event that remediation of the surface is required in the locations of the artefact scatter sites.

Further assessments of the potential impacts on the open sites are provided in a report by *RPS* (2012b).

6.18.4. Impact Assessments for the Grinding Groove Site

There is one confirmed grinding groove site within the SMP Area, being Site 45-7-0260, and a possible additional grinding groove site at Site 45-7-0005/45-7-0310.

Site 45-7-0260 is located around 150 metres east of the proposed longwalls. At this distance, the predicted conventional subsidence movements are negligible (i.e. less than the order of survey tolerance). It is unlikely, therefore, that the extraction of the proposed longwalls would result in any adverse impacts on the grinding grooves at Site 45-7-0260.

It is noted, however, that minor and isolated fracturing have been observed in stream beds up to around 400 metres from longwall mining in the NSW Coalfields. Fracturing at a distance of 150 metres from longwall mining, such as the case for Site 45-7-0260, is rare and generally associated with large river valleys in the Southern Coalfield. Whilst it is possible that minor and isolated fracturing could occur, the likelihood that fracturing would be coincident with the grinding grooves at Site 45-7-0260 is considered extremely low.

Site 45-7-0005 / 45-7-0310 is located directly above the proposed Longwall 101. The predicted maximum tilt for this site is 1.0 mm/m (i.e. 0.1 %), which represents changes in grade of 1 in 1,000. It is unlikely that this site would experience any adverse impacts resulting from the mining induced tilt of this magnitude.

The predicted maximum curvatures at Site 45-7-0005 / 45-7-0310 are 0.06 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 17 kilometres and greater than 50 kilometres, respectively. The maximum predicted conventional strains for this site, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.6 mm/m tensile and 0.2 mm/m compressive (i.e. in the order of survey tolerance).

Fracturing in bedrock has been observed in the past, as a result of longwall mining, where tensile strains were greater than 0.5 mm/m or where compressive strains were greater than 2 mm/m. It is possible, therefore, that fracturing of the bedrock could occur in the vicinity of Site 45-7-0005 / 45-7-0310.

Preventive measures could be implemented at the possible grinding grooves at Site 45-7-0005 / 45-7-0310, if required, including slotting of the bedrock around the site to isolate it from the ground curvatures and strains. It is possible, however, that the preventive measures could result in greater impacts on the site than those which would have occurred as a result of mine subsidence movements.

Further assessments of the potential impacts on the grinding groove site are provided in a report by *RPS* (2012b).

6.18.5. Impact Assessments for the Rock Shelter

There is one shelter site within the SMP Area, being Site 45-7-0005/45-7-0310, which is located above the maingate of the proposed Longwall 101. The maximum predicted tilt for the shelter is 1.0 mm/m (i.e. 0.1 %), which represents a change in grade of 1 in 1,000. It is unlikely that this site would experience any adverse impacts resulting from the mining induced tilt.

The maximum predicted curvatures for the shelter are 0.06 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 17 kilometres and 50 kilometres, respectively. The maximum predicted conventional strains for this site, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.6 mm/m tensile and 0.2 mm/m compressive (i.e. in the order of survey tolerance).

It is extremely difficult to assess the likelihood of instabilities for the rock shelter based upon predicted ground movements. The likelihood of the shelter becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rockmass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of the shelter naturally or when it is exposed to mine subsidence movements.

The predicted curvatures and conventional strains are less than the typical movements in the Southern Coalfield, where these is extensive experience of mining beneath rock shelters. It has been reported that, where longwall mining has previously been carried out in the Southern Coalfield, beneath 52 shelters, that approximately 10 % of the shelters have been affected by fracturing of the strata or shear movements along bedding planes and that none of the shelters have collapsed (Sefton, 2000). This suggests that the likelihood of any significant physical impacts on the rock shelter within the SMP Area, resulting from the extraction of the proposed longwalls, is relatively low.

The experience from the Southern Coalfield indicates that the likelihood of significant physical impacts on rock shelters is relatively low. Further assessments of the potential impacts on the rock shelters are provided in a report by *RPS* (2012b).

6.18.6. Impact Assessments for the Archaeological Sites Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be 20 mm/m (i.e. 2 %, or 1 in 50) for the open sites and 2.0 mm/m (i.e. 0.2 %, or 1 in 500) for the grinding groove and shelter site. These types of archaeological sites are not adversely affected by tilt and, therefore, the likelihoods of impact would not be expected to increase.

If the actual curvatures or strains at the open sites exceeded those predicted by a factor of 2 times, the likelihoods and extents of cracking in the surface soils would also increase. It would still be unlikely that the artefacts themselves would be impacted by the surface cracking and the methods of remediation, if required, would not be expected to change.

If the actual curvatures or strains at the grinding groove and shelter site exceeded those predicted by a factor of 2 times, the likelihoods and extents of fracturing in the bedrock would also increase. Whilst the observed curvatures could exceed those predicted, the experience from the Southern Coalfield indicates that the likelihood of significant impacts on shelters is relatively low. Preventive measures could be implemented at the grinding grooves, however, the preventive measures could result in greater impacts on the site than those which would have occurred as a result of mine subsidence movements.

6.18.7. Recommendations for the Archaeological Sites

It is recommended that a detailed survey of the archaeological sites is undertaken and a monitoring programme established to record the effects of mine subsidence on these sites.

6.19. Heritage Sites

No heritage sites have been identified within the SMP Area.

6.20. Survey Control Marks

The locations of the state survey control marks within the vicinity of the proposed longwalls are shown in Drawing No. MSEC537-10. The locations and details of the survey control marks were obtained using the *Six Viewer* (2012).

There are three state survey control marks located within the Study Area, being TS666, SS77112 and SS77113, which are located directly above the proposed longwalls. These survey control marks could experience the full range of predicted subsidence movements, which are described in Chapter 4.

The state survey control marks located outside and in the vicinity of the SMP Area are also expected to experience small amounts of subsidence and small far-field horizontal movements. It is possible that other survey control marks outside the immediate area could also be affected by far-field horizontal movements, up to 3 kilometres outside the SMP Area. Far-field horizontal movements and the methods used to predict such movements are described further in Sections 3.4 and 4.5.

It will be necessary on the completion of the longwalls, when the ground has stabilised, to re-establish any state survey control marks that are required for future use. Consultation between the Centennial and the Department of Lands will be required to ensure that these survey control marks are reinstated at the appropriate time, as required.

6.21. Houses

No houses have been identified within the SMP Area.

The non-residential building structures within the SMP Area include those associated with the Toronto Adventist Primary School (refer to Section 6.9), the Toronto Country Club (refer to Section 6.10), the Newcastle Lake Macquarie Clay Target Club (refer to Section 6.11), the Westlakes Automobile Club (refer to Section 6.12) and the Awaba Waste Management Facility (refer to Section 6.17).

6.22. Structures or Infrastructure Associated with the Properties

6.22.1. On-Site Waste Water Systems

Some properties within the SMP Area have on-site waste water systems. These systems are expected to experience the full range of predicted movements. A summary of the maximum predicted conventional subsidence movements within the SMP Area is provided in Chapter 4.

The maximum predicted tilt within the SMP Area is 16 mm/m (i.e. 1.6 %, or 1 in 65), which occurs in the north-western corner of the proposed mining area, where the depth of cover is the shallowest. The predicted tilts at the properties within the SMP Area are generally in the order of 1 % or less. It is unlikely, therefore, that the maximum predicted tilts would result in any adverse impacts on the on-site waste water systems. It is possible, that the serviceability of some buried pipes could be adversely impacted, if the existing grades of these pipes are very small, say less than 1 %.

The maximum predicted conventional strains within the SMP Area, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 4 mm/m tensile and 6 mm/m compressive, which also occur in the north-western corner of the mining area, where the depth of cover is the shallowest. The analysis of strains measured in the Newcastle Coalfield, for previously extracted longwalls having similar width-to-depth ratios as the proposed longwalls and panels, is provided in Section 4.3.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The on-site waste water system tanks are generally small, typically less than 3 metres to 5 metres in diameter, are constructed from reinforced concrete or polymer shells, and are usually bedded in sand and backfilled. It is unlikely, therefore, that the maximum predicted curvatures and strains would be fully transferred into the tank structures.

It is possible, however, that the buried pipelines associated with the on-site waste water tanks could be impacted by the strains if they are anchored by the tanks or other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be readily repaired. With the implementation of these remedial measures, it would be unlikely that there would be any adverse long term impacts on the pipelines associated with the on-site waste water systems.

6.22.2. Rigid External Pavements

Adverse impacts on rigid external pavements are often reported to the Mine Subsidence Board in the NSW Coalfields. This is because pavements are typically thin relative to their length and width. The design of external pavements is also not regulated by Council or the Mine Subsidence Board.

A study by MSEC of 120 properties at Tahmoor and Thirlmere indicated that 98 % of the properties with external concrete pavements demonstrated some form of cracking prior to mining. These cracks are sometimes difficult to distinguish from cracks caused by mine subsidence. It is therefore uncertain how many claims for damage can be genuinely attributed to mine subsidence impacts.

Concrete pavements are typically constructed with tooled joints which do not have the capacity to absorb compressive movements. It is possible that some of the smaller concrete footpaths or pavements within the SMP Area, in the locations of the larger compressive strains, could buckle upwards if there are insufficient movement joints in the pavements. It is expected, however, that the buckling of footpaths and pavements would not be common, given the magnitudes of the predicted ground strains, and could be easily repaired.

6.23. Any Known Future Developments

The Awaba Waste Management Facility (AWMF) is proposing to expand the waste emplacement area and to provide an Alternative Waste Treatment (AWT) area, which are described in Section 6.17. A new sewerage pipeline is also proposed along Wilton Road to service the AWMF, which is also described in that section.

There are no other known future developments within the SMP Area.

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the more common mining terms used in the report are defined below:-

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Closure	The reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill movements and other possible strata mechanisms.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*. Curvature can be either **hogging** (i.e. convex) or **sagging** (i.e. concave).
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	The measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.

Shear deformations The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.

Strain The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation.

Tensile Strains are measured where the distance between two points or survey pegs increases and **Compressive Strains** where the distance between two points decreases. Whilst mining induced **strains** are measured **along** monitoring lines, ground **shearing** can occur both vertically, and horizontally **across** the directions of the monitoring lines.

Sub-critical area An area of panel smaller than the critical area.

Subsidence The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.

Subsidence Effects The deformations of the ground mass surrounding a mine, sometimes referred to as 'components' or 'parameters' of mine subsidence induced ground movements, including vertical and horizontal displacements, tilts, curvatures, strains, upsidence and closure.

Subsidence Impacts The physical changes or damage to the fabric or structure of the ground, its surface and natural features, or built structures that are caused by the subsidence effects. These impacts considerations can include tensile and shear cracking of the rock mass, localised buckling of strata, bed separation, rock falls, collapse of overhangs, failure of pillars, failure of pillar floors, dilation, slumping and also include subsidence depressions or troughs.

Subsidence Consequences The knock-on results of subsidence impacts, i.e. any change in the amenity or function of a natural feature or built structure that arises from subsidence impacts. Consequence considerations include public safety, loss of flows, reduction in water quality, damage to artwork, flooding, draining of aquifers, the environment, community, land use, loss of profits, surface improvements and infrastructure. Consequences related to natural features are referred to as environmental consequences.

Super-critical area An area of panel greater than the critical area.

Tilt The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.

Uplift An increase in the level of a point relative to its original position.

Upsidence Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The term uplift is used for the cases where the ground level is raised above the pre-mining level, i.e. when the upsidence is greater than the subsidence. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

APPENDIX B. REFERENCES

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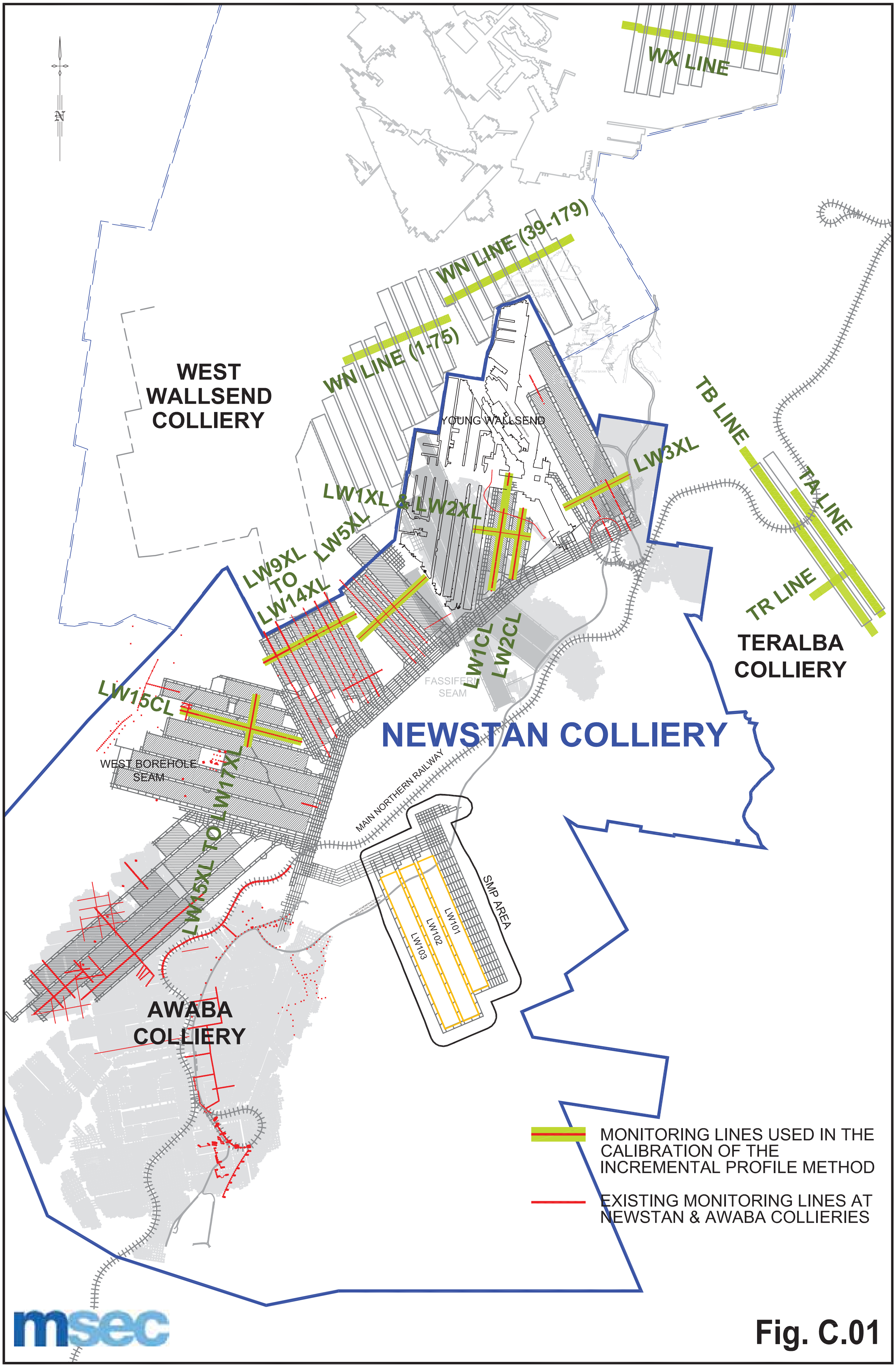
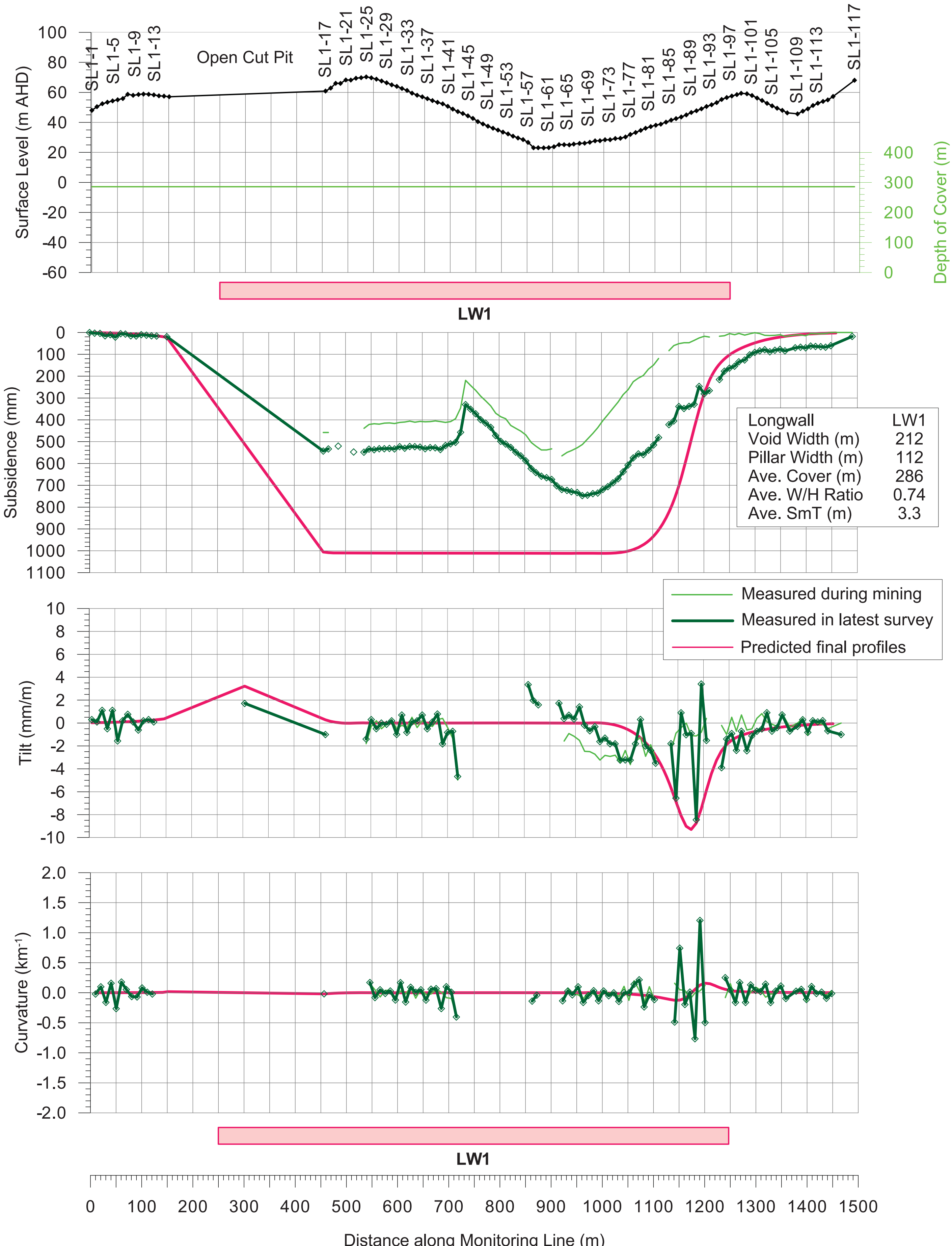
APPENDIX C. COMPARISON BETWEEN OBSERVED AND PREDICTED MINE SUBSIDENCE MOVEMENTS AT NEWSTAN, TERALBA AND WEST WALLSEND COLLIERIES


WX LINE
WN LINE (39-179)
WN LINE (1-75)
WEST
WALLSEND
COLLIERY
YOUNG WALLSEND
TB LINE
TA LINE
LW3XL
LW1XL & LW2XL
LW5XL
LW9XL
TO
LW14XL
TR LINE
TERALBA
COLLIERY
LW1CL
LW2CL
FASSIFERN
SEAM
LW15CL
NEWSTAN COLLIERY
WEST BOREHOLE
SEAM
LW15XL TO LW17XL
MAIN NORTHERN RAILWAY
SMP AREA
LW101
LW102
LW103
AWABA
COLLIERY
MONITORING LINES USED IN THE
CALIBRATION OF THE
INCREMENTAL PROFILE METHOD
EXISTING MONITORING LINES AT
NEWSTAN & AWABA COLLIERIES

msec

Fig. C.01

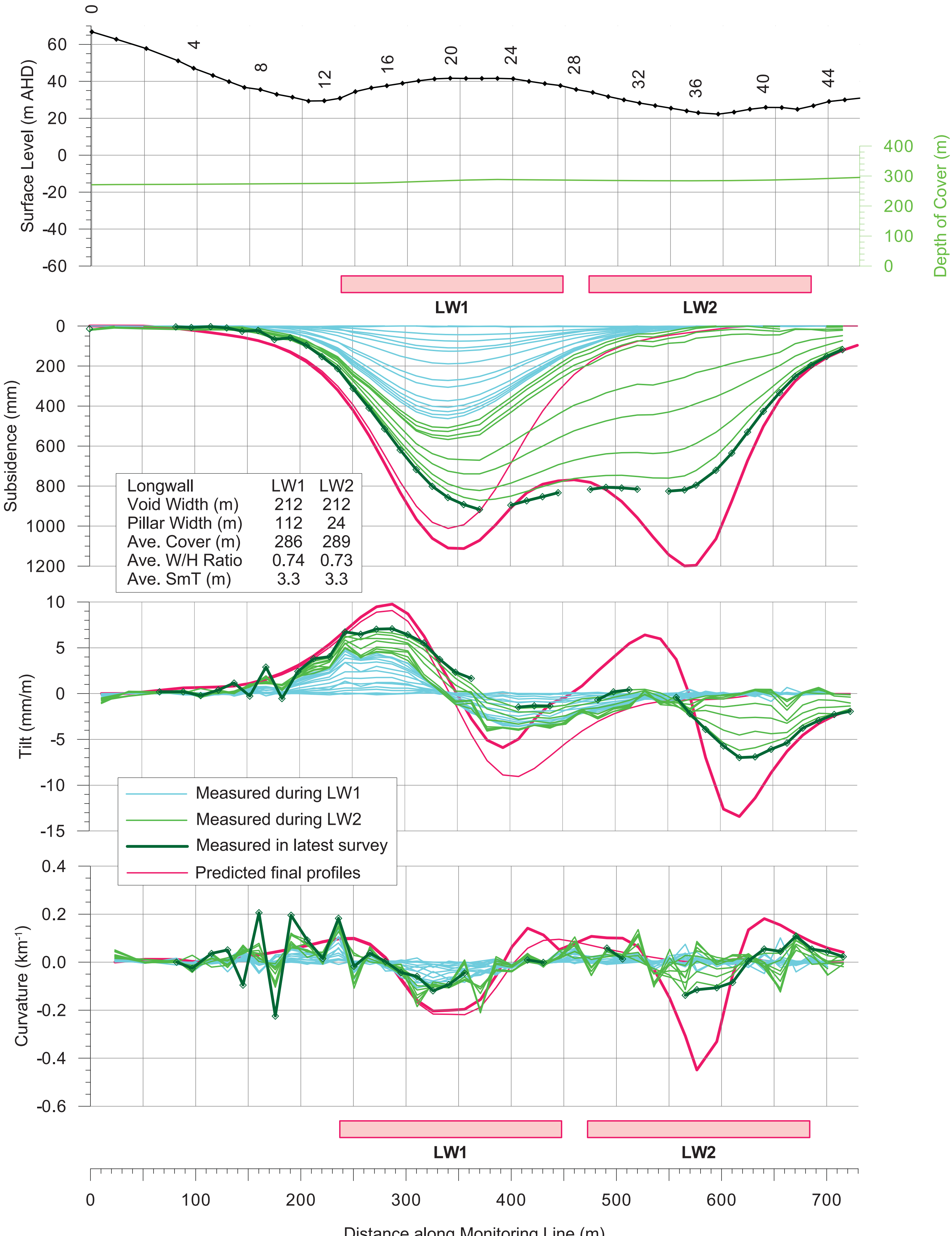
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW1CL Line during Newstan LW1



msec

Fig. C.02

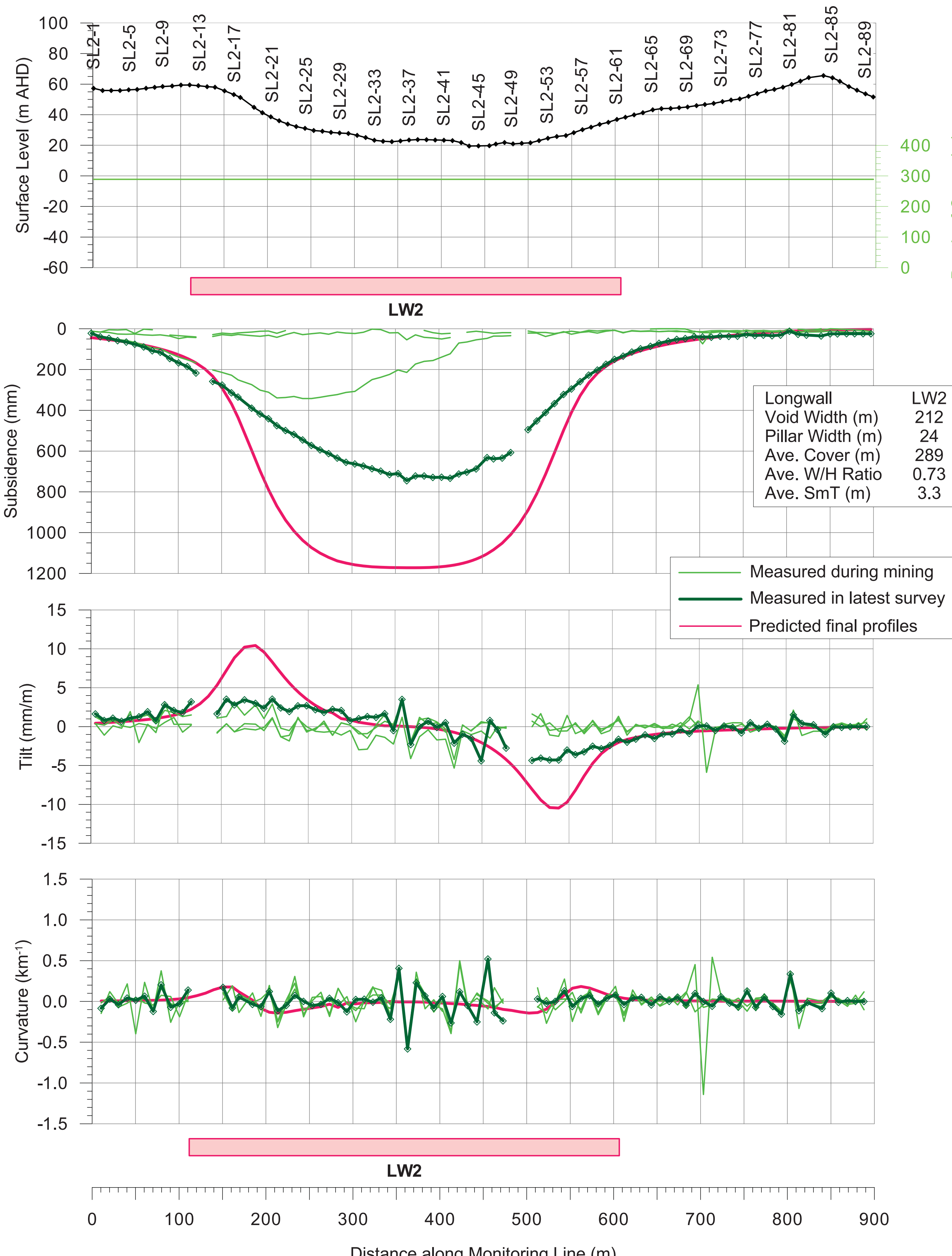
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW1XL & LW2XL Lines during Newstan LW1 & LW2



msec

Fig. C.03

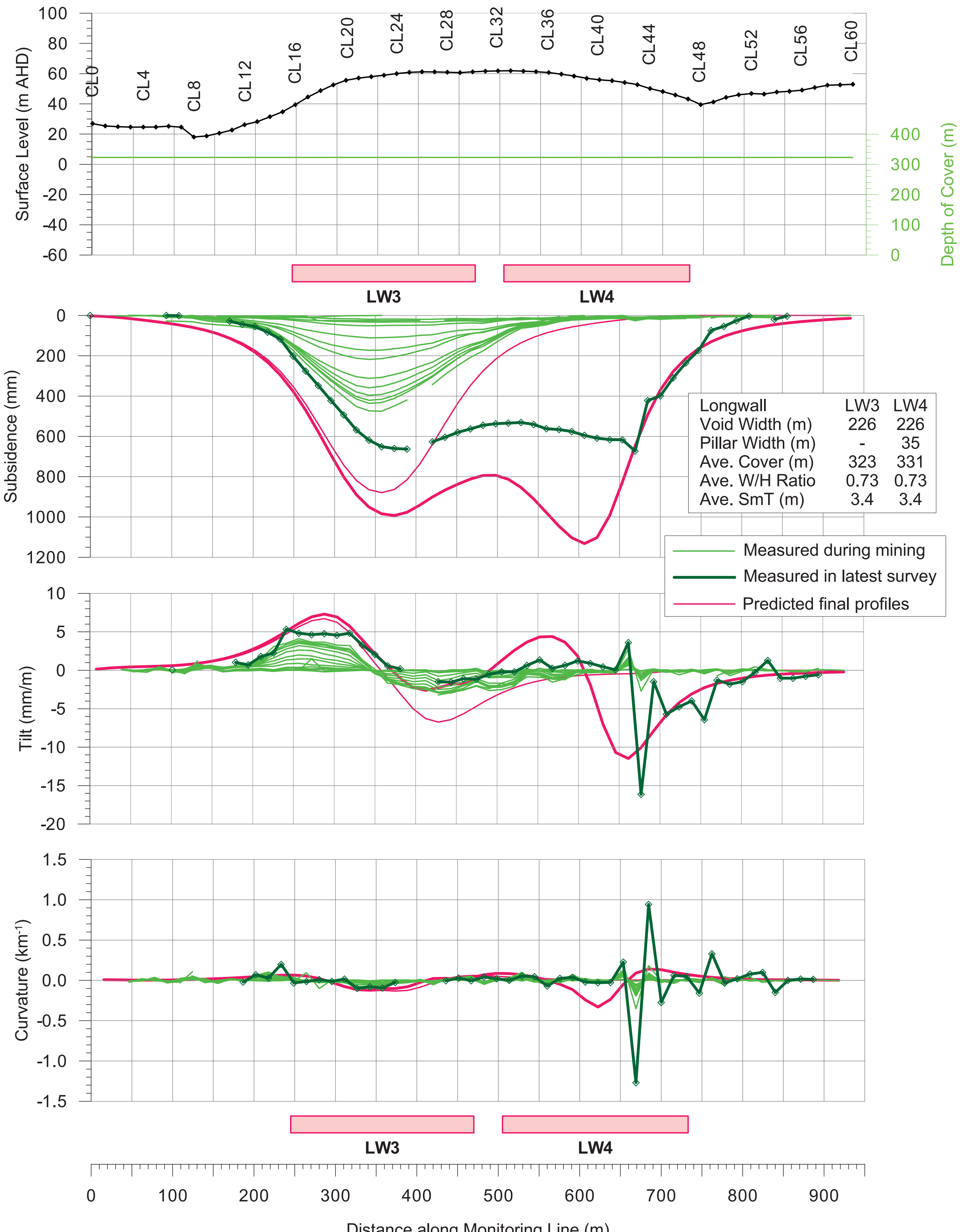
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW2CL Line during Newstan LW2



msec

Fig. C.04

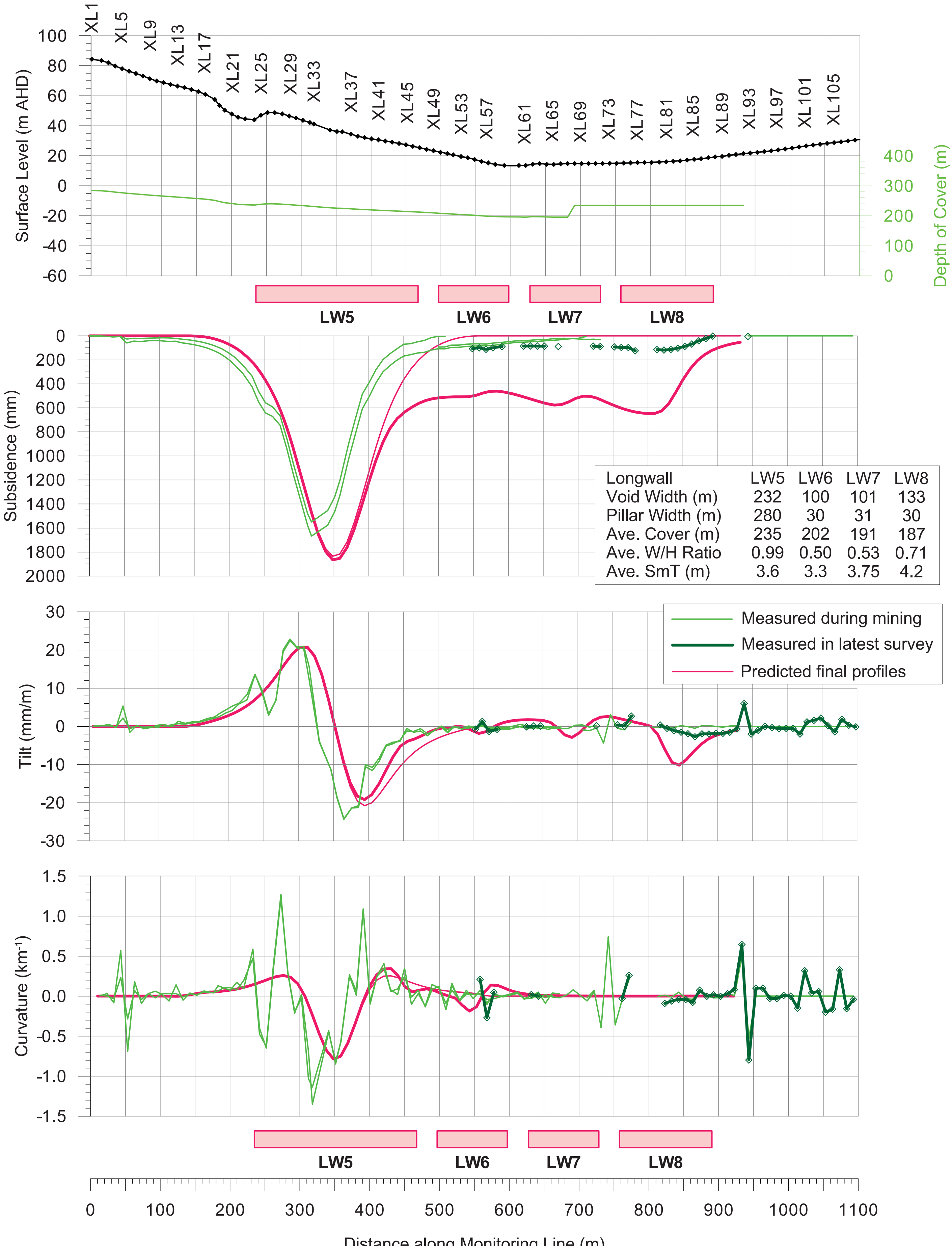
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW3XL Line during Newstan LW3 and LW4



msec

Fig. C.05

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW5XL Line during Newstan LW5 to LW8



Longwall	LW5	LW6	LW7	LW8
Void Width (m)	232	100	101	133
Pillar Width (m)	280	30	31	30
Ave. Cover (m)	235	202	191	187
Ave. W/H Ratio	0.99	0.50	0.53	0.71
Ave. SmT (m)	3.6	3.3	3.75	4.2

msec

Fig. C.06

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along LW9XL to LW14XL Lines during Newstan LW9 to LW14

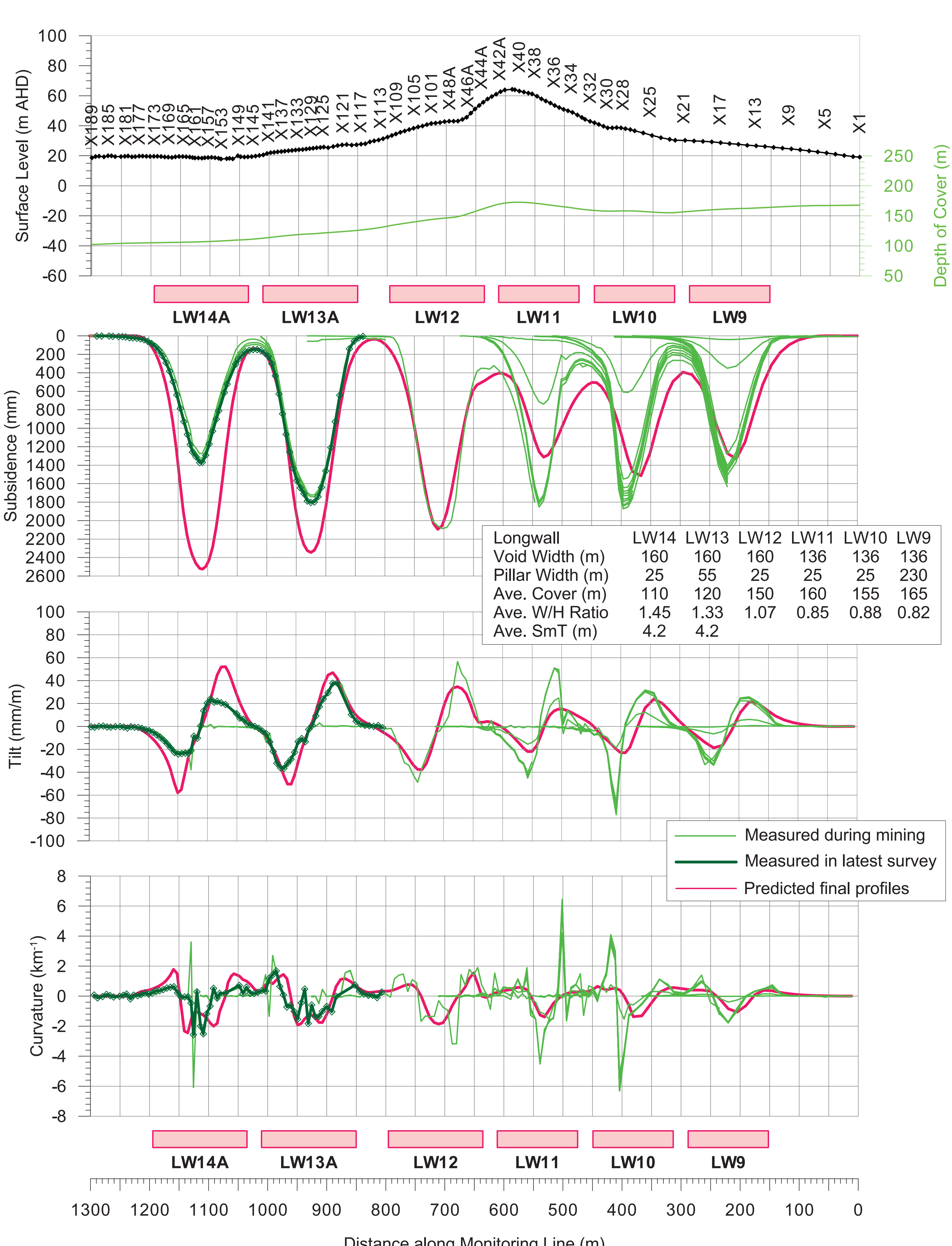
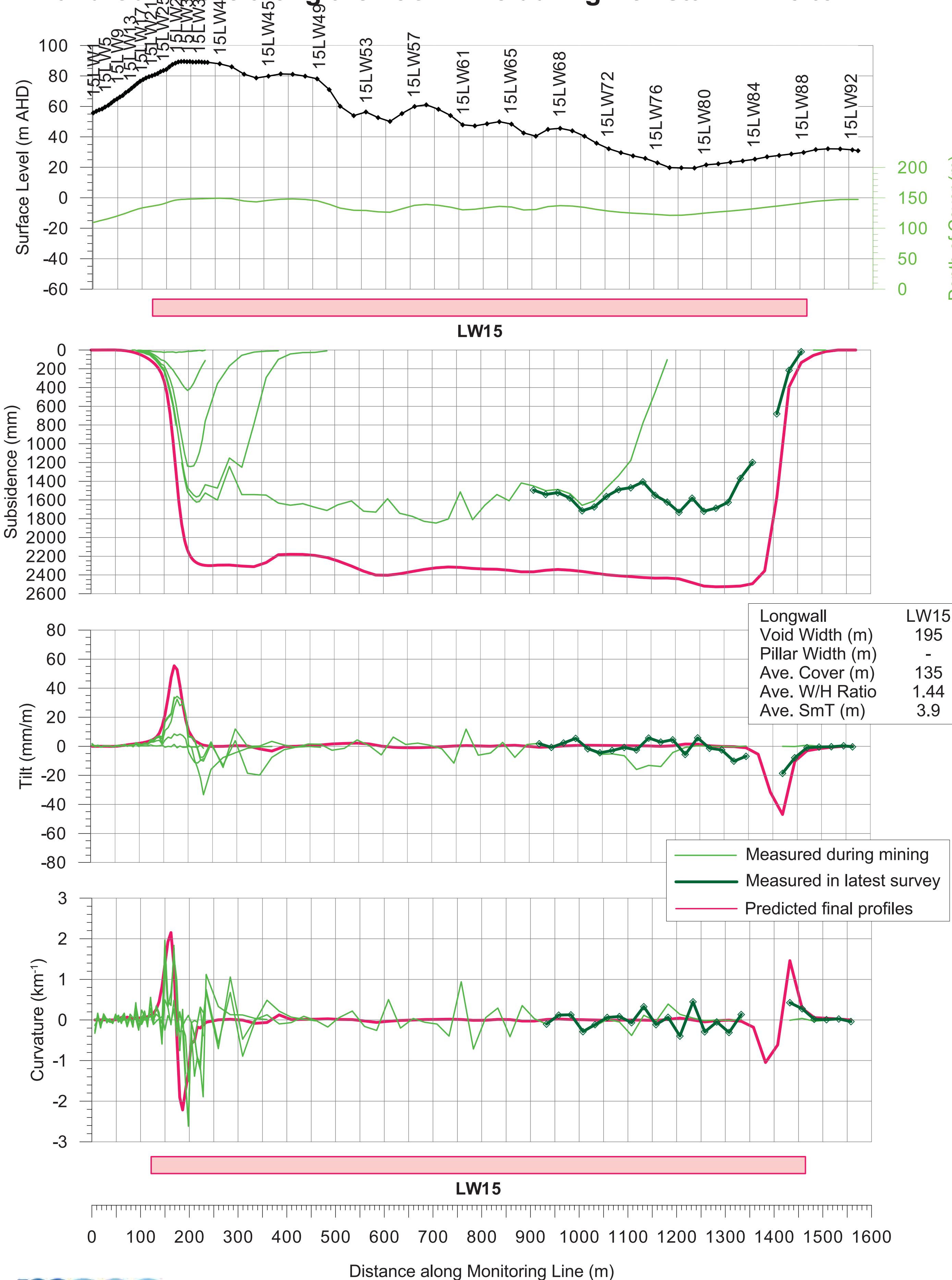


Fig. C.07

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 15CL Line during Newstan LW15 to LW21

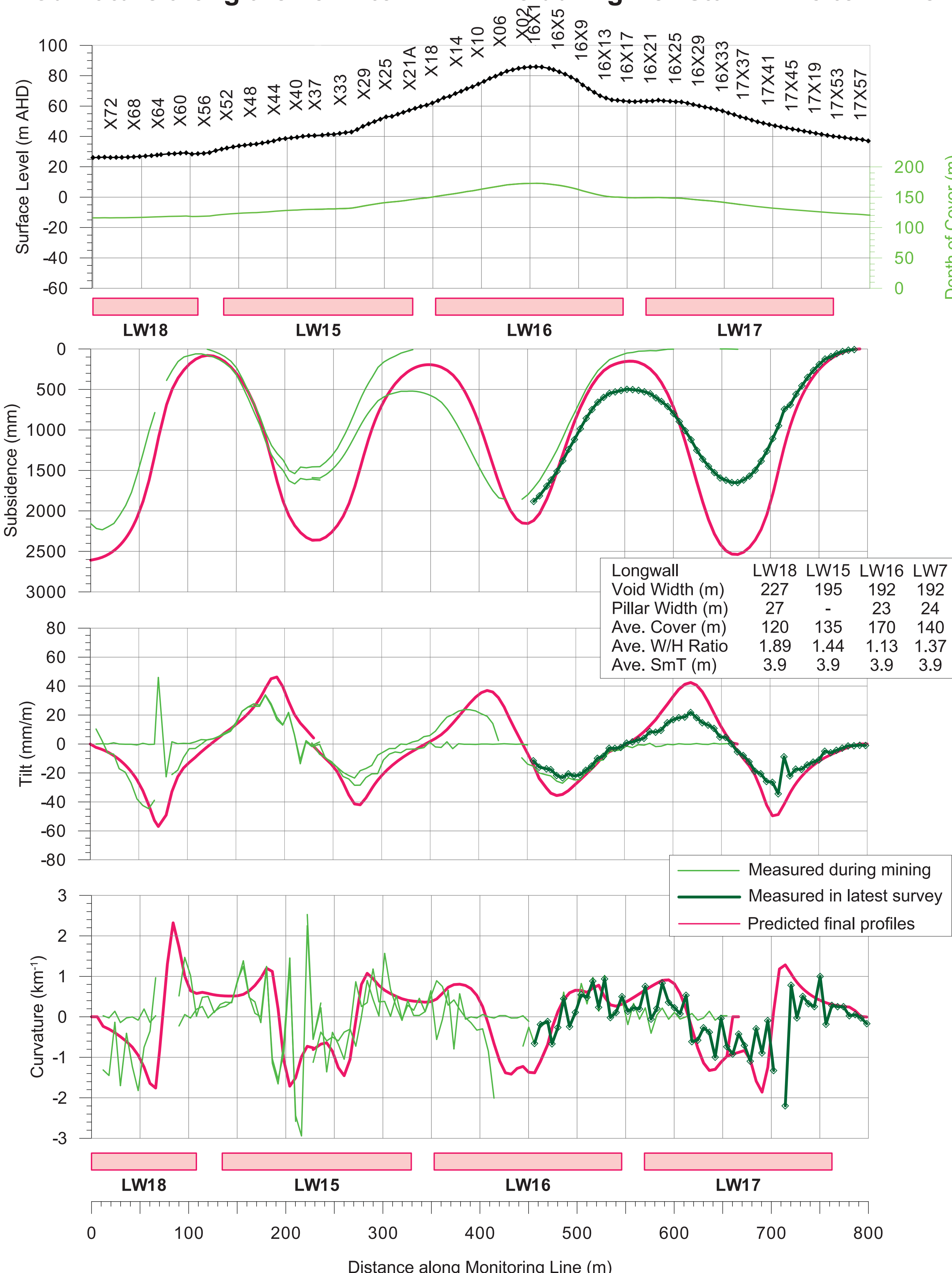


msec

Fig. C.08

I:\Projects\Newstan\MSEC537 - Longwalls 1 to 3 SMP Report\Subsdata\Calibration\Newstan\Fig. C.09 - LW15XL to LW17XL.grf.....23-Feb-12

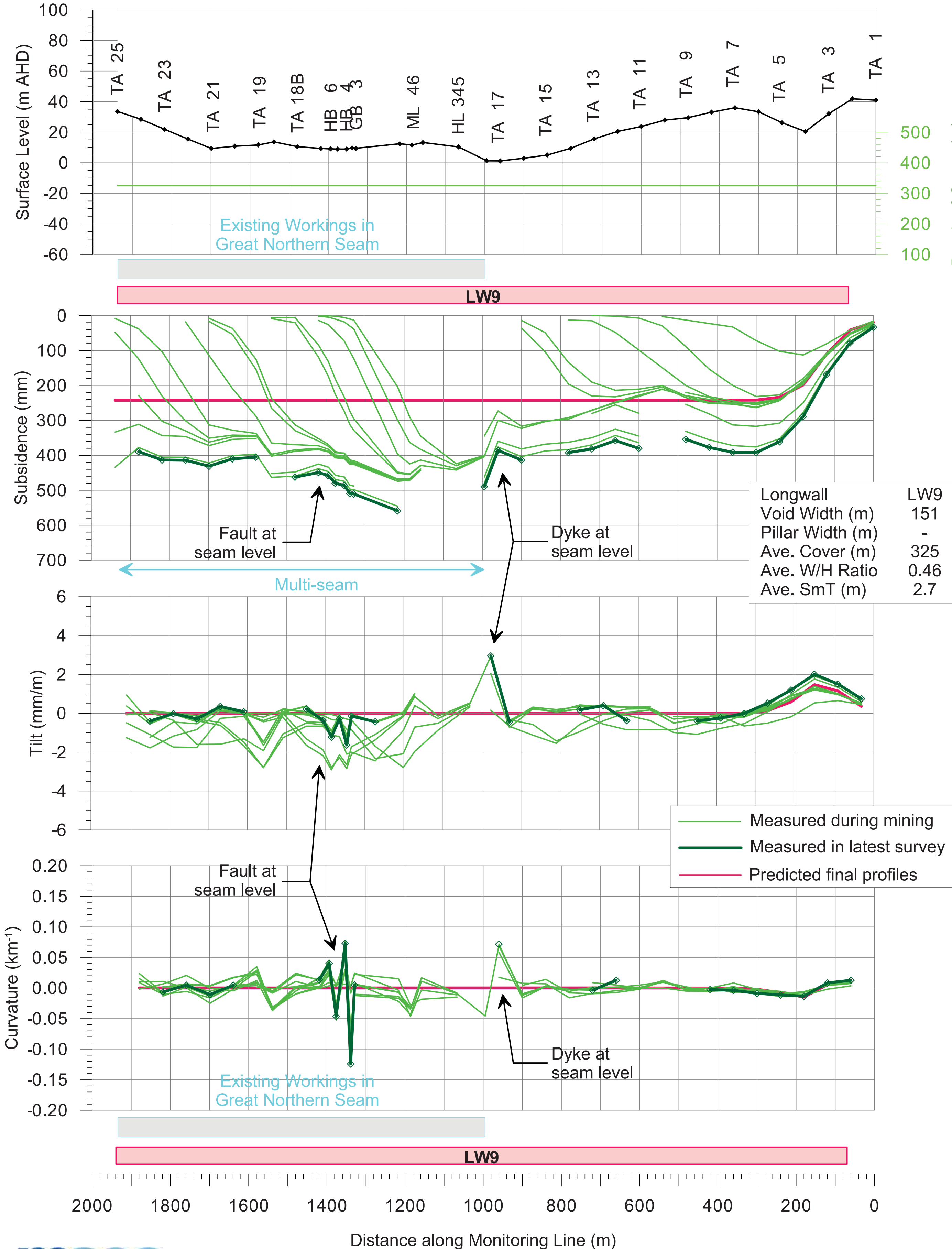
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 15XL to 17XL Line during Newstan LW15 to LW18



msec

Fig. C.09

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the TA Line during Teralba LW9

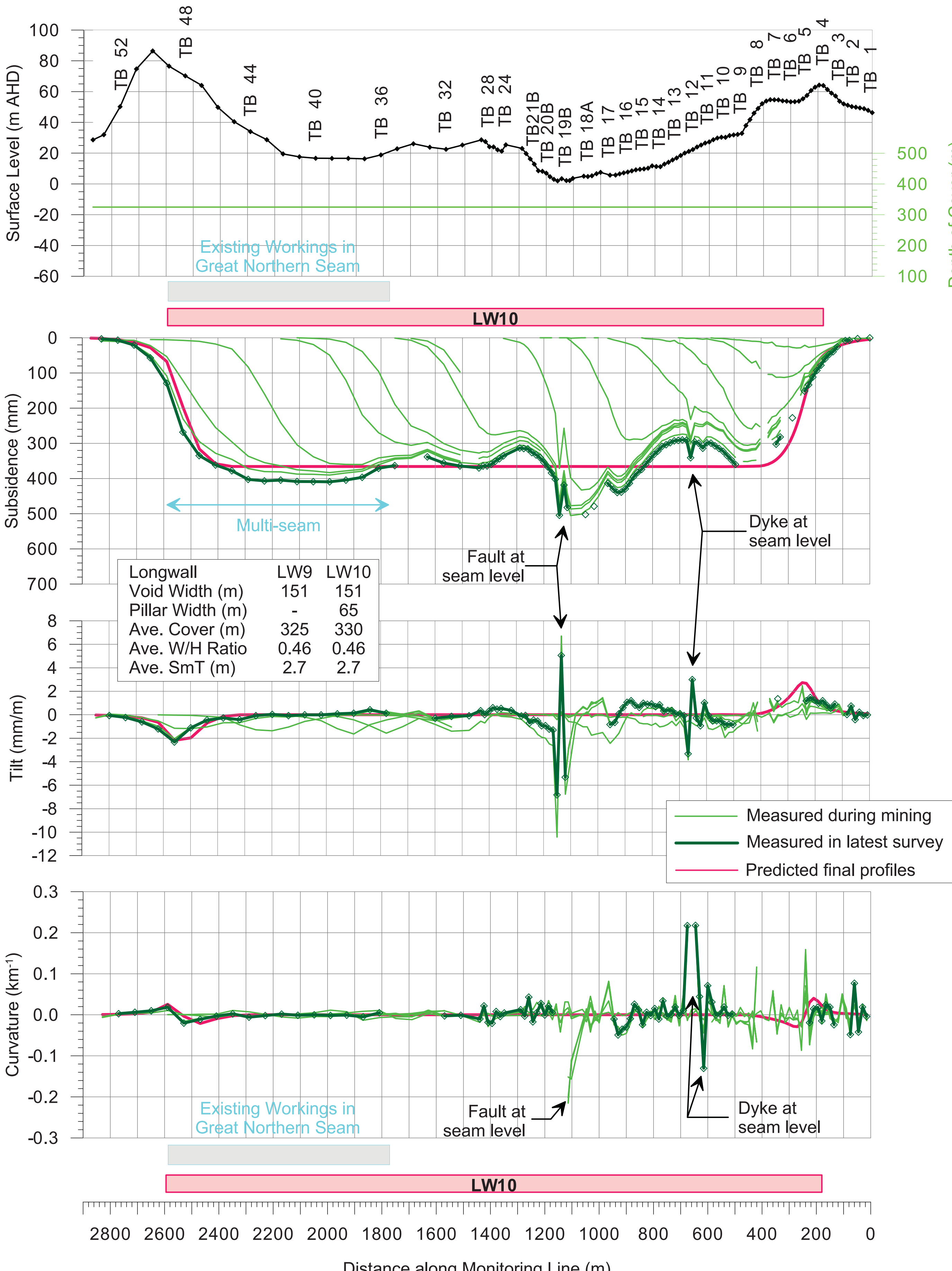


msec

Fig. C.10

I:\Projects\Newstan\MSEC537 - Longwalls 1 to 3 SMP Report\Subsdata\Calibration\Teralba\Fig. C.11 - TB Line.grf.....23-Feb-12

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the TB Line during Teralba LW10



msec

Fig. C.11

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the TR Line during Teralba LW9 and LW10

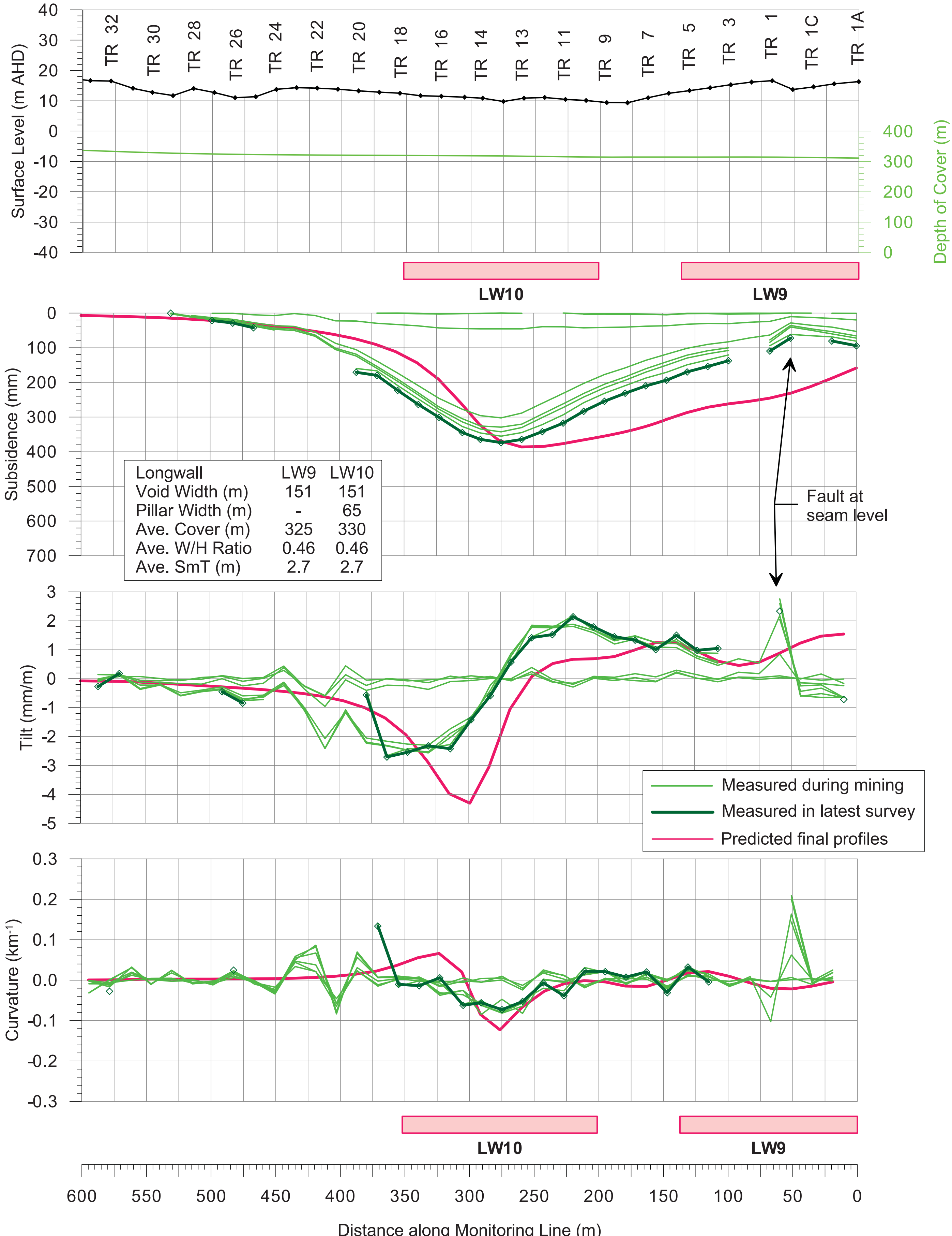
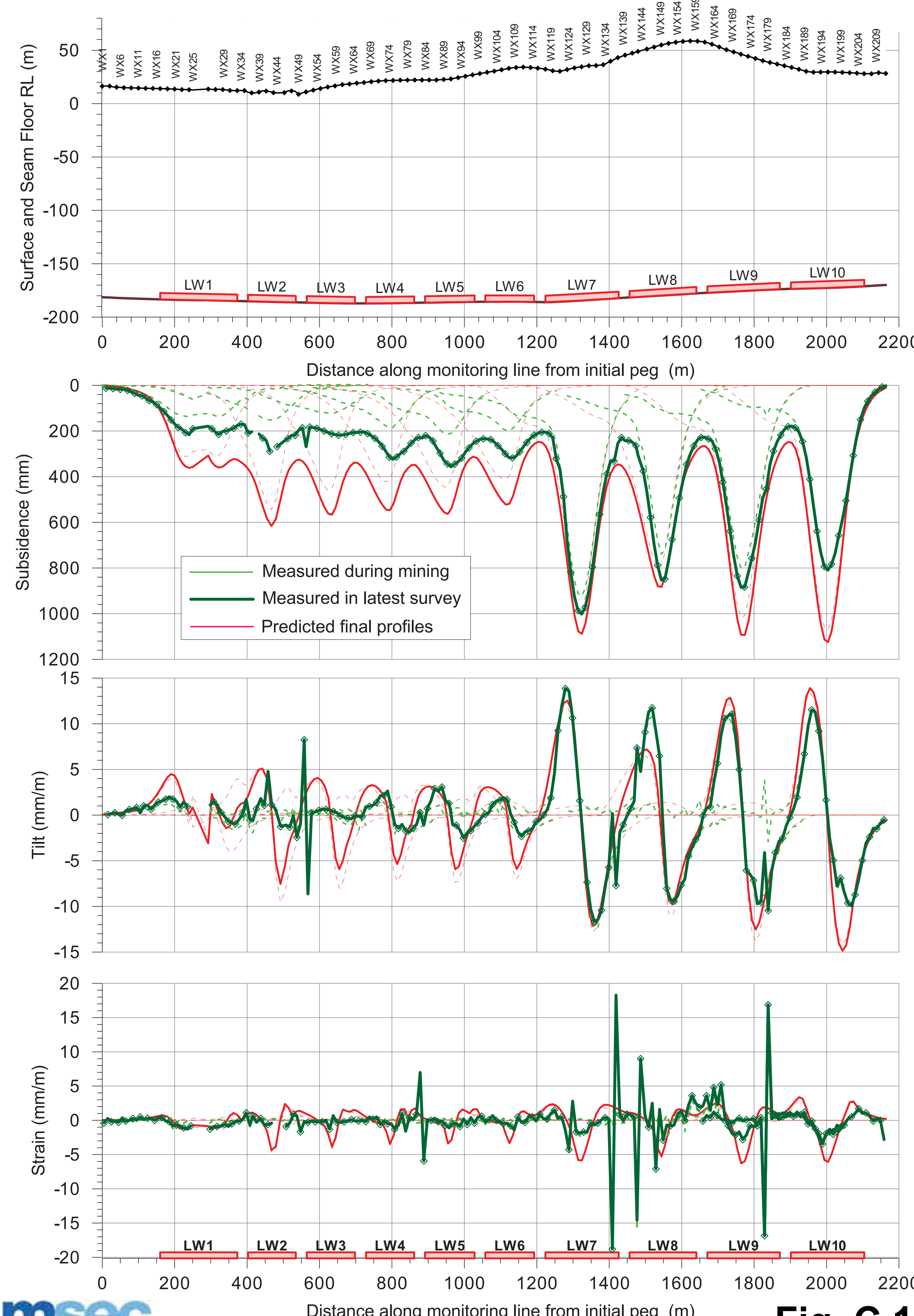


Fig. C.12

Observed and Predicted Profiles of Total Subsidence, Tilt and Strain along the WX Line during West Wallsend LW1 to LW10

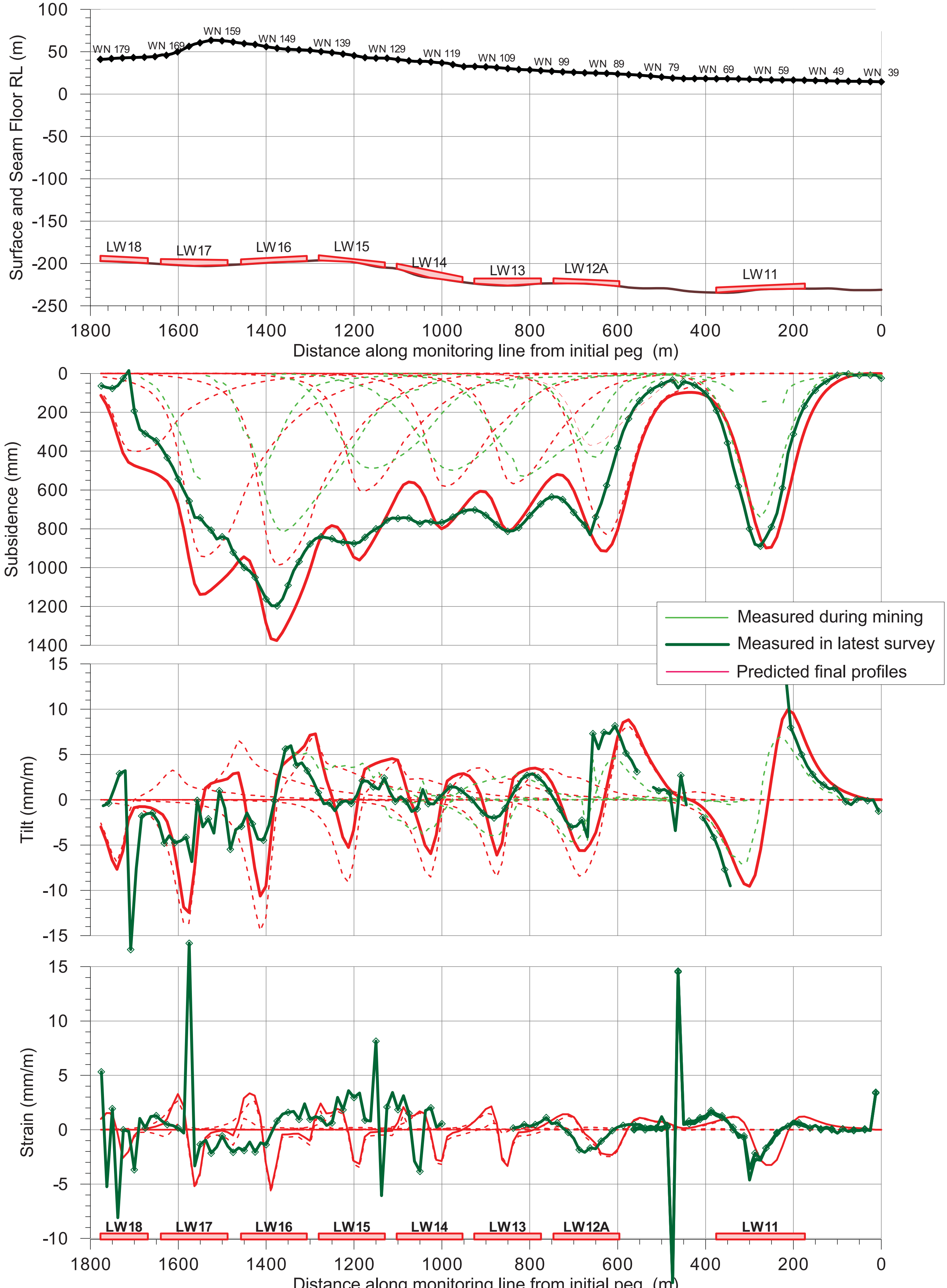


msec

Fig. C.13

I:\Projects\Newstan\MSEC537 - Longwalls 1 to 3 SMP Report\Subsdata\Calibration\West Wallsend\Fig. C.14 - LW11 to 18 WN Line Narrow+wide.grf 23-Feb-12

Observed and Predicted Profiles of Total Subsidence, Tilt and Strain along the WN Line during West Wallsend LW11 to LW18

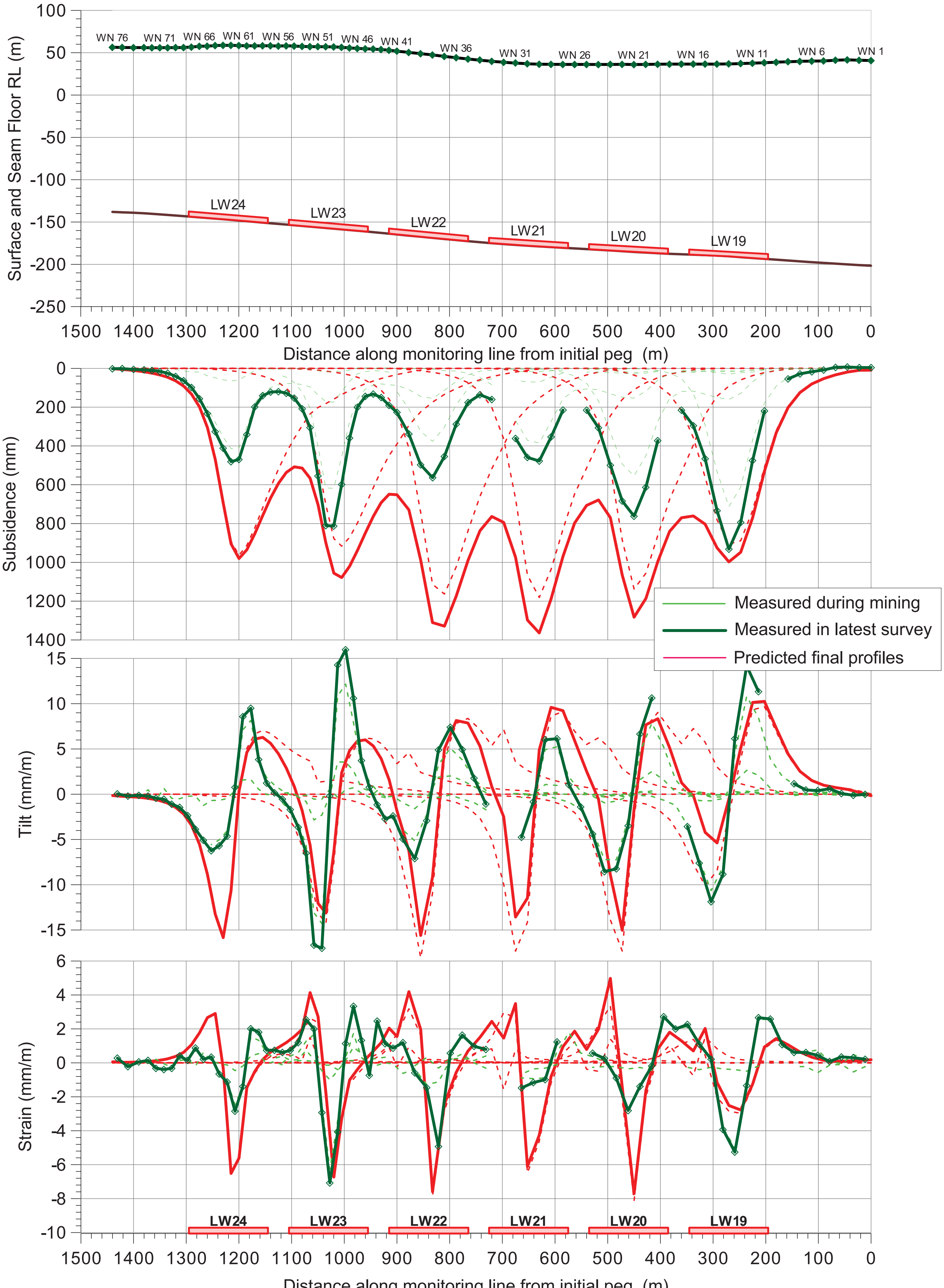


msec

Fig. C.14

I:\Projects\Newstan\MSEC537 - Longwalls 1 to 3 SMP Report\Subsdata\Calibration\West Wallsend\Fig. C.15 - LW19 to 24 WN Line.grf 23-Feb-12

Observed and Predicted Profiles of Total Subsidence, Tilt and Strain along the WN Line during West Wallsend LW19 to LW24



msec

Fig. C.15

APPENDIX D. TABLES

Table D.01 - Predicted Subsidence Parameters for the Building Structures Resulting from the Extraction of Newstan Longwalls 101 to 103

Ref.	Property	Type	Easting	Northing	Longest Building Dimension (m)	Number of Storeys	Predicted Total Subs after LW101 (mm)	Predicted Total Subs after LW102 (mm)	Predicted Total Subs after LW103 (mm)	Predicted Total Tilt after LW101 (mm/m)	Predicted Total Tilt after LW102 (mm/m)	Predicted Total Tilt after LW103 (mm/m)	Predicted Total Hogging Curvature after LW101 (1/km)	Predicted Total Hogging Curvature after LW102 (1/km)	Predicted Total Hogging Curvature after LW103 (1/km)	Predicted Total Sagging Curvature after LW101 (1/km)	Predicted Total Sagging Curvature after LW102 (1/km)	Predicted Total Sagging Curvature after LW103 (1/km)
AW001_pa01	Newcastle Lake Macquarie Clay Target Club	Clubhouse	365225	6344025	21	1	< 20	< 20	75	< 0.5	< 0.5	1.0	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01
AW001_pa02	Newcastle Lake Macquarie Clay Target Club	Timber cottage	365200	6344025	8	1	< 20	< 20	50	< 0.5	< 0.5	1.0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_pa03	Newcastle Lake Macquarie Clay Target Club	Demountable	365175	6343975	8	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_pa04	Newcastle Lake Macquarie Clay Target Club	Demountable	365150	6343950	12	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r01	Newcastle Lake Macquarie Clay Target Club	Fabricated steel trap	365300	6344050	17	1	< 20	< 20	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r02	Newcastle Lake Macquarie Clay Target Club	Fabricated steel trap	365225	6343975	18	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r03	Newcastle Lake Macquarie Clay Target Club	Fabricated steel trap	365175	6343925	17	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r04	Newcastle Lake Macquarie Clay Target Club	Fabricated steel trap	365150	6343875	18	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r05	Newcastle Lake Macquarie Clay Target Club	Brick trap house	365300	6344075	2	1	< 20	< 20	75	< 0.5	< 0.5	1.0	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01
AW001_r06	Newcastle Lake Macquarie Clay Target Club	Brick trap house	365275	6344050	2	1	< 20	< 20	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r07	Newcastle Lake Macquarie Clay Target Club	Brick trap house	365250	6344025	2	1	< 20	< 20	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r08	Newcastle Lake Macquarie Clay Target Club	Brick trap house	365225	6343975	2	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r09	Newcastle Lake Macquarie Clay Target Club	Steel tower and stair	365175	6343950	2	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r10	Newcastle Lake Macquarie Clay Target Club	Brick enclosure	365300	6344050	2	1	< 20	< 20	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r11	Newcastle Lake Macquarie Clay Target Club	Brick enclosure	365250	6344025	2	1	< 20	< 20	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r12	Newcastle Lake Macquarie Clay Target Club	Brick enclosure	365225	6344000	2	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r13	Newcastle Lake Macquarie Clay Target Club	Brick enclosure	365200	6343950	2	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r14	Newcastle Lake Macquarie Clay Target Club	Brick enclosure	365150	6343900	2	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW001_r15	Newcastle Lake Macquarie Clay Target Club	Container	365300	6344075	13	1	< 20	< 20	75	< 0.5	< 0.5	1.0	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
AW002_pa01	Awaba Waste Management Facility	Admin Building and Weighbridge	364700	6344925	10	1	< 20	< 20	100	< 0.5	< 0.5	2.0	< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01
AW002_pa02	Awaba Waste Management Facility	Substation	364550	6345000	11	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW002_pa03	Awaba Waste Management Facility	Substation container	364550	6345000	6	1	< 20	< 20	25	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW002_pa04	Awaba Waste Management Facility	Shed	364775	6344925	25	1	< 20	< 20	650	< 0.5	< 0.5	10.5	< 0.01	< 0.01	0.15	< 0.01	< 0.01	0.05
AW002_pa05	Awaba Waste Management Facility	Shed	364750	6344925	5	1	< 20	< 20	350	< 0.5	< 0.5	7.0	< 0.01	< 0.01	0.14	< 0.01	< 0.01	0.03
AW002_pa06	Awaba Waste Management Facility	Shed	364775	6344950	13	1	< 20	< 20	700	< 0.5	< 0.5	10.5	< 0.01	< 0.01	0.15	< 0.01	< 0.01	0.05
AW002_pa07	Awaba Waste Management Facility	Tank	364825	6345300	4	1	< 20	150	650	< 0.5	3.0	3.5	< 0.01	0.07	0.08	< 0.01	0.01	0.05
AW002_pa08	Awaba Waste Management Facility	Shed	364800	6345300	5	1	< 20	150	700	< 0.5	2.5	4.0	< 0.01	0.05	0.08	< 0.01	0.01	0.05
AW003_pa02	Awabawac Park	Demountable	364675	6344525	6	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW003_pa03	Awabawac Park	Toilet block	364700	6344525	12	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa01	Toronto Country Club	Clubhouse	365800	6344500	25	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa02	Toronto Country Club	Awning	365825	6344500	13	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa03	Toronto Country Club	Shed	365875	6344500	18	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa04	Toronto Country Club	Shed	365875	6344500	12	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa05	Toronto Country Club	Shed	365875	6344500	22	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR001_pa06	Toronto Country Club	Lean-to	365900	6344500	3	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR003_pa01	Toronto Adventist Primary School	Hall	366025	6344725	24	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR003_pa03	Toronto Adventist Primary School	Classrooms	366000	6344650	32	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR003_pa04	Toronto Adventist Primary School	Admin building	366025	6344675	25	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR003_pa05	Toronto Adventist Primary School	Toilet block	366025	6344700	13	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
TR003_r01	Toronto Adventist Primary School	Garden shed	366000	6344650	6	1	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Table D.02 - Predicted Subsidence Parameters for the Dams Resulting from the Extraction of Newstan Longwalls 101 to 103

Ref.	Property	Easting	Northing	Longest Dimension (m)	Area (m2)	Predicted Total Subs after LW101 (mm)	Predicted Total Subs after LW102 (mm)	Predicted Total Subs after LW103 (mm)	Predicted Total Tilt after LW101 (mm)	Predicted Total Tilt after LW102 (mm)	Predicted Total Tilt after LW103 (mm)	Predicted Total Hogging Curvature after LW101 (1/km)	Predicted Total Hogging Curvature after LW102 (1/km)	Predicted Total Hogging Curvature after LW103 (1/km)	Predicted Total Sagging Curvature after LW101 (1/km)	Predicted Total Sagging Curvature after LW102 (1/km)	Predicted Total Sagging Curvature after LW103 (1/km)
AW001_d01	Newcastle Lake Macquarie Clay Target Club	365400	6343925	53	1665	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW002_d01	Awaba Waste Disposal Facility	364650	6344975	86	2627	< 20	< 20	150	< 0.5	< 0.5	2.5	< 0.01	< 0.01	0.06	< 0.01	< 0.01	0.01
AW002_d02	Awaba Waste Disposal Facility	364725	6344975	51	1260	< 20	< 20	450	< 0.5	< 0.5	9.0	< 0.01	< 0.01	0.15	< 0.01	< 0.01	0.04
AW002_d03	Awaba Waste Disposal Facility	364525	6345025	26	339	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW002_d04	Awaba Waste Disposal Facility	364450	6345100	29	597	< 20	< 20	< 20	< 0.5	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AW002_d05	Awaba Waste Disposal Facility	364725	6345525	107	4398	< 20	300	850	< 0.5	6.0	5.0	< 0.01	0.12	0.18	< 0.01	0.02	0.06
TR002_d01	-	365675	6344650	23	296	75	75	75	1.5	1.5	1.5	0.03	0.03	0.03	< 0.01	< 0.01	< 0.01
TR002_d02	-	365600	6344650	10	65	250	300	300	4.5	5.0	5.0	0.03	0.04	0.04	0.04	0.04	0.04
TR002_d03	-	365600	6344700	9	47	250	250	250	3.5	4.0	4.0	0.04	0.04	0.04	0.03	0.03	0.03

Table D.03 - Predicted Subsidence Parameters for the Archaeological Sites Resulting from the Extraction of Newstan Longwalls 101 to 103

ID	Type	Predicted Total Subs after LW101 (mm)	Predicted Total Subs after LW102 (mm)	Predicted Total Subs after LW103 (mm)	Predicted Total Tilt after LW101 (mm)	Predicted Total Tilt after LW102 (mm)	Predicted Total Tilt after LW103 (mm)	Predicted Total Hogging Curvature after LW101 (1/km)	Predicted Total Hogging Curvature after LW102 (1/km)	Predicted Total Hogging Curvature after LW103 (1/km)	Predicted Total Sagging Curvature after LW101 (1/km)	Predicted Total Sagging Curvature after LW102 (1/km)	Predicted Total Sagging Curvature after LW103 (1/km)
45-7-0260	Grinding Grooves	50	50	50	0.5	0.5	0.5	0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
45-7-0295	Isolated Find	100	100	100	1.5	1.5	1.5	0.02	0.02	0.02	< 0.01	< 0.01	< 0.01
45-7-0296	Isolated Find	75	200	200	1.5	2.0	2.0	0.03	0.04	0.04	< 0.01	< 0.01	< 0.01
45-7-0297	Isolated Find	50	150	200	1.0	1.5	2.0	0.01	0.02	0.03	< 0.01	< 0.01	< 0.01
45-7-0298	Isolated Find	25	150	150	< 0.5	1.5	2.0	< 0.01	0.03	0.03	< 0.01	< 0.01	< 0.01
45-7-0299	Artefact Scatter	700	800	800	5.5	6.0	6.0	0.07	0.07	0.07	0.12	0.12	0.12
45-7-0303	Isolated Find	< 20	25	50	< 0.5	< 0.5	0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
45-7-0309	Isolated Find	25	700	850	< 0.5	10.0	8.5	< 0.01	0.14	0.17	< 0.01	0.09	0.09
45-7-0005/0310	Rockshelter and Grinding Grooves	400	650	650	4.5	1.5	1.0	0.04	0.05	0.06	0.02	0.02	0.02

APPENDIX E.   FIGURES

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Prediction Line 1 Resulting from the Extraction of Longwalls 101 to 103

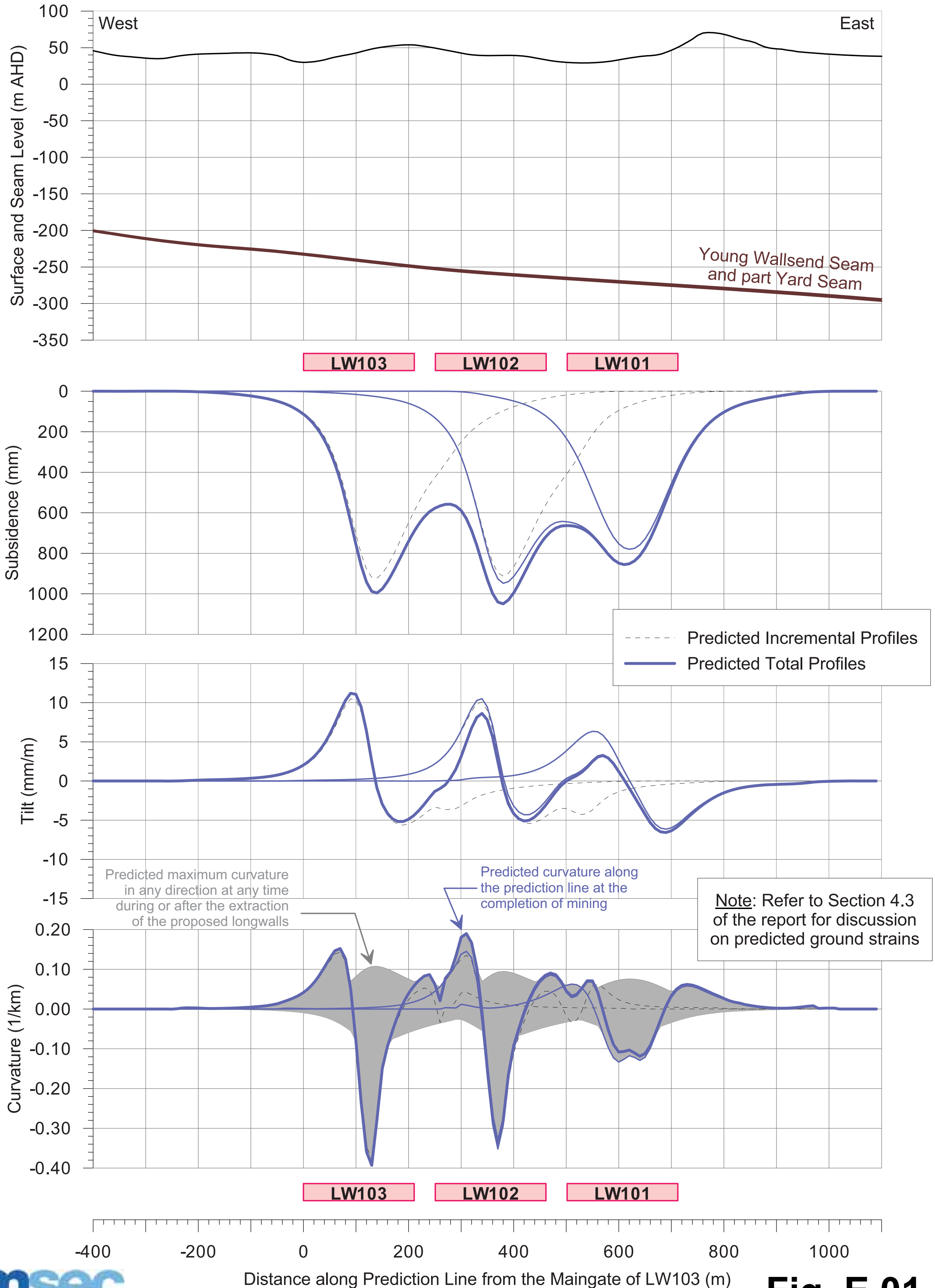


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Fig. E.01

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Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Prediction Line 2 Resulting from the Extraction of Longwalls 101 to 103

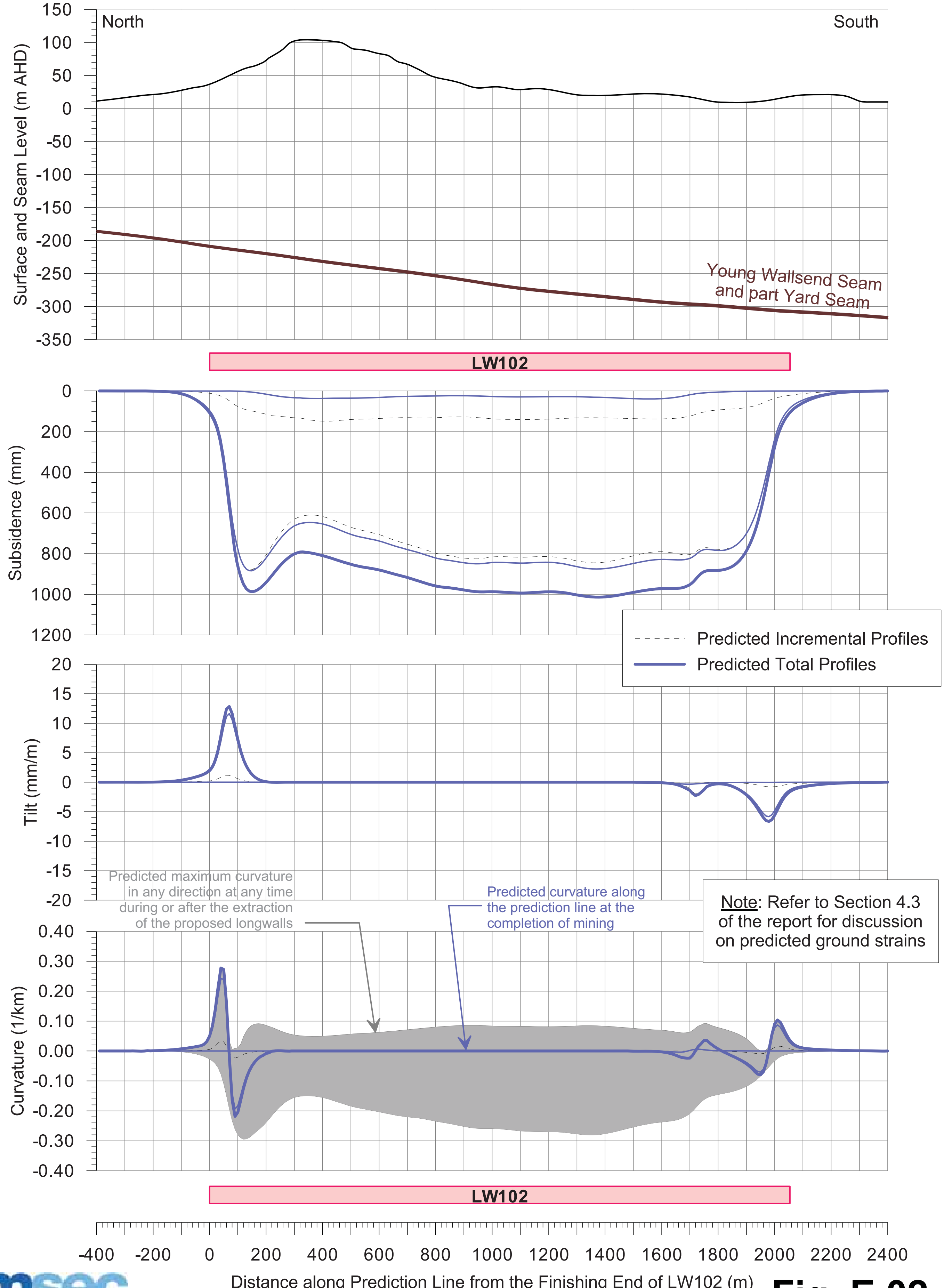
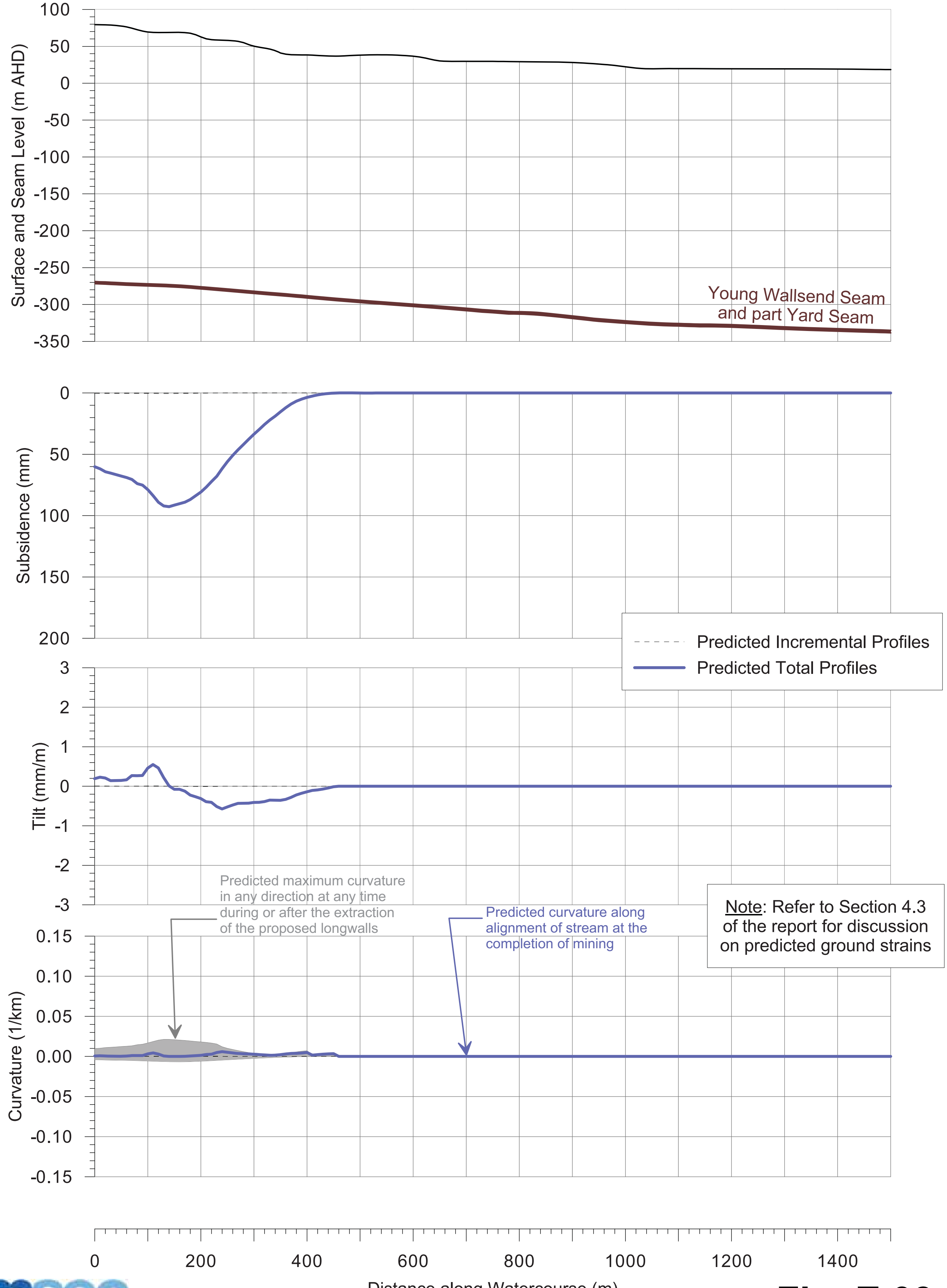


Fig. E.02

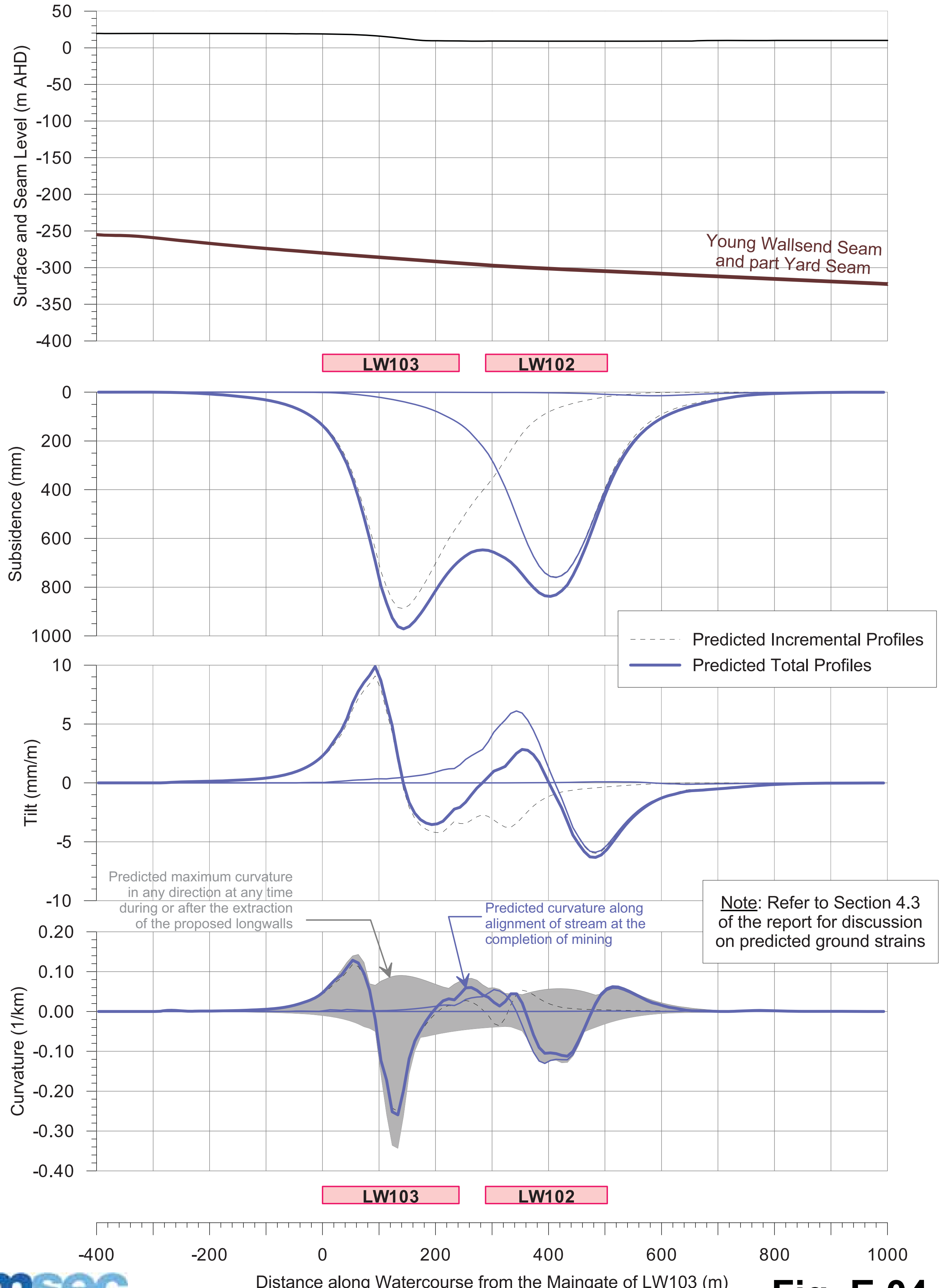
Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Watercourse WC3 Resulting from the Extraction of Longwalls 101 to 103



msec

Fig. E.03

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Watercourse WC5 Resulting from the Extraction of Longwalls 101 to 103



msec

Fig. E.04

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Watercourse WC11 Resulting from the Extraction of Longwalls 101 to 103

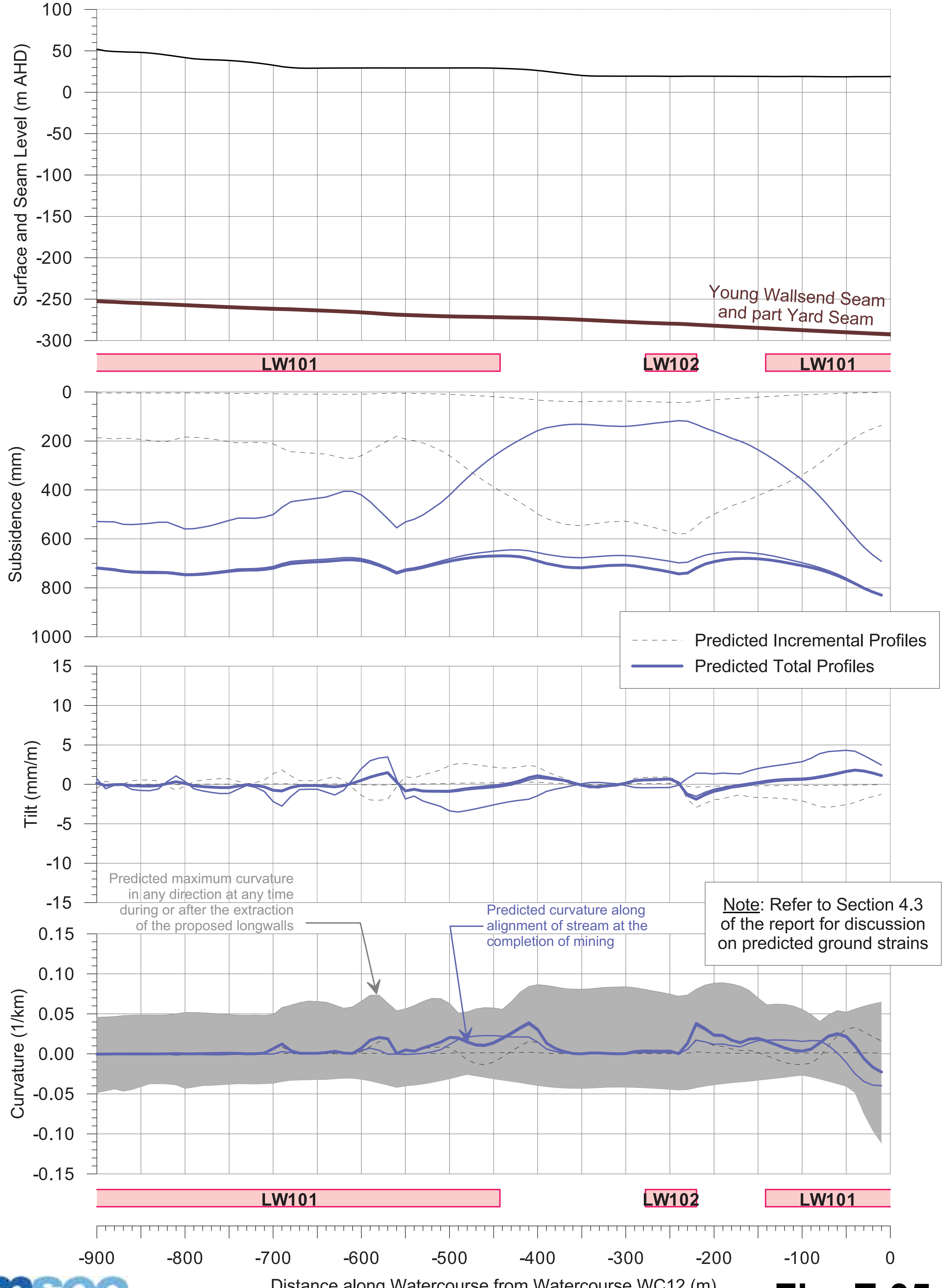


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Fig. E.05

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along WC6, WC12 and WC10 Resulting from the Extraction of LWs 101 to 103

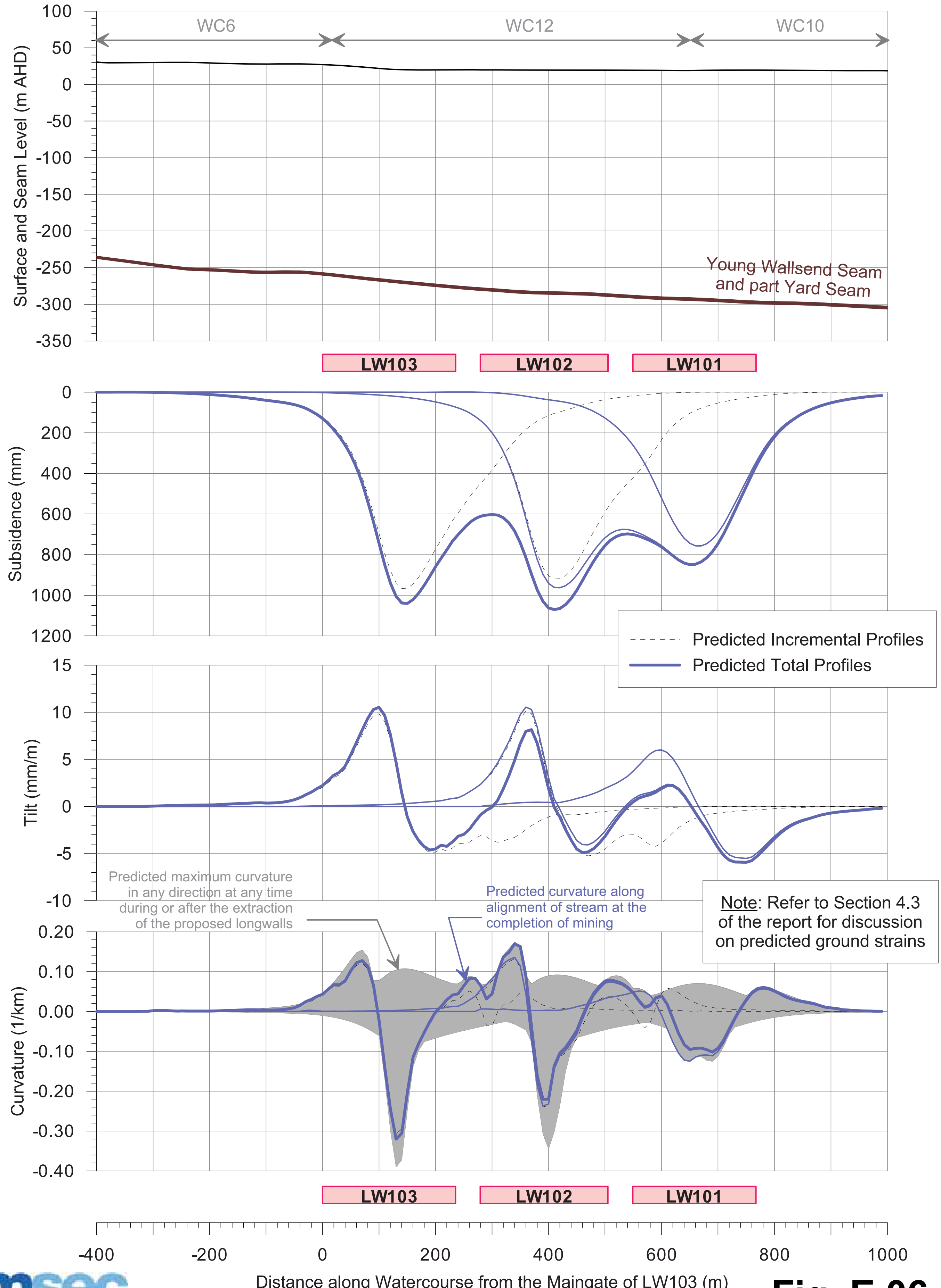

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Fig. E.06

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Wilton Road Resulting from the Extraction of Longwalls 101 to 103

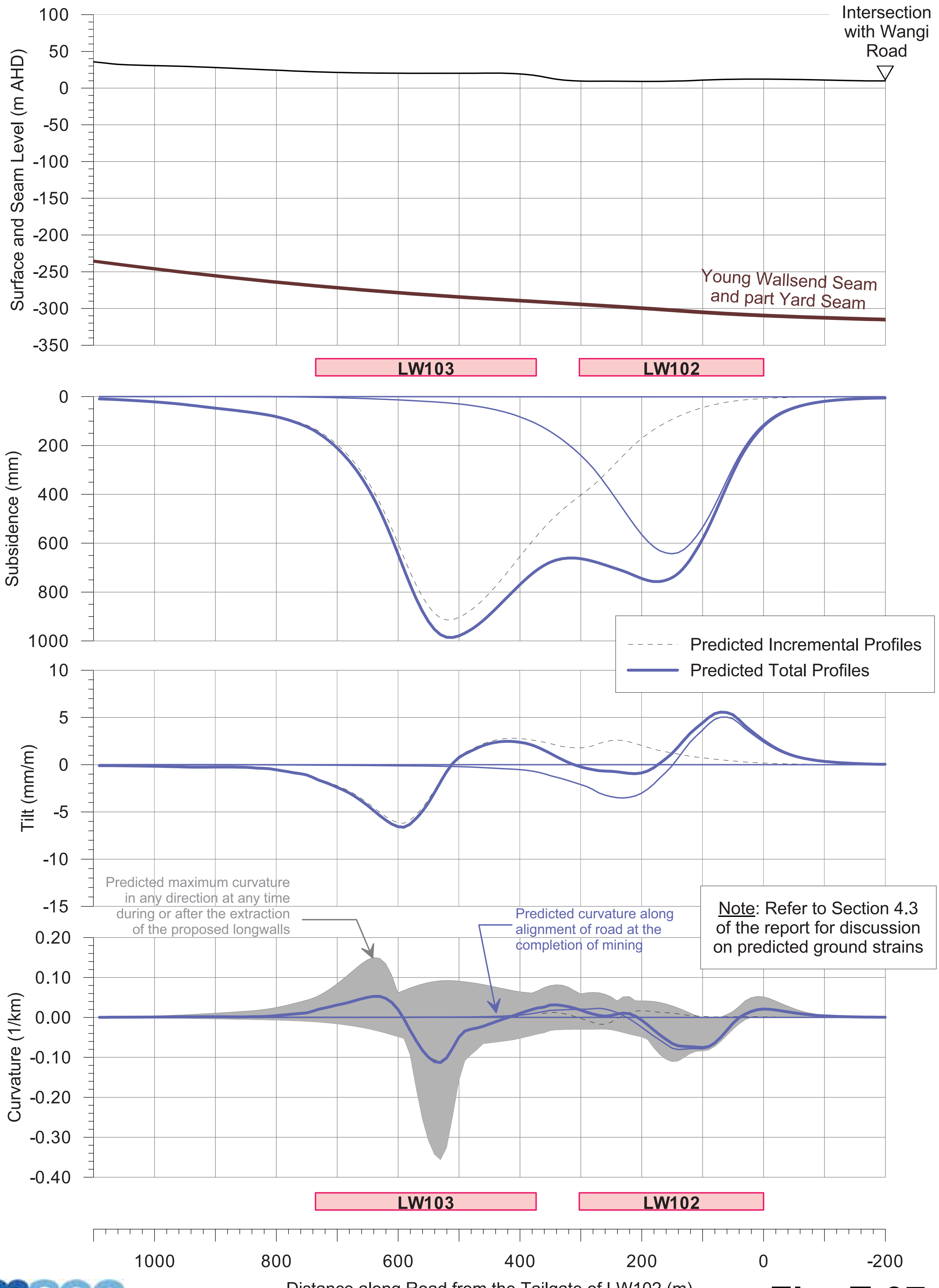

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Fig. E.07

Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Wangi Road Resulting from the Extraction of Longwalls 101 to 103

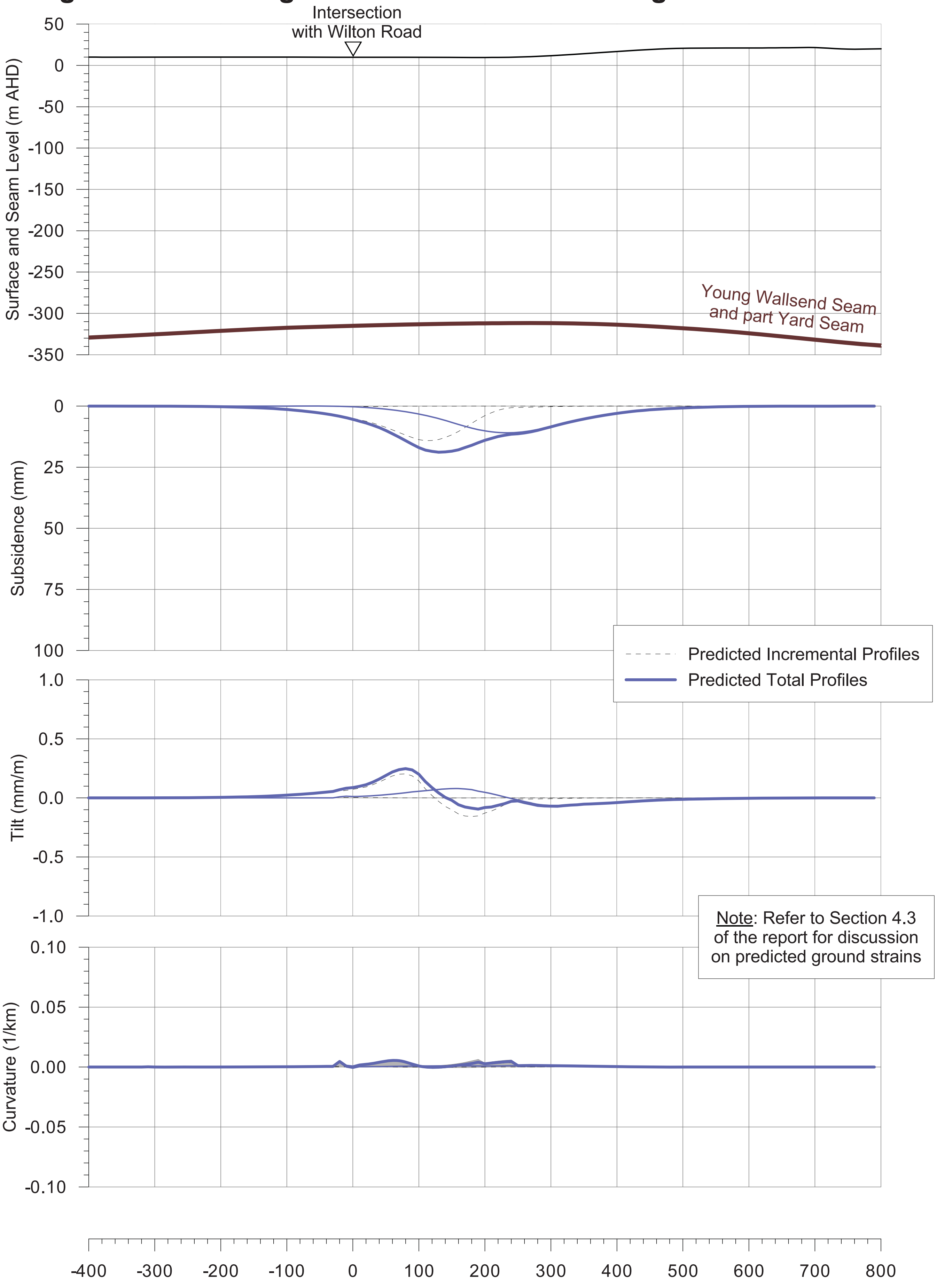

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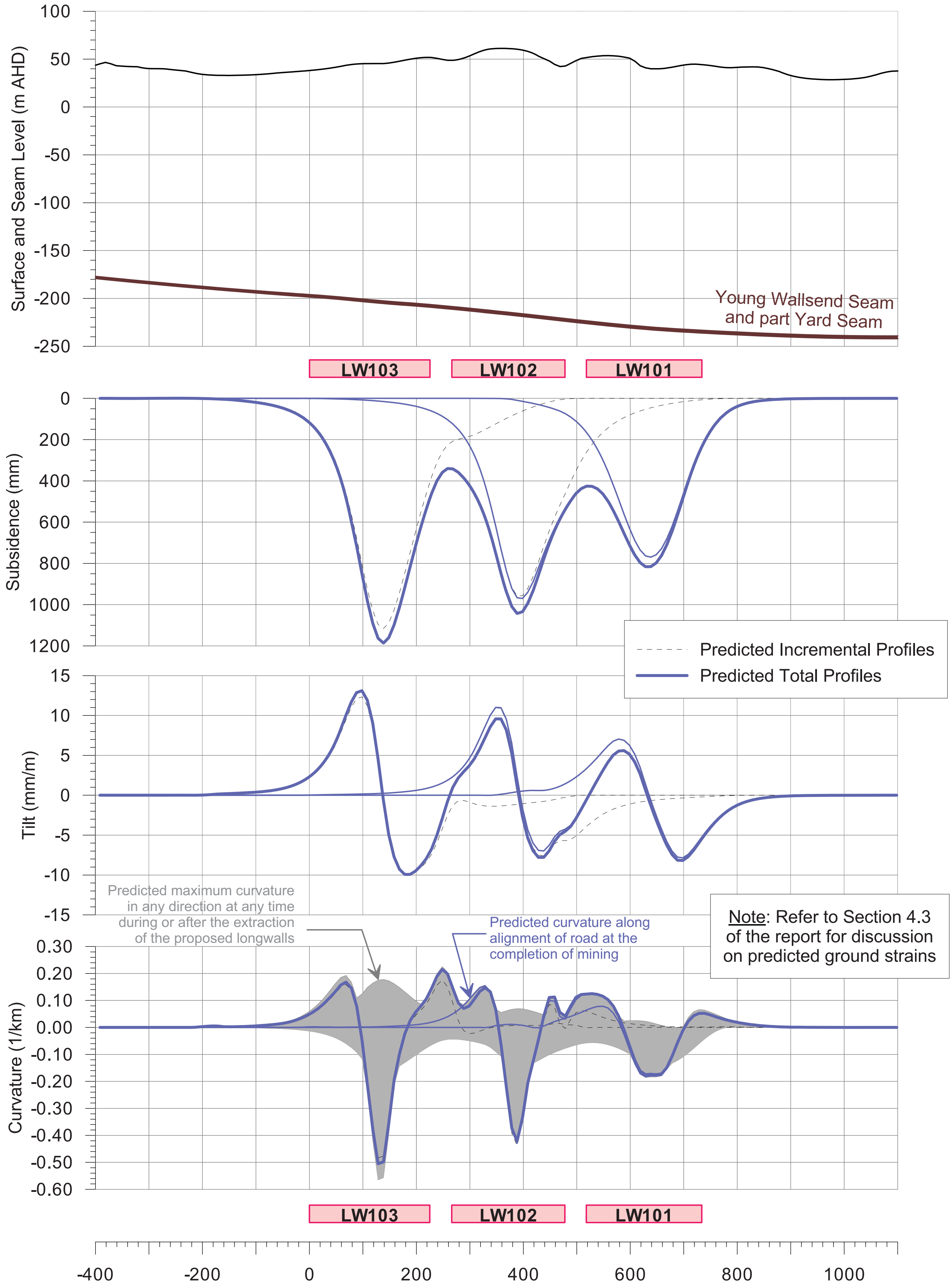
Fig. E.08

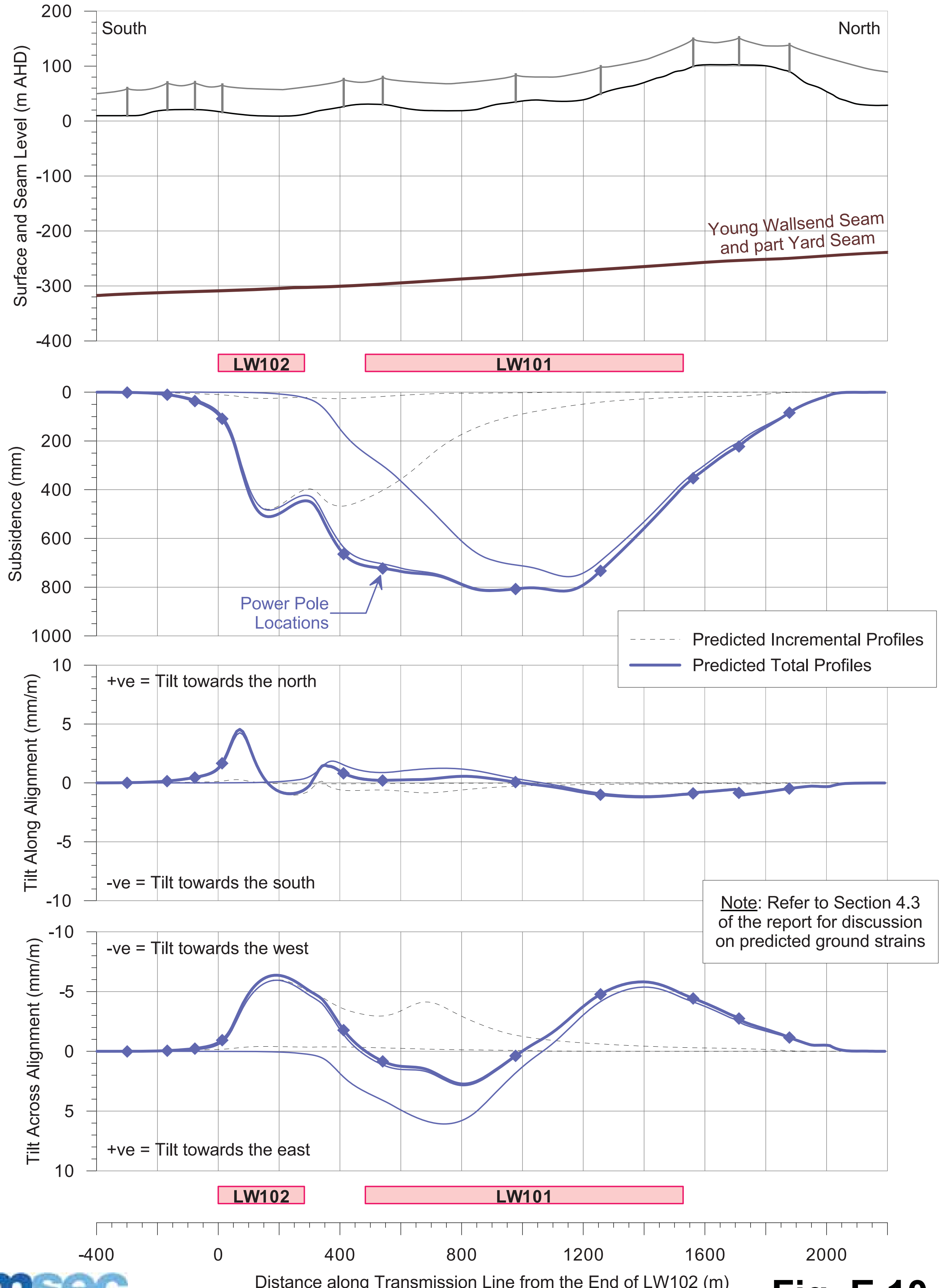
Predicted Profiles of Conventional Subsidence, Tilt and Curvature along the Mine Haul Road Resulting from the Extraction of Longwalls 101 to 103



msec

Fig. E.09

Predicted Profiles of Conventional Subsidence, Tilt Along and Tilt Across the 132kV Transission Line (West) Resulting from the Extraction of LWs 101 to 103



msec

Fig. E.10

Predicted Profiles of Conventional Subsidence, Tilt Along and Tilt Across the 132kV Transission Line (East) Resulting from the Extraction of LWs 101 to 103

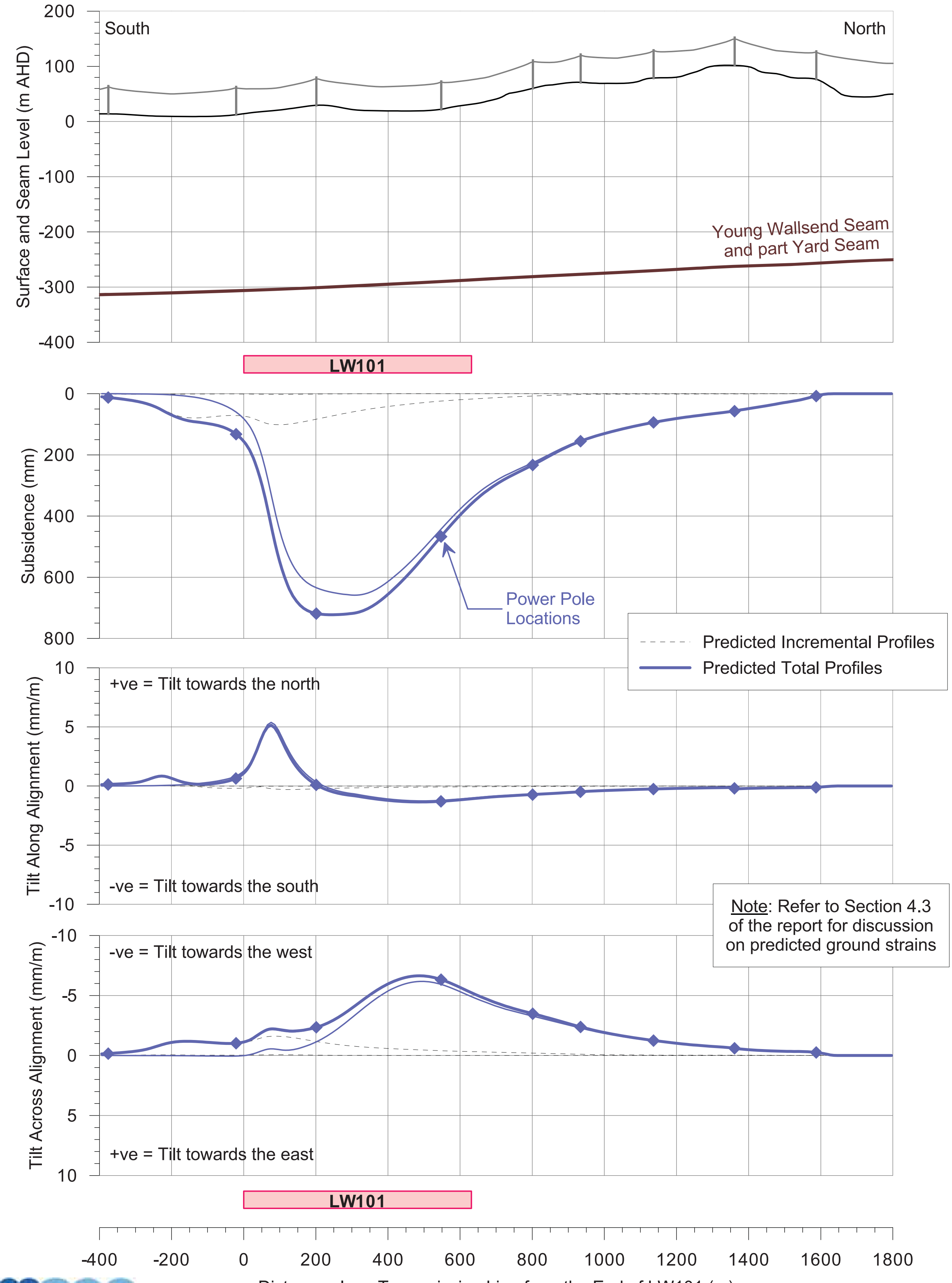


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Fig. E.11

APPENDIX F. DRAWINGS

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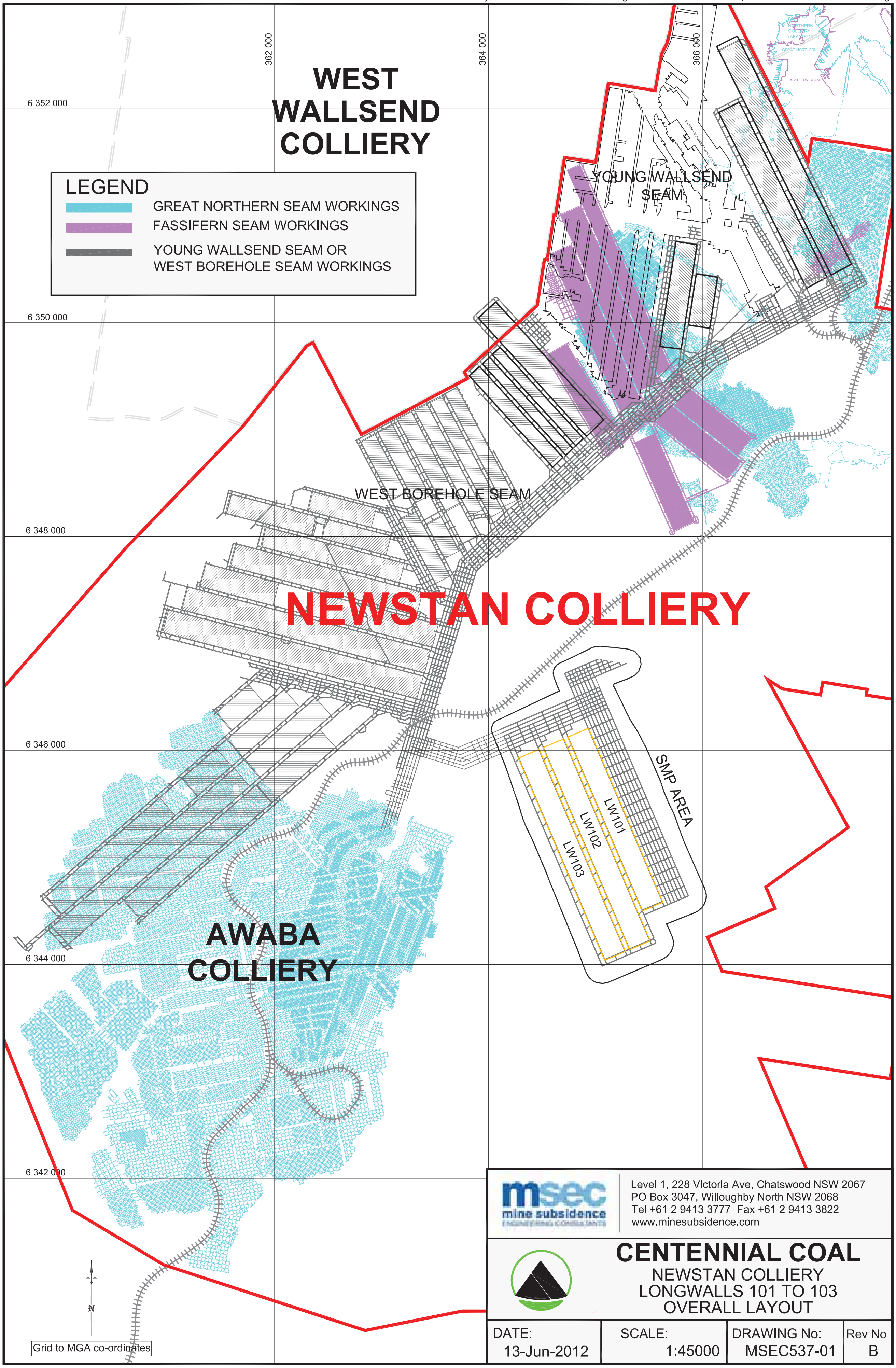

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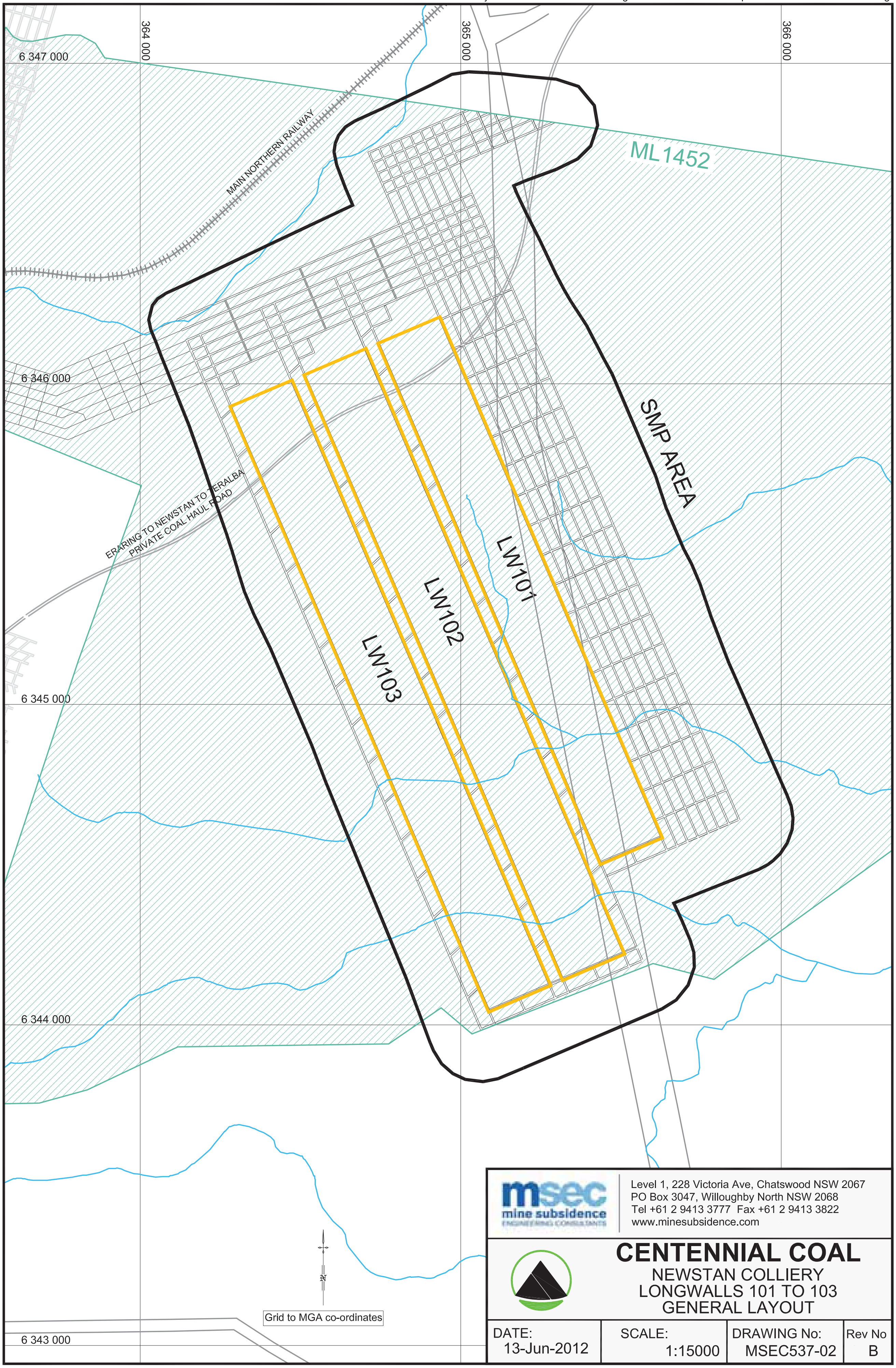

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PO Box 3047, Willoughby North NSW 2068
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CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
GENERAL LAYOUT

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-02	B

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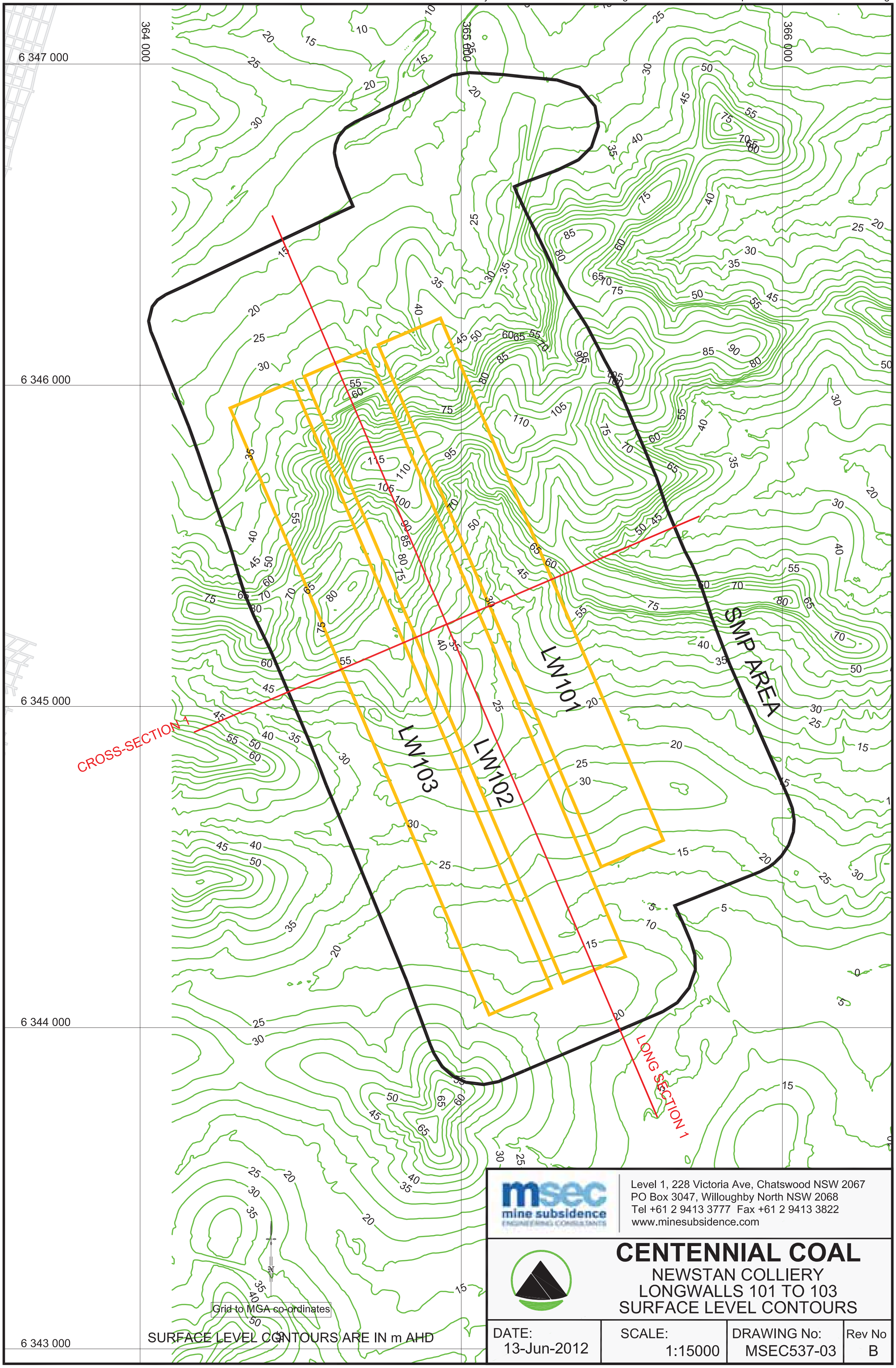

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CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
SURFACE LEVEL CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-03	B

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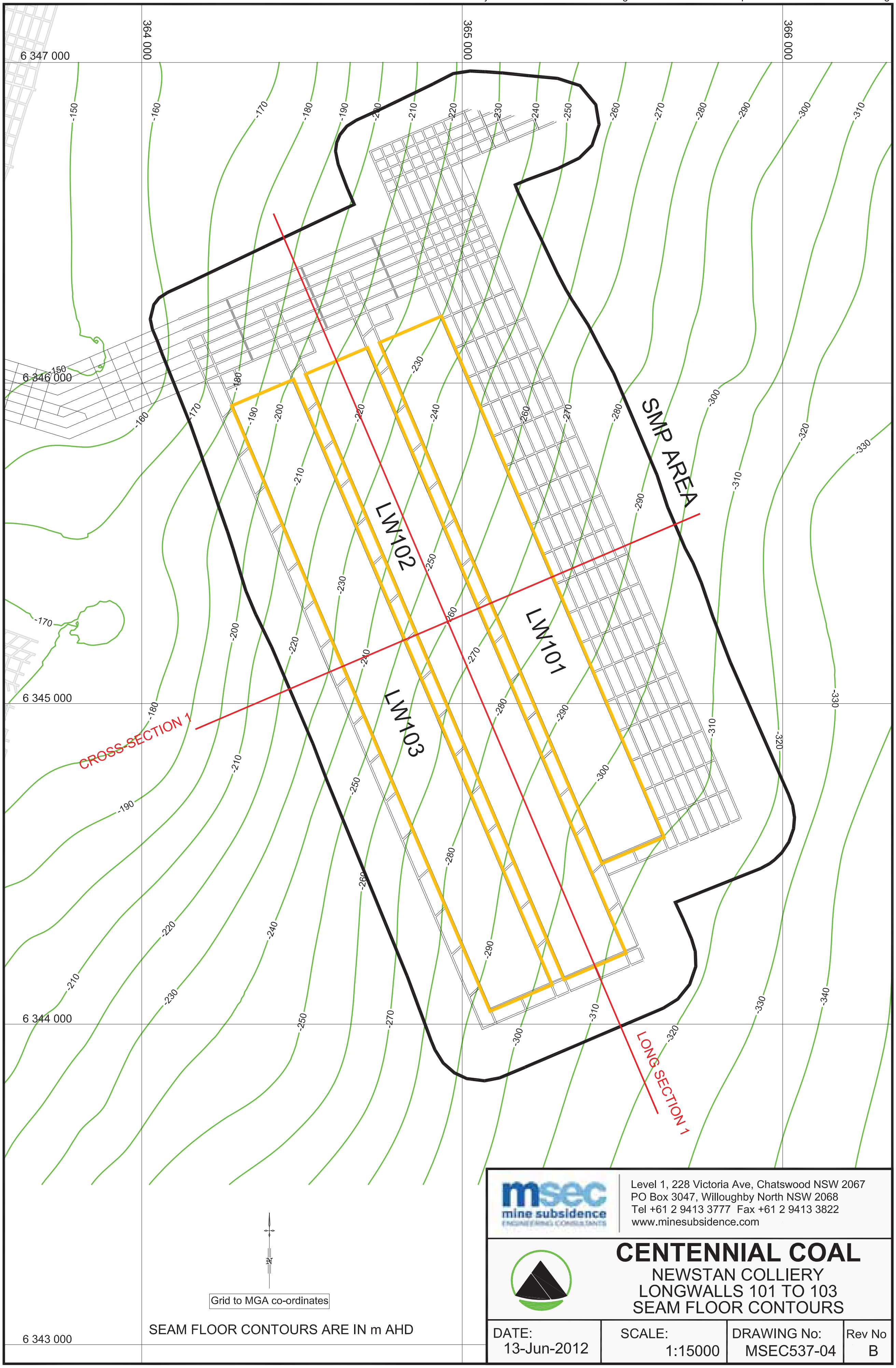

SEAM FLOOR CONTOURS ARE IN m AHD

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CENTENNIAL COAL

NEWSTAN COLLIERY
LONGWALLS 101 TO 103
SEAM FLOOR CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-04	B

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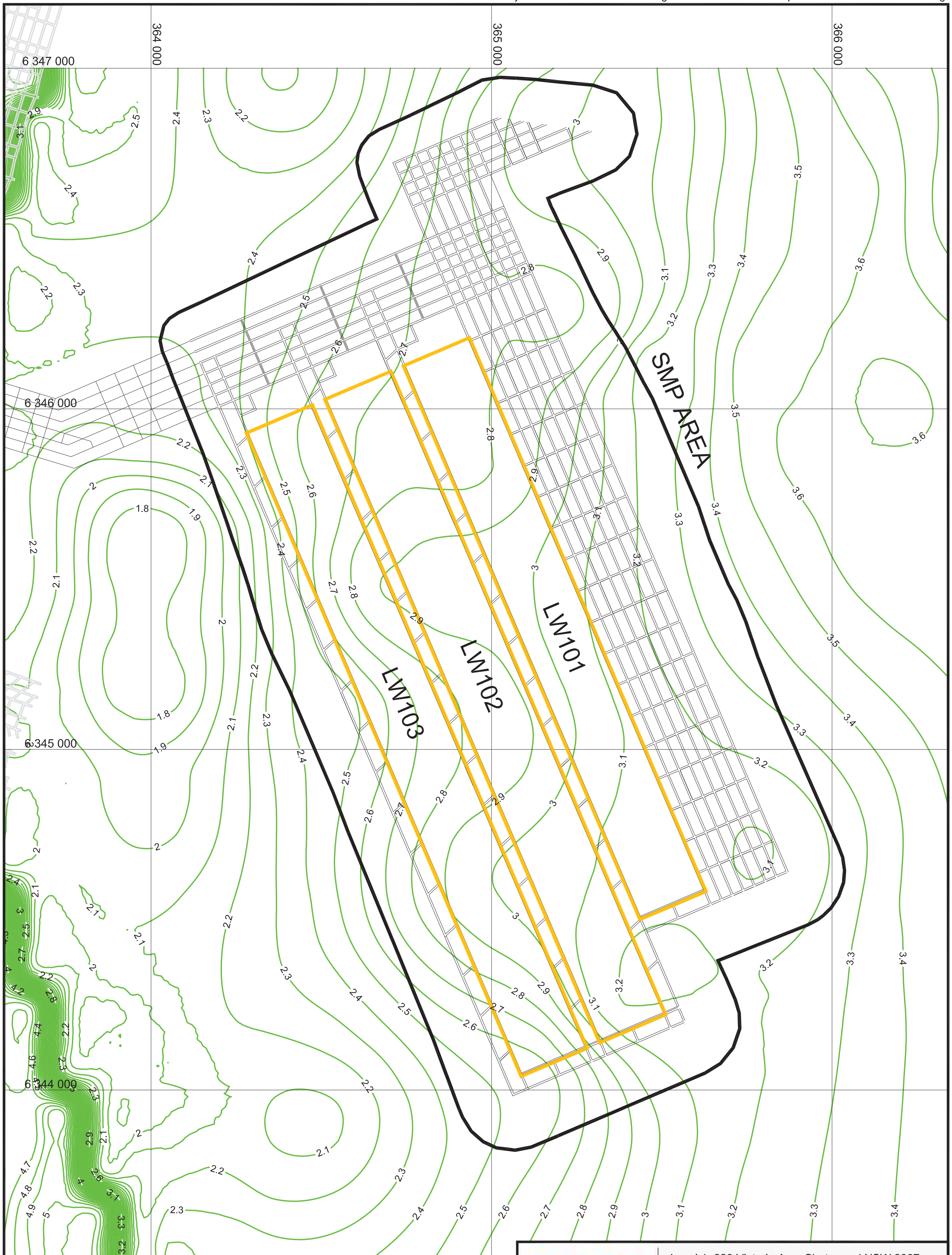

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SEAM THICKNESS CONTOURS ARE IN METRES

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CENTENNIAL COAL

NEWSTAN COLLIERY
LONGWALLS 101 TO 103
SEAM THICKNESS CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-05	B

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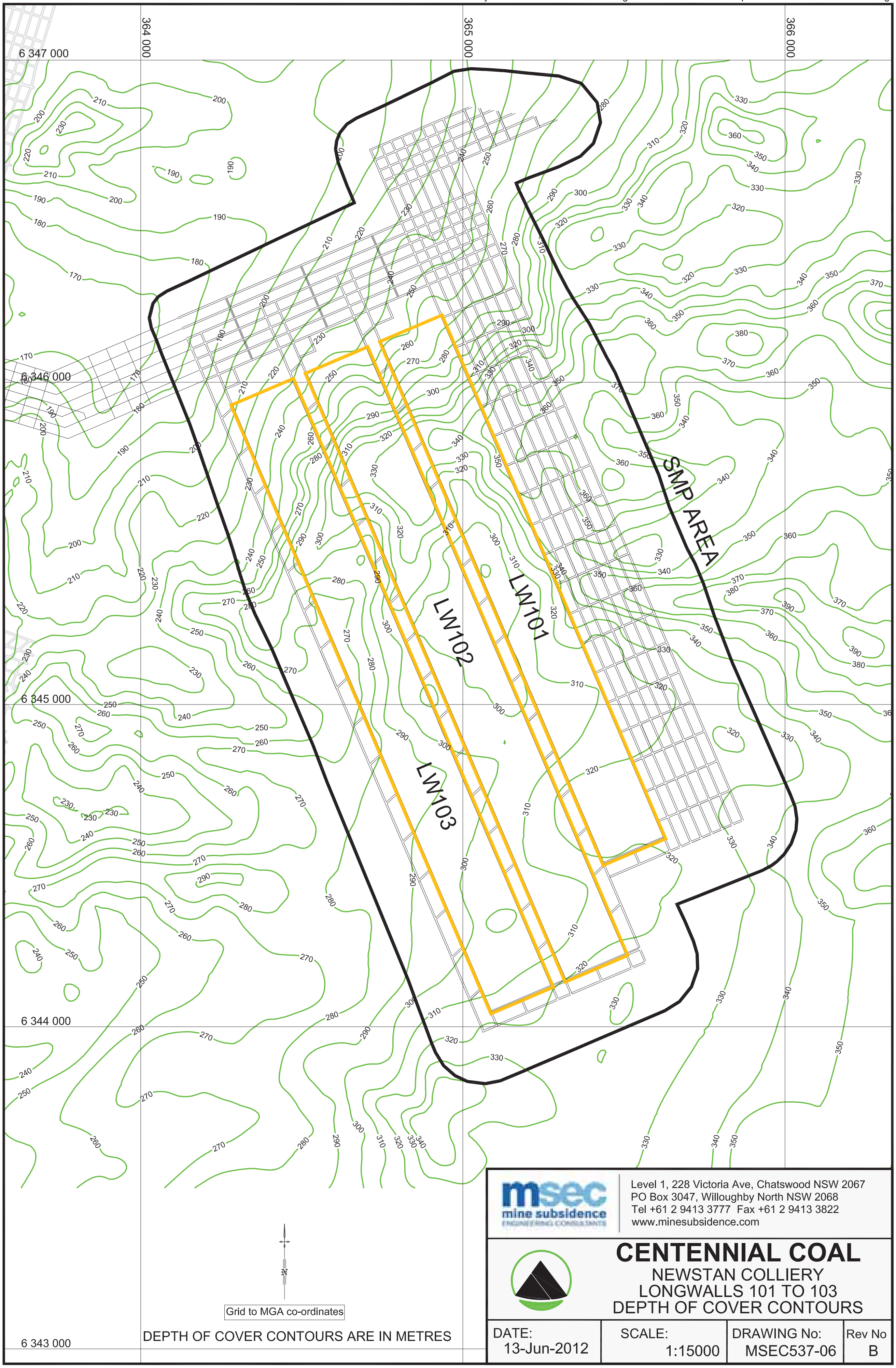

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CENTENNIAL COAL

NEWSTAN COLLIERY
LONGWALLS 101 TO 103
DEPTH OF COVER CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-06	B

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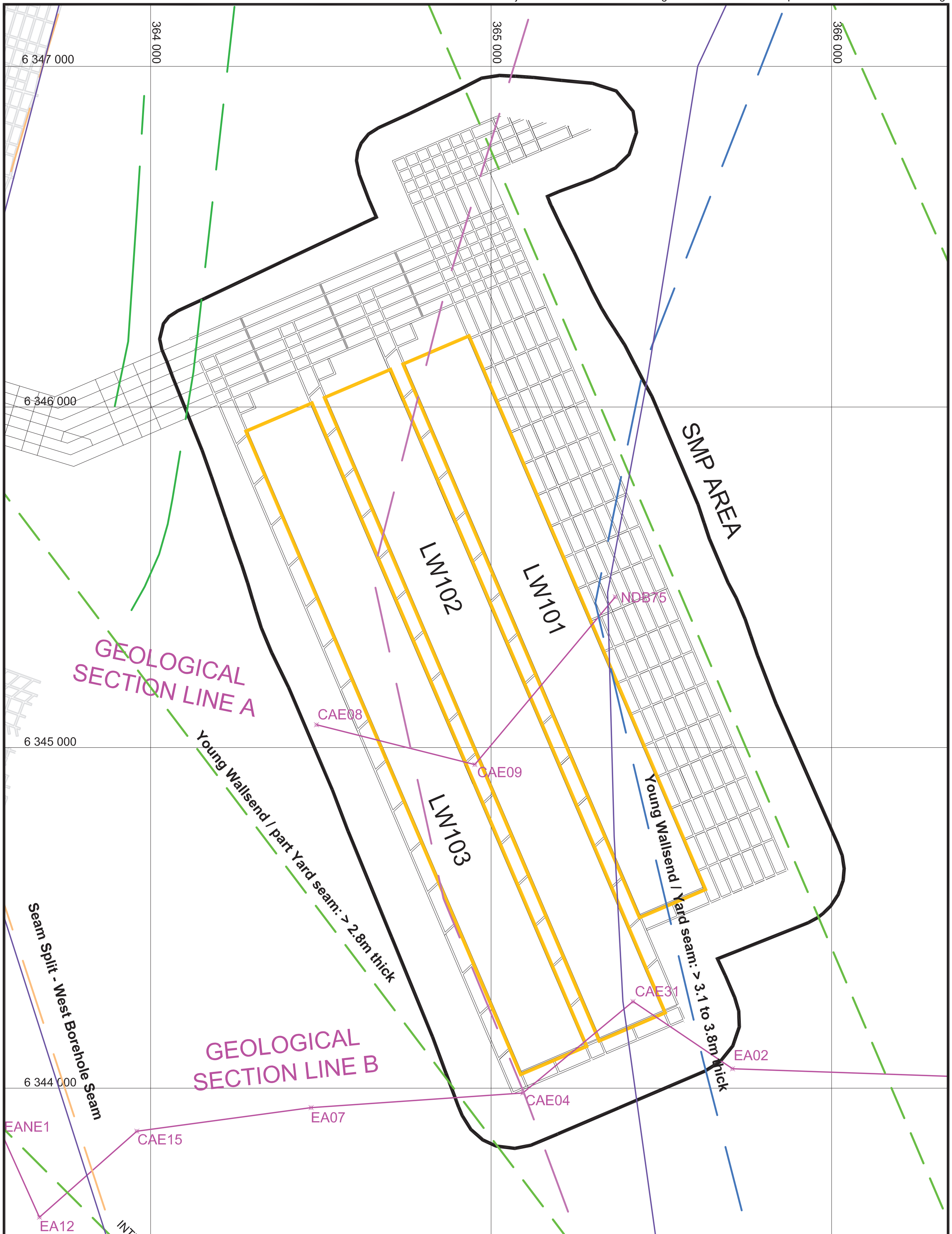

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CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
GEOLOGICAL CROSS SECTIONS

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-07	B

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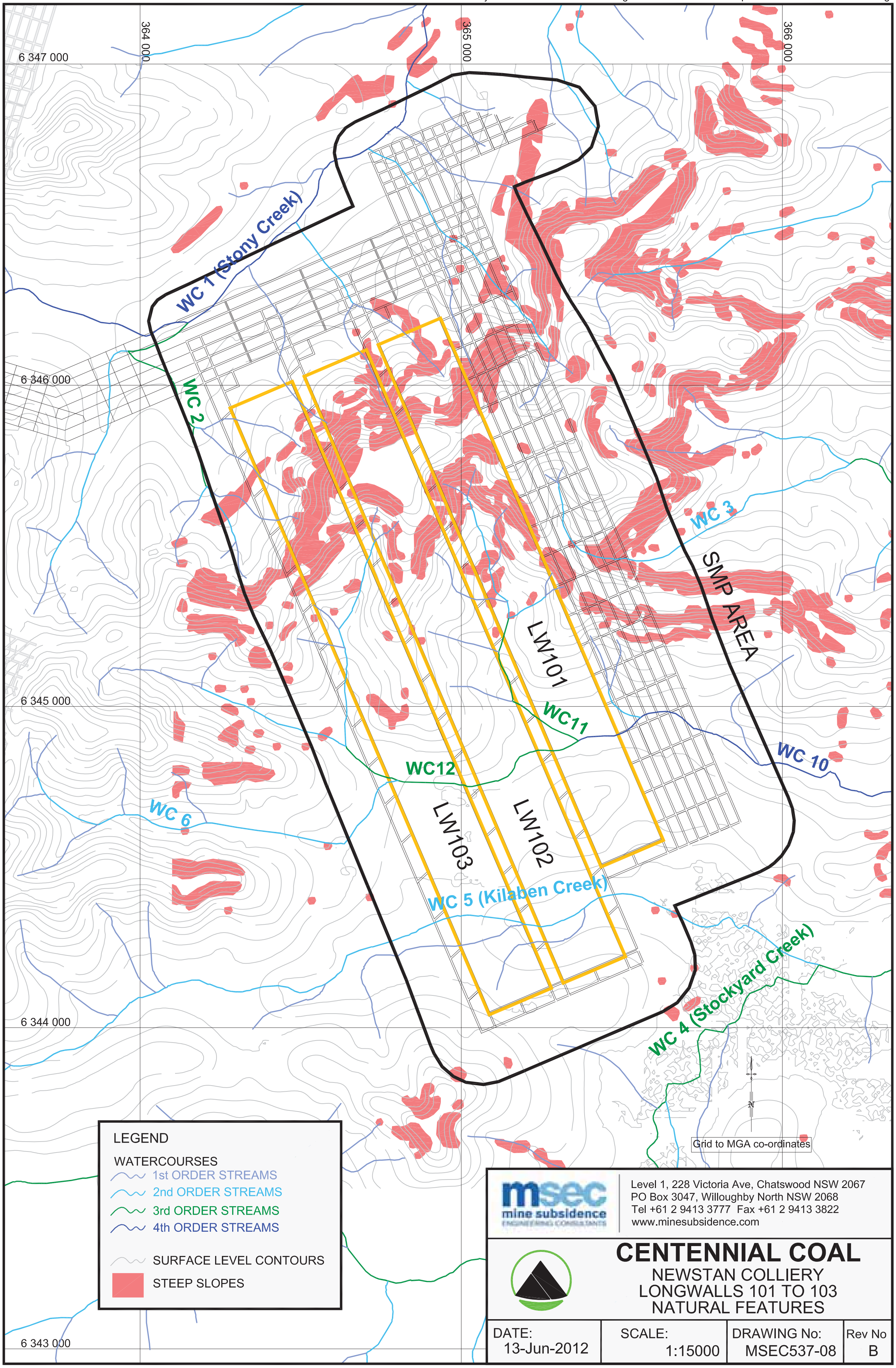

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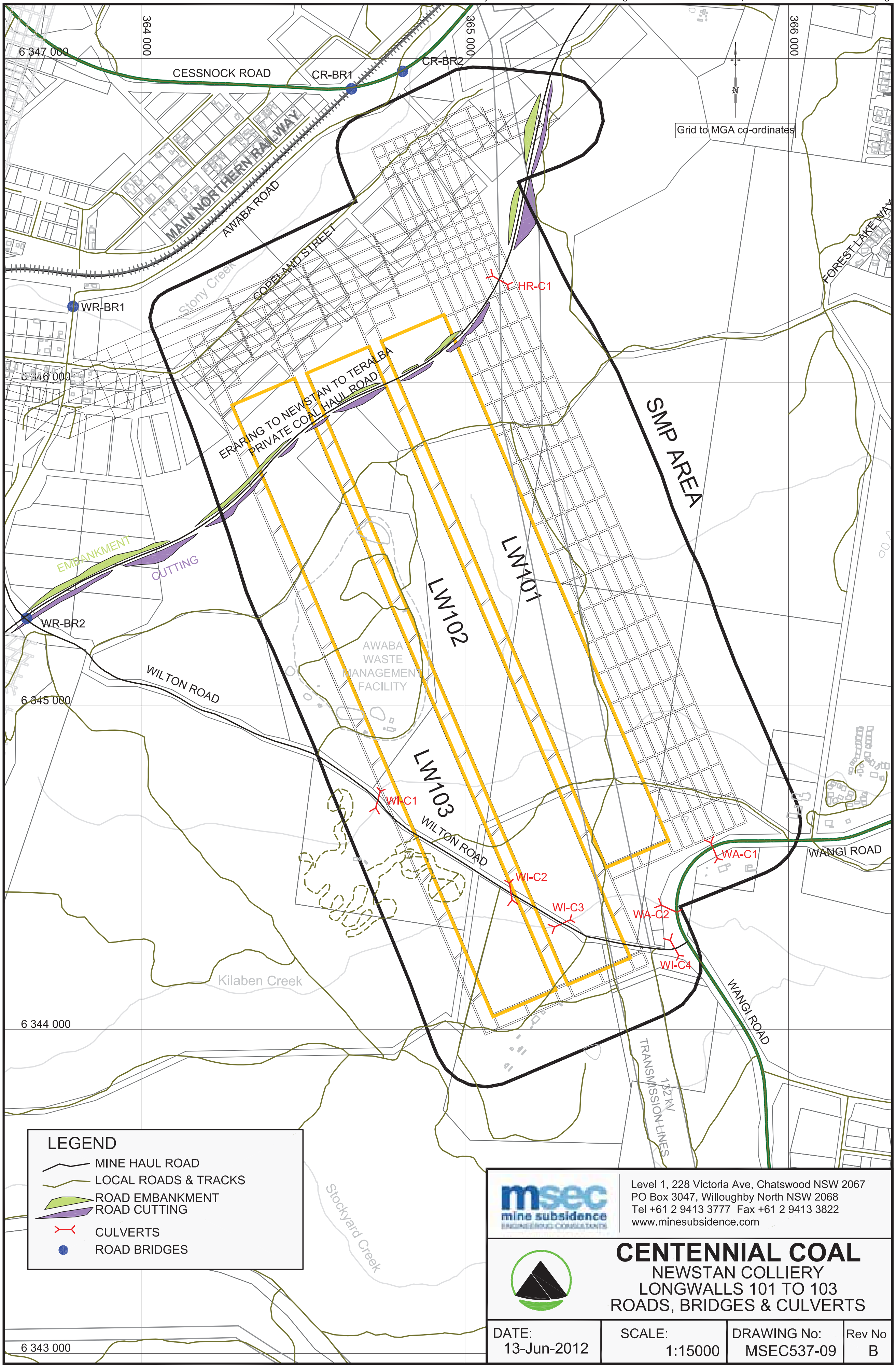

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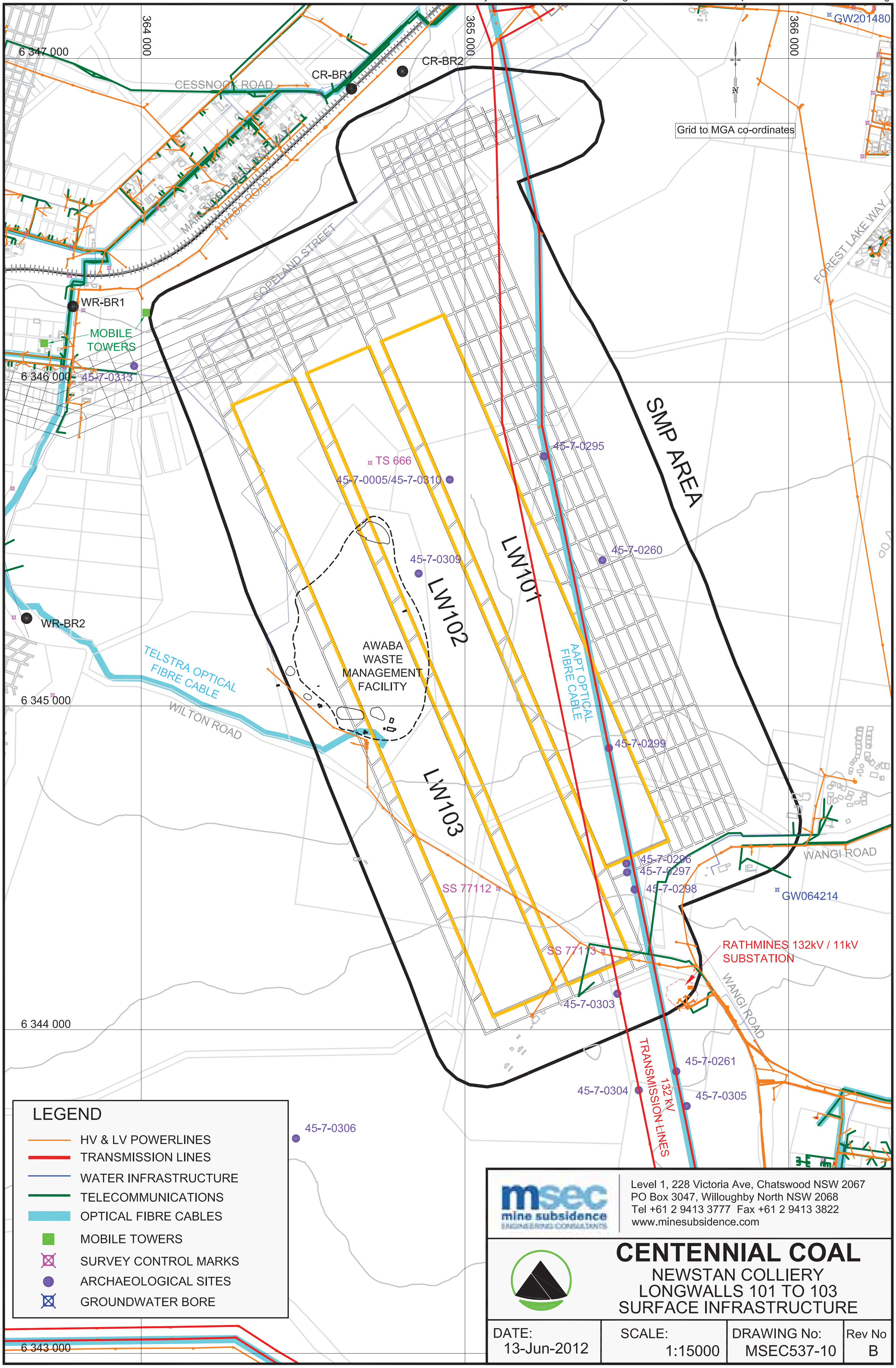

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CENTENNIAL COAL
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LONGWALLS 101 TO 103
SURFACE INFRASTRUCTURE

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-10	B

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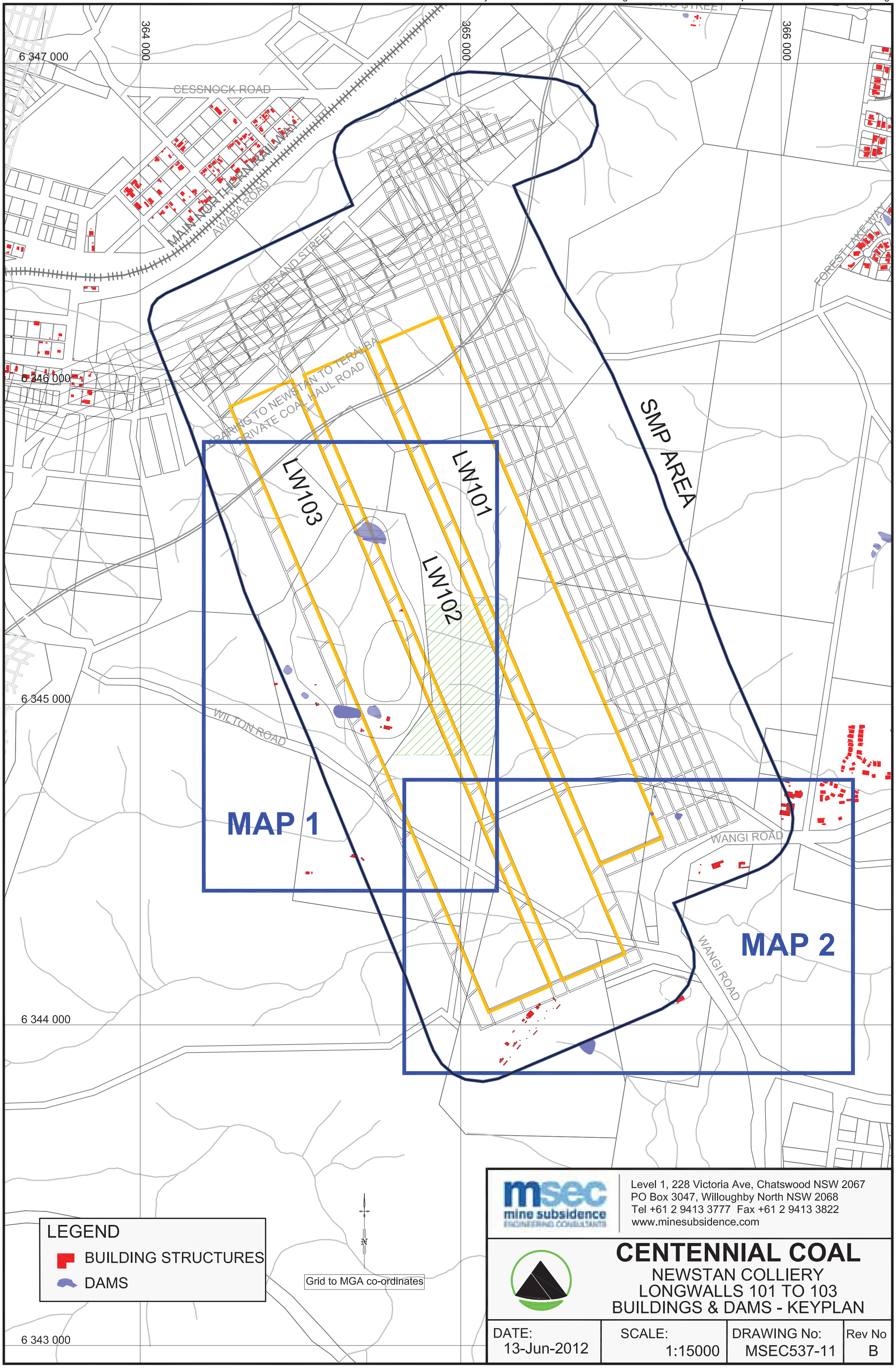

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CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
BUILDINGS & DAMS - KEYPLAN

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13-Jun-2012	1:15000	MSEC537-11	B

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CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
BUILDINGS & DAMS - MAP 1

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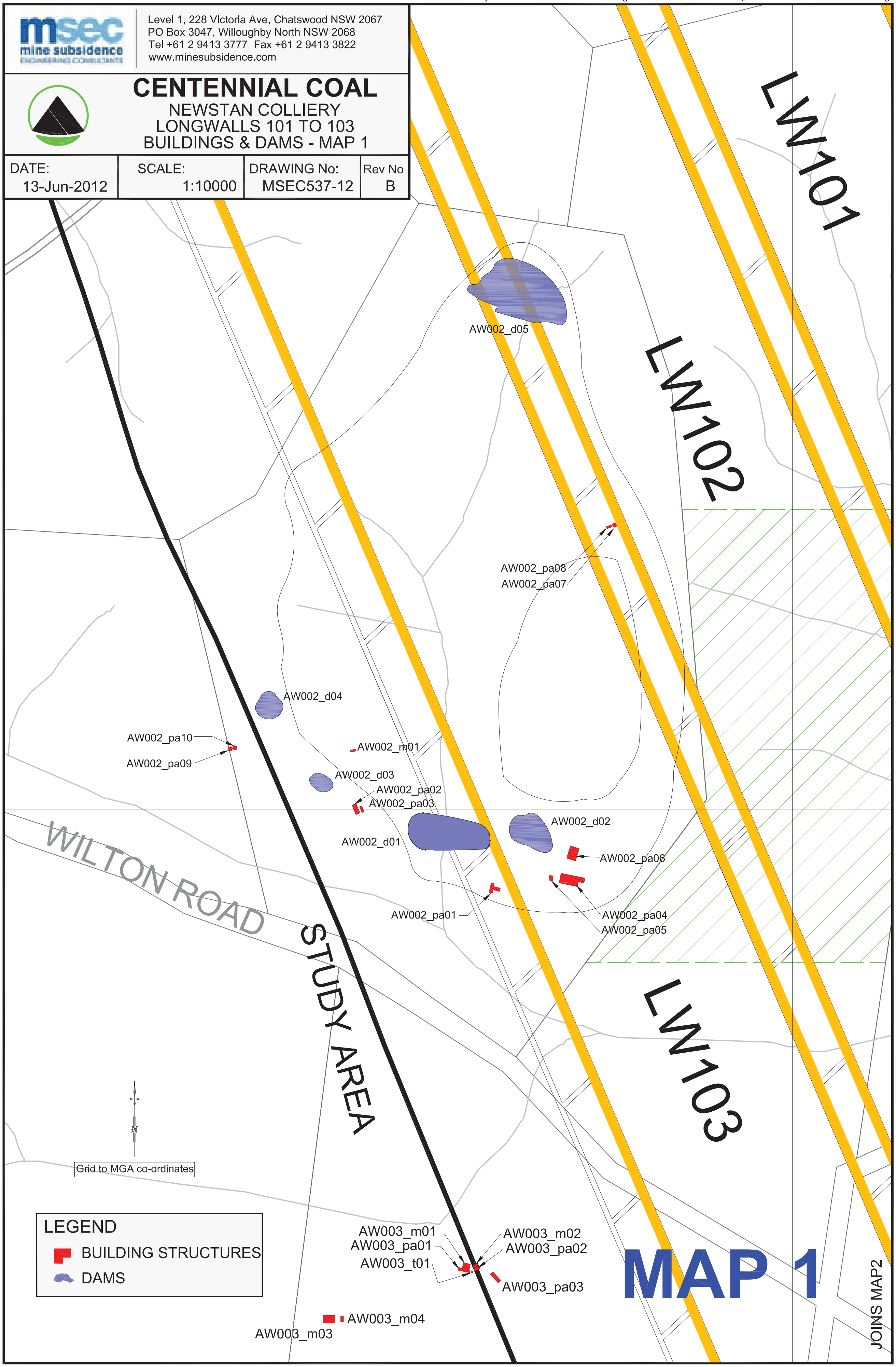
13-Jun-2012	1:10000	MSEC537-12	B



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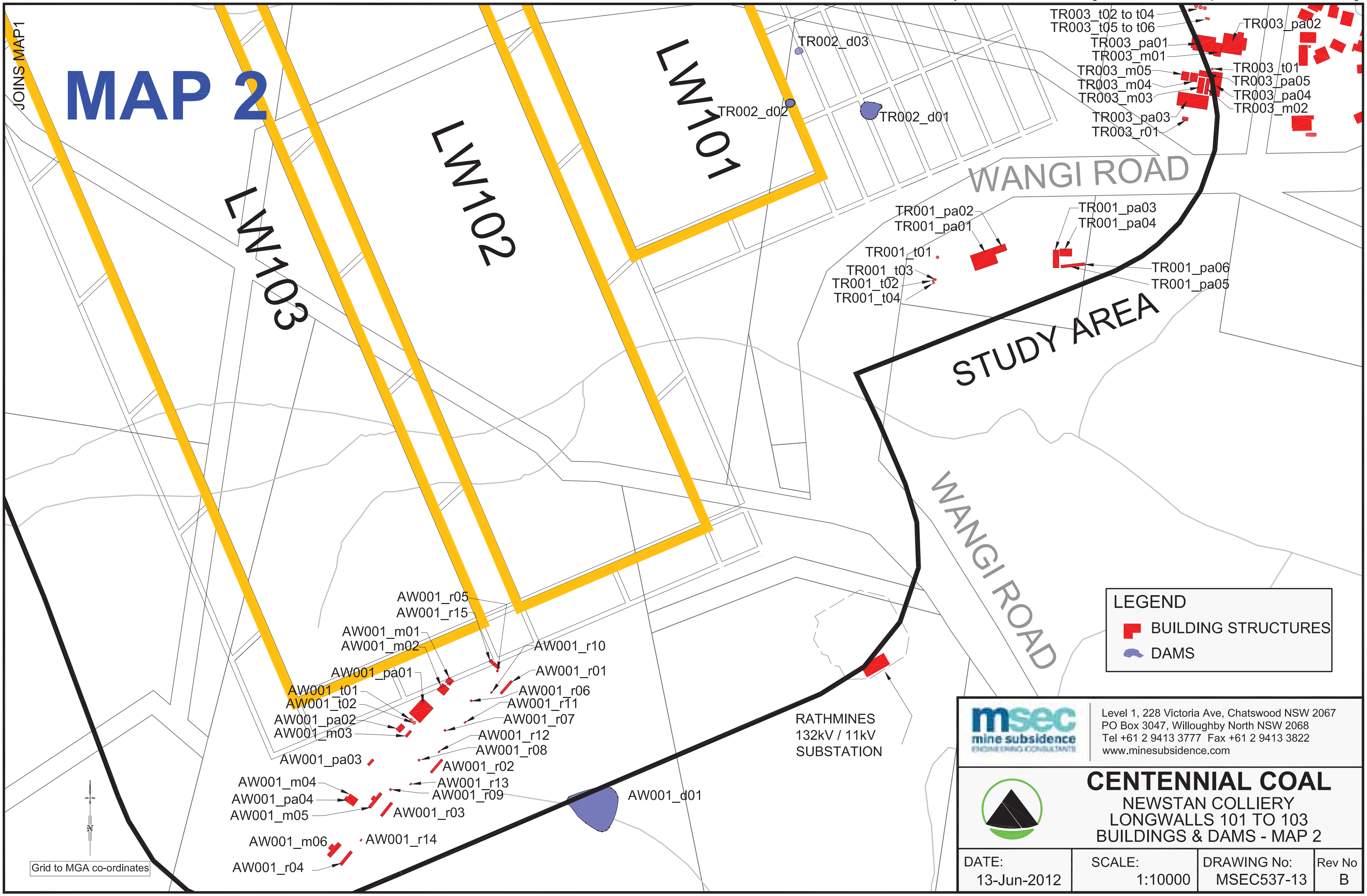

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CENTENNIAL COAL

NEWSTAN COLLIERY
LONGWALLS 101 TO 103
BUILDINGS & DAMS - MAP 2

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:10000	MSEC537-13	B

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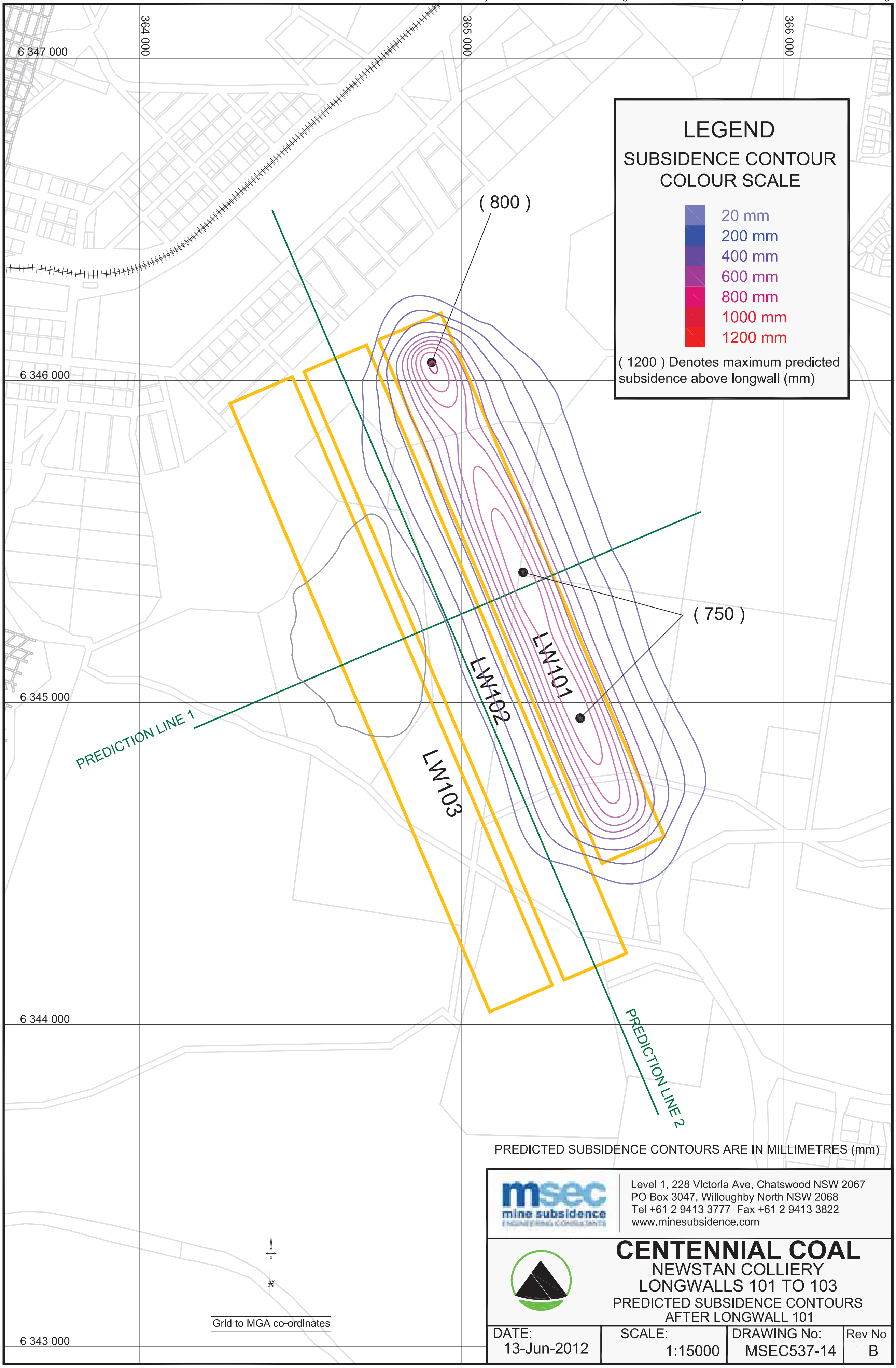

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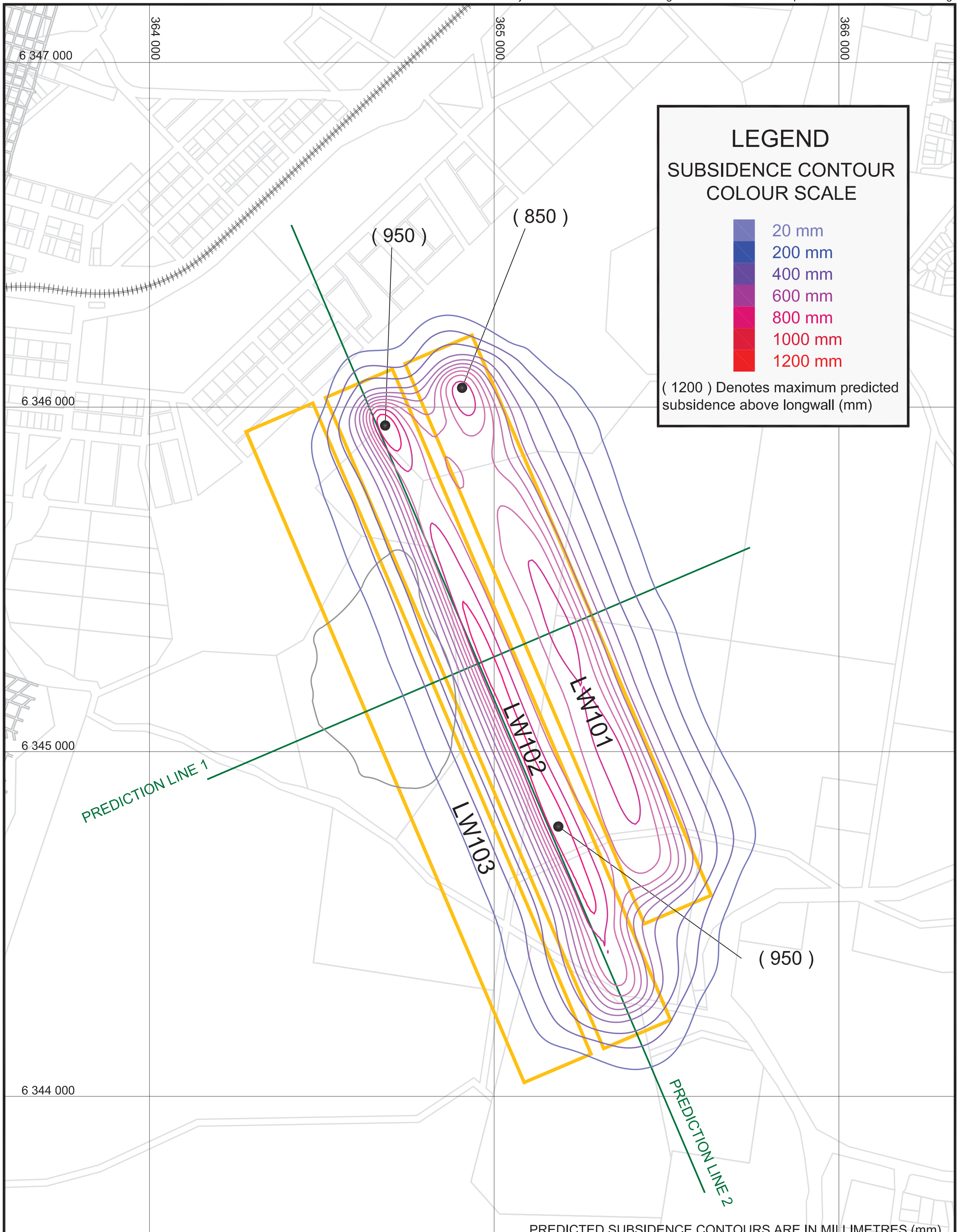

PREDICTED SUBSIDENCE CONTOURS ARE IN MILLIMETRES (mm)

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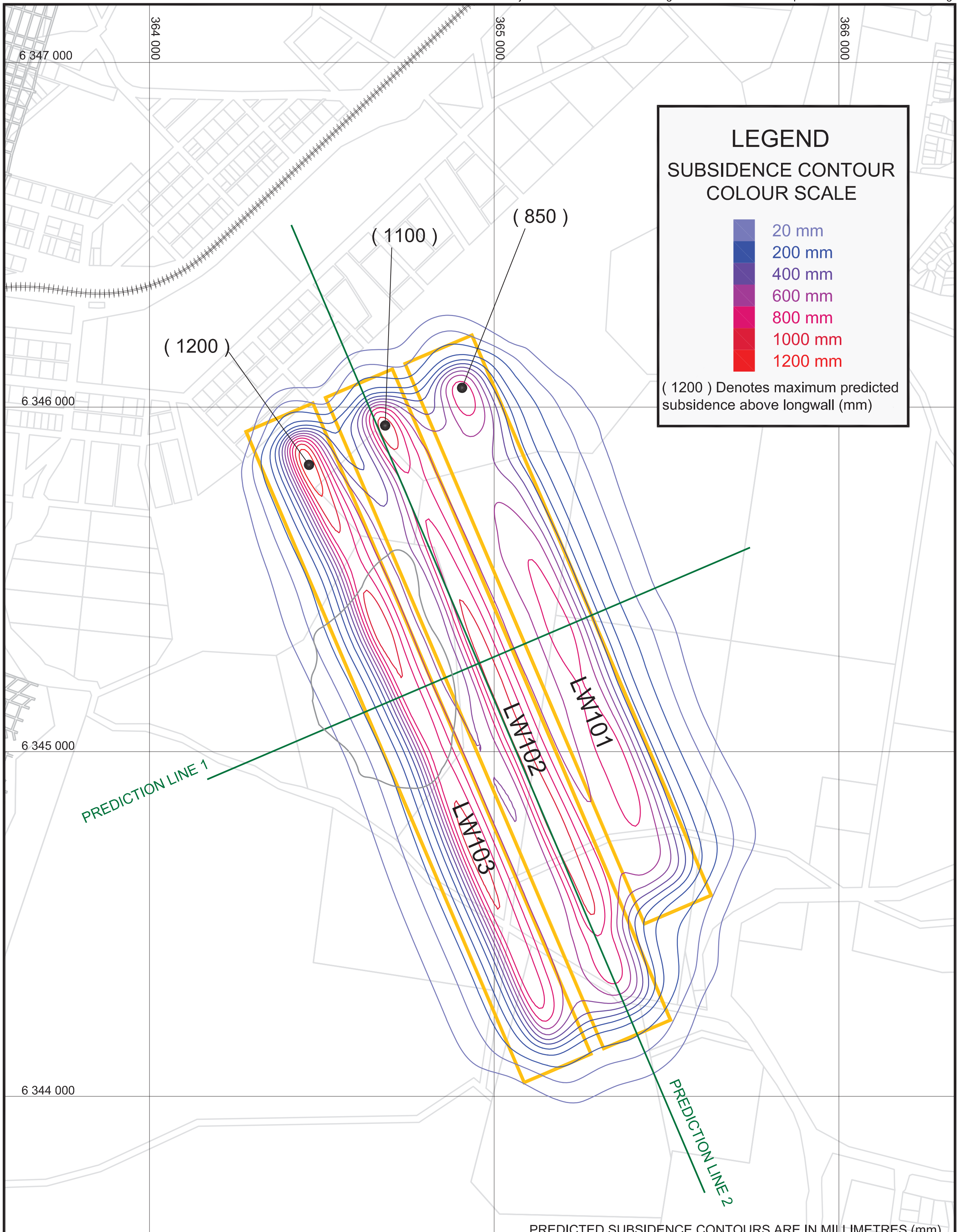
CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
PREDICTED TOTAL SUBSIDENCE CONTOURS AFTER LONGWALL 102

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-15	B



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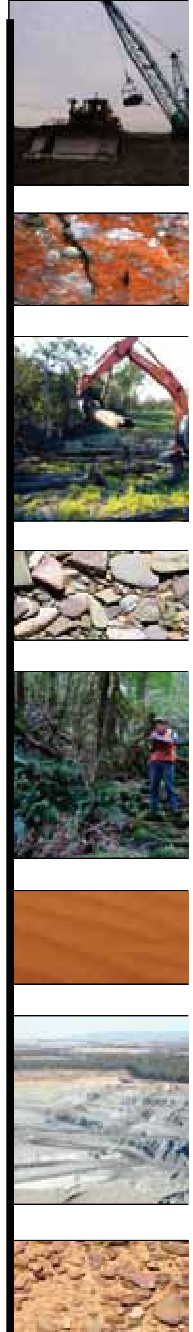
CENTENNIAL COAL
NEWSTAN COLLIERY
LONGWALLS 101 TO 103
PREDICTED TOTAL SUBSIDENCE CONTOURS
DUE TO LONGWALLS 101 TO 103

DATE:	SCALE:	DRAWING No:	Rev No
13-Jun-2012	1:15000	MSEC537-16	B



APPENDIX 5

Consultation

Powercoal
Newstan

RB

4th August 1999

Mr. Peter O'Kane
Surveyor Generals Department
P.O. Box 5051
NEWCASTLE WEST NSW 2302

Dear Sir,

On 6th July 1999 a lease extension to Newstan Colliery was granted enabling further development of our workings to the south and west of our present holding boundary.Part of the conditions within the lease was to notify the Newcastle Surveyors General's office (see copy of clause 37 (a) and (b) enclosed).In an effort to keep your office informed of the colliery's future planning I have enclosed a copy of the lease extension area for your perusal and comment on locations of marks as per clause 37.Please note that notice shall continue to be given to your office prior to the colliery making application for longwall extraction.

Yours faithfully,
NEWSTAN COLLIERY

R. Black
COLLIERY SURVEYOR

N.B. Sent copy of plan No M 26880R.

Powercoal Pty Ltd ACN 052 533 070
Newstan Colliery
Wakefield Road
Fassifern NSW 2283
c/- Post Office Toronto
NSW 2283 Australia
Facsimile 049) 50 4230
Telephone 049) 59 1266

CATCHMENT AREAS

33 (a) Operations shall be carried out in such a way as not to cause any pollution of the **Lake Macquarie** Catchment Area.

(b) If the lease holder is using or about to use any process which in the opinion of the Minister is likely to cause contamination of the waters of the said Catchment Area the lease holder shall refrain from using or cease using as the case may require such process within twenty four (24) hours of the receipt by the lease holder of a notice in writing under the hand of the Minister requiring the lease holder to do so.

(c) The lease holder shall comply with any regulations now in force or hereafter to be in force for the protection from pollution of the said Catchment Area.

TRIG. STATIONS AND SURVEY MARKS

37 (a) The lease holder shall contact the Newcastle Surveyor-General's office prior to the mining of each section to ascertain which marks will be disturbed.

(b) In the event of operations being likely to interfere with or damage any Trigonometrical Station, Permanent Mark or State Survey Mark (under the Survey Co-ordination Act 1949) erected on or near the subject area, the lease holder shall inform the Surveyor General's office (Newcastle) and shall comply with any directions given by the Surveyor General with respect to re-establishing any Trigonometrical Station, Permanent Mark or State Survey Mark after mining is completed.

TRANSMISSION LINES, COMMUNICATION LINES AND PIPELINES

41 The lease holder shall as far as is practicable so conduct operations as not to interfere with or impair the stability or efficiency of any transmission line, communication line or pipeline traversing the surface or the excepted surface of the subject area and shall comply with any direction given or which may be given by the Minister in this regard.

LABOUR/EXPENDITURE

44 The lease holder shall during each year of the term of the authority:

(a) ensure that at least **64** workers are efficiently employed on the subject area or

(b) expend on operations carried out in the course of prospecting or mining the subject area, an amount of not less than **$1,120,000.**

Table 1 Consultation Process with Potentially Affected* Private Stakeholders

(Note * = within predicted 20mm subsidence contour and 26.5 degree angle of draw)

Stakeholder	Dates Contacted	Modes	Description/Key Issues	Resolution
Eraring Power Station (Eraring Haul Road)	14/9/10	Meeting	Introduction to the Project	
	8/5/12	Meeting	Eraring Haul Road transects LW101-103 at the northern end of the longwalls. Eraring Energy have requested Newstan to provide predicted subsidence impacts on the Eraring Haul Road. Eraring Energy have requested that Newstan check compliance with the Continuing Haul Road Use Agreement.	Newstan have provided Eraring Energy with subsidence predictions. Impacts to the Eraring Haul Road will be managed via a Private Road Management Plan which will be developed in consultation with Eraring Energy and submitted to DTIRIS – DRE with the SMP Application. Eraring will review the subsidence impact report on the haul road and provide feedback to Centennial.
	19/6/12	Meeting	Meeting with senior Eraring management to discuss interactions Communication channels and progress updates	
	5/7/12	Visit	Characterisation of the Eraring infrastructure to finalise impact assessments	
	15/7/12	Visit	Characterisation of the Eraring infrastructure to finalise impact assessments	
AAPT	15/6/12	Phone call	Discuss the project with AAPT and future impacts	Asked to provide subsidence predictions
	02/07/12	email	Mail to Neil Mcleod to provide subsidence predictions	No further comment received from AAPT
Telstra	23/01/2012	phone call	Phone call to arrange characterisation of infrastructure and intention of project	No further comment received
Newcastle Lake Macquarie Clay Target Club	31/8/10	Meeting	Introduction to SMP processes and overview of proposed mining projects	
	25/1/12	Meeting	Likely need for routine re-levelling of clay target throwers at trap houses to maintain target delivery accuracy within the required +/- 1m; Potential impacts to the club house; Potential impacts to rainwater storage tanks; and Management of potential surface subsidence cracking.	Discussed the role of the MSB and Centennial in the repair of affected infrastructure.
Westlakes Automobile Club (AWABAWAC)	16/7/10	Phone	Phone discussion to request access for infrastructure assessment	

Stakeholder	Dates Contacted	Modes	Description/Key Issues	Resolution
	19/03/2012	Meeting	Introduction to the SMP process and overview of proposed mining projects at the AGM	The club was concerned about the repair of any damage to the infrastructure. Discussed the role of the MSB as well as Centennial in the process and achieved resolution
Ausgrid (Previously Energy Australia)	28/6/98	Letter	Letter requesting consideration of impacts on electrical infrastructure as a result of the proposed Newstan Colliery Life Extension Area EIS	
	26/08/08	Email	Acknowledgement from Energy Australia that it will be Energy Australia's responsibility to design the substation taking into consideration potential future mining	
	29/07/09	Letter	Details of proposed substation upgrades and provision of a draft REF for comment	
	18/08/09	Letter	Request for further meetings and discussions regarding the detailed design of the substation taking into consideration future mining potential	
	26/08/09	Meeting	Meeting to discuss options for substation construction without limiting future mining potential	
	1/09/09	Email	Provision of substation design recommendations taking into consideration typical subsidence parameters than could be expected	
	6/11/09	Meeting	Meeting to discuss potential subsidence parameters for consideration in substation design	
	14/4/10	Letter	Update from Energy Australia regarding substation project progress	
Toronto Country Club	8/2/12	Phone	Phone discussion to request access for infrastructure assessment	
Toronto Adventist School	28/02/12	Phone	Call to school requesting access for infrastructure assessment	
	16/7/11	phone	Introduction to EIS & SMP process and the project	
	8/3/12	meeting	presentation of impact assessments	The principal was interested in the impact assessments and the protection offered to the school. The role of the MSB and the impact assessments were discussed
	01/03/12	Visit	Characterisation of infrastructure	
Hunter Water	15/02/2012	Phone call	Call to discuss mine plan and future interaction and arrange characterization	

Table 2 Consultation Process with Government and Other Stakeholders

Stakeholder	Dates Consulted	Modes	Key Issues Raised	Resolution
DTIRIS – Division of Resource and Energy	20/3/12	Meeting	Centennial project briefing session to discuss Centennials northern projects including proposed SMP application	
	31/1/12	Meeting	Meeting to inform DTIRIS of the planned upcoming SMP submission and to scope any additional requirements from DTIRIS	
	8/3/12	Meeting	Mine Plan presentation – request for risk assessment to consider cracking of the unlined cell of the AWMF	
	14/8/12	Meeting	Pre SMP submission meeting with DTIRIS.	
Division of Catchments and Lands	20/3/12	Meeting	Centennial project briefing session to discuss Centennials northern projects including proposed SMP application	
	26/3/12	Email	Request meeting to discuss Newstan SMP issues in more detail	
	4/5/12	Email	Request meeting to discuss Newstan SMP issues in more detail	
Environmental Protection Authority	20/3/12	Meeting	Centennial project briefing session to discuss Centennials northern projects including proposed SMP application	
	Ongoing	Meeting	Centennial Newstan has undertaken extensive consultation over a number of years with OEH regarding water management at the Newstan Colliery. This consultation in ongoing.	
NSW Office of Water (NOW)	20/3/12	Meeting	Centennial project briefing session to discuss Centennials northern projects including proposed SMP application	
Department of Planning and Infrastructure (DP&I)	20/3/12	Meeting	Centennial project briefing session to discuss Centennials northern projects including proposed SMP application	
Roads and Maritime Services (RMS) (Wangi Road)	7/5/12	Meeting	No issues raised. Wangi road is situated directly south of LW101 but within the 26.5^{o} Angle of Draw. Newstan would not directly undermine Wangi Road. Management of Wangi Road will be undertaken in SMP document	RMS to check if Wangi Road is a bound or flexible construction in the areas of interest. Newstan to provide predicted subsidence impacts on Wangi Road. Centennial to provide details of predicted structural impacts from MSEC report and provide a copy of the traffic assessments once complete

Stakeholder	Dates Consulted	Modes	Key Issues Raised	Resolution
LMCC (Wilton road, Culverts and Bridges)	16/5/12	Meeting	No Issues raised. LMCC undertaking upgrades on Wilton Road. LMCC will look at designing the upgrade in relation to predicted subsidence impacts	Newstan to send LMCC Roads department the extract on Wilton Rd from MSEC report. Impacts to Wilton Road will be managed via a Public Road Management Plan which will be developed in consultation with LMCC and submitted for approval prior to undermining LW102
LMCC & AWMF (Awaba Waste Management Facility)	24/2/12	Meeting	Preliminary meeting to discuss mining under the facility and the SMP project in general	
	28/2/12	Email	Meeting minutes and actions distributed	
	24/2/12	Letter	Distribution of a CD containing Project Briefing Papers and invitation to attend project briefing session	
	29/2/12	Phone	Request for meeting to discuss mining on AWMF	
	8/2/12	Meeting	Discussion of mine layout and potential impacts on AWMF Concerns of impact that undermining will have on non-lined landfill cell and infrastructure on site.	Conduct site inspections, detailed characterisation, development of a project team specific to the AWMF, conduct further risk assessments, and develop a management plan in consultation with LMCC and AWMF to ensure the continued operation of the AWMF during mining operations. Further details refer to **Section 8.3.3.**
	14/2/12	Visit	Gas management infrastructure	
	6/3/12	Meeting	Technical design meeting to discuss the technical issues posed by the undermining of an operational waste management facility	
	20/3/12	Meeting	Progress update on studies undertaken Concerns about the extent of any possible existing groundwater contamination	
	4/4/12	Meeting	Discussion of possible groundwater contamination and the execution of a baseline study to determine current contamination levels	
	15/5/12	Meeting	Risk Assessment for undermining AWMF	
Mining Subsidence Board (MSB)	30/6/2011	Meeting	Meeting with MSB to discuss SMP and larger EIS project plans.	

Stakeholder	Dates Consulted	Modes	Key Issues Raised	Resolution
	25/01/12	Meeting	SMP and EIS project update meeting with MSB	
Community Consultative Committee (CCC)	15/11/11	Meeting	Introduce intention to seek SMP approval for mining within existing consent boundary	
	28/2/12	Meeting	Update on SMP	
	29/5/12	Meeting	Update on SMP	
Railcorp*	27/3/12	Meeting	Discussion of mining within the RailCorp corridor and the workings below the corridor. RailCorp queried whether it is possible to move the development further south and/or intersect the line perpendicularly.	The development was moved south. New layout acceptable to Railcorp
	27/3/12	Meeting	Meeting with RailCorp to discuss mining methodology and update progress. RailCorp were shown the underground work and adherence to plan from survey measurements.	RailCorp happy with the progress of project
	8/7/12	Email	Provision of mine design to RailCorp	
Toronto Adventist Centre	28/2/12	Phone	Call to school requesting access for infrastructure assessment and arrange meeting	
	8/3/12	meeting	Presented mine plan and subsidence predictions to principal	Principal concerned about impact to school. Agreed to develop management plan

* located beyond 20mm subsidence contour and 26.5 degree angle of draw

Centennial Coal news

Community Contact Numbers
(for information or complaints)

Awaba	02 4950 3435
Mandalong	1800 730 919
Mannering	02 4358 0580
Myuna	02 4970 0263
Newstan	1800 247 662

Our People

Nathan Yule
Ventilation Officer, Myuna

What do you enjoy most about living in the local area?

The location and the people as the locals are always friendly. I also enjoy the fact there are some great beaches and spots on the lake.

What do you do in your leisure time?

I enjoy spending time on our boat either cruising around the lake or just going out fishing.

Whom do you most admire?

I most admire my wife. I think I would be lost without her!

What is your favourite food?

It's hard to beat a BBQ in the summer months.

Which book or movie are you looking forward to reading / seeing?

I am really looking forward to seeing The Hobbit. It doesn't come out for until next Christmas, so I have a little while to wait!

Centennial project update

In February of this year, Centennial Coal submitted Briefing Papers for three of its development projects to the NSW Department of Planning & Infrastructure (NSW DP&I).

The three project are; Mandalong Mine's – Mandalong Southern Extension Project, Newstan Colliery's - Extension of Mining Project and the Northern Coal Services Coal Logistics Project.

The Briefing Papers are available both on Centennial Coal's and the NSW DP&I's website.

Centennial Coal is expecting to receive Director Generals Requirements for each of these three Projects in March 2012.

The Director Generals Requirements detail what is required to be addressed within the Environmental Impact Statement.

Newstan:

In May 2012, Newstan Colliery is aiming to submit a Subsidence Management Plan to the NSW Department of Trade, Investment, Regional Services and Infrastructure for the development of three longwalls at the Newstan Colliery.

This submission will be made in accordance with Newstan Colliery's existing Development Consent.

The Subsidence Management Plan will be developed in consultation with a number of government agencies, local land and infrastructure stakeholders.

Mandalong:

Mandalong Mine is currently preparing an Environmental Impact Assessment for a modification to increase the volume of coal distributed from its Cooranbong site to both the Eraring Power Station and the Newstan Colliery.

Currently, Mandalong Mine has approval to transport up to 2 million tonnes per annum (Mtpa) from Cooranbong to the Newstan Colliery via Mandalong's private haul road and up to 2 Mtpa from Cooranbong to the Eraring Power Station via the Eraring owned enclosed overland conveyor.

The modification is seeking the approval to transport up to 4 Mtpa to Newstan and up to 4 Mtpa to Eraring.

The total volume of coal handled at the Cooranbong facility will not exceed 4 Mtpa.

Mannering:

As reported in the last edition of Centennial Coal's News Page, Mannering Colliery is seeking to modify its existing planning approval.

The application was made to the NSW DP&I and was on public exhibition until February 24. As the public exhibition has now closed, Mannering Colliery will start to respond to the NSW DP&I to address any concerns or issues raised throughout the public exhibition process.

For more information:

For further information on any of Centennial's projects please visit Centennial's website: www.centennialcoal.com.au or the NSW DP&I website www.planning.nsw.gov.au.

If you would like to discuss any of these projects with Centennial Coal please call our Community Information Lines.

Morisset Agricultural Show

The 58th Annual Morisset and Lake Macquarie Agricultural Show enjoyed one of its most popular years yet with the weather doing little to dampen the Show's spirits.

With an array of live musical acts, amusement rides and traditional show activities such as wood chopping and equestrian events, the Show was one to remember.

Keeping the Show's tradition alive, the Morisset and Lake Macquarie Agricultural Showgirl competition returned again this year with three local girls competing for the title.

Taking home the tiara this year was Wyee's Morgan Clancy, who was crowned by last year's winner Miranda Rumore.

Morgan and her fellow Showgirl contestants, runner up Kate Davidson and Racheal Gattera underwent a series of judging sessions.

The girls were judged on their local, regional, state, federal and rural knowledge as well as their deportment, etiquette and speech.

Putting her newly acquired skills into practise, Morgan will attend business breakfasts and luncheons, community events and travel to regional areas to attend rural shows and continue etiquette classes as part of her role.

Future Showgirl contestants are given a chance to practice their skills in the Princess category. The Princess category is for young girls aged 17 years and under and is a great introduction to show activities and gives them the opportunity to attend a mini deportment class.

As outgoing Showgirl, Miranda not only crowned Morgan as the new Showgirl for 2012, but she also contested her Showgirl title in Lithgow for the finals of the Land Sydney Royal Show Girl Competition.

L-R: Showgirl contestants Racheal Gattera, Kate Davidson, Miss Morisset Showgirl 2012 Morgan Clancy, Miranda Rumore and Showgirl organiser Jan Coulter.

Centennial Coal news

Community Contact Numbers
(for information or complaints)

Awaba	02 4950 3435
Mandalong	1800 730 919
Mannering	02 4358 0580
Myuna	02 4970 0263
Newstan	1800 247 662

Our People

Ross Mackenzie
Control Room Co-ordinator, Myuna

What do you enjoy most about living in the local area?

The relaxed lifestyle, the quality beaches and of course the great fishing.

What do you do in your leisure time?

Surfing, fishing and spending time with my family.

Whom do you most admire?

My wife Laure with all of her energy and enthusiasm. She defiantly motivates me, without her I would not have done half the things in my life.

What is your favourite food?

My wife's cooking especially her 'Chicken in Hazelnut Cream,' and her 'Thai green curry.'

Which book or movie are you looking forward to reading / seeing?

I don't generally read books, but my two teenage children are the ones who look forward to the movies so I just transport them.

Centennial project update

State Significant Development Projects

Centennial Coal is progressing with mine and infrastructure designs as well as environmental assessments for the three significant development projects; Mandalong Mine – Mandalong Southern Extension Project, the Newstan Colliery Extension of Mining Project and the Northern Coal Servies – Coal logistics Project.

These assessments will continue over the next six months and will form part of the Environmental Impact Statement (EIS) required to be prepared to support the projects.

Once prepared the EIS for each project will be submitted to NSW Department of Planning and Infrastructure (NSW DP&I).

Centennial has been and will continue to consult with relevant landholders, residents and stakeholders.

Newstan

Newstan Colliery is currently preparing a subsidence management plan for an area of proposed longwall mining within Newstan's existing development consent boundary.

The subsidence management plan is required to be completed as part of Newstan's mining lease conditions.

A range of environmental assessments are currently being prepared to support the subsidence management plan application.

Once completed, the plan will be submitted to the NSW Department of Trade, Investment, Regional Infrastructure and Services – Division of Resources and Energy for assessment and approval.

It is anticipated that the subsidence management plan will be submitted in late June, at which time it will be made publicly available.

Mandalong Modification

Centennial Mandalong has lodged an Environmental Assessment to support a modification to the Mandalong Mine Development Consent to increase the volume of coal transported from Mandalong Mine's Cooranbong Entry Site (located near Dora Creek) to the Newstan Colliery and the Eraring Power Station.

If approved, the increase in volume of coal will be from 2 million tonnes per annum each way to up to 4 million tonnes per annum each way via Centennial's private dedicated haul road.

The Environmental Assessment is currently being assessed by the Department of Planning and Infrastructure and is available for viewing on the Centennial Coal website.

For more information:

For further information on any of Centennial's projects please visit Centennial's website www.centennialcoal.com.au or the NSW DP&I website www.planning.nsw.gov.au.

If you would like to discuss any of these projects with Centennial Coal please call our Community Information Lines.

Mandalong South drilling drawing to an end

The exploration drilling programme for Mandalong South is drawing to an end with 46 holes completed.

Centennial intends to drill a further 5 holes to complete the programme.

A mine plan has now been selected which will extend the life of Mandalong Mine through to 2034. The mine plan has taken into account the geological and surface constraints which include:

- An igneous sill where there is no coal;
- A coal seam split (coal is 3.6m to 4.4m thick to the west and 2.8m to 1.8m in the east);
- Dykes (these are magnetic features and run in a north-west to south-east direction);
- Volcanic plugs (there are two in the southern area);
- Dwellings;
- 330 kV power lines;
- Creeks and low lying areas susceptible to flooding;
- Steep slopes; and
- The Buttonderry Waste Management Facility.

The longwall width will be up to 200m.

The control of the subsidence of the surface features has been addressed by altering the size of the coal pillars that are left behind.

This will see similar levels of surface impact that is currently being experienced at Mandalong Mine.

The data gathered from the existing Mandalong Mine, coupled with 6 years of experience in the area, has been used to predict the subsidence parameters in the southern area.

The design is aimed at meeting the Mine Subsidence Board's criteria of safe, serviceable and repairable for homes.

The Mandalong South Project team has recently wrapt up a series of 10 community information sessions to discuss the extension of Mandalong's mine plan.

"We have run a series of information sessions for the local community and landholders to talk through and discuss the mine plan and subsidence controls and it has been encouraging to hear their questions, thoughts and feedback,"

"We look forward to working with them over the next stages of the project," said Mandalong South Project Manager, Peter Cook.

Morisset Community Festival

The Morisset Community Festival was back for its 12th year and is showing no signs of losing its popularity.

"It is a great way to meet with some our community's familiar faces and to meet some new ones who were keen to look at Mandalong South's extension projects plans," said Centennial's James Wearne.

On display at the Centennial marquee was information and plans on the Mandalong South extension project as well as a few goodies including green – eco bags, hats and free temporary tattoos which was a favourite with the young and old alike.

"People were really interested in learning more about what stage of the process we are currently going through with the Mandalong South extension project, what the next steps for the project are and about future employment opportunities," continued James.

Centennial was just one of the stands at the festival, which was designed to encourage the community to get together for an entertaining day out with little cost to those who attend.

With plenty of rides for the kids, the festival also included several local dance companies showing off their slick routines, singers, musicians, art and craft stalls.

The Morisset Community Festival showcases the local area and provides the community a day of fun festivities.

Centennial's James Wearne talking with community members

Centennial Coal
news

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(for information or complaints)

Awaba	02 4950 3435
Mandalong	1800 730 919
Mannering	02 4358 0580
Myuna	02 4970 0263
Newstan	1800 247 662

Our People

Bill Burton
Maintenance Planner, Myuna

What do you enjoy most about living in the local area?

The climate is not too hot and not too cold and the area provides a huge range of educational, employment, social and recreational opportunities for my family

What do you do in your leisure time?

I en oy travelling in the outback regions of Australia hilst at home I play in a country blues band and play a little golf Mostly though I spend time with family and friends

Whom do you most admire?

My parents 48 years ago they packed up their young family in ngland and moved us here to Australia y taking that huge decision they enabled my brothers and I to live a life we could only have dreamed about

What is your favourite food?

Any meal my wife Cris produces he is culinary genius Her seafood creations are particularly awesome

Which book or movie are you looking forward to reading / seeing?

I am currently reading a history of domestic life by ill ryson as well as ric Claptons autobiography I don't watch movies

Centennial project update

State Significant Development Projects

Centennial Coal is progressing with mine and infrastructure designs as well as environmental assessments for the three State Significant Development Projects; Mandalong Mine – Mandalong Southern Extension Project, the Newstan Colliery Extension of Mining Project and the Northern Coal Services – Coal logistics Project.

These assessments will continue over the next six months and will form part of the Environmental Impact Statement (EIS) required to be prepared to support the projects.

Once prepared the EIS for each project will be submitted to NSW Department of Planning and Infrastructure (NSW DP&I).

Centennial has been and will continue to consult with relevant landholders, residents and stakeholders.

Newstan

Newstan Colliery is currently preparing a subsidence management plan for an area of proposed longwall mining within Newstan's existing development consent boundary.

The subsidence management plan is a required to be completed as part of Newstan's mining lease conditions.

A range of environmental assessments are currently being prepared to support the subsidence management plan application and once completed, will be submitted to the NSW Department of Trade, Investment, Regional Infrastructure and Services – Division of Resources and Energy for assessment and approval.

It is anticipated that the subsidence management plan will be submitted in late July, at which time it will be made publicly available.

Newstan Modification

Newstan Colliery is seeking a modification to its existing Development Consent to allow the receipt of an additional 2 Mtpa of coal from the Mandalong Mine and the construction of a new men and materials drift at the Awaba Colliery. The drift will replace a men and materials downcast shaft which was originally proposed to be constructed.

The drift will provide additional ventilation to the underground mining operations and future access for the workforce.

An Environmental Assessment is currently being prepared to support the Project. It is anticipated the Environmental Assessment will be lodged with the Department of Planning and Infrastructure by the end of July 2012.

Mandalong Modification

Centennial Mandalong has lodged an Environmental Assessment to support a modification to the Mandalong Mine Development Consent to increase the volume of coal transported from Mandalong Mine's Cooranbong Entry Site (located near Dora Creek) to the Newstan Colliery and the Eraring Power Station.

If approved, the increase in volume of coal will be from 2 million tonnes per annum each way to up to 4 million tonnes per annum each way.

The Environmental Assessment is currently being assessed by the Department of Planning and Infrastructure and is available for viewing on the Centennial Coal website.

Workforce Redeployment

To support Centennial's operations approximately half the workforce from Centennial's Mannering Mine will be redeployed to the Newstan Mine.

This will allow Mannering to maintain small scale operations while the appropriate studies and approvals are undertaken and completed in order to expand future mining operations and for Newstan to further progress and prepare for its proposed new underground extension using a skilled and experienced workforce.

The workforce has been consulted and the redeployment process will commence on 23 July.

For further information on any of Centennial's projects please visit Centennial's website www.centennialcoal.com.au or the NSW DP&I website www.planning.nsw.gov.au.

If you would like to discuss any of these projects with Centennial Coal please call our Community Information Lines.

Myuna Colliery calling for interested community members to join CCC.

Myuna Colliery is currently seeking members to form its first Community Consultative Committee (CCC).

The CCC will provide a forum for open discussion between representatives of Myuna Colliery, the community, Lake Macquarie City Council and other relevant stakeholders.

Topics which will be discussed at CCC meetings relate to any issues directly relating to Myuna Colliery operations, environmental performance and community activities.

The CCC meetings help keep the local community informed on these areas.

The CCC requires between three and five members of the community to take part and who will be willing to contribute, provide feedback to the local community and stakeholder groups, have an awareness of relevant issues and be a current resident in the local area.

Myuna Colliery's CCC will be chaired by retired State MP and long serving former Local Government Councillor, Gerard Martin.

Gerard also has an interest in regional development and has served as Deputy Chair of the Central West Regional Development Board.

Please submit your expression of interest to: myunacolliery@centennialcoal.com.au, or via post to PO Box 1000, Toronto NSW 2283; addressed to Gerard Martin.

Expressions of interest are due by the 19th of July 2012.

If you require any further information please contact Myuna Colliery's Environment and Community Coordinator, Veronica Warren on 02 4970 0263.

TLC Band sporting new stands

The Toronto Learning Community (TLC) Band is sporting new music stands which is making practicing and public performances an easier and more enjoyable musical experience.

"It is great to see the TLC Band waste no time in putting their new music stands to good use,"

"They are such a talented young group of musicians who play at a lot of our local community events and we were glad to assist them in making their musical performances an easier task with new music stands," said Veronica Warren, Centennial's Myuna Mine Environment and Community Co-ordinator.

The TLC Band is a truly local initiative, as it is made up of the most talented music students from Awaba, Arcadia Vale, Rathmines, Toronto, Biraban, Coal Point, Blackalls Park Public Schools and Toronto High School.

The TLC aims to enhance the learning outcomes of students through a co-operative effort by all the schools.

The local area is proving to be a haven for talented musicians with Arcadia Vale Public School having 70 of its 101 students participating in one of its musical programmes.

"While the school is one of the smallest in the area, it has the second largest band and it is great to see its' students play such an active part in the TLC Band," concluded Veronica.

Centennial Coal
Newstan

100 Miller Road
Fassifern NSW 2283
PO Box 1000
Toronto NSW 2283 Australia

T: 61 2 4956 0200
F: 61 2 4950 4230
E: info@centennialcoal.com.au
W: www.centennialcoal.com.au

SMP and EIS Project Community Consultation RMS

Date: 07 May 2012

Time: 15:00

Location: RMS Office, 59 Darby Street, Newcastle

Attendees:

Attendees	Organisation
David Young	RMS
Colin Nonn	RMS
Michael Dixon	RMS
Kevin Whittaker	RMS
Terry O'Brien	Centennial
Jason Boersma	Centennial
Chris Rowland	Centennial
James Wearne	Centennial
Don Kay	MSEC
Jeffrey Gary	Intersect Traffic

Agenda:

Minutes	Required Actions	By Who	By When
Terry O'Brien conducted an introduction and brief overview of the Newstan SMP and EIS projects.			
James Wearne described the potential impact for RMS to consider would be from subsidence to their roads and changing traffic flows.			
RMS raised the issue of level rail crossings at Adamstown and Clyde Street. It was discussed that the impact of increased rail traffic through this area could be considered.			
Jason Boersma conducted an overview of the Newstan SMP project. It was highlighted that the original mining consent from 1998 (ML1452) stipulated no direct mining under Wangi Road.			

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Newstan

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F: 61 2 4950 4230
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RMS informed Centennial that the Wilton Road intersection is an RMS intersection, not a Council intersection.			
RMS are interested in strains and any shear failure that may be associated with the subsidence from mining. They also highlighted their interest in understanding potential impacts on culverts and drainage.			
No major concerns with the SMP were raised by RMS in the meeting. RMS is to get the pavements people involved and check if Wangi Road is flexible or bound in the areas of interest.	RMS to check if Wangi Road is a bound or flexible construction in the areas of interest.	RMS – David Young	31/05/2012
Don Kay discussed current undermining of the Hume Highway and the monitoring, preventative and repair measures in place.			
Jason Boersma asked RMS what information they required.	Centennial to provide RMS with: - Details of the predicted structural impacts to the road (from MSEC report) - How the Longwall components will be brought onto site.	Jason Boersma	18/05/2012
Centennial informed RMS that no coal or coal rejects are to be transported on public roads. Centennial also discussed that new longwall/heavy equipment will not be trucked to site for over 18 months.			
Discussion was held on the impact of increasing employee levels. RMS requested that when the Intersect Traffic report is completed they receive a copy.	Centennial to send RMS a copy of Intersect Traffic report when complete.	James Wearne	06/07/2012

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Fassifern NSW 2283
PO Box 1000
Toronto NSW 2283 Australia

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W: www.centennialcoal.com.au

SMP, EIS and Water Project Community Consultation Eraring Energy

Date: 08 May 2012

Time: 13:00

Location: Eraring Power Station

Attendees:

Attendees	Organisation
Neil Williams	Eraring
Antony Cotic	Eraring
Owen Suters	Eraring
Peter Hahn	Eraring (via video link)
Clement Leung	Eraring (via video link)
Grant Watson	Centennial
Terry O'Brien	Centennial
Jason Boersma	Centennial
Paul Williams	Centennial
David Randall	Centennial
Jeff Dunwoodie	Centennial
Chris Rowland	Centennial

Agenda:

Minutes	Required Actions	By Who	By When
Terry O'Brien conducted an introduction to the meeting.			
Jason Boersma provided an overview of the SMP Project.			
Eraring asked about subsidence and tilt parameters for the haul road. Centennial discussed maximum subsidence of approximately 1200mm and maximum tilt of 13mm/m.	Eraring to review the subsidence impact report on the haul road and provide feedback to Centennial.	Eraring	01/07/12
Eraring asked about the approvals process. Centennial advised it is within the current development consent for Newstan, however, the orientation of the longwall blocks has changed slightly. With current approval, the SMP requires			

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consultation only.			
Eraring requested a copy of the extract from the MSEC subsidence prediction report relating to the Mine Haul Road.	Centennial to provide Eraring with MSEC extract relating to Mine Haul Road, bridges and culverts.	JB	11/05/12
Owen Suters raised the Continuing Haul Road Use Agreements and the conditions of these. Eraring requested Centennial check compliance with these agreements.	Centennial to check compliance with existing Continuing Haul Road Use Agreements (see Paul Duncan)	JB	19/05/12
The greater Newstan EIS project was discussed. Eraring raised the possibility that the ash dam may no longer be in use by the time mining is to take place underneath.			
Centennial advised that mining is proposed to be by Flexible Conveyor Train (FCT) however this could change in the future, along with the mine plans and layout.			
During discussions of Newstan's proposed EIS application, Eraring raised concerns with the potential impact of subsidence on Eraring Energy infrastructure, including, but not limited to the rail unloader loop, stockpile, fuel tanks and ash dam. Centennial explained that prior to any mining under Eraring Energy infrastructure that may cause subsidence, a Subsidence Management Plan will be required to be submitted to, and approved by, DTIRIS. This management plan will be created in consultation with Eraring Energy. Currently, the EIS is a conceptual mine plan only.			
Neil Williams raised that Eraring would be willing to share their ecology/threatened species reports with Centennial for the EIS project.			
Centennial and Eraring have agreed to the process where Centennial will provide Eraring the subsidence prediction reports.	Centennial to provide draft Private Road Management Plan to Eraring for comment, discussion	JB	20/06/12

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Centennial will draft a management plan for the Mine Haul Road and finalise its development in consultation with Eraring to ensure both parties agree to the management strategy and plan.	and finalisation once it has been the draft has been developed.		
Water: - Centennial is currently looking at what to do with its excess water. - Eraring currently pays for water, Centennial identified them as a potential recipient of excess water. - Current water monitoring at 10 South is not of the quality required for Eraring. Other bores may provide a better quality of water. - Dialogue is to continue. - Newstan is currently building a water processing plant that Eraring may be able to use the water from, as an alternative to Centennial discharging the cleaned water.			
Awaba: - Grant Watson informed Eraring that a sinkhole has developed on Eraring land. This poses no threat to the Mine Haul Road, however, the area is mowed. - Remediation work is to commence over the next two months.	Inform Eraring Energy when work is complete.	JB	20/07/12
Eraring informed Centennial that Geoff Burns is the contact if Centennial wishes to transport equipment down the Mine Haul Road for the new fan shaft site.			
The potential for flyash storage was discussed. Issues identified were – a lack of storage capacity and potential water contamination. Dialogue to continue.			

Centennial Coal Newstan

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SMP and EIS Community Consultation LMCC Roads and Infrastructure

Date: 16 May 2012

Time: 09:00

Location: Newstan Colliery

Attendees:

Attendees	Organisation
Allen Brierly	LMCC Roads and Infrastructure Coordinator
Jason Boersma	Centennial
Chris Rowland	Centennial

Agenda:

Minutes	Required Actions	By Who	By When
Jason Boersma outlined the history of the Newstan mine and the proposed EIS and SMP applications.			

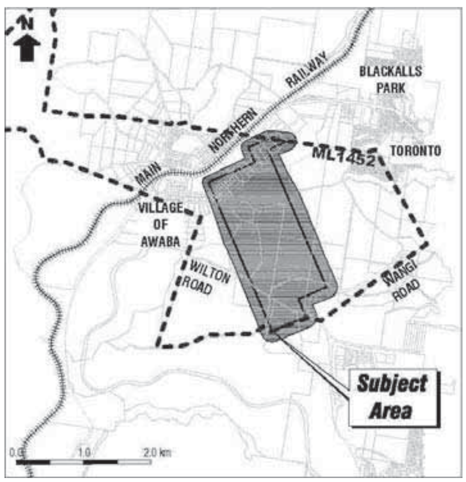
The main details of the SMP application were discussed, including:
- Mining is proposed under Wilton Road for Longwall 102 (LW102) and Longwall 103 (LW103).
- The depth of mining for the SMP area varies from approximately 180 to 250 metres.
- Subsidence predictions have been undertaken by SPGL, PSM and MSEC with all indicating similar levels of predicted subsidence.
- All subsidence impacts to Wilton Road are predicted to be in the safe, serviceable and repairable range.
- The approximate timing of mining is:
  - LW101 Q4 2014
  - LW102 Q3 2015			

- LW103 Q2 2016			
Centennial will develop a Public Roads Management Plan (PRMP). When a draft is complete, it will be sent to LMCC Roads for comment. This plan may include the implementation of monitoring lines along Wilton Road.	Centennial to send draft PRMP to LMCC Roads for comment.	CR	01/07/12
Allen Brierley requested the extract of the MSEC subsidence assessment and impact report.	Centennial to send LMCC Roads the Wilton Road extract from the MSEC subsidence assessment and impact report.	CR	18/05/12
Allen Brierley informed Centennial that LMCC Roads are currently designing and planning for Wilton Road upgrades to be carried out over approximately the next 12 months. LMCC Roads will look at designing the upgrade in relation to predicted subsidence impacts.			
The Wilton Road upgrade will be for select areas only, totalling approximately 300 metres. It was indicated that one area of potential upgrade is around the Awaba Waste Management Facility.			

CENTENNIAL NEWSTAN PTY LIMITED
A.B.N 68 101 508 865

Centennial Coal

Centennial Newstan Pty Ltd wishes to advise its intent to submit a Subsidence Management Plan (SMP) Application for the development and extraction of longwall panels LW101-103 within Mining Lease ML1452, approved for underground longwall mining under existing Development Consent DA73-11-98. The SMP Application can be viewed at the Newstan Colliery (100 Miller Road, Fassifern) from Monday 27 August to Friday 28 September 2012 and also on the Centennial Coal website www.centennialcoal.com.au



Please address all submissions concerning the proposed SMP Application by Friday 28 September to either the:

Environmental Coordinator - Newstan
Centennial Newstan
PO Box 1000
Toronto NSW 2283
or
Director of Environment and Sustainability,
NSW Department of Trade, Investment, Regional Infrastructure and Services – Division of Resources and Energy,
PO Box 344
Hunter Region Mail Centre
NSW 2310

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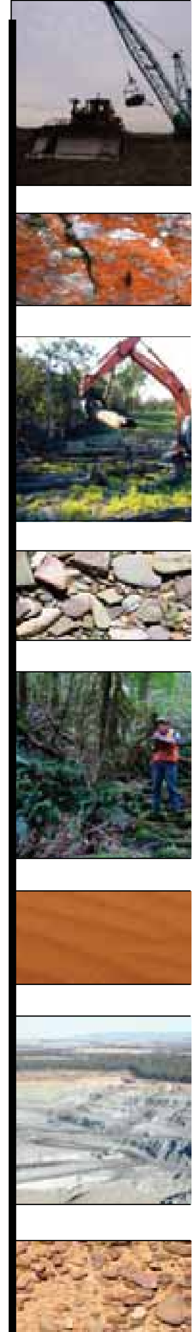


Risk Assessment Report

APPENDIX 6

Dyadem Stature for Risk Management:

Risk Assessment Title: Newstan SMP (LW1-3)
Version: 1
Region: North
Site: Newstan
Stature Risk Assessment No.: 1000199001

Background

Longwall extraction is proposed in the eastern areas of the Newstan Colliery life Extension Area targeting the Young Wallsend (Nobby's and Dudley seams) and Yard seams. The proposed longwalls are aligned generally north south, are 200m wide and range in length. The targeted resource lies approximately 170 to 400 metres below the surface.

An SMP Application is required to be submitted to NSW DRE for determination prior to the commencement of secondary extraction. In accordance with the NSW Department of Primary Industries - Mineral Resources (DPI-MR) *Guideline for Applications for Subsidence Management Approvals* (2003), a risk based process and assessment is required for the application. Specifically, risk aspects are to be considered in accordance with the requirements of sections s6.10.2 and s6.10.3 of the guidelines.

Objectives

The following key objectives of the risk assessment for the **Newstan SMP Area (LW1-3)** include:

- To establish an appropriate SMP risk assessment team of suitably qualified and experienced Centennial staff and specialist consultants;
- Discuss and review existing information known for the Newstan SMP Area and experience in adjacent mining areas;
- Identify, assess & evaluate potential subsidence impacts to surface and subsurface features (natural & man-made) for the aspects required by the DPI-MR Guideline for Applications for Subsidence Management Approvals (2003), and in accordance with the Centennial Risk Management Standard (004) using the Centennial Risk Matrix (probability matrix of consequence and likelihood), with a focus on identifying and addressing potentially high risks or potentially severe consequences. This will also consider both expected/predicted maximum subsidence.
- To establish a Draft SMP Risk Register (WRAC Worksheet) and risk report for the Newstan SMP Area for review and comment by the risk team;
- The identification of additional controls required (including with respect to updating Centennial management plans for the SMP application); and
- To produce a Final SMP Risk Assessment Report (including the SMP Risk Register/WRAC Worksheet) for the Newstan SMP Area Application to DPI-MR.

The Centennial risk assessment standard lists the following Hierarchy of Controls and was followed in undertaking this risk assessment. Note that the effectiveness of a control that is intended to reduce as a risk decreases from top to bottom of the list. Which in other words, the closer the control type is to the top of the hierarchy, the more potentially effective the control.

- Eliminate the hazard or energy source (do not use the energy);
- Minimise or replace the hazard or energy source (reduce the amount of energy to a less damaging level or replace the energy with another that has less potential negative consequences);
- Control the hazard or energy using engineered devices (ex. Lock outs, chemical containers, mechanical roof support, gas monitors, etc);
- Control the hazard or energy by using physical barriers (ex. machine guarding, warning signs, etc);
- Control the hazard or energy with procedures (ex. Isolation procedures, standard operating procedures, etc);
- Control the hazard or energy with personal protective equipment (ex. hard hats, boots with toe caps, gloves, safety glasses, welding gear, etc); and
- Control the hazard or energy with warnings and awareness (ex. posters, labels, stickers, verbal warnings, etc).

The primary hazard to be assessed is surface cracking and deformation resulting from subsidence.

Scope

The scope of the risk assessment for the Newstan SMP Area includes:

- Consideration of the Newstan SMP Area (LW1-3) defined as the proposed workings plus 26.5 degree angle of draw;
- The risk assessment will consider the potential subsidence impacts to surface and subsurface features (natural and man-made).

The undertaking of the worst case scenario assessment will allow for a focus on the key risk aspects if identified and, subsequently, consideration under the base case scenario (expected mining predicted subsidence scenario) of whether the identified risks and controls required further consideration and assessment.

In accordance with DPI-MR *Guideline for Applications for Subsidence Management Approvals* (2003), the following subsidence and environmental related hazard categories/aspects were considered within the context of risks discussed and assessed by the risk team (as a minimum):

- Public Safety;
- Areas of high environmental, heritage or archaeological significance;
- Wetlands, swamps and water related ecosystems;
- Catchment Areas causing or exacerbating erosion and drainage pattern changes;
- Significant water courses including surface flows, water quantity and quality, and ecological integrity;
- Significant groundwater resources including levels and quality;
- Threatened & protected species under TSC Act 1995;
- Stability of escarpments & significant clifflines, pagodas or steep slopes;
- The serviceability of major public utilities and/or amenities;
- Surface improvements (including roads) causing damage beyond safety, serviceability and reparability;
- Agricultural suitability or productivity;
- Industrial, commercial and business establishments;
- Foreshores and land prone to flooding or inundation;
- Prescribed Dams or structures under the Dam Safety Act 1978; and
- Any other areas or features causing significant concern to the community, local and state government agencies.

Risk Assessment Method

Yes/No	Method
Yes	Workplace Risk Assessment and Control (WRAC)
No	Fault Tree Analysis (FTA)
No	Safety Integrity Level Analysis to Australian Standard 61508 (SIL)
No	Bow Tie Analysis (BTA)
No	Failure Modes and Effects Analysis (FMEA)
No	Hazard and Operability Analysis (HAZOP)

Information Provided

A presentation was provided to the risk assessment team at the start of the risk assessment workshop which provided an overview of the key characteristics of the Newstan LW1-3 SMP Area, and aspects required for discussion and assessment during the risk assessment.

Preliminary mapping/figures were presented for natural and constructed surface features and land ownership within the SMP Area. Comment was provided on each relevant aspect by the specialists present at the risk assessment meeting for ecology, archaeology/Aboriginal heritage, surface/groundwater and mine subsidence.

Risk Assessment Scoping, Assessment and Review

Date	Description	Location	Start Time	End Time
1. 21-Oct-2011	Scoping	Newstan Environmental Office	9:00 AM	11:00 AM
2. 07-Nov-2011	Assessment	Newstan Environmental Office	8:00 AM	1:00 PM
3. 08-Nov-2011	Review	Newstan Environmental Office	2:00 AM	3:00 AM
4. 21-Feb-2012	Review	Newstan Environmental Office	11:00 AM	12:00 PM

Risk Assessment Participants

Name	Title	Company
Jeffrey Dunwoodie	Environmental & Community Coordinator	Newstan Colliery
James Wearne	Environment & Community Coordinator	Centennial Coal
Jason Boersma	Senior Mining Engineer - Projects	Centennial Newstan
Terry O'Brien	Mine Manager	Newstan Colliery
Andrew Cameron	Mine Surveyor	Newstan Colliery
Gareth Swarbrick	Geotechnical Engineer	PSM
Craig Bagnall	Environmental Consultant	GSS Environmental
Rhys Worrall	Environmental Consultant	GSS Environmental
Stuart Gray	Environmental Consultant	GHD
Ian Jolieff	Environmental Consultant	GHD
Tessa Boer-Mah	Environmental Consultant	RPS
Toby Lambert	Environmental Consultant	RPS
Nerida Manley	Environment & Community Coordinator	Newstan Colliery
Mitch Graham	Geologist	Centennial Fassifern

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
1. Public Safety	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Personal injury and/or vehicle damage or Privately owned lands.	1.1.a. Mine design - panel width designed relative to known geology. 1.1.b. Mine design has taken into consideration the depth of cover. 1.1.c. A draft subsidence assessment has been prepared.	**E** (D)	2 (PI)	16 (M)	31. Develop a Public Safety Management Plan for the SMP
2. Areas of high environmental, heritage or archaeological significance.	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to Aboriginal heritage material within the SMP area or Impacts on European heritage within the SMP area or Non-compliance with current Indigenous Land Use Agreement.	2.1.a. An archaeological survey has been completed over the SMP area. 2.1.b. Consultation has been undertaken in accordance with the Office of Environment and Heritage 2010 guidelines. 2.1.c. An Aboriginal and Cultural heritage Management Plan is currently being drafted for the Newstan Colliery. 2.1.d. There are no identified European heritage sites within the SMP area. 2.1.e. Two of the identified Aboriginal heritage sites are located in relation to the mine design. 2.1.f. Exploration program has been completed to determine geology. 2.1.g. A geotechnical model has been developed 2.1.h. Mine design - panel width designed relative to known geology.	**C** (D)	4 (R)	18 (M)	1. A section 90 permit is required for rock shelter and grinding groove sites. 2. The subsidence assessment is to determine tensile strains. 3. A site inspection with archaeologist and subsidence consultant to be undertaken to look at site specific attributes of the sandstone based Aboriginal sites (grinding grooves and rockshelters). 4. Assessment of likelihood of impacts to sandstone based sites to be included in subsidence assessment. 5. Baseline archaeological recording of sandstone based sites is to be undertaken prior to the commencement of mining activities.

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
	There is a risk to Newstan from ::: Subsidence repairs ::: Caused by: Mining Operations Resulting in: Damage to Aboriginal heritage material within the SMP area or Impacts on European heritage within the SMP area or Non compliance with current Indigenous Land Use Agreement/Native Title.	2.2.a. An Aboriginal and Cultural heritage Management Plan is currently being drafted for the Newstan Colliery. 2.2.b. An archaeological survey has been completed over the SMP area. 2.2.c. Pre-disturbance surveys are undertaken.	**D** (D)	4 (R)	21 (L)	
3. Wetlands, swamps and water related ecosystems	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Reduced flow or changes to water quality flowing into wetlands and/or swamps.	3.1.a. Baseline creek surveys have been completed 3.1.b. A flood model is being developed which covers the SMP area 3.1.c. Mapping of the vegetation communities has been undertaken over the SMP area 3.1.d. No SEPP 14 wetlands have been identified within the SMP area. 3.1.e. Two SEPP 14 wetlands have been mapped downstream and outside of the SMP area 3.1.f. Mine design - panel width designed relative to known geology. 3.1.g. A geotechnical model has been developed 3.1.h. Exploration program has been completed to determine geology. 3.2.c. Mapping of the vegetation communities has been undertaken over the SMP area 3.2.d. A geotechnical model has been developed 3.2.e. Mine design - panel width designed relative to known geology.	**C** (D)	4 (E)	18 (M)	6. Surface water assessment to include an assessment on ponding. 7. Assess the sensitivity of known SEPP 14 wetlands to freshwater flow following the completion of the ponding assessment. 33. Centennial to consider submission of an EPBC referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). Submission if required should be done as early as possible in the process. 34. Consider undertaking further more detailed ecology surveys within groundwater dependent communities to confirm or otherwise the presence of any Endangered Ecological Communities within these areas.

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
4. Catchment areas	There is a risk to Newstan from ::: Subsidence Impacts / repairs ::: Caused by: Mining Operations Resulting in: Erosion within stream bed and bank during re-establishment of creek grades or Loss of water into overburden strata resulting in reduced surface flows or Significant changes in ponding & reduction in surface water flows in creeks within the SMP area.	4.1.a. Baseline creek surveys have been completed 4.1.b. A flood model is being developed which covers the SMP area 4.1.c. Mapping of the vegetation communities has been undertaken over the SMP area 4.1.d. Mine design - panel width designed relative to known geology. 4.1.e. A geotechnical model has been developed 4.1.f. Mine design has taken into consideration the depth of cover. 4.1.g. History of mining at the Newstan Colliery	**B** (D)	5 (E)	19 (M)	6. Surface water assessment to include an assessment on ponding.
5. Surface water - significant water courses	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Cracking of creek bed.	5.1.a. Baseline creek surveys have been completed 5.1.b. A flood model is being developed which covers the SMP area 5.1.c. Mapping of the vegetation communities has been undertaken over the SMP area 5.1.d. Mine design - panel width designed relative to known geology. 5.1.e. A geotechnical model has been developed 5.1.f. Mine design has taken into consideration the depth of cover. 5.1.g. History of mining at the Newstan Colliery	**E** (D)	4 (E)	23 (L)	
6. Surface water - significant water courses	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in:	6.1.a. Baseline creek surveys have been completed 6.1.b. A flood model is being developed which covers the SMP area 6.1.c. Mapping of the vegetation communities has been undertaken over the SMP area	**D** (D)	4 (E)	21 (L)	

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
	Loss of water flows, impacts to water quality & loss of aquatic habitat.	6.1.d. Mine design - panel width designed relative to known geology. 6.1.e. A geotechnical model has been developed 6.1.f. Mine design has taken into consideration the depth of cover. 6.1.g. History of mining at the Newstan Colliery				
7. Alluvial groundwater - Significant groundwater resources including groundwater level and quality	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Aquifer cracked leading to loss of ground water or Impact on third party user outside SMP area or Inflow of ground water into underground workings.	7.1.a. An existing hydro-geological model exists for the Newstan Colliery. 7.1.b. Baseline groundwater data has been obtained. 7.1.c. A groundwater monitoring program is in place. 7.1.d. Centennial Newstan has Identified other groundwater users in the vicinity of the SMP area. 7.1.e. A preliminary groundwater assessment has been undertaken by Aurecon	**E** (D)	4 (E)	23 (L)	9. A figure is required to be prepared showing the licensed bores within and immediately adjacent to the SMP area. 32. Investigate bore water use by the golf course or other users in the vicinity of the SMP area.
8. Other groundwater users	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Aquifer cracked leading to loss of ground water or Impact on third party user outside SMP area or Inflow of ground water into underground workings.	8.1.a. An existing hydro-geological model exists for the Newstan Colliery. 8.1.b. Baseline groundwater data has been obtained. 8.1.c. A groundwater monitoring program is in place. 8.1.d. Centennial Newstan has Identified other groundwater users in the vicinity of the SMP area. 8.1.e. A preliminary groundwater assessment has been undertaken by Aurecon	**E** (D)	4 (R)	23 (L)	9. A figure is required to be prepared showing the licensed bores within and immediately adjacent to the SMP area. 32. Investigate bore water use by the golf course or other users in the vicinity of the SMP area.
9. Flora and fauna - Threatened and protected species under the Threatened Species Conservation Act (1995).	There is a risk to Newstan from ::: Subsidence Impacts / repairs ::: Caused by: Mining Operations	9.1.a. A baseline creek survey has been completed 9.1.b. A flood model is being developed which covers the SMP area 9.1.c. Baseline ecological survey	**D** (D)	4 (E)	21 (L)	33. Centennial to consider submission of an EPBC referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). Submission if required should be done as early as possible in the process.

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
	Resulting in: Changes to flooding regimes or Changes to water courses including stream bed and banks or damage or changes to habitat resulting in species population decline.	have been completed over the SMP area 9.1.d. Mine design - panel width designed relative to known geology. 9.1.e. A geotechnical model has been developed 9.1.f. Mine design has taken into consideration the depth of cover. 9.1.g. History of mining at the Newstan Colliery				
10. Groundwater Dependent Ecosystems (GDEs)	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Groundwater loss or inflow impacting on Groundwater dependent ecosystems.	10.1.a. Baseline ecological survey have been completed over the SMP area 10.1.b. An existing hydro-geological model exists for the Newstan Colliery. 10.1.c. Baseline groundwater data has been obtained. 10.1.d. A groundwater monitoring program is in place. 10.1.e. Centennial Newstan has Identified other groundwater users in the vicinity of the SMP area. 10.1.f. A preliminary groundwater assessment has been undertaken by Aurecon 10.1.g. A flood model is being developed which covers the SMP area 10.1.h. Mapping of the vegetation communities has been undertaken over the SMP area 10.1.i. Mine design - panel width designed relative to known geology. 10.1.j. A geotechnical model has been developed 10.1.k. Mine design has taken into	**C** (D)	4 (E)	18 (M)	8. A Watercourse Management Plan is to be developed for SMP area. 6. Surface water assessment to include an assessment on ponding. 34. Consider undertaking further more detailed ecology surveys within groundwater dependent communities to confirm or otherwise the presence of any Endangered Ecological Communities within these areas. 33. Centennial to consider submission of an EPBC referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). Submission if required should be done as early as possible in the process.

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
		consideration the depth of cover. 10.1.l. History of mining at the Newstan Colliery				
11. Public and private utilities - power lines	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to power poles (Energy Australia) or loss of power and possible injury to a member of the public.	11.1.a. Mine design has taken into consideration the depth of cover. 11.1.b. A geotechnical model has been developed 11.1.c. Mine design - panel width designed relative to known geology. 11.1.d. Preliminary discussions with AusGrid have been held regarding substation at Rathmines. 11.1.e. Known infrastructure has been mapped.	**C** (D)	3 (F)	13 (S)	2. The subsidence assessment is to determine tensile strains. 10. Commence consultation with AusGrid regarding impacts on AusGrid owned infrastructure 14. An Infrastructure Management Plan is to be developed for the SMP area.
12. Public infrastructure - roads	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to Wilton and/or Wangi Road or injury to a member of the public.	12.1.a. A traffic assessment for Wilton Road was completed for the Awaba Colliery Environmental Assessment. 12.1.b. Mine design has taken into consideration the depth of cover. 12.1.c. A geotechnical model has been developed 12.1.d. Mine design - panel width designed relative to known geology.	**D** (D)	2 (PI)	12 (S)	11. Commence consultation with Lake Macquarie City Council and the Roads and Traffic Authority to determine road construction details and impact assessment requirements. 13. Undertake geotechnical mapping of cuttings along the roads including the Newstan-Eraring haul road. 14. An Infrastructure Management Plan is to be developed for the SMP area.
13. Private owned infrastructure - Newstan-Eraring private haul road	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to Eraring Haul Road or injury to operators.	13.1.a. Mine design has taken into consideration the depth of cover. 13.1.b. A geotechnical model has been developed 13.1.c. Mine design - panel width designed relative to known geology. 13.1.d. Centennial Newstan has an established relationship with Eraring Energy 13.1.e. There is restricted access to the Newstan-Eraring private haul road	**D** (D)	3 (BI)	17 (M)	12. Commence discussions with Eraring Energy regarding the project. 13. Undertake geotechnical mapping of cuttings along the roads including the Newstan-Eraring haul road. 14. An Infrastructure Management Plan is to be developed for the SMP area.

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
14. Privately owned infrastructure	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to private property including buildings beyond safe serviceable and repairable.	14.1.a. Land ownership over the SMP area is known 14.1.b. Centennial Newstan has commenced some discussions with the Leisure Life Village 14.1.c. Preliminary discussions have been held regarding the project with government (DRE and DP&I)	**D** (D)	4 (F)	21 (L)	15. Consultation with all landowners to commence/continue. 16. Investigate the need for a baseline condition assessment of building structures 17. Consultation with Mine Subsidence Board regarding the project to commence/continue 19. Confirm subsidence impacts are within SSR guidelines 18. Distribute the project consultation log to the Project team
15. Public infrastructure - Waste Management Facilities	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Impacts on the Awaba Waste Management Facility and historical waste management facility (including future expansions to the Awaba Waste Management Facility).	15.1.a. Consultation has commenced with Lake Macquarie City Council regarding mining under the waste management facility at Awaba. 15.1.b. A draft subsidence assessment has been prepared 15.1.c. The draft subsidence assessment indicates vertical subsidence is within the 1998 Development Consent criteria for vertical subsidence under the waste management facility 15.1.d. Discussions have been had with Lake Macquarie City Council in regards to the future waste management facility design	**C** (D)	3 (F)	13 (S)	18. Distribute the project consultation log to the Project team 20. Continue discussions with Lake Macquarie City Council regarding impacts to the waste management facilities and undertake a baseline assessment 14. An Infrastructure Management Plan is to be developed for the SMP area.
16. Public and private infrastructure - Main Northern Railway Line	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Impacts on the Main Northern Railway Line.	16.1.a. Mining will be undertaken outside of rail corridor 16.1.b. Centennial Newstan have held discussions with RailCorp regarding the project.	**D** (D)	4 (F)	21 (L)	21. The subsidence assessment is to consider far field impacts - in particular impacts on the rail corridor. 14. An Infrastructure Management Plan is to be developed for the SMP area.
17. Surface improvements causing damage beyond safety, serviceability and reparability	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations		**D** (D)	4 (F)	21 (L)	22. A 'dial before you dig' is to be done over the SMP area 23. Centennial Newstan to commence consultation with utility owners 24. Identify if there are any communications towers within the SMP area (i.e. mobile/Telstra towers)

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
	Resulting in: Impacts on optic fibre, sewage, water pipes, communications etcetera.					
18. Agricultural suitability and productivity	There is a risk to Newstan from ::: Subsidence Impacts / repairs ::: Caused by: Mining Operations Resulting in: Impact on agricultural lands.	18.1.a. There are limited agricultural uses in the area	**D** (D)	4 (E)	21 (L)	25. Review the Newstan Colliery 1998 Environmental Impact Statement for information on soils and land capability and provide information to GSS Environmental 26. Consider requirements to undertake soil sampling across the SMP area 27. Assess agricultural and land capability impacts of the mine within the SMP
19. Industrial, commercial and business establishments	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to private property including buildings including Seventh Day Adventist School and retirement village or Impacts on Toronto Golf Course / Club.	19.1.a. Land ownership over the SMP area is known 19.1.b. Centennial Newstan have commenced some discussions with Leisure Life Village 19.1.c. A geotechnical model has been developed 19.1.d. Mine design - panel width designed relative to known geology. 19.1.e. Mine design has taken into consideration the depth of cover.	**D** (D)	3 (F)	17 (M)	28. Consultation with all landowners to commence/continue. 16. Investigate the need for a baseline condition assessment of building structures 17. Consultation with Mine Subsidence Board regarding the project to commence/continue 18. Distribute the project consultation log to the Project team 29. Confirm subsidence impacts are within the Mine Subsidence Board Safe Serviceable and Repairable guidelines 30. Commence discussions with Toronto Golf Club regarding subsidence impacts
20. Foreshores and land prone to flooding or inundation	There is a risk to Newstan from ::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Changes to flooding regimes.	20.1.a. The High Water Subsidence Control Zone is mapped and known. 20.1.b. No secondary extraction will be undertaken within the High Water Subsidence Control Zone (HWSCZ) 20.1.c. A flood model is being developed that covers the SMP area 20.1.d. A geotechnical model has been developed 20.1.e. Mine design - panel width designed relative to known geology.	**E** (D)	4 (E)	23 (L)	
21. Prescribed Dams	There is a risk to Newstan from	21.1.a. No prescribed dams in SMP	**E**	5	25	

Step	Potential Incident	Current Controls	L	MRC	RR	Recommended Control
(including stored waters and reservoirs) and / or structures	::: Subsidence Impacts ::: Caused by: Mining Operations Resulting in: Damage to prescribed dams.	area - NOT APPLICABLE	(D)	(E)	(L)	

Recommended Controls	Place(s) Used	Allocated To	Required By Date
1. A section 90 permit is required for rock shelter and grinding groove sites.	Events: 2.1	Jeffrey Dunwoodie	15-Dec-2012
2. The subsidence assessment is to determine tensile strains.	Events: 2.1, 11.1	Jason Boersma	21-Nov-2011
3. A site inspection with archaeologist and subsidence consultant to be undertaken to look at site specific attributes of the sandstone based Aboriginal sites (grinding grooves and rockshelters).	Events: 2.1	James Wearne	15-Dec-2011
4. Assessment of likelihood of impacts to sandstone based sites to be included in subsidence assessment.	Events: 2.1	Jason Boersma	21-Nov-2011
5. Baseline archaeological recording of sandstone based sites is to be undertaken prior to the commencement of mining activities.	Events: 2.1	James Wearne	15-Feb-2012
6. Surface water assessment to include an assessment on ponding.	Events: 3.1, 3.2, 4.1, 10.1	James Wearne	15-Dec-2011
7. Assess the sensitivity of known SEPP 14 wetlands to freshwater flow following the completion of the ponding assessment.	Events: 3.1	James Wearne	15-Dec-2011
8. A Watercourse Management Plan is to be developed for SMP area.	Events: 3.2, 10.1	Jeffrey Dunwoodie	14-Jun-2012
9. A figure is required to be prepared showing the licensed bores within and immediately adjacent to the SMP area.	Events: 7.1, 8.1	James Wearne	15-Dec-2011
10. Commence consultation with AusGrid regarding impacts on AusGrid owned infrastructure	Events: 11.1	Jason Boersma	30-Nov-2011
11. Commence consultation with Lake Macquarie City Council and the Roads and Traffic Authority to determine road construction details and impact assessment requirements.	Events: 12.1	Jason Boersma	30-Nov-2011
12. Commence discussions with Eraring Energy regarding the project.	Events: 13.1	Jason Boersma	30-Nov-2011
13. Undertake geotechnical mapping of cuttings along the roads including the Newstan-Eraring haul road.	Events: 12.1, 13.1	James Wearne	31-Dec-2011
14. An Infrastructure Management Plan is to be developed for the SMP area.	Events: 11.1, 12.1, 13.1, 15.1, 16.1	Jason Boersma	14-Jun-2012
15. Consultation with all landowners to commence/continue.	Events: 14.1	Jeffrey Dunwoodie	15-Dec-2011
16. Investigate the need for a baseline condition assessment of building structures	Events: 14.1, 19.1	Jason Boersma	18-Jan-2012
17. Consultation with Mine Subsidence Board regarding the project to commence/continue	Events: 14.1, 19.1	Jason Boersma	30-Nov-2011
18. Distribute the project consultation log to the Project team	Events: 14.1, 15.1, 19.1	James Wearne	30-Nov-2011
19. Confirm subsidence impacts are within SSR guidelines	Events: 14.1	Jason Boersma	15-Dec-2011
20. Continue discussions with Lake Macquarie City Council regarding impacts to the waste management facilities and undertake a baseline assessment	Events: 15.1	Jason Boersma	15-Dec-2011
21. The subsidence assessment is to consider far field impacts - in particular impacts on the rail corridor.	Events: 16.1	Jason Boersma	15-Dec-2011
22. A 'dial before you dig' is to be done over the SMP area	Events: 17.1	Andrew Cameron	30-Nov-2011
23. Centennial Newstan to commence consultation with utility owners	Events: 17.1	Jason Boersma	15-Dec-2011
24. Identify if there are any communications towers within the SMP area (i.e. mobile/Telstra towers)	Events: 17.1	Andrew Cameron	15-Dec-2011
25. Review the Newstan Colliery 1998 Environmental Impact Statement for information on soils and land capability and provide information to GSS Environmental	Events: 18.1	Jeffrey Dunwoodie	15-Dec-2011
26. Consider requirements to undertake soil sampling across the SMP area	Events: 18.1	James Wearne	15-Dec-2011
27. Assess agricultural and land capability impacts of the mine within the SMP	Events: 18.1	James Wearne	15-Dec-2011
28. Consultation with all landowners to commence/continue.	Events: 19.1	Jeffrey Dunwoodie	15-Dec-2011

Recommended Controls	Place(s) Used	Allocated To	Required By Date
29. Confirm subsidence impacts are within the Mine Subsidence Board Safe Serviceable and Repairable guidelines	Events: 19.1	Jason Boersma	15-Dec-2011
30. Commence discussions with Toronto Golf Club regarding subsidence impacts	Events: 19.1	Jason Boersma	15-Dec-2011
31. Develop a Public Safety Management Plan for the SMP	Events: 1.1	Jeffrey Dunwoodie	14-Jun-2012
32. Investigate bore water use by the golf course or other users in the vicinity of the SMP area.	Events: 7.1, 8.1	Jeffrey Dunwoodie	15-Dec-2011
33. Centennial to consider submission of an EPBC referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). Submission if required should be done as early as possible in the process.	Events: 3.1, 9.1, 10.1	James Wearne	30-Nov-2011
34. Consider undertaking further more detailed ecology surveys within groundwater dependent communities to confirm or otherwise the presence of any Endangered Ecological Communities within these areas.	Events: 3.1, 10.1	James Wearne	30-Nov-2011

CENTENNIAL RISK MATRIX

Consequence

Note: Consequence may result from a single event or may represent a cumulative impact over a period of 12 months. Use the worst case reasonable consequence if there is more than one.

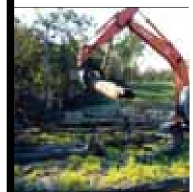
Rating	Impact to Annual Business Plan (F)	Personal Injury (PI)	Business Interruption (BI)	Legal (L)	Reputation (R)	Environment (E)	Likelihood: A Certain	B Probable	C Possible	D Remote	E Improbable	Description (D)
							Common"	Has Happened within Centennial"	"Could Happen & has happened in non-CEY operations	Not Likely	"Practically impossible	Probability (Pb)
							Frequent incidents	Regular incidents	Infrequent incidents	Unlikely to occur. Very few recorded or known incidents	May occur in exceptional circumstances. Almost no recorded incidents.	Incident Frequency (IF)
							Operations – within 3 months	Operations – within 2 years	Operations – within 5 years	Operations – within 10 years	Operations – within 30 years	Operations (Op)
							Project – Every project	Project – Every 2 projects	Project – Every 5 projects	Project – Every 10 projects	Project – Every 30 projects	Project (Pr)
1. Catastrophic	>$50m	Multiple Fatalities	> 1month	Prolonged litigation, heavy fines, potential jail term	Prolonged International media attention	Long term impairment habitats/ ecosystem	1 (E)	2 (E)	5 (H)	7 (H)	11 (S)	
2. Major	$10m - $50m	Single Fatality	1 week to 1 month	Major breach/ major litigation	International media attention	Long term effects of ecosystem	3 (E)	4 (E)	8 (H)	12 (S)	16 (M)	
3. Moderate	$1m - $10m	Serious/ Disabling Injury	1 day to 1 week	Serious breach of regulation. prosecution/ fine	National media attention	Serious medium term environmental effects	6 (H)	9 (H)	13 (S)	17 (M)	20 (L)	
4. Minor	$100k - $1m	Lost Time Injury	12 hrs to 1 day	Non-compliance, breaches in regulation	Adverse local public attention	Minor effects to physical environment	10 (S)	14 (S)	18 (M)	21 (L)	23 (L)	
5. Insignificant	<$100k	First Aid Treatment Only	< 12 hrs	Low level compliance issue	Local complaints	Limited physical damage	15 (S)	19 (M)	22 (L)	24 (L)	25 (L)	

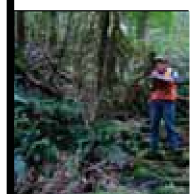
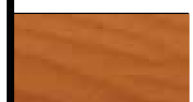
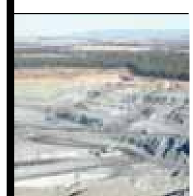
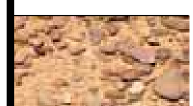
Risk Rating	Risk Category		Generic Management Actions
1 to 4	E	Extreme	Immediate intervention required from senior management to eliminate or reduce this risk
5 to 9	H	High	Imperative to eliminate or reduce risk to a lower level by the introduction of control measures. Management planning required at senior levels
10 to 15	S	Significant	Corrective action required, senior management attention needed to eliminate or reduce risk
16 to 19	M	Moderate	Corrective action to be determined, management responsibility must be specified
20 to 25	L	Low	Monitor and manage by corrective action where practicable

BOW TIE ANALYSIS - Control Effectiveness Matrix

TYPE OF CONTROL				CONTROL – Impact / Status / Quality				
Examples	Description	Rank	Control Category	A >= 80%	B 50 – 80%	C 50 / 50%	D 50 – 20%	E <= 20%
Replace electric hand tools with compressed air alternatives in wet conditions	Eliminates a hazard by removal	1.	**Elimination of hazard**	100	45.0	40.0	14.0	10.0
Replace large diameter, heavy cables with smaller ones that are easier to handle manually	Replace element with less risky alternative	2.	**Substitution**	85.0	40.0	35.0	13.0	8.5
Automatic fire fighting sprinkler systems	An automatic device that operates without intervention by personnel	3.	**Engineered without people**	70.0	30.0	25.0	12.0	7.0
Fire alarm that sounds & the operator then has to initiate an evacuation	A device that requires personnel to respond to a stimulus	4.	***Engineered with people***	50.0	20.0	14.0	10.0	5.0
Inspection, maintenance and repair of machinery	A process carried out by personnel	5.	**Procedural**	20.0	15.0	10.0	6.5	2.0
Employee made aware of dangers of large moving equipment where the operators have limited vision	Induction training programs	6.	**Awareness**	5.0	3.0	2.5	1.5	1.0





Flora and Fauna Assessment

APPENDIX 7

RPS

Flora and Fauna Assessment

Centennial Newstan

Proposed LW101 to LW103 Mining Area

Prepared by:

RPS

PO Box 428
HAMILTON NSW 2303

T: +61 2 4949 4200
F: +61 2 4961 6794
E: newcastle@rpsgroup.com.au
W: rpsgroup.com.au

Prepared for:

Centennial Newstan

PO Box 1000
TORONTO NSW 2283

Report No: 110457
Version/Date: Final / June 2012

Document Status

Version	*Purpose of Document*	*Orig*	*Review*	*Review Date*	*Format Review*	*Approval*	*Issue Date*
Draft A	*Draft for internal review*	*RS*	*TL*	*29-3-12*	*-*	*T.Lambert*	*29-3-12*
Draft B	*Draft for client review*	*RS*	*PH*	*4-4-12*	*-*	*P. Hillier*	*5-4-12*
Draft C	*Draft for client review*	*PH*		*-*	*-*	*T.Lambert*	*23-4-12*
Final	*Final For Issue*	*PH*	*TL*	*24-4-12*	*VD*	*T. Lambert*	*24-4-12*
Final	*Final for Issue*	*PH*	*TL*	*7-6-12*	*-*	*T.Lambert*	*7-6-12*

Disclaimers

Executive Summary

Introduction

RPS Australia East Pty Ltd (RPS) was engaged by Centennial Newstan Pty Limited (Centennial Newstan) to undertake a Flora and Fauna Assessment for the Subsidence Management Plan (SMP) application associated with the proposed extension of the Newstan Colliery (Newstan) into LW101 to LW103, this area is henceforth referred to as “the SMP Study Area”. A larger study area encompasses the SMP Study Area which is comprised of the entire mine lease and/or exploration area. This larger study area has been surveyed by various methods and for various purposes over a number of years. A range of flora and fauna survey methods were employed within the larger study area to detect a representative sample of species present. Combined with the previous surveys undertaken by other ecological consultants the likely ecological issues for the SMP application have been identified.

Vegetation

Ground truthing of the SMP Study Area identified five vegetation communities. One of these vegetation communities, Swamp Mahogany/ Paperbark Forest, is commensurate with the ‘Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions’ Endangered Ecological Community (EEC) listed under the TSC Act 1995. The Swamp Mahogany/ Paperbark Forest is the only vegetation community within the SMP Study Area considered to have potential to be a Groundwater Dependent Ecosystem (GDE) or be partially dependent on groundwater. The vegetation communities are described in accordance with LHCCREMS vegetation community profiles (NSW NPWS 2003):

- MU 15 Coastal Foothills Spotted Gum Ironbark Forest;
- MU 30 Coastal Plains Smooth-barked Apple Woodland;
- MU 31 Coastal Plains Scribbly Gum Woodland;
- MU 37 Swamp Mahogany/ Paperbark Forest (EEC); and
- Cleared Land.

Four threatened flora species, namely *Acacia bynoeana* (Bynoe's Wattle) (Endangered under the TSC Act 1995 and Vulnerable under the EPBC Act 1999), *Angophora inopina* (Charmhaven Apple) (Vulnerable under the TSC Act 1995 and the EPBC Act 1999), *Grevillea parviflora* subsp. *parviflora* (Vulnerable under the TSC Act 1995 and the EPBC Act 1999) and *Tetratheca juncea* (Black-eyed Susan) (Vulnerable under the TSC Act 1995) were also recorded within the SMP Study Area. Some threatened species not detected cannot be discounted off-hand due to seasonality and other factors, and are therefore addressed in terms of their potential for occurrence based on ecological factors.

Habitat

Habitats within the SMP Study Area were generally found to be in good condition, although some areas of disturbance were evident in areas such as the Waste Management Facility and along various easements, tracks, fire trails and public roads. Recent fire history throughout the SMP

Study Area was evident, with the last major wildfire occurring in Spring 2001. Smaller, lower intensity fires have occurred more recently in some areas. The majority of vegetation is of high quality with a mixture of mature, over-mature (hollow-bearing) trees and varying complexity within the understorey, in response to variation in topographic position and other environmental factors. Fallen timber and a dense groundcover provides suitable shelter for a wide range of terrestrial species, with hollow-bearing trees providing suitable breeding and nesting habitat for avifauna and arboreal species. Habitats within the SMP Study Area are therefore considered to exhibit a high capacity to support many faunal guilds.

Fauna

A total of 58 fauna species were recorded within the SMP Study Area, which is a portion of the collective total of 124 species recorded within the larger study area. Of the 58 species recorded, there were five terrestrial mammal, four arboreal mammal, eight bat, 36 bird, two reptile and three frog species. Overall, a total of five threatened species were identified within the SMP Study Area, namely the Masked Owl (*Tyto novaehollandiae*), Grey-headed Flying-fox (*Pteropus poliocephalus*), East-coast Freetail-bat (*Mormopterus norfolkensis*), Little Bentwing-bat (*Miniopterus australis*) and Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*).

Conclusions

The proposed SMP application will result in longwall subsidence of up to 1200 mm. It is predicted that no significant impacts will occur to any threatened species or ecological communities however, it is recommended that precautions to protect important landscape features occur during subsidence management activities.

Recommendations

The following mitigation measures have been recommended to minimise the potential impacts of the proposal:

- Monitoring of stream bed morphology within the Swamp Mahogany / Paperbark Forest should be undertaken to detect any changes in the stream bed from subsidence. Likely indicators are the formation of new cracks, changes in direction of the stream bed and ponded areas;
- Newstan Colliery will develop a Watercourse Management Plan for the SMP study area (or adopt equivalent principles in the Newstan Flora and Fauna Management Plan - FFMP); and
- Where subsidence cracks are found that require remediation, then remediation will be undertaken in accordance with the Newstan Colliery Watercourse Management Plan or FFMP and in consultation with relevant regulatory agencies.

Terms & Abbreviations

Abbreviation	Description
AoS	Assessment of Significance
API	Aerial Photograph Interpretation
DEC	Department of Environment and Conservation – now known as OEH
DECCW	Department of Environment, Climate Change and Water– now known as OEH
DEWHA	Department of Environment, Water, Heritage and Arts now known as SEWPaC
EEC	Endangered Ecological Communities
EP&A Act 1979	NSW Environmental Planning and Assessment Act 1979
EPBC Act 1999	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
GIS	Geographic Information System
GPS	Global Positioning System
KTP	Key Threatening Process
LGA	Local Government Act
LHCCREMS	Lower Hunter and Central Coast Regional Environment Management Strategy
NES	National Environmental Significance
NSW NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage
PFC	Projected Foliage Cover
ROTAP	Rare or Threatened Australian Plants
RPS	RPS Australia East Pty Ltd
SEPP	State Environmental Planning Policy
SEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
TSC ACT 1995	NSW Threatened Species Conservation Act 1995

Contents

Figures

Tables

Appendices

1 Introduction

RPS Australia East Pty Ltd (RPS) was engaged by Centennial Newstan Pty Limited (Centennial Newstan) to undertake a Flora and Fauna Assessment for the Subsidence Management Plan (SMP) application associated with the proposed extension of mining at the Newstan Colliery (Newstan) The location and extent of the SMP Study Area under investigation consists of the proposed Longwalls LW101 to LW103 and their associated areas of possible subsidence effects as shown in Figure 1-1. The SMP Study Area is located within a larger area which has been extensively surveyed for flora and fauna as well as vegetation community mapping.

This assessment aims to examine the likelihood of the proposal to have a significant effect on any threatened species, populations or ecological communities listed within the Threatened Species Conservation Act 1995 (TSC Act 1995). The report recognises the relevant requirements of the EP&A Act 1979 as amended by the Environmental Planning and Assessment Amendment Act 1997. Assessment is also made with regard to those threatened entities listed federally under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999).

The assessment herewith contains a 7-part test on threatened species, populations and/or Endangered Ecological Communities (EEC's) that were found to occur or may potentially occur within the proposed development area (the SMP Study Area).

This report has been prepared in accordance with the ‘Guideline for Applications for Subsidence Management Approvals’ (DPI-MR (now DTIRIS-DRE), December 2003), herein referred to as the ‘SMP Guidelines’.

Table 1-1: Requirements of the SMP Guidelines

Requirement	Where Addressed in this report
6.2 Application Area	Chapter 1
6.4 Site Conditions of the application area	Chapter 4
6.6.1 Identification of surface and sub-surface features	Chapter 4
6.6.2 Characterisation of Surface and Sub-surface Features	Chapter 4
6.6.3 Areas of Environmental Sensitivity	-
6.8 Community Consultation	-
6.9 Statutory Requirements	Chapter 1
6.10 Subsidence Impacts	Chapter 5
7 Proposed management plans	Chapter 10
Appendix B – Surface and Sub-surface features that may be affected by Underground coal mining.	Chapter 5

In accordance with section 6.6.3 of the SMP Guidelines, the following areas of environmental sensitivity have been identified and considered as part of this Flora and Fauna Assessment.

Table 1-2: Areas of Environmental Sensitivity within the SMP Area (NSW Department of Mineral Resources; 2003)

Feature	Within SMP Study Area	Details	Section Reference Number
Land reserved as State conservation area under *National Parks and Wildlife Act 1974 (NPWA74)*	No	-	-
Land identified as wilderness by the Director NPWS under the *Wilderness Act 1987*	No	-	-
Land subject to a conservation agreement under *NPWA74*	No	-	-
Land acquired by Minister for the Environment under *Part 11 of the NPWA74*	No	-	-
Land within State Forests mapped as Forestry Management Zones 1, 2 or 3	No	-	-
Wetlands mapped under SEPP14 – Coastal Wetlands	No	-	-
Wetlands listed under the Ramsar Wetlands Convention	No	-	-
Lands mapped under SEPP 26 – Coastal Rainforests	No	-	-
Areas listed on the Register of National Estate	No	-	-
Land declared as critical habitat under the *Threatened Species Conservation Act 1995*	No	-	-
Land reserved or dedicated under the *Crowns Land Act 1989* for the preservation of flora, fauna, geological formations or other environmental protection purposes	No	-	-
Lake foreshores and flood prone areas	No	-	-
Cliffs, escarpments and other significant natural features	No	-	-
Areas containing significant ecological values	No	-	-

1.1 Site Particulars

Locality	Newstan Colliery is located near Fassifern, on the western side of Lake Macquarie. Lake Macquarie is located in the Hunter region approximately 20kms from Newcastle NSW.
LGA	Lake Macquarie City Council
Area	352.8ha
Boundaries	The SMP Study Area is located to the south-east of the town of Awaba and east of the Newstan mine pit top. The study area is bounded to the north-west by the Main Northern Railway, to the south-east by native bushland and the Toronto Golf Course, to the south-west by bushland and to the north-east by bushland and rural holdings.
Current Land Use	Centennial Newstan Pty Ltd is a 100% subsidiary of Centennial Coal which currently owns and operates Newstan Colliery.

Topography	The SMP Study Area is located on undulating land with areas of mine subsidence throughout. Numerous drainage lines are present throughout the study area which drains eastwards into Lake Macquarie.

TITLE: FIGURE 1-1: SITE LOCATION MAP
LOCATION: NEWSTAN
DATUM: (GDA 94) PROJECTION: MGA ZONE 56
DATE: 19/01/2012 PURPOSE: ECOLOGICAL
VERSION (PLAN BY): C A5 (AS-PH-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-2

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

1.2 Description of the Proposal

Newstan is an underground coal mine owned and operated by Centennial Newstan. Newstan is located approximately 25 kilometres south-west of Newcastle and approximately 140 kilometres north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan pit top and surface facilities are located approximately four kilometres north of the township of Toronto on the western side of Lake Macquarie. The SMP Study Area is shown in Figure 1-1).

Mining operations at Newstan first commenced in 1887 and has since undertaken extensive mining within the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole coal seams. Mining at Newstan is currently undertaken using a combination of modern longwall retreat and bord and pillar mining methods. Both soft coking coal and thermal coal is produced for the domestic and export markets, providing NSW with coal for the state's coal fired electricity. Newstan has approval to produce up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal which is transported by private haul road to Eraring Power Station for domestic power production and by rail to the Port of Newcastle for the export market.

In 1998, Powercoal Pty Limited, the (then) owners of Newstan, submitted an Environmental Impact Statement (EIS, 1998) to the then New South Wales Department of Planning (DoP), seeking approval for the expansion of Newstan, which was referred to as the Life Extension Area (LEA). On the 14th May 1999, the (then) Minister for Urban Affairs and Planning, granted development consent under Part 4 of the Environmental Planning and Assessment Act (EP&A Act) for the Newstan Colliery Life Extension Area pursuant to Development Application 73-11-98 (DA 73-11-98). Following modifications to the approval, the mine currently operates under DA 73-11-98 MOD 3 and the following approvals relevant to this SMP Application:

- Mining Lease ML1452;
- Mining Operations Plan (MOP) (2005 -2012); and
- Environment Protection Licence (EPL) 395.

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a *Subsidence Management Plan (SMP)* prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103, which are located wholly within ML1452 and DA 73-11-98.

The findings of the SMP report (MSEC, 2012), which may be relevant to ecological; impacts within the SMP Study Area are as follows:

- The watercourses in the mining area are ephemeral, but have ponds in the flatter sections along the lower reaches of the streams. The watercourses typically have shallow incisions into the natural surface soils, but have rock outcropping along the steeper sections. The watercourses are located across the mining area and, therefore, are expected to experience the full range of predicted subsidence movements.
- Increased ponding could occur along the flatter sections of the Schedule 2 streams, as a result of mining, however, natural ponding was evident along these watercourses due to the relatively flat natural grades. Fracturing of the exposed bedrock along the upper reaches of the watercourses could result in some spalling or dislodgement of loose rocks. Continuous fracturing is not expected between the seam and the surface and, therefore, no loss of water from the catchment is anticipated.
- Rock outcrops and steep slopes are located above the northern ends of the proposed longwalls. Fracturing of the exposed bedrock could result in some minor rockfalls, however, previous experience in the NSW Coalfields indicates that the percentage of rock outcrops impacted is likely to be small. Tensile cracking could also occur along the tops of the steep slopes and, in some locations, it may be necessary to remediate the larger cracks.
- The Awaba Waste Disposal Facility (AWDF) is located directly above the proposed Longwall 103 and comprises the waste disposal area, leachate and sediment ponds, leachate collection and spray systems, gas drainage and flare infrastructure, a gas powered generator installation, weigh bridges, administration building and storage structures. The facility is also proposing to expand the waste emplacement area and to construct an Alternative Waste Treatment (AWT) facility, which are the subjects of a current development application submitted in December 2011.

The proposed mining beneath the waste emplacement could result in the development of surface cracking and downslope movements which could then increase permeability of the capping layer. The AWDF has established procedures to maintain the integrity of the surface capping layer, due to the natural settlement of the waste emplacement, which is estimated to be greater than the subsidence resulting from mining.

The unlined section of the waste disposal area uses the natural bedrock levels to funnel leachate downslope to the leachate collection well. The extraction of the proposed longwalls will result in fracturing and dilation of the topmost bedrock layers which will increase permeability of these near surface strata layers. Experience from the area indicates that continuous cracking would not extend from the seam up to the surface and, therefore, the leachate is expected to be confined to the near surface strata.

It has been observed in the past, that the depth of fracturing and dilation of the uppermost bedrock, resulting from valley related movements, is generally less than 10 metres to 15 metres. It has been recommended, however, that a model is developed (numerical, or otherwise) to assess the changes in permeability of the near surface strata and, therefore, better assess the adequacy of the existing leachate collection system after mining.

The potential impacts on the infrastructure associated with the AWDF, including the leachate and sediment ponds, gas drainage infrastructure, gas powered generation plant. building structures and weigh bridges, could be managed with the implementation of suitable management plans.

The findings of the Surface Water Impact Assessment report (GHD, 2012c), which may be relevant to environmental impacts within the SMP Study Area are as follows:

- From the assessment of the predicted maximum subsidence impacts, changes are likely to occur in the alignment of minor drainage channels within the upper catchment positions, but catchment boundaries are unlikely to be affected by subsidence.
- Areas of increases in waterway gradient and flow velocities were observed in two watercourses. The increases observed in waterway gradient due to subsidence, resulted in flow velocity increases in the order of 0.4 m/s for the 2 year Average Recurrence Interval event. The hydraulic modelling also indicated instances of reduction in waterway gradients and subsequent flow velocity. From the geomorphic investigation of the subsided results, flow velocities were found to be maintained above 0.2 m/s for the flow events modelled. Given that the waterways traversing the project area are typically fine-grained systems that predominantly transport suspended sediments, it is unlikely that any aggradation of sediment along waterways will occur due to the subsidence impacts.
- The impact on flood depth, due to predicted subsidence, was found to be greatest in the 2 year ARI event. This indicated that the flooding inundation had a maximum increase of 3.7% within the subsidence project area. The areas indicating the greatest impact were identified as Kilaben Creek and the unnamed creek. The greatest increase in flood depth was in the order of 0.5 m for the 100 year ARI and 0.35 m for the 2 year ARI.
- Flood velocities were assessed for change between the existing and subsided model. Velocities remained consistent in the subsided surface with instances of reductions in velocity. Change in velocity was greatest within Kilaben Creek and the unnamed watercourse. The change in velocity is due to the reduction in bed grade of the waterway which in turn increases the flood depth.

The findings of the Groundwater Impact Assessment report (GHD, 2012a), which may be relevant to environmental impacts within the SMP Study Area are as follows:

- An analysis of the shallow aquifers suggests that there would be a negligible movement in groundwater from the top 5 m of strata (including alluvium and outcropping rock) to the underlying strata as a result of extraction of coal within the SMP Study Area. For all hydraulic conductivity increase scenarios, this change is predicted to be less than 0.2 ML/year throughout the entire SMP Study Area. It is noted that an annual extraction of less than 3 ML/year from an aquifer is considered by the NOW to be typical of use under basic landholder rights and generally low impact.
- GDEs located within the SMP Study Area may experience a drawdown of up to 0.2 m as a result of mining. It is not anticipated that GDEs located outside the SMP Study Area will be impacted.

- There is a risk of additional contamination impact to groundwater from leachate at the AWMF. Additional impact would move the groundwater chemistry to a more sodium bicarbonate type and increase concentrations of parameters such as electrical conductivity (EC), ammonia, metals and hydrocarbons.

The findings of the Hydraulic Assessment report (GHD, 2012b), which may be relevant to environmental impacts within the SMP Study Area are as follows:

- The hydraulic modelling indicates that the predicted subsidence will only have relatively minor impacts on the 'existing' hydraulic characteristics, which for the most part remain dominated by the steep terrain. This minimal change as a result of the predicted subsidence is evidenced in the following key changes in the flood behaviour:

    - An increase in the area of inundation of only a 3.4 % - 3.7 % in the area of interest around the SMP application area for the modelled scenarios.
    - The general isolation of major changes to the two major flow paths through the SMP application area (which includes WC5, WC10, WC11, and WC12) and moderate changes to some of the minor flow paths exiting the area of predicted subsidence to the north.
    - The relatively minor changes in flow hydrograph peaks and timing.

- Although the overall impact was minor, the study did identify the following two general changes in the flood behaviour in the study area:

    - An increase in ponding where the predicted subsidence causes a flattening or reversal of the slope, and a decrease in ponding where the predicted subsidence increases the slope.
    - A speeding up of flow where the predicted subsidence increases the slope, and a slowing of flow where there is increased ponding or reduced slope – this resulted in an increase in the proportion of flows at the two extremes of the velocity distribution, and a decrease for the others.

1.3 Scope of the Study

The scope of this flora and fauna assessment report is to:

- identify vascular plant species found within the SMP Study Area;
- identify and map existing vegetation communities;
- assess the status of identified plant species and vegetation communities under relevant legislation;
- identify existing habitat types within the SMP Study Area and assess the habitat potential for threatened species, populations, or ecological communities known from the proximate area;
- identify threatened fauna potentially using the SMP Study Area; and
- assess the potential of the proposal to have a significant impact on any threatened

species, populations or ecological communities identified during field surveys or as having potential habitat within the SMP Study Area.

Whilst survey work has been undertaken within the bounds of the SMP Study Area, consideration has been afforded to survey results for areas immediately adjacent to and more broadly outside of this in order to appreciate its broader environmental context.

The purpose of this report is to:

- satisfy the assessment requirements of the SMP Guidelines;
- ensure planning, management and development decisions are based on sound scientific information and advice by documenting the presence of any biodiversity components or potential significant impacts that may exist within the SMP Study Area; and
- provide information to enable compliance with applicable assessment requirements contained within the TSC Act 1995, EP&A Act 1979, the EPBC Act 1999, and any other relevant state, regional and local environmental planning instruments.

2 Qualifications and Licensing

2.1 Qualifications

This report was written by Paul Hillier BEnvSc, Toby Lambert BEnvSc, Robert Sansom B.Sc (Hons.) and Lauren Vanderwyk BSc of RPS. The academic qualifications and professional experience of RPS consultants involved in the project are documented in Appendix 5.

2.2 Licensing

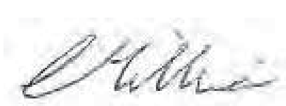
Research and surveys were conducted under the following licences:

- NSW National Parks and Wildlife Service Scientific Investigation Licence S10300 (Valid 30 November 2012);
- Animal Research Authority (Trim File No: 01/1142) issued by NSW Agriculture (Valid 12 March 2013);
- Animal Care and Ethics Committee Certificate of Approval (Trim File No: 01/1142) issued by NSW Agriculture (Valid 12 March 2013); and
- Certificate of Accreditation of a Corporation as an Animal Research Establishment (Trim File No: 01/1522 & Ref No: AW2001/014) issued by NSW Agriculture (Valid 22 May 2014).

2.3 Certification

As the principal author, I, Paul Hillier make the following certification:

- The results presented in the report are, in the opinion of the principal author and certifier, a true and accurate account of the species recorded, or considered likely to occur within the SMP Study Area;
- All research workers have complied with relevant laws and codes relating to the conduct of flora and fauna research, including the Animal Research Act 1995, National Parks and Wildlife Act 1974 and the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes.



Paul Hillier
Senior Ecologist
RPS Australia East Pty Ltd
June 2012

3 Methodology

A number of previous studies have undertaken comprehensive flora and fauna surveys across the SMP Study Area and surrounding areas. Umwelt/Gunninah undertook surveys from April to December 1997 and Cumberland Ecology from Aug 2005 to February 2006, while RPS undertook surveys from 29 November 2010 to 11 February 2011. These surveys included methodologies such as terrestrial and arboreal Elliott trapping, terrestrial hair funnels, wire cage trapping, harp trapping, Anabat recording, call playback, diurnal bird surveys, herpetological surveys, spotlighting, fauna habitat assessments and SEPP 44 Koala habitat assessments. Additional surveys and reports undertaken within and near to the SMP Study Area have also been considered within this report. Details of previous flora and fauna survey effort and methodologies are provided in Table 3-1 and Table 3-4.

A variety of field survey techniques were employed by RPS over the course of fieldwork for the previous assessment (RPS 2011) to record a representative sample of flora species and fauna guilds across the larger study area. The flora surveys included a site inspection, vegetation community surveys and various fauna survey methods including opportunistic sightings and habitat assessments. Targeted searches for threatened flora and fauna species were also undertaken.

The methodology was designed to meet the Threatened Biodiversity Survey and Assessment Guidelines (DEC 2004).

3.1 Literature Review

A literature review was undertaken to assist in identifying distributions, suitable habitats and known records of threatened species so that field investigations could more efficiently focus survey effort. Information sources included:

- Aerial Photograph Interpretation (API) and literature reviews to determine the broad categorisation of vegetation within the SMP Study Area;
- Review of the Lower Hunter and Central Coast Regional Environment Management Strategy Vegetation Survey, Classification and Mapping (LHCCREMS) (NPWS 2003);
- Review of fauna and flora records contained in the Office of Environment and Heritage (OEH) Atlas of NSW Wildlife within a 10km radius of the SMP Study Area;
- Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) EPBC Act 1999 Protected Matters Search (accessed 2nd May 2012) within a 10km radius of the SMP Study Area;
- DEC Threatened Species, Populations and Ecological Communities website (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/);
- Birdata (web version of Birds Australia's New Atlas of Australian Birds);
- Review of the Newstan Colliery Life Extension Project SIS written by Umwelt (Australia) Pty Ltd 1998;

- A review of Geographic Information System (GIS) data including (but not limited to) aerial photography, topographic maps, State Environmental Planning Policy (SEPP) 14 Wetland Mapping, Soil Landscapes and Acid Sulphate Soil Potential; and
- Collective knowledge gained from extensive work in the area.

3.1.1 Previous Studies

A number of ecological studies previously conducted in and near the SMP Study Area were reviewed with regards to timing, survey methodology, effort and results. RPS previously undertook a Gap Analysis in June 2010 to investigate the previous studies and to identify additional surveys that may be warranted as a supplement and update to the previous studies.

A summary of the previous survey effort in relation to flora and fauna are provided in Tables 3-1 & 3-2, respectively. It is noted that whilst all of these previous reports were produced using various methods for different purposes, in combination they provide a solid set of baseline data to refer to as part of the ecological assessment process. Of the 14 previous ecological studies considered in this assessment, 11 performed vegetation mapping surveys. The results of these vegetation mapping surveys are detailed within Table 4-2.

Only three previous studies (Umwelt/Gunninah 1998; Cumberland Ecology 2007 and RPS 2011) have conducted comprehensive and systematic fauna surveys across multiple seasons using a variety of trapping and observational techniques. The remaining ten reports undertaken within the larger study area have either: relied on other trapping results or they provide no information as to field survey effort could be obtained (Table 3-2).

Table 3-1: Summary of Previous Flora Survey Effort and Methods in the Centennial Newstan Holdings

Report Year	Report Month	Author	Project	Field Survey Date	Vegetation Mapping	Maps produced	Effort	Targeted Aquatic/ Riparian Flora	Effort	Targeted Threatened Flora Survey	Effort
2011	October	Lake Macquarie City Council	Awaba AWT Site Preliminary Environmental Assessment	None supplied	Y	Y	Not specified	N	Not specified	Y	Not specified
2011	August	RPS	Newstan Lochiel Extension Area	18-22 Oct to 5 Nov 2010; 31 Jan to 11 Feb 2011	Y	Y	41x(20x20m) Quadrats; 41 x 100m transects; >150 Flora Rapid Assessment Points;.	Y	41x(20x20m) Quadrats; 41 x 100m transects; >25 Flora Rapid Assessment Points;	Y	18 to 27 Oct 2010 & 16 to 26 November 2010
2011	January	Hunter Eco	Newstan Colliery S75W Modification	None supplied	Y	Y	>160 ground-truthed rapid data points (RPD)	N	n/a	N	n/a
2009b	May	Hunter Eco	Awaba East Exploratory Drilling Program, REF, Ecology Stage 2	None supplied	Y	Y	375 ground-truthed rapid data points (RPD)	Y	Not specified	N	Opportunistic only
2009a	Jan	Hunter Eco	Centennial Coal Haul Road Vegetation Communities	None supplied	Y	Y	Ground truthing and aerial photo interpretation	N	Not specified	N	Not specified
2008b	Nov	Hunter Eco	Centennial Coal, Proposed Cooranbong Colliery to Awaba Haul Road, Threatened flora investigation	None supplied	N	Not specified	Not specified	N	Not specified	Y	belt transect survey of 11 transects of 1.4km long and 200m apart (278 hectares)
2008	Aug	Cumberland Ecology	Newstan Colliery, Longwall Panel 25, REF, Ecological Impact Assessment	2005/2006	Y	Y (based on CE 2007)	Not specified	N	Not specified	Y seasonal surveys	Not specified

Report Year	Report Month	Author	Project	Field Survey Date	Vegetation Mapping	Maps produced	Effort	Targeted Aquatic/ Riparian Flora	Effort	Targeted Threatened Flora Survey	Effort
2008a	June	Hunter Eco	Awaba East Exploratory Drilling Program, REF, Ecology Stage 1	None supplied	Y	Y	521 ground-truthed rapid data points (RPD)	Y	Not specified	N	Opportunistic only
2008	May	HWR	Stony Creek Baseline Study	Nov 2007, Feb, April & May 2008	Y (limited to wetland communities)	Y (limited to wetland communities)	General description of creek system including dominant flora	Y	5 monitoring transects photos and dominant sp	N	
2007	Feb	Cumberland Ecology	Newstan Colliery, modification to development consent, SEE, Ecological Impact Assessment	Aug 2005 - Feb 2006, 6 Oct 2006	Y	Y	Spring - general flora 2 ecologists for 1 day; Quadrats 2 ecologists for 5 days	Not specified	Not specified	Y seasonal surveys	Spring - 1 botanist for 1 day; 2 ecologists for 5 days; Summer - 2 ecologists for 3 days
2005	Sept	Eco Biological	Awaba Outbye SMP	None supplied	Y	Y	107 ground-truthed data points, 10km of walking transects	Y	Not specified	Y	Targeted *T. juncea* and *G. parviflora* only
2005	April	Umwelt	Targeted threatened plant survey	Dec 2004-Feb 2005	N	Not specified	Not specified	Not specified	Not specified	Y seasonal surveys	70.25 person hours over five days; 61 random meander transects
2004	March	Umwelt	Centennial Newstan Longwall 22-23 Flora and Fauna Assessment	Dec 2003	Y	N	Two 20mx20m quadrats	Y	3 walking transects along drainage lines	N	Opportunistic only
1998	Oct	Umwelt/ Gunninah	Life Extension Project 1998 Flora and Fauna Assessment and SIS	April-Dec 1997	Y	Y	July 97 - 3 days; Oct 97 - 2 days, walked transects and 3 sites	N	Not specified	Y	Oct 97 - 1 day, random meander

Table 3-2: Summary of Previous Fauna Survey Methods and Effort

Report Year	Author	Field Survey Date	Fauna Surveys	Terrestrial Elliot A	Terrestrial Hair funnel	Arboreal Elliot B	Arboreal Hair funnel	Wire Cage Traps	Harp Trap	Anabat	Call-playback	Diurnal Birds	Herps	Spotlight	Fauna Habitat	Koala Habitat (SEPP44)	Scat, track, sign
2011b	Hunter ECO, 2010 in Lake Macquarie City Council (2011).	None Supplied	Y							Survey Effort Not Specified							
2011	RPS	29 Nov to 3 Dec, 6 to 17 Dec 2010; 31 Jan to 11 Feb 2011	Y	1000 trap nights summer	400 trap nights summer	1000 trap nights summer	400 trap nights summer	240 trap nights summer	80 trap nights summer	20 nights	20 locations	>20 person hours summer	>10 person hours	40 person Hours	>10 person hours	Op	Op
2011a	Hunter Eco	None Supplied	N														
2009b	Hunter Eco	None supplied	N														
2009a	Hunter Eco	None supplied	N														
2008b	Hunter Eco	None supplied	N														
2008	Cumberland Ecology	2005/2006	Y	Relied on Cumberland Ecology 2007 trapping results													
2008a	Hunter Eco	None supplied	N														
2008	HWR	Nov 2007, Feb, April & May 2008	N														
2007	Cumberland Ecology	Aug 2005 - Feb 2006, 6 Oct 2006	Y	spring - 400 trap nights over 10 locations; summer 200 trap nights over 5 locations	spring - 500 tube nights in 10 locations; summer - 250 tube nights in 5 locations	spring - 400 trap nights over 10 locations; summer 200 trap nights over 5 locations	spring - 500 tube nights in 10 locations; summer - 250 tube nights in 5 locations	spring - 80 trap nights over 10 locations; summer - 40 trap nights over 5 locations	6 trap nights	spring - 5 nights; summer - 3 nights	spring - 3 locations over 2 nights; summer- 2 locations over 2 nights	winter - 14 hrs over two days; spring - 37 hrs over 4 days	summer - 2 days and 1 night by 2 ecologists; spring Op & targeted	spring - 2 nights by four ecologists; summer- two nights by two ecologists	Op		spring - Op; summer - 12 sites by 4 ecologists, 1 day general walking
2005	Eco Biological	None supplied	Y									Op	Threatened amphibians		Op		Op
2005	Umwelt	Dec 2004-Feb 2005	N														
2004	Umwelt	Dec 2003	N												3 walking transects on drainage lines		
1998	Umwelt/ Gunninah	April-Dec 1997	Y	April 97 - 462 trap nights, Nov - 296 trap nights	April - 66 trap nights; Nov - 44 trap nights	April - 88 trap nights; Nov - 104 trap nights		April - 22 trap nights; Nov - 38 trap nights	April - 9 trap nights; Nov - 14 trap nights	April - 7 nights; Nov - 14 nights	April - 2.3 person hours	April - all habitats; Nov - all habitats	April - 13.5 person hours diurnal, 16 person hours nocturnal; Nov - 8 person hours	April - 17.5 person hours; Nov - 19.5 person hours	April - all of study area; Nov - all of study area	Apr-Dec - 44 person hours	April & Nov - Op

Op= opportunistic survey

3.2 Flora Survey

3.2.1 Vegetation Mapping

A total of 41 quadrats (20m x 20m) and transects (≥ 100m) have been undertaken throughout the greater Newstan Colliery Holdings. 30 quadrats and 30 transects were undertaken within the eastern portion of the Newstan Colliery Holdings on 20-27 October 2010 (Figure 4-1). These quadrats and transects were stratified based on LHCCREMS (2003) and Hunter Eco (2008a, 2009b, 2011) vegetation mapping. A further two quadrats (20m x 20m) were undertaken in the eastern portion of the holdings on 9 February 2011 to sample riparian vegetation. Most mapped vegetation types were sampled at least once, with more extensive vegetation types targeted for increased sampling effort.

A further nine quadrats (20m x 20m) were undertaken within the western portion of the holdings on 31 January – 4 February 2011. These quadrats were stratified based on Cumberland Ecology (2007) vegetation mapping and sampled each community at least once. Additionally, 205 ground-truthing Rapid Data Points (RDPs) were also undertaken during the Jan-Feb 2011 field surveys. This method involved the rapid confirmation of vegetation community structure and dominant species in each strata, and recording the vegetation type.

Further vegetation delineation was undertaken while in transit across the SMP Study Area and in the course of targeted threatened flora and fauna surveys.

Additional site inspections were undertaken by two RPS ecologists on 16th November 2011 to accurately delineate the riparian vegetation with regard to extent and vegetation community type within the SMP Study Area.

Parts of the SMP Study Area are a combination of utility or transport easements, industrial infrastructure, cleared sporting or waste management sites, or rural-residential areas. These areas are highly disturbed, have a high incidence of exotic species or are mostly devoid of native vegetation and therefore were not sampled during RPS field surveys.

3.2.2 Significant Flora Survey

A list of potentially occurring significant flora species from the locality (10km radius) was compiled, which included threatened species (Endangered or Vulnerable) and EEC's listed under the TSC Act 1995 and EPBC Act 1999, as well as any other species deemed to be of local importance. The results of the desktop review are provided in Table 4-4.

Two ecologists undertook targeted threatened flora searches on 18–22 and 24–27 October and 16–19 and 22–26 November 2010. Threatened flora previously recorded in the locality Table 3-3) and any species that have the potential to exist in the SMP study area were targeted by surveys (seasonal where required).

The standardised method as set out by Payne *et al.* (2002) for counting *Tetratheca juncea* (Black-eyed Susan) clumps involves the delineation of each plant clump by a distance of

30cm. The numbers of stems were counted for *Grevillea parviflora* subsp *parviflora* as this species is multi-stemmed and individuals are difficult to differentiate. The locations of all threatened flora species were recorded by the use of a Trimble differential GPS unit with sub-metre accuracy.

Targeted flora surveys were undertaken during of the flowering period for cryptic flora species such as *Caladenia tessellata* (Tessellated Spider Orchid), *Cryptostylis hunteriana* (Leafless Tongue Orchid), *Acacia bynoeana* (Bynoe's Wattle), *Rhizanthella slateri* (Eastern Underground Orchid) and *Tetratheca juncea* (Black-eyed Susan) when they are most likely to be detected. All other species are non-cryptic or easily identifiable outside of their flowering period.

3.3 Habitat Survey

An assessment of the relative flora and fauna habitat value present within the SMP Study Area was undertaken. This assessment focused primarily on the identification of specific habitat types and resources favoured by known threatened flora and fauna species in the region. The assessment also considered the potential value of the SMP Study Area (and surrounds) for all major guilds of native flora and fauna.

Habitat assessment was based on the specific habitat requirements of each threatened fauna species in regards to home range, feeding, roosting, breeding, movement patterns and corridor requirements. Consideration was given to contributing factors including topography, soil, light and hydrology for threatened flora and assemblages.

Table 6-1 summarises the preferred habitat, likelihood of occurrence within the SMP Study Area and if further assessment with regard to impact (through a 7 Part Test) is required

3.4 Fauna Survey

The fauna survey methodology initially consisted of the production of an Expected Fauna Species List for the area (Appendix 1) and an assessment of the potential use of the SMP Study Area by threatened fauna species (as listed under the TSC Act 1995) identified from its vicinity (NPWS 2011; and RPS Aug 2011). This was achieved by undertaking literature and database reviews followed by confirmation through field surveys. Any additional species observed were noted on the list.

Fauna surveys were undertaken over the Larger Study Area over five weeks with two trapping transects completed each week (29 November to 3 December, 2010, 6–10 December, 2010, 13–17 December, 2010, 31 January to 4 February, 2011 and 7–11 February, 2011). The survey time period for this site was 7–11 February 2011. Each trapping transect included: terrestrial fauna and microchiropteran bats (microbat) trapping, microbat echolocation call recording, avifauna surveys, herpetofauna surveys, spotlighting, secondary indications (e.g. scats, scratches and diggings) and incidental observations

The location and effort of each survey methodology was determined based on the fauna habitat located within the Larger Study Area.

3.4.1 Arboreal Trapping

Arboreal trapping was undertaken using six Elliott B size traps per trapping transect set for four nights. Traps were mounted on brackets set at approximately 2m height on trees with a DBH greater than 30cm. Traps were baited with a rolled oats, peanut butter and honey mixture and the tree trunks were sprayed liberally with a brown sugar and water mix each day in the late afternoon. Traps were checked early each morning. The location of each trap line is shown on Figure 4-1.

Arboreal traps targeted arboreal mammals including the threatened Squirrel Glider (*Petaurus norfolcensis*) which has been previously recorded from the surrounding area. A total of 10 trapping transects were undertaken, resulting in 240 arboreal trap nights within the Larger Study Area.

Two trap lines were set within the SMP area during field surveys.

3.4.2 Terrestrial Trapping

Terrestrial trapping was undertaken using 25 Elliott A, 25 Elliott B and 6 cage traps set per trapping transect for four nights. Elliott traps were baited with rolled oats, peanut butter and honey. Cage traps were baited with chicken necks or chicken thighs. Traps were checked early each morning, with any captures identified and released at point of capture. Traps were re-baited where necessary. The location of each trap line is shown on Figure 4-1.

Terrestrial Elliott A traps targeted small terrestrial mammals such as dasyurids (eg. antechinus and dunnarts) and rodents (eg. rats and mice) and terrestrial Elliott B and Cage traps targeted larger terrestrial species such as bandicoots and quolls. A total of 10 trapping transects were undertaken within the Larger Study Area, resulting in 1000 Elliott A trap nights, 1000 Elliott B trap nights and 240 cage trap nights.

Of these trap lines, two were set within the SMP area during field surveys resulting in 200 Elliot A trap nights, 200 Elliot B trap nights and 48 cage trap nights.

3.4.3 Hair Funnels

Surveys were undertaken using 20 Faunatech Hair Funnels and wafers over four nights at each site. These were baited with rolled oats, peanut butter and honey. At each site 10 arboreal and 10 terrestrial were set. The location of each trap line is shown on Figure 4-1.

Hair funnels targeted small-medium mammals such as dasyurids (e.g. Antechinus and Dunnarts), rodents (eg. rats and mice), gliders and bandicoots. A total of 10 hair tube transects were undertaken within the Larger Study Area, resulting in 400 arboreal hair tube nights and 400 terrestrial hair tube nights. Of these, two hair tube transects occurred within the SMP Study Area, consisting of 80 arboreal hair tube nights and 80 terrestrial hair tube nights.

3.4.4 Bat Trapping – Harp Traps

A total of two harp traps were placed along a track or other suitable flyways within the open forest habitats throughout the Larger Study Area for a total of two consecutive nights at each trapping transect. Traps were checked early each morning, with any microchiropteran bat captures identified and released at point of capture. The location of each is shown on Figure 4-1.

A total of 80 harp trap nights were undertaken within the Larger Study Area during surveys. Of these, eight occurred within the SMP Study Area.

3.4.5 Bat Echolocation Call Recording

Microbat echolocation calls were recorded using two Anabat II Detector and CF ZCAIM units set to remotely record for the entire night (18:00–06:00). Each survey site had two consecutive entire nights of sampling, with emphasis placed on those areas deemed likely to provide potential hunting sites for microbats. The location of each microbat call survey site is shown on Figure 4-1.

Recorded bat call analysis was undertaken by Anna McConville who is experienced in the analysis of bat echolocation calls. A total of two consecutive nights of bat call recording at each of the 10 trapping sites was undertaken within the Larger Study Area during surveys. Within the SMP Study Area, a total of 6 survey nights were undertaken totalling 54 hours of recordings.

3.4.6 Avifauna Survey

The observation of avifauna on the SMP Study Area was undertaken via targeted diurnal and opportunistic census during other diurnal fieldwork, including works scheduled for peak activity periods i.e. dawn and dusk. Incidental recordings were supplemented by targeted searches for avifauna, predominantly at each of the standard survey sites (due to survey timing) as well as other areas throughout the SMP Study Area. Emphasis was placed on areas that display high bird activity or had favourable habitat condition (such as undisturbed areas, flowering trees). Identification was made by either direct observation or by distinctive calls. Other features, such as evidence of breeding, dominant species etc. were also noted. Threatened species that have been previously recorded in the locality were specifically targeted during such surveys.

Birds were identified by direct observation, by recognition of calls or through recognition of distinctive features such as nests, feathers, and owl regurgitation pellets etc. The potential for threatened avifauna to use the SMP Study Area was also assessed by identification of habitat attributes occurring within the site and their capacity to support threatened species that are known to occur in the wider locality.

Of the targeted bird surveys that were undertaken during field surveys, one 20 minute bird survey occurred within the SMP area and one occurred just outside the SMP area.

3.4.7 Herpetofauna Survey

Opportunistic herpetofauna searches were conducted during fauna surveys at each transect and when moving throughout the Larger Study Area with a focus on suitable habitat areas. Known occurrences of threatened herpetofauna species from the region were taken into account during assessment of onsite habitat, to determine the potential for the site to support such species. Targeted diurnal and spotlighting surveys for threatened species were also undertaken, including one within the SMP Study Area.

3.4.8 Spotlighting

Spotlighting was undertaken across the site via the use of 35-Watt hand-held spotlights and head torches during walking and vehicular transects. A total of 40 person hours of spotlighting was undertaken within the Larger Study Area (4 person hours per site and surrounds). Specific spotlighting transects that occurred within the SMP Study Area are shown in Figure 4-1.

3.4.9 Owl Call Playback

Pre-recorded calls of owl species with the potential to occur within the Larger Study Area were broadcast during the surveys in an effort to elicit vocal responses from the owls or to attract an owl to the playback site. The calls were broadcast through an amplification system (loud hailer) designed to project the sound for at least 1km under still night conditions.

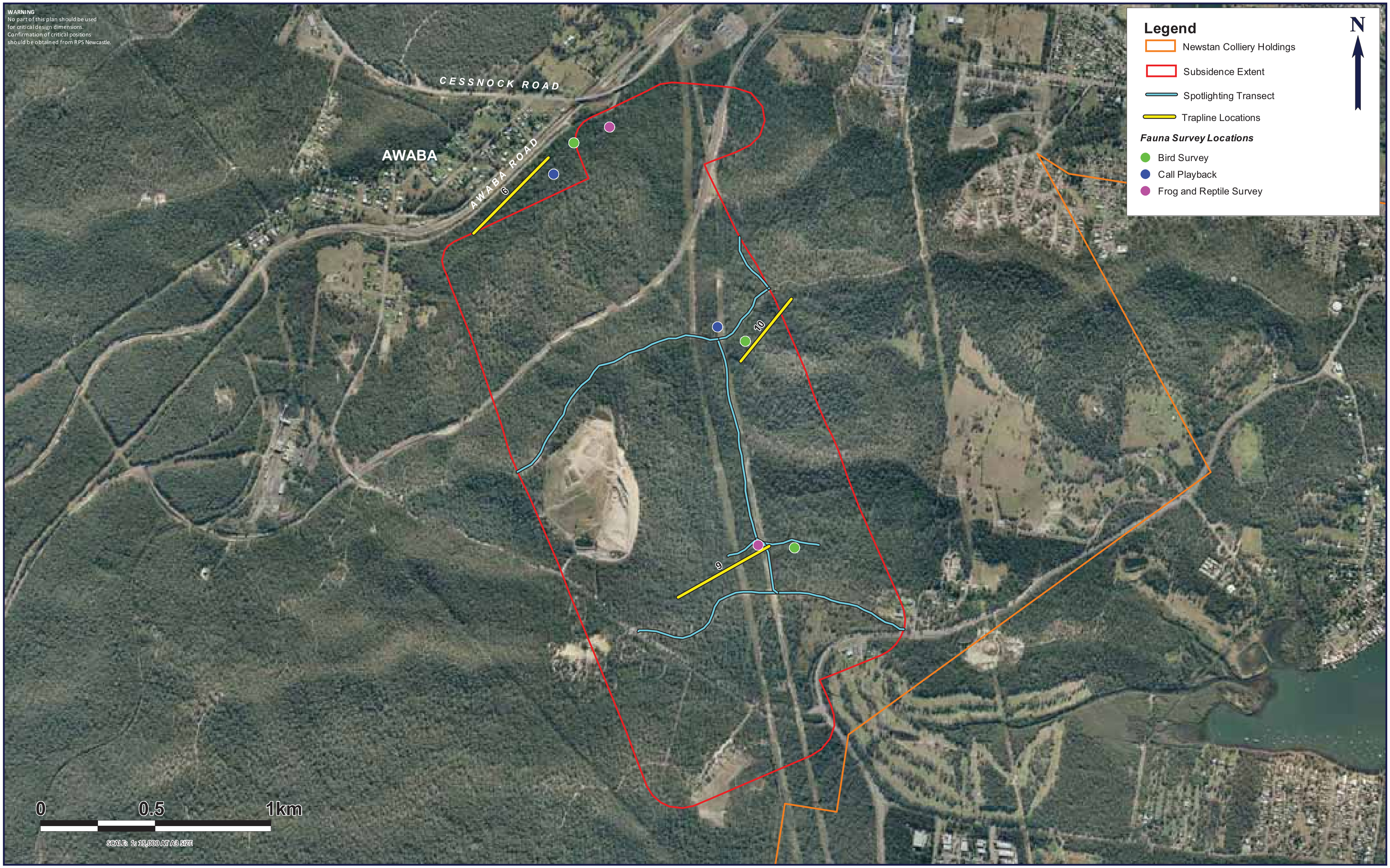
As described by Kavanagh and Peake (1993) and Debus (1995), the call of each species was broadcast for at least five minutes, followed by five minutes of listening, and stationary spotlighting. Following the final broadcast and listening, the area was spotlighted on foot. Species targeted included Powerful Owl (*Ninox strenua*), Barking Owl (*N. connivens*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*T. novaehollandiae*). A total of 20 call playback surveys were undertaken within the Newstan Holdings. One call playback survey was conducted within the SMP Study Area, as shown in Figure 4-1.

3.4.10 Secondary Indications and Incidental Observations

Opportunistic sightings of secondary indications (scratches, scats, diggings, tracks etc.) of resident fauna were noted. Such indicators included:

- Distinctive scats and scents left by mammals;
- Collection of predator scats for analysis;
- Nests made by various guilds of birds;
- Whitewash, regurgitation pellets and prey remains from owls;
- Skeletal material of vertebrate fauna;
- The calls of fauna;
- Footprints left by mammals;
- Chewed she-oak (*Allocasuarina* spp.) cones indicative of feeding by Glossy Black-cockatoo (*Calyptorhynchus lathami*);

- Chewed fruit remains indicative of past feeding by frugivorous birds such as fruit-doves; and
- Any other obvious signs of fauna occupation.



TITLE: FIGURE 3-1: FAUNA SURVEY METHODOLOGIES

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 19/01/2012
PURPOSE: ECOLOGICAL

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-2 Eco\10. Drafting\MapInfo Workspaces\Report Figures
VERSION (PLAN BY): A A3 (AS-PH-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-2

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

3.5 Survey Limitations

The limitations associated with this survey and report is presented herewith. The limitations have been taken into account specifically in relation to threatened species assessments, results and conclusions.

In instances where surveys were not able to reliably detect a particular species or guild, a precautionary approach has been adopted; as such 'assumed presence' of known and expected threatened species, populations and ecological communities has been made where relevant and scientifically justified to ensure a holistic assessment.

3.5.1 Flora Species

The flowering and fruiting plant species that attract some nomadic or migratory threatened species, often fruit or flower in cycles spanning a number of years. Furthermore, these resources might only be accessed in some areas during years when resources more accessible to threatened species fail. As a consequence threatened species may be absent from some areas where potential habitat exists for extended periods.

Additionally, the cryptic nature of a number of flora species means that surveys may not have been able to detect species, despite being present. There is a range of common albeit cryptic plant species that have a brief flowering period and hence small 'window' of effective 'detectability'. In addition, the seasonality of surveys also places limits on the number of flora species identified. Therefore, some threatened species not detected cannot be discounted off-hand due to seasonality and other factors, and are therefore addressed in terms of their potential for occurrence based on ecological factors.

3.5.2 Fauna Species

The presence of fauna within a particular area is not static over time, may be seasonal or in response to the availability of a particular resource. The environmental conditions during which fauna surveys are undertaken greatly influence the species which are recorded. In terms of herpetofauna, conditions such as humidity, rainfall, temperature and barometric pressure can greatly affect the detectability of certain species. As such, where survey effort targeting particular threatened fauna species has not specifically met guidelines recommended by DEC (2004), habitat assessment and prediction of the occurrence of threatened fauna species has been applied.

Nevertheless, it is considered that the combined survey effort and dataset from all of the investigations undertaken to date within the locality provide a substantial picture of the fauna species and habitat values occurring within the SMP Study Area.

3.5.3 Data Availability and Accuracy

The collated threatened flora and fauna species records provided by the Atlas of NSW Wildlife for the region are known to vary in accuracy and reliability. Traditionally this is due to the reliability of information provided to OEH for collation and/or the need to protect specific threatened species locations. During the review of threatened species records sourced from Atlas of NSW Wildlife, consideration has been given to the date and accuracy of each threatened species record in addition to an assessment of habitat suitability within the SMP Study Area.

Similarly EPBC Protected Matters Searches provide a list of threatened species and communities that have been recorded within 10km or which are predicted to have suitable habitat within the area.

In order to address these limitations in respect to data accuracy, threatened species records have been used to provide a guide only to the types of species which occur within the locality of the SMP Study Area. Habitat assessment and the results of surveys conducted within the site have been used to assess the likelihood of occurrence of threatened species, populations and ecological communities to occur.

4 Results

The prevailing weather conditions during the survey period are presented in Table 4-1 below with the dates of survey within the SMP Study Area.

Table 4-1: Prevailing Weather Conditions

Date	17 Oct 2010	18 Oct 2010	19 Oct 2010	20 Oct 2010	21 Oct 2010	22 Oct 2010	23 Oct 2010
Temperature °C	8–22	11–20	13–18	13–19	15–20	14–22	14–27
Rain (24hrs to 9:00am) mm	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Sun Rise	06:10	06:09	06:08	06:07	06:06	06:05	06:03
Sun Set	19:06	19:07	19:08	19:09	19:09	19:10	19:11
Moon Rise	13:58	14:52	15:46	16:40	17:35	18:31	19:29
Moon Set	02:47	03:17	03:45	04:12	04:39	05:08	05:39
Date	**24 Oct 2010**	**25 Oct 2010**	**26 Oct 2010**	**27 Oct 2010**	**28 Oct 2010**	**29 Oct 2010**	**30 Oct 2010**
Temperature °C	15	14–18	13–22	14–23	17–19	17–21	17–23
Rain (24 hrs to 9:00am) mm	15.8	19.6	0.2	0.0	3.4	0.0	0.0
Sun Rise	06:02	06:01	06:00	05:59	05:58	05:57	05:56
Sun Set	19:12	19:13	19:14	19:14	19:15	19:16	19:17
Moon Rise	20:28	21:27	22:26	23:21		00:12	00:58
Moon Set	06:14	06:54	07:39	08:31	09:29	10:32	11:37
Date	**31 Oct 2010**	**1 Nov 2010**	**2 Nov 2010**	**3 Nov 2010**	**4 Nov 2010**	**5 Nov 2010**	**6 Nov 2010**
Temperature °C	19–23	18–20	12–20	12–22	15–18	13–17	14–20
Rain (24 hrs to 9:00am) mm	0.0	2.6	20.8	0.0	0.0	21.8	7.4
Sun Rise	05:55	05:54	05:53	05:52	05:51	05:51	05:50
Sun Set	19:18	19:19	19:20	19:20	19:21	19:22	19:20
Moon Rise	01:39	02:16	02:51	03:26	04:01	04:38	05:20
Moon Set	12:44	13:51	14:58	16:06	17:15	18:25	19:34
Date	**30 Jan 2011**	**31 Jan 2011**	**1 Feb 2011**	**2 Feb 2011**	**3 Feb 2011**	**4 Feb 2011**	**5 Feb 2011**
Temperature °C	19–29	20–27	22–38	25–30	24–39	23–32	24–38
Rain (24 hrs to 9:00am) mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sun Rise	06:14	06:15	06:16	06:17	06:18	06:19	06:19
Sun Set	19:58	19:58	19:57	19:56	19:55	19:55	19:54
Moon Rise	02:18	03:15	04:14	05:13	06:11	07:08	08:03
Moon Set	17:04	17:53	18:35	19:12	19:46	20:16	20:44
Date	**6 Feb 2011**	**7 Feb 2011**	**8 Feb 2011**	**9 Feb 2011**	**10 Feb 2011**	**11 Feb 2011**	**12 Feb 2011**
Temperature °C	26–36	17–22	19–25	20–25	20–25	20–32	23–26
Rain (24 hrs to 9:00am) mm	0.0	9.8	0.0	0.0	3.0	0.0	0.0
Sun Rise	06:20	06:21	06:22	06:23	06:24	06:25	06:26
Sun Set	19:53	19:52	19:51	19:51	19:50	19:49	19:48
Moon Rise	08:57	09:51	10:45	11:39	13.32	13:33	14:31
Moon Set	21:11	21:39	22:08	22:39	23:14	23:55	24:53

4.1 Flora Survey

4.1.1 Previous Vegetation Community Mapping

Vegetation surveys have previously been undertaken within the larger study area by HunterEco (2008a, 2009b and 2011a) and Cumberland Ecology (2007). The results of these vegetation mapping surveys are detailed within Table 4-2. Those vegetation communities that have been confirmed to be present within the SMP Study Area, following ground-truthing, are listed in Table 4-3.

Table 4-2: Vegetation Communities Previously Mapped within the Larger Study Area

Vegetation Community Name	Equivalent LHCCREMS MU	Corresponds to TSC Act EEC	Source
Sydney Peppermint-Smooth Barked Apple Forest	MU 11		Cumberland Ecology 2007
Spotted Gum-Ironbark-White Mahogany-Grey Gum Forest	MU 15		Cumberland Ecology 2007 HunterEco 2008a, 2009b, 2011a
Hunter Lowlands Redgum Forest	MU 19	Hunter Lowlands Redgum Forest	Hunter Eco 2011
Smooth-barked Apple-White Mahogany-Sydney Peppermint Forest & Woodland	MU 30		Cumberland Ecology 2007 HunterEco 2008a, 2009b, 2011a
Scribbly Gum-Red Bloodwood Woodland	MU 31		Cumberland Ecology 2007 HunterEco 2008a, 2009b, 2011a
Swamp Sclerophyll Forest	MU 37	Swamp Sclerophyll Forest of the Floodplains of the North Coast, Sydney Basin and Southeast Corner Bioregions	HunterEco 2008a, 2009b, 2011a
Blue Gum-Forest Red Gum-Rough Barked Apple Forest	MU 38	River Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions	Cumberland Ecology 2007 HunterEco 2009b
Swamp Oak – Rushland Forest	MU 40	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions.	HunterEco 2009b
Swamp Mahogany/Paperbark Forest	MU42	Swamp Sclerophyll Forest of the Floodplains of the North Coast, Sydney Basin and Southeast Corner Bioregions	Cumberland Ecology 2007 Hunter Eco 2011a
Paperbark Scrub	MU 42a	River Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions	HunterEco 2009b
Salt Marsh	MU 47a	Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions.	HunterEco 2009b
Blackbutt Open Forest	MU 9		Cumberland Ecology 2007 Hunter Eco 2011a
Blue Gum-Lilly Pilly Forest	MU 37	River Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions	Cumberland Ecology 2007
Eucalypt-Angophora-Melaleuca Riparian Forest	MU 37	River Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and Southeast Corner Bioregions	HunterEco 2008a, 2009b

4.1.2 Vegetation Community Mapping

Existing mapping by HunterEco (2008a, 2009b, and 2011a), Cumberland Ecology (2007) and LHCCREMS (2003) was found to be relatively accurate. All of these vegetation community descriptions were based on LHCCREMS vegetation communities for easy comparison. Ground truthing of the vegetation identified five vegetation communities occurring within the SMP Study Area. These vegetation communities are described in accordance with LHCCREMS vegetation community profiles (NSW NPWS 2003):

- MU 15 Coastal Foothills Spotted Gum Ironbark Forest;
- MU 30 Coastal Plains Smooth-barked Apple Woodland;
- MU 31 Coastal Plains Scribbly Gum Woodland;
- MU 37 Swamp Mahogany/ Paperbark Forest; and
- Cleared Land.

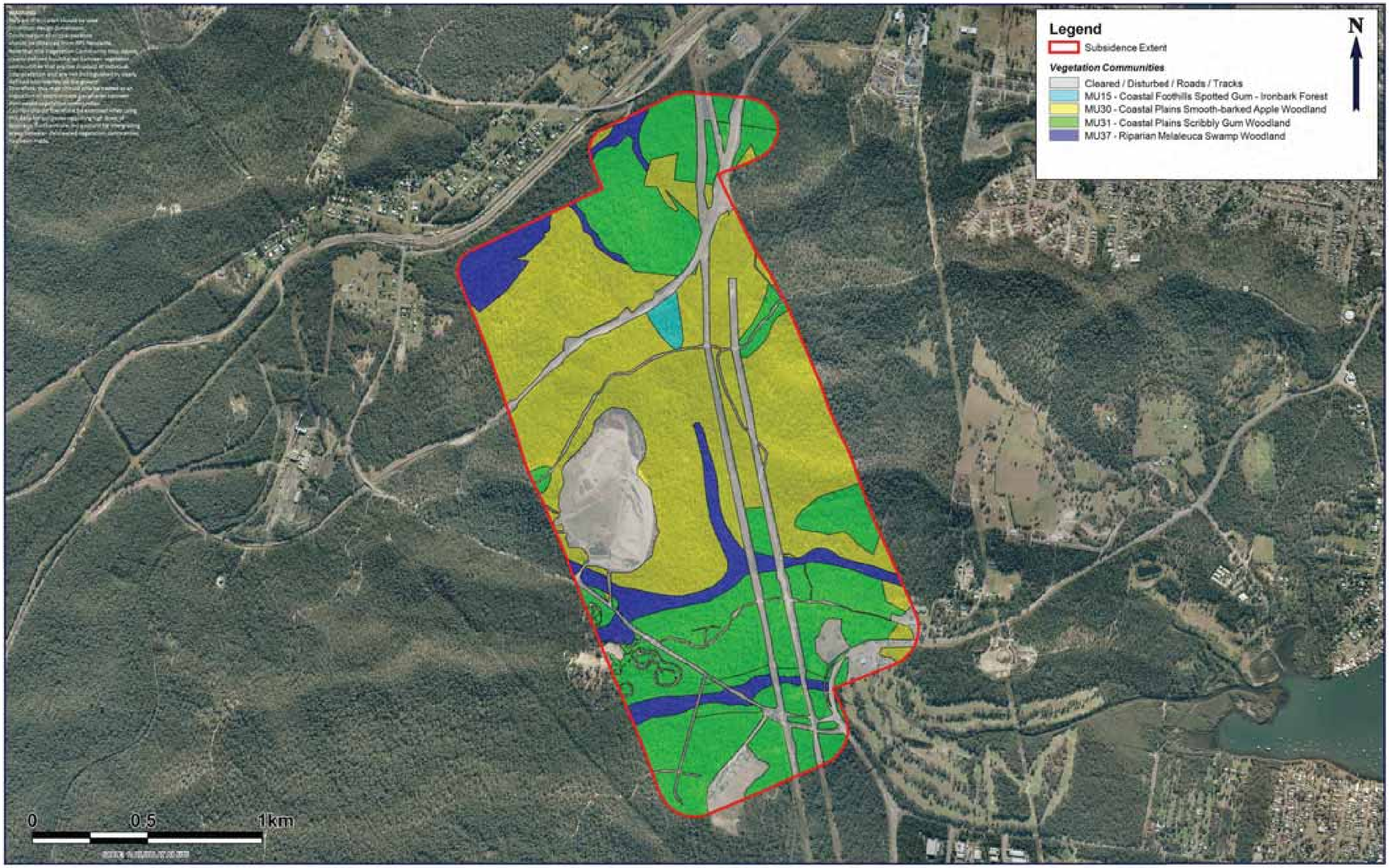
Some minor modifications were made to the mapping in certain areas following ground-truthing and a combined SMP Study Area vegetation map was prepared. Five vegetation types exist, one of which is commensurate with a single TSC Act 1995 listed EEC, namely *Swamp Sclerophyll Forest of the Floodplains of the North Coast, Sydney Basin and Southeast Corner Bioregions* (Table 5-4; Figure 4-1).

LHCCREMS terminology was used to describe the vegetation communities in order to standardise the vegetation communities with respect to previous vegetation mapping in the area. This standardisation enables comparison with regional data and all prior surveys. See Figure 4-1 for the final vegetation map of the SMP area incorporating results of RPS flora ground-truthing surveys.

The following section provides a brief outline of the dominant floral characteristics of each identified vegetation community. The area of each community is provided in Table 4-3 below. A full list of flora species is provided in Appendix 2.

Table 4-3: Vegetation Communities Confirmed within the SMP Study Area

Vegetation Community	LHCCREMS MU	TSC Act EEC Equivalent	Area (ha)
Coastal Foothills Spotted Gum - Ironbark Forest	MU 15		2.3
Coastal Plains Smooth-barked Apple Woodland	MU 30		145.1
Coastal Plains Scribbly Gum Woodland	MU 31		108.6
Swamp Mahogany - Paperbark Forest	MU 37	Swamp Sclerophyll Forest of the Floodplains of the North Coast, Sydney Basin and Southeast Corner Bioregions	29.1
Cleared, Disturbed, Tracks and Easements	None		67.7
Total			352.8



TITLE: FIGURE 4-1: VEGETATION COMMUNITIES WITHIN THE SMP AREA

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 19/01/2012
PURPOSE: ECOLOGICAL

VERSION (PLAN BY): A A3 (AS-PH-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-2

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

RPS

Coastal Foothills Spotted Gum – Ironbark Forest (LHCCREMS MU 15)

Description: This vegetation community occurred on the upper slopes of parts of the study area. The dominant canopy species was *Corymbia maculata* (Spotted-gum) with *Eucalyptus fibrosa* (Broad-leaved Ironbark), *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus acmenoides* (White Mahogany) also present. Where Ironbarks weren't present on the top of ridges, Grey Gums (*Eucalyptus punctata*) were sub-dominant. The shrub layer was dominated by *Persoonia linearis* (Narrow-leaved Geebung), *Podolobium ilicifolium* (Native Holly), *Leucopogon lanceolatus*, *Notelaea longifolia* (Large Mock-olive) and *Daviesia ulicifolia* (Gorse Bitter Pea). The ground layer vegetation was comprised of a large percentage of *Imperata cylindrica* (Blady Grass), *Themeda australis* (Kangaroo Grass) and *Poa labillardieri* (Tussock Grass).

Canopy Layer: 20m – 40-60% Percentage Foliage Cover (PFC). The dominant canopy species was *Corymbia maculata* (Spotted-gum) with *Eucalyptus fibrosa* (Broad-leaved Ironbark), *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus acmenoides* (White Mahogany) also present. Where Ironbarks were not present on the top of ridges, Grey Gums (*Eucalyptus punctata*) were sub-dominant. Other canopy species include *Corymbia gummifera* (Red Bloodwood) and *Eucalyptus umbra* (Broad-leaved White Mahogany).

Sub-canopy Layer: 6m – 10-20% Percentage Foliage Cover (PFC). The dominant species was *Allocasuarina torulosa* (Forest Oak) and juveniles of the canopy species.

Shrub Layer: 1-2m – 20-30% Percentage Foliage Cover (PFC). Dominant shrub species included *Persoonia linearis* (Narrow-leaved Geebung), *Podolobium ilicifolium* (Native Holly), *Leucopogon lanceolatus*, *Notelaea longifolia* (Large Mock-olive) and *Daviesia ulicifolia* (Gorse Bitter Pea). Other species included *Platylobium formosum* (Handsome Flat Pea), *Acrotriche divaricata*, *Pittosporum undulatum* (Sweet Pittosporum) and the non-native *Chrysanthemoides monilifera* (Bitou Bush).

Ground Layer: 0m to 0.8m – 50-60% Percentage Foliage Cover (PFC). Dominant species included *Imperata cylindrica* (Blady Grass), *Themeda australis* (Kangaroo Grass) and *Poa labillardieri* (Tussock Grass). Other species recorded include *Pratia purpurascens* (Whiteroot), *Entolasia stricta* (Wiry Panic), *Panicum simile* (Two-colour Panic), *Pteridium esculentum* (Bracken) and *Cymbopogon refractus* (Barbed-wire Grass).

Classification: This community does not correspond to any Endangered Ecological Community as listed within the NSW TSC Act 1995.

Coastal Plains Smooth-barked Apple Woodland (LHCCREMS MU 30)

Description: This vegetation community occurred extensively throughout the SMP Study Area. The dominant canopy species are *Angophora costata*

(Smooth-barked Apple), *Eucalyptus piperita* (Sydney Peppermint) and *Corymbia gummifera* (Red Bloodwood). The sub-canopy layer was dominated by *Allocasuarina littoralis* (Black She-oak) while the shrub layer was dominated by *Leptospermum trinervium* (Slender Tea-tree), *Leptospermum polygalifolium* (Tantoon), *Melaleuca sieberi* (Snow in summer) and *Banksia spinulosa* (Hairpin Banksia). The ground layer vegetation is dominated by grasses *Entolasia stricta* (Wiry Panic) and *Themeda australis* (Kangaroo Grass). Other common species occurring within the community included; *Lomandra obliqua* (Twisted Mat-rush) and *Dodonaea triquetra* (Hop-bush).

Canopy Layer: 20 to 25m – 30-60% Percentage Foliage Cover (PFC). Dominant species included *Angophora costata* (Smooth-barked Apple), *Eucalyptus piperita* (Sydney Peppermint) and *Corymbia gummifera* (Red Bloodwood), with *Eucalyptus umbra* (Broad-leaved White Mahogany), *Eucalyptus capitellata* (Brown Stringybark), *Eucalyptus globoidea* (White Stringybark) and *Eucalyptus resinifera* subsp. *resinifera* (Red Mahogany) also occurring less commonly. Rarely within the SMP Study Area *Eucalyptus haemastoma* (Scribbly Gum), was recorded.

Sub Canopy Layer: 10m to 15m – 20-30% PFC. Dominant species included *Allocasuarina littoralis* (Black She-oak) and juvenile canopy species *Eucalyptus piperita* (Sydney Peppermint) and *Angophora costata* (Smooth-barked Apple).

Shrub Layer: 1.5m to 6m – 10-30% Percentage Foliage Cover (PFC). Dominant tall shrub species included; *Leptospermum trinervium* (Slender Tea-tree), *Leptospermum polygalifolium* (Tantoon), *Melaleuca sieberi* (Snow in summer) and juvenile canopy Eucalypt species. Dominant small shrub species included *Dodonaea triquetra* (Hop-bush), *Banksia spinulosa* (Hairpin Banksia), *Persoonia levis* (Broad-leaved Geebung), *Lambertia formosa* (Mountain Devil) and juvenile canopy Eucalypt species.

Ground Layer: 0m to 0.7m – 70% Percentage Foliage Cover (PFC). Dominant species included *Entolasia stricta* (Wiry Panic), *Pultenaea paleacea* and *Themeda australis* (Kangaroo Grass). Other species recorded included; *Lomandra obliqua* (Twisted Mat-rush), *Pimelea linifolia* subsp. *linifolia* (Slender Rice Flower), *Lepidosperma laterale*, *Lepidosperma neesii*, *Dianella caerulea* (Blue Flax Lily) and *Pratia purpurascens* (Whiteroot). The exotic species *Andropogon virginicus* (Whisky Grass) and *Pennisetum clandestinum* (Kikuyu) were also present. The vines and climbers, *Cassytha glabella* forma *glabella* (Slender Devil's Twine) and *Glycine clandestina* (Twining Glycine) were also recorded within this community.

Classification: This community does not correspond to any Endangered Ecological Community as listed within the NSW TSC Act 1995.

Coastal Plains Scribbly Gum Woodland (LHCCREMS MU 31)

Description: This vegetation community occurred extensively throughout the SMP Study Area. The dominant canopy species are *Eucalyptus haemastoma* (Scribbly Gum) and *Corymbia gummifera* (Red Bloodwood). If present, the sub-canopy layer was dominated by *Allocasuarina littoralis* (Black She-oak) while the shrub layer was dominated by *Banksia serrata* (Old-man Banksia), *Persoonia levis* (Broad-leaved Geebung), *Xanthorrhoea laterale* (Grass Tree) and *Banksia spinulosa* (Hairpin Banksia). Dominant ground layer species included *Entolasia stricta* (Wiry Panic), *Themeda australis* (Kangaroo Grass), *Lepidosperma neesii* and *Cyathochaeta diandra*.

Canopy Layer: 12 to 20m – 20-40% Percentage Foliage Cover (PFC). Dominant species included *Eucalyptus haemastoma* (Scribbly Gum) and *Corymbia gummifera* (Red Bloodwood) with *Angophora costata* (Smooth-barked Apple), *Eucalyptus piperita* (Sydney Peppermint) and *Eucalyptus capitellata* (Brown Stringybark) also occurring less commonly.

Sub Canopy Layer: 5m to 8m – 10-15% PFC. If present, dominant species included *Allocasuarina littoralis* (Black She-oak), *Leptospermum trinervium* (Slender Tea-tree) and juvenile canopy species.

Shrub Layer: 1.5m to 3m – 20-30% Percentage Foliage Cover (PFC). Dominant shrub species included *Banksia serrata* (Old-man Banksia), *Persoonia levis* (Broad-leaved Geebung), *Xanthorrhoea laterale* (Grass Tree) and *Banksia spinulosa* (Hairpin Banksia). Other shrub species included *Dodonaea triquetra* (Hop-bush), Isopogon anemonifolius (Broad-leaved Drumsticks), *Hakea bakeriana*, *Lambertia formosa* (Mountain Devil) and juvenile canopy Eucalypt species.

Ground Layer: 0m to 1m – 60-90% Percentage Foliage Cover (PFC). Dominant species included *Entolasia stricta* (Wiry Panic), *Themeda australis* (Kangaroo Grass), *Lepidosperma neesii* and *Cyathochaeta diandra*. Other species recorded included *Lomandra obliqua* (Twisted Mat-rush), *Lepidosperma laterale*, *Dianella caerulea* (Blue Flax Lily), *Austrostipa mollis*, *Xanthorrhoea macronema* (Grass Tree) and *Ptilothrix deusta*.

Classification: This community does not correspond to any Endangered Ecological Community as listed within the NSW TSC Act 1995.

Swamp Mahogany – Paperbark Forest (LHCCREMS MU 37)

Description: This vegetation community occurs in areas of impeded drainage such as broad, flat drainage lines. This community may potentially be influenced by groundwater or be partially groundwater dependent. The dominant canopy species were *Eucalyptus robusta* (Swamp Mahogany), *Eucalyptus tereticornis* (Forest Red Gum), *Melaleuca quinquenervia* (Broad-leaved Paperbark) and *Casuarina glauca* (Swamp Oak). If present the dominant species in the sub-canopy layer included *Allocasuarina torulosa* (Forest Oak), *Pittosporum undulatum* (Sweet Pittosporum), *Glochidion ferdinandi* (Cheese Tree) and juveniles of canopy species. The shrub layer was dominated by *Pteridium esculentum* (Bracken), *Phragmites australis* (Common Reed), *Gahnia clarkei* (Tall Saw-sedge), *Lonicera japonica* (Japanese Honeysuckle), *Lantana camara* (Lantana) and *Parsonsia straminea* (Common Silk Pod). Dominant ground layer species included *Oplismenus aemulus* (Basket Grass), *Entolasia marginata* (Bordered Panic), *Pteridium esculentum* (Bracken), *Phragmites australis* (Common Reed) and *Dichondra repens* (Kidney Weed).

Canopy Layer: 25 to 27m – 50-70% Percentage Foliage Cover (PFC). Dominant species included *Eucalyptus robusta* (Swamp Mahogany), *Eucalyptus tereticornis* (Forest Red Gum), *Melaleuca quinquenervia* (Broad-leaved Paperbark) and *Casuarina glauca* (Swamp Oak). *Angophora costata* (Smooth-barked Apple) and *Eucalyptus resinifera* (Red Mahogany) were also present.

Sub-canopy Layer: 6m to 8m – 20-30% Percentage Foliage Cover (PFC). If present the dominant species in the sub-canopy layer included *Allocasuarina torulosa* (Forest Oak), *Pittosporum undulatum* (Sweet Pittosporum), *Glochidion ferdinandi* (Cheese Tree), *Acmena smithii* (Lilly Pily), *Callistemon salignus* (Willow Bottlebrush), *Melaleuca styphelioides* (Prickly-leaved Tea Tree) and juveniles of canopy species.

Shrub Layer: 2m to 3m – 70-80% Percentage Foliage Cover (PFC). Dominant shrub species included *Pteridium esculentum* (Bracken), *Phragmites australis* (Common Reed), *Gahnia clarkei* (Tall Saw-sedge), *Lonicera japonica* (Japanese Honeysuckle), *Lantana camara* (Lantana) and *Parsonsia straminea* (Common Silk Pod). Other species recorded include *Senna pendula*, *Ochna serrulata* and *Polyscias sambucifolia* (Elderberry Panax).

Ground Layer: 0.5m – 5-10% Percentage Foliage Cover (PFC). Dominant species included *Oplismenus aemulus* (Basket Grass), *Entolasia marginata* (Bordered Panic), *Pteridium esculentum* (Bracken), *Phragmites australis* (Common Reed), *Lonicera japonica* (Japanese Honeysuckle) and *Dichondra repens* (Kidney Weed). Other species recorded included *Centella asiatica* (Indian Pennywort), *Imperata cylindrica* (Blady Grass), *Baumea juncea* and *Cynodon dactylon* (Couch).

Classification: This community is commensurate to *Swamp Sclerophyll Forest of the Floodplains of the North Coast, Sydney Basin and Southeast Corner Bioregions* which is an Endangered Ecological Community as listed within the NSW TSC Act 1995.

Cleared Land (LHCCREMS MU - None)

Description: This vegetation community occurs in areas affected by removal of the canopy and majority of the shrub layers. This community occurs within areas such as powerlines, pipeline or road easements, fire trails, landfill and sporting facilities. Large areas are often disturbed by various means such as off-road vehicles and bikes, regular slashing, periodic removal of shrubs and tree saplings, erosion, rubbish dumping and other anthropogenic disturbances.

Canopy Layer: Usually none or very sparse young regrowth. If young regrowth is present, it is generally consistent with the species composition of adjoining undisturbed vegetation.

Shrub Layer: Usually none or very sparse young regrowth. If young regrowth is present, it is generally consistent with the species composition of adjoining undisturbed vegetation.

Ground Layer: 0.04 to 1.0m – Highly variable Percentage Foliage Cover (PFC). Dominant species generally similar to adjacent undisturbed vegetation with a higher proportion of exotic grass, forb and herb species.

Classification: This community does not correspond to any Map Unit described or mapped within the LHCCREMS Project (NPWS 2003). This vegetation community does not correspond to any Endangered Ecological Community as listed within the NSW TSC Act 1995.

4.1.3 Significant Flora

The Atlas of NSW Wildlife and the EPBC Protected Matters tool were queried for threatened flora listed within the NSW TSC Act 1995 and the Commonwealth EPBC Act 1999 recorded in the area 10km around the SMP Study Area. The results of these searches are summarised in Table 4-4. The results of reviewing the previous surveys that have been undertaken within the locality (Table 3-1) have also been included below. A total of 17 threatened flora species, five Rare or Threatened Australian Plants (ROTAP) listed species (Briggs and Leigh 1996) and one other species deemed to be of local importance have been recorded in the locality (Table 4-4).

Table 4-4: Flora of Conservation Significance Previously Recorded in the Region

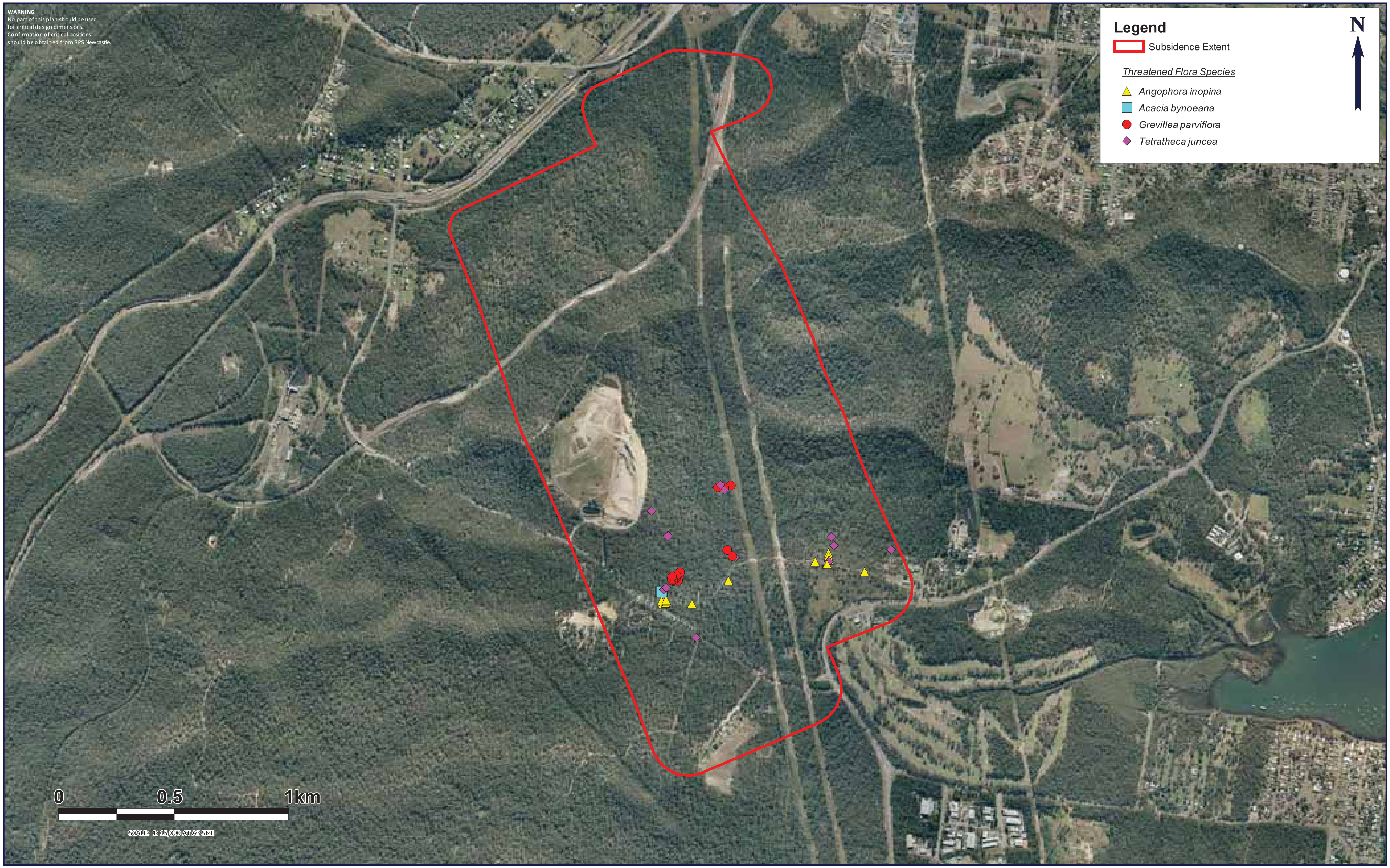
Scientific Name	Common Name	TSC Act Status	EPBC Act Status	ROTAP	Locally Rare	Source
Acacia bynoeana	Bynoe's Wattle	E	V			Umwelt 2005, Cumberland Ecology 2007, 2008 HunterEco 2008a, 2008b, 2009b, 2011b Atlas of NSW Wildlife 2012 EPBC PMST 2012 RPS August 2011
Angophora inopina	Charmhaven Apple	V	V			Cumberland Ecology 2007, 2008 HunterEco 2008a, 2009b, 2011b Atlas of NSW Wildlife 2012 EPBC PMST 2012 RPS 2011
Caladenia tessellata	Tessellated Spider Orchid	E	V			Atlas of NSW Wildlife 2012 EPBC PMST 2012
Callistemon linearifolius	Crimson Bottlebrush	V				Umwelt 2004 Atlas of NSW Wildlife 2012
Corybas dowlingii	Red Helmet Orchid	E				Atlas of NSW Wildlife 2012
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V			Atlas of NSW Wildlife 2012 EPBC PMST 2012
Cymbidium suave	Snake Orchid				X	Umwelt 2004 Cumberland Ecology 2007, 2008
Cynanchum elegans	White-flowered Wax Plant	E	E			Atlas of NSW Wildlife 2012
Diuris praecox	Rough Doubletail	V	V			Atlas of NSW Wildlife 2012 EPBC PMST 2012
Eucalyptus camfieldii	Heart-leaved Stringybark	V	V			EPBC PMST 2012
Eucalyptus fergusonii subsp dorsiventralis	Fergusons Ironbark			X		Cumberland Ecology 2007, 2008
Eucalyptus fergusonii subsp fergusonii	Ferguson Ironbark			X		Umwelt 1998
Goodenia glomerata				X		Umwelt 1998
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V			Umwelt 2005 EcoBiological 2005 Cumberland Ecology 2007, 2008 HunterEco 2008a, 2008b, 2011a, , 2011b Atlas of NSW Wildlife 2012 EPBC PMST 2012 RPS 2011
Hakea bakeriana				X		Umwelt 1998, 2004, 2005 Cumberland Ecology 2007, 2008 HunterEco 2008a, 2009a, 2009b

Scientific Name	Common Name	TSC Act Status	EPBC Act Status	ROTAP	Locally Rare	Source
Macrozamia flexuosa				X		Umwelt 1998, 2005 Cumberland Ecology 2007, 2008
Maundia triglochinoides	-	V				Atlas of NSW Wildlife 2012
Melaleuca biconvexa	Biconvex Paperbark	V	V			Atlas of NSW Wildlife 2012 EPBC PMST 2012
Pelargonium sp. Striatellum (G.W.Carr 10345)			E			EPBC PMST 2012
Pterostylis gibbosa	Illawarra Greenhood	E	E			EPBC PMST 2012
Pultenaea maritima	Coast Headland Pea	V	-			Atlas of NSW Wildlife 2012
Prasophyllum sp. Wybong (C.Phelps ORG 5269)			CE			EPBC PMST 2012
Rhizanthella slateri	Eastern Underground Orchid	V	E			EPBC PMST 2012
Syzygium paniculatum	Magenta Lillypilly	E	V			Atlas of NSW Wildlife 2012 EPBC PMST 2012
Tetratheca juncea	Black-eyed Susan	V	V			Umwelt 1998, 2004, 2005 EcoBiological 2005 Cumberland Ecology 2007, 2008 HunterEco 2008a, 2008b, 2011a, 2011b Atlas of NSW Wildlife 2012 EPBC PMST 2012 RPS 2011

Four threatened flora species have previously been recorded within the SMP Study Area by this and previous ecological surveys. These species were:

- *Acacia bynoeana* (Bynoes Wattle);
- *Angophora inopina* (Charmhaven Apple);
- *Grevillea parviflora* subsp. *parviflora* (Small-flowered Grevillea); and
- *Tetratheca juncea* (Black-eyed Susan).

Specific locations of these species are provided in Figure 4-2. It is noted that the results provided are representative of potentially larger populations of these species. This stance is supported by literature reviews, including the results by HunterEco (2011b), which recorded a substantially larger population of Black-eyed Susan to that shown in Figure 4-2. The potential for impact upon these species as a result of the proposal is given consideration in Table 6-1.



TITLE: FIGURE 54-2: THREATENED FLORA SPECIES

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 19/01/2012
PURPOSE: ECOLOGICAL

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-2 Eco\10. Drafting\MapInfo Workspaces\Report Figures
VERSION (PLAN BY): A A3 (AS-PH-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-2

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

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4.2 Fauna Survey

A total of 58 fauna species were recorded within and immediately adjacent to the SMP area during surveys, including five terrestrial mammals, four arboreal mammals, 36 birds, eight bats, two reptiles and three frogs. These species form a collective portion of the 124 species that were recorded within the larger survey area.

Appendix 1 lists all RPS-recorded fauna species in the study area. Refer to Figure 4-3 for threatened fauna locations.

Results from the desktop review of the Atlas of NSW Wildlife, EPBC Protected Matters tool and previous surveys have been summarised in Table 4-5. 13 threatened fauna species listed under TSC Act 1995 and/or the EPBC Act 1999 have been recorded in the Newstan Mine Holdings area by previous ecological surveys and are shown in **bold** below.

Table 4-5: Fauna of Conservation Significance Recorded in the Larger Study Area

Scientific Name	Common Name	TSC Act Status	EPBC Act Status	Source
Crinia tinnula	Wallum Froglet	V		Atlas of NSW Wildlife 2012
Litoria aurea	Green and Golden Bell Frog	E	V	EPBC PMST 2012
Litoria littlejohni	Littlejohn's Tree Frog	V	V	EPBC PMST 2012
Mixophyes balbus	Stuttering Frog	E		Atlas of NSW Wildlife 2012 EPBC PMST 2012
Mixophyes iteratus	Giant Barred Frog	E	E	EPBC PMST 2012
Heleioporus australiacus	Giant Burrowing Frog	V	V	EPBC PMST 2012
Pseudophryne australis	Red-crowned Toadlet	V		Atlas of NSW Wildlife 2012
Hoplocephalus stephensii	**Stephens' Banded Snake**	**V**		RPS 2011 Atlas of NSW Wildlife 2012
Oxyura australis	Blue-billed Duck	V		Atlas of NSW Wildlife 2012
Hieraaetus morphnoides	Little Eagle	V		Atlas of NSW Wildlife 2012
Ephippiorhynchus asiaticus	Black-necked Stork	E		Atlas of NSW Wildlife 2012
Irediparra gallinacea	Comb-crested Jacana	V		Atlas of NSW Wildlife 2012
Rostratula australis	Australian Painted Snipe	E	V	EPBC PMST 2012
Dasyornis brachypterus	Eastern Bristlebird	E	E	EPBC PMST 2012
Botaurus poiciloptilus	Australasian Bittern	E	E	EPBC PMST 2012
Ixobrychus flavicollis	Black Bittern	V		Atlas of NSW Wildlife 2012
Circus assimilis	Spotted Harrier	V		Atlas of NSW Wildlife 2012
Erythrotriorchis radiatus	Red Goshawk	CE	V	Atlas of NSW Wildlife 2012
Pandion haliaetus	Osprey	V		Atlas of NSW Wildlife 2012
Burhinus grallarius	Bush Stone-curlew	E		Atlas of NSW Wildlife 2012
Callocephalon fimbriatum	Gang-gang Cockatoo	V		Atlas of NSW Wildlife 2012
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		Atlas of NSW Wildlife 2012
Glossopsitta pusilla	**Little Lorikeet**	**V**		RPS 2011 Atlas of NSW Wildlife 2012
Lathamus discolor	Swift Parrot	E	E	Atlas of NSW Wildlife 2012 EPBC PMST 2012
Neophema pulchella	Turquoise Parrot	V		Atlas of NSW Wildlife 2012
Pyrrholaemus saggitatus	Speckled Warbler	V		Atlas of NSW Wildlife 2012
Ninox connivens	Barking Owl	V		Atlas of NSW Wildlife 2012
Ninox strenua	**Powerful Owl**	**V**		RPS 2011

Scientific Name	Common Name	TSC Act Status	EPBC Act Status	Source
				Atlas of NSW Wildlife 2012
Tyto novaehollandiae	**Masked Owl**	**V**		Cumberland Ecology 2007 Atlas of NSW Wildlife 2012
Tyto tenebricosa	**Sooty Owl**	**V**		Cumberland Ecology 2007 Atlas of NSW Wildlife 2012
Climacteris picumnus	Brown Treecreeper	V		Atlas of NSW Wildlife 2012
Anthochaera phrygia	Regent Honeyeater	CE	E	Atlas of NSW Wildlife 2012 EPBC PMST 2012
Daphoenositta chrysoptera	**Varied Sittella**	**V**		HunterEco 2009b RPS 2011
Petroica boodang	Scarlet Robin	V		Atlas of NSW Wildlife 2012
Petaurus australis	Yellow-bellied Glider	V		Atlas of NSW Wildlife 2012
Dasyurus maculatus	Spotted-tailed Quoll	V		Atlas of NSW Wildlife 2012
Phascolarctos cinereus	Koala	V		Atlas of NSW Wildlife 2012
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	EPBC PMST 2012
Petaurus norfolcensis	**Squirrel Glider**	**V**		Gunninah 1998 HunterEco 2009b RPS 2011 Atlas of NSW Wildlife 2012
Chalinolobus dwyeri	**Large-eared Pied Bat**	**V**	**V**	Gunninah 1998 RPS 2011 Atlas of NSW Wildlife 2012 EPBC PMST 2012
Myotis macropus	Southern Myotis	V		Atlas of NSW Wildlife 2012
Potorous tridactylus	Long-nosed Potoroo	V		Atlas of NSW Wildlife 2012 EPBC PMST 2012
Pseudomys novaehollandiae	New Holland Mouse		V	EPBC PMST 2012
Pteropus poliocephalus	**Grey-headed Flying-fox**	**V**	**V**	Cumberland Ecology 2007 RPS 2011
Mormopterus norfolkensis	**East-coast Freetail-bat**	**V**		Cumberland Ecology 2007 HunterEco 2009b RPS 2011 Atlas of NSW Wildlife 2012
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V		Atlas of NSW Wildlife 2012
Kerivoula papuensis	Golden-tipped Bat	V		Atlas of NSW Wildlife 2012
Miniopterus australis	**Little Bentwing-bat**	**V**		Gunninah 1998 Cumberland Ecology 2007 HunterEco 2009b RPS 2011 Atlas of NSW Wildlife 2012
Miniopterus schreibersii oceanensis	**Eastern Bent-wing Bat**	**V**		Gunninah 1998 HunterEco 2009b RPS 2011 Atlas of NSW Wildlife 2012
Scoteanax rueppellii	Greater Broad-nosed Bat	V		Atlas of NSW Wildlife 2012
Vespadelus troughtoni	Eastern Cave Bat	V		Atlas of NSW Wildlife 2012
Saccolaimus flaviventris	**Yellow-bellied Sheathtail Bat**	**V**		Cumberland Ecology 2007
Epinephelus daemelii	Black Rockcod		V	EPBC PMST 2012

4.2.1 Terrestrial Mammals

During terrestrial trapping across and immediately adjacent to the SMP area, 47 Bush Rats (*Rattus fuscipes*), 13 Brown Antechinus (*Antechinus stuartii*) and seven Brown Bandicoots (*Isoodon macrourus*) were caught (including possible recaptures). Hair samples analysed by Barbara Triggs also confirmed these species. One common macropod species was observed, namely the Swamp Wallaby (*Wallabia bicolor*).

No introduced mammals were recorded within the SMP Study Area but have been recorded within the larger survey area.

A full list of mammals recorded within the SMP Study Area is provided in Appendix 1.

4.2.2 Arboreal Mammals

A total of four arboreal mammals were recorded within the SMP area, including the Common Brushtail Possum (*Trichosurus vulpecular*), Common Ringtail Possum (*Pseudoechirus peregrinus*), Sugar Glider (*Petaurus breviceps*), and Feathertail Glider (*Acrobates pygmaeus*). The Common Ringtail Possum was regularly recorded throughout the SMP Study Area and one Brushtail Possum was captured within an arboreal trap. The Sugar Gliders were trapped in arboreal Elliott traps. The presence of this species was also confirmed by analysis of hair samples from the hair tubes by Barbara Triggs. A Feathertail Glider was also observed during vehicle spotlighting. This species is rarely detected during fauna surveys due to its small size, but it is expected to be a common species throughout the SMP Study Area and wider locality.

4.2.3 Bats

Seven species of microchiropeteran bats were confidently identified within the SMP area from Anabat echo-location call recording surveys. Recordings were of the White-striped Freetail-bat *(Austronomus australis*), Gould's Wattled-bat (*Chalinolobus gouldi*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), East-coast Freetail-bat (*Mormopterus norfolkensis*), Eastern Freetail-bat (*Mormopterus* Species 2) and Eastern horseshoe bat (*Rhinolophus megaphyllus*).

Of these species, three are listed as Vulnerable under the NSW TSC Act 1995, namely Little Bentwing-bat, Eastern Bentwing-bat and Eastern Freetail-bat.

The Grey-headed Flying-fox (*Pteropus poliocephalus*) which is listed as Vulnerable under the TSC Act 1995 and EPBC Act 1999 was recorded immediately adjacent to the SMP area and at various other locations within the broader study area.

4.2.4 Avifauna Survey

A total of 36 bird species were recorded within the SMP area during the survey period. Most species were recorded evenly across the areas surveyed. Species recorded include the Yellow-faced Honeyeater (*Lichenostomus chrysops*), Striated Thornbill (*Acanthiza lineata*), Grey Fantail (*Rhipidura fuliginosa*), White-cheeked Honeyeater (*Phylidonyris niger*), Australian Raven (*Corvus coronoides*), White-throated Nightjar (*Eurostopodus mystacalis*), Australian Owlet Nightjar (*Aegotheles cristatus*), and Variegated Fairy-Wren (*Malurus lamberti*). These species represent a portion of the 76 bird species that were recorded across the Larger Study Area.

One threatened forest owl was recorded within the SMP area, specifically the Masked Owl (*Tyto novaehollandiae*) (Figure 4-3). Call playback commenced immediately after dusk and the owl responded shortly after, indicating that it was roosting only a short distance from the call playback site.

The threatened Varied Sittella (*Daphoenositta chrysoptera*), Little Lorikeet (*Glossopsitta pusilla*) and Powerful Owl (*Ninox strenua*) were observed in varying habitats within the Larger Study Area surrounding the SMP area during surveys conducted by RPS. These species are listed as Vulnerable under the TSC Act 1995.

The Sooty Owl has also been recorded immediately adjacent to the Larger Study Area by Cumberland Ecology (2007). This species was recorded in Swamp Mahogany/ Paperbark Swamp forest, which also occurs within the SMP Study Area. It is therefore ascertained that suitable habitat is likely to be present.

A full list of bird species observed within the SMP Study Area is provided in Appendix 1.

4.2.5 Herpetofauna

One targeted survey in unison with opportunistic surveys was conducted for amphibians and reptiles within the SMP area. Three common amphibian species, namely Broad-palmed Rocket Frog (*Litoria latopalmata*), Red-backed Toadlet (*Pseudophryne coriacea*) and Common Eastern Froglet (*Crinia signifera*) were either seen or heard calling

Two common reptile species were recorded in the SMP area, namely the Robust Skink (*Ctenotus robustus*) and Garden Skink (*Lampropholis delicata*).

One Stephens' Banded Snake (*Hoplocephalus stephensii*), which is listed as Vulnerable under the TSC Act 1995, was recorded within the Larger Survey Area in a dry sclerophyll forest community during previous surveys conducted by RPS. The juvenile specimen was recorded moving across a gravel road during a nocturnal survey.

4.2.6 Threatened Aquatic Species

A search for threatened aquatic species was undertaken online at the NSW Department of Primary Industries website. There are four threatened aquatic (fish) species known in the Hunter / Central Rivers CMA. These are listed in Table 4-6.

Table 4-6: Threatened aquatic (fish) species of the Hunter / Central Rivers CMA

Scientific Name	Common Name	NSW Status
Carcharius taurus	Grey nurse shark	Critically endangered
Pristis zijsron	Green sawfish	Presumed extinct
Carcharadon carcharias	Great white shark	Vulnerable
Epinephelus daemelii	Black cod	Vulnerable

All of these species are wholly marine and do not occur within the SMP Study Area.

TITLE: FIGURE 4-3:THREATENED FAUNA	LOCATION: NEWSTAN	DATUM: (GDA 94) PROJECTION: MGA ZONE 56	DATE: 20/01/2012 PURPOSE: ECOLOGICAL	LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-2 Eco\10. Drafting\MapInfo Workspaces\Report Figures VERSION (PLAN BY): A A3 (AS-PH-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-2

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
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4.3 Habitat Survey

4.3.1 Terrestrial Habitats

Habitat within the SMP Study Area was assessed for their potential to support native fauna species including threatened fauna for which records occur within the wider locality. Broad habitat types recorded within the SMP Study Area included; open forest/woodland areas, riparian areas and cleared/developed areas.

Open forest communities provide moderately suitable habitat for a number of terrestrial mammals. They also provide abundant foraging resources such as foliage, pollen, nectar and invertebrates for possums, gliders and flying-foxes. Several arboreal mammal species were recorded during spotlighting including Common Brushtail Possum (*Trichosurus vulpecula*), Common Ringtail Possum (*Pseudocheirus peregrinus*), Feathertail Glider (*Acrobates pygmaeus*), and Sugar Gliders (*Petaurus breviceps*). No Koalas, or signs of their presence, were recorded during the surveys.

The supply of nectar attracts insect populations for a range of microbats that occur within the locality. There is also a high incidence of hollow-bearing trees throughout the SMP Study Area providing roosting and nesting habitat for a number of microbat species. There is limited roosting and den habitat for cave dwelling species, with no rocky outcrops, however the older mine subsidence areas located in the north west of the SMP Study Area and a large culvert in the southern portion of the SMP Study Area may provide roosting some roosting opportunities for these species.

The high incidence of hollow-bearing trees also provides habitat opportunities for a wide range of arboreal mammals including the threatened Squirrel Glider. These vegetated areas also provide suitable foraging resources, nesting and roosting opportunities for a variety of sedentary and breeding-migrant bird species. The numerous hollows throughout the SMP Study Area provide an opportunity for hollow-dependent birds such as forest owls, treecreepers and parrots within the Coastal Plains Smooth Barked Apple Woodland.

There is a high abundance of fallen logs, dead tree stags and ground debris providing shelter opportunities for a wide range of terrestrial mammals, reptiles and amphibian species.

She-oak stands (*Allocasuarina littoralis* and *A. torulosa*) are favoured food sources of Glossy Black-cockatoo (*Calyptorhynchus lathami*) and are scattered throughout the SMP Study Area, suggesting this species is likely to utilise the area. Terrestrial mammal species, such as Bush Rats (*Rattus fuscipes*) and Brown Antechinus (*Antechinus stuartii*), were found to be reasonably abundant within the locality and are likely to provide hunting opportunities for Masked Owl (*Tyto novaehollandiae*). The Common Ringtail Possum (*Pseudocheirus peregrinus*) was also recorded at most sites within the Larger Study Area and are a known food source for Powerful Owl (*Ninox strenua*) which was also recorded within the larger study area.

The areas with the greatest potential habitat for herpetofauna species exist within the Coastal Plains Smooth-barked Apple Woodland along the drainage lines. The drainage lines also provide intermittent foraging opportunities for common snake and turtle species, with wooded areas likely to provide habitat for common lizard and snake species. Five snake species were recorded within the Larger Study Area with one listed as vulnerable under the TSC Act 1995 being Stephens' Banded Snake (*Hoplocephalus stephensii*). The other species were Green Tree Snake (*Dendrelaphis punctulata*), Red-bellied Black Snake (*Pseudechis porphyriacus),* Golden-crowned Snake (*Cacophis squamulosus*) and Blackish Blind Snake (*Ramphotyphlops nigrescens*). There is potential for all species to occur within the SMP Study Area based on adequate habitat and resources.

The drainage lines within the SMP Study Area offer semi-ephemeral habitats with ponding occurring for a substantial period after rain. These riparian habitats are likely to provide habitat for a range of ground and tree frog species. However, less than optimal weather conditions during surveys did not allow these species to be representatively sampled and only three common frog species have been recorded within the SMP Study Area. The artificial dams within the SMP Study Area offer less structurally diverse habitats likely to be only occupied by the most tolerant of frog species such as the Common Eastern Froglet (*Crinia signifera*) and Broad-palmed Rocket Frog (*Litoria latopalmata*).

The cleared and disturbed areas occurring within the SMP Study Area are considered to be of low value in terms of providing habitat for native fauna species aside from providing foraging habitat along the ecotone between cleared and forested areas (such as for hunting by microchiropteran bat species).

4.3.2 Corridors and Habitat Linkages

The SMP Study Area is mapped within the Lake Macquarie Native Vegetation and Corridors (Version 2 – Lake Macquarie City Council 2007) Mapping as 'Remnant Native Vegetation'. The SMP Study Area is predominantly vegetated and therefore provides a variety of internal habitat linkages along creeks, gullies and ridgelines. There are also altitudinal linkages between the highest parts of the SMP Study Area and the shores of Lake Macquarie to the south and east.

In general, linkages to adjacent habitats are limited to those to the west. Linkages to the north are patchy due to urban development, linkages to the east are limited by urban development and Lake Macquarie and linkages to the south are limited by Eraring Power Station and reservoir, although a linkage extends from the southern portion of the site to the shores of Myuna Bay on Lake Macquarie.

5 Potential Ecological Impacts

5.1 Impacts to Flora

MSEC (2012) has predicted a maximum subsidence of 1200 mm within the SMP Study Area. No vegetation clearing is to be undertaken, therefore impacts to flora species and their habitats is expected to be minor. The four threatened flora species known within the SMP Study Area (*Acacia bynoeana, Angophora inopina, Grevillea parviflora* and *Tetratheca juncea*) are located on ridgetops and side slopes and are not expected to be significantly affected by the proposed subsidence levels.

Cryptostylis hunteriana is known to occur within a range of habitats including woodlands to swamp heaths this species has some potential to occur within many parts of the SMP Study Area, including the lower lying wetter areas. *Cryptostylis hunteriana* has not been recorded during the recent surveys or within any areas of the Newstan holdings, despite targeted surveys during its flowering period. Suitable habitat does exist and due to its cryptic nature, the potential presence of this species cannot be completely discounted.

The expected subsidence of a maximum of 1200 mm (MSEC 2012) may have an effect on riparian and poorly drained areas by causing additional ponding. This may have minor localised impacts on potential habitat for *Cryptostylis hunteriana*, however given that this species has not been recorded and can occur in a range of habitat types, the amount of potential habitat to be influenced by the predicted effects of subsidence would be minor. The influence of localised ponding may also not result in the degradation of habitat for *Cryptostylis hunteriana* where such ponding is ephemeral, as this species is known to tolerate damp habitats. If present, the impacts upon this species or potential habitat are therefore expected to be low.

5.1.1 Groundwater Dependent Ecosystems

One vegetation unit mapped within the SMP Study Area (Swamp Mahogany Paperbark Forest) may potentially be influenced by groundwater or be partially groundwater dependent. This vegetation type is associated with drainage lines and floodplains within the site.

The impact expected from the longwall mining under this GDE is expected to be a maximum subsidence of 1200 mm (MSEC 2012). Increased ponding could occur along the flatter sections of the Schedule 2 streams as a result of mining, however, natural ponding was evident along these watercourses due to the relatively flat natural grades.

GDEs located within the SMP Study Area may experience a drawdown of up to 0.2 m as a result of mining. This may potentially cause some drying out if this community is found to be heavily reliant on ground water for influences. It is not anticipated that GDEs located outside the SMP Study Area will be impacted (GHD 2012a).

Continuous fracturing is not expected between the seam and the surface and, therefore, no loss of water from the catchment is anticipated (MSEC 2012).

It is expected that the effects of the predicted maximum subsidence may have minor ponding effects within this Groundwater Dependent Ecosystem. It is also expected that the GDE will adjust over time to accommodate the changed levels through natural sedimentation of hollows and the natural hydrology of the GDE will be maintained.

5.2 Impacts to Fauna

MSEC (2012) has predicted a maximum subsidence of 1200 mm within the SMP Study Area. Impacts to fauna species and their habitats are expected to be minor. The proposal is not likely to remove habitat such as hollows, foraging habitat, leaf litter or dead wood and the site does not contain any caves suitable for roosting bats. Most threatened fauna species known or potentially occurring in the area are mobile and are not expected to be significantly affected by the proposed subsidence levels.

6 Threatened Species and Communities Assessment

6.1 Identification of Subject Species and Communities

Threatened flora and fauna species (listed under the TSC Act 1995 and/or the EPBC Act 1999) that have been gazetted and recorded within a 10 km radius of the SMP Study Area have been considered within this assessment. Endangered Ecological Communities (EEC's) known from the broader area have also been addressed. Each species / community is considered for its potential to occur on the site.

This assessment deals with the following heads of consideration in tabulated form (refer to Table 6-1 overleaf):

'Species / Community'/ Population' – Lists each threatened species / population / EEC known from the vicinity. The status of each threatened species under the TSC Act 1995 and the EPBC Act 1999 are also provided.

'Habitat Description' – Provides a brief account of the species / community / population and the preferred habitat attributes required for the existence / survival of each species / community.

'Chance of Occurrence on Site' – Assesses the likelihood of each species / community to occur along or within the immediate vicinity of the site in terms of the aforementioned habitat description and taking into account local habitat preferences, results of current field investigations, data gained from various sources (such as DECC Atlas of NSW Wildlife, HBOC records etc) and previously gained knowledge via fieldwork undertaken within other RPS ecological assessments in the locality.

Table 6-1: Assessment of Likelihood of Occurrence of Threatened Species and Communities and Assessment of Potential Impacts

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
PLANTS			
Acacia bynoeana Bynoe's Wattle (E, V*)	Small, prostrate shrub found in low heath and open woodland, generally on loamy clays and sand. Occurs from the Lower Hunter south to Southern Highlands. Has also been recently recorded as isolated populations within Yellow Bloodwood Woodland and Blue-leaved Stringybark Woodland.	This species has been **recorded** on the site within MU31 Coastal Plains Scribbly Gum Woodland and MU30 Coastal Plains Smooth-Barked Apple Woodland.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3, as well an **AoS** (EPBC Act) in Appendix 4.
Angophora inopina Charmhaven Apple (V, V*)	Small to medium tree found in shallow sandy soils in open woodland, swamp woodland and wet heath. The main occurrences of this species are in the Wyong and Lake Macquarie LGA's (from Charmhaven to Wyee and Morisset, and north to near Toronto), with disjunct populations also in Port Stephens LGA (south of Karuah).	This species was **recorded** in the site within the eastern portion of the site in MU31 open forests on dry northern or western aspects dominated by Scribbly Gum (*Eucalyptus haemastoma*) and Red Bloodwood (*Corymbia gummifera*).	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely.** Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3, as well an **AoS** (EPBC Act) in Appendix 4.
Caladenia tessellata Tessellated Spider Orchid (E, V*)	Small terrestrial herb found in grassy sclerophyll woodland on clay loam or sandy soils. Small (6cm x 5mm), single leaf regrows every year. Flowers between Sept-Nov. Species has been found in Spotted Gum (*Corymbia maculata*)-Ironbark (*Eucalyptus fibrosa*) grassy open forests in the Lower Hunter Valley.	Marginal habitat for this species occurs throughout the site within the Spotted Gum-Ironbark-White Mahogany-Grey Gum Forest. This species is known to occur in the region, however, records are sparse. This species is known from sites ~14km south-east (Bongon Head) and 25km south-west (Wyong). However, It is considered **unlikely** to occur on site.	Due to the minimal suitable habitat present in the study area and the low number of records in the area this species is **unlikely** to be affected by the proposed activities; therefore AoS for this species is not required.
Callistemon linearifolius Netted Bottle Brush (V)	Shrub that grows in dry sclerophyll forest on the coast and adjacent ranges. Re-sprouting / juvenile specimens difficult to distinguish from other *Callistemon* species such as *C. rigidus* (Stiff Bottlebrush) or *C. linearis* (Narrow-leaved Bottlebrush) without the aid of flowering parts.	This species was recorded within the larger study area by Umwelt (2004) within an unspecified habitat in the Longwall 22 & 23 area. The Exact location of this record is not known as it was included as part of the general flora list by Umwelt. It has **potential** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Corybas dowlingii Red Helmet Orchid (E)	Small terrestrial herb found in sheltered areas such as gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200m. The orchid has a solitary heart-shaped to circular, dark green leaf 15-35mmx15-35mm ending in a point. Flowers from June-August. Has been recorded in Sydney Peppermint (*Eucalyptus piperita*)-Smooth-barked Apple (*Angophora costata*) and Blackbutt (*Eucalyptus pilularis*) dominated open forests.	The site contains suitable habitat for the species and one of the species 4 known localities is Freemans Waterhole which is less than 5km from the site. This species was not recorded during previous or recent RPS surveys, however, due to its cryptic nature it cannot be discounted from occurring within the site. There is **potential** for this species to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Cryptostylis hunteriana Leafless-tongue Orchid (V, V*)	A very rare leafless, saprophytic orchid, which has a symbiotic relationship with a mycorrhizal fungi which provides the plant with all its nutrient requirements. This orchid remains underground for the majority of its lifecycle, flowering periodically, when conditions are optimal to reproduce. This species is extremely cryptic as it does not flower every year. This species is known to occur within a range of habitats including woodlands to swamp heaths. Within the Hunter region larger populations have been typically found in woodland dominated by *Eucalyptus racemosa* (Scribbly Gum) and prefer areas with an open grassy understorey. The species typically prefers moist sandy soils in sparse to dense heath and sedgeland, or moist to dry clay loams in coastal forests.	The site contains vegetation that is suitable habitat for the species. Preferred habitat within the Hunter tends to be Scribbly Gum Woodland which occurs extensively within the SMP Study Area. This species was not recorded by RPS or previous surveys. However, due to the cryptic nature of the species, the wide range of habitats where it has been recorded and the presence of *Cryptostylis subdulata* (Cumberland Ecology 2007), which it is often found in association with, it cannot be entirely discounted from occurring within the site. Therefore it is considered this species has **potential** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **possible**. The proposed activities may impact on this species habitat. A 7-part test of significance (TSC Act) has been applied to this species in **Appendix 3**, as well an AoS (EPBC Act) in **Appendix 4**.
Cynanchum elegans White-flowered Wax Plant (E, E*)	Occurs scattered along the NSW Northern Coast to Wollongong usually in dry, littoral or subtropical rainforest. A climbing or twining plant species that flowers from August to May with peak flowering in November. One record within the Atlas of NSW Wildlife data occurs within the Lower Hunter Region and Central Coast at Green Point to the north of Belmont.	Suitable habitats for this species (dry, littoral or subtropical rainforest) are not present within the site. Furthermore, no individuals were recorded during RPS or previous surveys. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Diuris praecox Rough Doubletail (V, V*)	A small, terrestrial herb which grows on hills and slopes of near-coastal districts in open forests which have a grassy to fairly dense understorey. Exists as subterranean tubers most of the year and produces leaves and flowers in winter. In the Hunter Valley, this species has been recorded in Spotted Gum (*Corymbia maculata*)-Ironbark (*Eucalyptus fibrosa*) open forest, Blackbutt (*Eucalyptus pilularis*) open forest, Scribbly Gum (*Eucalyptus haemastoma*) woodland, Sydney Peppermint (*Eucalyptus piperita*)-Smooth-barked Apple (*Angophora costata*) forest as well as Forest Red Gum (*Eucalyptus tereticornis*), Melaleuca and *Casuarina glauca* dominated riparian or swamp areas.	The site contains several vegetation communities that are suitable habitat for this species. These preferred habitat vegetation communities occur extensively within the site. This species was not recorded by RPS or previous surveys. However, due to the cryptic nature of the species and the wide range of habitats that it has been recorded in it cannot be entirely discounted from occurring within the site. Therefore there is **potential** for this species to occur on site.	This species is fairly tolerant of disturbance and due to its cryptic nature is unlikely to be affected by the proposed activities. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3, as well an **AoS** (EPBC Act) in Appendix 4.
Eucalyptus camfieldii Camfield's Stringybark (V, V*)	A small/ medium sized tree with a scattered distribution from Waterfall in the south to Raymond Terrace in the north. Occurs in coastal environments on shallow sandy soils derived from Hawkesbury Sandstone. Often found growing with Scribbly Gum, Brown Stringybark and Narrow Leaf Stringybark	Some suitable habitat occurs on the site and Gunninah (1998) recorded a single individual to the northwest of the site near the Newstan Colliery surface operations. However habitat is not well known for this species and occurrences are low. As this conspicuous species was not recorded, it is considered **unlikely** to occur on site.	The site is out of the main range for this species and based on low occurrences it is considered **unlikely** to be affected by the proposed activities on site; therefore AoS is not required for this species.
Grevillea parviflora subsp. *parviflora* Small-flower Grevillea (V, V*)	Occurs in light, clayey soils in woodlands. Most plants appear capable of suckering from a rootstock. Relatively widespread within the Cessnock LGA. Occurs within Werakata National Park. Much confusion surrounds the taxonomy of this species and other similar *Grevillea* taxa and a NPWS-funded study of the species is currently in progress.	This species was **recorded** by RPS and previous surveys throughout the site within the Coastal Plains Smooth-barked Apple Woodland, Scribbly Gum Woodland and Riparian communities.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3, as well an **AoS** (EPBC Act) in Appendix 4.
Maundia triglochinoides (V)	Perennial plant to 80cm high. Grows in swamps, creeks or shallow freshwater 30-60cm deep on heavy clay, low nutrients. Associated with wetland species *Triglochin procera.* Spreads vegetatively with tufts of leaves arising along rhizome. Flowers Nov-Jan. Prefers Swamp Mahogany (*Eucalyptus robusta*), *Melaleuca sieberi* and/or *Melaleuca nodosa* dominated habitats.	The site contains no areas of suitable habitat for the species as it largely requires semi-inundated habitat in the form of creeks and streams. Gunninah 1998 has recorded *Triglochin procera,* which occurs with *M. Triglochinoides,* previously in the study area. *M. triglochinoides* was not recorded by RPS or most other previous surveys. Therefore it is considered **unlikely** to occur on site.	Due to unsuitable habitat on site it is considered **unlikely** to be affected by the proposed activities, therefore AoS is not required for this species.
Melaleuca biconvexa Biconvex Paperbark (V, V*)	A shrub to small tree, which grows in poorly drained areas on the Central Coast with outlying populations at Jervis Bay and Port Macquarie. Records in the Hunter Region are confined to western Lake Macquarie (Atlas of NSW Wildlife data). It may occur in dense stands adjacent to watercourses, in association with other *Melaleuca* species or as an understorey species in wet forest.	Suitable habitat for this species exists along the creeklines within the site. However, this species was not recorded within the site or larger study area during extensive flora surveys by RPS or previous field surveys. Therefore it is considered **unlikely** to occur on site.	Due to unsuitable habitat on site it is considered **unlikely** to be affected by the proposed activities, therefore AoS is not required for this species.
Pelargonium sp. Striatellum (G.W.Carr 10345) (V*)	It is known to occur in habitat usually located just above the high water level of irregularly inundated or ephemeral lakes. During dry periods, the species is known to colonise exposed lake beds.	This species has not been recorded within 10km of the site. This species was not recorded by RPS or previous surveys and the associated habitats were not recorded. Therefore it is considered **unlikely** to occur on site.	Due to the lack of recordings within the area it is unlikely to occur and therefore **unlikely** to be affected by proposed activities on site. Therefore AoS is not required for this species.
Pterostylis gibbosa Illawarra Greenhood (E, E*)	Ground-dwelling orchid which grows in open forest or woodland on flat or gently sloping land with poor drainage. It is a deciduous orchid that is only visible above the ground between late summer and spring, only when soil moisture levels can sustain its growth. In the Hunter region, the species grows in open woodland dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*), Forest Red Gum (*Eucalyptus tereticornis*) and Black Cypress Pine (*Callitris endlicheri*).	This species has not been recorded within 10km of the site. This species was not recorded by RPS or previous surveys and the associated habitats were not recorded. Therefore it is considered **unlikely** to occur on site.	Due to the lack of recordings within the area it is unlikely to occur and therefore **unlikely** to be affected by proposed activities on site. Therefore AoS is not required for this species.
Pultenaea maritima Coast Headland Pea (V, V*)	A prostrate mat-forming shrub with hairy stems which grows in grassland, shrublands and heath on exposed coastal headlands. It is restricted to within 1km of the coast.	Suitable habitats for this species (coastal headlands) are not present within the site. Furthermore, no individuals were recorded during RPS or previous surveys. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Prasophyllum sp. Wybong (C.Phelps ORG 5269) (CE*)	Leek orchids are generally found in shrubby and grassy habitats in dry to wet soil. *Prasophyllum* sp. Wybong is known to occur in open eucalypt woodland and grassland.	This species has not been recorded within 10km of the site. This species was not recorded by RPS or previous surveys and the associated habitats were not recorded. Therefore it is considered **unlikely** to occur on site.	Due to the lack of recordings within the area it is unlikely to occur and therefore **unlikely** to be affected by proposed activities on site. Therefore AoS is not required for this species.
Rhizanthella slateri Eastern Underground Orchid (V, E)	*Rhizanthella slateri* (Eastern Australian Underground Orchid) is an underground orchid with a whitish, fleshy underground stem to 15 cm long and 15 mm diameter. In NSW, it is currently only known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. At each location, only a few individuals are known. However, *R. slateri* is difficult to detect, it is usually located when the soil is disturbed, and there may well be more locations of the species within its known range. The species grows in eucalypt forest but no informative assessment of the likely preferred habitat for the species is available.	Due to the cryptic nature of this species and the broad habitats in which it has been found, it cannot be entirely discounted from occurring within the site. Very little is known about this species. No individuals of this species have been recorded on the site by RPS or previous surveys. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site or within 10km of the site, thus is considered **unlikely** to be affected by the proposed activities; therefore AoS is not required for this species.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Syzygium paniculatum Magenta Lilly Pilly (V, V*)	A shrub to small tree, found in sub-tropical and littoral rainforest on sandy soils or sheltered gullies mostly near water courses. Distributed between Bulahdelah and Jervis Bay. Hunter Region records are confined to the Lake Macquarie hinterland (Atlas of NSW Wildlife data).	Suitable habitat for this species occurs along the creek lines within the site. However, no individuals were recorded within the site or greater study area by RPS or previous surveys. It is considered **unlikely** to occur on site.	This species was not recorded within the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Tetratheca juncea Black-eyed Susan (V, V*)	Occurs in a variety of forested and heathy habitats. Locally found in Open Forests and Woodlands with dense, undisturbed understorey, often in association with *Angophora costata / Corymbia gummifera* on slopes with south-easterly aspects.	This species was **recorded** by RPS and previous surveys throughout the site and greater study area within several vegetation communities.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3, as well an **AoS** (EPBC Act) in Appendix 4.
HERPETOFAUNA			
Hoplocephalus bungaroides Broad-headed Snake (E, V*)	Largely confined to Triassic sandstones, including the Hawkesbury, Narellan and Shoalhaven formations, within the coast and ranges. Nocturnal, sheltering in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.	Suitable habitats for this species (sandstone escarpments with rock shelters etc) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Hoplocephalus stephensii Stephens' Banded Snake (V)	A nocturnal, partly arboreal snake. It inhabits eucalypt forest and rainforest from Gosford NSW north to southern Queensland. This snake is usually found under loose bark on trees or in hollow limbs. The diet consists of lizards, frogs, birds and small mammals.	This species was recorded within the greater study area approximately 1.5km South-west of the site during recent RPS surveys. The site contains a broad area of suitable habitat and is likely to contain a local population of this species. It is considered therefore **likely** that this species will occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Crinia tinnula Wallum Froglet (V)	Occurs in coastal, low-lying acid Paperbark forest, within the 'wallum country' (often on sandy soils). Although some marginal potential habitat could exist within the Paperbark Scrub, it is generally not typical of the wallum habitats preferred by this species. Regional records for this species are confined to three main areas; Lake Macquarie, Central Coast and Medowie and Port Stephens (Atlas of NSW Wildlife data).	Suitable habitats for this species (low-lying acid Paperbark forests/Paperbark Swamp Forest) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Litoria littlejohni Little John's Tree Frog (V, V*)	A pale brown frog with dark speckles which occurs along permanent rocky creeks with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops. Occurs on the plateaus and eastern plains of the Great Dividing Range. Records within the Hunter Region occur from within the Watagan State Forest.	Suitable habitats for this species (permanent rocky creeks) are not present within the site. Furthermore, this species typically prefers habitats within sandstone escarpments such as the Watagan Mountains to the west of the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Litoria aurea Green and Golden Bell Frog (E, V*)	Inhabits swamps, lagoons, streams and ponds as well as dams, drains and storm water basins. Thought to be displaced from more established sites by other frog species, thus explaining its existence on disturbed sites. Previously widespread within the region, but now sparsely distributed within the Lower Hunter and Central Coast areas. A relatively stable population occurs on Kooragang Island.	The field survey did not record this species within the site. Although there is marginal habitat occurring along the drainage lines and artificial dams, this species only persists in the region within sites which exhibit a saline influence and records from Western Lake Macquarie are historical only. Therefore it is considered **unlikely** to occur on site.	Due to the current isolated populations of this species and lack of suitable habitat on site it is unlikely to occur and thus **unlikely** to be affected by the proposed activities on site. Therefore AoS for this species is not required.
Mixophyes balbus Southern Barred Frog (E, V*)	Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. Breed in streams during summer after heavy rain, outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor. Eggs are laid on rock shelves or shallow riffles in small, flowing streams.	Suitable habitats for this species (rainforest and wet, tall open forests in the foothills and escarpment and undisturbed rocky streams) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Mixophyes iteratus Giant Barred Frog (V, E*)	Mostly restricted to wet sclerophyll forest and rainforest, including Antarctic Beech forest. Usually found within close proximity to permanent running water (Robinson, M, 1998). Hunter Region records are largely confined to the Watagan National Park and to the north of Heaton State Forest (Atlas of NSW Wildlife data).	Suitable habitats for this species (rainforest and wet, tall open forests in the foothills and escarpment and undisturbed rocky streams) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Pseudophryne australis Red-crowned Toadlet (V)	Generally restricted to Hawkesbury Sandstone where it may be found beside temporary creeks, gutters and soaks and under rocks and logs. Breeds in deep leaf litter inundated with heavy rain (Robinson, M, 1998). Records from the Hunter Region exist in Olney State Forest.	This species is generally restricted to Hawkesbury Sandstone which is not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Heleioporus australiacus Giant Burrowing Frog (V, V*)	Generally restricted to sandstone areas of the Sydney Basin. Southern population on the south coast of NSW. Occurs in a range of habitats including heathland, open forest and woodland.	This species is generally restricted to Hawkesbury Sandstone which is not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
AVIFAUNA			
Sternula nereis nereis Australian Fairy Tern (V*)	Fairy Terns utilise a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands, beaches and spits. Fairy Terns nest in small colonies on coral shingle on continental islands or coral cays, on sandy islands and beaches inside estuaries, and on open sandy beaches.	This species is restricted to coastal environments which are not present within the site Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Rostratula australis Australian Painted Snipe (E, V*)	A small freshwater and estuarine wader, which prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. This species has been recorded in Pambalong N.R., Ash Island and Lenaghan's Flat (HBOC, 2011).	Suitable habitats for this species (water bodies with dense fringing cover) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Botaurus poiciloptilus Australasian Bittern (E, E*)	A secretive species inhabiting permanent freshwater swamps possessing stands of tall rush species such as *Typha* sp. (Bull Rushes) and *Eleoacharis* sp. (Spike Rushes) (DEC 2005). Feeds mainly at night on aquatic fauna, insects and snails. Hides during the day amongst dense reeds and rushes. Does feed during the day when overcast or low light levels. Nests are usually a dense platform of reeds in a secluded area of dense vegetation	Suitable habitats for this species (water bodies with dense reeds) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Ixobrychus flavicollis Black Bittern (V)	Solitary species, living near water (estuarine to brackish) in mangroves and other trees which need to form only a narrow fringe of cover. A riparian species that occasionally ventures into the open within estuarine habitats. Sedentary resident along Dora and Stockton Creeks in western Lake Macquarie has also been recorded semi-regularly in the Paterson River but is likely to occur in any brackish to estuarine forested coastal creeks in the lower NSW coast.	The survey did not record this species within the site. The site lacks potential habitat suitable for this species, having no estuarine or brackish wetland habitat. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Dasyornis brachypterus Eastern Bristlebird (E, E*)	Found in dense, low vegetation including heath and open woodland with a heathy understorey; in northern NSW occurs in open forest with tussocky grass understorey.	Suitable habitats for this species (dense, low vegetation including heath and open woodland) are not present within the site. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Daphoenositta chrysoptera Varied Sittella (V)	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	This species was observed within the greater study area adjacent to riparian vegetation approximately 1.5km to the north-west of the site. Therefore it is considered **highly likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Irediparra gallinacea Comb-crested Jacana (V)	This species inhabits mostly deep permanent freshwater wetlands that are abundant with floating aquatic vegetation that forms dense mats or rafts on the surface of the water. Known to breed within the Hunter as far south as Mandalong. Has been known to arrive at suitable temporary vegetation eg. Rathluba Lagoon at East Maitland. Hunter records have regularly come from Colliery Dam in the Mulbring area, which contains floating aquatic vegetation. Breeding records have also been recorded from Colliery Dam.	The survey did not record this species within the site. The site lacks permanent freshwater wetlands with floating aquatic vegetation. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Pandion cristatus Osprey (V)	Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern NSW coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south eastern Australia. There are a handful of records from inland areas.	The survey did not record this species within the site. The site lacks potential habitat (large wetlands and ocean with mod-large fish species) suitable for this species. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Charadrius mongolus Lesser Sand Plover (V, M*)	When in Australia, this migratory species inhabits sheltered bays, harbours and estuaries with large intertidal sand flats or mudflats. Prey includes molluscs, worms, crustaceans and insects. Low numbers of this species visit the Hunter estuary during the austral summer.	The survey did not record this species within the site. The site lacks potential habitat suitable as this species primarily inhabits coastal areas. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Ephippiorhynchus asiaticus Black-necked Stork (E)	Inhabits swamps associated with river systems and large permanent pools but sometimes appears on the coast or in estuaries. It has also been recorded on farm dams and sewage treatment ponds. Within the Hunter Region it occurs spasmodically on freshwater or estuarine wetlands, along coastal and near coastal environments such as Gloucester.	The site lacks potential habitat suitable for this species having no swamps, permanent pools or estuarine habitats. However, there are a number of dams within the site which provide sub-optimal habitat. This species was not observed within the site by RPS or any previous survey. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Haematopus longirostris Pied Oystercatcher (V)	This species prefers undisturbed sandy shell-grit or pebble beaches, sandspits and sandbars, tidal mudflats and estuaries, coastal islands. Occasionally rocky reefs, shores rock-stacks, brackish or saline wetlands. Also grassy paddocks, golf-courses or parks near coast. Forages for molluscs, crustaceans, polychaetes, ascidians, echinoderms and small fish, probes for worms in short wet grass. In the Hunter this species is relatively common in the Hunter Estuary in small numbers and more common on the open beaches and river mouths around sandspits.	No potential habitat exists on site with this species inhabiting primarily coastal estuarine areas. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Ptilinopus regina Rose-crowned Fruit-Dove (V)	Generally lives in rainforest of many variations, though it also frequents brushes of coastal districts as well as Eucalypt forests and mangroves. Favoured rainforest habitat consists of sub-tropical to dry rainforest and quite commonly littoral rainforest. They feed entirely on fruit from vines, trees and shrubs and mostly feed in the tops of trees or just under the foliage, where the fruit grows. *Ptilinopus regina* can be locally nomadic according to fruiting or part migratory according to fruit ripening. In the Hunter most records have come from Littoral rainforest around Harrington and at Mungo Brush, also records in rainforest at Seal Rocks.	This species was not recorded within the site during field surveys. No suitable habitat (rainforest) is present within the site for this species. Therefore it is considered **unlikely** to occur on site.	No potential habitat is present in the study area, and thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Calyptorhynchus lathami Glossy Black-cockatoo (V)	Occurs in forests and woodlands where it forages predominantly on *Allocasuarina* cones. Requires large Eucalypt tree hollows for nesting. Sparse occurrences on the valley floor, but resident in ranges and adjacent areas surrounding the Hunter Valley. Most commonly encountered around the south and south western areas of the lake and in the Watagan Mountains N.P. These locations have good stands of *Allocasuarina* sp., especially *Allocasuarina littoralis* (Black She-oak)	It is considered that the site provides potential foraging habitat for this species within the scattered occurrence of *Allocasuarina littoralis* and *A. torulosa*. However, this species or evidence of it (chewed *Allocasuarina* sp. cones) was not observed within the study area or the site during field surveys. Some tree hollows located on site may also provide nesting habitat for this species; however, preferred nesting sites are typically located within high densities of *Allocasuarina* sp. which were not observed within the site. Therefore it is considered **likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Callocephalon fimbriatum Gang-gang Cockatoo (V)	Found in the summer months in tall mountain forests and woodlands, and mature wet sclerophyll forests. In winter, may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. Within the Hunter Region this species has been found in the Kurri Kurri/Cessnock area during winter and in the Watagan Mountains areas during the summer.	The survey did not record this species within the site. However, due to seasonal movements of this species and the occurrence of potential Eucalyptus feed trees within the site and adjacent areas, there is the chance that this species may use habitat within the site on an intermittent basis. Therefore it is considered as having **potential** to occur on site.	This species was not recorded on site and is highly mobile, thus this species is **unlikely** to be affected by the proposed activities. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Lathamus discolor Swift Parrot (E, E*)	On the mainland this species frequents Eucalypt forests and woodlands with large trees having high nectar production during winter. Mainland winter foraging sites often vary from year to year. Nests only in Tasmania, but regularly visits the Hunter Region in winter. Visits the Hunter Region when food sources are abundant or food sources are lacking in other areas. Food sources used in the Hunter include *Eucalyptus robusta* (Swamp Mahogany) on the coast, and near coastal to inland *Lathamus discolour* uses *Corymbia maculata* (Spotted Gum), *E. fibrosa* (Broad-leaved Ironbark) and *E. crebra* (Narrow-leaved Ironbark). Occasional records have come from *E. alba* (White Box) and *E. sideroxylon* (Mugga Ironbark). These food source trees have been recorded as roosting sites for *L. discolor*.	This species was not recorded within the site during field surveys. Preferred winter-flowering feed tree species (*Eucalyptus robusta* and *Corymbia maculata*) known from the Hunter region are present on the site and the NSW Atlas shows several records from the Awaba district. This species is therefore considered **highly likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3 as well an **AoS** (EPBC Act) in Appendix 4.
Glossopsitta pusilla Little Lorikeet (V)	*Glossopsitta pusilla* extends from Cairns to Adelaide coastally and to inland locations. Commonly found in dry, open eucalypt forests and woodlands. Can be found in roadside vegetation to woodland remnants. *G. pusilla* feeds on abundant flowering Eucalypts, but will also take nectar from *Melaleuca* sp and *Mistletoe* sp. *Eucalyptus albens* (White Box) and *E. melliodora* (Yellow Box) are favoured food sources on the western slopes in NSW. On the eastern slopes and coastal areas favoured food sources are *Corymbia maculata* (Spotted Gum), *E. fibrosa* (Broad-leaved Ironbark), *E. robusta* (Swamp Mahogany) and *E. pilularis* (Blackbutt). Nesting takes place in hollow bearing trees.	This species was recorded during diurnal surveys flying over the centre of the greater study area. Suitable habitat for this highly mobile species exists within flowering canopy species within the site and potential nesting sites exist in hollow-bearing trees. This species is therefore considered **highly likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Neophema pulchella Turquoise Parrot (V)	Inhabits forests and woodlands with suitable nest hollows and grassy foraging areas. Needs a sparse understorey as it prefers to feed in the shade of trees and spend most of its time on the ground searching for seeds of grasses and herbaceous plants. Generally found in more western locations within the Hunter Region (found coastally north of Port Stephens), although some isolated records from the forested areas within the Cessnock LGA do exist.	This species was not observed within the site during field surveys. Potential foraging habitat exists on site with potential nesting and roosting habitat, however chance of occurrence is considered low as no records exist within the region. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and is highly mobile, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Ninox connivens Barking Owl (V)	Occurs mainly in dry sclerophyll woodland. Nests in large Eucalypt hollows, and roosts in hollows or thick vegetation. . Can be found roosting in dense *Acacia* sp. and *Casuarina* sp. or the dense clumps of Eucalypt trees. Hunts a range of prey species including birds and both terrestrial and arboreal mammals. Spasmodic Hunter Region records are largely limited to the south-western ranges and adjacent forests on the valley floor. Records from Ellalong, Yengo N.P. and Wybong area (HBOC records).	This species was not recorded during owl call back and nocturnal spotlighting surveys. This species is rarely recorded in coastal regions; however, a number of widely scattered records for this species occur within the Lower Hunter. However, the possibility that the site is part of the home range of individuals or pairs is considered unlikely. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and is highly mobile, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Ninox strenua Powerful Owl (V)	Occurs in wet or dry sclerophyll forests and woodlands where suitable prey species occur (being predominantly arboreal mammals). Requires large hollows, usually in Eucalypt trees, for nesting. Roosts in dense vegetation within such areas. Roosts in dense vegetation within such species as *Syncarpia glomulifera* (Turpetine), *Allocasuarina littoralis* (Black She-Oak), *Acacia melanoxylon* (Blackwood), *Angophora floribunda* (Rough-barked Apple), *Exocarpus cupressiformis* (Cherry Ballart) and *Melaleuca nodosa* (Ball Honeymyrtle). Many records across the Hunter region, a lot coastal.	This species was recorded during owl call back at two playback sites within the Larger Study Area to the south-west of the site. Arboreal prey species (eg. Common Ringtail Possum) are likely to be present within the site and potential hunting habitat does occur. Potential roosting habitat exists within some denser riparian vegetation. This species responded quickly to call playback at dusk and therefore, it is likely that the site provides roosting habitat for the Powerful Owl. This species is therefore considered **highly likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Tyto novaehollandiae Masked Owl (V)	Found in a range of habitats, locally within sclerophyll forests and woodlands where appropriate / preferred prey species occur (being predominantly terrestrial mammals). Requires large Eucalypt hollows for nesting and prefers to roost in these hollows as well. Recorded at Medowie, Heddon Greta and the Dungog area (HBOC).	This species was **recorded** at one call playback location within the site and another in the western portion of the Larger Study Area. Terrestrial prey items (Bush Rats, Antechinus) were also captured throughout the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Tyto tenebricosa Sooty Owl (V)	Occurs in wet Eucalypt forest and rainforest with tall emergent trees, often in easterly facing gullies. Within these areas this species hunts for a range of mainly mammalian prey at all levels of the forest strata, even recorded feeding on ground (RPS ecologist pers. obs.). Roosts in tree hollow or dense canopy vegetation. Also nests in large Eucalypt tree hollows. Most Hunter records exist from the Watagan mountains (Atlas of NSW Wildlife data), but this species has also been observed to the southwest of Awaba (HBOC).	This species was not recorded by RPS during targeted owl call back and nocturnal spotlighting surveys, although has been previously recorded by Cumberland Ecology within the study area approximately 3km west of the site. Dense wet creekline vegetation present is considered to provide suitable habitat for this species. This species is therefore considered **highly likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Chthonicola sagittata Speckled Warbler (V)	Occupies Eucalypt and Cypress woodlands in drier coastal areas and on the western slopes of the Great Dividing Range. Appears unable to persist in districts where no forested fragments larger than 100ha remain. Occurs in the central and southern Hunter Region where suitable habitat exists. Associated with extensive stands of *Bursaria spinosa* (Blackthorn) in some areas (HBOC).	This species was not recorded within the site during field surveys. Habitat within the site is considered sub-optimal for this species which is typically found in more western habitats. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and is highly mobile, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Climacteris picumnus victoriae Brown Treecreeper (V)	Frequents drier forests and woodlands, particularly open woodland lacking a dense understorey. Also found in grasslands in proximity to wooded areas where there are sufficient logs, stumps and dead trees nearby. Occasionally found in mallee and *Eucalyptus camaldulensis* (River Red Gum) forest bordering wetlands with an open understorey of *Acacia* sp., *Muehlenbeckia* sp. (Lignum), *Typha sp*. (Cumbungi) and *Poa* sp. (grasses). Feeds on invertebrate larvae and small insects, particularly ants. Utilises hollows for roosting/nesting.	Marginal habitat exists for this species within the site; however, it was not recorded during surveys. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and is highly mobile, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Anthochaera phrygia Regent Honeyeater (CE, E*)	Nomadic Honeyeater that disperses to non-breeding areas, including the coast, in winter, where flowering trees are sought. Within the region, mostly recorded in Box-Ironbark Eucalypt associations along creek flats, river valleys and foothills. Coastal swamp forests in Lower Hunter are used when more western resources fail. The main feed tree for coastal areas is *Eucalyptus robusta* (Swamp Mahogany). Hunter records are more common in near coastal areas such as Cessnock LGA. Feed trees in this region are *Corymbia maculata* (Spotted Gum), *E. fibrosa* (Broad-leaved Ironbark), *E. crebra* (Narrow-leaved Ironbark) and various stringybark sp.. Nests mainly west of the divide, although local breeding attempts have occurred at Quorrobolong.	This species was not recorded within the site during field surveys. Preferred winter-flowering tree species (*Eucalyptus robusta* and *Corymbia maculata*) are known from the site. This species is therefore considered **likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3 as well an **AoS** (EPBC Act) in Appendix 4.
MAMMALS			
Dasyurus maculatus maculatus Spotted-tailed Quoll (V, E*)	Found in a variety of forested habitats. This species creates a den in fallen hollow logs or among rocky outcrops. Generally does not occur in otherwise suitable habitats that are in close proximity to urban development. Hunter Region records are largely confined to the surrounding ranges (Atlas of NSW Wildlife data).	This species was not recorded within the site during field surveys. Road kill animals have been recorded in the past 10 years in Western Lake Macquarie, suggesting that at least a transient population does occur. Suitable foraging and den habitat exists within all vegetation communities on the site, in particular in areas with large fallen logs and hollow bearing trees. Therefore it is considered as having **potential** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3 as well an **AoS** (EPBC Act) in Appendix 4.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Petaurus australis Yellow-bellied Glider (V)	Usually associated with tall, mature wet Eucalypt forest. Also known from tall dry open forest and mature woodland. The diverse diet of this species is primarily made up of Eucalypt nectar, sap, honey dew, manna and invertebrates found under decorticating bark and pollen. Tree hollows for nest sites are essential, as are suitable food trees in close proximity. Most records in the Lower Hunter Region occur in the Watagan Mountains and other areas exhibiting significant stands of forest (Atlas of NSW Wildlife data).	This species or feeding incisions on tree trunks were not recorded within the site during field surveys. Habitat within the site is considered sub-optimal for this species with no tall, mature and wet Eucalypt forests is present within the site. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Petaurus norfolcensis Squirrel Glider (V)	Occurs in eucalypt forests and woodlands where it feeds on sap exudates and blossoms. In these areas tree hollows are utilised for nesting sites. This species also requires winter foraging resources when the availability of normal food resources may be limited, such as winter-flowering shrub and small tree species. Widely distributed across the lower hunter region (Atlas of NSW Wildlife data).	This species was recorded by RPS within the Larger Study Area approximately 750 metres to the west of the site during field surveys within the Scribbly Gum Coastal Plains Woodland community. The site provides suitable resources for this species. This species is therefore considered **highly likely** to occur on the site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Petrogale penicillata Brush-tailed Rock Wallaby (E, V*)	Occurs in forests and woodlands along the Great Divide and on the western slopes in escarpment country with rocky outcrops, steep rocky slopes, gorges, boulders and isolated rocky areas. The majority of populations favour north-facing aspects, but some southern aspects have been recorded. Apart from the critical rock structure *Petrogale penicillata* also requires adjacent vegetation types, associated types include, dense rainforest, wet sclerophyll, vine thicket, dry sclerophyll forest and open forest. They also require suitable caves and rocky overhangs for shelter and also for 'lookout' posts. Records exist from the Watagan Mountains where it is associated with the above habitats (Atlas of NSW Wildlife 2011; HBOC).	This species was not recorded within the site during field surveys. Habitat within the site is considered sub-optimal for this species with no critical rock structures present within the site. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Phascolarctos cinereus Koala (V)	Occurs in forests and woodlands where it requires suitable feed trees (particularly *Eucalyptus* spp.) and habitat linkages. Will occasionally cross open areas, although it becomes more vulnerable to predator attack and road mortality during these excursions. Records from the Lower Hunter Region are largely confined to the greater Port Stephens area, the Lake Macquarie hinterland and the Watagan Mountains, with a small number of records from Cessnock LGA (Atlas of NSW Wildlife data).	This species was not recorded within the site during field surveys. Potential habitat occurs in the communities containing Forest Red Gum, Grey Gum, Scribbly Gum and Swamp Mahogany vegetation communities. Local records exist; however a local population, should it exist is likely to occur at low density. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Potorous tridactylus Long-nosed Potoroo (V, V*)	Prefers cool rainforest, wet sclerophyll forest and heathland. Sleeps by day in a nest on the ground, and digs for succulent roots, tubers, fungi and subterranean insects. Some diggings seemingly attributable to this species may belong to *Isoodon macrourus* (Northern Brown Bandicoot). Records exist from the Karuah vicinity (Gunninah 1999) and the Gosford LGA (Atlas of NSW Wildlife data).	This species or diggings were not recorded within the site during field surveys and suitable habitat is not present. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Pteropus poliocephalus Grey-headed Flying-fox (V, V*)	This species forages over a large area for nectar/fruits. Seasonally roosts in communal base camps situated within wet sclerophyll forests or rainforests. Frequently observed to forage in flowering Eucalypts. May occur anywhere within the Hunter Region where food or roosting resources are available.	This species was **recorded** by RPS immediately adjacent to the SMP area. Roosting habitat is absent from the site with creekline areas unlikely to be of sufficient size to be utilised by a camp, however foraging habitat exists with the occurrence of potential flowering and fruiting feed trees within the site and adjacent areas. Therefore, due to the high mobility of the species and the presence of suitable foraging habitat, the species is considered likely to use the site for foraging when canopy species are flowering.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3 as well an **AoS** (EPBC Act) in Appendix 4.
Pseudomys novaehollandiae New Holland Mouse (V*)	This species has a patchy distribution within open woodlands, heathlands and in hind dune vegetation throughout Eastern Australia. In the Hunter Region the species stronghold is in the Myall Lakes region.	This species is typically found in more sparse, open habitats. Suitable habitat does not occur on site. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
Chalinolobus dwyeri Large-eared Pied Bat (V, V*)	This species forages in tall open forests and the edges of rainforest. It roosts in mine shafts and similar structures. Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of *Hirundo ariel* (Fairy Martin), frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years. Found in well-timbered areas containing gullies. The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy. Hunter Region records for this species are largely confined to the Watagan Mountains, but it has been recorded on the southern side of Port Stephens (Atlas of NSW Wildlife data).	This species was recorded in the Larger Study Area during field surveys by RPS and it has been recorded within the Newstan Lease area previously. Potential roosting habitat occurs within the older mine subsidence areas located in the north west of the site, with possible foraging habitat throughout the woodland areas of the site. This species has been recorded from the vicinity of the site previously. Therefore it is considered **highly likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3 as well an **AoS** (EPBC Act) in Appendix 4.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Falsistrellus tasmaniensis Eastern False Pipistrelle (V)	This species is found in a variety of forest types such as open forests, woodlands and wetter sclerophyll forests (usually with trees >20m). This species roosts in tree hollows. Appears to locally favour upland habitats. A limited number of records occur on the central coast and the Lower Hunter Region (Atlas of NSW Wildlife data).	This species was not recorded within the site during field surveys. However foraging habitat within the site is considered likely to support this species. Possible roosting habitat also exists within the numerous tree hollows of the site. Therefore it is considered **likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Miniopterus australis Little Bentwing-bat (V)	Prefers to forage in well-vegetated areas, such as within wet and dry sclerophyll forests and rainforests. Requires caves or similar structures for roosting habitat. Largely confined to more coastal areas in the Lower Hunter Region (Atlas of NSW Wildlife data).	This species was **recorded** by RPS at two locations within the site during field surveys. Suitable sub-canopy and forest edge foraging and drinking habitats (artificial dams) occur throughout the site with potential roosting habitat possible in the older mine subsidence areas located in the north west of the site. This species has been recorded from the vicinity of the site previously.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Miniopterus schreibersii oceanensis Eastern Bentwing-bat (V)	This species utilises a range of habitats for foraging, including rainforest, wet and dry sclerophyll forests, woodlands and open grasslands. Requires caves or similar structures for roosting habitat. Widely distributed across the Lower Hunter Region (Atlas of NSW Wildlife data).	This species was **recorded** within the study area during field surveys. Suitable sub-canopy and forest edge foraging and drinking habitats (artificial dams) occur throughout the site with potential roosting habitat possible in the older mine subsidence areas located in the north west of the site. This species has been recorded from the vicinity of the site previously.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Mormopterus norfolkensis East-coast Freetail-bat (V)	This species is distributed south of Sydney extending north into south-eastern Queensland. There are no records west of the Great Dividing Range. Most records of this species have been reported from dry Eucalypt forest and woodland. It is expected that open forested areas and the cleared land adjacent to bushland, constitutes important habitat for this species, It is a predominantly tree-dwelling species, roosting in hollows or behind loose bark in mature Eucalypts. Widely distributed across the Lower Hunter Region (Atlas of NSW Wildlife data).	This species was **recorded** by RPS within the site during field surveys. Suitable over-canopy and forest edge foraging and drinking habitats (artificial dams) occur throughout the site with potential roosting habitat within the numerous tree hollows. This species has been recorded from the vicinity of the site previously.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has been recorded within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Saccolaimus flaviventris Yellow-bellied Sheathtail-bat (V)	Range of habitats from rainforest to arid shrubland, roosts in tree-hollows. A limited number of records occur on the central coast and the Lower Hunter Region (Atlas of NSW Wildlife data).	This species has been previously recorded within the Larger Study Area during field surveys. Foraging habitat within the site is considered likely to support this species. Possible roosting habitat also exists within the numerous tree hollows of the site. Therefore it is considered **likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Myotis macropus Southern Myotis (V)	Usually found near bodies of water, including estuaries, lakes, reservoirs, rivers and large streams, often in close proximity to their roost site. Although usually recorded foraging over wet areas, it also utilises a variety of wooded habitats adjacent to such areas including rainforest, wet and dry sclerophyll forest, woodland, and swamp forest. Roosts in small colonies of between 15 and several hundred individuals in caves, mines and disused railway tunnels. A number of records from the Central Coast, with fewer numbers in the Lower Hunter Region (Atlas of NSW Wildlife data) and Central Hunter Region (RPS pers. obs.).	This species was not recorded within the study area or the site during field surveys. However, potential roosting habitat occurs within the older mine subsidence areas located in the north west of the site, with possible foraging habitat within the open water habitats of the artificial dams. This species has been recorded from the vicinity of the site previously. Therefore it is considered **likely** to occur on site.	A maximum subsidence of 1200mm is expected within the SMP Study Area. No vegetation clearing is proposed. Impacts to this species or its habitat are **unlikely**. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
Phoniscus papuensis (syn. *Kerivoula papuensis*) Golden-tipped Bat (V)	Rainforest, rainforest gullies within wet sclerophyll forests. Also records from recently logged dry sclerophyll forests. Hunter records west of Port Stephens and from the Watagan Mountains (Atlas of NSW Wildlife data).	This species was not recorded within the site during field surveys. Habitat within the site is considered sub-optimal for this species with small areas of gully forest present. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and suboptimal habitat exists on site, thus this species is **unlikely** to be affected by the proposed activities. Notwithstanding, as this species has potential to occur within the SMP Study Area, a **7-part test of significance** (TSC Act) has been applied to this species in Appendix 3.
Scoteanax rueppellii Greater Broad-nosed Bat (V)	Forages in moister gullies and wet sclerophyll forests as well as in lightly wooded areas and open spaces/ecotones. This species roosts in tree hollows and is relatively widespread within the Lower Hunter Region (Atlas of NSW Wildlife data).	This species was not recorded within the site during field surveys. However foraging habitat within the site is considered likely to support this species. Possible roosting habitat also exists within the numerous tree hollows of the site. Therefore it is considered **likely** to occur on site.	The proposed activities may impact on this species habitat. A **7-part test of significance** (TSC Act) has been applied to this species in **Appendix 3.**
Vespadelus troughtoni Eastern Cave Bat (V)	A cave dweller, known from wet sclerophyll forest and tropical woodlands from the coast and Dividing Range to the drier forests of the semi-arid zone. It has been found roosting in small groups in sandstone overhangs, in mine tunnels and occasionally in buildings. In all situations, the roost sites are frequently in reasonably well-lit areas. The distribution of this species is largely to the north of the Hunter Region (Strahan 1995).	This species was not recorded within the study area during field surveys. Only scattered records for this species exists within the locality. Habitats within the site are considered to be suitable for the species and potential roosting habitat also exists within older mine subsidence areas located in the north west of the site. Therefore it is considered **unlikely** to occur on site.	This species was not recorded on site and few records exist for this species, thus this species is **unlikely** to be affected by the proposed activities, therefore AoS for this species is not required.
ENDANGERED ECOLOGICAL COMMUNITIES			
Themeda Grassland on sea cliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner bioregions (E)	Community occurring on sandstone, old sand dunes and basalt, which is characterised by *Themeda australis* (Kangaroo Grass). *T. australis* within the community is sometimes limited to only a few metres square, but on some substrates, such as old sand dunes the community can be relatively extensive in size. *T. australis* within the community is often stunted and prostrate as are the shrubs and trees occurring within the community. In the Lower Hunter and Central Coast regions this community occurs on coastal landforms with *Pimelea linifolia* (Slender Rice Flower), *Westringia fruticosa* (Coast Rosemary), and *Banksia integrifolia* (Coastal Banksia) the most commonly associated species.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (E)	Found on gentle slopes arising from depressions and drainage flats on permian sediments of the Hunter Valley floor in the Sydney Basin and NSW North Coast Bioregions. Dominant canopy species include *Eucalyptus tereticornis, E. amplifolia* (Cabbage Gum) and *E. moluccana* (Grey Box) with scattered other Eucalypt species also present. Classified by the Lower Hunter Central Coast Regional Biodiversity Conservation Strategy (LHCCREMS) as Map Unit (MU) 19.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (E, CE*)	Littoral rainforest occurs on both sand dunes and on soils derived from underlying rocks. Littoral Rainforest is a closed forest in structure, and the species composition is strongly influenced by the close proximity to the ocean. The floristic composition consists of predominantly rainforest species with evergreen mesic or coriaceous leaves. Several species have compound leaves, and vines may be a major component of the canopy. Littoral Rainforest comprises the *Cupaniopsis anacardioides – Acmena* spp. alliance of Floyd (1990). This alliance as described by Floyd includes five sub-alliances – *Syzygium leuhmannii – Acmena hemilampra, Cupaniopsis anacardioides, Lophostemon confertus, Drypetes – Sarcomelicope – Cassine – Podocarpus* and *Acmena smithii – Ficus - Livistona – Podocarpus.* While the canopy is dominated by rainforest species, scattered emergent individuals of sclerophyll species, such as *Angophora costata* (Smooth-barked Apple), *Banksia integrifolia* (Coastal Banksia), *Eucalyptus botryoides* (Bangalay) and *E. tereticornis* (Forest Red Gum) occur in many stands.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion (E)	This community is widespread throughout the central to lower Hunter Valley, with forests between Cessnock and Beresfield forming the core of its distribution. This community is dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus fibrosa* (Broad-leaved Ironbark) with occasional occurrences of *E. punctata* (Grey Gum) and *E. crebra* (Grey Ironbark). Classified by the Lower Hunter Central Coast Regional Biodiversity Conservation Strategy (LHCCREMS) as Map Unit (MU) 17.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (E)	Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. Composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus tereticornis* (Forest Red Gum), *E. amplifolia* (Cabbage Gum), *Angophora floribunda* (Rough-barked Apple) and *A. subvelutina* (Broad-leaved Apple). Correlates with LHCCREMS communities - 'Central Hunter Riparian Forest' Map Unit (MU) 13, 'Wollombi Redgum-River Oak Woodland' MU14 and 'Redgum Roughbarked Apple Swamp Forest' MU38.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.

Species / Community	Habitat Description	Likelihood of Occurrence	Potential for Impact
White Box Yellow Box Blakely's Red Gum Woodland (E) White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (CE*)	White Box Yellow Box Blakely's Red Gum Woodland (commonly referred to as Box-Gum Woodland) is an open woodland community (sometimes occurring as a forest formation), in which the most obvious species are one or more of the following: *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) and *E. blakelyi* (Blakely's Red Gum). Intact sites contain a high diversity of plant species, including the main tree species, additional tree species, some shrub species, several climbing plant species, many grasses and a very high diversity of herbs. The community also includes a range of mammal, bird, reptile, frog and invertebrate fauna species. Intact stands that contain diverse upper and mid-storeys and groundlayers are rare. Modified sites include the following: 1. areas where the main tree species are present ranging from an open woodland formation to a forest structure, and the groundlayer is predominantly composed of exotic species; and 2. sites where the trees have been removed and only the grassy groundlayer and some herbs remain.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (E)	The most widespread and abundant dominant trees include *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenervia* (Broad-leaved Paperbark) and, south from Sydney, *Eucalyptus botryoides* (Bangalay) and *Eucalyptus longifolia* (Woollybutt). Other trees may be scattered throughout at low abundance or may be locally common at few sites, including *Callistemon salignus* (Sweet Willow Bottlebrush), *Casuarina glauca* (Swamp Oak) and *Eucalyptus resinifera* subsp. *hemilampra* (Red Mahogany), *Livistona australis* (Cabbage Palm) and *Lophostemon suaveolens* (Swamp Turpentine). A layer of small trees may be present, including *Acacia irrorata* (Green Wattle), *Acmena smithii* (Lilly Pilly), *Elaeocarpus reticulatus* (Blueberry Ash), *Glochidion ferdinandi* (Cheese Tree), *Melaleuca linariifolia* and *M. styphelioides* (paperbarks). Shrubs include *Acacia longifolia*, *Dodonaea triquetra*, *Ficus coronata*, *Leptospermum polygalifolium subsp. polygalifolium* and *Melaleuca* spp. Occasional vines include *Parsonsia straminea*, *Morinda jasminoides* and *Stephania japonica var. discolor*. The groundcover is composed of abundant sedges, ferns, forbs, and grasses including *Gahnia clarkei*, *Pteridium esculentum*, *Hypolepis muelleri*, *Calochlaena dubia*, *Dianella caerulea*, *Viola hederacea*, *Lomandra longifolia*, *Entolasia marginata* and *Imperata cylindrica*. On sites downslope of lithic substrates or with soils of clay-loam texture, species such as *Allocasuarina littoralis, Banksia oblongifolia, B. spinulosa, Ptilothrix deusta* and *Themeda australis* may also be present in the understorey.	The Map Unit 37 - Swamp Mahogany / Paperbark Forest vegetation community has been **recorded** within the creeklines of the site, which is considered to be commensurate with this EEC.	The proposed activities may impact on this recorded community. A 7-part test of significance (TSC Act) has been applied to this community in **Appendix 3.**
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (E)	This community is found on the coastal floodplains of NSW. It has a dense to sparse tree layer in which *Casuarina glauca* (Swamp Oak) is the dominant species northwards from Bermagui. Other trees including *Acmena smithii* (Lilly Pilly), *Glochidion* spp. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. Tree diversity decreases with latitude, and *Melaleuca ericifolia* is the only abundant tree in this community south of Bermagui. The understorey is characterised by frequent occurrences of vines, *Parsonsia straminea, Geitonoplesium cymosum* and *Stephania japonica var. discolor*, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter. The composition of the ground stratum varies depending on levels of salinity in the groundwater. Under less saline conditions prominent ground layer plants include forbs such *Centella asiatica, Commelina cyanea, Persicaria decipiens* and *Viola banksii*; graminoids such as *Carex appressa, Gahnia clarkei, Lomandra longifolia, Oplismenus imbecillis*; and the fern *Hypolepis muelleri*. On the fringes of coastal estuaries, where soils are more saline, the ground layer may include the threatened grass species, *Alexfloydia repens*, as well as *Baumea juncea, Juncus kraussii, Phragmites australis, Selliera radicans* and other saltmarsh species.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (E)	Coastal Saltmarsh occurs in the intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. It is frequently found as a zone on the landward side of mangrove stands. Characteristic plants include *Baumea juncea, Juncus krausii, Sarcocornia quinqueflora, Sporobolus virginicus, Triglochin striata, Isolepis nodosa, Samolus repens, Selliera radicans, Suaeda australis* and *Zoysia macrantha*. Occasionally mangroves are scattered through the saltmarsh. Tall reeds may also occur, as well as salt pans.	The vegetation communities mapped within the site are not considered to be commensurate with this EEC. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.
ENDANGERED POPULATIONS			
Eucalyptus parramattensis subsp. *parramattensis* population in the Wyong and Lake Macquarie Local Government Areas.	Small-to-medium sized woodland tree which is associated with low, moist areas alongside drainage lines and adjacent to wetlands often on sandy soils. The population occurs on sandy alluvium within a floodplain community which also supports Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*Eucalyptus tereticornis*), Sydney Bloodwood (*Corymbia gummifera)*, as well as Paperbarks (*Melaleuca* sp.). Endangered population number approximately 1300.	Suitable habitat for this species exists along the creeklines within the site. However, this species was not recorded during RPS or previous field surveys. The known population of this species is located near the south-eastern end of Lake Macquarie a distance of approximately 8km from the subject site. Therefore it is considered **unlikely** to occur on site.	This community was not recorded on site, thus this species is **unlikely** to be affected by the proposed activities, and therefore AoS for this species is not required.

Notes:
(V) = Vulnerable Species listed under the Threatened Species Conservation Act 1995.
(E) = Endangered Species listed under the Threatened Species Conservation Act 1995.
(CE) = Critically Endangered Species listed under the Threatened Species Conservation Act 1995.
(V*) = Vulnerable Species listed under the Commonwealth EPBC Act 1999.
(E*) = Endangered Species listed under the Commonwealth EPBC Act 1999.
(CE*) = Critically Endangered Species listed under the Commonwealth EPBC Act 1999.

7 Assessment of Significant Species/Communities

As per the assessment carried out within Table 6-1, the following species / communities have been applied further detailed assessment via the application of 7-part tests due to potential levels of impacts likely to result from the proposal.

Threatened Flora

- *Acacia bynoeana* (Bynoe's Wattle);
- *Angophora inopina* (Charmhaven Apple);
- *Callistemon linearifolius* (Netted Bottlebrush);
- *Corybas dowlingii* (Red Helmet Orchid);
- *Cryptostylis hunteriana* (Leafless-tongue Orchid);
- *Diuris praecox* (Rough Doubletail)
- *Grevillea parviflora* subsp *parviflora* (Small-flowered Grevillea); and
- *Tetratheca juncea* (Black-eyed Susan).

Endangered Ecological Communities

- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

Threatened Fauna

- Stephen's Banded Snake (*Hoplocephalus stephensii*);
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*);
- Regent Honeyeater (*Anthochaera phrygia*);
- Swift Parrot (*Lathamus discolor*);
- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*);
- Sooty Owl (*Tyto tenebricosa*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- Little Lorikeet (*Glossopsitta pusilla*);
- Spotted Tail Quoll (*Dasyurus maculatus*);
- Squirrel Glider (*Petaurus norfolcensis*);
- Large eared Pied Bat (*Chalinolobus dwyeri*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Eastern Bentwing-bat (*Miniopterus schreibersiioceanensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*);
- Southern Myotis (*Myotis macropus*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

8 Key Threatening Processes

Key Threatening Processes (KTPs) are listed under Schedule 3 of the TSC Act 1995. There are 12 KTPs that have the potential to affect the site as a consequence of the proposal, being:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands;
- Loss of hollow-bearing trees;
- Removal of dead wood and dead trees;
- Clearing of native vegetation;
- Invasion, establishment and spread of *Lantana camara* (Lantana);
- Human-caused climate change;
- Degradation of native riparian vegetation along NSW watercourses;
- Introduction and establishment of Exotic Rust Fungi of the order *Pucciniales* pathogenic on plants of the family Myrtaceae;
- Alteration of habitat following subsidence due to longwall mining;
- Loss and/or degradation of sites used for hill-topping by butterflies;
- Predation by feral cats; and
- Invasion of native plant communities by exotic perennial grasses.

"Alteration of the natural flow regimes of rivers, streams, floodplains and wetlands"
This KTP may be considered relevant to the Swamp Sclerophyll Forest on Coastal Floodplains EEC. The proposal is likely to incrementally contribute to the Key Threatening Process "Alteration of the natural flow regimes of rivers, streams, floodplains & wetlands" due to the expected maximum subsidence of 1200 mm along the streams within the site (MSEC 2012). The hydraulic modelling indicates that the predicted subsidence will only have relatively minor impacts on the 'existing' hydraulic characteristics, which for the most part remain dominated by the steep terrain.

"Loss of hollow-bearing trees"
The proposed development will not require the removal of hollow-bearing trees and as such will not contribute to the Key Threatening Process "Removal of Hollow-bearing Trees".

"Removal of dead wood and dead trees"
The proposed development will not require the removal of dead trees or ground debris and as such will not contribute to the Key Threatening Process "Removal of Dead Wood and Dead Trees".

“Clearing of Native Vegetation”

The proposed development will not require the removal of native vegetation and as such is not likely to incrementally contribute to the Key Threatening Process “Clearing of Native Vegetation”.

“Invasion, establishment and spread of Lantana, (*Lantana camara*)”

The proposal is unlikely to further contribute to the Key Threatening Process “*Lantana camara*” due to some disturbed areas within the site already contain *Lantana camara*.

“Human Caused Climate Change”

The proposal is unlikely to directly contribute to the Key Threatening Process “Human Caused Climate Change.”

“Degradation of native riparian vegetation along NSW watercourses”

The proposal will cause subsidence to a maximum expected 1200mm. This level of subsidence may produce increased ponding along the flatter sections of the Schedule 2 streams, as a result of mining, however, natural ponding was evident along these watercourses due to the relatively flat natural grades. Fracturing of the exposed bedrock along the upper reaches of the watercourses could result in some spalling or dislodgement of loose rocks. Continuous fracturing is not expected between the seam and the surface and, therefore, no loss of water from the catchment is anticipated. The proposal is likely to incrementally contribute to the KTP ‘Degradation of native riparian vegetation along NSW watercourses’ as the proposal involves the possible minor subsidence of vegetation along streams. It is considered that the proposal is unlikely to result in a decline of groundwater dependent species.

“Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae”

The proposal may increase the level of stress and lower resistance of some members of the family Myrtaceae due to slight alteration of their habitat within the site. Exotic Rust Fungi may be introduced into the site by increased movement of plant, vehicles and workers across the site. The proposal is for an underground mine, therefore vehicle movements on the surface will be minimal. It is expected that anti-contamination procedures can be enacted for personnel and equipment to minimise the chance of infection.

“Alteration of habitat following subsidence due to longwall mining”

The proposal is likely to incrementally contribute to the KTP ‘Alteration of habitat following subsidence due to longwall mining.’ This is due to a predicted maximum subsidence level of 1200 mm within the Subsidence extent area.

“Loss and/or degradation of sites used for hill-topping by butterflies”

Part of the SMP site is a high point, containing a trigonometric station. This area may be used by butterflies for breeding. However due to the low amount of disturbance to the habitat within the SMP site, it is considered that the proposed action will not significantly contribute to the KTP.

“Predation by feral cats”

While feral cats occur in the bushland in Western Lake Macquarie, this proposal is unlikely to contribute to an increase in the level of predation by feral cats, thus does not contribute to this KTP.

“Invasion of native plant communities by exotic perennial grasses”

The proposal is unlikely to directly contribute to the Key Threatening Process “Invasion of native plant communities by exotic perennial grasses” However, some disturbed areas within the site already contain exotic perennial grasses.

9 Other Legislative Considerations

9.1 State Environmental Planning Policies (SEPPs)

9.1.1 SEPP 14 - Coastal Wetlands

Two SEPP-14 - Coastal Wetlands are located adjacent to the Newstan – Lochiel study area boundary. These wetlands are:

- SEPP-14 Wetland No. 872 - located at the western end of Kilaben Bay (outside of the study area) and occupies 11.30 hectares.
- SEPP-14 Wetland No. 882a – Also known as Whiteheads Lagoon is located at the western end of Myuna Bay (outside of the study area) and occupies 6.924 hectares.

No areas designated as SEPP-14 Coastal Wetlands occur within or immediately adjacent to the site of the proposal. Therefore the proposal is not expected to impact upon any area of SEPP-14 Wetland.

9.1.2 SEPP 44 – Koala Habitat Protection

SEPP-44 applies to Lake Macquarie Local Government Area. This policy states that there is potential habitat for Koalas (*Phascolarctos cinereus*) if there is 15% density or more of Koala feed trees as listed in Schedule 2 of SEPP-44.

Some feed trees listed within Schedule 2 are present within the subject site. These include:

- *Eucalyptus punctata* (Grey Gum) (in Coastal Foothills Spotted Gum - Ironbark Forest);
- *Eucalyptus haemastoma* (Scribbly Gum) (in Coastal Plains Scribbly Gum Woodland); and
- *Eucalyptus robusta* (Swamp Mahogany) (in Swamp Mahogany - Paperbark Forest).

These vegetation communities provide various levels of Potential Koala Habitat as defined in SEPP-44. However, these areas were not observed to contain Koalas and therefore they do not provide “Core Koala Habitat” as defined in SEPP-44.

However, the possibility of a low density or ‘transient’ koala population occurring along the western side of Lake Macquarie (including the site) cannot be entirely discounted.

9.2 Considerations under the Environment Protection and Biodiversity Conservation Act 1999

Considerations have been made under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999). An EPBC Act 1999 Protected Matters Search was undertaken within the SEWPaC on-line database (accessed May 2012) to generate a list of those matters of National Environmental Significance (NES) from within 10km of the site, which may have the potential to occur within the site. This data, combined with other local knowledge and records, was utilised to assess whether the type of activity proposed on the site will have, or is likely to have a significant impact upon a matter of NES, or on the environment of Commonwealth land.

The matters of NES and site-specific responses are listed below.

World Heritage Properties

The site is not a World Heritage Property, and is not in close proximity to any such area. Therefore the proposal will not impact upon any World Heritage Property.

National Heritage Places

The site is not a National Heritage Place, and is not in close proximity to any such area. Therefore the proposal will not impact upon any National Heritage Place.

Wetlands of International Importance (declared Ramsar wetlands)

Hunter Estuary Wetlands are a declared Ramsar wetland located within 10km of the site, however they or their catchment area do not occur within the site. Therefore the proposal will not impact upon any Wetlands of International Importance.

Nationally listed threatened species and ecological communities

A total of 38 threatened species (five of which are wholly marine) listed under the EPBC Act 1999 have been recorded or have suitable habitat within a 10 km radius of the site (see Table 6-1 for likelihood of occurrence of threatened species listed under EPBC Act 1999). The potential for the proposal to significantly impact on individuals or local populations have been assessed in Table 6-1 above and likely impacts assessed in **Appendix 4**.

Due to the nature of the project (being entirely underground) and that no vegetation removal is required as part of this SMP application, no significant impacts are expected to occur on nationally threatened species or communities.

Nationally listed migratory species

A total of 36 migratory species listed under the EPBC Act 1999 have been recorded or have suitable habitat within a 10 km radius of the site. However the proposal is unlikely to; substantially modify, destroy or isolate an area of important habitat, result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat or seriously disrupt the lifecycle of an ecological significant proportion of the population of a migratory species.

All nuclear actions

No type of nuclear activity is proposed for the site.

Commonwealth marine areas

No Commonwealth marine areas exist within or adjacent to the site.

Commonwealth Land

The site is not land owned by the Commonwealth, and therefore the proposal will not impact upon any Commonwealth Land.

The Great Barrier Reef Marine Park

The Great Barrier Reef Marine Park does not occur within or adjacent to the site, therefore the proposal will not impact upon any areas of the Great Barrier Reef Marine Park.

Summary Statement:

Based on the above, it is considered that no significant impacts are expected to occur on nationally threatened species or communities or on any other matters of NES.

10 Conclusion and Recommendations

10.1 Conclusion

RPS was engaged by Centennial Newstan Pty Limited (Centennial Newstan) to undertake a Flora and Fauna Assessment for the proposed Newstan Subsidence Management Plan (SMP). A range of flora and fauna survey methods were employed within the site to detect a representative sample of species present within the SMP site and adjoining lands. Vegetation communities were identified using nomenclature from the LHCCREMS project (NPWS 2003). There were five vegetation communities identified as occurring on the site, being:

- MU 15 Coastal Foothills Spotted Gum Ironbark Forest;
- MU 30 Coastal Plains Smooth-barked Apple Forest;
- MU 31 Scribbly Gum-Red Bloodwood Woodland
- MU 37 Swamp Mahogany / Paperbark Forest; and
- Cleared Land.

A single Endangered Ecological Community (EEC) known as '*Swamp Sclerophyll Forest, on floodplains in the North Coast, Sydney Basin and South-east Corner Bioregions'* listed under TSC Act 1995 was recorded within the SMP site during surveys. This EEC is commensurate to MU 37 Swamp Mahogany / Paperbark Forest.

Habitats within the site were found to be in good condition, although some disturbance has occurred, predominantly along electricity easements and other developments such as the Awaba Waste Facility. The majority of vegetation is of a high quality with a mixture of mature hollow-bearing trees and a diverse, structurally complex understorey. Fallen timber and a dense groundcover provides suitable shelter for a wide range of terrestrial species, with hollow-bearing trees providing suitable breeding and nesting habitat for avifauna and arboreal species. Therefore, habitats within the site are considered to exhibit a high capacity to support many faunal guilds in isolation.

Four threatened flora species and five threatened fauna species listed under TSC Act 1995 and/or EPBC Act 1999 were recorded within the site during surveys. Furthermore, three additional threatened cryptic flora species and 15 additional threatened fauna species were considered likely to occur within the site based on habitat assessment and local records within the study area (Table 6-1).

Seven-part tests and EPBC assessment of significance have been conducted for threatened flora and fauna species and the EEC recorded or considered likely to occur within the site. The results of this assessment have concluded that the proposal is unlikely to have a significant impact on threatened species or the EEC, due to the proposal being an underground longwall mine, which is not expected to affect the habitats for which these species are reliant upon.

10.2 Recommendations

The following mitigation measures have been recommended to minimise the potential impacts of the proposal:

- Monitoring of stream bed morphology within the Swamp Mahogany / Paperbark Forest should be undertaken to detect any changes in the stream bed from subsidence. Likely indicators are the formation of new cracks, changes in direction of the stream bed and ponded areas;
- Newstan Colliery will develop a Watercourse Management Plan for the SMP study area (or adopt equivalent principles in the Newstan Flora and Fauna Management Plan - FFMP); and
- Where subsidence cracks are found that require remediation, then remediation will be undertaken in accordance with the Newstan Colliery Watercourse Management Plan or FFMP and in consultation with relevant regulatory agencies.

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Appendix 1

Known and Expected Fauna Species List

Known and Expected Fauna Species List

Below is a list of fauna species that could be *reasonably* expected to be found within the study area at some occurrence. Such an approach has been taken given the low probability of recording *all* potentially occurring species within an area during formal fauna surveys (due to seasonality, climatic limitations, crypticism etc).

Family sequencing and taxonomy follow for each fauna class:

<u>Birds</u> – Christidis and Boles (2008).

<u>Herpetofauna</u> - Cogger (1996).

<u>Mammals</u> - Van Dyck and Strahan (ed) (2008).

Appendix Key:

X = Species Detected
* **=** Introduced species
(E) = Species listed under NSW TSC Act 1995 as Endangered.
(V) = Species listed under NSW TSC Act 1995 as Vulnerable.
(V*) = Species listed under the Commonwealth EPBC Act 1999 as Vulnerable
(E*) = Species listed under the Commonwealth EPBC Act 1999 as Endangered
(M*) = Species listed under the Commonwealth EPBC Act 1999 as Migratory
(C) = Species listed under CAMBA
(J) = Species listed under JAMBA

Data Source: **1 =** Species recorded by RPS during this survey

Known and Expected Bird List

Family Name	Scientific Name	Common Name	
Casuariidae (Emu)	*Dromaius novaehollandiae*	Emu	
Megapodiidae (Mound Builders)	*Alectura lathami*	Australian Brush-turkey	
Phasianidae (True Quails, Pheasants and Fowls)	*Coturnix pectoralis*	Stubble Quail	
	Coturnix ypsilophora	Brown Quail	
	Excalfactoria chinensis	King Quail	
Anseranatidae (Magpie Goose)	***Anseranas semipalmata***	**Magpie Goose (V)**	
Anatidae (Swans, Geese and Ducks)	*Dendrocygna eytoni*	Plumed Whistling-Duck (M*)	
	Dendrocygna arcuata	Wandering Whistling-Duck (M*)	
	Oxyura australis	**Blue-billed Duck (V, M*)**	
	Stictonetta naevosa	**Freckled Duck (V, M*)**	
	Biziura lobata	Musk Duck (M*)	
	Cygnus atratus	Black Swan (M*)	
	Chenonetta jubata	Australian Wood Duck (M*)	
	Anas platyrhynchos	*Northern Mallard (M*)	
	Anas superciliosa	Pacific Black Duck (M*)	
	Anas rhynchotis	Australasian Shoveler (M*)	
	Anas gracilis	Grey Teal (M*)	
	Anas castanea	Chestnut Teal (M*)	
	Malacorhynchus membranaceus	Pink-eared Duck (M*)	
	Aytha australis	Hardhead (M*)	
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe	

Family Name	Scientific Name	Common Name	
(Grebes)			
	Poliocephalus poliocephalus	Hoary-headed Grebe	
	Podiceps cristatus	Great Crested Grebe	
Sphenicidae (Penguins)	*Eudyptula minor*	Little Penguin	
Anhingidae (Darters)	*Anhinga novaehollandiae*	Australasian Darter	
Phalacrocoracidae (Cormorants)	*Phalacrocorax carbo*	Great Cormorant	
	Microcarbo melanoleucos	Little Pied Cormorant	
	Phalacrocorax sulcirostris	Little Black Cormorant	
	Phalacrocorax varius	Pied Cormorant	
Pelecanide (Pelicans)	*Pelecanus conspicillatus*	Australian Pelican	
Ardeidae (Herons, Bitterns and Egrets)	*Ardea pacifica*	White-necked Heron	
	Egretta novaehollandiae	White-faced Heron	
	Ardea ibis	Cattle Egret (C,J, M*)	
	Egretta garzetta	Little Egret (J)	
	Egretta sacra	Eastern Reef Egret (C)	
	Ardea modesta	Eastern Great Egret (C,J, M*)	
	Ardea intermedia	Intermediate Egret	
	Nycticorax caledonicus	Nankeen Night Heron	
	Ixobrychus dubius	Australian Little Bittern	
	Butorides striatus	Striated Heron	
	Ixobrychus flavicollis	**Black Bittern (V)**	
	Botaurus poiciloptilus	**Australasian Bittern (V)**	
Threskiornithidae (Ibises and Spoonbills)	*Plegadis falcinellus*	Glossy Ibis (C, M*)	

Family Name	Scientific Name	Common Name	
	Threskiornis molucca	Australian White Ibis	
	Threskiornis spinicollis	Straw-necked Ibis	
	Platalea flavipes	Yellow-billed Spoonbill	
	Platalea regia	Royal Spoonbill	
Ciconiidae (Storks)	***Ephippiorhynchus asiaticus***	**Black-necked Stork (E)**	
Accipitridae (Hawks, Kites and Eagles)	***Pandion cristatus***	**Eastern Osprey (V)**	
	Aviceda subcristata	Pacific Baza (M*)	
	Elanus axillaris	Black-shouldered Kite (M*)	
	Lophoictinia isura	**Square-tailed Kite (V, M*)**	
	Haliastur sphenurus	Whistling Kite (M*)	
	Haliastur indus	Brahminy Kite (M*)	
	Haliaeetus leucogaster	White-bellied Sea-Eagle (C, M*)	
	Circus assimilis	Spotted Harrier (M*)	
	Circus approximans	Swamp Harrier (M*)	
	Accipiter fasciatus	Brown Goshawk (M*)	
	Accipiter novaehollandiae	Grey Goshawk (M*)	
	Accipiter cirrhocephalus	Collared Sparrowhawk (M*)	
	Aquila audax	Wedge-tailed Eagle (M*)	
	Hieraaetus morphnoides	Little Eagle (M*)	
Falconidae (Falcons)	*Falco berigora*	Brown Falcon (M*)	
	Falco longipennis	Australian Hobby (M*)	
	Falco subniger	Black Falcon (M*)	
	Falco peregrinus	Peregrine Falcon (M*)	
	Falco cenchroides	Nankeen Kestrel (M*)	

Family Name	Scientific Name	Common Name	
Rallidae (Crakes, Rails and Gallinules)	*Gallinula philippensis*	Buff-banded Rail	
	Lewinia pectoralis	Lewin's Rail	
	Porzana pusilla	Baillon's Crake	
	Porzana fluminea	Australian Spotted Crake	
	Porzana tabuensis	Spotless Crake	
	Porphyrio porphyrio	Purple Swamphen	
	Gallinula tenebrosa	Dusky Moorhen	
	Tribonyx ventralis	Black-tailed Native-hen	
	Fulica atra	Eurasian Coot	
Burhinidae (Stone-curlews))	***Burhinus grallarius***	**Bush Stone-curlew (E)**	
	Esacus magnirostris	**Beach Stone-curlew (CE)**	
Turnicidae (Button-Quails)	*Turnix varius*	Painted Button-quail	
	Turnix maculosus	**Red-backed Button-quail (V)**	
Jacanidae (Jacanas)	***Irediparra gallinacea***	**Comb-crested Jacana (V)**	
Rostratulidae (Painted Snipe)	***Rostratula australis***	**Australian Painted Snipe (M*, E*, V*,C)**	
Haematopodidae (Oystercatchers)	***Haematopus longirostris***	**Australian Pied Oystercatcher (E)**	
	Haematopus fuliginosus	**Sooty Oystercatcher (V)**	
Charadriidae (Lapwings, Plovers and Dottrels)	*Erythrogonys cinctus*	Red-kneed Dotterel (M*)	
	Elseyornis melanops	Black-fronted Dotterel (M*)	
	Vanellus miles	Masked Lapwing (M*)	
Laridae (Gulls and Terns)	*Chroicoephalus novaehollandiae*	Silver Gull	

Family Name	Scientific Name	Common Name	
	Sternula albifrons	**Little Tern (E, M*,C)**	
Columbidae (Pigeons and Doves)	**Columba livia*	Rock Dove	
	Chalcophaps indica	Emerald Dove	
	Columba leucomela	White-headed Pigeon	
	Geopelia humeralis	Bar-shouldered Dove	
	Geopelia striata	Peaceful Dove	
	Leucosarcia picata	Wonga Pigeon	
	Macropygia amboinensis	Brown Cuckoo-Dove	
	Ocyphaps lophotes	Crested Pigeon	
	Phaps chalcoptera	Common Bronzewing	
	Phaps elegans	Brush Bronzewing	
	Ptilinopus magnificus	**Wompoo Fruit-dove (V)**	
	Ptilinopus superbus	**Superb Fruit-dove (V)**	
	Ptilinopus regina	**Rose-Crowned Fruit-dove (V)**	
	**Streptopelia chinensis*	Spotted Dove	
Cacatuidae (Cockatoos)	***Calyptorhynchus lathami***	**Glossy Black-Cockatoo (V)**	
	Calyptrohynchus funereus	Yellow-tailed Black-Cockatoo	
	Callocephalon fimbriatum	**Gang-gang Cockatoo (V)**	
	Eolophus roseicapillus	Galah	
	Cacatua tenuirostris	Long-billed Corella	
	Cacatua sanguinea	Little Corella	
	Cacatua galerita	Sulphur-crested Cockatoo	
Psittacidae (Parrots)	*Alisterus scapularis*	Australian King Parrot	
	Lathamus discolor	**Swift Parrot (E, E*)**	
	Neophema pulchella	**Turquoise Parrot (V)**	

Family Name	Scientific Name	Common Name	
	Platycercus elegans	Crimson Rosella	
	Platycercus eximius	Eastern Rosella	
	Psephotus haematonotus	Red-rumped Parrot	
	Trichoglossus haematodus	Rainbow Lorikeet	X
	Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet	
	Glossopsitta concina	Musk Lorikeet	
	Glossopsitta pusilla	**Little Lorikeet (V)**	
Cuculidae (Old World Cuckoos)	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	X
	Cacomantis variolosus	Brush Cuckoo	
	Chalcites basalis	Horsfield's Bronze-Cuckoo	
	Chalcites lucidus	Shining Bronze-Cuckoo	
	Cacomantis pallidus	Pallid Cuckoo	
	Eudynamys orientalis	Eastern Koel	X
	Scythrops novaehollandiae	Channel-billed Cuckoo	X
Centropodidae (Coucals)	*Centropus phasianinus*	Pheasant Coucal	
Strigidae (Hawk Owls)	***Ninox strenua***	**Powerful Owl (V)**	
	Ninox connivens	**Barking Owl (V)**	
	Ninox boobook	Southern Boobook	
Tytonidae (Barn Owls)	*Tyto javanica*	Eastern Barn Owl	
	Tyto longimembris	**Eastern Grass Owl (V)**	
	Tyto novaehollandiae	**Masked Owl (V)**	X
	Tyto tenebricosa	**Sooty Owl (V)**	
Podargidae (Frogmouths)	*Podargus strigoides*	Tawny Frogmouth	X
Caprimulgidae	*Eurostopodus mystacalis*	White-throated Nightjar	X

Family Name	Scientific Name	Common Name	
(Nightjars)			
Aegothelidae (Owlet-nightjars)	*Aegotheles cristatus*	Australian Owlet-nightjar	X
Apodidae (Typical Swifts)	*Hirundapus caudacutus*	White-throated Needletail (M*,C)	
	Apus pacificus	Fork-tailed Swift (M*,C)	
Alcedinidae (True Kingfishers)	*Alcedo azureus*	Azure Kingfisher	
Halcyonidae (Kingfishers and Kookaburras)	*Dacelo novaeguineae*	Laughing Kookaburra	
	Todiramphus sanctus	Sacred Kingfisher	X
	Todiramphus macleayii	Forest Kingfisher	
Meropidae (Bee-eaters)	*Merops ornatus*	Rainbow Bee-eater (M*)	
Coraciidae (Typical Rollers)	*Eurystomus orientalis*	Dollarbird	X
Menuridae (Lyrebirds)	*Menura novaehollandiae*	Superb Lyrebird	
Climacteridae (Australo-Papuan Treecreepers)	*Cormobates leucophaea*	White-throated Treecreeper	X
	Climacteris picumnus	**Brown Treecreeper (V)**	
Maluridae (Fairy-Wrens and Emu-Wrens)	*Malurus cyaneus*	Superb Fairy-wren	X
	Malurus lamberti	Variegated Fairy-wren	X
Pardalotidae (Pardalotes, Scrubwrens, Thornbills)	*Pardalotus punctatus*	Spotted Pardalote	
	Paradalotus striatus	Striated Pardalote	
	Sericornis frontalis	White-browed Scrubwren	X
	Sericornis magnirostra	Large-Billed Scrubwren	

Family Name	Scientific Name	Common Name	
	Chthonicola sagittata	**Speckled Warbler (V)**	
	Gerygone mouki	Brown Gerygone	X
	Gerygone albogularis	White-throated Gerygone	X
	Gerygone levigaster	Mangrove Gerygone	
	Acanthiza pusilla	Brown Thornbill	X
	Acanthiza reguloides	Buff-rumped Thornbill	
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill	
	Acanthiza nana	Yellow Thornbill	X
	Acanthiza lineata	Striated Thornbill	X
	Smicrornis brevirostris	Weebill	
Meliphagidae (Honeyeaters)	*Anthochaera carunculata*	Red Wattlebird	
	Plectrhyncha lanceolata	Striped Honeyeater	
	Anthochaera chrysoptera	Little Wattlebird	
	Philemon corniculatus	Noisy Friarbird	X
	Anthochaera phrygia	**Regent Honeyeater (CE, E*)**	
	Manorina melanophrys	Bell Miner	
	Manorina melanocephala	Noisy Miner	
	Meliphaga lewinii	Lewin's Honeyeater	X
	Lichenostomus chrysops	Yellow-faced Honeyeater	X
	Lichenostomus melanops	Yellow-tufted Honeyeater	
	Lichenostomus fuscus	Fuscous Honeyeater	
	Lichenostomus penicillatus	White-plumed Honeyeater	
	Melithreptus brevirostris	Brown-headed Honeyeater	
	Melithreptus lunatus	White-naped Honeyeater	
	Melithreptus gularis	**Black-chinned Honeyeater (V)**	
	Entomyzon cyanotis	Blue-faced Honeyeater	
	Lichmera indistincta	Brown Honeyeater	

Family Name	Scientific Name	Common Name	
	Phylidonyris novaehollandiae	New Holland Honeyeater	
	Phylidonyris niger	White-cheeked Honeyeater	X
	Acanthorhynchus tenuirostris	Eastern Spinebill	X
	Myzomela sanguinolenta	Scarlet Honeyeater	X
	Epthianura albifrons	White-fronted Chat	
Eopsaltriidae (Robins)	*Microeca fascinans*	Jacky Winter	
	Petroica boodang	**Scarlet Robin (V)**	
	Petroica rosea	Rose Robin	
	Eopsaltria australis	Eastern Yellow Robin	
	Melanodryas cucullata	**Hooded Robin (V)**	
Pomatostomidae (Australo-Papuan Babblers)	***Pomatostomus temporalis***	**Grey-crowned Babbler (V)**	
Cinclosomidae (Quail-thrushes and allies)	*Psophodes olivaceus*	Eastern Whipbird	X
	Cinclosoma punctatum	Spotted Quail-thrush	
Neosittidae (Sittellas)	***Daphoenositta chrysoptera***	**Varied Sittella (V, V*)**	
Pachycephalidae (Whistlers, Shrike-tit, Shrike-thrushes)	*Falcunculus frontatus*	Crested Shrike-tit	
	Pachycephala pectoralis	Golden Whistler	X
	Pachycephala rufiventris	Rufous Whistler	
	Colluricincla harmonica	Grey Shrike-thrush	X
Dicruridae (Monarchs, Fantails and Drongo)	*Monarcha melanopsis*	Black-faced Monarch	
	Myiagra rubecula	Leaden Flycatcher	
	Myiagra inquieta	Restless Flycatcher	
	Grallina cyanoleuca	Magpie-lark	

Family Name	Scientific Name	Common Name	
	Rhipidura rufifrons	Rufous Fantail (M*)	
	Rhipidura albiscarpa	Grey Fantail	X
	Rhipidura leucophyrs	Willie Wagtail	
	Dicrurus bracteatus	Spangled Drongo	
Campephagidae (Cuckoo-shrikes and Trillers)	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	X
	Coracina papuensis	White-bellied Cuckoo-shrike	
	Coracina tenuirostris	Cicadabird	
	Lalage sueurii	White-winged Triller	
Oriolidae (Orioles and Figbird)	*Oriolus sagittatus*	Olive-backed Oriole	X
	Sphecotheres vieilloti	Australasian Figbird	
Artamidae (Woodswallows, Butcherbirds, Currawongs)	*Artamus leucorynchus*	White-breasted Woodswallow	
	Artamus cyanopterus	Dusky Woodswallow	
	Cracticus torquatus	Grey Butcherbird	X
	Cracticus nigrogularis	Pied Butcherbird	X
	Cracticus tibicen	Australian Magpie	X
	Strepera graculina	Pied Currawong	
Corvidae (Crows and allies)	*Corvus coronoides*	Australian Raven	X
Cororacidae (Mud-nesters)	*Corcorax melanorhamphos*	White-winged Chough	
Ptilinorhynchidae (Bowerbirds)	*Ptilonorhynchus violaceus*	Satin Bowerbird	
Motacillidae (Old World Wagtails,Pipits)	*Anthus novaeseelandiae*	Australasian (Richard's) Pipit	
	Alauda arvensis	Eurasian Skylark	
Passeridae	**Passer domesticus*	House Sparrow	

Family Name	Scientific Name	Common Name	
(Sparrows, Weaverbirds, Waxbills)			
	Taeniopygia guttata	Zebra Finch	
	Stagonopleura guttata	**Diamond Firetail (V)**	
	Taeniopygia bichenovii	Double-barred Finch	
	Neochmia temporalis	Red-browed Finch	
Dicaeidae (Flowerpeckers)	*Dicaeum hirundinaceum*	Mistletoebird	
Hirundinidae (Swallows and Martins)	*Cheramoeca leucosterna*	White-Backed Swallow	
	Hirundo neoxena	Welcome Swallow	
	Petrochelidon nigricans	Tree Martin	
	Petrochelidon ariel	Fairy Martin	
Sylviidae (Old World Warblers)	*Acrocephalus australis*	Australian Reed Warbler	
	Cincloramphus mathewsi	Rufous Songlark	
	Cisticola exilis	Golden-headed Cisticola	
	Megalurus gramineus	Little Grassbird	
	Megalurus timorensis	Tawny Grassbird	
Zosteropidae (White-eyes)	*Zosterops lateralis*	Silvereye	X
Muscicapidae (Thrushes)	*Zoothera lunulata*	Bassian Thrush (M*)	
	Zoothera heinei	Russet-tailed Thrush (M*)	
Sturnidae (Starlings and allies)	*Sturnus vulgaris*	*Common Starling	
	Sturnus tristis	*Common Mynah	

Known and Expected Mammal List

Family Name	Scientific Name	Common Name	
Tachyglossidae (Echidnas)	*Tachyglossus aculeatus*	Short-beaked Echidna	
Family Ornithorhynchidae (Platypus)	*Ornythorhynchus anatinus*	Platypus	
Dasyuridae (Dasyurids)	*Antechinus stuartii*	Brown Antechinus	**X**
	Antechinus swainsonii	Dusky Antechinus	X
	Dasyurus maculatus	**Spotted-tailed Quoll (V, E*)**	
	Phascogale tapoatafa	**Brush-tailed Phascogale (V)**	
	Planigale maculata	**Common Planigale (V)**	
Peramelidae (Bandicoots and Bilbies)	*Isoodon macrourus*	Northern Brown Bandicoot	**X**
	Peremeles nasuta	Long-nosed Bandicoot	
Phascolarctidae (Koala)	***Phascolarctos cinereus***	**Koala (V)**	
Vombatidae (Wombats)	*Vombatus ursinus*	Common Wombat	
Burramyidae (Pygmy Possums)	***Cercartetus nanus***	**Eastern Pygmy Possum (V)**	
Petauridae (Wrist-winged Gliders)	*Petaurus breviceps*	Sugar Glider	**X**
	Petaurus norfolcensis	**Squirrel Glider (V)**	
	Petaurus australis	**Yellow-bellied Glider (V)**	
Pseudocheiridae (Ringtail Possums, Greater Glider)	*Petauroides volans*	Greater Glider	
	Pseudocheirus peregrinus	Common Ringtail Possum	**X**

Family Name	Scientific Name	Common Name	
Acrobatidae (Feathertail Glider)	*Acrobates pygmaeus*	Feathertail Glider	X
Phalangeridae (Brushtail Possums and Cuscuses)	*Trichosurus vulpecula*	Common Brushtail Possum	X
Potoroidae (Potoroos and Bettongs)	***Potorous tridactylus***	**Long-nosed Potoroo (V, V*)**	
Macropodidae (Wallabies and Kangaroos)	*Macropus giganteus*	Eastern Grey Kangaroo	
	Macropus robustus	Common Wallaroo	
	Macropus rufogriseus	Red-necked Wallaby	
	Petrogale penicillata	**Brush-tailed Rock-Wallaby (E, V*)**	
	Wallabia bicolor	Swamp Wallaby	X
Pteropodidae (Flying-foxes, Blossom-bats)	***Pteropus poliocephalus***	**Grey-headed Flying-fox (V, V*)**	X
	Pteropus scapulatus	Little Red Flying-fox	
Rhinolophidae (Horseshoe-bats)	*Rhinolophus megaphyllus*	Eastern Horseshoe-bat	X
Emballonuridae (Sheathtail-bats)	***Saccolaimus flaviventris***	**Yellow-bellied Sheathtail-bat (V)**	
Molossidae (Freetail-bats)	***Mormopterus norfolkensis***	**East-coast Freetail-bat (V)**	X
	Mormopterus sp.2	Eastern Freetail-bat	X
	Tadarida australis	White-striped Freetail-bat	X
Vespertilionidae (Vespertilionid Bats)	***Miniopterus australis***	**Little Bentwing-bat (V)**	X
	Miniopterus schreibersii	**Common Bentwing-bat (V)**	X
	Nyctophilus geoffroyi	Lesser Long-eared Bat	
	Nyctophilus gouldii	Gould's Long-eared Bat	

Family Name	Scientific Name	Common Name	
	Chalinolobus dwyeri	**Large-eared Pied Bat (V, V*)**	
	Chalinolobus gouldii	Gould's Wattled Bat	X
	Chalinolobus morio	Chocolate Wattled Bat	
	Falsistrellus tasmaniensis	**Eastern Falsistrelle (V)**	
	Myotis macropus	**Southern Myotis (V)**	
	Scoteanax rueppellii	**Greater Broad-nosed Bat (V)**	
	Scotorepens greyii	Little Broad-nosed Bat	
	Scotorepens orion	Eastern Broad-nosed Bat	
	Vespadelus darlingtoni	Large Forest Bat	
	Vespadelus regulus	Southern Forest Bat	
	Vespadelus pumilus	Eastern Forest Bat	
	Vespadelus vulturnus	Little Forest Bat	
Muridae (Murids)	*Hydromys chrysogaster*	Water Rat	
	Melomys burtoni	Grassland Melomys	
	**Mus musculus*	House Mouse	
	Pseudomys novaehollandiae	**New Holland Mouse (V*)**	
	Rattus fuscipes	Bush Rat	X
	Rattus lutreolus	Swamp Rat	
	**Rattus norvegicus*	Brown Rat	
	**Rattus rattus*	Black Rat	
Canidae (Dogs)	**Canis familiaris*	Dog	
	Canis familiaris dingo	Dingo	
	**Vulpes vulpes*	Red Fox	
Felidae (Cats)	**Felis catus*	Feral Cat	

Family Name	Scientific Name	Common Name	
Leporidae (Rabbit and Hare)	**Oryctolagus cuniculus*	European Rabbit	
	**Lepus capensis*	Brown Hare	
Equidae (Horse and Donkey)	**Equus caballus*	Horse	
Suidae (Pigs)	**Sus scrofa*	Pig	
Bovidae (Horned Ruminants)	**Bos taurus*	Cow	
	**Capra hircus*	Goat	
Cervidae (Deer)	**Cervus timorensis*	Rusa Deer	

Known and Expected Reptile List

Family Name	Scientific Name	Common Name	
Cheloniidae (Turtles)	***Chelonis mydas***	**Green Turtle (V, V*, M*)**	
Chelidae (Tortoises)	*Chelodina longicollis*	Long-necked Tortoise	
Agamidae (Dragons)	*Amphibolurus muricatus*	Jacky Lizard	
	Amphibolurus nobbi	Nobbi	
	Physignathus lesuerii	Eastern Water Dragon	
	Pogona barbata	Eastern Bearded Dragon	
Pygopodidae (Legless Lizards)	*Lialis burtonis*	Burton's Snake Lizard	
	Pygopus lepidopus	Common Scaly-foot	
	Delma plebeia	Leaden Delma	
Gekkonidae (Geckoes)	*Diplodactylus vittatus*	Wood Gecko	
	Phyllurus platurus	Southern Leaf-tailed Gecko	
	Oedura lesueurii	Lesueur's Velvet Gecko	
	Underwoodisaurus milii	Thick-tailed Gecko	
Varanidae (Monitors)	*Varanus gouldii*	Gould's Monitor	
	Varanus varius	Lace Monitor	
Scincidae (Skinks)	*Carlia tetradactyla*	Rainbow Skink	
	Cryptoblepharus virgatus	Wall Lizard	
	Ctenotus taeniolatus	Copper-tailed Skink	
	Ctenotus robustus	Robust Skink	X
	Cyclodomorphus casuarinae	She-oak Skink	
	Egernia cunninghamii	Cunningham's Skink	

Family Name	Scientific Name	Common Name	
	Egernia major	Land Mullet	
	Egernia modesta		
	Egernia striolata	Tree-crevice Skink	
	Egernia saxatilis	Black Rock Skink	
	Egernia whitii	White's Skink	
	Eulamprus quoyii	Eastern Water Skink	
	Eulamprus tenuis		
	Lampropholis delicata	Grass Skink	X
	Lampropholis guichenoti	Garden Skink	
	Lygisaurus foliorum	Tree-base Litter-skink	
	Morethia boulengeri	South-eastern Morethia	
	Pseudomoia platynota	Red-throated Skink	
	Saiphos equalis	Three-toed Skink	
	Saproscincus mustelinus	Weasel Skink	
	Tiliqua scincoides	Eastern Blue-tongued Lizard	
Typhlopidae (Blind Snakes)	*Ramphotyphlops bituberculatus*	Prong-snouted Blind Snake	
	Ramphotyphlops weidii	Brown-snouted Blind Snake	
	Ramphotyphlops nigrescens	Black Blind Snake	
Boidae (Pythons)	*Morelia spilota*	Diamond Python	
Colubridae (Tree Snakes)	*Boiga irregularis*	Brown Tree Snake	
	Dendrelaphis punctulata	Green Tree Snake	
Elapidae (Venomous Snakes)	*Furina diadema*	Red-naped Snake	
	Acanthopis antarcticus	Death Adder	
	Cacophis krefftii	Dwarf Crowned Snake	

Family Name	Scientific Name	Common Name	
	Cacophis squamulosus	Golden Crowned Snake	
	Demansia psammophis	Yellow-faced Whip Snake	
	Furina diadema	Red-naped Snake	
	Hoplocephalus bitorquatus	**Pale-headed Snake (V)**	
	Hoplocephalus stephensii	**Stephens' Banded Snake (V)**	
	Notechis scutatus	Eastern Tiger Snake	
	Pseudonaja textilis	Eastern Brown Snake	
	Cryptophis nigrescens	Eastern Small-eyed Snake	
	Vermicella annulata	Bandy Bandy	
	Hemiaspis signata	Black-bellied Swamp Snake	
	Pseudechis porphyriacus	Red-bellied Black Snake	

Known and Expected Frog List

Family Name	Scientific Name	Common Name	
Hylidae (Tree Frogs)	***Litoria aurea***	**Green and Golden Bell Frog (E, V*)**	
	Litoria caerulea	Green Tree Frog	
	Litoria chloris	Red-eyed Green Tree Frog	
	Litoria dentata	Bleating Tree Frog	
	Litoria fallax	Eastern Dwarf Tree Frog	
	Litoria latopalmata	Broad-palmed Frog	X
	Litoria lesueuri	Lesueur's Frog	
	Litoris nasuta	Rocket Frog	
	Litoria peronii	Peron's Tree Frog	
	Litoria phyllochroa	Green Leaf Tree Frog	
	Litoria tyleri	Tyler's Tree Frog	
	Litoria verreauxii	Verreaux's Frog	
Myobatrachidae (Ground Frogs)	*Adelotus brevis*	Tusked Frog	
	Crinia signifera	Common Eastern Froglet	X
	Crinia tinnula	**Wallum Froglet (V)**	
	Limnodynastes dumerilli	Eastern Banjo Frog	
	Limnodynastes ornatus	Ornate Burrowing Frog	
	Limnodynastes peronii	Striped Marsh Frog	
	Limnodynastes tasmaniensis	Spotted Grass Frog	
	Mixophyes fasciolatus	Great Barred Frog	
	Pseudophryne coriacea	Red-backed Toadlet	X
	Pseudophryne bibronii	Brown Toadlet	
	Uperoleia fusca	Dusky Toadlet	
	Uperoleia laevigata	Smooth Toadlet	

Appendix 2

Flora Species List

Family	Scientific Name	Common Name	TSC Act Status	EPBC Status	Umwelt/ Gunninah 1998	Umwelt 2004	Umwelt 2005	Eco-Biological 2005	Cumberland Ecology 2007	HWR 2008	HunterEco 2008a	Cumberland Ecology 2008	HunterEco 2008b	HunterEco 2009a	HunterEco 2009b	RPS 2010	RPS 2011
Acanthaceae	*Brunoniella australis*	Blue Trumpet			x				x			x					
Acanthaceae	*Brunoniella pumilio*	Dwarf Blue Trumpet							x			x					
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower			x	x			x	x		x				x	x
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair			x	x			x	x		x				x	x
Adiantaceae	Adiantum formosum	Giant Maidenhair														x	
Anthericaceae	*Caesia parviflora* var. *parviflora*	Pale Grass Lily														x	
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily			x												
Anthericaceae	*Thysanotus juncifolius*	Fringed Lily														x	
Anthericaceae	*Thysanotus tuberosus*	Fringed Lily			x				x			x				x	
Anthericaceae	*Tricoryne elatior*	Yellow Rush Lily														x	
Anthericaceae	*Tricoryne simplex*	Yellow Rush-lily				x										x	
Apiaceae	*Centella asiatica*	Swamp Pennywort			x	x			x			x				x	x
Apiaceae	*Cyclospermum leptophyllum**	Slender Celery														x	
Apiaceae	*Hydrocotyle bonariensis**	Kurnell Curse / Pennywort														x	
Apiaceae	*Hydrocotyle geraniifolia*	Forest Pennywort							x			x					
Apiaceae	*Hydrocotyle peduncularis*	Pennywort				x			x	x		x					
Apiaceae	*Platysace linearifolia*	Narrow-leafed Platysace			x											x	
Apiaceae	*Trachymene incisa* subsp. *incisa*	Native Parsnip			x												
Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia			x												
Apiaceae	*Xanthosia tridentata*	Rock Xanthosia			x											x	
Apocynaceae	*Parsonsia straminea*	Common Silkpod			x	x			x	x		x				x	x
Araceae	*Colocasia esculenta**	Taro														x	
Araceae	*Gymnostachys anceps*	Settlers Flax				x											
Araliaceae	*Astrotricha floccosa*	-														x	
Araliaceae	*Astrotricha latifolia*	Broad-leaf Star-hair														x	
Araliaceae	*Polyscias sambucifolia*	Elderberry Panax			x	x			x	x		x				x	x
Arecaceae	*Livistona australis*	Cabbage Tree Palm														x	
Asclepiadaceae	*Marsdenia suaveolens*	Scented Marsdenia							x			x					
Asparagaceae	*Asparagus aethiopicus**	Asparagus Fern														x	
Asparagaceae	*Protasparagus densiflorus**	Asparagus Fern														x	
Asparagaceae	*Protasparagus plumosus**	Climbing Asparagus Fern							x			x					
Asteraceae	*Actinotus helianthi*	Flannel Flower			x												
Asteraceae	*Actinotus minor*	Lesser Flannel Flower			x												
Asteraceae	*Ageratina adenophora**	Crofton Weed			x	x										x	
Asteraceae	*Bidens pilosa**	Cobbler's Pegs			x											x	
Asteraceae	*Brachyscome angustifolia*	-			x											x	
Asteraceae	*Cassinia aculeata*	Dolly Bush							x			x					
Asteraceae	*Cassinia cunninghamii*	Cunningham's Everlasting			x												
Asteraceae	*Cassinia uncata*	Sticky Cassinia							x			x					

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Asteraceae	***Chrysanthemoides monilifera* subsp. *monilifera****	**Boneseed**	**KTP**		x												
Asteraceae	***Chrysanthemoides monilifera* subsp. *rotundata****	**Bitou Bush**	**KTP**													x	
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting			x												
Asteraceae	*Cirsium vulgare**	Spear Thistle			x											x	
Asteraceae	*Conyza albida = C. sumatrensis**	Tall Fleabane															x
Asteraceae	*Conyza bonariensis**	Flax-leaf Fleabane			x	x											
Asteraceae	*Conyza canadensis**	Canadian Fleabane			x												
Asteraceae	*Epaltes australis*	Spreading Nut-heads			x												
Asteraceae	*Euchiton involucratus*	Star Cudweed			x												
Asteraceae	*Hypochaeris radicata**	Flatweed			x												x
Asteraceae	*Lagenophora stipitata*	-			x											x	
Asteraceae	*Onopordum acanthium* subsp. *acanthium*	Scotch Thistle			x												
Asteraceae	*Ozothamnus diosmifolius*	Ball Everlasting			x				x			x					
Asteraceae	*Senecio madagascariensis**	Fireweed			x	x			x			x					
Asteraceae	*Sigesbeckia orientalis*	Indian Weed			x	x											
Asteraceae	*Sonchus oleraceus**	Common Sow-thistle			x												
Asteraceae	*Taraxacum officinale**	Dandelion				x			x			x					
Asteraceae	*Vernonia cinerea* var. *cinerea*	-			x	x			x			x					
Avicenniaceae	*Avicennia marina* var. *australasica*	Grey Mangrove														x	
Azollaceae	*Azolla pinnata*	Ferny Azolla			x												
Bignoniaceae	*Pandorea pandorana*	Wonga Vine			x	x			x			x				x	
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern			x					x							
Blechnaceae	*Blechnum indicum*	Swamp Water Fern				x			x			x				x	
Blechnaceae	*Blechnum nudum*	Fishbone Water Fern			x												
Blechnaceae	*Doodia caudata var caudata*	Small Rasp Fern							x			x					
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell			x												
Campanulaceae	*Wahlenbergia stricta* subsp. *stricta*	Austral Bluebell			x												
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle														x	
Caprifoliaceae	*Sambucus australasica*	Yellow Elderberry			x												
Casuarinaceae	*Allocasuarina distyla*	-			x												
Casuarinaceae	*Allocasuarina littoralis*	Black She-oak			x	x			x		x	x				x	x
Casuarinaceae	*Allocasuarina torulosa*	Forest Oak			x			x	x	x	x	x				x	x
Casuarinaceae	*Casuarina glauca*	Swamp Oak			x											x	
Celastraceae	*Maytenus silvestris*	Orange Bush			x	x			x	x		x					
Chenopodiaceae	*Chenopodium ambrosioides**	Mexican Tea			x												
Clusiaceae	*Hypericum gramineum*	Small St Johns Wort			x												
Colchicaceae	*Burchardia umbellata*	Milkmaids							x			x				x	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew			x												
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew			x											x	
Convolvulaceae	*Convolvulus erubescens*	Blushing Bindweed							x			x					
Convolvulaceae	*Dichondra repens*	Kidney Weed			x	x			x	x		x				x	x

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Convolvulaceae	*Polymeria calycina*	Bindweed			x	x											x
Cunoniaceae	*Callicoma serratifolia*	Black Wattle			x	x			x	x	x	x				x	
Cunoniaceae	*Ceratopetalum gummiferum*	NSW Christmas Bush				x			x	x		x				x	
Cyatheaceae	*Cyathea cooperi*	Straw Treefern				x				x							
Cyperaceae	*Baumea articulata*	Jointed Twig-Rush			x												
Cyperaceae	*Baumea juncea*	-														x	
Cyperaceae	*Carex appressa*	Tall Sedge			x	x			x	x		x				x	x
Cyperaceae	*Carex inversa*	Knob Sedge			x												
Cyperaceae	*Caustis pentandra*	Thick Twist Rush			x												
Cyperaceae	*Cyathochaeta diandra*	-			x				x			x				x	
Cyperaceae	*Cyperus difformis*	Variable Flat-sedge			x												
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge			x												
Cyperaceae	*Cyperus involucratus**	-														x	
Cyperaceae	*Cyperus polystachyos*	-			x											x	
Cyperaceae	*Cyperus sp.*	-															x
Cyperaceae	*Eleocharis sphacelata*	Tall Spike-rush			x												
Cyperaceae	*Fimbristylis dichotoma*	Common Fringe-rush			x												
Cyperaceae	*Gahnia aspera*	Saw Sedge			x	x											
Cyperaceae	*Gahnia clarkei*	Tall Saw-sedge						x	x	x	x	x				x	x
Cyperaceae	*Gahnia melanocarpa*	Black-fruit Saw-sedge			x												
Cyperaceae	*Gahnia radula*	-						x									
Cyperaceae	*Gahnia sieberiana*	Red-fruited Saw-sedge			x												
Cyperaceae	*Lepidosperma filiforme*	-			x				x			x					
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge			x	x			x			x				x	x
Cyperaceae	*Lepidosperma longitudinale*	Pithy Sword Sedge								x							
Cyperaceae	*Lepidosperma neesii*	-														x	x
Cyperaceae	*Ptilothrix deusta*	-			x	x		x	x		x	x		x		x	
Cyperaceae	*Schoenoplectus mucronatus*	River Clubrush			x												
Cyperaceae	*Schoenus brevifolius*	Bog-rush			x											x	
Cyperaceae	*Tetraria capillaris*				x												
Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern							x	x		x				x	x
Dennstaedtiaceae	*Pteridium esculentum*	Bracken			x	x		x	x	x		x		x		x	x
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern				x			x	x		x				x	
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower			x				x	x		x				x	x
Dilleniaceae	*Hibbertia dentata*	Twining Guinea Flower			x	x				x						x	x
Dilleniaceae	*Hibbertia diffusa*	Wedge Guinea Flower			x											x	
Dilleniaceae	*Hibbertia empetrifolia subsp. empetrifolia*	-			x				x			x					
Dilleniaceae	*Hibbertia linearis*	-				x											
Dilleniaceae	*Hibbertia obtusifolia*	Grey Guinea Flower							x			x					
Dilleniaceae	*Hibbertia scandens*	Climbing Guinea Flower			x				x			x					
Dioscoreaceae	*Dioscorea transversa*	Native Yam				x			x	x		x					x

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Doryanthaceae	*Doryanthes excelsa*	Gymea Lily			x	x		x	x		x	x				x	x
Droseraceae	*Drosera auriculata*	Sundew							x			x					
Droseraceae	*Drosera burmanii*					x											
Droseraceae	*Drosera peltata*	Sundew			x												
Droseraceae	*Drosera pygmaea*	Pygmy Sundew			x												
Droseraceae	*Drosera spathulata*	Common Sundew														x	
Elatinaceae	*Elatine gratioloides*	waterwort			x												
Eleocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash				x											
Epacridaceae	*Acrotriche divaricata*	-														x	
Epacridaceae	*Astroloma humifusum*	Native Cranberry			x												
Epacridaceae	*Brachyloma daphnoides*	Daphne Heath			x												
Epacridaceae	*Epacris microphylla*	Coral Heath			x				x			x					
Epacridaceae	*Epacris pulchella*	Wallum Heath			x	x			x			x				x	x
Epacridaceae	*Leucopogon appressus*	-				x											
Epacridaceae	*Leucopogon attenuatus*				x												
Epacridaceae	*Leucopogon juniperinus*	Prickly Beard-heath			x											x	x
Epacridaceae	*Leucopogon lanceolatus*	Lance-leaf Beard-heath				x			x			x				x	x
Epacridaceae	*Melichrus procumbens*	Jam Tarts			x											x	
Epacridaceae	*Melichrus urceolatus*	Urn Heath							x			x					
Epacridaceae	*Monotoca elliptica*	Tree Broom-heath			x												
Epacridaceae	*Monotoca scoparia*	Prickly Broom-heath			x				x			x					
Euphorbiaceae	*Breynia oblongifolia*	Coffee Bush			x	x			x	x		x				x	
Euphorbiaceae	*Glochidion ferdinandii*	Cheese Tree			x	x		x	x	x	x	x				x	x
Euphorbiaceae	*Phyllanthus hirtellus*	Thyme Spurge			x				x			x				x	x
Euphorbiaceae	*Poranthera ericifolia*	-			x				x			x				x	
Euphorbiaceae	*Poranthera microphylla*	-			x											x	
Euphorbiaceae	*Ricinus communis**	Caster Oil Plant														x	
Fabaceae/Cesalpinioideae	*Senna pendula* var. *glabrata**	-														x	
Fabaceae/faboideae	*Bossiaea heterophylla*	Variable Bossiaea			x											x	
Fabaceae/faboideae	*Bossiaea obcordata*	Spiny Bossiaea			x	x			x		x	x				x	x
Fabaceae/faboideae	*Bossiaea rhombifolia*	-			x	x											
Fabaceae/faboideae	*Daviesia acicularis*	-			x												
Fabaceae/faboideae	*Daviesia genistifolia*	Broom Bitter Pea			x	x											
Fabaceae/faboideae	*Daviesia mimosoides*	-						x	x			x					
Fabaceae/faboideae	*Daviesia squarrosa*	-			x	x			x			x				x	
Fabaceae/faboideae	*Daviesia ulicifolia*	Gorse Bitter Pea							x			x				x	x
Fabaceae/faboideae	*Desmodium rhytidophyllum*	-							x			x				x	
Fabaceae/faboideae	*Desmodium varians*	-														x	
Fabaceae/faboideae	*Dillwynia glaberrima*	Parrot Pea			x												
Fabaceae/faboideae	*Dillwynia phylicoides*	-			x												
Fabaceae/faboideae	*Dillwynia retorta*	Eggs and Bacon			x	x		x	x		x	x				x	x

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Fabaceae/faboideae	*Glycine clandestina*	Twining Glycine			x	x			x	x		x				x	x
Fabaceae/faboideae	*Glycine microphylla*	Small-leaf Glycine			x	x			x			x					x
Fabaceae/faboideae	*Glycine tabacina*	Twining Glycine														x	
Fabaceae/faboideae	*Gompholobium glabratum*	Dainty Wedge-pea			x												
Fabaceae/faboideae	*Gompholobium grandiflorum*	Golden Glory Pea				x											
Fabaceae/faboideae	*Gompholobium huegelii*	Pale Wedge Pea			x												
Fabaceae/faboideae	*Gompholobium latifolium*	Broad-leaf Wedge-pea			x	x			x			x				x	x
Fabaceae/faboideae	*Gompholobium pinnatum*	Pinnate Wedge-pea			x				x			x				x	
Fabaceae/faboideae	*Hardenbergia violacea*	False Sarsparilla			x				x			x				x	x
Fabaceae/faboideae	*Hovea linearis*	-			x											x	
Fabaceae/faboideae	*Hovea purpurea*	-			x												
Fabaceae/faboideae	*Jacksonia scoparia*	Dogwood			x				x			x				x	
Fabaceae/faboideae	*Kennedia rubicunda*	Dusky Coral Pea			x	x			x			x				x	x
Fabaceae/faboideae	*Medicago arabica**	Spotted Burr Medic			x												
Fabaceae/faboideae	*Medicago polymorpha**	Burr Medic			x												
Fabaceae/faboideae	*Mirbelia rubiifolia*	Heathy Mirbelia			x				x			x				x	x
Fabaceae/faboideae	*Mirbelia speciosa*	-				x											
Fabaceae/faboideae	*Oxylobium ilicifolium* (now Podolobium ilicifolium)	Native Holly			x	x		x	x		x	x				x	x
Fabaceae/faboideae	*Platylobium formosum*	Handsome Flat-pea			x	x										x	x
Fabaceae/faboideae	*Platylobium formosum* subsp. *parviflorum*	Handsome Flat-pea						x	x			x					
Fabaceae/faboideae	*Podolobium ilicifolium*	Prickly Shaggy Pea							x			x				x	
Fabaceae/faboideae	*Pultenaea daphnoides*	Large-leaf Bush Pea														x	
Fabaceae/faboideae	*Pultenaea elliptica*				x				x			x				x	
Fabaceae/faboideae	*Pultenaea euchilla*	Orange Pultenaea							x			x				x	
Fabaceae/faboideae	*Pultenaea paleacea*	-			x	x			x			x				x	x
Fabaceae/faboideae	*Pultenaea polifolia*	Dusky Bush-pea							x			x					
Fabaceae/faboideae	*Pultenaea retusa*	-			x	x					x					x	
Fabaceae/faboideae	*Pultenaea rosmarinifolia*	-			x												
Fabaceae/faboideae	*Pultenaea villosa*	Hairy Bush-pea			x	x		x	x		x	x				x	
Fabaceae/faboideae	*Trifolium repens**	White Clover			x											x	x
Fabaceae/faboideae	*Vicia sativa* subsp *sativa**	Common Vetch														x	
Fabaceae/faboideae/Faboideae	*Aotus ericoides*	-			x												
Fabaceae/faboideae/Faboideae	*Phyllota phylicoides*	Heath Phyllota			x												
Fabaceae/faboideae/Mimosoideae	*Acacia brownii*	Heath Wattle			x											x	
Fabaceae/faboideae/Mimosoideae	*Acacia buxifolia*	Box-leaf Wattle				x											
Fabaceae/faboideae/Mimosoideae	***Acacia bynoeana***	**Bynoe's Wattle, Tiny Wattle**	**E**	**V**			x		x		x	x	x				
Fabaceae/faboideae/Mimosoideae	*Acacia elata*	Cedar Wattle				x											
Fabaceae/faboideae/Mimosoideae	*Acacia falcata*	-				x			x			x				x	
Fabaceae/faboideae/Mimosoideae	*Acacia filicifolia*	Fern-leaved Wattle			x												
Fabaceae/faboideae/Mimosoideae	*Acacia fimbriata*	Fringed Wattle			x												
Fabaceae/faboideae/Mimosoideae	*Acacia floribunda*	White Sally Wattle			x												

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Fabaceae/faboideae/Mimosoideae	*Acacia implexa*	Hickory Wattle							x			x					x
Fabaceae/faboideae/Mimosoideae	*Acacia irrorata* subsp. *irrorata*	Sydney Green Wattle			x	x			x	x		x				x	x
Fabaceae/faboideae/Mimosoideae	*Acacia linifolia*	White Wattle			x											x	
Fabaceae/faboideae/Mimosoideae	*Acacia longifolia* var. *longifolia*	Sydney Golden Wattle			x	x			x		x	x				x	x
Fabaceae/faboideae/Mimosoideae	*Acacia myrtifolia*	Red Stem Wattle			x	x			x			x				x	
Fabaceae/faboideae/Mimosoideae	*Acacia parramattensis*	Sydney Green Wattle			x												
Fabaceae/faboideae/Mimosoideae	*Acacia schinoides*	Green Cedar Wattle			x												
Fabaceae/faboideae/Mimosoideae	*Acacia suaveolens*	Sweet Scented Wattle			x	x			x			x				x	
Fabaceae/faboideae/Mimosoideae	*Acacia terminalis subsp. longaxilis*	Sunshine Wattle			x	x			x		x	x					
Fabaceae/faboideae/Mimosoideae	***Acacia terminalis subsp. terminalis***	**Sunshine Wattle**	**E**	**E**												x	
Fabaceae/faboideae/Mimosoideae	*Acacia trinervata*	Three Veined Wattle			x												
Fabaceae/faboideae/Mimosoideae	*Acacia ulicifolia*	Prickly Moses			x	x			x		x	x				x	x
Gentianaceae	*Centaurium erythraea**	Common Centaury				x											
Gentianaceae	*Centaurium tenuiflorum**				x												
Geraniaceae	*Erodium crinitum*	Storksbill			x												
Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern														x	
Gleicheniaceae	*Sticherus flabellatus*	Umbrella Fern														x	
Goodeniaceae	*Dampiera purpurea*	Purple Dampiera							x			x					
Goodeniaceae	*Dampiera stricta*	Blue Dampiera			x	x			x			x				x	
Goodeniaceae	*Goodenia bellidifolia*	Daisy-leaved Goodenia			x				x			x				x	
Goodeniaceae	***Goodenia glomerata***		**ROTAP**		x												
Goodeniaceae	*Goodenia hederacea* subsp. *hederacea*	Ivy-leaved Goodenia			x												
Goodeniaceae	*Goodenia heterophylla* subsp. *heterophylla*	Variable Leaved Goodenia			x	x			x	x		x				x	x
Goodeniaceae	*Goodenia ovata*	Hop Goodenia				x			x	x		x				x	
Goodeniaceae	*Goodenia paniculata*	Swamp Goodenia			x												
Goodeniaceae	*Scaevola ramosissima*	Purple Fan Flower			x	x			x			x				x	x
Haemodoraceae	*Haemodorum corymbosum*	Bloodroot			x				x			x					
Haemodoraceae	*Haemodorum planifolium*	Bloodroot				x										x	
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort							x			x				x	
Haloragaceae	*Gonocarpus teucroides*	Raspwort			x											x	x
Haloragaceae	*Myriophyllum crispatum*	Common Water Milfoil			x												
Iridaceae	*Patersonia glabrata*	Leafy Purple-flag			x	x			x			x				x	
Iridaceae	*Patersonia sericea*	Wild Iris			x	x			x			x				x	
Iridaceae	*Watsonia meriana**	Wild Watsonia														x	
Juncaceae	*Juncus cognatus**	-			x												
Juncaceae	*Juncus continuus*	-			x												
Juncaceae	*Juncus krausii*	Sea Rush														x	
Juncaceae	*Juncus mollis*				x												
Juncaceae	*Juncus polyanthemus*	-			x												
Juncaceae	*Juncus prismatocarpus*	Branching Rush			x												
Juncaceae	*Juncus sp.*	-							x			x					

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Juncaceae	*Juncus usitatus*	Common Rush			x	x										x	x
Juncaginaceae	*Triglochin procera*	Water Ribbons			x												
Lamiaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum			x					x							
Lamiaceae	*Plectranthus parviflorus*	Cockspur Flower			x												
Lamiaceae	*Prostanthera incisa*	Cut-leaf Mintbush								x							
Lamiaceae	*Prunella vulgaris**	Self Heal			x												
Lauraceae	*Cassytha glabella* forma *glabella*	Slender Devil's Twine			x	x			x	x		x				x	x
Lauraceae	*Cassytha pubescens*	Common Devil's Twine			x	x			x			x				x	x
Lauraceae	*Cinnamomum camphora**	Camphor Laurel			x											x	
Lentibulariaceae	*Utricularia biloba*	Moth Bladderwort			x												
Liliaceae	*Lilium formosanum**	Formosan Lily														x	
Lindsaeaceae	*Lindsaea linearis*	Screw Fern			x	x			x			x				x	x
Lindsaeaceae	*Lindsaea microphylla*	Lacy Wedge-fern			x	x			x			x				x	x
Lobeliaceae	*Lobelia alata*	-														x	
Lobeliaceae	*Lobelia gracillis*	Trailing Lobelia				x											
Lobeliaceae	*Pratia pedunculata*	Matted Pratia			x												
Lobeliaceae	*Pratia purpurascens*	Whiteroot			x	x			x	x		x				x	x
Loganiaceae	*Logania albiflora*	-			x				x	x		x					
Loganiaceae	*Logania pusilla*								x			x					
Lomandraceae	*Lomandra confertifolia subsp. pallida*	-							x			x					
Lomandraceae	*Lomandra cylindrica*	-														x	
Lomandraceae	*Lomandra filiformis* subsp. *coriacea*	Wattle Mat-rush							x			x				x	
Lomandraceae	*Lomandra filiformis* subsp. *filiformis*	Wattle Mat-rush			x	x			x			x				x	
Lomandraceae	*Lomandra glauca*	Pale Mat-rush														x	
Lomandraceae	*Lomandra gracilis*															x	
Lomandraceae	*Lomandra longifolia*	Spiky-headed Mat-rush			x	x			x	x		x				x	x
Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush			x	x			x			x				x	x
Lomandraceae	*Lomandra obliqua*	Twisted Mat-rush			x	x			x			x				x	x
Loranthaceae	*Dendrophthoe vitellina*	Mistletoe							x			x				x	
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry			x	x			x	x		x				x	x
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily			x	x			x			x				x	
Malvaceae	*Howittia trilocularis*					x											
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne			x											x	x
Menispermiaceae	*Sarcopetalum harveyanum*	Pearl Vine				x				x							
Menispermiaceae	*Stephania japonica* var. *discolor*	Snake Vine			x				x			x				x	
Menispermiaceae	*Stephania japonica var. japonica*	Snake Vine			x											x	
Menyanthaceae	*Villarsia exaltata*	Yellow Marsh Flower			x												
Moraceae	*Ficus coronata*	Sandpaper Fig														x	x
Myoporaceae	*Myoporum acuminatum*	Boobialla														x	
Myrsinaceae	*Myrsine howittiana*	Brush Muttonwood							x			x					
Myrsinaceae	*Rapanea variabilis* (now Myrsine variabilis)	Muttonwood				x											

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Myrtaceae	*Acmena smithii*	Lillypilly			x	x			x	x	x	x					x
Myrtaceae	*Angophora costata*	Smooth-barked Apple			x	x		x	x	x	x	x		x		x	x
Myrtaceae	*Angophora floribunda*	Rough-barked Apple							x			x					x
Myrtaceae	***Angophora inopina***	**Charmhaven Apple**	**V**	**V**					x		x	x				x	x
Myrtaceae	***Callistemon linearifolius***	**Crimson Bottlebrush**	**V**			x											
Myrtaceae	*Callistemon citrinus*	Crimson Bottlebrush															x
Myrtaceae	*Callistemon linearis*	Narrow-leaved Bottlebrush							x			x					x
Myrtaceae	*Callistemon rigidus*	Stiff Bottlebrush			x												
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush			x	x			x			x				x	x
Myrtaceae	*Corymbia gummifera*	Red Bloodwood			x	x		x	x		x	x		x		x	x
Myrtaceae	*Corymbia maculata*	Spotted Gum			x	x		x	x	x	x	x				x	x
Myrtaceae	*Eucalyptus acmenoides*	White Mahogany														x	x
Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum															x
Myrtaceae	*Eucalyptus capitellata*	Brown Stringybark			x	x		x	x		x	x		x		x	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark				x										x	
Myrtaceae	*Eucalyptus eugenioides*	Thin-leaved Stringybark														x	
Myrtaceae	***Eucalyptus fergusonii subsp dorsiventralis***	**Ferguson Ironbark**	**ROTAP**						x			x					
Myrtaceae	***Eucalyptus fergusonii subsp fergusonii***	**Ferguson Ironbark**	**ROTAP**		x												
Myrtaceae	*Eucalyptus fibrosa*	Broad Leaved Ironbark			x												x
Myrtaceae	*Eucalyptus globoidea*	White Stringybark			x			x	x		x	x				x	x
Myrtaceae	*Eucalyptus haemastoma*	Scribbly Gum			x	x		x	x		x	x		x		x	x
Myrtaceae	*Eucalyptus paniculata* subsp. *paniculata*	Grey Ironbark							x		x	x				x	x
Myrtaceae	*Eucalyptus pilularis*	Blackbutt							x			x					x
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint			x	x		x	x	x	x	x		x		x	x
Myrtaceae	*Eucalyptus punctata*	Grey Gum			x	x			x		x	x					
Myrtaceae	*Eucalyptus racemosa*	Narrow-leaved Scribbly Gum				x					x					x	
Myrtaceae	*Eucalyptus resinifera* subsp. *resinifera*	Red Mahogany			x	x		x	x		x	x				x	
Myrtaceae	*Eucalyptus robusta*	Swamp Mahogany			x	x			x	x		x				x	x
Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum			x				x			x					x
Myrtaceae	*Eucalyptus siderophloia*	Northern Grey Ironbark			x												
Myrtaceae	*Eucalyptus sparsifolia*	Narrow-leaved Stringybark			x				x			x					
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum							x			x				x	x
Myrtaceae	*Eucalyptus umbra*	Broad-leaved White Mahogany			x			x	x		x	x				x	
Myrtaceae	*Euryomyrtus ramosissima*	Rosy Baekea			x												
Myrtaceae	*Harmogia densifolia*	-			x												
Myrtaceae	*Kunzea ambigua*	Tick Bush			x	x			x			x				x	x
Myrtaceae	*Kunzea capitata*	Pink Buttons			x												
Myrtaceae	*Leptospermum juniperinum*	Prickly Tea-tree									x					x	
Myrtaceae	*Leptospermum polyanthum*				x												
Myrtaceae	*Leptospermum polygalifolium* subsp. *cismontanum*	Tantoon			x				x	x		x					
Myrtaceae	*Leptospermum polygalifolium* subsp.	Tantoon			x	x			x			x		x		x	x

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	polygalifolium																
Myrtaceae	*Leptospermum polygalifolium* subsp. *transmontanum*	Tantoon									x						
Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree			x	x		x	x		x	x		x		x	x
Myrtaceae	*Melaleuca decora*	-			x	x											
Myrtaceae	*Melaleuca linariifolia*	Snow in Summer			x				x	x	x	x				x	x
Myrtaceae	*Melaleuca nodosa*	Ball Honey Myrtle			x				x			x				x	x
Myrtaceae	*Melaleuca quinquenervia*	Broad-leaved Paperbark														x	
Myrtaceae	*Melaleuca sieberi*	-			x				x		x	x				x	x
Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree			x	x		x	x	x	x	x				x	x
Myrtaceae	*Melaleuca thymifolia*	Thyme Honey Myrtle				x										x	x
Myrtaceae	*Rhodomyrtus psidioides*	Native Guava							x			x					
Myrtaceae	*Sannantha bidwillii*	Tall Baeckea			x												
Myrtaceae	*Syncarpia glomulifera*	Turpentine			x	x			x			x				x	
Myrtaceae	*Syzygium oleosum*	Blue lillypilly			x			x			x						
Ochnaceae	*Ochna serrulata**	Mickey Mouse Plant														x	
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet			x												
Oleaceae	*Ligustrum sinense**	Small-leaved Privet			x				x			x				x	x
Oleaceae	*Notelaea longifolia*	Mock Olive			x				x	x		x				x	x
Onagraceae	*Ludwigia peploides* subsp. *montevidensis*	Water Primrose			x												
Orchidaceae	*Acianthus fornicatus*	Pixie Caps														x	
Orchidaceae	*Calochilus paludosus*	Red Beard Orchid							x			x				x	
Orchidaceae	*Cryptostylis subulata*	Large Tongue Orchid							x			x				x	
Orchidaceae	***Cymbidium suave***	**Snake Orchid**	**locally rare**				x		x			x				x	
Oxalidaceae	*Oxalis corniculata**	Yellow Wood Sorrel			x	x			x			x					
Oxalidaceae	*Oxalis perrenans*	Yellow-flowered Wood Sorrel			x				x			x				x	
Oxalidaceae	*Oxalis pes-caprae**	Soursob			x												
Philydraceae	*Philydrum lanuginosum*	Woolly Frogmouth			x											x	
Phormiaceae	*Dianella caerulea* var. *assera*	Flax Lily							x			x					
Phormiaceae	*Dianella caerulea* var. *caerulea*	Flax Lily				x										x	x
Phormiaceae	*Dianella caerulea* var. *producta*	Blue Flax Lily			x	x			x	x		x					
Phormiaceae	*Dianella longifolia*	Blue Flax Lily			x												
Phormiaceae	*Dianella revoluta* var. *revoluta*	Spreading Flax Lily							x			x					
Phytolaccaceae	*Phytolacca octandra**	Inkweed			x												
Pittosporaceae	*Billardiera scandens*	Hairy Appleberry			x	x			x			x				x	x
Pittosporaceae	*Bursaria spinosa* var. *spinosa*	Blackthorn														x	
Pittosporaceae	*Hymenosporum flavum*	Native Frangipani				x											
Pittosporaceae	*Pittosporum revolutum*	Yellow Pittosporum			x	x			x	x		x					
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum			x											x	
Plantaginaceae	*Plantago lanceolata**	Ribwort			x											x	x
Plantaginaceae	*Plantago varia*	-			x												
Poaceae	*Andropogon virginicus**	Whisky Grass				x			x			x				x	

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Poaceae	*Anisopogon avenaceus*	Oat Speargrass							x		x	x				x	
Poaceae	*Aristida ramosa*	Purple Wiregrass			x												
Poaceae	*Aristida vagans*	Three-awn Speargrass			x				x			x				x	x
Poaceae	*Aristida warburgii*	-														x	
Poaceae	*Austrodanthonia pilosa*	Velvet Wallaby Grass			x											x	
Poaceae	*Austrodanthonia tenuior*	Wallaby Grass														x	x
Poaceae	*Austrostipa mollis*															x	
Poaceae	*Austrostipa pubescens*	Tall Speargrass			x											x	x
Poaceae	*Austrostipa rudis*	Bamboo Grass			x												
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass			x												
Poaceae	*Avena fatua**	Wild Oats			x												
Poaceae	*Axonopus affinis* = A. fissifolius*	Narrow-leaved Carpet Grass							x			x					
Poaceae	*Axonopus fissifolius**	Narrow-leaved Carpet Grass															x
Poaceae	*Bothriochloa decipiens*	Redleg Grass			x												
Poaceae	*Bromus cartharticus**	Prairie Grass														x	
Poaceae	*Chloris gayana**	Rhodes Grass			x												
Poaceae	*Cortaderia selloana**	Pampas Grass			x				x			x				x	
Poaceae	*Cymbopogon refractus*	Barbwire Grass			x	x			x			x					x
Poaceae	*Cynodon dactylon**	Common Couch			x				x			x				x	x
Poaceae	*Dichelachne micrantha*	Short-hair Plume Grass				x			x			x				x	
Poaceae	*Digitaria parviflora*	Small-flowered Finger Grass							x			x					x
Poaceae	*Digitaria ramularis*	-							x			x					
Poaceae	*Echinopogon caespitosus* var. *caespitosus*	Tufted Hedgehog Grass			x											x	x
Poaceae	*Entolasia marginata*	Bordered Panic			x	x			x	x		x				x	x
Poaceae	*Entolasia stricta*	Wiry Panic			x			x	x	x	x	x		x		x	x
Poaceae	*Eragrostis brownii*	Brown's Lovegrass			x				x			x				x	x
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass			x												
Poaceae	*Glyceria maxima**	Reed Sweetgrass			x												
Poaceae	*Hyparrhenia hirta**	Coolatai Grass															x
Poaceae	*Imperata cylindrica*	Blady Grass			x	x		x	x		x	x		x		x	x
Poaceae	*Joycea pallida*	Silvertop Wallaby Grass						x			x						
Poaceae	*Lolium perrenne**	Perennial Ryegrass															x
Poaceae	*Melinis repens**	Red Natal Grass			x				x			x					
Poaceae	*Microlaena stipoides* var. *stipoides*	Weeping Rice Grass			x				x			x				x	
Poaceae	*Oplismenus aemulus*	Basket Grass				x			x	x		x				x	x
Poaceae	*Oplismenus imbecillis*	-			x				x			x					
Poaceae	*Panicum simile*	Two Colour Panic							x			x				x	x
Poaceae	*Paspalidium distans*	-							x			x					
Poaceae	*Paspalum dilatatum**	Paspalum			x	x											x
Poaceae	*Paspalum urvillei**	Vasey Grass				x										x	
Poaceae	*Pennisetum clandestinum**	Kikuyu			x											x	

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Poaceae	*Phragmites australis*	Common Reed														x	
Poaceae	*Poa labillardieri* var. *labillardieri*	Tussock Grass														x	
Poaceae	*Poa seiberiana*	Tussock Grass							x			x					
Poaceae	*Setaria gracilis**	Slender Pigeon Grass														x	x
Poaceae	*Setaria pumila**	Pale Pigeon Grass			x												
Poaceae	*Setaria sphacelata**	South African Pigeon Grass														x	
Poaceae	*Sporobolus virginicus*	Sand Couch														x	
Poaceae	*Stenotaphrum secundatum**	Buffalo Grass														x	
Poaceae	*Tetrarrhena sp.*								x			x					
Poaceae	*Themeda australis*	Kangaroo Grass			x	x		x	x		x	x				x	x
Polygalaceae	*Comesperma ericinum*	Pyramid Flower			x	x			x			x				x	
Polygonaceae	*Persicaria decipiens*	Slender Knotweed			x	x											
Polygonaceae	*Persicaria lapathifolia*	Pale Knotweed			x												
Polygonaceae	*Persicaria strigosa*	-							x			x					
Polygonaceae	*Rumex crispus**	Curled Dock														x	
Potamogetonaceae	*Potamogeton tricarinatus*				x												
Primulaceae	*Anagallis arvensis**	Scarlet Pimpernel			x												
Primulaceae	*Samolus repens*	Creeping Brookweed														x	
Proteaceae	*Banksia aemula*	Wallum Banksia			x												
Proteaceae	*Banksia cunninghamii subsp. cunninghamii*	-							x			x					
Proteaceae	*Banksia oblongifolia*	Fern-leaf Banksia				x			x		x	x		x		x	
Proteaceae	*Banksia serrata*	Old Man Banksia				x										x	
Proteaceae	*Banksia spinulosa*	Hairpin Banksia				x		x			x			x		x	x
Proteaceae	*Banksia spinulosa* var. *collina*	Hairpin Banksia			x												
Proteaceae	*Banksia spinulosa* var. *spinulosa*	Hairpin Banksia			x				x			x					
Proteaceae	*Grevillea buxifolia* subsp. *buxifolia*	Grey Spider Flower			x												
Proteaceae	*Grevillea linearifolia*	White Spider Flower			x											x	
Proteaceae	***Grevillea parviflora* subsp. *parviflora***	**Small-flower Grevillea**	**V**	**V**			x	x	x		x	x	x			x	x
Proteaceae	*Grevillea sericea*	Pink Spider Flower			x			x	x			x				x	x
Proteaceae	***Hakea bakeriana***	**-**	**ROTAP**		x	x	x		x		x	x		x		x	x
Proteaceae	*Hakea dactyloides*	Broad-leaved Hakea			x	x			x			x				x	
Proteaceae	*Hakea gibbosa*	Needlebush			x												
Proteaceae	*Hakea laevipes*										x						
Proteaceae	*Hakea salicifolia*	Willow Hakea				x											
Proteaceae	*Hakea sericea*	Needlebush			x											x	x
Proteaceae	*Hakea teretifolia*	Dagger Hakea			x											x	
Proteaceae	*Isopogon anemonifolius*	Flat-leaved Drumsticks			x	x			x		x	x		x		x	
Proteaceae	*Lambertia formosa*	Mountain Devil			x	x		x	x		x	x		x		x	x
Proteaceae	*Lomatia silaifolia*	Crinkle Bush			x	x			x			x				x	x
Proteaceae	*Persoonia lanceolata*	Lance-leaved Geebung														x	
Proteaceae	*Persoonia laurina*	Laurel Geebung							x			x					

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Proteaceae	*Persoonia levis*	Broad-leaved Geebung			x	x			x		x	x				x	x
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung			x	x			x	x		x				x	x
Proteaceae	*Petrophile pulchella*	Conesticks			x											x	
Proteaceae	*Xylomelum pyriforme*	Woody Pear			x	x			x			x				x	
Ranunculaceae	*Clematis aristata*	Old Man's Beard				x				x							x
Ranunculaceae	*Ranunculus inundatus*	River Buttercup			x												
Ranunculaceae	*Ranunculus muricatus**	Sharp Buttercup														x	
Ranunculaceae	*Ranunculus repens**	Creeping Buttercup			x												
Restionaceae	*Baloskion tetraphyllum* subsp. *meiostachyum*	Plume Rush			x												
Restionaceae	*Empodisma minus*	-			x						x						
Restionaceae	*Leptocarpus tenax*	Slender Twine-rush			x												
Restionaceae	*Lepyrodia scariosa*	Scale Rush			x				x			x				x	
Restionaceae	*Sporadanthus gracilis*	Slender Scale-rush			x												
Rhamnaceae	*Pomaderris elliptica*	-								x							
Rosaceae	*Rubus fruticosus* species aggregate*	Blackberry			x	x			x			x				x	x
Rosaceae	*Rubus moluccanus* var. *trilobus*	Native Raspberry			x	x											
Rosaceae	*Rubus ulmifolius**	Blackberry														x	
Rubiaceae	*Asperula conferta*	Common Woodruff			x												
Rubiaceae	*Galium binifolium*	-							x			x					
Rubiaceae	*Morinda jasminoides*	Sweet Morinda				x			x	x		x					x
Rubiaceae	*Opercularia aspera*	Common Stinkweed														x	
Rubiaceae	*Opercularia diphylla*	-			x				x			x				x	
Rubiaceae	*Opercularia varia*	Variable Stinkweed			x											x	
Rubiaceae	*Pomax umbellata*	Pomax			x	x			x			x				x	x
Rubiaceae	*Richardia brasiliensis**	White Eye															x
Rutaceae	*Boronia ledifolia*	Sydney Boronia			x												
Rutaceae	*Boronia pinnata*	Pinnate Boronia			x												
Rutaceae	*Boronia polygalifolia*	Dwarf Boronia							x			x				x	
Rutaceae	*Eriostemon australasius*	Pink Wax Flower			x												
Rutaceae	*Eriostemon myoporoides* subsp. *myoporides*	Long-leaved Wax Flower			x												
Rutaceae	*Phebalium squamulosum* subsp. *squamulosum*	Forest Phebalium			x												
Rutaceae	*Zieria smithii*	Sandfly Zieria															x
Santalaceae	*Exocarpos cupressiformis*	Native Cherry			x	x			x			x					
Sapindaceae	*Dodonaea triquetra*	Hop-bush			x	x		x	x	x	x	x				x	x
Schizaeaceae	*Schizaea bifida*	Forked Comb-fern							x			x				x	x
Scrophulariaceae	*Verbascum virgatum**	Twiggy Muellein															x
Scrophulariaceae	*Veronica plebia*	Creeping Speedwell			x				x			x					
Selaginallaceae	*Selaginella uliginosa*	Swamp Selaginella			x												
Sinopteridaceae	*Cheilanthes sieberi* subsp. *sieberi*	Poison Rock Fern			x				x			x				x	x
Smilacaceae	*Smilax australis*	Lawyer Vine			x	x			x	x		x				x	x
Smilacaceae	*Smilax glyciphylla*	Sarsaparilla			x			x		x						x	

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Solanaceae	*Duboisia myoporoides*	Corkwood			x					x							
Solanaceae	*Solanum mauritianum**	Wild Tobacco								x						x	
Solanaceae	*Solanum nigrum**	Black Nightshade			x												
Solanaceae	*Solanum pseudocapsicum**	Jerusalem Cherry			x												
Stackhousiae	*Stackhousia viminea*	Slender Stackhousia			x											x	
Sterculiaceae	*Commersonia fraseri*	Brush Kurrajong			x	x											
Sterculiaceae	*Rulingia dasyphylla*	Kerrawang			x												
Stylidiaceae	*Stylidium graminifolium*	Grass Trigger Plant														x	
Stylidiaceae	*Stylidium lineare*	Narrow-leaved Trigger Plant							x			x					
Thelypteridaceae	*Christella dentata*	Binung								x						x	
Thymelaeaceae	*Pimelea linifolia* subsp. *linifolia*	Slender Rice Flower			x	x			x			x				x	x
Tremandraceae	*Tetratheca ericifolia*	Black-eyed Susan				x											
Tremandraceae	***Tetratheca juncea***	**Black-eyed Susan**	**V**	**V**	x	x	x	x	x		x	x	x			x	
Tremandraceae	*Tetratheca thymifolia*	Black-eyed Susan							x			x				x	x
Typhaceae	*Typha orientalis*	Cumbungi			x	x										x	
Uvulariaceae	*Schelhammera undulata*	Lilac Lily														x	
Verbenaceae	*Lantana camara**	Lantana			x	x			x			x				x	
Verbenaceae	*Verbena bonariensis**	Purpletop			x											x	
Verbenaceae	*Verbena rigida**	Veined Verbena			x											x	x
Violaceae	*Hybanthus monopetalus*	Slender Violet														x	
Violaceae	*Viola hederacea*	Ivy-leaved Violet			x	x			x			x				x	
Vitaceae	*Cissus hypoglauca*	Water Vine				x											
Xanthorrhoaceae	*Xanthorrhoea fulva*	-							x			x					
Xanthorrhoaceae	*Xanthorrhoea latifolia*	-									x			x		x	x
Xanthorrhoaceae	*Xanthorrhoea latifolia* subsp. *latifolia*	-			x												
Xanthorrhoaceae	*Xanthorrhoea macronema*	-						x	x			x				x	x
Xanthorrhoaceae	*Xanthorrhoea media*	Forest Grass Tree			x												
Xanthorrhoaceae	*Xanthorrhoea minor* subsp. *minor*	-				x											
Xanthorrhoaceae	*Xanthorrhoea sp.*	-							x			x				x	x
Zamiaceae	*Macrozamia communis*	Burrawang				x										x	
Zamiaceae	***Macrozamia flexuosa***	**-**	**ROTAP**		x		x		x			x				x	

Appendix 3

TSC Act Assessment of Significance (7-Part Test)

As per the assessment carried out within Table 6-1, the following species / communities have been applied further detailed assessment via the application of 7-part tests due to potential levels of impacts likely to result from the proposal.

Threatened Flora

- *Acacia bynoeana* (Bynoe's Wattle);
- *Angophora inopina* (Charmhaven Apple);
- *Callistemon linearifolius* (Netted Bottlebrush);
- *Corybas dowlingii* (Red Helmet Orchid);
- *Cryptostylis hunteriana* (Leafless-tongue Orchid);
- *Diuris praecox* (Rough Doubletail)
- *Grevillea parviflora* subsp *parviflora* (Small-flowered Grevillea); and
- *Tetratheca juncea* (Black-eyed Susan).

Endangered Ecological Communities

- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

Threatened Fauna

- Stephen's Banded Snake (*Hoplocephalus stephensii*);
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*);
- Regent Honeyeater (*Anthochaera phrygia*);
- Swift Parrot (*Lathamus discolor*);
- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*);
- Sooty Owl (*Tyto tenebricosa*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- Little Lorikeet (*Glossopsitta pusilla*);
- Spotted Tail Quoll (*Dasyurus maculatus*);
- Squirrel Glider (*Petaurus norfolcensis*);
- Large eared Pied Bat (*Chalinolobus dwyeri*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Eastern Bentwing-bat (*Miniopterus schreibersiioceanensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*);
- Southern Myotis (*Myotis macropus*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

a) **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

Threatened Flora

Ecological surveys have recorded *Acacia bynoeana*, *Angophora inopina*, *Grevillea parviflora* and *Tetratheca juncea* occurring within the southern areas of the site. The majority of these recorded species occur within the Scribbly Gum woodland community. Approximately 108.577ha of Scribbly Gum woodland occurs throughout the site. The remaining four species are considered to have potential habitat within the forested areas of the SMP Study Area. The proposed action is likely to produce some minor surface cracking, with subsidence ranging between 20-1200mm expected to occur (MSEC 2012). This may result in minor changes to hydrology and minor soil disturbances. In some areas remediation work of the surface cracking and other subsidence may be required however it is considered that most cracks will be minor and self-healing. The effects of these minor surface impacts are considered unlikely to cause a decline in any of the flora species considered such that a viable local population of these species is likely to be placed at risk of extinction.

The expected subsidence of a maximum of 1200 mm (MSEC 2012) may have an effect on riparian and poorly drained areas by causing additional ponding. This may have minor localised impacts on potential habitat for *Cryptostylis hunteriana*, however given that this species has not been recorded and can occur in a range of habitat types, the amount of potential habitat to be influenced by the predicted effects of subsidence would be minor. The influence of localised ponding may also not result in the degradation of habitat for Cryptostylis hunteriana where such ponding is ephemeral, as this species is known to tolerate damp habitats. If present, the impacts upon this species or potential habitat are not expected cause a significant impact such that a viable local population of this species is likely to be placed at risk of extinction.

Threatened Fauna

The vegetation within the site provides potential habitat for habitat number of threatened fauna species, as listed above. The proposal is likely to cause subsidence impacts of a maximum of 1200 mm. Minor surface cracking or subsidence ranging between 20-1200mm is not expected to greatly alter these habitat attributes for these species. Thus it is unlikely that the proposal will affect the life cycle of the fauna on site such that a viable local population of any species is likely to be placed at risk of extinction.

b) **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,**

There was no endangered population considered to have a potential of occurring within the study area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Swamp Sclerophyll Forest has an open to dense tree layer of eucalypts and paperbarks. The vegetation composition described for this EEC was found to correspond to Map Unit 37 and occurs in a number drainage lines within the study area (29.1ha). The proposed action is likely to produce some minor surface cracking, with subsidence ranging between 20-1200mm expected to occur. This may cause slight localised alterations in hydrology, such as ponding (MSEC 2012), however is not expected to affect the survival of vegetation that comprise this community. In some areas remediation work of the surface cracking may be required however it is considered that most cracks will be minor and self-healing. Thus it is unlikely that the proposal will effect or modify the extent or composition of the Swamp Sclerophyll Forest such that its local occurrence is likely to be placed at risk of extinction.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed,

The proposal is for an underground longwall mine. The extent to which habitat for this species is likely to be removed or modified as a result of the action proposed is none.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal is for an underground longwall mine. Thus, no area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The proposal is for an underground longwall mine. Thus, no areas of habitat for this species are likely to be removed, modified, fragmented or isolated such as to threaten the long-term survival of threatened species or ecological communities in the locality.

e) **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat for any threatened species does not occur within the study area. Therefore the action proposed is unlikely to have an adverse effect on critical habitat (either directly or indirectly).

f) **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,**

Of the threatened species under consideration for this study area, none of the species had a recovery plans or threat abatement plan (except for the species assessed below).

Forest Owls

- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*); and
- Sooty Owl (*Tyto tenebricosa*).

The proposed action is unlikely to contravene any objectives or actions necessary to maintain the local population of these threatened species.

g) **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

The KTP relevant to the project is “Subsidence due to Longwall Mining”. The proposed mining is expected to result in subsidence with a maximum of 1200 mm as determined by MSEC (2012). The proposal will cause subsidence and therefore will enact this KTP.

Conclusion

The above seven-part tests have been conducted for threatened flora and fauna species and the EEC recorded or considered likely to occur within the site. The results of this assessment have concluded that the proposal will not have a significant impact on threatened species or the EEC, due to the proposal being an underground longwall mine, which is not expected to affect the habitats for which these species are reliant upon.

Appendix 4

EPBC Act: Assessments of Significance

Table 4- 1: Assessment of Significance for Vulnerable species

Significant Impacts	*Acacia bynoeana*	*Angophora inopina*	*Cryptostylis hunteriana*	*Grevillea parviflora var parviflora*	*Tetratheca juncea*	Grey-headed Flying-fox	Large-eared Pied-bat
Lead to a long-term decrease in the size of an important population.	**No.** The impacts of subsidence are not expected to lead to a long-term decrease in the size of an important population as this species can continue residing in affected areas without impact.	**No.** The impacts of subsidence are not expected to lead to a long-term decrease in the size of an important population as this species can continue residing in affected areas without impact.	**No.** This species was not recorded on site however if a population was in the area of subsidence it would not experience an impact such that it would experience a decrease in population size.	**No.** The impacts of subsidence are not expected to lead to a long-term decrease in the size of an important population as this species can continue residing in affected areas without impact.	**No.** The impacts of subsidence are not expected to lead to a long-term decrease in the size of an important population as this species can continue residing in affected areas without impact.	**No.** This species is highly mobile and will not be losing any suitable habitat due to the proposed activities on site. Therefore no long-term decrease in population size will occur.	**No.** The proposed activity will result in subsidence of a minimum 20mm will not affect the habitat of this species. Suitable habitat is also available for this species in surrounding vegetation. Therefore no long-term decrease in the size of a population will result from the proposed activities.
Reduce the area of occupancy of the species.	**No.** The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.	**No.** The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.	**No**. This species was not recorded on site so it is unlikely that its area of occupancy on site will be reduced as a result of the proposed activities.	**No.** The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.	**No.** The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.	**No.** The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.	**No**. The occupied area available to this species will not be reduced regardless of potential subsidence occurring on site.
Fragment an existing important population into two or more populations.	**No.** The populations that exist on site will not be impacted so that fragmentation of populations occurs.	**No.** The populations that exist on site will not be impacted so that fragmentation of populations occurs.	**No.** No existing populations are known on site so it is unlikely that any populations will be fragmented as a result of this project.	**No.** The populations that exist on site will not be impacted so that fragmentation of populations occurs.	**No.** The populations that exist on site will not be impacted so that fragmentation of populations occurs.	**No.** No clearing will be occurring and this species is highly mobile therefore no populations will be fragmented.	**No.** No clearing will be occurring and this species is highly mobile therefore no populations will be fragmented.
Adversely affect habitat critical to the survival of a species.	**No.** The subsidence impacts involved in this project will not affect critical habitat for this species.	**No.** The subsidence impacts involved in this project will not affect critical habitat for this species.	**No.** Critical habitat is not known on site however the subsidence impact will not be affecting any suitable habitat for this species that could adversely affect its' survival.	**No.** The subsidence impacts involved in this project will not affect critical habitat for this species.	**No.** The subsidence impacts involved in this project will not affect critical habitat for this species.	**No.** This species is highly mobile and critical habitat for this species survival does not exist on site.	**No.** This species is highly mobile and critical habitat for this species survival does not exist on site.
Disrupt the breeding cycle of a population.	**No.** If this species is present, breeding cycles will remain functional regardless of the subsidence occurrence as a result of this proposal.	**No.** If this species is present, breeding cycles will remain functional regardless of the subsidence occurrence as a result of this proposal.	**No.** If this species is present, breeding cycles will remain functional regardless of the subsidence occurrence as a result of this proposal.	**No.** If this species is present, breeding cycles will remain functional regardless of the subsidence occurrence as a result of this proposal.	**No.** If this species is present, breeding cycles will remain functional regardless of the subsidence occurrence as a result of this proposal.	**No**. The area is mainly used for foraging not breeding and this species is capable of moving to other nearby areas easily if required.	**No.** There is suitable habitat in surrounding areas to support the breeding of this species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** The maximum expected subsidence is not expected to destroy and/or modify habitat so that the species is likely to decline.	**No.** The maximum expected subsidence is not expected to destroy and/or modify habitat so that the species is likely to decline.	**No.** The maximum expected subsidence is not expected to destroy and/or modify habitat so that the species is likely to decline.	**No.** The maximum expected subsidence is not expected to destroy and/or modify habitat so that the species is likely to decline.	**No.** The maximum expected subsidence is not expected to destroy and/or modify habitat so that the species is likely to decline.	**No.** Maximum subsidence of 1200mm will not modify, destroy or remove habitat so that the species will decline.	**No.** Maximum subsidence of 1200mm will not modify, destroy or remove habitat so that the species will decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.
Introduce disease that may cause the species to decline.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.
Interfere substantially with the recovery of the species.	**No.** The maximum subsidence is not expected to impact on this species therefore it will not interfere substantially with the recovery of this species.	**No.** The maximum subsidence is not expected to impact on this species therefore it will not interfere substantially with the recovery of this species.	**No.** The maximum subsidence is not expected to impact on this species therefore it will not interfere substantially with the recovery of this species.	**No.** The maximum subsidence is not expected to impact on this species therefore it will not interfere substantially with the recovery of this species.	**No.** The maximum subsidence is not expected to impact on this species therefore it will not interfere substantially with the recovery of this species.	**No.** No there is suitable habitat for this species in surrounding areas and this species is highly mobile-capable of moving freely to available habitat. Therefore the proposed activity will not interfere substantially with the recovery of this species.	**No.** No there is suitable habitat for this species in surrounding areas and this species is highly mobile-capable of moving freely to available habitat. Therefore the proposed activity will not interfere substantially with the recovery of this species.

Table 4- 2: Assessment of Significance for Endangered Species

Significant Impacts	Regent Honeyeater	Swift Parrot	Spotted-tail Quoll
Lead to a long-term decrease in the size of a population.	**No.** Foraging habitat on site for this species will not be affected and suitable habitat is available in surrounding areas, therefore the proposed activities will not lead to a long-term decrease in the size of a population.	**No.** Foraging habitat on site for this species will not be affected and suitable habitat is available in surrounding areas, therefore the proposed activities will not lead to a long-term decrease in the size of a population.	**No.** Habitat for this species will not be affected by the subsidence impacts so that a decrease in population size occurs.
Reduce the area of occupancy of the species.	**No.** This species is still capable of occupying the area, whilst utilising foraging resources and shelter adjacent to the affected area.	**No.** This species is still capable of occupying the area, whilst utilising foraging resources and shelter adjacent to the affected area.	**No.** This species will still be capable of occupying the area during the proposed activities.
Fragment an existing important population into two or more populations.	**No.** This species is highly mobile and nomadic in its behaviour. The affected area is surrounded by extensive areas of potential habitat for this species.	**No.** This species is highly mobile and migratory. The affected area is surrounded by extensive areas of potential habitat for this species.	**No.** This species will still be capable of occupying the area during the proposed activities; therefore no fragmentation of existing populations will occur.
Adversely affect habitat critical to the survival of a species.	**No.** The area affected is not considered critical habitat and is unlikely to affect the survival of this species.	**No.** The area affected is not considered critical habitat and is unlikely to affect the survival of this species.	**No.** The area affected is not considered critical habitat and is unlikely to affect the survival of this species.
Disrupt the breeding cycle of a population.	**No.** The subsidence impact on this species habitat is unlikely to affect this species ability in the area, given the abundance of suitable habitat surrounding the site.	**No.** This species only breeds in Tasmania.	**No.** This species will continue to conduct natural behaviours including breeding despite the proposed activities occurring.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** Sufficient habitat for this species exists around the site, therefore the proposed activities will not decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** Sufficient habitat for this species exists around the site; therefore the proposed activities will not decrease the availability or quality of habitat to the extent that the species is likely to decline.	**No.** Sufficient habitat for this species exists around the site; therefore the proposed activities will not decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.	**No.** It is unlikely that the affected area will experience an increase in non native species due to the proposed activities.
Introduce disease that may cause the species to decline.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.	**No.** The proposed activity is unlikely to lead to an introduced disease to the area.
Interfere with the recovery of the species.	**No.** The impact of proposed activities will not reduce habitat or interfere with the behaviour of this species therefore not interfering with this species' recovery.	**No.** The impact of proposed activities will not reduce habitat or interfere with the behaviour of this species therefore not interfering with this species' recovery.	**No.** The impact of proposed activities will not reduce habitat or interfere with the behaviour of this species therefore not interfering with this species' recovery.

Conclusion

The above EPBC test of significance tests have been conducted for EPBC listed flora and fauna species recorded or considered likely to occur within the site. The results of this assessment have concluded that the proposal is unlikely to have a significant impact on threatened species, due to the proposal being an underground longwall mine, which is not expected to affect the habitats for which these species are reliant upon.

Appendix 5

Qualifications

RPS

Curriculum Vitae

TOBY LAMBERT

Principal Ecologist

Newcastle, NSW

Bachelor of Environmental Science, University of Newcastle, 1993 - 1996

Accredited BioBanking Assessor, Tafe NSW – Ryde, 2009

NSW Driver's Licence (Class C)

OH&S Induction Training (Green Card)

NPWS Scientific Investigation Licence and NSW Animal Ethics Research Authority

AREAS OF EXPERTISE:

Toby has over fifteen years experience in undertaking and managing a diverse array of ecological and environmental surveys and assessments. As a Principal Ecologist, he supervises all facets of flora and fauna assessment and related reports: planning, supervision of field and reporting staff, project scheduling, budget management, liaising with clients and Government departments and providing advice of all kinds. He has also been called upon to prepare expert evidence for matters at the NSW Land and Environment Court. Toby has produced ecological and environmental documentation for private and public projects ranging in complexity. These include a number of wind farms throughout Australia and New Zealand, coal mines and a range of infrastructure projects within the Hunter region. Toby has also managed ecological master planning for residential projects in Sydney, the Central Coast and the Hunter. Toby's fields of expertise are Environmental Impact Assessment and mediation, flora, fauna and habitat survey method, design and identification, detailed understanding of legislation and threatened species issues, terrestrial fauna surveys and project management. He has experience in conducting comprehensive fauna surveys and preparing related documentation in a broad array of environments throughout New South Wales, with most projects located in the greater Sydney area, Mid-West, Blue Mountains, Central Coast, Hunter and Forster / Great Lakes regions. Toby has also undertaken ecological projects in Western Australia, Queensland, the ACT and New Zealand.

SELECTED PROJECT EXPERIENCE:

Ecology

- **Centennial Coal -** Environmental Project Manager for consultancy works to Centennial Coal covering a broad range of disciplines, but primarily focussed on ecological impact assessments, monitoring and management at numerous coal mines in the Mid-West, western Blue Mountains and Lake Macquarie NSW.
- **Peabody Energy Australia -** Senior Project Manager for project specific and ongoing monitoring requirements for Wambo Coal Mine at Warkworth in the Upper Hunter Valley, Toby liases directly with the Environmental Manager of the mine in relation to requirements to fulfil consent conditions for the ongoing development and operation of the project.
- **Allco Wind Energy -** This involved undertaking fauna surveys for a 100 turbine wind farm on the North Island of New Zealand and coordinating other ecological specialists to prepare an ecological impact assessment for submission to Taranaki Council. Aspects included regular liason with the Department of Conservation regarding issues of significance, survey methodology, and mitigation and management measures to protect significant ecological features. Local bird groups were also involved and Toby was involved in the public consultation sessions.
- **Stockland Wallarah Peninsula -** This Lake Macquarie, NSW project required a multi-disciplinary approach to an innovative residential proposal on environmentally sensitive land. Project management of, and participation in, a large and diverse planning team were major features of this work. Toby was a pivotal member of the

project management team that provided the detailed ecological input and advice that was required from the early stages of the planning process to the point of submission to determining authorities. The proposal required sophisticated and creative impact assessment and reporting. Toby made a major contribution to the production of a series of comprehensive ecological reports that ensured the ecological integrity of the site was maintained in the post-development landscape.

- **Hunter Economic Zone Industrial Estate -** Project Manager for the environmental component of the development of the Hunter Economic Zone industrial estate at Kurri Kurri, to be the largest industrial estate in NSW.

PREVIOUS EXPERIENCE:

Senior Project Manager - Cumberland Ecology, Epping **2005**
Duties included flora and fauna surveying and survey design; overseeing and contribution to the preparation of complex ecological and environmental reports for both small and large projects; flora and fauna surveying and survey design; liaison with both the private sector and federal, state and local government departments.

Principal Consultant / Co-Founder - Keystone Ecological, Kariong **2004 - 2005**
Preparation and development of Keystone Ecological Flora and Fauna Impact Assessment report format; development of client database, including organisation of promotional material, logo design and customer relations; administration including preparation of quotes and invoices and organising accounts and BAS statements; Flora and fauna surveying and survey design; along with Anabat II Data Analysis.

Project Manager - Ecology - Conacher Travers Environmental, Somersby **1998 - 2004**
Supervision of flora and fauna survey design; report quality control; production of technical reports such as Review of Environmental Factors, Flora & Fauna Assessments, Statement of Environmental Effects, Species Impact Statements and Plans of Management, Land and Environment Court Evidence preparation, EPBC Act Referrals and Preliminary Information preparation; Flora & fauna surveying; liaison with Department of Environment and Conservation, Department of Environment and Heritage, Department of Infrastructure, Planning and Natural Resources, Department of Agriculture, Local Governments and private clients; Anabat II Data Analysis; Water Testing; Data Recording and Statistical Analysis.

Volunteer for Green and Golden Bell Frog Survey - Australian Museum, North Avoca **1999 - 2001**
Survey and searches for the endangered species Green & Golden Bell Frog; assisting in weighing, measuring and micro-chipping frogs for on-going research purposes.

Environmental Scientist - Australian Defence Industries (ADI), St Marys **1998**
Bore Water Sampling; statistical analysis of test results; and report production.

Environmental Scientist - Anne Clements & Associates, North Sydney **1997**
Field Assistant to Botanist and data recording.

Research Assistant - University of Newcastle **1996**
Initiation of design of final year project for Biology Dept; research into fire regimes on species composition & regeneration in open woodland; use of advanced scientific equipment including infra red gas analyser in the field, and replication of experiments using computer database; theoretical knowledge on soils, nutrient cycles & vegetation types.

MEMBERSHIPS & ACHIEVEMENTS:

- Ecological Consultants Association of NSW (ECA) – Council Member
- Newcastle Green Drinks for Environmental Professionals organising committee

Curriculum Vitae

PAUL HILLIER

Senior Ecologist

Newcastle, NSW

Bachelor of Environmental Science (Environmental Management)

NSW Driver's Licence (Class C)

OH&S Induction Training (White Card)

Senior First Aid

Dive Master (PADI Scuba Diver)

AREAS OF EXPERTISE:

Paul has broad range of Ecological Assessment reporting experience from 8 years of professional ecological work both in Australia and abroad. Project experience has primarily included a range of flora and fauna assessment disciplines as required by a wide range of corporate and domestic client requirements. Paul has been employed both within the private and public sector, providing a strong knowledge and understanding of the role of both developers and government in legislation and planning.

Paul has the majority of his experience within the consultancy industry, primarily focussing on the preparation of Flora and Fauna Assessments, Environmental Assessments, Environmental Impact Statements, Review of Environmental Factors and Statement of Environmental Effects. Paul has experience with targeted threatened flora and fauna surveys, including a strong knowledge of Geographic Information Systems mapping and analyses.

SELECTED PROJECT EXPERIENCE:

Ecology

- **Ecological Constraints Master Plan** – Huntlee, Singleton and Cessnock, NSW (2007-2010)
- **Ecosystem Function Analysis** – Wambo Coal, Singleton NSW (2010).
- **Ecological Assessment Report** – White Rock Wind Farm, Glen Innes, NSW (2011).

PREVIOUS EXPERIENCE:

Ecological Records Officer – West Yorkshire Ecology **(2007-2009)**
Duties included collection and collation of ecological records from across West Yorkshire, United Kingdom; Preparation of fee proposals for ecological services; GIS/ spatial analysis and database management; Database searches and reporting; Liaison with client, stakeholder groups, state and local governing bodies; Review of local planning applications and consequent consultations to local councils.

Ecologist – Harper Somers O'Sullivan **(2004-2006)**
Duties included flora and fauna surveying and survey design; overseeing and contribution to the preparation of complex ecological and environmental reports for both small and large projects; liaison with both the private sector and federal, state and local government department.

MEMBERSHIPS & ACHIEVEMENTS:

- For Australian Wildlife Needing Aid (FAWNA), NSW Australia

Curriculum Vitae

ROB SANSOM

Botanist/Ecologist

Newcastle, NSW

Bachelor of Science (Hons), University of New England

AREAS OF EXPERTISE:

Robert has over eleven years experience in undertaking a diverse array of ecological and environmental surveys and assessments. Rob has also produced or sourced background information on ecological and environmental matters for use by expert witnesses in support of clients in the NSW Land and Environment Court.

Rob's fields of special competence are Threatened Flora species searches; Threatened Flora, Vegetation and Bushland Management Plans; delineation and GPS plotting of Vegetation Community boundaries; and species / community / wetland monitoring surveys and reporting.

- Environmental and ecological impact assessment, monitoring and reporting
- Terrestrial flora and habitat survey design, execution, analysis and reporting
- Spatial mapping of vegetation and threatened flora species using differentially corrected
- GPS accurate to less than 1 metre
- Understanding of threatened species legislation, issues and requirements
- Bushland and vegetation management planning and monitoring
- Threatened Flora Management Plans and Monitoring
- Bushfire Threat Assessments
- Production of a wide variety of reports and assessments
- Targeted threatened flora surveys
- Flora identification and habitat assessment
- Delineation and GPS mapping of vegetation community boundaries
- Ecological Community quality assessments and reports
- Experience in PATN Statistical package

SELECTED PROJECT EXPERIENCE:

Mining

- **Angus Place** – Flora and Fauna Impact Assessment for proposed longwall mining. Includes vegetation surveys, Community Mapping, Flora Species Identification and assessment under the NSW Threatened Species Conservation Act 1995, (TSC Act 1995) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, (EPBC Act 1999).

- **Bulga Mine Refuelling Facility** – Flora and Fauna Impact Assessment including field survey, vegetation community mapping, flora species identification, writing of Flora and Fauna Assessment to address the requirements of the TSC Act (1995) and the EPBC Act (1999).

Infrastucture

- **Transgrid - Mangrove Mountain** – Targeted searches for threatened flora species (*Tetratheca glandulosa* and *Prostanthera junonis*) prior to regular maintenance of high voltage power line easements, mark-up and mapping of locations, population extent and counts.

- **Transgrid - Bulga** – Targeted searches for threatened flora species and endangered ecological communities prior to regular maintenance of high voltage power line easements, mark-up and mapping of locations and extent. Flora and Fauna Assessment to address the requirements of the TSC Act (1995) and the EPBC Act (1999).

- **Wallarah Peninsula** – Searches for Threatened species (*Tetratheca juncea, Syzygium paniculatum* and *Grevillea parviflora*) for proposed water supply and sewer lines.

Monitoring

- **Karuah** – Annual monitoring flora and fauna surveys and reporting for a Hard Rock Quarry and Processing Plant.
- **Wambo Coal Mine** – 2 yrs annual surveys and field works associated with Landscape Function Analysis (LFA) of rehabilitated areas.

Vegetation Management

- **Cliftleigh** – Vegetation Management Plan for riparian / constructed wetland area associated with large residential development.
- **Cessnock** – Vegetation Management Plan for proposed residential development and upgrade to golf course.
- **Newnes Junction** – Flora and Fauna Management Plan for proposed sand extraction quarry.

PREVIOUS EXPERIENCE:

Botanist – Conacher Travers Pty Ltd **(12 years)**
Involved in the production of a wide assortment of ecological reports such as Flora and Fauna Assessments (FFA), Environmental Impact Assessments (EIS), Review of Environmental Factors (REF), Bush Fire Assessments (BFA) Vegetation Management Plans (VMP), Annual Monitoring Reports (AMR) and Species Impact Statements (SIS). Responsible for flora surveys, vegetation community mapping, flora species identification and flora input into reports. Also responsible for acquiring ecological data and maintaining this data to the most up-to-date status.

Botanist – Conacher Environmental Group **(1$^{1}/_{2}$ years)**
Small Project coordinator; Botanist; Data acquisition, management, manipulation and Statistical analysis. Production of a a wide variety of Reports such as FFAs, BFAs, EIS, REFs, VMPs AMR, and SIS.

Botanist / Ecologist – RPS Australia East Pty Ltd **(1 year)**
Undertaking flora and fauna field surveys, Monitoring, Land Function Analysis (LFA) and a wide variety of reports for various purposes and types of clients.

MEMBERSHIPS & ACHIEVEMENTS:

- OH&S Induction Training (Green Card)
- NPWS Scientific Investigation Licence
- NSW Animal Ethics Research Authority
- Planning for Bushfire Prone Areas (Short course)
- Trimble Short Course – Using Trimble Hand-held GPS Datalogger with Terrasync software and desktop Pathfinder Software.
- Erosion and Sediment Control – Fundamentals of Erosion and Sediment Control (Short course)

Curriculum Vitae

LAUREN VANDERWYK

Graduate Ecologist

Newcastle, NSW

Bachelor of Science, University of Newcastle

AREAS OF EXPERTISE:

Lauren has a broad range of ecological field experience and experience in Ecological Assessment reporting. Her experience within the consulting industry has primarily included a wide range of flora and fauna assessment disciplines as required by a wide range of public and private clients. Lauren's knowledge of the Central Coast and Newcastle regions has expanded extensively since the commencement of her career, particularly in the area of threatened flora and fauna species.

SELECTED PROJECT EXPERIENCE:

Environment

- Flora and fauna identification and habitat assessment
- Targeted threatened flora and fauna surveys
- Delineation and mapping of vegetation communities
- Endangered Ecological Community (EEC) assessment
- Conducting Field Surveys for Flora, Fauna and Habitat Identification
- Report Preparation including Fauna & Flora Assessments
- Ecological Monitoring and Reporting
- Bushfire Threat Assessment & Management reporting
- Understanding of environmental legislation.

Ecology

- **Centennial Coal Charbon**– Field surveys identifying management issues for the development of a Compensatory Habitat Management Plan at Charbon Colliery
- **Morisset** – Flora and fauna surveys to produce an Ecological Assessment and Bushfire Threat Assessment

PREVIOUS EXPERIENCE:

Environmental Scientist - Ecobiological (2011)

Primary roles included bush regeneration and the identification of a wide range of native and non-native plant species for rehabilitation of various sites. Some ecological surveys and Ecological Assessment reporting was carried out during her time with Ecobiological.

Trainee Ecologist - Pygmy Possum Ecological Consulting (2008-2010)

Ecological field surveys were the main role at Pygmy Possum. Fauna surveys carried out across the Central Coast have provided for an increased knowledge in common and threatened fauna species as well as the vegetation communities in which they inhabit. Exposure to ecological reporting also occurred.

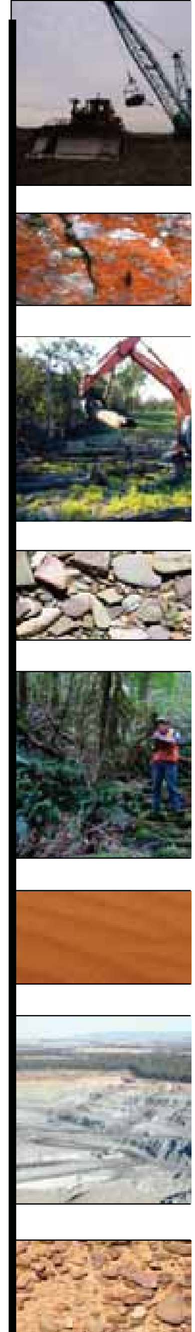
Volunteer Experience including:

- Biodiversity research for independent researchers and Australian Geographic in East Kimberley (2011);
- Amphibian (*Litoria subglandulosa* and *Mixophyes balbus*) research at the New England Tablelands with Simon Clulow, Carl Gerhardt and Marion Anstis (2010);

- Bandicoot Research in Manly with the Australian Wildlife Conservancy (2010);
- Microbat dietary surveys and tracking at Empire Bay with Leroy Gonsalves (2010);
- Green and Golden Bell frog research at the Sydney Olympic Park (2010);
- Bush regeneration at Wamberal Lagoon Nature Reserve with National Parks and Wildlife Services primarily restoring Littoral Rainforest (EEC) (2007-2010);
- Fauna research including pit trapping, Elliot trapping, triangulation (for amphibians) and spotlighting for the Watagans fauna database (2007); and
- Bush-stone Curlew surveys at Empire Bay on the Central Coast undertaking call play back methods (2010).

MEMBERSHIPS & ACHIEVEMENTS:

- NSW Driver's Licence (Class C)
- OH&S Induction Training (White Card)
- ChemCert II certification
- Landscape Function Analysis Training
- Member of the Ecological Society of Australia (ESA)
- Member of the Hunter Bird Observatory Club (HBOC)



Groundwater Impact Assessment

APPENDIX 8

Centennial Coal

GHD

GROUNDWATER IMPACT ASSESSMENT

NewstanSubsidence Management Plan LW 101-103

May 2012

Centennial Coal
Environment Matters

Executive Summary

An assessment of potential subsidence impacts to groundwater sources (aquifers) arising from the development of longwall panels LW101, 102 and 103 within the Young Wallsend and Yard seams at Newstan Colliery has been undertaken. The assessment has been carried out in accordance with the Subsidence Management Plan (SMP) Guidelines and relevant statutory conditions.

The groundwater sources in the vicinity of the study area (referred to as the SMP Study Area) are generally low yielding and limited to shallow alluvium, underlying fractured rock and coal seams. There is minimal use and reliance on this groundwater for stock, domestic and irrigation purposes. However, it is possible that groundwater dependent ecosystems (GDEs) associated with Kilaben, Stockyard and Stony Creeks are located in the vicinity of the SMP Study Area.

There are no registered bores within the SMP Study Area, although two monitoring bores (GW064213 and GW064214) are located within the Toronto Country Club to the south east of LW101. These monitoring wells are screened in rock at depths of approximately 20 m to 24 m below ground level (bgl). No registered bores within Kilaben Creek or Stony Creek alluvium were identified.

The groundwater impact assessment for the development and extraction of LW101, 102 and 103 at Newstan is based on statistical trend analyses of existing groundwater monitoring data as well as predictions from a preliminary hydrogeological model.

Existing groundwater hydrographs were compared to the Cumulative Rainfall Departure (CRD) curve for the selected rainfall dataset to establish the relationship between groundwater levels and rainfall, and to identify whether other natural or anthropocentric factors have been influencing these groundwater levels. Where possible, a statistical comparison was undertaken using the HARTT (Hydrograph Analysis: Rainfall and Time Trends) statistical methodology, to reduce the uncertainty inherent with visual interpretation of time series graphs. The analysis does not provide evidence that previous longwall mining at Newstan has had long term impacts on groundwater levels within Lords Creek alluvium, either via loss of groundwater into deep vertical interconnected fractures or in terms of localised reductions in groundwater levels associated with surface subsidence, deformation and changes in near surface hydraulic conductivity.

Based on available data, there is some geochemical evidence of existing interaction of leachate with shallow groundwater at the Awaba Waste Management Facility (AWMF), situated within the SMP Study Area. An increase in hydraulic conductivity of the uppermost bedrock due to subsidence cracking may increase the movement of leachate within the upper 10 – 15 m of rock, however it is not expected that leachate would move downwards to the mine.

The preliminary hydrogeological model was developed with reference to the Groundwater Flow Modelling Guideline (Murray-Darling Basin Commission, 2000). Modelling was undertaken using MODFLOW-NWT, a version of MODFLOW based on MODFLOW 2005 that provides a different formulation of the groundwater flow equation (Newton formulation) designed to solve models that are non-linear due to unconfined cells or non-linear boundary conditions. The hydrogeological model has been calibrated under steady state and transient conditions.

Based on the MODFLOW hydrogeological model, the development and extraction of LW101, 102 and 103 is expected to intercept deeper Permian groundwater at a rate of approximately 200 – 280 ML/year.

This estimation takes into account an expected increase in the hydraulic conductivity of strata overlying the coal seam. The additional water will be incorporated into Newstan's existing water balance and options for water reuse and underground transfers will be explored as part of the EIS process. Aquifer depressurisation is not anticipated to impact registered stock, domestic or irrigation bores. The groundwater monitoring bore at the Toronto Country Club (GW064214) may experience some minor drawdown associated with mining although this is expected to be in the order of 0.1 m and negligible compared to climatic variation.

The movement of shallow groundwater into underlying strata as a result of mining operations is expected to be small, totalling only 0.2 ML/year throughout the entire SMP Study Area. No continuous fracturing between shallow aquifers and the mine workings are expected. Potential GDEs located within the SMP Study Area may experience a drawdown of up to 0.2 m as a result of mining. It is not anticipated that GDEs located outside the SMP Study Area will be impacted.

Additional potential groundwater impacts have been considered, should actual conventional subsidence movements exceed predicted subsidence movements by a factor of two times.

In response to the predicted groundwater impacts, it is recommended that a Trigger, Action and Response Plan (TARP) be developed and included in the Newstan Water Management Plan. Monitoring should be undertaken with reference to the NSW Office of Water's 'Draft Groundwater Monitoring Guidelines for Mine Sites within the Hunter Region' (DIPNR, 2003) and should focus on monitoring potential groundwater impacts at AWMF and potential GDEs. Note that prior to mining under the AWMF, additional investigations will be undertaken to identify leachate migration pathways at AWMF and estimate likely changes in the hydraulic conductivities of near surface strata resulting from mining.

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Glossary

Angle of Draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20 mm.
Aquifer	A groundwater bearing formation sufficiently permeable to transmit and yield groundwater.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as or larger than the selected event.
Bord and pillar	A mining system whereby coal is extracted leaving ‘pillars’ of untouched coal to support the strata above.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Community	Anyone who is interested in or affected by subsidence issues associated with the proposed mining project.
Cumulative Rainfall Departure	Monthly accumulation of the difference between the observed monthly rainfall and long term average monthly rainfall.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Groundwater	Water within an aquifer (as defined above).
Guideline	Numerical concentration or narrative statement supporting or maintaining a designated water use.
Headings	A roadway driven in to the coal seam for access to underground operations by personnel and machinery.
Hydrograph	A graph which shows how the discharge of stage/flood level at any particular location changes with time during a flood. Also shows the change in groundwater levels over time.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.
pH	Value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Probability	A statistical measure of the expected chance of flooding.

Risk	The chance of something happening that will have an impact upon objectives. It is measured in terms of consequence and likelihood.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Strata	Geological layers below the ground surface.
Structure	The combination or spatial arrangement of primary soil particles (clay, silt, sand, gravel) into aggregates such as peds or clods, and their stability to deformation.
Subsidence	For the purposes of SMP approval process, subsidence is defined as mining-induced movements and deformations at the ground surface where (i) the vertical downward surface movements are greater than 20 mm, or (ii) the potential impacts on major surface infrastructure, structures or natural features may be significant, notwithstanding that the vertical downward surface movements are less than 20 mm.
Surface Water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Tailings	Fine reject material produced as a result of the coal processing process.
Vertical Subsidence	Vertical downward movements of the ground surface caused by underground coal mining.

Abbreviations

AHD	Australian Height Datum
ARI	Average Recurrence Interval
AWMF	Awaba Water Management Facility
bgl	below ground level
BOM	Bureau of Meteorology
CRD	Cumulative Rainfall Departure
DA	Development Application
DRE	Division of Resources and Energy
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
EC	Electrical conductivity
EIS	Environmental Impact Statement
GDEs	Groundwater Dependent Ecosystems
GHB	General Head Boundary
GHD	GHD Pty Ltd
km	kilometre
LEA	Life Extension Area
LGA	Local Government Area
m	metres
mm	millimetres
NOW	NSW Office of Water
ROM	Run of Mine
SMP	Subsidence Management Plan
SRMSE	Scaled root mean square error
TARP	Trigger, Action and Response Plan
VWPs	vibrating wire piezometers

1. Introduction

1.1 Background

Centennial Newstan Pty Ltd (Centennial Newstan) owns and operates Newstan Colliery (Newstan), situated approximately 25 km south west of Newcastle NSW and approximately 140 km north of Sydney within the Lake Macquarie Local Government Area (LGA).

Centennial Newstan was granted development consent (DA 73-11-98) in May 1999 under Part 4 of the Environment Planning and Assessment Act 1979 for continued development of workings within the West Borehole seam (combined Young Wallsend and Yard seams) within the Newstan Colliery Life Extension Area (LEA). Extraction of coal from the West Borehole seam at Newstan first commenced in 1990 and 25 longwall panels have been developed over this time.

Centennial Newstan proposes to extract coal from a further three longwall panels within the DA 73-11-98 area, named LW101, 102 and 103. Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a *Subsidence Management Plan (SMP)* prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, 102 and 103, which are located wholly within ML1452 and DA 73-11-98.

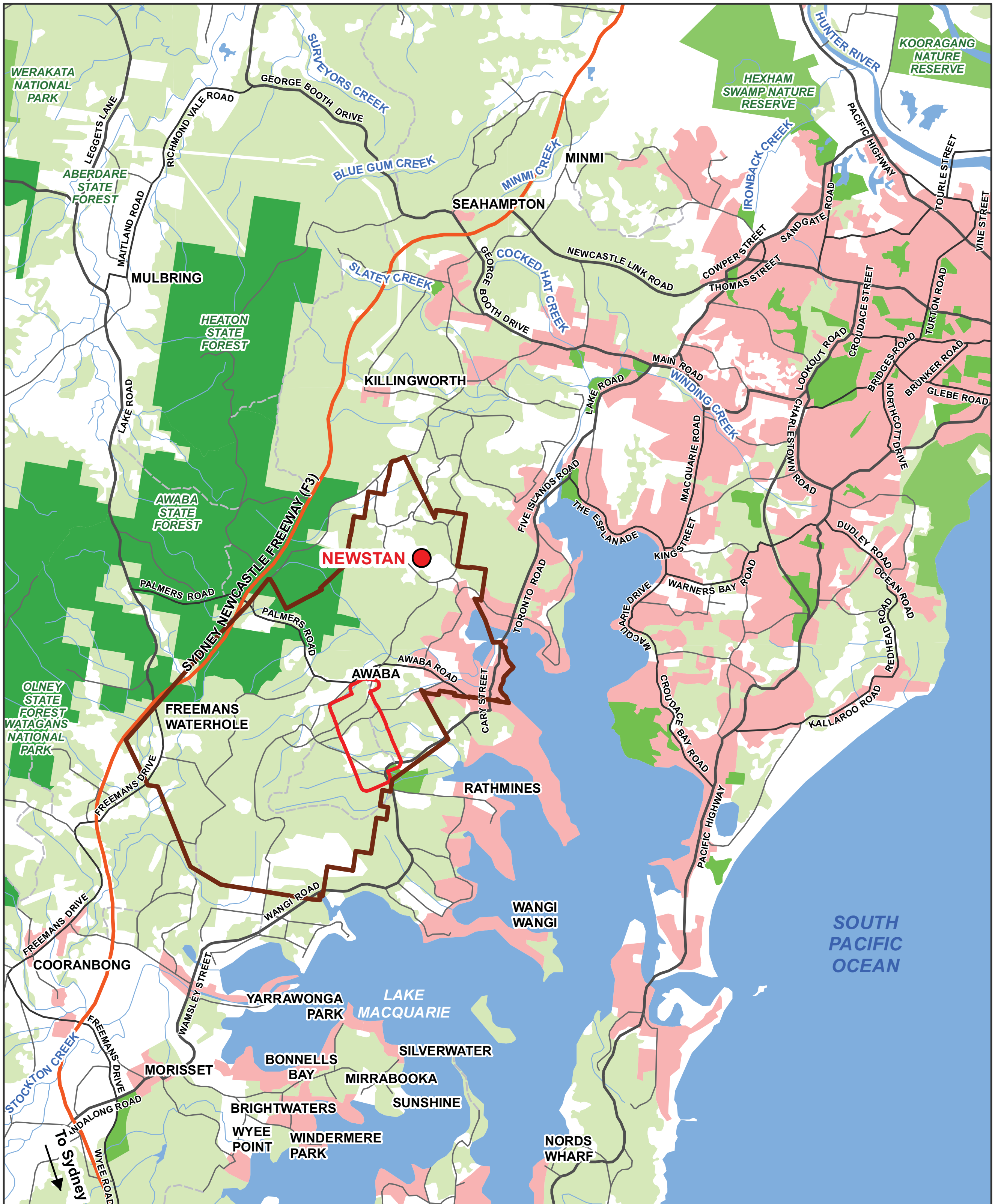
GHD Pty Ltd (GHD) was engaged by Centennial Newstan to undertake an assessment of potential subsidence impacts to groundwater sources (aquifers), in accordance with the SMP Guidelines and relevant statutory conditions, and provide this report in support of the SMP Application for LW101, 102 and 103. The scope of this report is detailed in Section 1.4.

1.2 SMP Study Area

The study area for this report (herein referred to as the SMP Study Area) has been conservatively defined beyond the minimum requirements of the SMP Guidelines (2003). The SMP Study Area incorporates the areas bounded by the following limits:

- A 26.5 degree angle of draw from the panel edge (limit of proposed extraction) of the proposed longwall panels LW101, 102 and 103 for the depth of cover (as per Section 6.2 of the SMP Guidelines). Additionally, the study area also conservatively includes a 26.5 degree angle of draw from associated *first workings* (mains headings and associated mine development roads) adjacent to the longwalls, acknowledging these areas do not significantly contribute to subsidence but have been conservatively included.
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour resulting from the extraction of the proposed longwall panels (as per Appendix A of the SMP Guidelines). Additionally, the footprint of potential direct impact by subsidence parameters for tilt, strain and curvature has also been considered in establishing the SMP Study Area.

Figure 1-1 shows the locality of the Newstan holding boundary and SMP Study Area. Figure 1-2 shows the mine plan for the existing workings within the West Borehole seam and proposed longwall panels.



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0 625 1,250 2,500 3,750 5,000
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Newstan Colliery
- SMP Study Area
- Proposed Final Newstan Colliery Holding Boundary
- Freeway
- Principal Road
- Secondary Road
- Minor Road
- Track
- Watercourse
- Water Body
- Built Up Areas
- Forest Or Shrub
- Nature Conservation Res
- State Forest

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

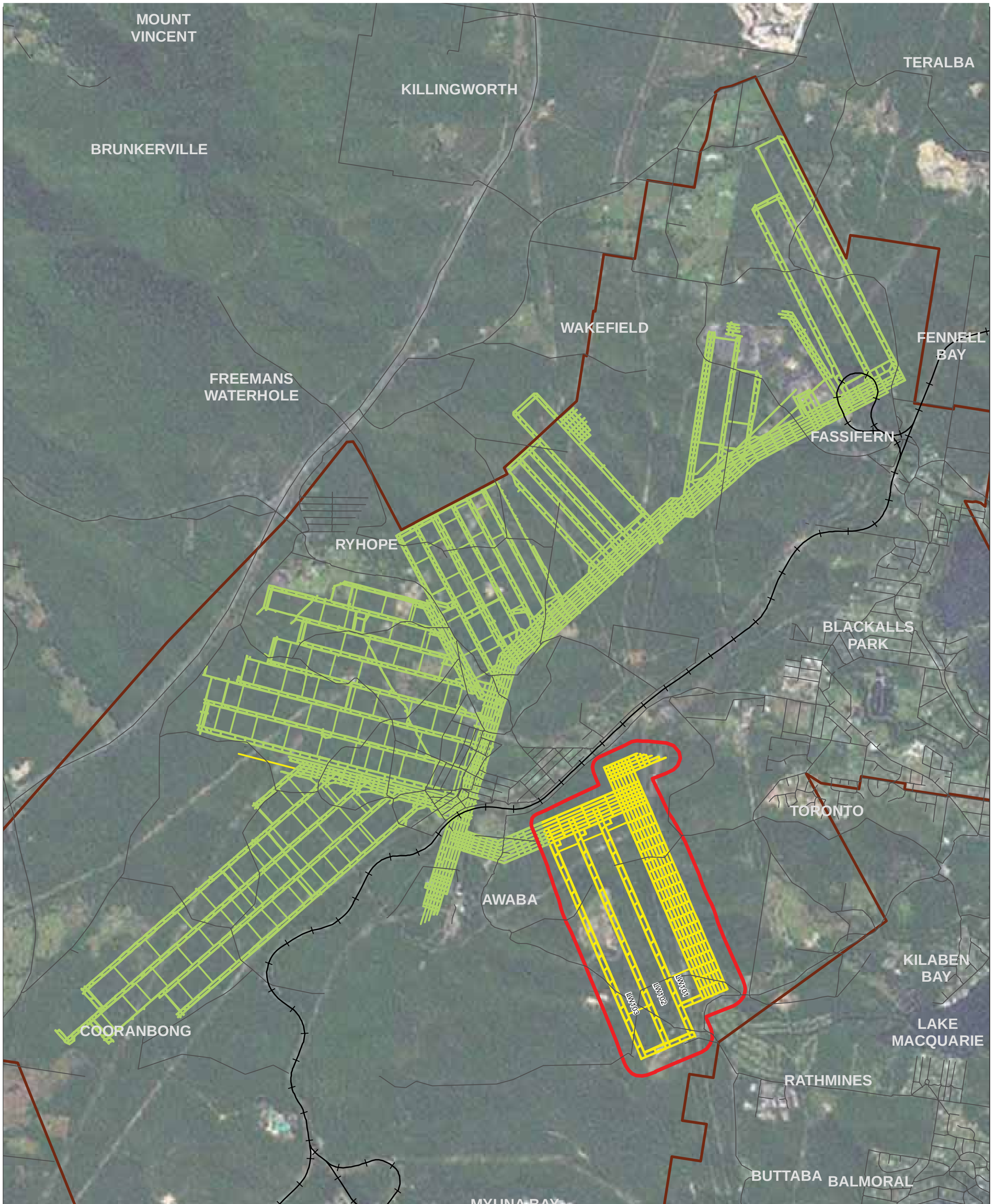
Newstan
Subsidence Management Plan
Groundwater Impact Assessment
Locality Plan

Centennial Newstan

DATE: 17/04/2012

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_000_Locality_20120306_A.mxd



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0 200 400 800 1,200 1,600
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Railway
- Roads
- Proposed Final Newstan Colliery Holding Boundary
- Existing/Proposed Approved Underground Workings
- SMP Longwalls
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Existing Newstan Workings
and Proposed Longwalls

Centennial Newstan

DATE 16-04-2012

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_002_ExistProposedLongwalls_Rev_A.mxd

1.3 SMP Risk Assessment

A risk assessment was held at Centennial Newstan on 7 November 2011 and identified the following potential groundwater impacts from LW101, 102 and 103:

- Loss of alluvial groundwater to underlying strata.
- Interception of deeper groundwater during mining operations.
- Impacts on third party groundwater users outside the SMP Study Area.
- Change in groundwater supply to Groundwater Dependent Ecosystems (GDEs).

Following the risk assessment, the seepage of leachate from Awaba Water Management Facility (AWMF) through subsidence cracks was identified as an additional potential impact to groundwater. AWMF is located directly above LW103, approximately halfway along the panel.

1.4 Objectives of this Report

This report provides information that will support the SMP Application to the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), in accordance with the SMP Guideline (DPI, 2003), as summarised in Table 1-1.

Table 1-1 Information Provided in Support of the SMP Application (DPI, 2003)

Requirement	Where Addressed in this report
Section 6.2, The Application Area	Section 1
Section 6.4, Site Conditions of the Application Area	Section 3
Section 6.6.1 - Identification of Surface Features	Section 3
Section 6.6.2 - Characterisation of Surface Features	Section 3
Section 6.8 - Community Consultation	Section 1
Section 6.9 - Statutory Requirements	Section 2
Section 6.10 - Subsidence Impacts	Sections 5 to 7
Section 7 - Proposed management plans	Section 8
Appendix B – Surface features that may be affected by Underground coal mining.	Sections 3 to 7

To undertake an assessment of potential groundwater impacts, a number of assessment elements were completed as part of this report. These are outlined in Section 2.3.2 and were obtained from DPI (2003). These assessment elements are specific to this groundwater impact assessment.

1.5 Scope of the Groundwater Impact Assessment

The scope of this assessment is as follows:

- Identify and characterise groundwater sources within the project area, based on available groundwater monitoring data, exploration drilling data and geological maps.
- Search of the NSW Groundwater Bore Database to identify registered bores (and available data) within an area of approximately 5 km from the proposed longwalls.
- Undertake statistical analysis on available alluvial groundwater hydrographs to assess the impacts of existing Newstan workings on alluvial groundwater.
- Develop a hydrogeological model of the target seam and overlying strata to predict the groundwater seepage into the mine as a result of primary and secondary extraction, and to predict the impact of mining and resulting subsidence on shallow groundwater levels, registered groundwater users and GDEs.
- Identify groundwater monitoring and management actions to mitigate potential groundwater impacts.

A risk-based approach has been undertaken during the development and preparation of the SMP application, which has conservatively included subsidence predictions and assessments for both the expected mining scenario as well as an unpredicted scenario of increased subsidence conditions. A specialist subsidence impact assessment has been carried out by Mine Subsidence Engineering Consultants MSEC (2012) which has been referenced and summarised, where appropriate, throughout this report to provide the basis for potential impact assessment. The full report by MSEC can be found in Appendix A to the SMP Written Report for the SMP Application.

1.6 Stakeholder and Community Consultation

Centennial Newstan has undertaken consultation for the SMP application in accordance with the Newstan Colliery Stakeholder Engagement Plan. Consultation to date has included detailed discussions regarding the project with the Newstan Colliery Community Consultative Committee, interested landowners and relevant government agencies.

A briefing Session with all relevant government agencies was held on 20 March 2012 at which the SMP application was discussed. No issues regarding water quality relating to subsidence from underground mining activities were raised. Centennial Newstan is currently liaising with Lake Macquarie City Council (Council) in regards to the proposed SMP application and its potential impacts to the Awaba Waste Management Facility (AWMF) and subsequent impacts to water quality. These discussions are continuing.

2. Relevant Legislation, Policies and Guidelines

The following section provides a brief overview of the legislation, policies and guidelines relevant to this groundwater impact assessment.

2.1 Legislation

2.1.1 Water Act 1912

The Water Act 1912 governs access, trading and allocation of licences associated with both surface and underground water for water sources where a water sharing plan has not been put in place. The elements to which the Water Act 1912 applies include extraction of water from a river, extraction of water from underground sources, aquifer interference and capture of surface runoff in dams.

At this point in time, the Water Act 1912 applies to groundwater interference, bore installation and extraction of groundwater within the Triassic and Permian formations within the project site.

2.1.2 Water Management Act 2000

The Water Management Act 2000 is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources commenced in August 2009 and regulates the interception and extraction of surface water and alluvium within the defined water sharing plan area. The alluvium within the project area is covered by this water sharing plan and is specifically within the North Lake Macquarie water source area. Therefore, the interference and extraction of alluvial groundwater and the installation of alluvial monitoring bores throughout the Newstan lease area generally requires interference approval and/or an access licence under the Water Management Act 2000. Note that exemptions are currently being proposed via the Draft NSW Aquifer Interference Policy released in March 2012 (Section 2.4).

2.2 Policies

2.2.1 NSW State Groundwater Policies

The objective of the NSW State Groundwater Policy Framework Document (NSW Government 1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Protection Policy.
- NSW Groundwater Quality Protection Policy.
- NSW Groundwater Dependent Ecosystems Policy.

NSW Groundwater Quantity Management Policy

The principles of this policy include:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.
- All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow and halt, or reverse any degradation in groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater.
- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

2.2.2 NSW Draft Aquifer Interference Policy

The Draft NSW Aquifer Interference Policy was released in March 2012 (DTIRIS, 2012) and clarifies the water licencing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this Policy will be given a legal effect through an Aquifer Interference Regulation.

The Policy indicates that the interference of an aquifer during mining from a groundwater source not covered by a water sharing plan requires a water licence under the Water Act 1912. Where mining results in the loss of water from an overlying source that is covered by a water sharing plan, an additional access licence is required under the Water Management Act 2000 to account for this take of water. Exemptions have been identified in the Policy, including the removal of less than 3 ML/year from a groundwater source, as well as when the flow of water is induced from one part of an aquifer to another part of the same aquifer.

Additional restrictions cover the interception of groundwater that underlies Biophysical Strategic Agricultural Land, its dependent ecosystems or other water users. Note that the SMP Study Area is not classified as Agricultural Land.

2.3 Guidelines

2.3.1 Draft Groundwater Monitoring Guidelines

The former NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) developed the 'Draft Groundwater Monitoring Guidelines for Mine Sites within the Hunter Region' in September 2003. This draft guideline is still used by the NSW Office of Water (NOW) as the benchmark for groundwater monitoring programs at mine sites within the Hunter Region.

2.3.2 NSW Department of Mineral Resources, Guideline for Applications for Subsidence Management Approvals

The Subsidence Management Approvals process was developed to identify all mining-induced subsidence impacts and mitigation measures prior to approval being granted under the conditions of an existing Mining Lease. This process requires that a SMP be prepared and approved by the DTIRIS Manager Environmental Operations prior to approval being granted under Section 239(2) of the *Mining Act 1992*.

The SMP must outline:

- Affected Area.
- Subsidence Predictions.
- Assessment of subsidence impacts on the area.
- Prevention, mitigation and or rehabilitation of subsidence impacts.

The natural features, public amenities, farm land and facilities, and industrial, commercial and business establishments addressed in this groundwater impact assessment are outlined in Table 2-1.

Table 2-1 Features Assessed in this Report

Elements	Within SMP Study Area	Where addressed in this Report
Natural Features		
Aquifers or Known Groundwater Resources	✓	Sections 3,4,5,6
Swamps, Wetlands or Water Related Ecosystems	✓	Sections 3.4, 7
Public Amenities		
Golf Courses	×	Sections 3.3.4, 7
Farm Land and Facilities		
Wells or Bores	×	Sections 3.3.4, 7
Industrial, Commercial and Business Establishments		
Waste Storages or Associated Plants	✓	Sections 3.2, 5.3.1

A summary of the features identified as *"Areas of Environmental Sensitivity"*, as defined in SMP Guideline (DPI, 2003), is provided in Table 2-2. It is not considered that the groundwater resources within or close to the SMP Study Area are classified as 'significant', although they have been identified and assessed for impact from mining.

Table 2-2 Areas of Environmental Sensitivity within the SMP Study Area

Elements	Within SMP Study Area	Where addressed in this Report
Significant groundwater resources identified through consultation with relevant government agencies	×	×

3. Existing Environment

The existing geological and hydrogeological environment in the vicinity of proposed LW101, 102 and 103 is outlined in this section.

3.1 Rainfall and Hydrology

A continuous daily rainfall dataset was generated from January 1901 to January 2012 using data from local Bureau of Meteorology (BOM) Stations, particularly Cooranbong (Station 061012). The dataset was used to generate a Cumulative Rainfall Departure (CRD) curve. CRD is the monthly accumulation of the difference between the observed monthly rainfall and long term average monthly rainfall.

The CRD over the period 1901 to 2012 is shown in Figure 3-1. The average annual rainfall over the period January 1901 to January 2012 was 1,116 mm. Monthly rainfall averages ranged from 60.9 mm in August to 126.9 mm in March. Any increase in the CRD reflects above average rainfall while a decrease in CRD reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall.

Figure 3-1 CRD Curve for Newstan (1901-2012)

In recent years, above average rainfall conditions generally dominated the periods between March 1998 and March 2000, and between May 2007 and November 2008. Below average rainfall generally dominated the period between March 2002 and May 2007. A change in rainfall pattern from below average to above average was triggered by a heavy rainfall event of about 180 mm over 48 hours (Average Recurrence Interval (ARI) of between 20 and 50 years) that occurred in June 2007.

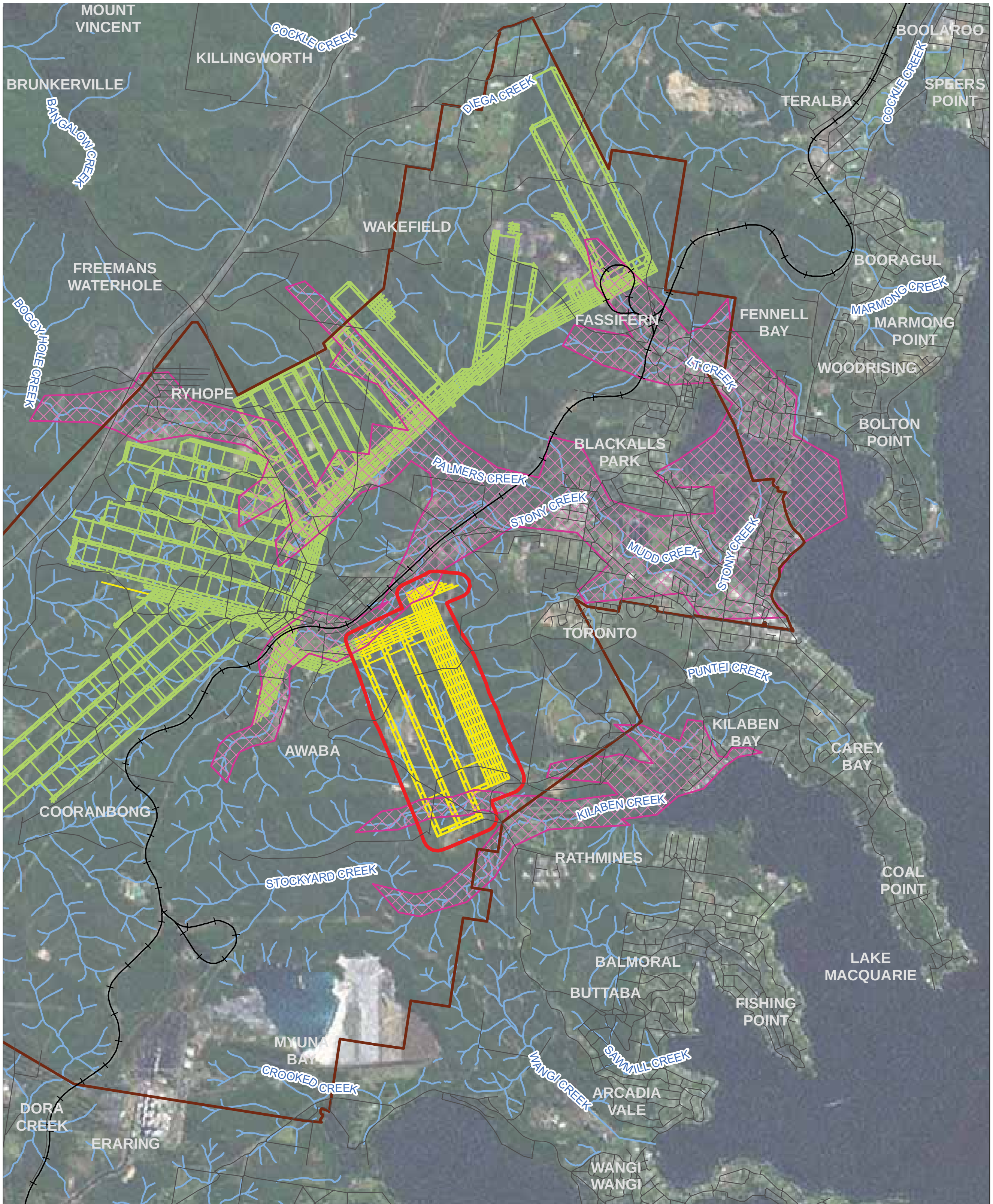
The ground surface topography within the SMP Study Area ranges from approximately 10 m to 120 m Australian Height Datum (AHD). The main surface drainage systems that intersect the SMP Study Area include Kilaben Creek (above the southern ends of LW102 and 103), an unnamed tributary of Kilaben Creek (overlies all three longwall panels and located to the south of the AWMF) and Stony Creek (above the first workings to the north of LW 103). The unnamed tributary of Kilaben Creek and Stony Creek are significant third and fourth order streams within the SMP Study Area. The locations of these waterways are shown in Figure 3-2.

3.2 Geology

The proposed SMP longwall panels will target the Young Wallend and Yard seams, contained within the Lambton Formation of the Newcastle Coal Measures. The stratigraphy at Newstan is listed and described in Table 3-1. This information has been sourced from the Newcastle Coalfields Regional Geology 1:100,000 map (Edition 1 1995) and the Newstan Colliery Life Extension Project Overburden Groundwater Study (Pacific Power International, 1998).

Table 3-1 Stratigraphic Sequence – Newstan Colliery

Period	Stratigraphy		Unit / Lithology	Coal Seams
	Group	Subgroup		
Quaternary			Alluvium	
Triassic	Narrabeen	Clifton	Conglomerate, sandstone, siltstone, claystone	
Permian	Newcastle Coal Measures	Moon Island Beach	Conglomerate, sandstone, siltstone, tuff, coal	Vales Point, Wallarah, Great Northern
		Awaba Tuff		
		Boolaroo	Sandstone, conglomerate, siltstone, coal, tuff	Fassifern, Upper Pilot, Lower Pilot, Hartley Hill
		Warners Bay Tuff		
		Adamstown	Conglomerate, sandstone, siltstone, coal, tuff	Australasian Montrose, Wave Hill, Fern Valley, Victoria Tunnel
		Nobby's Tuff		
		Lambton	Sandstone, siltstone, claystone, coal, tuff	West Borehole (Young Wallsend, Yard, Borehole)
	Waratah Sandstone			



1:60,000 for A4

0 250 500 1,000 1,500 2,000
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND
- Roads
- Railway
- Waterways
- Proposed Final Newstan Colliery Holding Boundary
- Alluvium
- SMP Study Area
- Existing/Proposed Approved Underground Workings
- SMP Longwalls

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Approximate Location of
Alluvium in Study Area

Centennial Newstan

DATE 16-04-2012

Figure 3-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_003_AlluviumInStudyArea_Rev_A.mxd

Based on a review of the Newcastle Coalfields Regional Geology map and exploration logs provided by Centennial Newstan, the surface lithology within the SMP Study Area comprises Quaternary alluvium (associated with Kilaben and Stony Creeks) as well as bedrock and surface deposits from the Narrabeen Group and the Moon Island Beach Group of the Newcastle Coal Measures.

The approximate location of the alluvium that is intersected by the SMP Study Area (based on available data) is shown in Figure 3-2. Based on a review of available borelogs, this alluvium is up to about 5 m thick in the vicinity of the SMP Study Area and comprises sandy clays and clayey/silty sands with some gravel. The Triassic and Permian rocks that comprise the surface lithology include conglomerate, sandstone, siltstone, claystone, tuff and coal.

The AWMF, located above LW103 approximately halfway along the panel, is underlain by Munmorah Conglomerate of the Lower Narrabeen Group. This is generally composed of high strength massive sandstone and conglomerate unit and extensive analysis of the response of this conglomerate and sandstone unit to longwall mining at Mandalong Colliery to the south has shown that it is generally less prone to fracturing.

The depth of cover above the target seams (Young Wallsend and Yard) within the SMP Study Area ranges from approximately 210 m to 350 m. The depth of cover above the longwall panels within this area ranges from about 230 m to 320 m. The seam thickness ranges from 2.2 m to 3.2 m in this area. The seams generally dip to the south and east. To the west of the SMP Study Area the Young Wallsend and Yard seams combine with the underlying Borehole seam and together they are referred to as the West Borehole seam. The split in the West Borehole seam generally runs north-south and coincides with the eastern boundary of the existing workings at Newstan. Depth of cover and seam thickness contours are shown in Figure 3-3 and Figure 3-4.

3.3 Hydrogeology

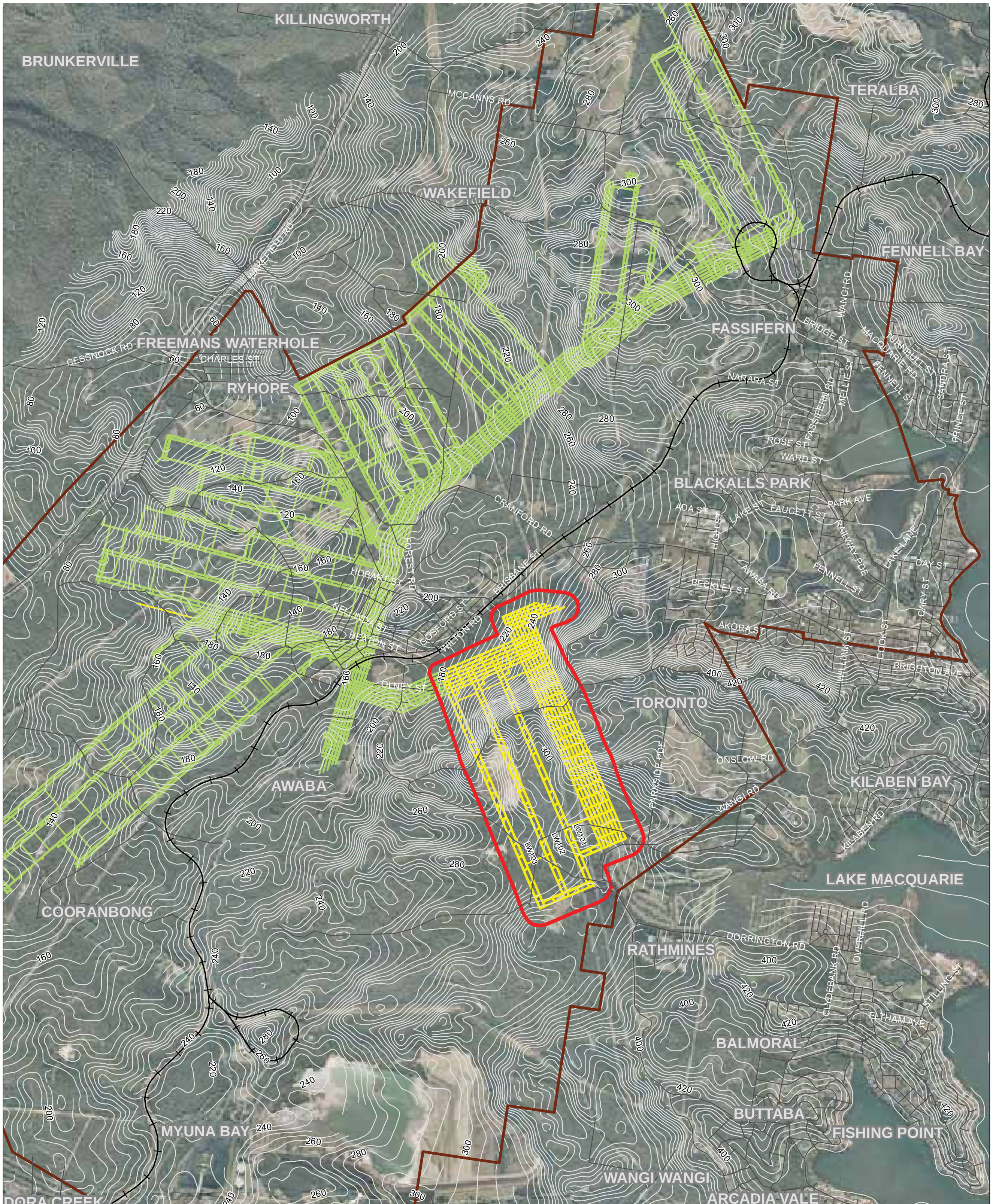
Groundwater sources within the stratigraphic sequence in Table 3-1 are predominantly within the Quaternary alluvium, weathered and/or fractured sandstone and coal seams.

3.3.1 Alluvium

The alluvium in the vicinity of the SMP Study Area forms a shallow aquifer with groundwater ranging in depth from less than 1 m to about 3 m below ground level (bgl), and aquifer thicknesses generally less than 5 m. Due to the thin alluvial deposits, clay content and minimal beneficial use (as detailed in Section 3.3.4) it is anticipated that yields are low. The alluvial groundwater is generally brackish and slightly acidic. The approximate boundary of alluvium in the vicinity of the SMP Study Area is shown in Figure 3-2.

Further to the west, alluvial groundwater associated with Lords Creek has been monitored by Centennial Newstan since 2005 to monitor potential impacts from LW 24. The thickness of this alluvium exceeds 10 m in some areas and the depth to groundwater is typically less than 5 m bgl. The Lords Creek alluvial groundwater is fresh to brackish and slightly acidic.

Further analysis of available groundwater monitoring data is presented in Section 5.



1:50,000 for A4 0 200 400 800 1,200 1,600 Metres Map Projection: Universal Transverse Mercator Horizontal Datum: Geodetic Datum of Australia 1994 Grid: Map Grid of Australia, Zone 56	N

LEGEND

- Railway
- Roads
- Proposed Final Newstan Colliery Holding Boundary
- SMP Study Area
- Depth of Cover Contours
- Existing/Proposed Approved Underground Workings
- SMP Longwalls

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment

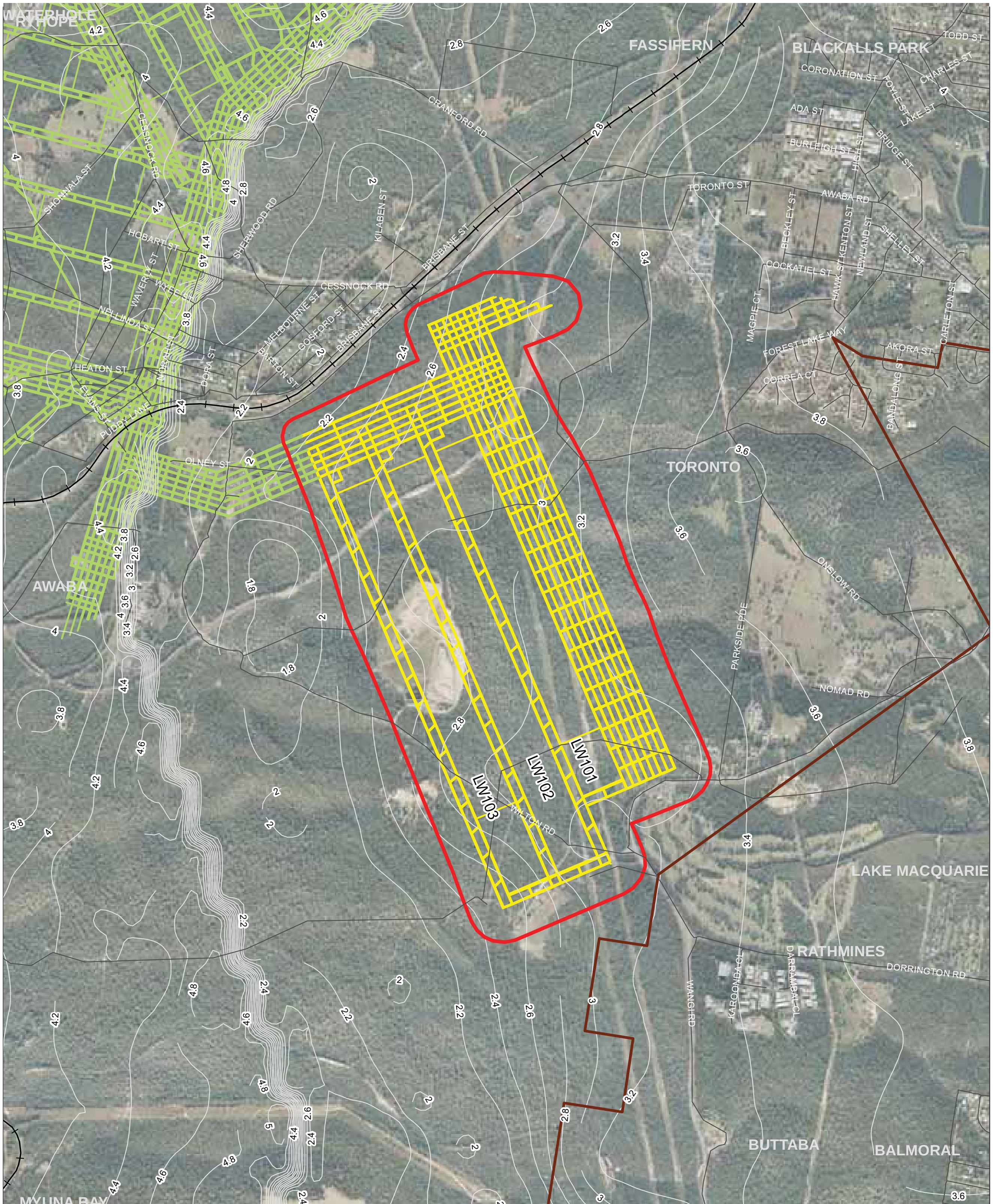
Depth of Cover Above Seam

Centennial Newstan

DATE 16-04-2012

Figure 3-3

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_004_DepthofCoverAboveSeam_Rev_A.mxd



1:25,000 for A4 0 100 200 400 600 800 Metres Map Projection: Universal Transverse Mercator Horizontal Datum: Geodetic Datum of Australia 1994 Grid: Map Grid of Australia, Zone 56	N	GHD	**LEGEND** Railway Roads Proposed Final Newstan Colliery Holding Boundary Seam Thickness Contours Existing/Proposed Approved Underground Workings SMP Longwalls SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment

Seam Thickness Contours

Centennial Newstan

DATE 16-04-2012

Figure 3-4

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_005_SeamThicknessContours_Rev_A.mxd

3.3.2 Coal Seams

Groundwater flow within the coal seams tends to follow the orientation and dip of the seams or move towards the areas of depressurisation. Where coal seam groundwater has not been depressurised, the groundwater head tends to be in the order of 0 m AHD. Packer testing undertaken as part of the Newstan exploration program indicates that the hydraulic conductivities of the Young Wallsend seam and overlying seams are generally in the order of 10^{-8} to 10^{-7} m/s.

Centennial Newstan's existing workings within the West Borehole Seam currently receive groundwater inflow of 1.4 to 3.0 ML/day (average 2.3 ML/day). This water is brackish and slightly alkaline, and sodium bicarbonate-chloride dominant. Underground water within the existing workings flows under gravity to underground dams, where they are transferred to the 19 cut through and/or 80 cut through dams and may be pumped to either the Newstan Colliery Fassifern seam underground water storage or Awaba Colliery Great Northern seam underground water storage.

3.3.3 Overburden and Interseam Rocks

According to Pacific Power (1997), the overburden and interseam strata (outlined in Section 3.2) within the Newcastle Coalfield tend to have very low hydraulic conductivities (in the order of 10^{-11} to 10^{-9} m/s), unless joints or fracturing creates a secondary permeability.

3.3.4 NSW Bore Database Search

A search of the NSW Groundwater Bore Database was undertaken to identify registered bores within a 5 km radius of the SMP Study Area. The search identified 26 bores, with the majority (17) being registered for domestic, irrigation and / or stock use and the remainder registered as monitoring/test bores (6), general use (1), waste disposal (1) and unknown (1). Bore details are outlined in Table 3-2 and the locations are shown in Figure 3-5.

The registered domestic and stock bores that were identified primarily extract groundwater from the sandstone and conglomerate formations, with yields generally less than 2 L/s. Only three alluvial bores for stock and domestic use were identified (GW063752, GW064025 and GW064067) and these extract groundwater from the Palmers Creek alluvium above existing LW14 and 17 to the north west of the SMP Study Area. These bores reportedly yield less than 1 L/s.

There are no registered bores within the SMP Study Area, although two monitoring bores (GW064213 and GW064214) are located within the Toronto Country Club to the south east of LW101. These monitoring wells are screened in rock at depths of approximately 20 m to 24 m bgl. No registered bores within Kilaben Creek or Stony Creek alluvium were identified.

Overall, the search of the Groundwater Bore Database indicates that groundwater usage and reliance for domestic, irrigation and stock watering purposes is generally limited in the vicinity of the SMP Study Area.

Table 3-2 Results of NSW Bore Database Search

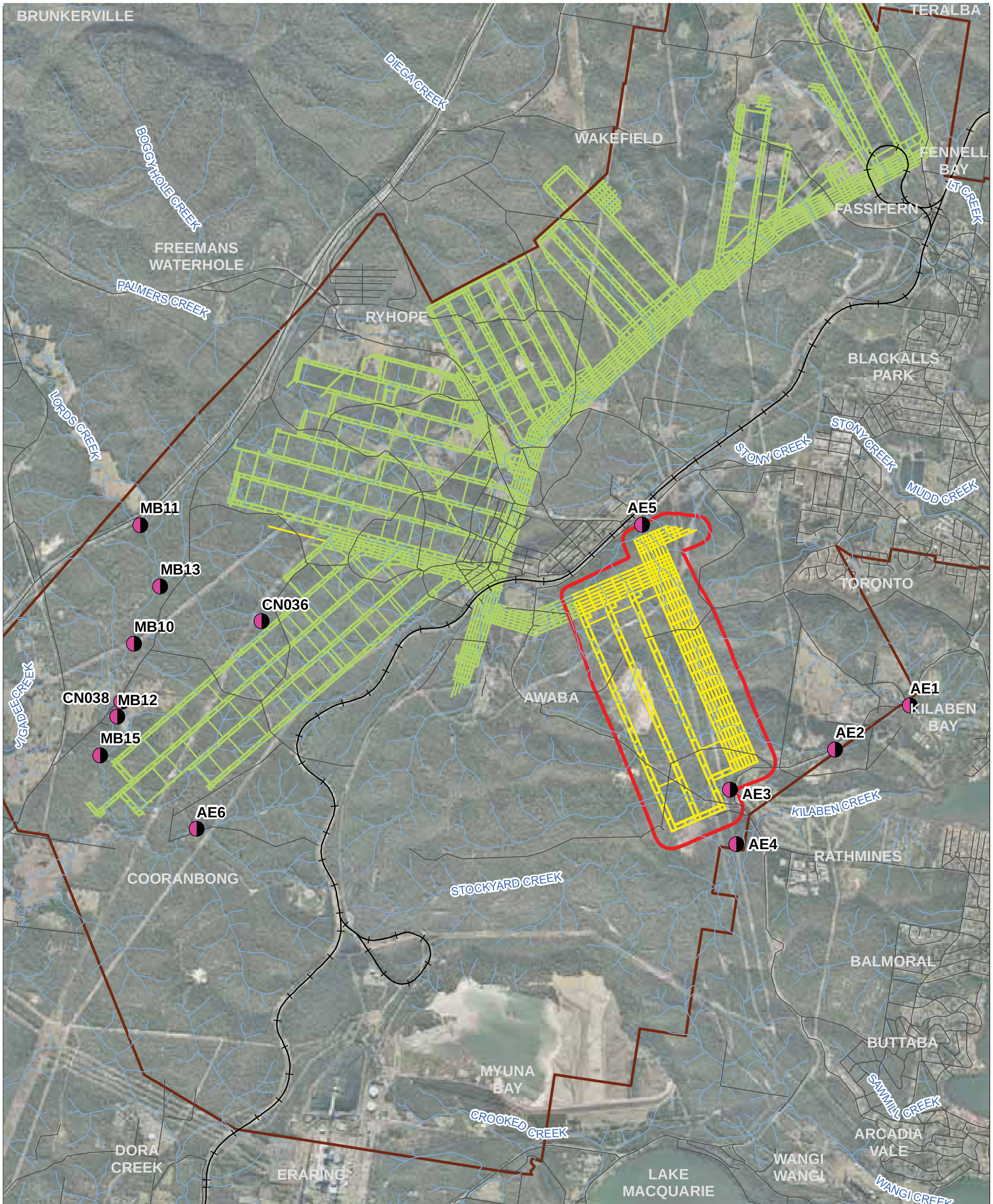
Bore No	Licence No	Location		Use	Screen Depth (m)	SWL (bgl)	Salinity (ppm)	Yield (L/s)	Aquifer
		mN	mE						
GW027551	20BL 019885	6352249	365443	Unknown	-	-	-	-	Sand
GW029567	20BL 023801	6340863	361864	General Use	3.00-3.00	2.10	Very Good	-	Clay/ Sandstone
GW029614	20BL 022850	6349319	358629	Domestic, irrigation	21.30-23.10	3.00	Good	1.26	Clay Sandy/ Shale/ Coal
GW033618	20BL 026909	6343594	358945	Stock	18.20-21.20	-	-	-	Shale/ Sandstone
GW033619	20BL 026910	6343596	359049	Stock	18.20-21.20	-	-	1.52	Shale/ Sandstone
GW043431	20BL 102125	6345915	359665	Stock, Irrigation	30.40-30.40	1.80	-	-	-
GW045155	20BL102967	6353092	366289	Domestic, stock, irrigation	-	-	-	-	Sandstone
GW052111	20BL 118649	6339227	359475	Stock	21.00-23.00 44.00-46.00	- 10.50	Good Good	0.10 2.27	Clay/ Conglomerate / Sandstone
GW052381	20BL 117030	6346746	357498	Domestic, stock	29.00-30.00	13.00	Good	0.76	Sandstone/ Coal, Shale
GW053438	20BL 117948	6339686	359235	Irrigation	47.00-50.00	-	-	0.44	Clay/ Shale/ Coal
GW060852	20BL 132224	6352905	366083	Domestic, stock	-	-	-	-	-
GW063014	20BL 135603	6341806	367661	Waste Disposal	-	-	-	-	-
GW063752	20BL 135419	6348578	362871	Domestic, stock	6.00-8.50	6.00	0-500	0.46	Sand Gravel/ Sand Coal
GW063947	20BL 135788	6345987	369396	Domestic Stock	15.2-18	-	1,001 – 3,000	0.79	Clay/ Sandstone/ Shale
GW064025	20BL 135308	6348700	362740	Domestic Stock	6-9	6.00	0 – 500	0.90	Clay/ Sandstone/ Coal
GW064067	20BL 135980	6348845	362141	Domestic Stock	6-12.1	4.00	1,001 – 3,000	0.40	Clay/ Sand/ Gravel
GW064213	-	6343917	366595	Monitoring Bore	21.3-24.3	-	-	0.10	Clay/ Conglomerate / Sandstone/ Coal/ Claystone
GW064214	-	6344432	365965	Monitoring Bore	20.40-23.40	-	-	0.10	Sandstone/ Conglomerate / Clay
GW066278	20BL 139104	6349471	358446	Domestic, stock	18.00-19.00	3.00	1,001-3,000	2.00	-

Bore No	Licence No	Location		Use	Screen Depth (m)	SWL (bgl)	Salinity (ppm)	Yield (L/s)	Aquifer
		mN	mE						
GW078486	20BL 167516	6345381	367252	Domestic	-	-	-	-	-
GW080494	20BL 168913	6349710	367738	Domestic	-	-	-	-	-
GW105161	20BL 157780	6343850	367850	Domestic	-	1.00	-	0.10	-
GW200825	20BL 172175	6346345	368935	Monitoring Bore	0.3-3.30	0.30	-	-	Fill/ Clay/ Gravelly Clay
GW200826	20BL 172176	6346364	368962	Monitoring Bore	0.7-3	0.70	-	-	Fill/ Clay/ Sandy Clay
GW200695	20BL 171774	6348500	359313	Test Bore	-	10.60	-	2.80	-
GW200696	20BL 171776	6347393	359964	Test Bore	-	23.00	-	1.50	-

3.4 Groundwater Dependent Ecosystems

One vegetation unit mapped by RPS (2012) within the SMP Study Area (Swamp Mahogany Paperbark Forest) may potentially be influenced by groundwater or be partially groundwater dependent. This vegetation type is associated with drainage lines and floodplains within the site.

This vegetation unit is mapped in Figure 3-6.



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0 200 400 800 1,200 1,600

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Shallow Bores
- Roads
- Railway
- Waterways
- Existing/Proposed Approved Underground Workings
- SMP Longwalls
- Proposed Final Newstan Colliery Holding Boundary
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

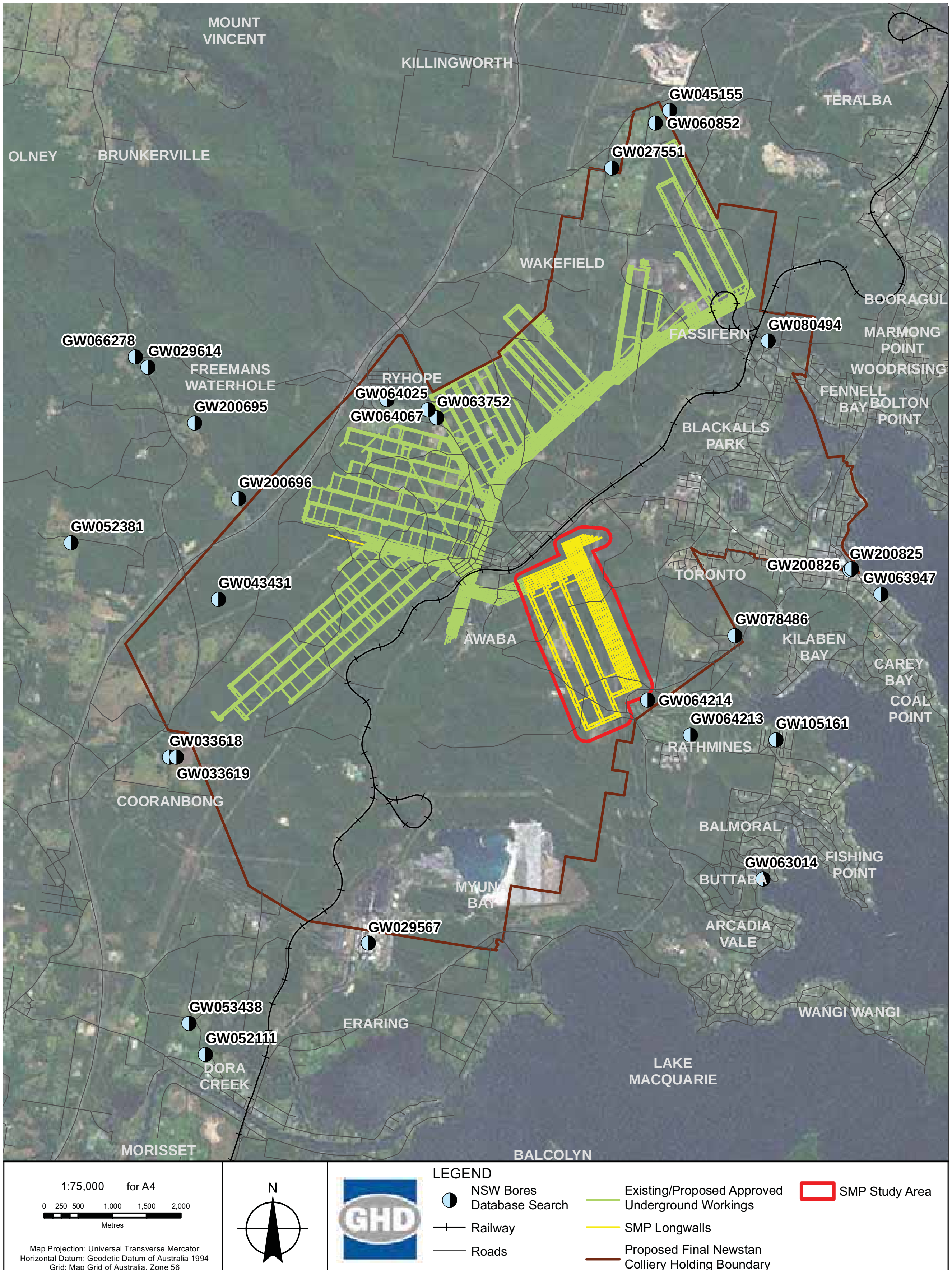
Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Groundwater Monitoring
Bores at Newstan Colliery

Centennial Newstan

DATE 16-04-2012

Figure 4-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_006_GroundwaterMonitoringBores_Rev_A.mxd



LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment

NSW Bore Database Search Results

Centennial Newstan

DATE 16-04-2012

Figure 3-5

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_007_NSWBoreDatabaseSearch_Rev_A.mxd

4. Assessment Method

The methodology adopted for this groundwater impact assessment is outlined below.

4.1 Review of Existing Data

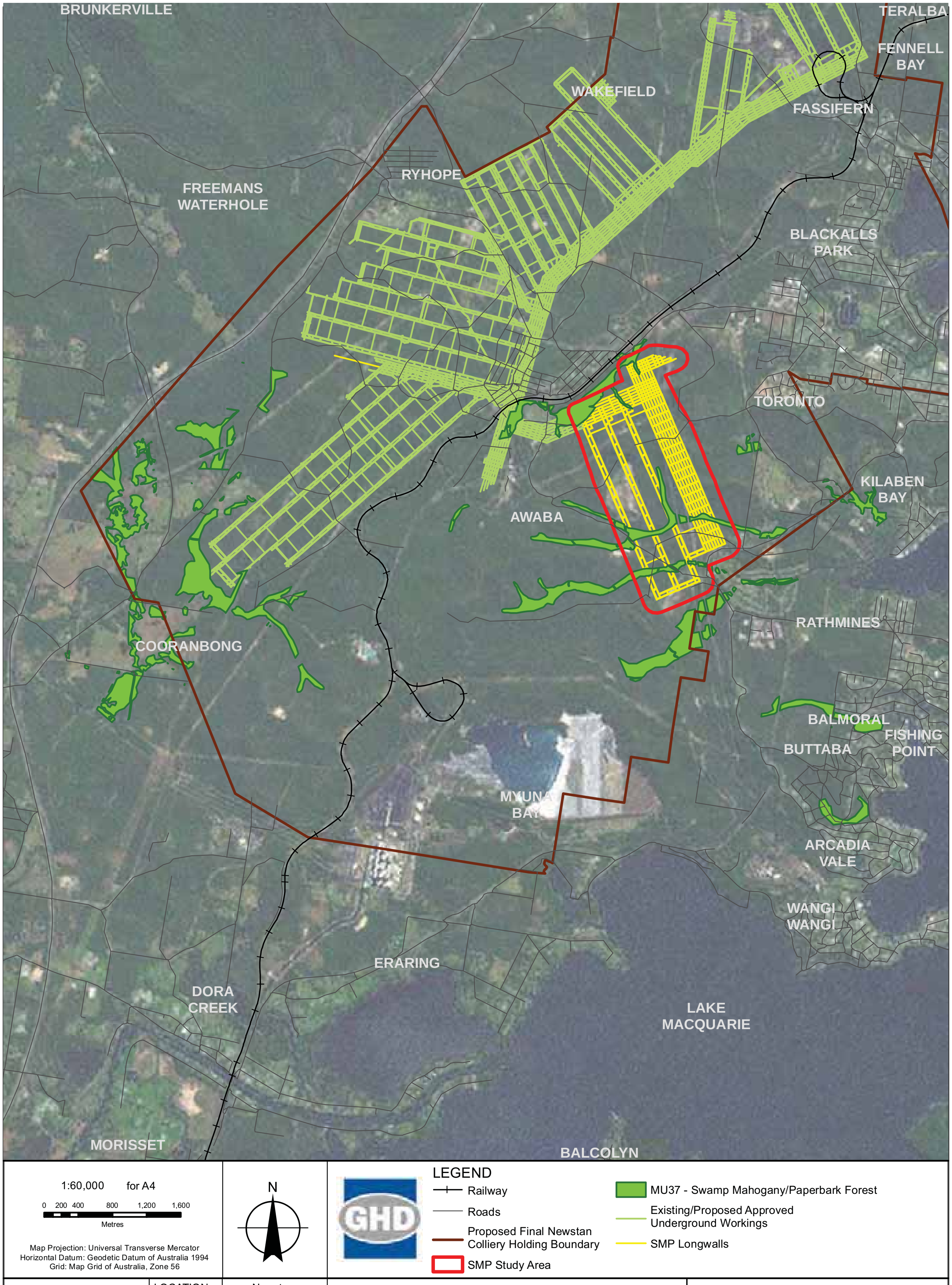
Statistical analysis of existing groundwater level data from the Newstan groundwater monitoring program was undertaken to assess groundwater impacts from previous longwall development at Newstan.

A groundwater monitoring network has been progressively established at Newstan since 2005 and consists of monitoring bores installed in alluvial and coal seam aquifers. The bores are generally monitored monthly - quarterly for groundwater levels and groundwater quality, although the AE alluvial bores contain water level loggers and the coal seams contain vibrating wire piezometers (VWPs).

Details of the groundwater data reviewed for this assessment are summarised in Table 4-1. Monitoring bore locations are shown in Figure 4-1. All monitoring bores have been licenced or are in the process of being licenced with the NOW. The Lords Creek alluvium bores and West Boreholes seam VWPs are located in the vicinity of existing longwall panels LW22 – 25 and were used to assess groundwater impacts from previous longwall development. Monitoring bores AE1 – AE6 are located in the vicinity of the SMP Study Area and the data were used to establish baseline conditions for the alluvium.

Table 4-1 Groundwater Monitoring Bore Details

Bores	Monitoring Period Reviewed	Lithology
MB10	Jan 06 – Oct 11	Lords Creek Alluvium
MB11	Jan 06 – Sept 11	Lords Creek Alluvium
MB12	Jan 06 – Sept 11	Lords Creek Alluvium
MB13	Jan 06 – Sept 11	Lords Creek Alluvium
MB15	Jan 06 – Sept 11	Lords Creek Alluvium
AE1	Apr 09 – Jan 12	Kilaben Creek Alluvium
AE2	Feb 09 – Jan 12	Kilaben Creek Alluvium
AE3	Feb 09 – Jan 12	Kilaben Creek Alluvium
AE4	Feb 09 – Jan 12	Stockyard Creek Alluvium
AE5	Feb 09 – Jan 12	Stony Creek Alluvium
AE6	Feb 09 – Jan 12	Jigadee Creek (east) Alluvium
CN036 (VWP)	Aug 05 – Oct 09	West Borehole Seam
CN038 (VWP)	Aug 05 – Oct 09	West Borehole Seam



Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Groundwater Dependent Ecosystems
Above Proposed Longwalls

Centennial Newstan

DATE 23-04-2012 Figure 3-6

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_008_GroundwaterDependentEcosystems_Rev_A.mxd

4.1.1 Alluvial Groundwater Levels

Groundwater hydrographs were plotted for each of the Lords Creek alluvium bores in Table 4-1 and compared to the Cumulative Rainfall Departure (CRD) curve for the rainfall dataset (Section 3.1) to establish the relationship between groundwater levels and rainfall, and to identify whether other natural or anthropocentric factors have been influencing these groundwater levels. CRD is the monthly accumulation of the difference between the observed monthly rainfall and long term average monthly rainfall. Hydrographs are included in Appendix A.

Where possible, a statistical comparison was undertaken using the HARTT (Hydrograph Analysis: Rainfall and Time Trends) statistical methodology, to reduce the uncertainty inherent with visual interpretation of time series graphs. HARTT is an Excel based regression model developed by the West Australian Department of Agriculture and Food that involves establishing an underlying time trend in groundwater level by separating the effect of above and below average rainfall. In this way, the relationship between groundwater change and atypical rainfall is established and it is possible to identify whether other factors are influencing groundwater level. Where conventional linear regression trend analysis is carried out for groundwater hydrographs, it is not possible to determine to what degree trends are associated with rainfall or other factors.

The HARTT analysis is based on the following regression equation (Ferdowsian et al., 2000):

$D = c + a\mathrm{CRD}_{t\text{-}L} + bt$

Where D is the depth to groundwater in an unconfined aquifer, CRD is the Cumulative Rainfall Departure (mm), t is time (months), L is the time lag (months) between rainfall and its impact on groundwater, and a, b and c are constants estimated from the multiple regression analysis.

Constant a represents the effect of non-average rainfall on groundwater level in m/mm. The value of a cannot be negative, since this would imply that rainfall recharge results in a fall in groundwater level. Constant b is the underlying rate of groundwater change in m/month without the effect of rainfall. The constant c represents the steady state groundwater level with no rainfall effects and no time trends. The best fit regression line is the non-linear approximation of the observed hydrograph with the highest R2 value.

The HARTT analysis also determines the statistical significance of the rainfall and time variables. A p-value less than 0.05 suggest that there is a statistically significant relationship between the depth to groundwater and the variable, while a p-value less than 0.01 suggests a high statistically significant relationship.

Generally, when the constant b is negative and the p-value for time is less than 0.05, this suggests that there is a statistically significant decreasing linear trend in groundwater level that is independent of rainfall. To assess how mining may be related to this trend, it is necessary to investigate how trends vary spatially and over different time periods (i.e. pre and post mining).

Groundwater hydrographs for alluvial bores AE1 – AE6 were also plotted and compared to the CRD curve to establish baseline shallow groundwater conditions in the vicinity of the SMP Study Area and establish the current relationship between these groundwater levels and rainfall. These hydrographs are also included in Appendix A.

4.1.2 Coal Seam Piezometric Head

According to Ferdowsian et al. (2000), the HARTT method is generally limited to the analysis of relatively shallow groundwater from unconfined aquifers. Therefore, it was necessary to make a visual assessment of hydrographs from deeper bores.

Hydrographs for VWPs within the West Borehole seam (CN036 and CN038) are shown in Appendix B. As shown in Figure 4-1, the existing workings have come within a few hundred metres of these VWPs.

4.2 Groundwater Flow Model

A preliminary hydrogeological model was developed to predict potential impacts to groundwater sources resulting from the proposed mining operations within the SMP Study Area. Due to limitations in historical groundwater data and geological data, the numerical model is a preliminary representation of the hydrogeological system. It has been developed with reference to the Groundwater Flow Modelling Guideline (Murray-Darling Basin Commission, 2000).

Modelling was undertaken using MODFLOW-NWT, a version of MODFLOW based on MODFLOW 2005 that provides a different formulation of the groundwater flow equation (Newton formulation) designed to solve models that are non-linear due to unconfined cells or non-linear boundary conditions. MODFLOW is a three-dimensional finite difference groundwater flow model from the United States Geological Survey (USGS) and is one of the industry standard codes for numerical groundwater modelling. The model was built using the Groundwater Modelling System (GMS) software. GMS is a three-dimensional user interface for the MODFLOW groundwater modelling code.

Data requirements for the hydrogeological model can be divided into hydrogeological framework data and hydrological stress data.

4.2.1 Hydrogeological Framework Data

Hydrogeological framework data includes extent, thicknesses and boundaries of geological (and aquifer) units, and aquifer properties (hydraulic conductivity, porosity, storage and specific yield). In typical modelling scenarios these parameters do not change over time, however in a mining context there may be changes due to rock fracturing and subsidence. These data have been sourced from the following:

- 1:100,000 Newcastle Coalfield Regional Geology map (NSW Department of Mineral Resources, 1995).
- Depth of cover and seam thickness drawings (supplied by Centennial Newstan).
- Newstan exploration logs and groundwater monitoring bore construction details (supplied by Centennial Newstan).
- 2 m and 5 m topographical contours (supplied by Centennial Newstan).
- Drawings of geological features such as faults, areas of seam splitting and deterioration, seam thickness and seam outcrops (supplied by Centennial Newstan).
- Past and future mine plans within the West Borehole and Young Wallsend/Yard seams at Newstan (supplied by Centennial Newstan).
- Existing reports detailing hydrogeological properties of the upper Newcastle Coal Measures, including Pacific Power (1997) Cooranbong Colliery Life Extension Project: Overburden Strata Groundwater Study.

- Results of packer testing undertaken during exploration at Newstan (supplied by Centennial Newstan).
- MSEC (2012) subsidence and fracturing predictions.

4.2.2 Hydrological Stress Data

Hydrological stress data includes the time varying hydrological data such as natural recharge, injection/extraction, drains, creeks and other sources and sinks. These data have been sourced from the following:

- Rainfall data as outlined in Section 3.1 (supplied by BOM).
- Underground water extraction data (supplied by Centennial Newstan).
- Groundwater level monitoring data (supplied by Centennial Newstan).

4.2.3 Model Calibration and Prediction Scenarios

The hydrogeological model has been calibrated under steady state and transient conditions. The calibrated model has been used to predict groundwater inflow over time into the workings within the SMP Study Area as well as losses (if any) from shallow aquifers overlying the workings.

Predictions have been made under several scenarios of hydraulic conductivity change, based on strata deformation and fracturing predictions provided in MSEC (2012). According to the analysis of fracturing height undertaken by MSEC (2012), continuous fracturing may extend up to the height of 130 – 160 m above the longwall panels. This is generally consistent with the analysis of deep groundwater impacts at Mandalong Mine to the south of Newstan, which suggests that vertical interconnected fracturing may extend up to 120 m above the longwall panels (GHD, 2012). MSEC (2012) also predicts that the height of discontinuous cracking could extend up to 220 – 280 m above the longwall panels.

Note that MSEC's predictions are based on an analysis of mine geometry using tensile strain and subsidence predictions.

5. Impact Assessment – Existing Data

An assessment of potential groundwater impacts, based on existing groundwater monitoring data, is included in this section.

5.1 Alluvial Groundwater

Groundwater hydrographs for the 11 alluvial monitoring bores listed in Table 5-1 and Table 5-2 have been plotted and compared to the CRD curve (Figure 3-1). Alluvial hydrographs are shown in Appendix A.

5.1.1 Kilaben/Stony/Stockyard Creek Alluvium

Hydrographs for bores AE1 – AE6 provide baseline groundwater level data within alluvium in the vicinity of the SMP Study Area. Observation data are shown in black and the CRD is shown in blue.

HARTT analysis has been undertaken for each of these alluvial datasets to establish the relationship between groundwater levels and rainfall. The best fit HARTT regression line is shown in red in each hydrograph in Appendix A. The HARTT statistical output for each alluvial hydrograph is given in Table 5-1.

Table 5-1 HARTT Analysis Results for AE Monitoring Bores

Bore	R^2	Rainfall Coeff. *a* (m/mm)	P rain	Time Coeff. *b* (m/mth)	P time	*c* (m)
AE1	0.45	0.0016	0.0001	0.01	0.1077	3.03
AE2	0.02	6.879	0.557	0.001	0.508	2.02
AE3	0.26	0.0002	0.004	0.001	0.332	1.28
AE4	0.33	0.001	0.002	-0.002	0.64	2.54
AE5	0.13	0.0004	0.08	0.0057	0.16	1.12
AE6[(a)]	0.9	0.011	1.186	0.18	2.94	-0.11

(a) Bore was dry for most of the monitoring period

The statistical analysis suggests there is a significant relationship between groundwater level and rainfall at monitoring bores AE1, AE3, AE4 and AE5 (i.e. p value for the rainfall variable less than 0.05). No underlying (rainfall independent) time trends were evident at any location (i.e. p value for the time variable greater than 0.05). The R^2 values of the HARTT regression line were generally low, suggesting that the bores may be situated at locations where the hydrograph cannot be adequately modelled by the HARTT variables. This implies that other factors (such as the close proximity to a creek or issues with monitoring bore construction) are affecting groundwater levels.

5.1.2 Lords Creek Alluvium

Hydrographs for monitoring bores MB10, MB11, MB12, MB13 and MB15 cover the period from 2005 to 2011. HARTT analysis was undertaken on each of these datasets to establish the relationship between groundwater levels and rainfall and detect underlying trends in groundwater level that are independent of rainfall. The HARTT statistical output for the MB bores is given in Table 5-2. Since bore MB15 is closest to the existing longwalls and more likely to be impacted by mining, an additional analysis was undertaken on the dataset recorded since the completion of the final longwall at Newstan (May 2009).

Table 5-2 HARTT Analysis Results for MB Monitoring Bores

Bore	R^2	Rainfall Coeff. *a* (m/mm)	P rain	Time Coeff. *b* (m/mth)	P time	*c* (m)
MB10	0.56	0.0019	0.00	-0.01	0.06	25.18
MB11	0.646	0.0014	0.00	-0.007	0.05	30.73
MB12	0.89	0.0018	0.00	-0.006	0.003	19.78
MB13	0.705	0.002	0.00	-0.012	0.006	27.08
MB15	0.72	0.0037	0.00	-0.0186	0.016	19.26
$MB15_{post}$	0.82	0.006	0.00	0.033	0.066	17.80

'post' – analysis of dataset from completion of mining i.e. May 2009

The p-value for the rainfall variable was less than 0.05 for all MB bores, indicating that there is a significant relationship between groundwater level and rainfall at all monitoring locations. The p-value for the time variable was less than 0.05 for the datasets of bores MB12, MB13 and MB15, indicating statistically significant linear time trends (independent of rainfall) in groundwater levels at these locations. Each of these statistically significant time trends were decreasing. No statistically significant time trend was evident for the post mining dataset at MB15. The R^2 values are generally high, indicating that the hydrographs are reasonably modelled by the HARTT variables (rainfall and linear time trends).

It should be noted that groundwater levels within the MB bores have been recorded manually and that the limit of reading of the measuring tape is 10 mm. The magnitude of the time trends at MB12 and MB13 were at or below the limit of reading of groundwater level measurements.

The analysis of the hydrograph at MB15 suggests that alluvial groundwater at this location appears to have responded temporarily to subsidence, however throughout the period since the completion of mining the decreasing trend was no longer detectable. Note that the temporary impact to groundwater levels at MB15 did not appear to change groundwater pH or EC. Groundwater remained fresh and slightly acidic at MB15 over the monitoring period, while up gradient groundwater (MB11) remained brackish and slightly acidic.

Therefore, the statistical analysis does not provide evidence that previous longwall mining at Newstan has had long term impacts on groundwater levels within Lords Creek alluvium, either via loss of groundwater into deep vertical interconnected fractures or in terms of localised reductions in groundwater levels associated with surface subsidence, deformation and changes in near surface hydraulic conductivity.

Note that there are a number of limitations to the HARTT regression model:

- The model assumes that average monthly rainfall does not change over the analysis period (eg due to climate change) and that the rainfall dataset selected for the analysis is appropriate.
- The method is generally limited to shallow groundwater in unconfined aquifers.
- The model assumes linear time trends.

5.2 Coal Seam Groundwater

Coal seam groundwater at CN036 and CN038 was monitored between 2005 and 2009 with VWPs. Hydrographs for these locations are shown in Appendix B.

The impacts of longwall mining on groundwater elevations within deeper rock formations are generally more obvious than for alluvial groundwater since these deeper groundwater sources are less influenced by changes in rainfall and they are more affected by strata deformations and fracturing because they are closer to the longwalls. The piezometric head of coal seam groundwater at CN036 and CN038 fell over the monitoring period by 15 – 20 m, indicating that these monitoring locations are within the radius of depressurisation resulting from mining.

5.3 Awaba Waste Management Facility

The existing AWMF is located to the north of the unnamed creek that flows into Kilaben Creek and located above the proposed LW103. As detailed in MSEC (2012), the facility was commissioned in 1986 and the original waste disposal area does not appear to have been designed for subsidence related impacts. The original waste disposal area was unlined, however an additional cell constructed in 2005 at the south-eastern corner of the site incorporates a Geosynthetic Clay Liner (GCL). The main existing leachate pond located near the southern end of the site contains a High Density Polyethylene Liner (HDPE).

5.3.1 Existing Groundwater Data

Council carries out routine groundwater quality monitoring at four monitoring locations down gradient of the main existing leachate pond, under its Environment Protection Licence (EPL 5873). Groundwater level data are not collected by Council since it is not a requirement under the EPL.

Groundwater quality data (covering the period February 2009 to September 2011) as well as leachate chemistry data were supplied by Council for review. In addition, a round of groundwater monitoring was undertaken by Centennial Newstan in April 2012, which included groundwater level measurement.

Groundwater Levels

Groundwater level measurements carried out in April 2012 indicate that the depth to groundwater ranges from less than 1 m to approximately 8 m below the existing ground level at the groundwater monitoring wells situated throughout the AWMF site. At the northern end of the site, monitoring wells intercept groundwater within the sandstone and shale strata while at the southern end of the site the groundwater occurs within sandstone and colluvium deposits. Based on the groundwater levels reported in April 2012 it is likely that:

- Groundwater to the north of the original waste disposal area is at a higher elevation than the base of the disposal area. There may therefore be seepage of groundwater into the original waste disposal area.
- The base of the main leachate pond is at an elevation similar to groundwater in that area.

Overall, an assessment of existing site levels and groundwater elevations indicates that the original waste disposal area and main leachate pond are currently in close proximity to groundwater.

Groundwater Chemistry

Major ion analysis is undertaken for groundwater and leachate as part of Council's monitoring program. A Piper Diagram of major ion analysis undertaken in June 2011 is shown in Figure 5-1. Piper diagrams are often used to make tentative conclusions regarding the origin of water as represented by major ion analysis. A Piper diagram is a trilinear diagram, where the apices of each diagram represent 100% of a component and the opposite end represents 0% of that component. The major ions are plotted as ratios.

Existing groundwater at monitoring wells MP2, MP3, MP4 and MP5, located down gradient of the main leachate pond, is characterised as sodium chloride type water. Note that MP2, MP3 and MP4 are immediately down gradient of the leachate pond, while MP5 is a further 40 m down gradient. Leachate (MP10) is sodium bicarbonate type. It is noted that groundwater at MP3 and MP4 have a higher bicarbonate content than MP2 and MP5, suggesting that there may be some existing interaction between leachate and groundwater at these locations. Further evidence of leachate interaction with groundwater is the 50th percentile ammonia concentrations at MP3 and MP4, which are 69.6 mg/L and 2.3 mg/L respectively. Based on the available data, the migration pathway of leachate to groundwater is unknown.

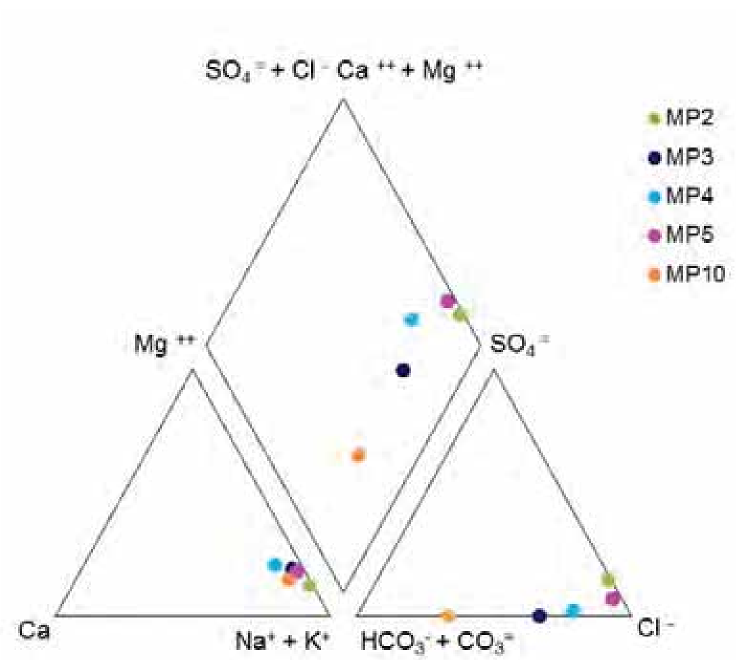


Figure 5-1 Piper Diagram for Groundwater and Leachate at AWMF

Leachate does not appear to have migrated as far as MP5 or to the unnamed tributary of Kilaben Creek.

5.3.2 Potential Impacts from Subsidence at AWMF

According to MSEC (2012) and historical observations from the Newcastle Coalfield, it is likely that fracturing of the uppermost bedrock above LW103 will extend to depths of no more than 10 – 15 m below the ground surface. Therefore, it is not expected that leachate from the AWMF would be able to migrate downwards to the mine. However, the hydraulic conductivity of the uppermost bedrock may increase, resulting in an increased potential for leachate to migrate to groundwater, particularly from the original waste disposal area, and for the spatial extent of any existing leachate plume to expand.

Further investigations will be undertaken separately from this assessment to confirm whether there is an existing leachate impact to groundwater, the spatial extent of the plume and the risk to the environment and human health, and the likely increase to these risks (if any) resulting from subsidence cracking. These investigations are detailed in Section 8.

6. Impact Assessment – Groundwater Flow Model

An overview of the conceptual model, boundary conditions, grid construction, model calibration and model prediction is provided in this Section.

6.1 Conceptual Model and Boundary Conditions

The spatial extent of the model (northern, western and southern boundaries) is generally limited by the extent of geological data of the Young Wallsend and Yard seams. The eastern extent is defined by Lake Macquarie. The active area polygon is shown in Figure 6-1.

The vertical boundaries of the model extend from the ground surface to a depth of -420 m AHD. The model has been divided into six layers:

- Alluvium and outcropping areas.
- Triassic sandstone and conglomerate (including Munmorah Conglomerate).
- Great Northern seam.
- Interbedded tuffs and coal.
- Young Wallsend / Yard / Borehole seams.
- Waratah Sandstone.

The northern and western extents of the model are generally defined by outcropping strata and no flow boundaries. Piezometric head is generally assumed to follow the south-eastern dip of the strata and therefore the southern and eastern boundaries are generally defined as General Head Boundaries (GHBs). The floor of Layer 6 is defined by a no flow boundary.

Due to limited creek bed elevation and flow data, the major waterways have been defined as drainage cells (rather than stream or river cells). Drainage cells have also been placed at ground surface along the outcropping areas to remove water that comes to the surface.

Boundary conditions for each model layer are summarised in Table 6-1. Conceptual representation of Layers 1 and 5 are shown in Figure 6-1 and Figure 6-2.

Table 6-1 Model Boundary Condition Details

Layer	Boundary Condition	Boundary Details
Layer 1 – Alluvium and Triassic outcropping areas	Recharge	Net recharge (ie rainfall after evaporation) initially set to 1% of annual rainfall across the entire area of Layer 1. Based on average annual rainfall between 1901 and 2012 of 1.16 m/year, this equates to a net recharge of 0.012 m/year. Final value was established through model calibration.
	General Head Boundary (GHB)	The eastern boundary of Layer 1 has been defined by GHB cells set at 0 m AHD to represent Lake Macquarie.

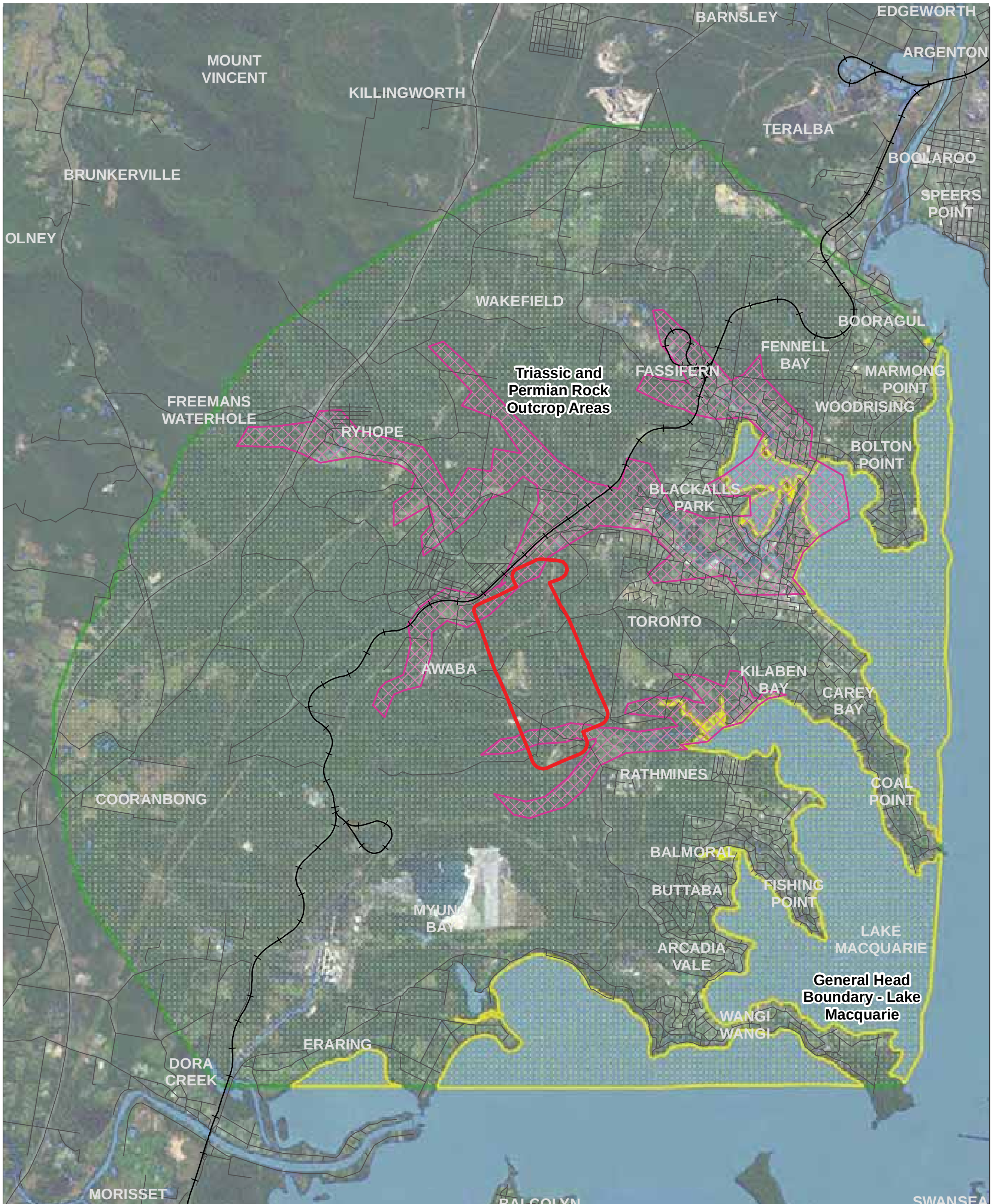
Layer	Boundary Condition	Boundary Details
	Drain	Main surface water features, including Kilaben Creek and Stony Creek, are represented by drain cells. The drain cell elevations have been determined from topographic elevation data along surface water features. Conductance values have been set to represent the hydraulic conductivity of the surrounding geology. In addition, drain cells have been set at ground level throughout Triassic outcropping areas to simulate the removal of groundwater that comes to the surface. Conductance values have been set to represent the hydraulic conductivity of the surrounding geology.
Layer 2 – Triassic overburden	General Head Boundary (GHB)	The southern and eastern boundaries of Layer 2 are considered to be the down-gradient extents of this formation (within the modelled domain) and have been defined by GHB cells set at 0 m AHD.
	No Flow	The northern and western boundaries of Layer 2 are considered to be no flow boundaries since these are generally the outcropping up gradient extents of this formation (within the modelled domain).
Layer 3 – Great Northern seam **Layer 5** – West Borehole / Young Wallsend / Yard seams	Drain	Drain cells have been used to represent the mined areas of the Great Northern and West Borehole / Young Wallsend / Yard seams. Conductance values have been set to represent the hydraulic conductivity of the surrounding geology.
	General Head Boundary (GHB)	The southern and eastern boundaries of Layers 3 and 5 are considered to be the down-gradient extents of these formations (within the modelled domain) and have been defined by GHB cells set at 0 m AHD.
	No Flow	The northern and western boundaries of Layers 3 and 5 are considered to be no flow boundaries since these are generally the up gradient extents of these formations (within the modelled domain).
Layer 4 – Interbedded tuffs and coal	General Head Boundary (GHB)	The southern and eastern boundaries of Layer 4 are considered to be the down-gradient extents of these formations (within the modelled domain) and have been defined by GHB cells set at 0 m AHD.
	No Flow	The northern and western boundaries of Layer 4 are considered to be no flow boundaries since these are generally the up gradient extents of these formations (within the modelled domain).

Layer	Boundary Condition	Boundary Details
Layer 6 – Waratah sandstone	General Head Boundary (GHB)	The southern and eastern boundaries of Layer 6 are considered to be the down-gradient extents of this formation (within the modelled domain) and have been defined by GHB cells set at 0 m AHD.
	No Flow	The northern and western boundaries of Layer 6 are considered to be no flow boundaries since these are generally the up gradient extents of this formation (within the modelled domain).

6.1.1 Model Assumptions

Since the hydrogeological model is based on limited data and a simplified conceptualisation of the hydrogeological system, it is necessary to make assumptions. Assumptions and limitations are outlined as follows:

- Potential groundwater impacts will not extend beyond the active area of the model.
- The water head level of Lake Macquarie is constant since tidal variations will have little effect on inflows into the deep underground workings or on shallow groundwater levels in the vicinity of the SMP Study Area.
- All other GHBs have constant piezometric head over time.
- Material properties are uniform throughout each material zone.
- Groundwater extractions from registered bores within the modelled domain are negligible and are assumed to have a negligible effect on model results.
- Surface water / groundwater interactions have not been considered in assessing shallow groundwater impacts.



1:80,000 for A4

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Roads
- Railway
- SMP Study Area
- Alluvium
- General Head Boundary - Lake Macquarie
- Triassic and Permian Rock Outcrop Areas
- Waterbody

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

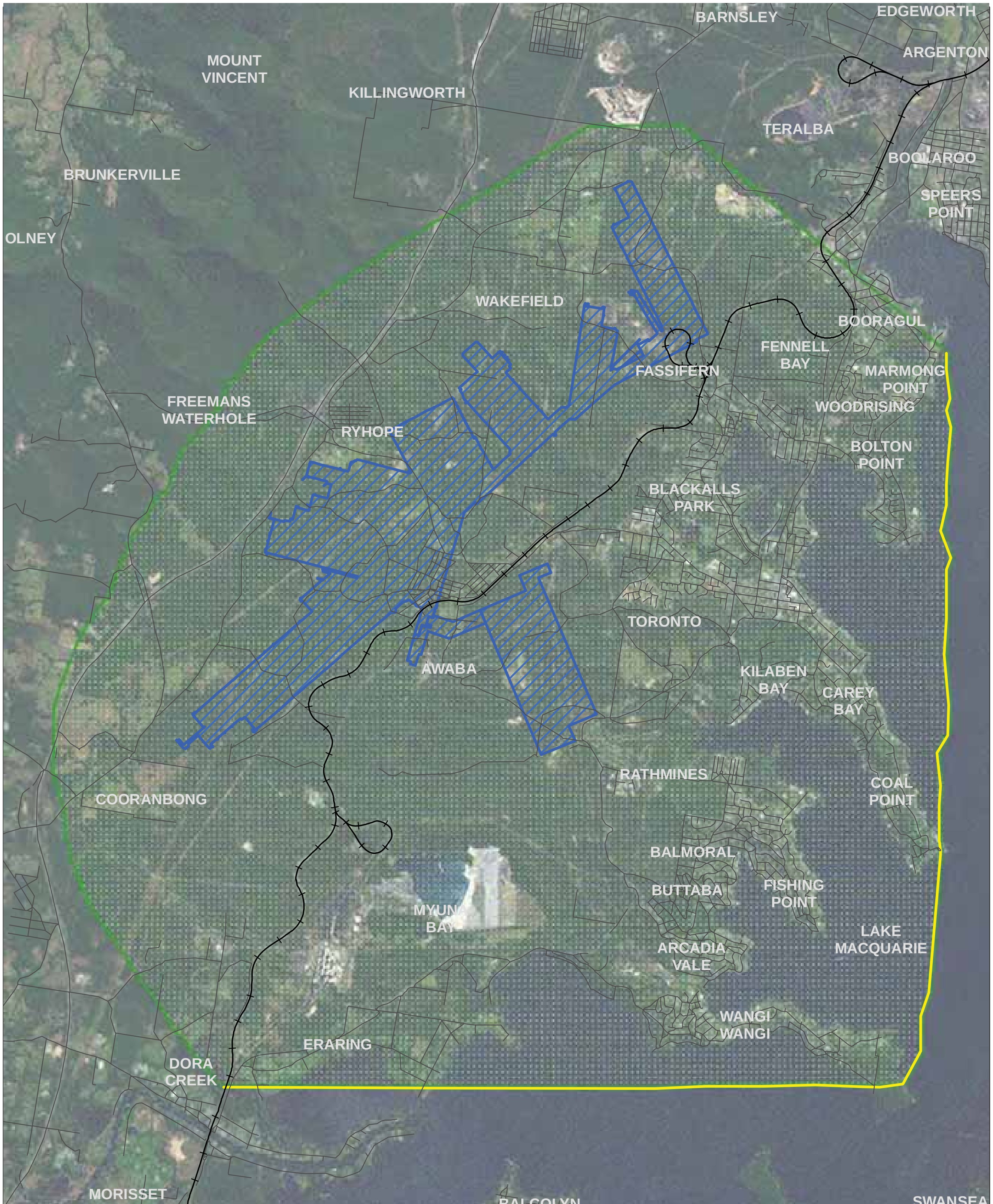
Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Conceptual Hydrogeological Model
Layer 1

Centennial Newstan

DATE 16-04-2012

Figure 6-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_009_ConceptualHydrogeologicalModel_Rev_A.mxd



1:80,000 for A4

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

Roads
Railway
General Head Boundary
Drain Cells
Coal Seam

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Groundwater Impact Assesment
Conceptual Hydrogeological Model
Layer 5

Centennial Newstan

DATE 16-04-2012

Figure 6-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SMP_Groundwater\2215922_010_ConceptualHydrogeologicalModel_No5_Rev_A.mxd

6.2 Grid Construction

The maximum horizontal extent of the active model covers an area of approximately 160 km^2, extending from N: 6339050 and E: 357750 in the southwest to N: 6353450 and E: 371150 in the northeast. The maximum east-west and north-south extents are approximately 13.4 km and 14.4 km respectively. The area has been divided into a grid consisting of 268 columns and 288 rows, generating equally sized cells with dimensions 50 m × 50 m. Active and inactive cells were defined by the available geological data and geological boundaries.

As outlined in the conceptualisation of the hydrogeological system, the model has been divided into six layers of varying thicknesses. In total, the model consists of 372,954 active cells. The top and base of each layer is defined in Table 6-2.

Table 6-2 Vertical Extent of Model Layers

Layer	Description	Top	Base
1	Alluvium and Triassic outcrop	Topographic Contours	Topographic Contours - 5 m
2	Triassic overburden	Topographic Contours – 5 m	Great Northern seam roof
3	Great Northern seam	Seam elevation data (provided by Centennial Newstan)	Seam elevation data (provided by Centennial Newstan)
4	Interbedded tuffs and coal	Great Northern Seam floor	West Borehole / Young Wallsend seam roof
5	West Borehole / Young Wallsend / Yard seams	Seam elevation data (provided by Centennial Newstan)	Seam elevation data (provided by Centennial Newstan)
6	Waratah sandstone	West Borehole / Yard seam floor	-420 m AHD

6.2.1 Material Properties

The hydrogeological model has been divided into six material types. The pre-calibration hydrogeological properties for each material type were derived from a combination of data presented in Pacific Power (1997), previous hydrogeological models developed by GHD for the Newcastle Coalfield, and packer test data from the Newstan exploration program. Values are shown in Table 6-3. Final values were established through model calibration.

Table 6-3 Pre-Calibration Hydrogeological Properties

Inferred Hydrogeological Unit	Model Layers	Horizontal Hydraulic Conductivity "K_h" (m/year)	Vertical Hydraulic Conductivity "K_v" (m/year)	Specific Storage "Ss" (1/m)	Effective Porosity (n_e).
Alluvium	Layer 1	365	36.5	0.005	0.3
Triassic sandstone and conglomerate	Layers 1 and 2	3.65	0.365	0.005	0.1
Coal seams	Layers 3 and 5	1.8	0.18	0.001	0.1
Interbedded tuff and coals	Layer 4	0.0365	0.00365	0.001	0.1
Fractured overburden	Layer 4	0.0365-0.365	0.00365-0.0365	0.001	0.1
Waratah sandstone	Layer 6	0.0365	0.00365	0.001	0.1

S_s = Specific storage
n_e = effective porosity
Alluvium boundary shown in Figure 6-1

6.3 Steady State Calibration

Calibration of the hydrogeological model was initially undertaken under steady state conditions using long term average rainfall. Material properties and the net recharge coefficient were adjusted in order to minimise the residual errors between modelled and observed steady state groundwater levels.

Observation datasets for monitoring locations AE1, AE2, AE3, AE4, AE5, MB10, MB11 and CN036 (shown in Figure 4-1) were used in the steady state calibration. Steady state groundwater levels for each location were selected to coincide with periods when the CRD (Section 3.1) was close to zero. Figure 6-3 shows the CRD for the period 2005 – 2012. Over this period, the CRD was closest to zero in April 2009. Monitoring data was available from each of the above monitoring locations at this time.

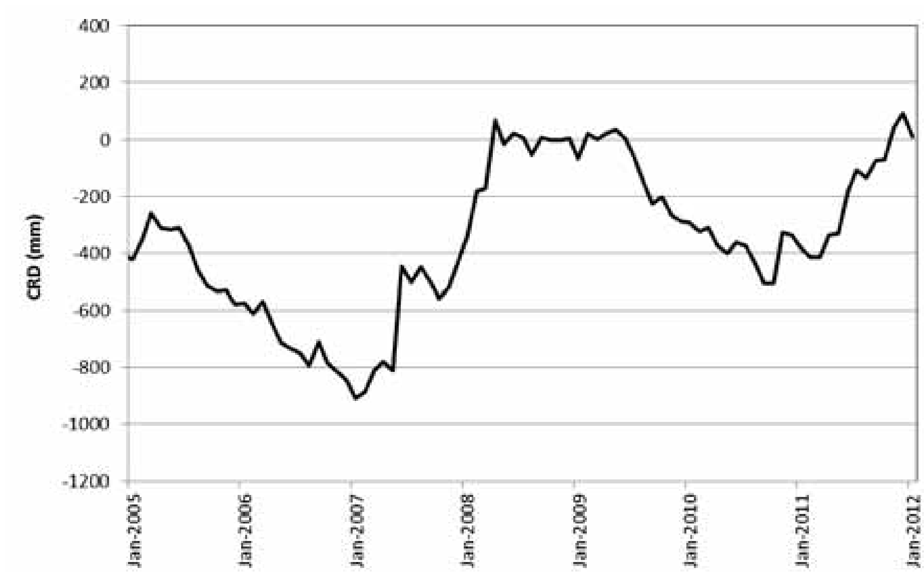


Figure 6-3 CRD for the Period 2005-2012

Residuals between steady state modelled and observed groundwater levels were assessed by calculating the scaled root mean square error (SRMSE). The lowest SRMSE obtained (using realistic material properties) for a converging steady state run was 5.9%. A scatterplot of modelled steady state groundwater levels versus observed levels is shown in Figure 6-4. The calibrated hydrogeological properties were unchanged from the pre-calibration values in Table 6-3. The net recharge across Layer 1 was reduced to 0.005 m/year to achieve the steady state calibration.

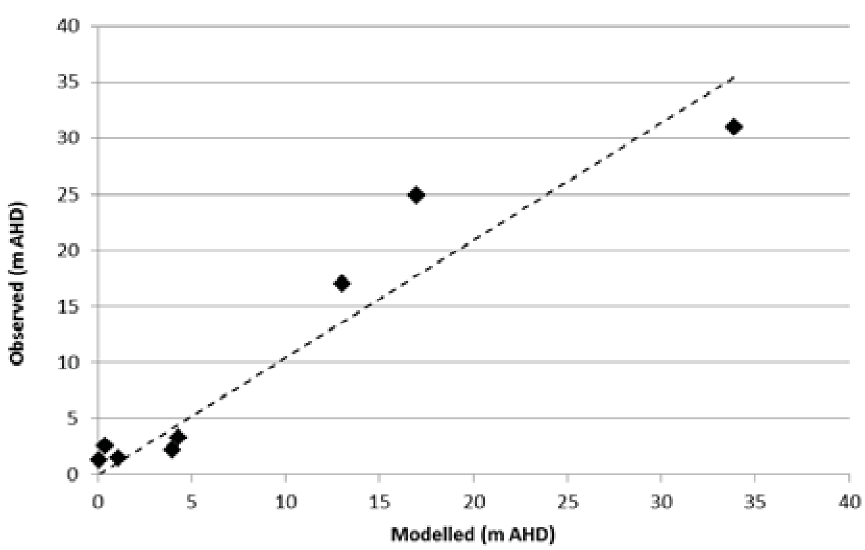


Figure 6-4 Steady State Calibration Results

6.4 Transient Calibration

The modelled steady state groundwater levels were used as the starting head levels for the transient model. The transient model was run annually from 1990 to coincide with the commencement of mining of the West Borehole seam at Newstan. The model was run over a 40 year period.

As outlined in Table 6-1, drain cells were established throughout Layer 5 to coincide with the development of existing workings within the West Borehole seam between 1990 and 2009. The longwall commencement and completion schedule (provided by Centennial Newstan) was used to active the drain cells throughout the layer.

The transient model was calibrated by adjusting hydrogeological properties in the strata overlying the mine footprint ('Fractured overburden' in Table 6-3) up to a height of 280 m (as predicted by MSEC (2012)) so that groundwater inflows into the existing workings at Newstan were as close as possible to the recorded extraction in 2009 (average of 2.3 ML/day or 840 ML/year). This established the likely increase in hydraulic conductivity in the strata overlying the existing workings as a result of strata deformation and fracturing. Note that underground water extraction data prior to 2009 is limited and therefore calibration focused on the value for 2009.

The groundwater level datasets utilised for steady state calibration were not used for transient calibration due to insufficient historical data. Recharge was not adjusted during transient calibration. The modelled change in groundwater inflow into the existing workings at Newstan is shown in Figure 6-5.

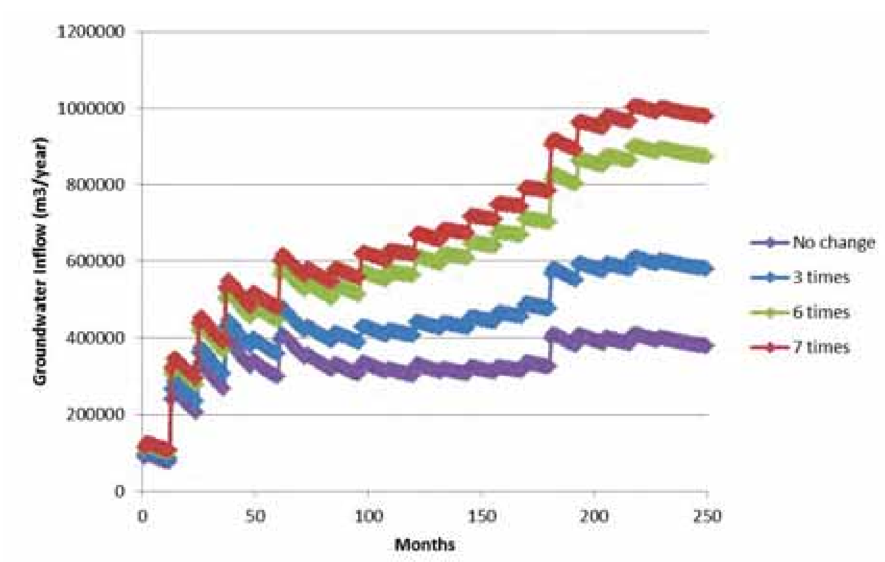


Figure 6-5 Modelled Groundwater Inflow into Existing Workings at Newstan

Models were run for various increases in the horizontal and vertical hydraulic conductivities in the strata overlying the existing workings (from zero to seven times). Note that the plot in Figure 6-5 covers the period (in months) from 1990 to 2009 and groundwater inflows are reported in m^3/year. It was considered that a hydraulic conductivity increase of six times gave the closest modelled groundwater inflow in year 2009 (after 240 months) to recorded data. The modelled value at this point in time is approximately 880,000 m^3/year (or 880 ML/year), compared to an average measured value of 840 ML/year.

6.5 Predictive Simulations

The calibrated transient model was used to predict groundwater inflow into the proposed workings within the SMP Study Area and groundwater loss (if any) from shallow aquifers. The model was run for a further 20 years to simulate groundwater flow between 2010 and 2029.

6.5.1 Groundwater Inflows

Figure 6-6 shows the range of predicted groundwater inflow values into the proposed SMP workings (LW101, 102 and 103 and associated main headings). The plot commences at year 1990 and it is assumed that extraction within the SMP Study Area commences after 23 years (2013). Groundwater inflow has been predicted for a zero, six times and seven times increase in horizontal and vertical hydraulic conductivities in the strata above the workings.

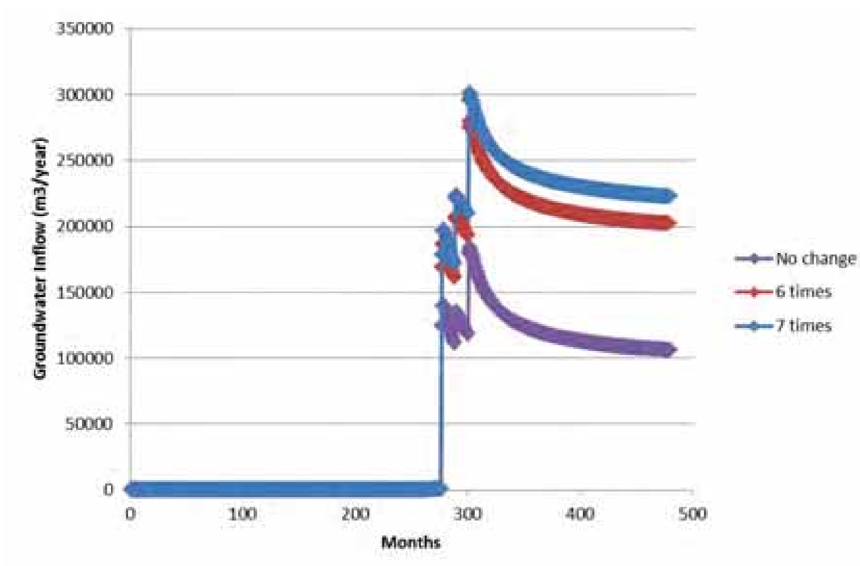


Figure 6-6 Predicted Groundwater Inflow into SMP Workings

For the ‘six times’ hydraulic conductivity increase scenario, it is predicted that the total groundwater inflow into the proposed SMP workings will peak at approximately 280 ML/year and stabilise over time to about 200 ML/year.

6.5.2 Aquifer Depressurisation

Based on the model output, the radius of depressurisation greater than 0.1 m for the 'six times' hydraulic conductivity increase scenario is as follows (distance from mine footprint):

- Young Wallsend/Yard seam (Layer 5): 800 m
- Waratah sandstone (Layer 6): 350 m.
- Interbedded tuff/coal (Layer 4): 150 m.

As shown in Figure 3-5, there are no registered bores for stock, domestic or irrigation use within these distances from the proposed workings.

For the upper layers, depressurisation greater than 0.1 m is confined to the SMP Study Area. It is predicted that groundwater drawdown would generally be less than 0.2 m throughout areas where possible GDEs are located.

An analysis of the shallow aquifers suggests that there would be a negligible movement in groundwater from the top 5 m of strata (including alluvium and outcropping rock) to the underlying strata as a result of extraction of coal within the SMP Study Area. For all hydraulic conductivity increase scenarios, this change is predicted to be less than 0.2 ML/year throughout the entire SMP Study Area. It is noted that an annual extraction of less than 3 ML/year from an aquifer is considered by the NOW to be typical of use under basic landholder rights and generally low impact.

7. Summary of Predicted Impacts

The groundwater impact assessment for the development and extraction of LW101, 102 and 103 at Newstan is based on an analysis of existing groundwater monitoring data and predictions from a preliminary hydrogeological model.

The following conclusions can be made:

- The groundwater sources in the vicinity of the SMP Study Area are generally low yielding and limited to shallow alluvium, underlying fractured rock and coal seams. There is minimal use and reliance on this groundwater for stock, domestic and irrigation purposes. However, it is possible that GDEs associated with Kilaben, Stockyard and Stony Creeks are located in the vicinity of the SMP Study Area.
- Based on the MODFLOW hydrogeological model, the development and extraction of LW101, 102 and 103 is expected to intercept deeper Permian groundwater at a rate of approximately 200 – 280 ML/year. The movement of shallow groundwater into underlying strata as a result of mining operations is expected to be small, totalling only 0.2 ML/year throughout the entire SMP Study Area. No continuous fracturing between shallow aquifers and the mine workings are expected. The additional groundwater inflow will be transferred to either the Fassifern seam underground water storage at Newstan or the Great Northern seam underground water storage at Awaba Colliery.
- Aquifer depressurisation is not anticipated to impact registered stock, domestic or irrigation bores. The groundwater monitoring bore at the Toronto Country Club (GW064214) may experience some minor drawdown associated with mining although this is expected to be in the order of 0.1 m and negligible compared to climatic variation.
- Potential GDEs located within the SMP Study Area may experience a drawdown of up to 0.2 m as a result of mining. It is not anticipated that GDEs located outside the SMP Study Area will be impacted.
- Based on available data, there is evidence of existing interaction of leachate with groundwater at the AWMF. An increase in hydraulic conductivity of the uppermost bedrock due to subsidence cracking may increase the movement of leachate within the upper 10 – 15 m of rock, however it is not expected that leachate would move downwards to the mine.

7.1 Greater Than Predicted Subsidence

Additional potential groundwater impacts have been considered, should actual conventional subsidence movements exceed predicted subsidence movements by a factor of two times. In this case, MSEC (2012) does not expect that continuous cracking would extend from the seam to the ground surface since the heights of fracturing predictions are based on actual historical observations from the Newcastle Coalfield. In addition, it is expected that the depth of subsidence cracking of the uppermost bedrock would remain less than 10 to 15 m (although the extents and widths of surface cracking would increase, leading to increased hydraulic conductivities).

Under the greater than predicted subsidence scenario, the following conclusions can be made regarding groundwater impacts:

- Groundwater inflows into the mine workings and depressurisation of deeper aquifers would remain the same since these predictions are based on observed inflows into existing workings and not on subsidence parameters.
- Groundwater drawdown in shallow aquifers within the SMP Study Area may be higher than predicted due to an increase in the hydraulic conductivity of the uppermost bedrock caused by greater subsidence cracking.
- The movement of leachate from the AWMF within the upper 10 – 15 m of rock may increase due to an increase in the hydraulic conductivity of the uppermost bedrock caused by greater subsidence cracking.

Methods to quantify and manage increases in hydraulic conductivity are detailed in Section 8.

8. Management Actions and Monitoring

The following management actions are proposed:

- Modify the existing water balances for Newstan and Awaba Collieries to incorporate the additional groundwater from LW101, 102 and 103. Centennial Newstan is currently undertaking this work as part of the Environmental Impact Statement (EIS) for the Newstan project. As part of this water balance modification, options for water reuse and underground transfers should be explored to reduce the volume of water required to be discharged from site.
- Develop a Trigger, Action and Response Plan (TARP) for monitoring potential groundwater impacts associated with LW101, 102 and 103. Monitoring should be undertaken with reference to the NSW Office of Water's 'Draft Groundwater Monitoring Guidelines for Mine Sites within the Hunter Region' (DIPNR, 2003). Triggers should be consistent with those specified within the Draft NSW Aquifer Interference Policy (DTIRIS, 2012). Groundwater monitoring should focus on:
  - Monitoring of groundwater levels and quality at the existing monitoring locations at the AWMF.
  - Monitoring of groundwater levels within alluvium in the vicinity of GDEs. Since any shallow impacts are anticipated to be limited to the SMP Study Area it is recommended that additional alluvial monitoring bores be installed within this area.

  This TARP will form part of the Newstan Water Management Plan which shall be revised and as part of the EIS.
- It is necessary to confirm whether there are existing impacts to groundwater from leachate at the AWMF and, if so, identify the migration pathways, the current spatial extent of any leachate plume and risks to the environment and human health.
- Utilise ground monitoring data from LW101 and LW102 to confirm the magnitude of changes in hydraulic conductivity of the near surface strata and use this information to refine predictions regarding any increase in leachate impact to groundwater resulting from LW103.

9. Limitations

This report has been prepared for use by Centennial Newstan who has commissioned the works in accordance with the project brief only, and has been based in part on data and information obtained from Centennial Newstan and other parties. GHD has not independently verified or checked this information beyond the agreed scope of work.

The advice herein relates only to this project and all results, conclusions and recommendations made should be reviewed by a person experienced in groundwater investigations before being used for any other purpose. GHD accepts no liability for use or interpretation by any person or body other than Centennial Newstan. This report should not be reproduced without prior approval by Centennial Newstan, or amended in any way without prior approval by GHD, and should not be relied upon by other parties, who should make their own enquires.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should additional information become available regarding conditions at the site, GHD reserves the right to review the report in the context of the additional information.

10. References

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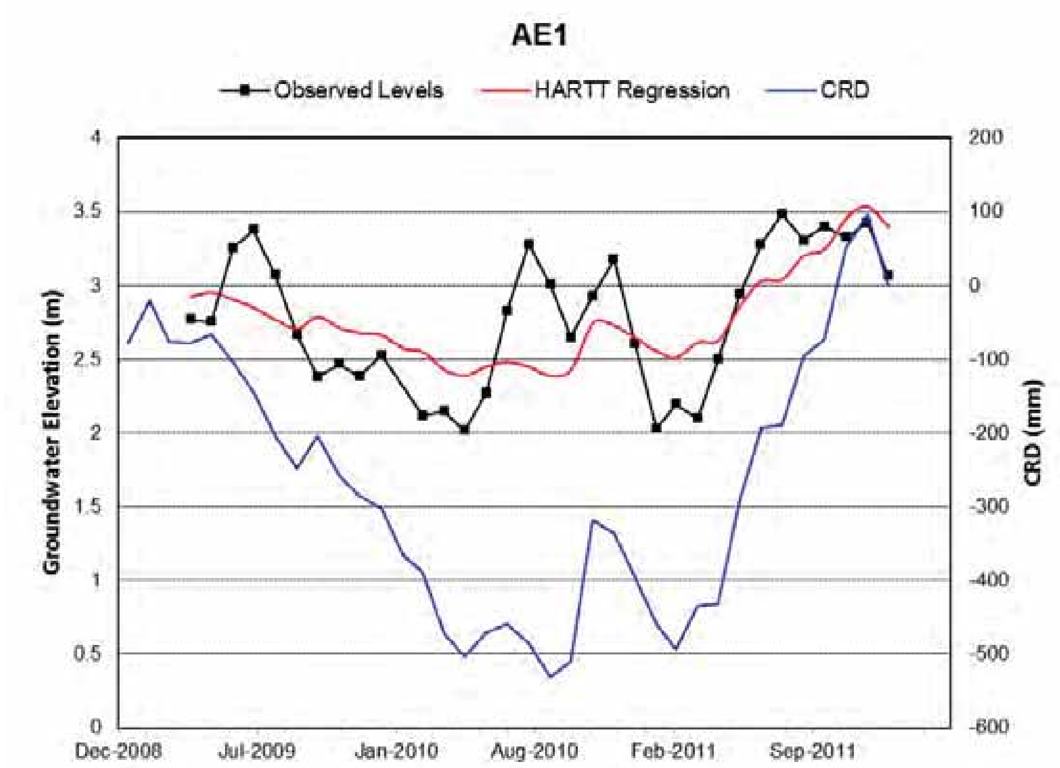
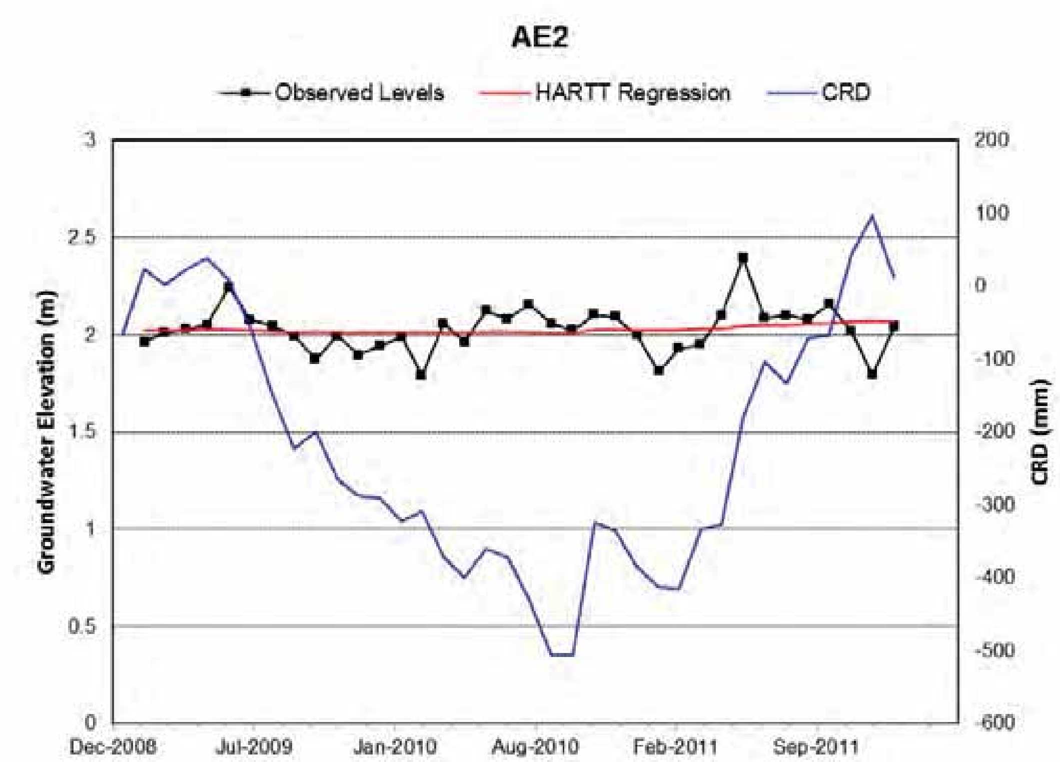
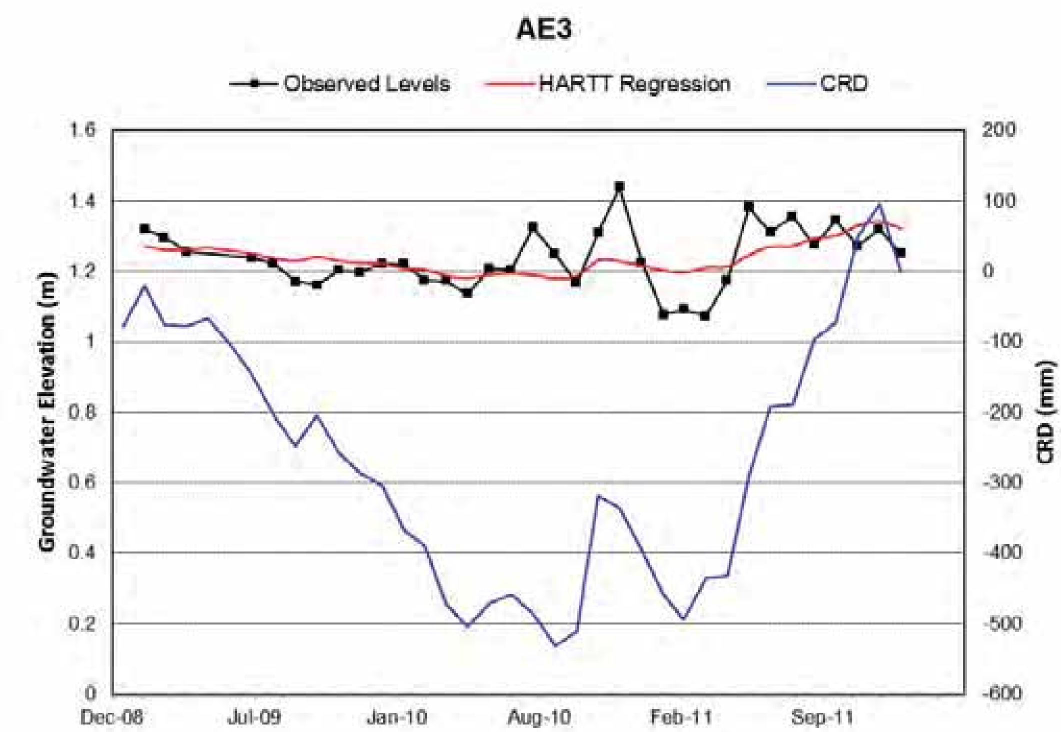
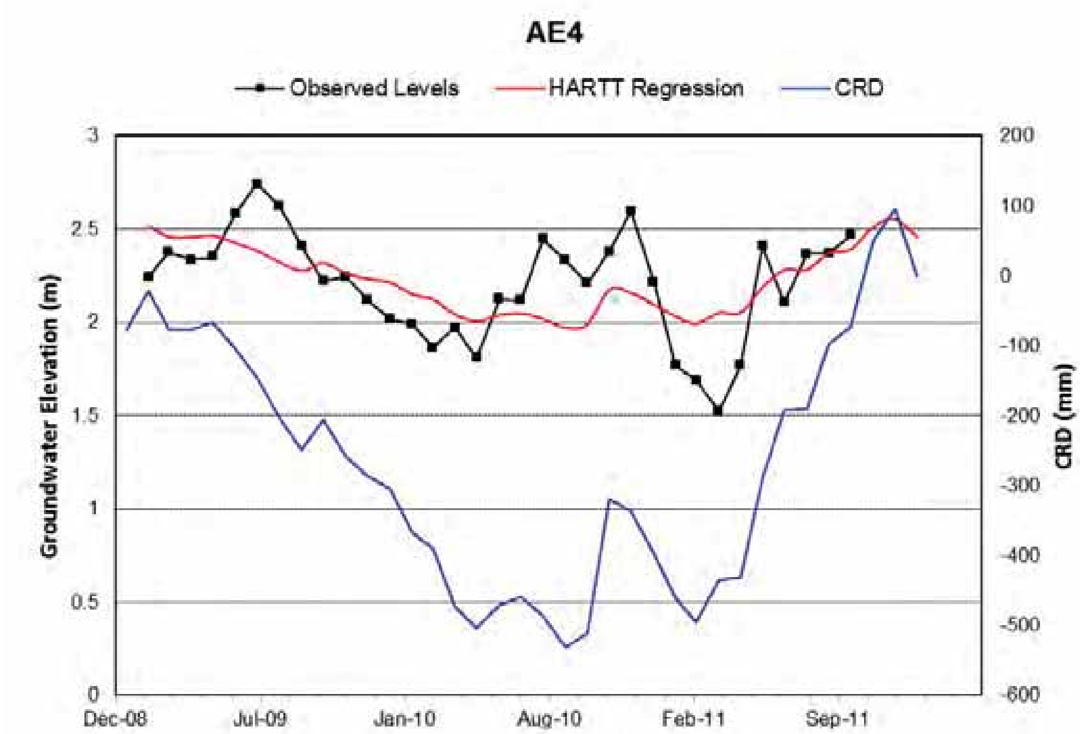
Appendix A

Groundwater Hydrographs - Alluvium


AE1
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
4
3.5
3
2.5
2
1.5
1
0.5
0
200
100
0
-100
-200
-300
-400
-500
-600
Dec-2008
Jul-2009
Jan-2010
Aug-2010
Feb-2011
Sep-2011


AE2
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
3
2.5
2
1.5
1
0.5
0
200
100
0
-100
-200
-300
-400
-500
-600
Dec-2008
Jul-2009
Jan-2010
Aug-2010
Feb-2011
Sep-2011


AE3
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
200
100
0
-100
-200
-300
-400
-500
-600
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11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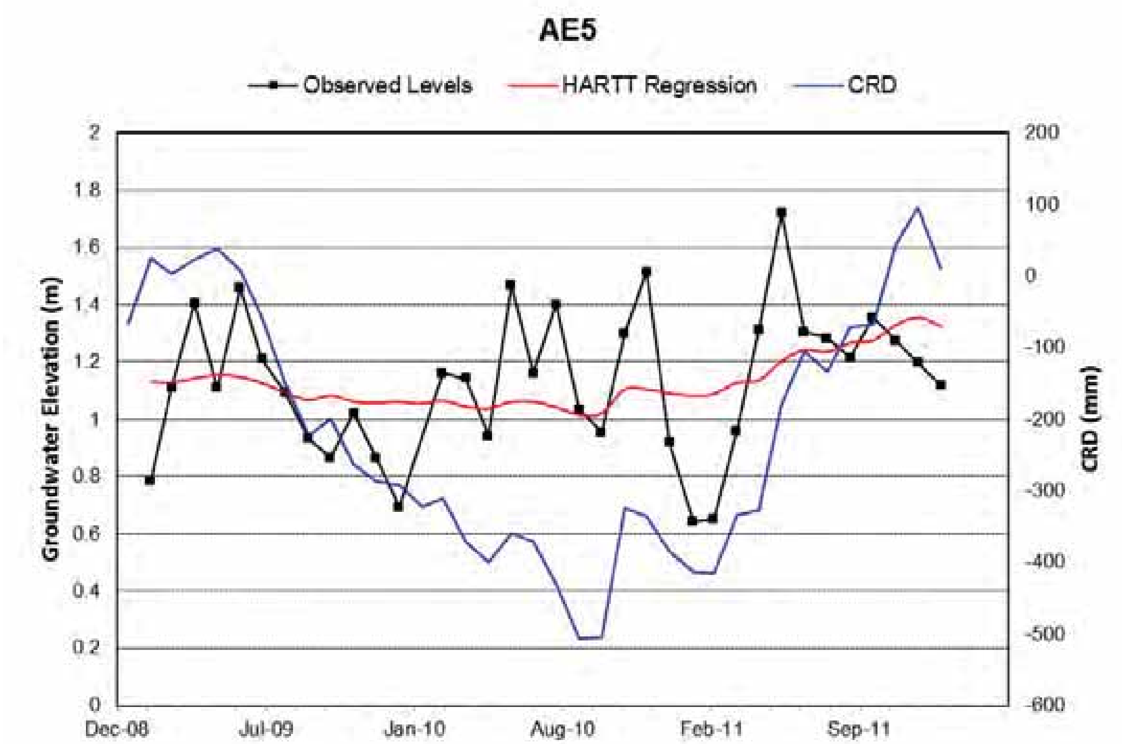
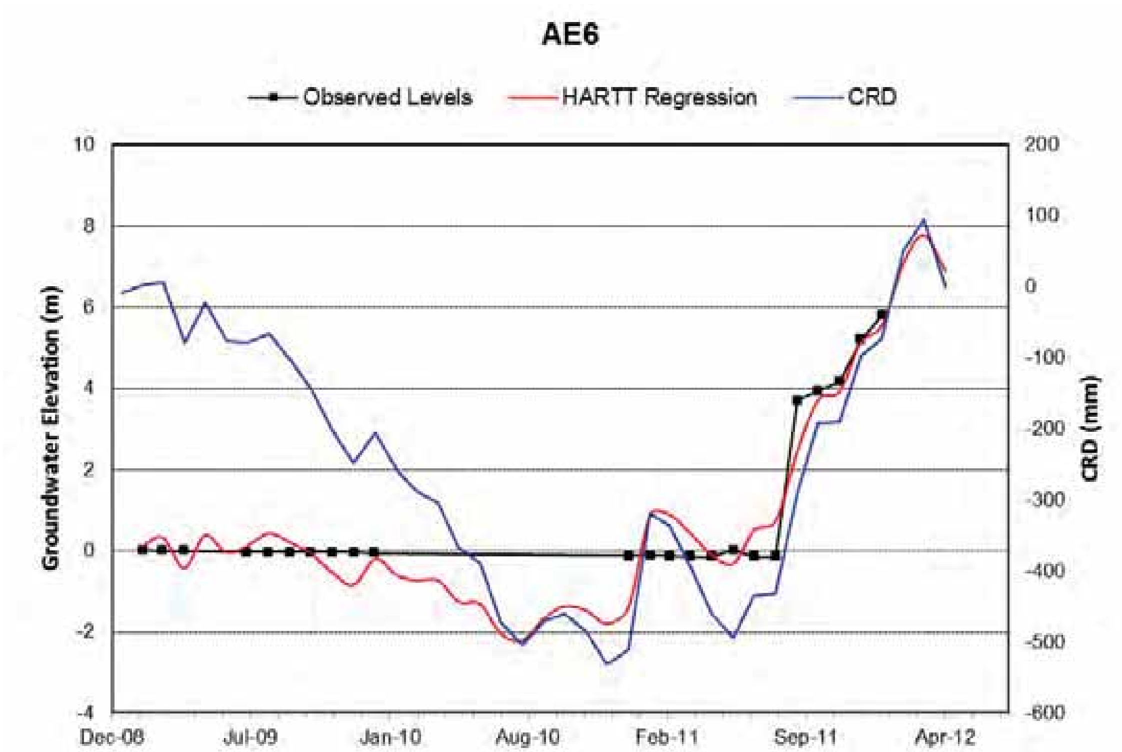
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
3
2.5
2
1.5
1
0.5
0
200
100
0
-100
-200
-300
-400
-500
-600
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11


AE5
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
200
100
0
-100
-200
-300
-400
-500
-600
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11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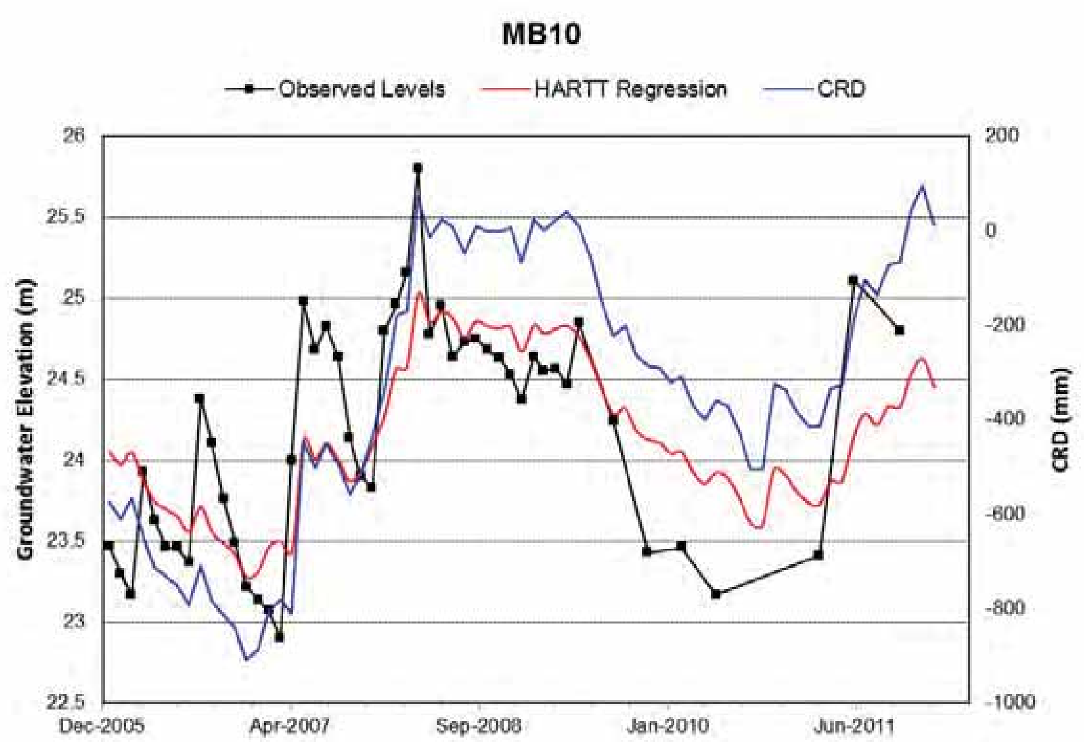
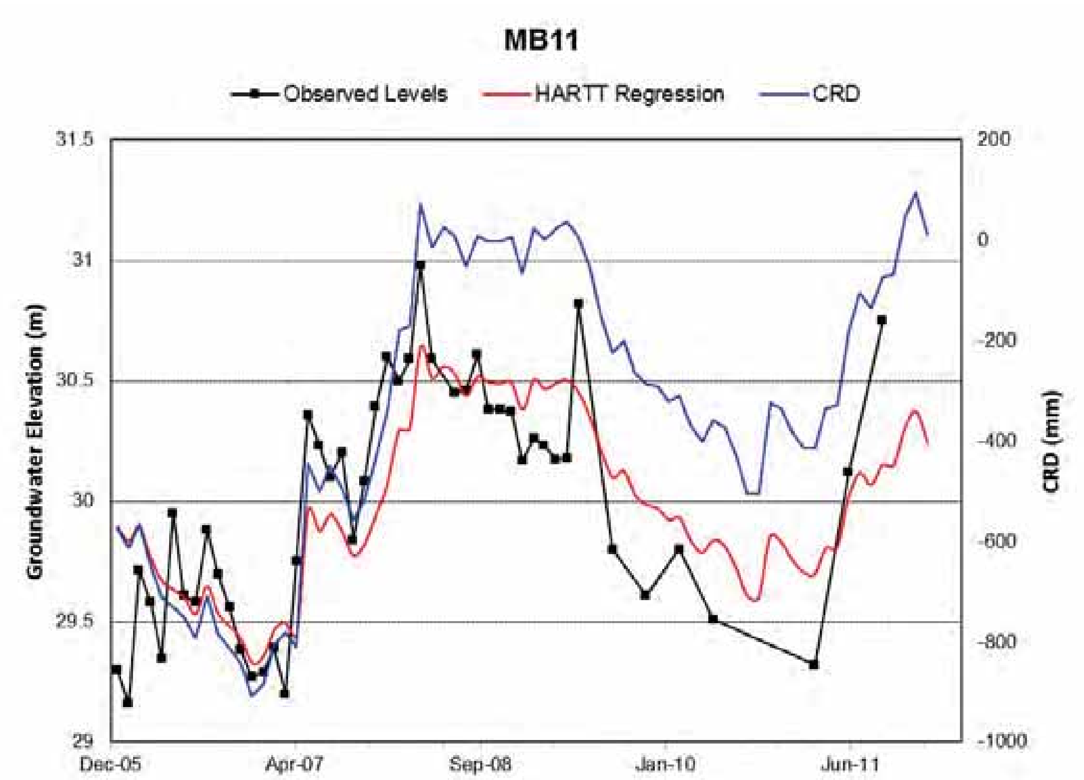
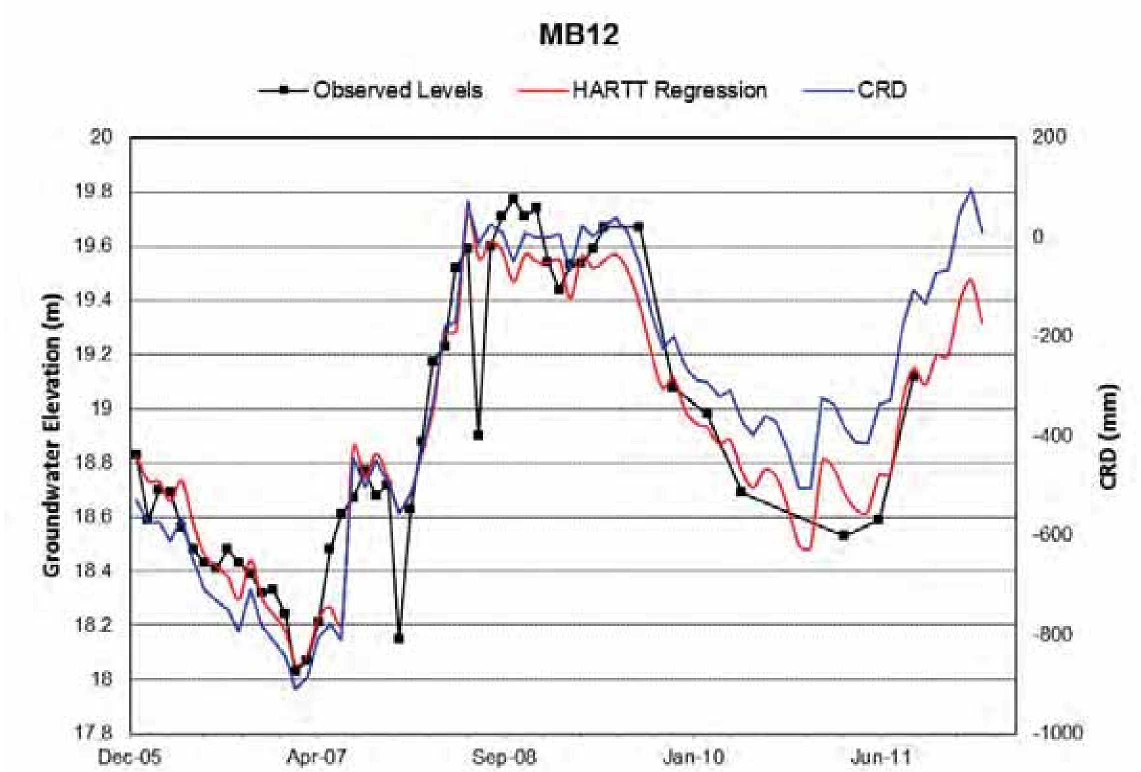
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
10
8
6
4
2
0
-2
-4
200
100
0
-100
-200
-300
-400
-500
-600
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12


MB10
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
26
25.5
25
24.5
24
23.5
23
22.5
200
0
-200
-400
-600
-800
-1000
Dec-2005
Apr-2007
Sep-2008
Jan-2010
Jun-2011


MB11
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
31.5
31
30.5
30
29.5
29
200
0
-200
-400
-600
-800
-1000
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11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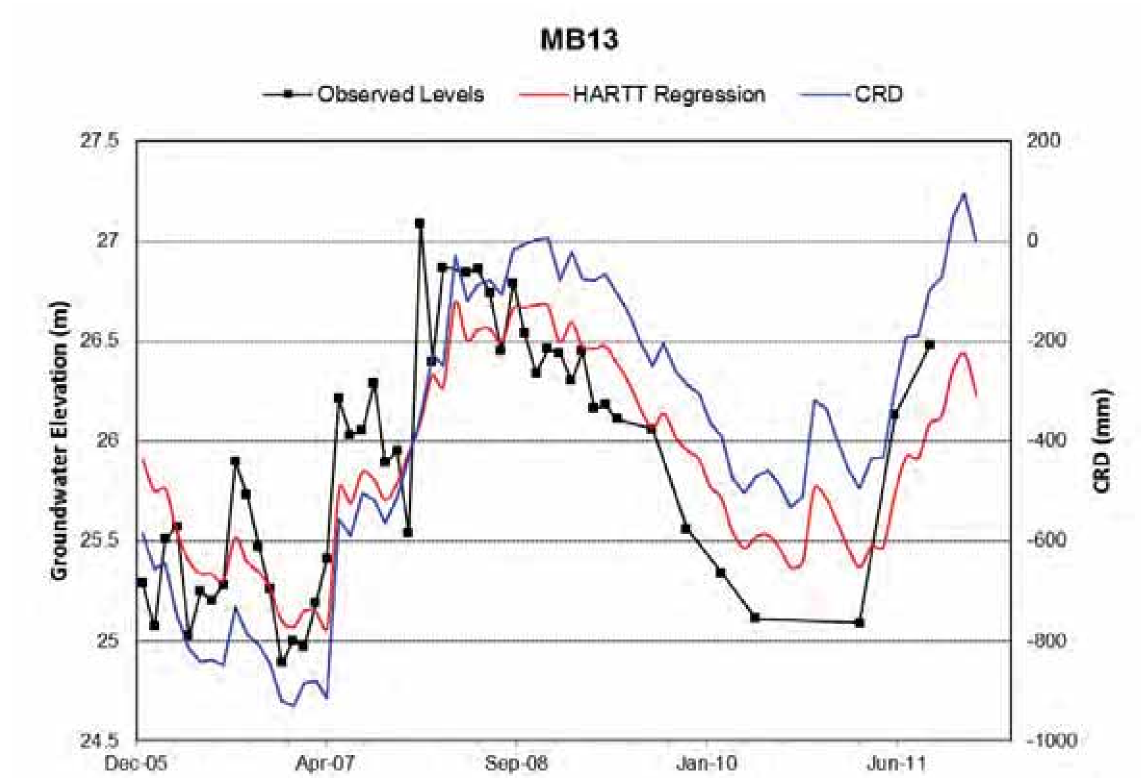
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
20
19.8
19.6
19.4
19.2
19
18.8
18.6
18.4
18.2
18
17.8
200
0
-200
-400
-600
-800
-1000
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11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Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
27.5
27
26.5
26
25.5
25
24.5
200
0
-200
-400
-600
-800
-1000
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11


MB15
Observed Levels
HARTT Regression
CRD
Groundwater Elevation (m)
CRD (mm)
20
18
16
14
12
10
8
6
4
2
0
200
0
-200
-400
-600
-800
-1000
Dec-05
Apr-07
Sep-08
Jan-10
Jun-11

Appendix B

Groundwater Hydrographs – Deeper Bores


CN036
Groundwater Elevation (m AHD)
18
15
12
9
6
3
0
-3
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06
Feb-07
Apr-07
Jun-07
Aug-07
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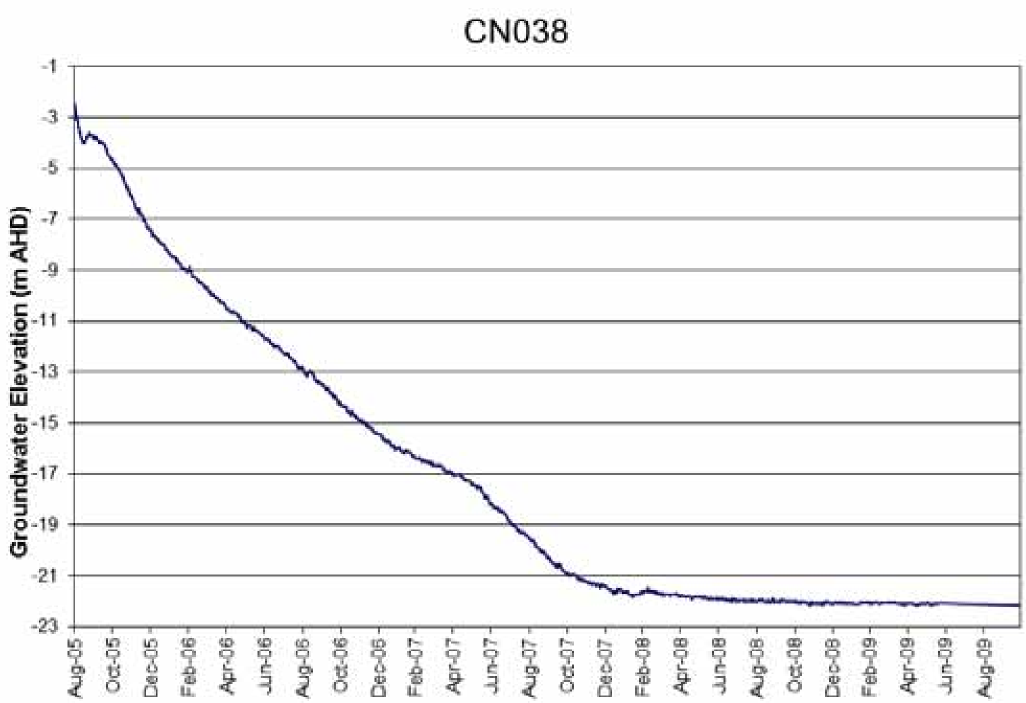
Feb-09
Apr-09
Jun-09
Aug-09


CN038
Groundwater Elevation (m AHD)
-1
-3
-5
-7
-9
-11
-13
-15
-17
-19
-21
-23
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06
Feb-07
Apr-07
Jun-07
Aug-07
Oct-07
Dec-07
Feb-08
Apr-08
Jun-08
Aug-08
Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09

GHD

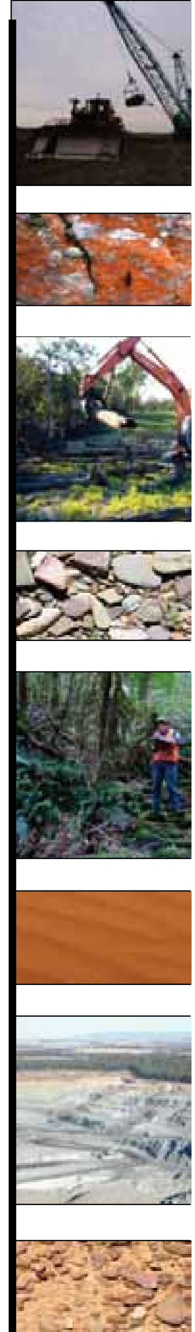
Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999   F: (02) 4979 9988   E: ntlmail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S Gray	S Charteris	[signature]	M Williamson	[signature]	01/05/12

Centennial Coal

Centennial Coal Company Limited
P O Box 1000
Toronto NSW 2283
www.centennialcoal.com.au



Aboriginal and European Cultural Heritage Assessment

APPENDIX 9

RPS

Aboriginal and European Cultural Heritage Assessment

Newstan Colliery SMP
Centennial Newstan, NSW

Prepared by:

RPS

241 Denison St
Broadmeadow NSW 2292
PO Box 428, Hamilton 2303

T: +61 2 4940 4200
F: +61 2 4961 6794
E: newcastle@rpsgroup.com.au
W: rpsgroup.com.au

Prepared for:

Centennial

PO Box 1000
Toronto NSW 2283

Report No: PR110457-1
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Draft B	Draft for Client Review	CYL	DR	12.4.2012	VD12.4.2012		
Final	Final for Client	CTL	TBM	1.6.2012	VD 5.6.2012	T.Boer-Mah	4.6.2012

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Acknowledgements

Centennial Newstan Pty Limited (Centennial Newstan) would like to acknowledge the Traditional Custodians of the Lake Macquarie region in which it operates. Although the territorial boundary and extent of each Aboriginal group's interest varies, all have identified a spiritual and cultural connection to the Country.

We acknowledge the importance of the Traditional Custodians in the greater understanding of Aboriginal culture in the Lake Macquarie region. Special acknowledgement is extended to the Elders (past, present and future) for they are the holders of knowledge, traditions, culture and aspirations of the Aboriginal people.

Centennial Coal would like to thank the registered Aboriginal stakeholders for their participation in this project and their invaluable contributions to the assessment report. Their generous contributions of their cultural knowledge have enriched our understanding of the cultural significance of the landscape.

Statements of Aboriginal Cultural Significance

Statements of Aboriginal cultural significance have been prepared by the registered Aboriginal stakeholder groups who expressed desire to have these included in the report. The cultural significance statements were provided on a volunteer basis and should not be interpreted as an indicator of participation or interest in the project. All registered stakeholder groups have a strong cultural and spiritual connection to the Country, but their manner of expressing their involvement in the project varies. As a result, this report has sought to cater for the different ways in which the registered Aboriginal stakeholder groups wished to participate and contribute to the understanding of Aboriginal culture, knowledge and spiritual connection to the land.

Although only some statements have been provided, the purpose is to acknowledge and recognise the cultural heritage, value and importance of the Lake Macquarie region to the Traditional Custodians, which includes the area of proposed underground mining works relevant to this assessment report. Centennial Newstan Pty Limited (Centennial) and RPS Australia East Pty Limited (RPS) recognise the primary role of the Aboriginal stakeholders registered for this project in confirming the Aboriginal cultural significance of the region and the Aboriginal cultural features and sites contained within the Study Area.

Awabakal Traditional Owners Aboriginal Corporation (ATOAC)

"The Awabakal iconic landmarks feature prominently within its surrounding landscape. This regions mythology, mystery and organic presence that are quite simply, uniquely Awabakal still to this day has an undeniable amount of fascination and attention regarding its cultural value and purpose. The Centennial Coal Mining Project areas are also included within the Awabakal landscape.

The Awabakal Traditional Owners have a personalised and ever-revitalised bond with our ancestors' culture, tradition & heritage. This inexplicable connection is reverberated within the surrounding landscape of the Awabakal region.

Additionally, we appreciate our unique role and responsibility for the care and protection of the integrity of this landscape, for and on behalf of its original First Peoples and their descendants.

We would like to take this opportunity to assert our focus on the critical flow of intergenerational equity and aim to ultimately safeguard the immeasurable life-changing impact to this and future generations. Intergenerational equity lays the foundation for identifying, assessing, protecting and maintaining the important cultural and heritage values of landscapes, resources, places, objects, customs and traditions so that we, and generations to come, can enjoy, learn from them, and appropriately manage these values

We believe that the principles of the Awabakal tradition and culture still exist today to keep intact the moral and spiritual fibre of this land. Equally, we also believe it is essential to nurture new visions that are inspired by the cultural integrity of our ancestral family and we are encouraged that so many people in the region are focused on gaining an ever growing respect and understanding for the Awabakal Peoples, this land and environment.

This land has had a wealth of knowledge walk over it, with each one of us deepening the footprints of our ancestral family, the Awabakal People"

(Quote from statements by Awabakal Traditional Owners Aboriginal Corporation and speeches by Nola Hawken, Awabakaleen Elder. Copyright, 2010).

Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC)

"This area, as part of what is the Traditional Awabakal Country, is considered by our People to be of great importance within our Cultural Heritage. There are a variety of reasons our People have benefited from using this location over thousands of years.

One of the earliest documented accounts of the importance of the areas around Lake Macquarie for the Awabakal is attributed to the Rev. L.E. Threlkeld. For us, this area has not just a physical presence within the Cultural Heritage of our People but it is part of our oral history and incorporates places of spiritual significance. The landforms and resources of this locale fulfilled not just the basic needs that underpinned our Peoples subsistence but also satisfied the many other aspects that made up what can only be described here as being part of the very cultural foundations of our People.

Needless to say, our People have had a long history within this area which is unsurpassed. Our apical Ancestor, Mahrahkah, an Awabakal woman and her two daughters were recorded by the Reverend L.E.Threlkeld and Jonathan Warner as living in and around these areas which all formed part of their Traditional Country. This apart from everything else makes it a very important location for our family, knowing that Mahrahkah walked these areas before any white man was ever seen in the Newcastle and Lake Macquarie region. She was intrinsically acquainted with her Land and she has left a legacy for us to carry on in this day and age and to pass onto our Descendants.

This area is of very high significance to the Awabakal and therefore it would be expected that after many generations of our People that have walked the pathways of their Ancestors it should be obvious there would be many areas that contain evidence of this connection resulting from thousands of years of occupation on varying levels by our People. Traditionally these areas were the supply of rich resources of which our People have depended on over millennia. There are physical reminders left by our Ancestors, some in the form of middens, scarred trees or stone tools (artefacts) and grinding grooves which provide us as Descendants of the Awabakal People an opportunity to make a connection through time with our Ancestors. This connection is manifest in a variety of ways; one is through the physical senses such as knowing we are seeing where they lived or touching what they used. By holding or touching something our Ancestors handled, something they made, possibly many thousands of years previously, gives rise to a sense of perception, appreciation, familiarity and recognition of who we are and reinforces where we belong and our birthright as Awabakal Descendants".

(Shane Frost, Managing Director – Awabakal Descent Traditional Owner Aboriginal Corporation March 2012)

Westlakes Aboriginal Community (WLAC)

"The area in which the Aboriginal Heritage Assessment is to be conducted is located in the Tribal Country of our people. The area is significant because our people have been the custodians of this Country for thousands of years, our people have hunted the land and fished the waters in the traditional way that has been passed down through the centuries. The area is in close proximity to significant sites that were used by our people. There are many sites located within the surrounding area which proves our spiritual connection to Country".

(Margaret Harvey, CEO Awabakal Local Aboriginal Land Council 2012)

Executive Summary

Newstan Colliery (Newstan) is an underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan), a wholly owned subsidiary of Centennial Coal Company (Centennial). Centennial is a wholly owned subsidiary of Banpu Public Company Limited (Banpu), who purchased Centennial in 2010. Newstan is located approximately 25 kilometres south-west of Newcastle and approximately 140 kilometres north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan pit top and surface facilities are located approximately four kilometres north of the township of Toronto on the western side of Lake Macquarie.

In 1998, Powercoal Pty Limited, the (then) owners of Newstan, submitted an Environmental Impact Statement (EIS, 1998) to the then New South Wales Department of Planning (DoP), seeking approval for the expansion of Newstan, which was referred to as the Life Extension Area (LEA). On the 14th May 1999, the (then) Minister for Urban Affairs and Planning, granted development consent under Part 4 of the Environmental Planning and Assessment Act (EP&A Act) for the Newstan Colliery Life Extension Area pursuant to Development Application 73-11-98 (DA 73-11-98).

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a Subsidence Management Plan (SMP) prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103. These panels are located wholly within ML1452 and the boundaries of DA 73-11-98. The proposed longwall panels have been designed to target the Young Wallsend and part Yard seams contained within the Newcastle Coal Measures.

RPS Australia East (RPS) were engaged by Centennial Newstan to undertake an assessment of potential subsidence impacts to Aboriginal and European heritage in accordance with the 'Guideline for Applications for Subsidence Management Approvals' (DPI-MR 2003), herein referred to as the 'SMP Guidelines' and provide this specialist report in support of the SMP Application.

Recommendation 1
Centennial Newstan will complete the development of the Northern Holdings Aboriginal Cultural Heritage Management Plan (ACHMP) currently being prepared in consultation with the registered Aboriginal stakeholders. The Northern Holdings ACHMP, once completed, will identify on-going consultation requirements between Centennial Newstan and the registered Aboriginal stakeholders, Aboriginal site monitoring, Aboriginal site management and, where applicable, cultural heritage offsets to be implemented at Newstan.

Recommendation 2
Grinding groove site (AHIMS #45-7-0260) has been assessed to be at moderate risk of harm from subsidence as a result of the extraction of LW 101. It is recommended that Centennial Newstan must monitor the site according to the protocols set for rockshelters in the Northern Holdings ACHMP. If a risk of impact is identified during the monitoring process, Centennial Newstan must apply for and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) from the Office of Environment and Heritage (OEH) (Director-General).

Recommendation 3
Rockshelter with possible grinding groove site (AHIMS #45-7-0310/45-7-0005) has been assessed to be at high risk of subsidence impact. Centennial Newstan must apply for and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) application prior to secondary extraction under the site so that appropriate recording and mitigation measures can be implemented in the case that the site is partially or completely destroyed.

Recommendation 4
It is recommended that the client ensures that the due diligence monitoring program designed in the Northern Holdings ACHMP (currently being prepared) be followed for the three scarred trees identified by Mr Shane Frost (currently being registered with OEH-see Section 8.1.3) and the sites within the Newstan SMP Study Area in the table below:

AHIMS # 45-7-0296	AHIMS # 45-7-0303	AHIMS # 45-7-0295
AHIMS # 45-7-0298	AHIMS # 45-7-0297	AHIMS # 45-7-0299
AHIMS # 45-7-0309		

Recommendation 5
All relevant Centennial staff should be made aware of their statutory obligations for heritage under NSW *NPW Act (1974)* and the NSW *Heritage Act (1977)*, which may be implemented as a heritage induction.

Recommendation 6
If more Aboriginal site/s are identified in the Study Area, Centennial Newstan is advised to refer to the Northern Holdings ACHMP (currently being prepared) for mitigation measures for newly identified sites. All newly identified site/s is also required to undergo an Aboriginal cultural assessment prior to the commencement of secondary workings beneath the site.

Recommendation 7
If human remains are located, Centennial Newstan is advised to refer to the Centennial Northern Holdings ACHMP currently being prepared which, once completed, will identify the consultation, monitoring and management requirements for newly identified sites.

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Items listed on the NSW Heritage Inventory

APPENDIX 6

Items listed in the Lake Macquarie Local Environmental Plan (LEP)

APPENDIX 7

AHIMS Search Results for Generic Study Area

APPENDIX 8

AHIMS Site #45-7-0005 Information held at Australian Museum

APPENDIX 9

Correspondence with OEH Regarding Deregistering AHIMS Site #45-7-0005

APPENDIX 10

Response from OEH about AHIMS Site #45-7-0005

APPENDIX 11

Aboriginal Consultation Log

1 Introduction

Newstan Colliery (Newstan) is an underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan), a wholly owned subsidiary of Centennial Coal Company (Centennial). Centennial is a wholly owned subsidiary of Banpu Public Company Limited (Banpu), who purchased Centennial in 2010. Newstan is located approximately 25 kilometres south-west of Newcastle and approximately 140 kilometres north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan pit top and surface facilities are located approximately four kilometres north of the township of Toronto on the western side of Lake Macquarie (site locality is shown in Figure 1-1). Currently, mining at Newstan is by means of continuous miner and longwall (LW) mining methods. Newstan produces both a semi soft coking coal and thermal coal for the export and domestic markets.

In 1998, Powercoal Pty Limited, the (then) owners of Newstan, submitted an Environmental Impact Statement (EIS, 1998) to the New South Wales Department of Planning (DoP), seeking approval for the expansion of Newstan, which was referred to as the Life Extension Area (LEA). On the 14th May 1999, the (then) Minister for Urban Affairs and Planning, granted development consent under Part 4 of the Environmental Planning and Assessment Act (EP&A Act) for the Newstan Colliery Life Extension Area pursuant to Development Application 73-11-98 (DA 73-11-98).

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a Subsidence Management Plan (SMP) prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103. These panels are located wholly within ML1452 and the boundaries of DA 73-11-98. The proposed longwall panels have been designed to target the Young Wallsend and part Yard seams contained within the Newcastle Coal Measures.

RPS Australia East (RPS) were engaged by Centennial Newstan to undertake an assessment of potential subsidence impacts to Aboriginal and European heritage in accordance with the 'Guideline for Applications for Subsidence Management Approvals' (DPI-MR 2003), herein referred to as the 'SMP Guidelines' and provide this specialist report in support of the SMP Application.

Table 1-1: Relevant Project Approval Conditions under the NSW Department of Mineral Resources SMP Guidelines (2003)

Requirements	Where Addressed in this Report
6.2 Application Area	Chapter 1
6.4 Site Conditions of the application area	Chapter 5, 6
6.6.1 Identification of surface and sub-surface features	Chapter 2
6.6.2 Characterisation of Surface and Sub-surface Features- ref mainly (3) and (5) Areas of Archaeological or Heritage Significance	Chapter 4,5,
6.6.3 Areas of Environmental Sensitivity	Chapter 5,6,7
6.8 Community Consultation	Section 1.4
6.9 Statutory Requirements	Section 1.3
6.10 Subsidence Impacts	Chapter 8
7 Proposed management plans	Chapter 8
Appendix B – Surface and Sub-surface features that may be affected by Underground coal mining. Also referenced in 6.6.1	Chapter 5, 8

1.1 The Study Area

The study area for this report (herein referred to as the SMP Study Area) is illustrated in Figure 1-2. The SMP Study Area incorporates:

- A 26.5 degree angle of draw around longwall panels LW101, 102 and 103 and all associated first workings adjacent to the longwalls; and
- The predicted limit of vertical subsidence. This is taken as the 20 millimetre subsidence contour resulting from the extraction of the proposed longwall panels (as per Appendix A of the SMP Guidelines).

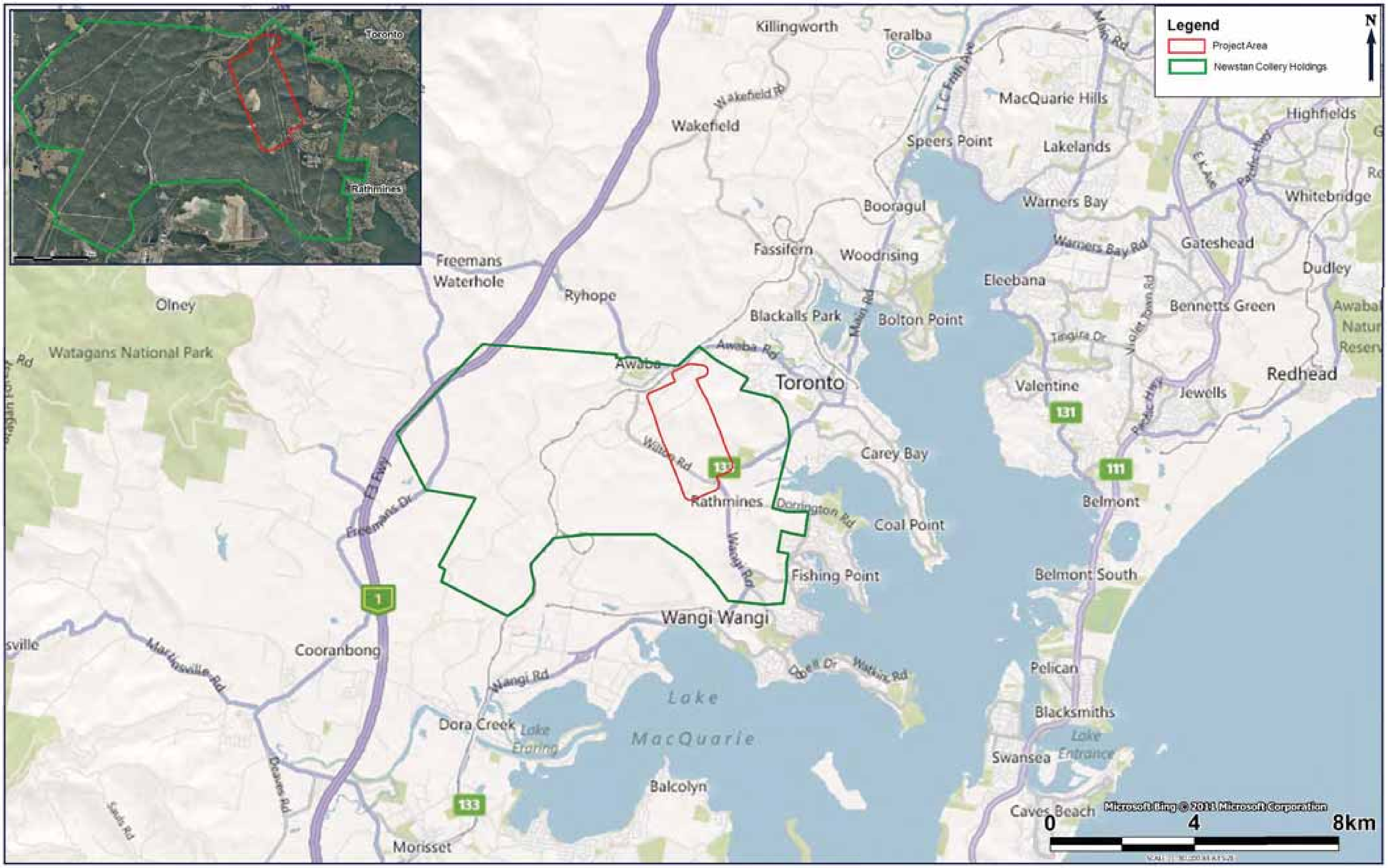
1.2 Background

This Cultural Heritage Assessment has been prepared to assess potential subsidence related impacts on cultural heritage sites (Aboriginal and European) within and surrounding the SMP Study Area in accordance with the 'SMP Guidelines'.

In accordance with section 6.6.3 of the SMP Guidelines, the following areas of environmental sensitivity have been identified and considered as part of this Cultural Heritage Assessment.

Table 1-2: Areas of Cultural Sensitivity within the SMP Area (NSW Department of Mineral Resources; 2003)

Features	Within SMP Study Area	Section Reference Number
Land declared as an Aboriginal Place under NSW NPW Act 1974 (Part 6, Division 1, Section 84)	N	Section 1.1.3,
Areas listed on the Register of National Estate	N	Section 3.2.1
Areas listed under the Heritage Act 1977 for which a plan of management has been prepared	N	Section 3.2.2
Surface features of community significance (including cultural, heritage or archaeological significance)	Y	Section 5,6,7 and 8



TITLE: FIGURE 1-1 STUDY AREA

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 31/01/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
VERSION (PLAN BY): B A3(CYL-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-1

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241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
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TITLE: FIGURE 1-3 NEWSTAN SURVEY AREAS CONDUCTED BY RPS IN 2010-2011

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 31/01/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
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T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

1.3 Legislative Context

The following overview of the legal framework relevant to this Cultural Heritage Assessment is provided solely for the information purposes of the client - it should not be interpreted as legal advice. RPS will not be liable for any actions taken by any person, body or group as a result of this general overview and recommend that specific legal advice be obtained from a qualified legal practitioner prior to any action being taken as a result of the summary below.

Aboriginal heritage (places, sites and objects) in NSW are protected by the *National Parks and Wildlife Act (1974, as amended)* [NPW 1974]. In some cases, Aboriginal heritage may also be protected under the *Heritage Act 1977*. The *Environmental Planning and Assessment Act (1979)* [EP&A Act 1979], along with other environmental planning instruments, triggers the requirement for the investigation and assessment of Aboriginal heritage as part of the development approval process. For crown land, provisions under the *Aboriginal Land Rights Act (1983)* and the *Native Title Act 1993)* may also apply.

1.3.1 Aboriginal Land Rights Act (1983)

The purpose of this legislation is to provide land rights for Aboriginal people within New South Wales and to establish Local Aboriginal Land Councils. The land able to be claimed by Aboriginal Land Councils on behalf of Aboriginal people is certain Crown land that (s36):

(a) Is able to be lawfully sold, leased, reserved or dedicated;

(b) Is not lawfully used or occupied;

(c) Does not comprise lands which, in the opinion of the Crown Lands Minister, are needed or are likely to be needed for residential purposes;

(d) Are not needed, nor likely to be needed for an essential public purpose;

(e) Does not comprise land under determination by a claim for native title; and

(f) Is not the subject of an approved determination under Native Title.

Claims for land are by application to the Office of the Registrar, Aboriginal Land Rights Act (1983).

1.3.2 Native Title Act (1993)

The Commonwealth Government enacted the *Native Title Act (1993)* to formally recognise and protect native title rights in Australia following the decision of the High Court of Australia in Mabo & Ors v Queensland (No. 2) (1992) 175 CLR 1 ("Mabo").

Although there is a presumption of native title in any area where an Aboriginal community or group can establish a traditional or customary connection with that area, there are a number of ways that native title can be extinguished. For example, land that was designated as having freehold title prior to 1 January 1994 extinguishes native title, as does any commercial, agricultural, pastoral or residential lease. Land that has been utilised for the construction or establishment of public works also extinguishes any native title rights and interests for as long as they are used for that purpose. Other land tenure, such as mining leases, may be subject to native title depending on when the lease was granted.

1.3.3 National Parks and Wildlife Act (1974, as amended)

The NSW Government is working toward standalone legislation to protect Aboriginal cultural heritage - a significant reform for NSW. The first stage of this work has been completed and includes significant changes in relation to this commission. The primary state legislation relating to Aboriginal cultural heritage in NSW is the NPW *(1974, as amended)*. The legislation is overseen by the Office of Environment and Heritage (OEH) (formerly the Department of Environment, Climate Change and Water) and specifically the Director-General of the OEH.

Changes to the NPW legislation made effective on 1 October, 2010 include:

- Increased penalties for Aboriginal heritage offences, in some cases from $22,000 up to $1.1 million in the case of companies who do not comply with the legislation;
- Ensuring companies or individuals cannot claim 'no knowledge' in cases of serious harm to Aboriginal heritage places and objects by creating new strict liability offences under the Act;
- Introducing remediation provisions to ensure people who illegally harm significant Aboriginal sites are forced to repair the damage, without need for a court order; and
- Unites Aboriginal heritage permits into a single, more flexible permit and strengthens offences around breaches of Aboriginal heritage permit conditions.

1.3.4 Heritage Act 1977

Historical archaeological relics, buildings, structures, archaeological deposits and features are protected under the *Heritage Act (1977)* (as amended 1999) and may be identified on the State Heritage Register (SHR) or by an active Interim Heritage Order. Certain types of historic Aboriginal sites may be listed on the SHR or be subject to an active Interim Heritage Order; in such cases they would be protected under the *Heritage Act (1977)* and may require approvals or excavation permits from the NSW Heritage Branch.

1.3.5 Environmental Planning & Assessment Act 1979 (EP&A ACT)

This Act regulates a system of environmental planning and assessment for New South Wales. Land use planning requires that environmental impacts are considered, including the impact on cultural heritage and specifically Aboriginal heritage. Within the EP&A Act, Parts 3, 4 and 5 relate to Aboriginal heritage.

Part 3 regulates the preparation of planning policies and plans. Part 4 governs the manner in which consent authorities determine development applications and outlines those that require an environmental impact statement. Part 5 regulates government agencies that act as determining authorities for activities conducted by that agency or by authority from the agency. The National Parks & Wildlife Service is a Part 5 authority under the EP&A Act.

In brief, the NPW Act provides protection for Aboriginal objects or places, while the EP&A Act ensures that Aboriginal cultural heritage is properly assessed in land use planning and development.

Further details on the relevant legislative Acts are provided in Appendix 1.

1.4 Aboriginal Community Consultation

The purpose of Aboriginal community consultation is to provide an opportunity for the relevant Aboriginal stakeholders to have input into the heritage management process. The NSW Office of Environment and Heritage (OEH) encourages consultation with Aboriginal people for matters relating to Aboriginal heritage. Guidelines for Aboriginal community consultation have been developed to be implemented in accordance with the relevant sections of the EP&A Act (1979), where applicable, and the NPW Act (1974).

In 2010, Centennial Newstan implemented the Office of Environment and Heritage (OEH) Aboriginal Cultural Heritage Consultation Requirements for Proponents (2010) which resulted in five Aboriginal groups (identified in Table 1-2) registering an interest in the consultation process for mining operations associated with Newstan. Centennial Newstan have been undertaking comprehensive consultation with the registered Aboriginal groups on the status and progress of mining projects at Newstan since 2010.

In addition to Centennial's implementation of the ACHCR (2010) process, Centennial is also involved in an Indigenous Land Use Agreement (ILUA) which is an agreement between a native title group and other parties who use or manage the land and waters in the area of concern. The ILUA which is set out in the Master Deed was entered into on the 28th of May 1999 by the Wonnarua People (Wonnarua Nation Aboriginal Corporation) and Powercoal Pty Ltd, which has since been acquired by Centennial. Centennial has made ongoing commitments to honour the terms of the ILUA by consult with the Wonnarua People and undertaking surveys in accordance with the terms and conditions of the ILUA.

Field surveys over the SMP Study Area were completed in 2010/11 by RPS and representatives of the registered Aboriginal stakeholder groups. The following representatives that participated in the field survey are listed in Table 1-4.

Table 1-3: Aboriginal stakeholders which registered their interested in the Study Area

Organisation	Name of Representative
Awabakal Descendants Traditional Owners Aboriginal Corporation	Mr Shane Frost
Awabakal Traditional Owners Aboriginal Corporation	Ms Kerrie Brauer
Cacatua Culture Consultants	Ms Donna and George Sampson
West Lakes Aboriginal Community (Koompahtoo LALC)	Mr Robert Sansom
Wonnarua Nation Aboriginal Corporation	Ms Marie Waugh

Table 1-4: Stakeholders who participated in the survey

Organisation	Name of Representative	Survey Unit
Awabakal Descendants Traditional Owners Aboriginal Corporation	Mr Shane Frost	B3, A6, A5, A2
Awabakal Descendants Traditional Owners Aboriginal Corporation	Mr James Frost	A5
West Lakes Aboriginal Community (Koompahtoo LALC)	Ms India Latimore	C5, C3
Awabakal Traditional Owners Aboriginal Corporation	Ms Kerrie Brauer	B3, A6, A5, A2
West Lakes Aboriginal Community (Koompahtoo LALC)	Mr Robert Sansom	C1,C2, C5, C3
Wonnarua Nation Aboriginal Corporation (WNAC)	Ms Marie Waugh	C1,C2, C5, C3

Centennial Newstan is currently consulting with the registered Aboriginal Stakeholder groups to develop an Aboriginal Cultural heritage Management Plan (ACHMP) for the Northern Holdings. The ACHMP, once completed, will identify on-going consultation requirements between Centennial Newstan and the registered Aboriginal stakeholders, Aboriginal site monitoring, Aboriginal site management and, where applicable, cultural heritage offsets to be implemented at Newstan. The ACHMP will be developed and approved in accordance with the requirements of the Newstan Development Consent (DA 73-11-98) prior to any secondary extraction occurring under Aboriginal Heritage sites at Newstan.

A log of consultation undertaken with the registered Aboriginal stakeholders has been provided as Appendix 11 to this report.

1.5 Authorship and Acknowledgements

This report was prepared by RPS Archaeologist Cheng Yen Loo and reviewed by Darrell Rigby (RPS Archaeology Manager) and Tessa Boer-Mah (Senior Archaeologist).

TITLE: FIGURE 1-3 NEWSTAN SURVEY AREAS CONDUCTED BY RPS IN 2010-2011

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 31/01/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
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1.6 Terms and Abbreviations

Abbreviation	Description
ADTOAC	Awabakal Descendants Traditional Owners Aboriginal Corporation
ALALC	Awabakal Local Aboriginal Land Council
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
DP&I	Department of Planning and Infrastructure
DRE	Division of Resource and Energy
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EP&A Act 1979	*Environmental Planning and Assessment Act (1979)*
ILUA	Indigenous Land Use Agreement
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plans
LGA	Local Government Area
LW	Longwalls
ML	Mining Leas
MSEC	Mine Subsidence Engineering Consultants
NPW Act1974	*National Parks and Wildlife Act (1974)*
OEH	Office of Environment and Heritage
PAD	Potential Archaeological Deposits
PSM	Pells Sullivan Meynink Engineering Consultants
REF	Review of Environmental Factors
REP	Regional Environmental Plans
SHR	State Heritage Register
SMP	Subsidence Management Plan
WLAC	West Lakes Aboriginal Community
WNAC	Wonnarua Nation Aboriginal Corporation

2 Environmental Context

An understanding of environmental context is important for the predictive modelling of Aboriginal sites, as well as for their interpretation. The local environment provided natural resources for Aboriginal people, such as stone (for manufacturing stone tools), food and medicines, wood and bark (for implements such as shields, spears, canoes, bowls and shelters, amongst others), as well as areas for camping and other activities. The nature of Aboriginal occupation and resource procurement is related to the local environment and it therefore needs to be considered as part of the cultural heritage assessment process.

2.1 Climate

Approximately 18,000 years ago, climatic conditions began to alter, affecting the movement and behaviour of past populations within their environs. During this time, notably at the start of the Holocene (more than 11,000 years ago), the melting of the ice sheets in the Northern Hemisphere and Antarctica caused the sea levels to rise, with a corresponding increase in rainfall and temperature. The change in climatic conditions reached its peak about 6,000 years ago (Short, 2000:19-21). Up until 1,500 years ago, temperatures decreased slightly and then stabilised about 1,000 years ago, which is similar to the temperatures currently experienced. Consequently, the climate of the Study Area for the past 1,000 years would probably have been much the same as present day, providing a year round habitable environment.

The SMP Study Area is located in the Lake Macquarie Local Government Area (LGA), which is situated in the Lower Hunter region. The SMP Study Area experiences a temperate climate that is affected by its proximity to the coast, swamps and mountain ranges. Summer and autumn are the wettest seasons with an average rainfall of approximately 840 millimetres and the temperatures can range between 6 degrees and 30 degrees Celsius (Bureau of Meteorology 2010). The temperate climate would be suitable for occupation for the majority of the year, providing suitable shelter could be obtained during the wet periods.

2.2 Geology and Soils

Aboriginal people often made stone tools using silicious, metamorphic or igneous rocks and therefore understanding the local geology can provide important information regarding resources in an area. The nature of stone exploitation by Aboriginal people depended on the characteristics of the source, for example whether it outcropped on the surface (a primary) source, or whether it occurred as gravels (secondary source) (Doelman, Torrence et al. 2008).

The geological formation of the SMP Study Area comprises the Narrabeen Group and Newcastle Coal Measures, predominantly the Clifton Subgroup and Singleton Subgroup (Matthei 1995:61). These formations include sandstone, interbedded sandstone and siltstone, claystone, tuff and coal. The presence of sandstone and tuff in the SMP Study

Area is important for Aboriginal occupation of the area as some types of silicified tuff have been used by Aboriginal people for manufacturing flaked stone tools and sandstone was used for grinding grooves, shelters (if rockshelters present) and engravings, amongst other uses.

The majority of the SMP Study Area consists of the Awaba soil landscape, although small areas of the Warners Bay and Doyalson soil landscapes are also represented in the SMP study area (Matthei 1995).

The Awaba Soil landscape is generally comprised of five dominant soil materials (aw1, aw2, aw3, aw4 and aw5) (Matthei 1995:227). Topsoil in this landscape is comprised of gravelly brown loam. Gravelly, hardsetting bleached sandy loam to sandy clay loam (aw2) underlies the topsoil as a shallow subsoil (Matthei 1995:228). The B horizon comprises gravelly, earthy, bright yellowish sandy clay loam (aw3) (Matthei 1995:228). Gravelly grey clay (aw4) occurs as a B_2 horizon and a well-structured sticky plastic clay (aw5) is found beneath it (Matthei 1995:228).

Three dominant soil materials have been identified in the Warners Bay soil landscape (wa1, wa2, wa3) (Matthei 1995:61). Topsoil is generally comprised of an A_1 and A_2 horizon; A_1 comprises friable brownish black loam (wa1) which is generally 20cm thick, while A_2 is hardsetting bleached clay loam (wa2), 10-40cm thick (Matthei 1995:61). The B horizon comprises mottled yellowish grey clay (wa3), 60-150cm thick (Matthei 1995:62). It is expected that Aboriginal artefacts are more likely to be present in wa1, less likely in wa2 and absent in wa3.

The Doyalson soil landscape is characterised by five dominant soil materials (do1, do2, do3, do4 and do5) (Matthei 1995:231). The topsoil consists of brown loose loamy sand (do1) with an A_1 Horizon comprising hardsetting, bleached yellowish-brown clayey sand (do2) (Matthei 1995:232). An earthy bright, yellowish-brown sand clay loam underlies the A_2 Horizon (do3), and underlying this is earthy light grey clay subsoil (do4) (Matthei 1995:232). Strongly pedal clay (do5) occurs at the B Horizon (Matthei 1995:232).

2.3 Topography and Hydrology

The topography of the SMP Study Area is characterised by undulating rises and low hills with broad drainage lines and ridges (Matthei 1995). In small sections of the Study Area the topography consists of steep low hills featuring uneven surfaces with many cobbles, stones and boulders (Matthei 1995).

2.4 Flora and Fauna

Flora species identified in and around the region of the SMP Study Area consist of several Eucalyptus species, such as Sydney peppermint (*Eucalyptus piperita*), scribbly gum (*Eucalyptus haemastoma*) and brown stringy gum (*Eucalyptus capitellata*) (Keith 2006:146). Common understorey in the SMP Study Area includes Tea tree (*Melaleuca*), flax- leaved wattle (*Acacia linifolia*), sunshine wattle (*A. Myrtifolia*) and hairpin banksia (*B.spinulosa*) (Keith 2006:146). Fauna species identified in and around the region of the SMP Study Area include various macropods, possums and bird species (National Parks and Wildlife Service NSW 2003). Such faunal species have been recovered from Aboriginal occupation sites in the Sydney region (Attenbrow 2002:72-73), but were also likely exploited in the Hunter region.

3 Historic Heritage Context

3.1 Historical Overview

European settlement in the Lake Macquarie region was formalised in 1826 when Lieutenant Percy Simpson took up a land grant of 2,000 acres (Payne n.d.:5). This land, that Simpson named “Kourumbung”, was described as running southwards from the southern bank of Dora Creek, then known as “Western Rivulet”. Before this grant was surveyed, Brisbane had also promised Simpson a second grant of 2,000 acres adjoining his first grant (Payne n.d.:6). The second grant in the Cooranbong area was made to Patrick Campbell and was 1,280 acres adjoining that of Simpson’s property on the north bank of Dora Creek (Payne n.d.:6). The grants at Cooranbong were subdivided after 1861.

In 1826, the Reverend Lancelot Threlkeld established an Aboriginal mission on 10,000 acres at Bah-ta-bah, the present site of Belmont on the north eastern shore of Lake Macquarie (Clack 1977:23). Threlkeld, with government assistance, was granted 1,280 acres of peninsula on the western shore of Lake Macquarie, which he called “Ebenezer”. The peninsula is now known as Coal Point. The site of Threlkeld’s mission and home farm is now the township of Toronto. Threlkeld operated his mission until 1840, when Government support was withdrawn (Clack 1977:23).

The town and district of Cooranbong progressed slowly through the development of the timber industry. From the 1830s, timber getting assumed greater importance, both in stands of cedar and from the 1860s hardwood (Chamberlain 1997:35). The completion of the ‘Homebush – Waratah’ Railway in the late 1880s helped establish settlements along the line at Wyong, Wyee, Morisset and Fassifern (Chamberlain 1997:40). As the railway line bypassed Cooranbong, it effectively ended the growth potential of the town and the population decreased.

The township of Toronto was established in the early 1880s and became a tourist destination. In 1887 Newstan was established by Northumberland Coal and Land Company (Clack 1977:48). Since this time the area has been mined by various operators, including the Fassifern Coal Company, Fassifern Colliery Pty Ltd, Newstan Colliery Pty Limited and Powercoal (Clack 1977:53). Newstan was one of the first mines to be lit by electric light in New South Wales.

3.2 Analysis of physical and documentary research

A number of searches were undertaken of Local, State and Federal heritage databases to confirm if there were any known heritage items that may be affected by the proposed works.

3.2.1 National Heritage Database

A search for Australian heritage sites was conducted in the Australian Heritage Database. This database contains information on more than 20,000 natural, historical and Aboriginal places and includes information from the World Heritage List, National Heritage List, Commonwealth Heritage List and the Register of the National Estate, amongst other databases.

The National Heritage List is now the lead statutory document for the protection of heritage places considered to have national importance. This list comprises Indigenous, natural and historic places that are of outstanding national heritage significance to Australia. Listed places are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). There are two places that have been nominated for heritage listing under the National Heritage List (Appendix 3), although they do not reside within the Awaba Study Area.

Prior to this, the Register of the National Estate was the primary document. While the Register of the National Estate still exists, it is now frozen and from 2012 will no longer have statutory status. The Minister is required to consider the Register when making some decisions under the EPBC Act. The Register of the National Estate includes 32 heritage sites within the Lake Macquarie area (Appendix 4), all of which do not reside within the Awaba Study Area.

The Commonwealth Heritage List comprises natural, Aboriginal and historic heritage places owned or controlled by the Commonwealth. Places on this list are also protected under the Environmental Protection Biodiversity Conservation Act 2000 (EPBC Act). No sites in the Lake Macquarie area are on the Commonwealth Heritage List.

3.2.2 NSW Heritage Inventory

Heritage items in NSW may be registered as important at the State level and/or the local level. The Heritage Council has developed criteria to help establish whether an item is State significant. Items of State significance are registered by the NSW Heritage Council under the NSW *Heritage Act (1977)* (Appendix 5). Those items are listed on the State Heritage Register as being under an Interim Heritage Order or protected under section 136 of the NSW *Heritage Act (1977)*.

Some heritage places and items that do not reach the threshold for listing on the State Heritage Register may be of heritage significance within an LGA. These places are listed by the local council under their Local Environmental Plans (LEP) and may be included on the NSW Heritage Inventory database (Appendix 6).

The NSW Heritage Inventory database is maintained by the OEH NSW Heritage Office. Items of State and local heritage value throughout NSW are registered on this website.

3.2.3 Local Government Heritage Registers

Items of significance at the local government level are included in the Local Government Environmental Plan (LEP) as Heritage Schedules. These are a list of European and some Aboriginal items which have been listed with a council as having heritage value. A search of the Lake Macquarie LEP schedule 4 has indicated that there are 266 items listed in the Lake Macquarie LGA, with 15 items recognised under State significance and 251 items of local significance (see Appendix 5). Although a total of 266 items have been listed in the Lake Macquarie LEP, none of the items fall within the SMP Study Area.

3.3 Discussion

Based on the search results of various national and state heritage bodies, it was determined that no heritage listed sites reside within the SMP Study Area.

4 Aboriginal Heritage Context

It is important that Aboriginal sites are contextualised within the local and regional landscape in order to inform the assessment of significance. The Aboriginal heritage context is also needed to develop a predictive model of Aboriginal sites in the Newstan SMP Area. Historical data also provides additional information for the interpretation of archaeological sites. A glossary of Aboriginal site types is provided in Appendix 2.

4.1 Historic Records of Aboriginal Occupation

It is important to acknowledge that early historical documents were produced for a number of reasons and thus may contain inaccuracies and/or bias in their reporting of events or other aspects of Aboriginal culture (L'Oste Brown 1998). Nonetheless, some historical documents provide important information and insights into local Aboriginal customs and material culture at the time of non-Indigenous settlement and occupation of the region.

4.2 Regional Archaeological Heritage Context

The SMP Study Area is located in the Lower Hunter Valley/Lake Macquarie region. Archaeological evidence suggests that Aboriginal occupation of the Hunter valley region began by at least 35,000 years ago (Koettig 1987). Additional chronological evidence was recovered from the Hunter Valley's northeast mountains for which the following dates were assigned: 34,580 ± 650 (Beta-17009), >20,000 (Beta-20056) and 13,020 ± 360 years BP (Beta-17271) (Koettig 1987, as cited in Attenbrow 2006). These dates show that the region was occupied during the Pleistocene (>10,000 years ago). Such sites are generally rare and therefore contain significant archaeological/scientific information, as well as demonstrating the long occupation of the region by Aboriginal people.

The majority of Aboriginal sites in the region, however, are dated to the more recent Holocene (<10,000 years ago). This may reflect Aboriginal occupation patterns, but may also be influenced by the inaccessibility of potential coastal Pleistocene sites which were inundated when sea levels rose and reached present levels approximately 6,000 years ago (Mulvaney and Kamminga 1999:223). Evidence for Holocene Aboriginal occupation has been recovered from Bobadeen (7,760 cal. years BP), as well as Milbrodale (1,420 cal. years BP) and Sandy Hollow (1,310 cal. years BP) (Moore 1970:58).

4.3 Local Archaeological Heritage Context

Gunson (1974:30) argues that the Awabakal were the largest clan in the Lake Macquarie region, but because of Threlkeld's (an early missionary) well-known studies in the area, Awabakal became the name which represented the entire group. Early government documents indicate this large group was composed of a number of clans - the Awabakal (Lake Macquarie and Newcastle region), the Five Islands clan, the Ash Island clan, the Kurungbong clan (Cooranbong) and the Pambalong clan (Swamps district and near Newcastle). Tindale (1974) presents the Awabakal as one independent group in

‘Aboriginal Tribes of Australia’. While the details of the clan boundaries are unclear, the broad geographical and cultural boundaries are relatively consistent between sources.

The Awabakal appear to have been people of the coast, estuaries, lakes and wetlands, but also with attachment to the rugged sandstone country through the Sugarloaf and Watagan Ranges. The traditional country of the Awabakal people was bounded to the north by the Worimi, to the west by the Wonnarua, to the south west by the Darkinjung and to the south along the coast by the Kuring-gai people.

It appears the various Aboriginal groups of the region displayed some level of interaction as reported by Threlkeld (Turner 1997) who noted that the ‘natives here are connected in kind of a circle extending to the Hawkesbury and Port Stephens’.

4.3.1 Implements for Gathering Food and Weapons

Threlkeld (in Gunson 1974) observed the use of stone hatchets (‘baibai’ ‘pukko’). Dawson (1830) observed grooved heads with a handle fastened by adhesive gum. He stated that gum obtained from wattle (Acacia spp.) and grass trees was used in the manufacture of much equipment. The stone was mainly basalt or diorite and ground on sandstone to form a bevelled cutting edge. There was evidence that shell scrapers were used to sharpen spears, but with the introduction of glass, that material quickly became preferred (Dawson 1830).

Threlkeld (in Gunson 1974) recorded many important aspects of the material culture of Aboriginal people:

“Their canoes were made of the bark of a tree about 12 or 14 feet long, and from 3 to 4 feet in width. They procure the limb of a tree and set it up against the standing trunk, as a ladder, on which they ascend and cut around the whole circumference of the tree in the same manner as done at the bottom. They then chop down a perpendicular line, when they insert their throwing-stick, which is of a wedgelike make at one end, betwixt the bark and the tree, and choosing the season when the sap is either ascending or descending…they proceed to separate the sheet of bark from the tree whilst it is most carefully allowed to slide down and then is laid flat on the ground, the rough outside of the bark being upward. A fire is then made upon the bark and being heated, the steam of the sap softens it so that they can crumble up each end like a folded fan, then which they tie securely with vines from the bush…’ (Threlkeld in Gunson 1974).”

He also described the manufacture of fishing, hunting, and fighting spears that were made from the flowering stem of the grass tree with one or more pieces of hardwood attached to the end, within which was set a barb of bone or quartz (or glass in post-contact times) (Gunson 1974:66). The resin from the grass tree or Acacia was used as the fixative. The spears were thrown using a throwing stick, the woomera. Woomeras were generally about four feet long, half an inch thick and tapered to a point at one end where a barb was affixed (Threlkeld in Gunson 1974:67). Threlkeld observed that spears were traded with groups inland for possum skin cloaks and ‘hanks of line, spun by hand from the fur of animals of the opossum tribe’ (Threlkeld in Gunson 1974:61).

4.3.2 Food and Useful Plants

The red ironbark was used as a resource plant and smooth barked apple was used as a medicinal and resource plant. The black wattle had gum that was used for food. The leaves were crushed and soaked to waterproof nets and its wood used for boomerangs, clubs and digging sticks. The false sarsaparilla was both a medicinal and a resource plant.

Brayshaw (1986) notes that shells were shaped for fish hooks and also used to sharpen or shape wooden implements. Kangaroo bones were made into awls to sew kangaroo and possum skin cloaks, belts and headbands.

4.3.3 Clothing

Summer weather and the milder days of autumn and spring required little in the way of protective clothing; winter however, saw the use of animal skins for both clothing and as blankets. Tench (Tench 1996(1789) :52) described Aboriginal people using opossum skin cloaks with a "girdle of spun opossum hair next to the skin" with their principal ornament a nautilus shell suspended around the neck on a string.

4.3.4 Campsites and Shelters

Campsites and shelters in the region of the Study Area were described by Tench (Tench 1996 (1798) as consisting:

"only of pieces of bark laid together in the form of an oven, open at one end, and very low, though long enough for a man to lie at full length in...they depend less on them for shelter, than on the caverns with which the rocks abound' (Tench 1996 (1789) :80)."

Collins observed that the huts were 'often large enough to hold six to eight people' (Collins 1802:555). These shelters were often grouped together.

4.3.5 Aboriginal Heritage Information Management System (AHIMS)

A search was undertaken of the OEH Aboriginal Heritage Information Management System (AHIMS) for the SMP Study Area and surrounds. The results are provided in Appendix 7. A total of 64 sites have been previously recorded within and surrounding the SMP Study Area (Figure 4-1).

Of the 64 sites recorded in the general vicinity of the SMP Study Area, 9 of these sites are located inside it. The most common site types are isolated finds, the majority of which are concentrated near the southern extent of the SMP Study Area (n=5, 50%). Other types of sites in the SMP Study Area include two artefact scatters, one rockshelter with possible grinding grooves and one single axe grinding groove. A summary of all sites recorded inside the SMP Study Area is detailed in Table 4.1.

Table 4-1:AHIMS results summarised by site types.

Site Type	Frequency	Percent
Isolated Find	5	50%
Axe Grinding Groove	1	10%
Artefact Scatter	2	20%
Shelter with possible grinding grooves	1	20%
Total	**9**	**100%**

TITLE: FIGURE 4-1 AHIMS SITES IN WIDE VICINITY OF PROJECT AREA

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 31/01/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
VERSION (PLAN BY): B A3(CYL-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-1

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241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

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4.4 Local Archaeological Studies

4.4.1 Umwelt (1998) Archaeological Survey for Newstan Colliery Life Extension Project

This survey was conducted for two purposes: the proposed Newstan surface facilities and the Newstan Life Extension Area. The proposed surface facilities concerned the extension of the Northern Reject Emplacement area, the Southern Reject Emplacement area and the upgrade to the rail loading facilities at Newstan. A total of three isolated artefacts were recorded in the area of the proposed rail load upgrade facility. All artefacts were manufactured from mudstone and consisted of a flake-core, a flake and broken flake. In the Life Extension Area, nine sandstone cliffs were inspected, with a total of three rock shelters found containing small archaeological deposits. A small grinding groove was also identified.

4.4.2 Umwelt (2004) Archaeological survey for Centennial Newstan Longwalls 22 and 23

This survey focussed on the tributaries of Lords and Stony Creeks, as well as a sample of other landforms (Umwelt 2004). The landscape was considered to be heavily disturbed and no new sites were identified.

4.4.3 ERM (2005) Archaeological Survey for Awaba Colliery Outbye Pillar Extraction

This survey was conducted immediately to the west of the SMP Study Area. Survey transects for this survey aimed to provide a sample of the 206 hectare impact area (ERM 2005). Vegetation coverage was extensive, with visibility and exposure generally 5 percent, although in confined areas such as vehicle tracks visibility and exposure were as high as 100 percent. No Aboriginal sites were identified during the survey.

4.4.4 Indigenous Outcomes (2007) Archaeological Survey Newstan Colliery Area

This survey included the area to the west of the Newstan pit top and SMP Study Area. One Aboriginal site (AA4 isolated find) had been previously recorded, but was not identified during the survey. One potential scarred tree was identified (AA3) which has since been confirmed by Shane Frost of ADTOAC as an actual scarred tree.

4.4.5 RPS HSO (2008) Stage 1 - Awaba East Exploratory Drilling Program - Aboriginal Heritage Assessment

In 2008, RPS prepared a detailed predictive model as part of the Stage 1 Awaba East Exploratory Drilling Area. The predictive model was developed based upon a review of previous archaeological assessments, results from AHIMS search results and landform mapping. Based on the review of the sources mentioned, it was determined that scarred/modified trees may be located in areas where there is old growth vegetation remaining, rockshelters suitable for habitation may be present in areas where suitable outcropping occurred and grinding grooves may be present where outcropping with smooth surfaces occurred in conjunction with a reliable water source. The majority of sites were expected to be isolated finds or small artefact scatters, which were more likely to occur on gentle slopes with a gradient less than 2 degrees.

4.4.6 RPS HSO (2008) Stage 2 - Awaba East Exploratory Drilling Program - Aboriginal Heritage Assessment

This study involved a desktop assessment for the for Awaba East Exploration Area Stage 2 Drilling area, located within 2 kilometres east of the current study area. It identified the locations which had been previously surveyed, areas which had previously been mined, as well as, areas which had neither been mined or subject to archaeological survey. This allowed heritage management zones for the exploration area to be defined, for which a set of heritage management protocols were devised (RPS HSO 2009b)

4.4.7 RPS HSO (2008) SMP Archaeological Assessment and Revised Predictive Model

RPS was commissioned by Centennial to develop an SMP and to revise the existing predictive model/sensitivity mapping within the Study Area. A field survey was undertaken to investigate the accuracy of the predictive model and it was determined that no archaeological sites were located within the SMP Study Area. The probability of sites was identified as unlikely for two main reasons: vegetation cover within the area was very dense, which reduced ground surface visibility, and potential archaeological deposits (PADs) identified during earlier assessments of the Study Area were no longer evident due to loss of soil across the SMP Study Area.

4.4.8 RPS (2009) Archaeological Assessment & Proposed Mitigation Strategies, Awaba East

RPS was commissioned to prepare an archaeological assessment and proposed mitigation strategy for Stage 2 Awaba East Exploration Area (AEEA) drilling program. A predictive modelling was developed based on landform features and known sites in the vicinity of the study area in order to ascertain areas of high, moderate and low archaeological sensitivity. Specific management strategies were developed accordingly.

4.4.9 RPS (2009) The Olstan Project, Cultural Heritage Assessment, Newstan Colliery

RPS was commissioned to undertake an Aboriginal and European cultural heritage assessment as part of a Part 3A application for the Olstan Study Area. The field survey that formed part of the overall assessment was conducted to check for the presence of Aboriginal sites and also confirm or refute the predictive model for the area. No Aboriginal sites were identified during the surveys.

4.4.10 RPS (2010) Cultural Heritage Impact Assessment for Awaba Colliery, Awaba Colliery

RPS was commissioned to provide a Cultural Heritage Impact Assessment (CHIA) which addresses mining activities within the Awaba Colliery mining areas. No items of Aboriginal heritage were identified during the field survey, but the Awaba Pit top complex and the abandoned Awaba-Wango rail line were assessed as items of historical value. This report led to further heritage assessments undertaken with culminated in the Awaba Post Mining Heritage Management Plan (RPS 2010).

5 Aboriginal Archaeology in the SMP Study Area

This chapter is intended to provide an overview of the Aboriginal sites present inside the Newstan SMP Study Area. As previously discussed in Section 4.3.5 of this report, a total of nine sites have been registered with AHIMS that fall within the SMP Study Area. A comprehensive description of each site is provided below.

Table 5-1: Aboriginal Sites Located in the Study Area

Site Type	AHIMS No.	RPS Reference No	Date Recorded	Survey Area Reference	Artefact Type	Location
Isolated Find	45-7-0296	RPS Newst 03	30/11/2010	A2	Flake	LW101-Roadways First Workings
Artefact Scatter	45-7-0299	RPS Newst 06	30/11/2010	A2	Hammerstone/ Flake	LW101
Isolated Find	45-7-0303	RPS Newst 10	07/12/2010	A3	Flake	Angle of Draw
Isolated Find	45-7-0309	RPS Newst 16	09/12/2010	A5	Adze	LW102
Isolated Find	45-7-0295	RPS Newst 02	09/12/2010	A5	Flake	Mains headings roadways (first workings)
Axe Grinding Groove	45-7-0260	RPS LEA10	30/11/2010	C2	Grinding Groove Complex	Mains headings roadways (first workings)
Isolated Find	45-7-0298	RPS Newst 05	30/11/2010	C3	Flake	Angle of Draw
Artefact Scatter	45-7-0297	RPS Newst 04	30/11/2010	C3	Flake/Flaked Piece	LW101-Roadways First Workings
Shelter with possible grinding grooves	45-7-0310 - 45-7-0005	RPS Newst 17	09/12/2010	A5	Rockshelter/ Grinding Groove	LW101

5.1.1 Isolated Find (AHIMS # 45-7-0296) - RPS Newst 3

Isolated find AHIMS #45-7-0296 was recorded on the 30th November, 2010 by RPS personnel with the assistance of Aboriginal Stakeholders Mr Shane Frost (ADTOAC) and Ms Kerrie Brauer (ATOAC). The isolated find was a transversely snapped flake which was located on the mid-slope of a steep hill (Plate 1; Plate 2). The nearest permanent water source was Kilaben Creek, located approximately 50 metres away within an open woodland forest. Isolated find AHIMS #45-7-0296 had been disturbed by vehicle damage and surface water movement.

5.1.2 Artefact Scatter (AHIMS #45-7-0299) - RPS Newst 6

Artefact scatter AHIMS #45-7-0299 was recorded on the 30th November, 2010 by RPS personnel with the assistance of Aboriginal Stakeholders Mr Shane Frost (ADTOAC) and Ms Kerrie Brauer (ATOAC). The artefact scatter was small, measuring approximately 3 metres x 1 metre and containing only two artefacts. The artefacts were a sandstone hammer stone which had been fragmented into three pieces and a single complete flake of silcrete (Plate 3; Plate 4; Plate 5). The artefacts were located on a service corridor on the lower slopes of a rolling hill in an open woodland forest. The nearest permanent water source was Kilaben Creek, situated approximately 500 metres away, while the nearest ephemeral water body is 100 metres away. Ground surface conditions were poor and there was evidence of erosion possibly caused by surface water washout.

5.1.3 Isolated Find (AHIMS #45-7-0303) - RPS Newst 10

Isolated find (AHIMS #45-7-0303) was recorded on the 7th December, 2010 by RPS personnel with the participation of Aboriginal Stakeholders Mr Shane Frost (ADTOAC) and Ms Kerrie Brauer (ATOAC). A single chert flake was recorded on the mid slope of a hill surrounded by forest vegetation (Plate 6; Plate 7). The area in which the flaked artefact was located was used as a power easement and subjected to disturbances such as vehicle traffic and natural erosion processes. The nearest permanent water source to the isolated find is Kilaben Creek, located approximately 100 metres away.

5.1.4 Isolated Find (AHIMS #45-7-0309) - RPS Newst 16

Isolated find (AHIMS #45-7-0309) was recorded on the 9th December, 2010 by RPS personnel with the participation of Aboriginal Stakeholders Ms Kerrie Brauer (ATOAC), Mr Shane Frost (ADTOAC) and Mr James Frost (ADTOAC). A single fine grained adze (chopper) was located on a flat ridge of a hill approximately 100 metres from the nearest permanent water source (Plate 8; Plate 9; Plate 10). The chopper was situated on Crown land surrounded by woodland vegetation. No evidence of disturbance to the ground surface was identified.

5.1.5 Isolated Find (AHIMS #45-7-0295) - RPS Newst 2

Isolated Find (AHIMS #45-7-0295) was recorded on the 30th November, 2010 by RPS personnel with the assistance of Aboriginal Stakeholders Ms Kerrie Brauer (ATOAC), Mr Shane Frost (ADTOAC) and Mr Shane Frost (ADTOAC). A single complete flake of chert was located on a mid slope of a steep hill approximately 500 metres from the nearest permanent water source and 10 - 20 metres away from an ephemeral drainage line (Plate 11; Plate 12). The surrounding vegetation consisted of open forest woodland situated on Crown Land. The flake was assessed to be in good condition, although the landscape is subject to water disturbance.

5.1.6 Axe Grinding Groove (AHIMS #45-7-0260) - RPS LEA 10

Site LEA 10 (AHIMS #45-7-0260) was a grinding groove complex that was originally found and recorded by Umwelt Australia for the Centennial EIS Life Extension area in 1998. Although LEA 10 was recorded, the Umwelt report indicated that the area may not be a site and therefore no site card was registered with OEH. In 2008, RPS was commissioned to revisit the area previously surveyed and submit site cards for those deemed to be sites. LEA 10 consisted of three grinding groove concentrations, two of which contained two grooves and the other three grooves. The grooves at their widest point were approximately 5 centimetres and were approximately 15 centimetres long (Plate 18; Plate 19; Plate 20).

The LEA 10 grinding grooves were situated in the sandstone conglomerate creek bed of a small drainage line. Surrounding vegetation in the area consisted of open woodland forest with a dense understorey of leaf litter and grass. Estimated ground surface visibility was moderate once the leaf litter was cleared.

5.1.7 Isolated Find (AHIMS #45-7-0298) - RPS Newst 5

Isolated find (AHIMS #45-7-0298) was recorded on the 30th November, 2010 by RPS personnel with the assistance of Ms Marie Waugh (WNAC), Mr Robert Samson (WLAC) and Ms India Latimore Volunteer (WLAC). A single complete flake of chert was identified on an eroded track within the flat terrace of a hill (Plate 21). The nearest water source was Kilaben Creek, located approximately 100 metres away. Ground surface conditions were relatively poor and the area has been subjected to vehicle and water disturbance.

5.1.8 Artefact Scatter (AHIMS #45-7-0297) - RPS Newst 4

Artefact scatter (AHIMS #45-7-0297) was recorded on the 30th November, 2010 by RPS personnel with the assistance of Ms Marie Waugh (WNAC), Mr Robert Samson (West Lakes Aboriginal Community) and Ms India Latimore Volunteer (WLAC). Two chert artefacts were located: one was a complete flake while the other was a flaked piece (Plate 22; Plate 23; Plate 24). The artefact scatter (AHIMS #45-7-0297) is small and located on the lower slope of a hill within an open forest surrounding. The nearest permanent water source was Kilaben Creek, approximately 50 metres away. The condition of the site was relatively poor and occasionally subject to surface water disturbance.

5.1.9 Rockshelter with possible grinding groove (AHIMS #45-7-0310/45-7-0005)-RPS Newst 17

Axe grinding groove with rockshelter (AHIMS #45-7-0005) was recorded by H. Barton using spherical co-ordinates (longitude/latitude), although the date it was recorded was unknown. The site was presumably near the head of a gully leading toward Toronto, where numerous rockshelters were present. RPS personnel groundtruthed the co-ordinates provided in the site description on the 14th February, 2011 but were unable to relocate the site. The co-ordinates on the AHIMS site card led the field crew to an area consisting of gently undulating plains intermittently separated by small tributaries with no sandstone to support the formation of rockshelters. This led RPS to investigate the matter further (see Section 6.2). It was ultimately concluded that AHIMS #45-7-0005 was actually site AHIMS #45-7-0310 which was recorded on the 9th December, 2010 by RPS personnel with the assistance of Aboriginal Stakeholders Mr Shane Frost and Mr James Frost (ADTOAC)

The sandstone rockshelter with possible grinding groove site was located on the mid slope of a steep hill on a sandstone platform. Partial rock collapse had destroyed parts of the shelter where the original length of the shelter is unknown. The aspect of the shelter faced south-east with an internal length of 6 metres by 1.2 metres wide and 1.4 metres in height (Plate 13; Plate 14; Plate 15; Plate 16). The shelter floor consisted of dry soft soil with areas of charcoal depositions and soot noted on the ceiling (Plate 17). Two fragments of bone were noted amongst pieces of charcoal on the floor of the cave with several small pieces of charcoal observed eroding from the soil immediately below the drip line. The front of the shelter was fairly expansive and contained good quality sandstone covered by soil and plant materials. Attempts were made to determine if there were grinding grooves at the shelter entrance. Although none were identified, it does not discount this possibility entirely due to the dense vegetation cover which significantly reduced surface visibility.

6 Archaeological Investigation

Based on the types of sites recorded within the SMP Study Area, the sites most sensitive to subsidence events are rockshelters and grinding grooves, whilst artefact scatters and isolated finds would be less prone to disturbance. This is largely because artefact scatters and isolated finds are not attached to the natural landform. Historically, rock shelters and grinding grooves are regarded as more sensitive to subsidence effects because they are usually manufactured from sandstone which is brittle. The sites of particular concern were grinding groove complex (AHIMS# 45-7-0260), and rockshelter with possible grinding groove site (AHIMS #45-7-0310 /45-7-0005).

On the 25th November, 2011, RPS personnel, in association with subsidence expert Mr Gareth Swarbrick of Pells Sullivan Meynink Engineering Consultants (PSM) reinspected AHIMS# 45-7-0260 and AHIMS #45-7-0310 /45-7-0005 to assess the potential impact of subsidence on the sites. The purpose of the investigation was to determine the current condition of the sites in order to gather metric information to assist in the future monitoring of the site during and after the commencement of proposed works. The assessment and outcome of the findings are reported below.

6.1 Archaeological Inspection of Site AHIMS # 45-7-0260 (Grinding Groove)

AHIMS #45-7-0260 (RPS LEA 10) was revisited by RPS personnel and Mr Gareth Swarbrick (PSM) on the 25th November 2011 to obtain an accurate assessment of the potential subsidence impacts to the grinding groove complex. As specified in Section 5.1.7 of this report, this site was originally found by Umwelt and later confirmed to be a site by RPS personnel in 2008. Due to poor weather conditions on the date of revisit, the sandstone pavement was completely inundated with flowing water and the grinding patches were not visible (Plate 25; Plate 26). This site is located within the mains heading roadways (first workings) (Figure 4-1).

6.2 Recent decisions about previously recorded site #45-7-0005 and #45-7-0310

As discussed in Section 5.1.9 of the report, AHIMS 45-7-0310/45-7-0005 was originally registered as two different sites being AHIMS #45-7-0310 and AHIMS 45-7-0005. However, archaeological investigation led to the conclusion that they are in fact the same site. The following description details the conclusions of this finding.

RPS with the participation of relevant stakeholder representatives, attempted to relocate AHIMS Site #45-7-0005 in February 2011 without success. In order to gain more information about the whereabouts of AHIMS Site #45-7-0005, RPS undertook investigative work to determine who H. Barton was and when this site may have been recorded. Ms Vanessa Finney and Ms Allison Dejanovic of Australian Museum (Collections Officer) were contacted to request any archival information about AHIMS Site #45-7-0005 stored at the museum repository. The only information held at the museum was the same site description as on the AHIMS site card (Appendix 8).

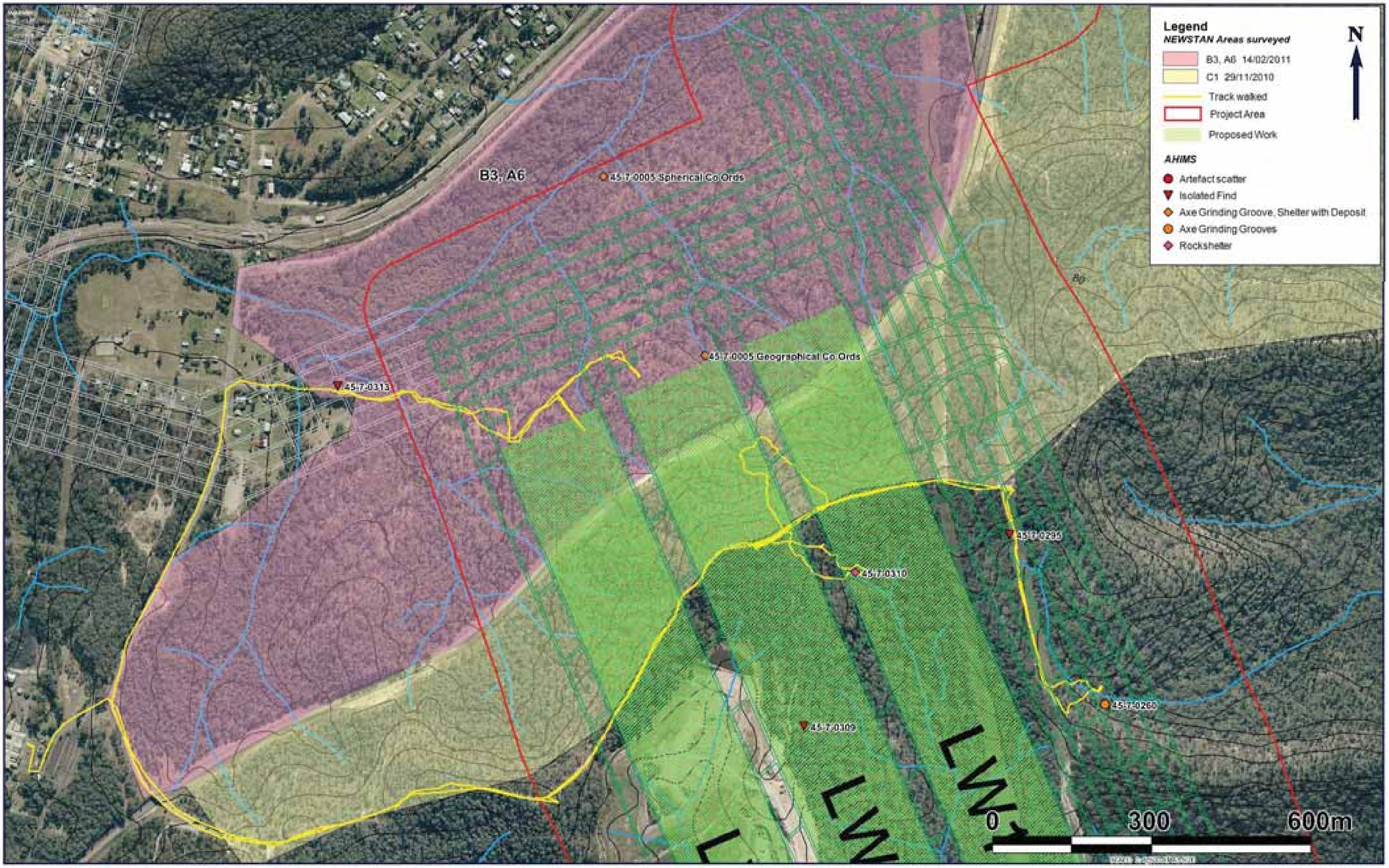
RPS also considered the possibility that the co-ordinates provided on the site card may have been correct, but written in the wrong co-ordinate system. Given that the location was provided as spherical co-ordinates (longitude/latitude), RPS converted these co-ordinates into geographical units to eliminate all possibilities that AHIMS #45-7-0005 was erroneously recorded.

Using the converted co-ordinates, RPS personnel, in association with subsidence expert Mr Gareth Swarbrick (PSM), attempted to relocate the site on the 25th November 2011. Unfortunately, these co-ordinates led the field team into an area not deemed suitable for rockshelter formation. The landscape was mostly flat country with an old cattle station nearby. The gentle slope of the terrain was less than 10° degrees (Plate 27; Plate 28) with only a small drainage zone nearby.

RPS therefore concluded that AHIMS Site #45-7-0005 was mistakenly recorded and that the site H. Barton described was most likely rockshelter #45-7-0310, recorded by RPS personnel on the 9th December, 2010 with the assistance of Aboriginal Stakeholders Mr Shane Frost (ADTOAC) and Mr James Frost (ADTOAC). It was concluded that AHIMS Site #45-7-0310 is the same site as AHIMS Site #45-7-0005 (See Section 6.3 of the report for more detail). The argument for this hypothesis was presented to Ms Cheryl Brown (OEH Information System and Assessment Section) on the 7th December, 2011 with the recommendation that AHIMS Site #45-7-0005 be deregistered (Appendix 9). The argument presented to Ms Cheryl Brown was as follows:

1) Geographically, AHIMS Site # 45-7-0310 was located in the general vicinity described by H. Barton, being east of Awaba railway station and north of the State Coal Mine;
2) AHIMS Site # 45-7-0310 was located at the head of a gully similar to H. Barton's description (Plate 28);
3) Sedimentation in AHIMS Site #45-7-0310 was deep enough to afford possible artefact deposits and was congruous with the description provided by H. Barton (Plate 29; Plate 30); and
4) The only difference observed was that H. Barton mentioned the presence of axe grinding grooves near the rockshelter and none were identified at AHIMS Site #45-7-0310. Although the outcome of two field inspections failed to identify grinding grooves near AHIMS Site #45-7-0310, there was potential for grooves based on the flat surface of the sandstone pavement in front of the rockshelter (Plate 31; Plate 32).

On the 9th December, 2011, OEH amended the co-ordinates on Site Card #45-7-0005 to those of AHIMS Site 45-7-0310 with a note advising that they are the same site. AHIMS #45-7-0005 was not deregistered as this was not an action that OEH could execute (Appendix 10). Based on recent updates to the site, it was possible to confirm that the rockshelter with possible grinding grooves was located near in the centre of LW 101. In order to avoid confusion, this rockshelter with possible grinding groove site has been referred to as AHIMS #45-7-0310/45-7-0005 in this report (Figure 6-1).



TITLE: FIGURE 6-1 SITE INSPECTION ROUTE CONDUCTED ON THE 25TH NOVEMBER 2011

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 31/01/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
VERSION (PLAN BY): B A3(CYL-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-1

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
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7 Significance Assessment of Aboriginal Sites

7.1 Aboriginal Cultural Significance Assessment

Archaeological field investigations are an effective way of determining the location of Aboriginal sites in the landscape. However, the cultural significance of the sites and landscape can only be assessed by the cultural knowledge holders because they draw on knowledge from their ancestors and their own experiences. Understanding the cultural significance of the landscape is an integral part of undertaking cultural heritage impact assessment in any study Area because the information can identify areas deemed more culturally significant to the Aboriginal community and assist in the development of appropriate management strategies taking into consideration any cultural sensitivities.

A cultural mapping and significance assessment workshop was conducted on the 23rd March 2012 at Newstan. All Aboriginal stakeholders who have registered their interest to participate in the consultation process for the Newstan mining projects were invited to participate. In addition, as the process is to be rolled out to all of Centennial's Northern operations, all other Aboriginal groups who have registered their interest in any of Centennial's other northern operations projects were invited to attend as observers.

Representatives of the ATOAC (Ms Kerrie Brauer, Mr Dene Hawken & Amanda Hawken) and ADTOAC (Mr Shane Frost) participated in the cultural significance workshop. Ms Sharon Hodgetts (Darkinjung LALC) attended the workshop as an observer and Ms Jane Delaney-John acted as a mediator. Representatives of Wonn 1 Contracting (Mr Arthur Fletcher), Cacautua Culture Consultants (Mrs Donna Sampson), Guringai Tribal Link (Ms Tracey Howie) and Bahtabah Local Aboriginal Land Council (Mr Michael Green and Mr Toby Whaleboat) expressed their apologies because they were not able to attend the workshop.

The workshop identified areas of cultural sensitivity that could not be determined through standard archaeological methods.

7.1.1 Methodology behind the Cultural Assessment

In the Burra Charter (1999), which is sponsored by the International Council of Monuments and Sites, cultural significance means the aesthetic, historic, scientific or social value of an item for past, present and future generations. The assessment of cultural significance has also been adopted by the NSW NPWS Guidelines (2011: 9). In order to rank the cultural significance value of Aboriginal sites in the Newstan SMP Study Area, ADTOAC and ATOAC developed a ranking process, which was based on the criteria listed in the Burra Charter (1999).

It is important to note that the process for ranking the cultural significance of an Aboriginal site is a matter for Aboriginal people. This assessment can only be made by the appropriate Aboriginal representatives of the relevant communities. This process for identifying the cultural significance of an Aboriginal site has been adopted by Centennial to assist in understanding what sites hold a higher significance to the Aboriginal community and understand the impacts of its operations on Aboriginal cultural heritage. The cultural significance assessment does not represent the true cultural values placed on these sites by the Aboriginal community. The results of the ranking of cultural significance are a result of the views held only of those Aboriginal people/groups participating in the process and are not representative of the cultural values placed on Aboriginal sites by all Aboriginal people/groups.

The aspects considered during the cultural significance assessment of the Aboriginal sites within and surrounding the Newstan SMP Study Area are detailed below.

Historic/ Social/Ceremonial/Spiritual/Dreaming Connection:

This criterion refers to any historic, social, ceremonial, spiritual or dreaming connection that the site may have to the registered Aboriginal stakeholder/group. This criterion also considers its past teaching potential.

Rarity:

This criterion refers to how rare the site is in reference to location, site type, site integrity on a local and regional scale. Rarity is also assessed on its archaeological potential.

Inter-relatedness:

This criterion refers to whether the site is believed to be related or associated another site in the landscape.

Teaching Potential:

This criterion refers to any potential future and/or present use for educational purposes in the teaching of culture and history.

Aesthetics:

This criterion refers to the sites aesthetic qualities. Please note that the notion of visual appeal is subjective.

Outlook:

Outlook refers to whether the site has an extensive outlook over the landscape and/or if the area of the site has an attractive perspective to the Aboriginal stakeholders.

7.1.2 Structure of the Cultural Significance Assessment Table

As discussed in the previous section, two Aboriginal stakeholder groups participated in the cultural significance workshop. The ADTOAC assessment of each criterion is highlighted in purple and the ATOAC assessment in green (Table 7-1). Each representative group ranked each criterion for each site on a scale of 1 to 5 points according to their level of cultural significance (Table 7-2). Given that all Aboriginal sites are considered highly important to Aboriginal people, the cultural significance ranking parameter is between high up to extremely high. Once the rank of cultural significance for each site was completed, the total number of points for each site from each group was tabulated and averaged in order to derive an overall result (Table 7-4).

The tabulated results collected was sent out to the relevant groups that participated in the workshop by Centennial staff Mr James Wearne on the 26th March 2012.

Table 7-1: Aboriginal Representatives which Participated in the Cultural significance Assessment Workshop

ADTOAC (Mr Shane Frost)	
ATOAC (Ms Kerrie Brauer, Mr Dene Hawken and Ms Amanda Hawken)	

Table 7-2: Each Criterion was assessed as follows:

High Cultural Significance	1 Point
High to Very High Cultural Significance	2 Points
Very High Cultural Significance	3 Points
Very High to Extremely High Cultural Significance	4 Points
Extremely High Cultural Significance	5 Points

Table 7-3: Overall Cultural Significance Rank per site (Average)

High Cultural Significance	1 to 6 Points
High to Very High Cultural Significance	7 to 13 Points
Very High Cultural Significance	14 to 20 Points
Very High to Extremely High Cultural Significance	21 to 27 Points
Extremely High Cultural Significance	28 to 35 Points

7.1.3 Summary of Cultural Significance to the ATOAC and ADTOAC

According to the outcome of the workshop, six sites were assessed with high to very high cultural significance, all of which were isolated finds or artefact scatters (Table 7-4). An isolated find (AHIMS # 45-7-0309) being a fine grained adze (chopper) was assessed with very high significance because the artefact type was considered unique. Rockshelter and grinding groove site (AHIMS # 45-7-0310/45-7-0005 & 45-7-0260) was considered to be more culturally significant compared to isolated finds and artefact scatters.

During the workshop, Mr Shane Frost (ADTOAC) informed Centennial and RPS personnel that there are three other sites located within the SMP Study Area which have been identified and currently in the process of being registered with OEH. The additional sites were identified during recent surveys commissioned by the Lake Macquarie City Council for the expansion of the Awaba Waste Management Facility and include three scarred trees located immediately west of the Awaba Waste Management Facility.

Mr Shane Frost also informed the group that there is a restricted site south of AHIMS #45-7-0303. This site is in the process of being registered with OEH.

Centennial has informed RPS and the registered Aboriginal stakeholders that the three scarred trees and the restricted site will undergo a cultural significance assessment prior to any secondary extraction works and the monitoring/management measures for these sites will be addressed in the Centennial Northern Holdings Aboriginal Cultural Heritage Management Plan (ACHMP) currently being developed in consultation with the Aboriginal stakeholders.

Table 7-4: ATOAC and ADTOAC Aboriginal Archaeological Site Significance Assessment for the sites within the Study Area

AHIMS	SITE TYPE	Ceremonial/Spiritual Dreaming Connection	Rarity	Inter-relatedness	Teaching Potenial/research potential	Aesthetics of Site	Outlook	Total Points	Overall Rank Summary of Signifiance (Per group)	Overall Rank (X) Average	Overall Cultural Signifiance
45-7-0295	Isolated Find	1	1	3	1	1	2	9	9	9	
		1	1	3	1	1	2	9	9		
45-7-0299	Artefact Scatter	1	3	3	1	1	2	11	11	11	
		1	3	3	1	1	2	11	11		
45-7-0296	Isolated Find	1	1	4	3	1	2	12	12	12	
		1	1	4	3	1	2	12	12		
45-7-0297	Isolated Find (IS an Artefact Scatter)	1	1	4	3	1	2	12	12	12	
		1	1	4	3	1	2	12	12		
45-7-0298	Isolated Find	1	1	4	3	1	2	12	12	12	
		1	1	4	3	1	2	12	12		
45-7-0303	Isolated Find	1	1	4	3	1	2	12	12	12	
		1	1	4	3	1	2	12	12		
45-7-0309	Isolated Find	3	4	3	3	2	2	17	17	17	
		3	4	3	3	2	2	17	17		
45-7-0260	Grinding Groove	4	4	4	4	4	4	24	24	24	
		4	4	4	4	4	4	24	24		
45-7-0310/45-7-0005	Rockshelter	5	5	5	5	5	5	30	30	30	
		5	5	5	5	5	5	30	30		

7.2 Scientific Significance

Scientific significance encompasses a multi-dimensional analysis of cultural object/s in the landscape. The evaluation is always connected to the research questions and the greater understanding of the archaeological record (Donald and Barbara 2009:69). According to the NSW NPWS Guidelines (2011: 9), scientific significance refers to the importance of landscape, area, place or object because of its rarity, representativeness and the extent to which it may contribute to further understanding and information (ICOMOS Burra Charter 1988).

Archaeological information exists on two interpretive levels. The first level consists of the observations made in the field about the cultural object such as the site type, form, shape, associations to other sites and content. The second level of assessment is largely linked to the ability to address the research question and its interpretive potential about past human activities (Binford 1983 in Donald and Barbara 2009: 70). Answers to questions about site formation processes, foodways, ancient environments, and subsistence activities are raised in this tier of assessment. However, the emphasis and direction of the analysis is largely dependent on the research question or the hypothesis for the overall project.

There is a distinction between academic archaeology and cultural resource management (CRM). The objective of academic archaeology is largely focused on addressing a number of complex research questions/hypothesis which can contribute to a better understanding of past cultures or a specialised field in the discipline of archaeology. Cultural resource management generally addresses basic research questions, rather than complex hypotheses because the main focus is on the development of site management strategies and mitigation measures for the correct handling of cultural objects. In order to develop an appropriate management plan, the scientific value is assessed by the heritage consultant.

7.2.1 Methodology-Assessment Criteria and Ranking System

Assessment of scientific significance is dependent on the research question and purpose of the investigation. Scientific significance for sites within the Newstan SMP Study Area was assessed according to the criteria listed in Table 7-5. The archaeological significance criteria are usually assessed on two scales: local and regional; in exceptional circumstances; however, state significance may also be identified. Archaeological significance criteria is assessed in three levels to which scores are assigned; low (score=1), moderate (score=2) and high (score=3). A combination of these scores then provides an overall significance ranking of the site to be determined (Table 7-6; Table 7-7). Explanations for the ranking outcome are provided in Table 7-8.

Table 7-5: Assessment of Scientific Significance Criteria

Criteria	Description
Research Potential	This criteria is used to identify whether a site has the potential to contribute new information which to the interpretation of Aboriginal occupation in the area.
Rarity	This criterion examines the frequency of the identified site types with others previously recorded in the local or regional landscape.
Representativeness	All sites are representative of a site type, however, some sites may be in better condition, or demonstrate more clearly a particular site type. Representativeness is based on the understanding of extant sites in the local or regional landscape and the purpose of this criteria is to ensure a representative sample of sites area conserved for future generations.
Integrity	This refers to site intactness. A site with contextual integrity can provide information relating to chronology, social systems, tool technology, site formation processes, habitation, frequency of use as well as other occupation indicators. Moderate to high levels of disturbance will generally result in low integrity.
Educational Potential	This refers to whether the subject area contains teaching sites or sites that might have teaching potential.

Table 7-6: Overall Scientific Significance

Low Significance	5 to 7 Points
Moderate Significance	8 to 11 Points
High Significance	12 to 15 Points

Table 7-7: Scientific Significance Scores for Aboriginal Sites in the Newstan SMP Study Area

AHIMS	SITE TYPE	Scope of Assessment	Research Potential	Rarity	Representativeness	Integrity	Educational Potential	Overall Rank (Local)	Overall Rank (Regional)
45-7-0295	Isolated Find	Local	1	1	1	1	1	Low	Low
		Regional	1	1	1	1	1		
45-7-0299	Artefact Scatter	Local	2	2	1	1	2	Moderate	Low
		Regional	1	1	1	1	1		
45-7-0296	Isolated Find	Local	1	1	1	1	1	Low	Low
		Regional	1	1	1	1	1		
45-7-0297	Isolated Find (IS an Artefact Scatter)	Local	1	1	1	1	1	Low	Low
		Regional	1	1	1	1	1		
45-7-0298	Isolated Find	Local	1	1	1	1	1	Low	Low
		Regional	1	1	1	1	1		
45-7-0303	Isolated Find	Local	1	1	1	1	1	Low	Low
		Regional	1	1	1	1	1		
45-7-0309	Isolated Find	Local	2	1	2	1	2	Moderate	Low
		Regional	1	1	1	1	1		
45-7-0260	Grinding Groove	Local	3	2	3	2	2	High	Moderate
		Regional	2	2	2	2	2		
45-7-0310/45-7-0005	Rockshelter	Local	2	2	3	2	3	High	Moderate
		Regional	2	2	1	1	3		

Table 7-8: Explanation of Scientific Significance Scores for Aboriginal Sites in the Newstan SMP Study Area

AHIMS	SITE TYPE	Research Potential	Rarity	Representativeness	Integrity	Educational Potential	Overall Rank (Local)	Overall Rank (Regional)
45-7-0295	Isolated Find	Little to no research potential on a local level, due to the nature of the site and artefact type being common.	They are common occurences in the landscape on a local and regional level. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place. The artefact is common.	The isolated find had a water worn cortex which has eroded the diagnostic features of the arefact. Its location on a service corridor also places its spatial integrity under scrutiny.	The nature of the site as an isolated artefact is not complex. The flaked chert is not uncommon on a local and regional level.	Low	Low
45-7-0299	Artefact Scatter	Research potential is limited to possible usage of the implements, being artefact manfacture	Although the objects comprised of a core and hammerstone, the samples were relatively crude in comparison to other samples in the region.	The two arefacts is at a substantial distance away from other sites in the area (greater than 50m away). The artefact is not rare but less frequently identifed.	The artefacts were located in an electricity easement, and thereforenot insitu. The objects have an eroded surface and was assessed to be in poor condition overall.	The density of the site is low, and the type of artefacts represented is not considered exceptionally rare or completed in its form.	Moderate	Low
45-7-0296	Isolated Find	Little to no research potential on a local level, due to the nature of the site and artefact type being common.	They are common occurences in the landscape on a local and regional scale. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place.	The artefact has been damaged possibly by water erosion and vehicle movement.	The nature of the site as an isolated artefact is not complex. The flaked chert is not uncommon on a local and regional level.	Low	Low
45-7-0297	Isolated Find (IS an Artefact Scatter)	Little to no research potential on a local level, due to the nature of the site and artefact type being common.	They are common occurences in the landscape on a local and regional scale. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place.	The artefact was in poor condition, exhibiting a very worn cortex and not found in situ.	Artefact assessed to be common in the region being flakes of chert.	Low	Low
45-7-0298	Isolated Find	Little to no research potential on a local level, due to the nature of the site and artefact type being common.	They are common occurences in the landscape on a local and regional scale. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place.	It is not possible to determine if the site was found in situ given that it was identified on an erodeded access track. Overall condition of the artefact was assess as low.	The nature of the site as an isolated artefact is not complex. The flaked chert is not uncommon on a local and regional level.	Low	Low
45-7-0303	Isolated Find	Little to no research potential on a local level, due to the nature of the site and artefact type being common.	They are common occurences in the landscape on a local and regional scale. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place. The quality of the artefact is in low-moderate condition.	The condition of the artefact was assessed as poor exhibiting vehicle damage and an eroded surface.	The nature of the site as an isolated artefact is not complex. The flaked chert is not uncommon on a local and regional level.	Low	Low
45-7-0309	Isolated Find	The artefact cannot be contextualised in space as a place of occupation. The artefact however was used for possible food preparation activities	They are common occurences in the landscape on a local and regional scale. This site type represents 50% of all total sites in the Project Area and 36.9% in Newstan Colliery.	Isolated finds are discrete tools that cannot be contextualised in space on a local level to determine the subsistence process that may have taken place. The artefact is in low-moderate condition	The integrity of the site is likely to be low given that it was located in an access corridor subjected to light vehicle movement.	Although this site type is not rare, there are diagnostic features on the tool that could be investigated further	Moderate	Low
45-7-0260	Grinding Groove	There is potential to test other research questions about the site. -If academic research is to be undertaken. Not necessary for the purpose of CRM	Although the site is not considered rare on a regional level, given that numberous grinding groove sites have been identified in Mandalong Colliery, they are considerably rarer in the Newstan region.	The site is located in a moderately sensitive lanform area which has the potential to offer shelter and other resources related to subsistence activites.	Overall integrity of the site was considered sound. However, natural weathering processes are taking place.	The site itself is not considered complex on a local scale given that it is not closely associated with oher site types in visial range. However, there are other sites including an rockshelter and artefact scatter in the viscinity of the grinding grooves which may also add to the research potential.	High	Moderate
45-7-0310/45-7-0005	Rockshelter	There is potential to test other research questions with the site. -If academic research is to be undertaken. Not necessary for the purpose of CRM. Only rockshelters with more than 10cm of sediment should be considered for test excavation.	Rockshelters are considerably rare on a local perspective, constituting 7.8% of all sites in the Newstan Colliery.	The site is located in a moderately sensitive lanform area which has the potential for further investigation on an academic level. However there is no potential for sub-surface artefacts outside the shelter because it is exposed sandstone.	The shelter has undergone partial roof collapse as a result of natural erosion processes. Full extent cannot be ascertained due to damage	The rockshelter does contain some charcoal and bone, but cannot conclusively be assocated with cultural events. Bush fires can add charcoal to the shelter ground surface and animals may have occupied the shelter in the recent past.	High	Moderate

8 Expected Subsidence, Impacts & Mitigation Measures

No European cultural heritage sites were located within the SMP Study Area however nine Aboriginal cultural heritage sites were. Of the nine sites identified (see Section 4.3.5), the rockshelter with possible grinding groove site (AHIMS 45-7-0310/45-7-0005) above LW101 and the grinding groove site (AHIMS 45-7-0260) above the mains headings roadways (first workings) would be most sensitive to subsidence effects due to the brittle nature of the Narrabeen group sandstone.

Mine Subsidence Engineering Consultants (MSEC) provided RPS with the subsidence predictions for each of the recorded Aboriginal sites within the SMP Study Area on 21 March, 2012. The term subsidence is commonly used to describe overall ground movement as a result of mining. Subsidence can have an impact on surface landforms such as changing the flow of drainage lines, causing cracks to appear on the ground surface and increasing the potential for erosion in areas. Based on the severity of the subsidence impact and the nature of the surface structure to be impacted, this could have a detrimental impact to the archaeological sites recorded in the SMP Study Area. A summary of predicted subsidence impacts to the Aboriginal sites within the SMP Study Area has been provided in Table 8-1.

Table 8-1: Impact Summary to Archaeological Sites from Subsidence Activity

Site Type	AHIS No.	RPS Reference No	Location	Maximum Vertical Subsidence Prediction (mm)	Maximum Total Tilt Prediction (mm/m)	Maximum Predicted Conventional Hogging Curvature (km-1)	Likelihood of Harm
Isolated Find	45-7-0296	RPS Newst 03	LW101- Roadways First Workings	200mm	2mm/m	0.02 (Km-1)	Low
Artefact Scatter	45-7-0299	RPS Newst 06	LW101	800mm	6mm/m	0.07 (km-1)	Low-Moderate
Isolated Find	45-7-0303	RPS Newst 10	Angle of Draw	50mm	0.5mm/m	<0.01 (km-1)	Low
Isolated Find	45-7-0309	RPS Newst 16	LW102	850mm	10.0mm/m	0.17 (km-1)	Low-Moderate
Isolated Find	45-7-0295	RPS Newst 02	Mains headings roadways (first workings)	100mm	1.5mm/m	0.02 (Km-1)	Low
Rockshelter	45-7-0310/45-7-0005	RPS Newst 17	LW101	650mm	1.0mm/m	0.06 (km-1)	High
Axe Grinding Groove	45-7-0260	RPS LEA10	Mains headings roadways (first workings)	50mm	0.5mm/m	0.01 (Km-1)	Low-Moderate
Isolated Find	45-7-0298	RPS Newst 05	Angle of Draw	150mm	2mm/m	0.03 (Km-1)	Low
Artefact Scatter	45-7-0297	RPS Newst 04	LW101- Roadways First Workings	200mm	2mm/m	0.03 (Km-1)	Low
Restricted site	Yet to Record	Yet to Record	Angle of Draw- Southern	<20 mm			Low

8.1 Review of Subsidence Impact to Archaeological Sites

In order to ascertain the potential impact/harm to each site, the subsidence results have been assessed in conjunction with the nature and composition of each site listed above (Table 8-1). What is evident from the subsidence results provided by MSEC is that the impact of subsidence is most pronounced directly above the longwalls. In general, stone assemblages (i.e.:artefact scatters/isolated finds) and scarred trees can withstand the impact of minor ground surface subsidence. Stone artefacts are the product of human deposition and are therefore not attached to the physical landscape, whilst a healthy scarred tree is usually kept in place by its root systems. However, there are instances where subsidence can prove to be harmful to a stone assemblage, especially where the nature of the site is part of a larger archaeological complex and the subsidence impact to the site will lower the integrity of the overall complex. Secondly, if an artefact assemblage is relatively expansive, ground surface cracking through the site can also destroy its integrity.

The types of archaeological sites most susceptible to harm caused by subsidence impacts are grinding grooves and rockshelters. Rockshelters and grinding grooves in the Hunter Region (NSW) are mostly sandstone formations that have been utilised for subsistence purposes by Aboriginal people in the past. Sandstone is an inherently brittle lithology which has a tendency to crack and sheer at points of weakness. Although natural weathering and erosion processes can also cause sandstone structures to collapse, exfoliate and crumble, the effects of subsidence can exacerbate the process and cause greater damage to these types of sites. Based on the factors discussed above, the risk assessment for each site has been formulated (Table 8-1).

Although a number of Aboriginal sites have been recorded beyond the boundary of the SMP Study Area (Figure 4-1), no harm to these sites are anticipated as a result of the extraction of LW101 - LW103, even if the subsidence predictions were exceeded by a factor of 2 times.

8.1.1 Sites Subjected to Low Risk of Impact

Isolated finds (AHIMS # 45-7-0296; 45-7-0303; 45-7-0295; 45-7-0298) and artefact scatter (AHIMS # 45-7-0297) are at low risk of subsidence impact caused by longwall coal extraction. Given that the four isolated finds and single artefact scatter are located either above the angle of draw or the roadways (First Workings), subsidence impact has been predicted to range between 50 millimetres – 200 millimetres. Although artefact scatters can be harmed by ground subsidence, artefact scatter (AHIMS # 45-7-0297) consists of two stone flakes which are no longer *in situ* and were assessed to be in poor condition. As a result, the integrity of the site will not be harmed by minor levels of ground displacement.

The restricted site that Mr Shane Frost identified during the cultural significance meeting is in the process of getting registered with AHIMS. The restricted site is located on the southern extent of the SMP Study Area, which is likely to experience less than 20 millimetres of subsidence resulting from the extraction of proposed longwalls 101 to 103 (MSEC 2012). Although it is possible that the restricted site could experience subsidence slightly greater than 20 millimetres, it would not be expected to experience any significant conventional tilts, curvatures or strains. It is therefore unlikely that the restricted site would experience any adverse impact resulting from proposed mining, even if the predictions were exceeded by a factor of 2 times.

Although these sites are at minimal risk of harm, it is recommended that Centennial Newstan identify the sites within the Northern Holdings ACHMP currently being developed in consultation with the Aboriginal stakeholders and comply with the management program and management strategy for isolated finds and artefact scatters.

8.1.2 Sites Subjected to Low – Moderate Risk of Impact

Artefact scatter (AHIMS # 45-7-0299) and isolated find (AHIMS # 45-7-0309) are at a low-moderate risk of subsidence impact, given that the projected subsidence effect is between 800 to 850 millimetres. These two sites are located directly above LW101 and LW102 respectively and represent small discrete occupation events. Due to the subsidence predicted, there is a small possibility that cracking of the surface soils may occur (MSEC 2012: 102). In any case, the likelihood of harm to the artefacts has been assessed as minimal, even if the predicted subsidence were exceeded by a factor of 2 times.

Although these sites are at a low - moderate risk of impact by subsidence mining activities due to the projected level of subsidence, it is recommended that the Centennial Newstan comply with the management strategy for isolated finds and artefacts scatters in the Northern Holdings ACHMP (RPS 2012).

8.1.3 Sensitive Site Subjected to Low-Moderate Risk of Impact (Grinding Groove -AHIMS # 45-7-0260)

Grinding Groove site (AHIMS # 45-7-0260) is at a low-moderate risk of harm from subsidence impact, even though the projected level of subsidence is 50 millimetres. As discussed in Section 7.1 of this report, this site is made from sandstone that is physically attached to the landscape and so is more susceptible to surface movement irregularities. Furthermore, the grinding grooves were created on a sandstone platform which is an inherently brittle lithology with a tendency to crack when subjected to surface stress. Centennial Newstan has tried to minimise potential impacts to site AHIMS # 45-7-0260 by designing the mine layout to located mains headings under the grinding grooves site. This has reduced the subsidence levels predicted to be experienced at the site to 50 millimetres.

The Southern Coalfield has an extensive history of mining below rockshelters and the predicted mine subsidence parameters for rockshelters located within the Southern Coalfields are similar to those in the Newstan SMP Study Area (MSEC:2011). According to MSEC (MSEC: 2011), minor and isolated cracking was previously observed in streams up to 400 metres away from the zone of impact (the mining area) in the Southern Coalfield, although this was primarily noted in large rivers. Given that Grinding Groove site AHIMS 45-7-0260 is located only 150 metres from LW101, the implication is that there is a moderate risk of impact to the grinding grooves. Although the movement of 50 millimetres may not necessarily result in complete cracking to the sandstone platform, the moderate likelihood that ground surface movement may lead to sandstone exfoliation and the subsequent damage to the groove complex is a factor to consider. If subsidence predictions were exceeded, the potential for the associated impacts discussed previously to site AHIMS # 45-7-0260 will also increase.

Based on the level of subsidence predicted for AHIMS #45-7-0260 and the low-moderate likelihood of harm to the site, the following mitigation measures have been identified:

1) Centennial Newstan are to complete the development of the Aboriginal Cultural Heritage Management Plan (ACHMP) currently being prepared in consultation with the registered Aboriginal stakeholders. The ACHMP should be developed and approved for implementation prior to any secondary extraction occurring within the SMP Study Area; and

2) Centennial must ensure that grinding groove site (AHIMS #45-7-0260) is monitored according to the protocols listed in the Northern Holdings ACHMP in spite the predicted subsidence level. The monitoring program should be aimed at determining if impact is eminent. If so, Centennial must apply and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) from OEH (Director-General) to destroy the site prior to the commencement of proposed works.

8.1.4 Sites Subjected to High Risk of Impact (Rockshelter with possible grinding groove) - AHIMS # 45-7-0310/45-7-0005)

The rockshelter with possible grinding groove site (AHIMS # 45-7-0310/45-7-0005) is at a high risk of harm from the subsidence impact predicted. The sandstone rockshelter is approximately located in the centre of the SMP Study Area, situated above LW 101. According to MSEC, the predicted subsidence below the sandstone rockshelter is 650 millimetres, which is deemed to be substantial for sandstone rockshelters. The predicted tensile strain of 0.6 mm/m has also been predicted which exceeds the safe limit given that fracturing in bedrock has been observed in the past as a result of longwall mining where tensile strains were greater than 0.5 mm/m (MSEC 2012).

MSEC (2011) has also informed RPS that the Southern Coalfield has undertaken longwall mining beneath 52 rockshelters and that approximately 10% of these shelters were affected by fracturing of the strata or shear movements along bedding planes, even though none of the 52 rockshelters have collapsed (Sefton 2000, in MSEC 2011). Given that the potential impacts on rockshelters can only be assessed based on previous experience of mining beneath these site types, the results yielded from the Southern Coalfield indicate that there is at least a 10% probability AHIMS #45-7-0310/45-7-0005 could be impacted by ground subsidence. The probability that the site will be impacted by subsidence increases if the subsidence predictions are exceeded.

Based on the predicted tensile strain of 0.6mm/m and vertical subsidence of 650 millimetres underneath rockshelter with possible grinding groove site (AHIMS #45-7-0310/45-7-0005) coupled with previous experience of longwall coal mining underneath rockshelters in the Southern Coalfields, the following mitigation measures have been identified:

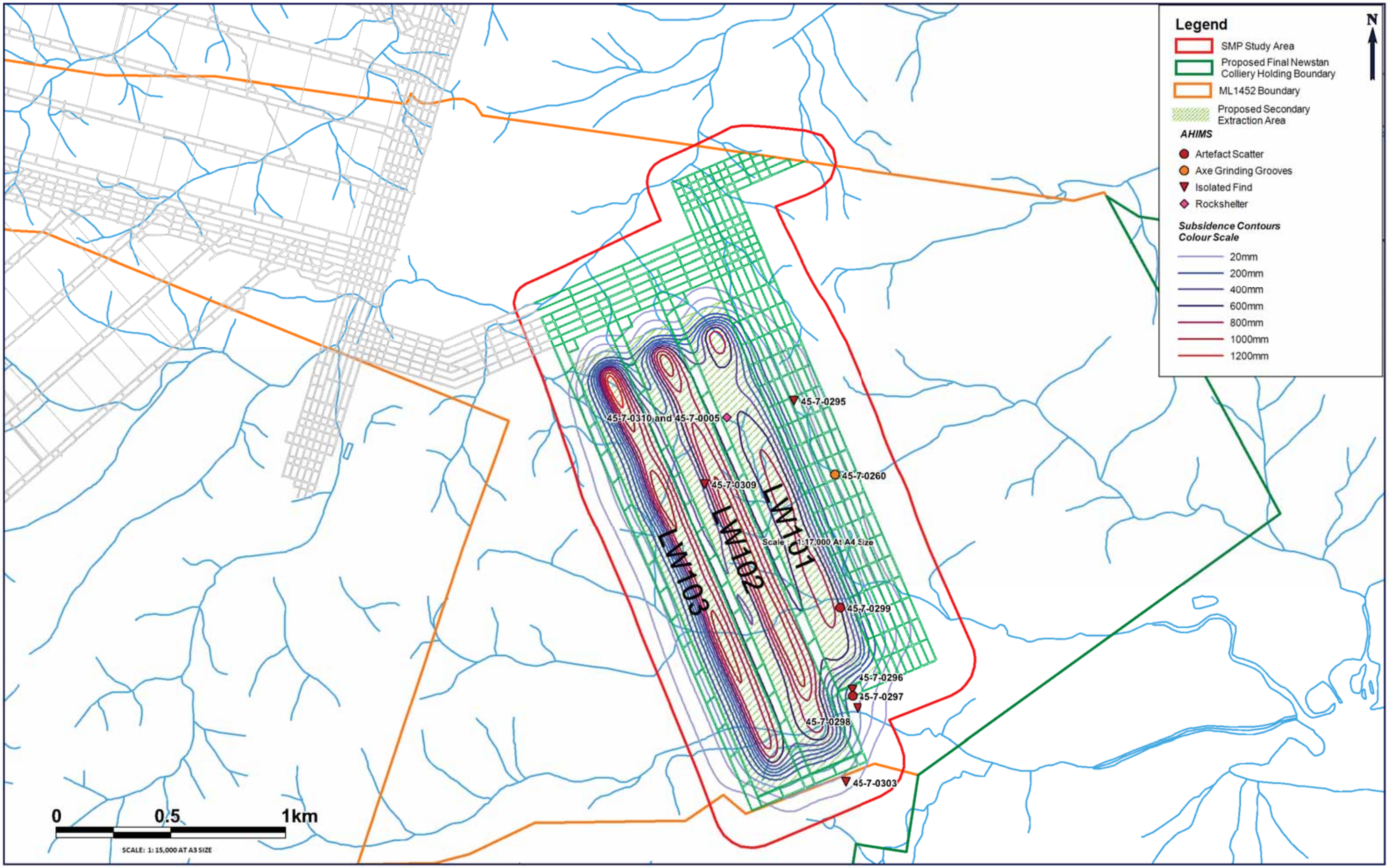
1) Centennial Newstan are to complete the development of the Aboriginal Cultural Heritage Management Plan (ACHMP) currently being prepared in consultation with the registered Aboriginal stakeholders. The ACHMP should be developed and approved for implementation prior to any secondary extraction occurring within the SMP Study Area; and

2) If it is not possible to avoid subsidence of 50 millimetres below the grinding groove site (AHIMS # 45-7-0310/0005), the client must apply and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) from OEH (Director-General) to destroy the site prior to the commencement of proposed works.

8.2 Principles of Ecologically Sustainable Development

The principles of ecologically sustainable development need to be considered under Section 2A (2) of the NPW Act (1974) and Section 2.5 of the Guide of Investigating, assessing and reporting on Aboriginal cultural heritage sites in NSW. Inter-generational equity is part of these principles, which allows future generations to access the cultural and environmental diversity of the present generations.

Inter-generational equity has been considered as part of the assessment of significance. State significant Aboriginal sites should be considered for blanket protection for future generations, as these sites have been assessed as having highest significance within NSW. As the record stands today, none of archaeological sites assessed in this report are classified as state significance, but mitigation measures and monitoring protocols have been implemented to ensure that all reasonable attempts are taken to protect the sites from harm.



TITLE: FIGURE 8-1: VIEW OF ABORIGINAL SITES WITH SUBSIDENCE PREDICTIONS

LOCATION: NEWSTAN

DATUM: (GDA 94)
PROJECTION: MGA ZONE 56

DATE: 4/04/2012
PURPOSE: SMP

LAYOUT REF: J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces
VERSION (PLAN BY): B A3(CYL-NW)

CLIENT: CENTENNIAL COAL
JOB REF: 110457-1

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

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9 Conclusion

This report has considered the available environmental and archaeological information for the SMP Study Area taking into consideration the land condition and the nature of the proposed works. The following management recommendations have been formulated with consideration to all the available information.

Recommendation 1
Centennial Newstan will complete the development of the Northern Holdings Aboriginal Cultural Heritage Management Plan (ACHMP) currently being prepared in consultation with the registered Aboriginal stakeholders. The Northern Holdings ACHMP, once completed, will identify on-going consultation requirements between Centennial Newstan and the registered Aboriginal stakeholders, Aboriginal site monitoring, Aboriginal site management and, where applicable, cultural heritage offsets to be implemented at Newstan.

Recommendation 2
Grinding groove site (AHIMS #45-7-0260) has been assessed to be at moderate risk of harm from subsidence as a result of the extraction of LW 101. It is recommended that Centennial Newstan must monitor the site according to the protocols set for rockshelters in the Northern Holdings ACHMP. If a risk of impact is identified during the monitoring process, Centennial Newstan must apply for and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) from the Office of Environment and Heritage (OEH) (Director-General).

Recommendation 3
Rockshelter with possible grinding groove site (AHIMS #45-7-0310/45-7-0005) has been assessed to be at high risk of subsidence impact. Centennial Newstan must apply for and gain approval for a Section 90 Aboriginal Heritage Impact Permit (AHIP) application prior to secondary extraction under the site so that appropriate recording and mitigation measures can be implemented in the case that the site is partially or completely destroyed.

Recommendation 4
It is recommended that the client ensures that the due diligence monitoring program designed in the Northern Holdings ACHMP (currently being prepared) be followed for the three scarred trees identified by Mr Shane Frost (currently being registered with OEH-see Section 8.1.3) and the sites within the Newstan SMP Study Area in the table below:

AHIMS # 45-7-0296	AHIMS # 45-7-0303	AHIMS # 45-7-0295
AHIMS # 45-7-0298	AHIMS # 45-7-0297	AHIMS # 45-7-0299
AHIMS # 45-7-0309		

Recommendation 5

All relevant Centennial staff should be made aware of their statutory obligations for heritage under NSW *NPW Act (1974)* and the NSW *Heritage Act (1977)*, which may be implemented as a heritage induction.

Recommendation 6

If more Aboriginal site/s are identified in the Study Area, Centennial Newstan is advised to refer to the Northern Holdings ACHMP (currently being prepared) for mitigation measures for newly identified sites. All newly identified site/s is also required to undergo an Aboriginal cultural assessment prior to the commencement of secondary workings beneath the site.

Recommendation 7

If human remains are located, Centennial Newstan is advised to refer to the Centennial Northern Holdings ACHMP currently being prepared which, once completed, will identify the consultation, monitoring and management requirements for newly identified sites.

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11 Plates

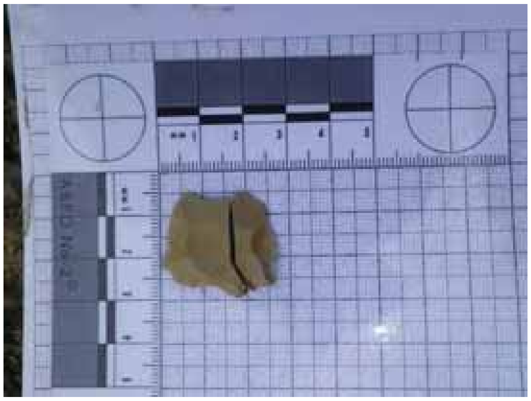

Plate 1: View of AHIMS #45-7-0296 (Dorsal Surface)

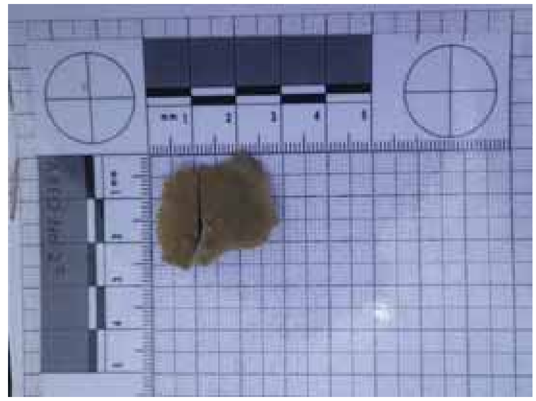

Plate 2: View of AHIMS #45-7-0296 (Ventral Surface)

Plate 3: View of AHIMS #45-7-0299 (Hammer stone in three pieces - conjoined)

Plate 4: View of AHIMS #45-7-0299 (Chert Core)

Plate 5: View of AHIMS #45-7-0299 (Chert Core)

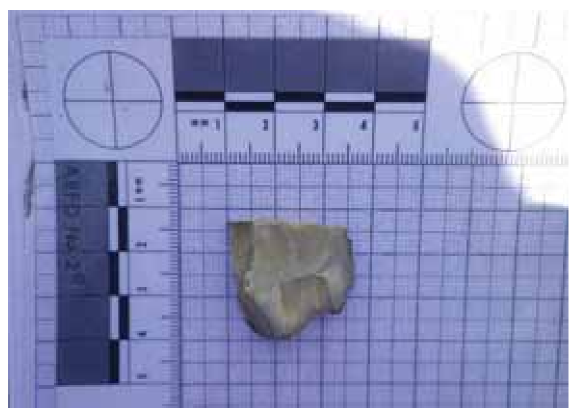

Plate 6: View of AHIMS #45-7-0303 (Dorsal Surface)

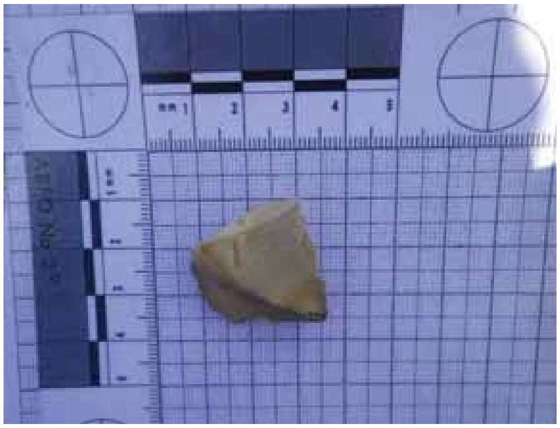

Plate 7: View of AHIMS #45-7-0303 (Ventral Surface)

Plate 8: View of AHIMS #45-7-0309

Plate 9: View of AHIMS #45-7-0309

Plate 10: View of AHIMS #45-7-0309

Plate 11: View of AHIMS #45-7-0295 (Chert Flake - Ventral Surface)

Plate 12: View of AHIMS #45-7-0295 (Chert Flake - Platform)

Plate 13: View of AHIMS #45-7-0310 (Sandstone Rockshelter)

Plate 14: View of AHIMS #45-7-0310 (Sandstone Rockshelter)

Plate 15: View of AHIMS #45-7-0310/0005 (Sandstone Rockshelter Interior)

Plate 16: View of AHIMS #45-7-0310/0005 (Sandstone Rockshelter Interior)

Plate 17: View of AHIMS #45-7-0310/0005 (Sandstone Rockshelter - Charcoal stained wall)

Plate 18: View of AHIMS #45-7-0260 (Sandstone Grinding Grooves)

Plate 19: View of AHIMS #45-7-0260 (View of Grinding Grooves)

Plate 20: View of AHIMS #45-7-0260 (Sandstone Grinding Groove Complex)

Plate 21: View of AHIMS #45-7-0298 (Chert Flake - Dorsal Surface)

Plate 22: View of AHIMS #45-7-0297 (Chert Flake - Ventral Surface)

Plate 23: View of AHIMS #45-7-0297 (Chert Flaked Piece - Ventral Surface)

Plate 24: View of AHIMS #45-7-0297 (Chert Flake Piece - Ventral Surface)

Plate 25: View of AHIMS # 45-7-0260 (Grinding Groove Complex - 25th November, 2011)

Plate 26: View of AHIMS # 45-7-0260 (Grinding Groove Complex - 25th November, 2011)

Plate 27: View of landscape at AHIMS #45-7-0005 geo co-ordinates)

Plate 28: View of landscape at AHIMS #45-7-0005 geo co-ordinates)

Plate 29: AHIMS #45-7-0310/0005-Rockshelter sedimentation

Plate 30: AHIMS #45-7-0310/0005-Rockshelter sedimentation

Plate 31: AHIMS #45-7-0310/0005 - Sandstone pavement in front of rockshelter

Plate 32: AHIMS #45-7-0310/0005 - Sandstone pavement in front of rockshelter

Appendix 1

Legislative Requirements

Summary of Statutory Controls

The following overview of the legal framework is provided solely for information purposes for the client, it should not be interpreted as legal advice. RPS will not be liable for any actions taken by any person, body or group as a result of this general overview and recommend that specific legal advice be obtained from a qualified legal practitioner prior to any action being taken as a result of the summary below.

COMMONWEALTH

The Australian Heritage Commission Act 1975

The Australian Heritage Commission Act (1975) established the Australian Heritage Commission which assesses places to be included in the National Estate and maintains a register of those places. Places maintained in the register are those which are significant in terms of their association with particular community or social groups and they may be included for social, cultural or spiritual reasons. The Act does not include specific protective clauses.

The Australian Heritage Council Act (2003) together with *The Environment Protection and Biodiversity Conservation Act (1999 as amended)* includes a National Heritage List of places of National heritage significance, maintains a Commonwealth Heritage List of heritage places owned or managed by the Commonwealth and ongoing management of the Register of the National Estate.

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Significant Impact Guidelines for *Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies*, provides guidance on the management of Commonwealth Heritage Places. These guidelines require that a heritage impact assessment is undertaken where an action has, will have, or is likely to have a significant impact on a Commonwealth Heritage Place.

STATE

It is incumbent on any land manager to adhere to state legislative requirements that protect Cultural heritage. The relevant legislation in NSW includes but is not limited to:

ENVIRONMENTAL PLANNING & ASSESSMENT ACT 1979 (EP&A ACT)

This Act regulates a system of environmental planning and assessment for New South Wales. Land use planning requires that environmental impacts are considered, including the impact on cultural heritage and specifically Aboriginal heritage. Within the *EP&A Act (1979)*, Parts 3, 4 and 5 relate to Aboriginal heritage.

Part 3 regulates the preparation of planning policies and plans. Part 4 governs the manner in which consent authorities determine development applications and outlines those that require an environmental impact statement. Part 5 regulates government agencies that act as determining authorities for activities conducted by that agency or by authority from the agency. The National Parks & Wildlife Service is a Part 5 authority under the *EP&A Act (1979)*.

In brief, the *NPW Act (1974)* provides protection for Aboriginal objects or places, while the *EP&A Act (1979)* ensures that Aboriginal cultural heritage is properly assessed in land use planning and development.

Part 3A of the *EP&A Act (1979)* relates to major projects and if applicable, obviates the need to conform to other specific legislation. In particular, s75U of the *EP&A Act (1979)* explicitly removes the need to apply for s87 or s90 permits under the *NPW Act (1974)*. This means that although Aboriginal cultural heritage is considered during the planning process, a permit is not required to disturb or destroy an Aboriginal object or place. However, the Director-General of Planning must nonetheless consult with other government agencies, including DECCW and National Parks & Wildlife, prior to any decision being made.

Aboriginal consultation under part 3A is required under the *draft 2005 Part 3A EP&A Act Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation*. This document stipulates that the ICCR process should be adhered to.

THE HERITAGE ACT 1977

This Act protects the natural and cultural history of NSW with emphasis on non-indigenous cultural heritage through protection provisions and the establishment of a Heritage Council. Although Aboriginal heritage sites and objects are primarily protected by the *National Parks & Wildlife Act (1974, as amended 2001)*, if an Aboriginal site, object or place is of great significance, it may be protected by a heritage order issued by the Minister subject to advice by the Heritage Council.

Other legislation of relevance to Aboriginal cultural heritage in NSW includes the NSW *Local Government Act (1993)*. Local planning instruments also contain provisions relating to indigenous heritage and development conditions of consent.

Appendix 2

Glossary of Site Types

Aboriginal site types

The following is a brief description of most Aboriginal site types.

Artefact Scatters

Artefact scatters are defined by the presence of two or more stone artefacts in close association (i.e. within fifty metres of each other). An artefact scatter may consist solely of surface material exposed by erosion, or may contain sub-surface deposit of varying depth. Associated features may include hearths or stone-lined fireplaces, and heat treatment pits.

Artefact scatters may represent:

- Camp sites: involving short or long-term habitation, manufacture and maintenance of stone or wooden tools, raw material management, tool storage and food preparation and consumption;
- Hunting or gathering activities;
- Activities spatially separated from camp sites (e.g. tool manufacture or maintenance); or
- Transient movement through the landscape.

The detection of artefact scatters depends upon conditions of surface visibility, including vegetation cover, ground disturbance and recent sediment deposition. Factors such as poor light, vegetation, leaf litter may obscure artefact scatters and prevent their detection during surface surveys.

Bora Grounds

Bora grounds are a ceremonial site associated with initiations. They are usually comprise two circular depressions in the earth, and may be edged with stone. Bora grounds generally occur on soft sediments in river valleys, although they may also be located on high, rocky ground in association with stone arrangements.

Burials

Human remains were often placed in hollow trees, caves or sand deposits and may have been marked by carved or scarred trees. Burials have been identified eroding out of sand deposits or creek banks, or when disturbed by development. The probability of detecting burials during archaeological fieldwork is extremely low.

Culturally Modified Trees

Culturally modified trees include scarred and carved trees. Scarred trees are caused by the removal of bark for use in manufacturing canoes, containers, shields or shelters. Notches were also carved in trees to permit easier climbing. Scarred trees are only likely to be present on mature trees remaining from original vegetation. Carved trees, the easiest to identify, are caused by the removal of bark to create a working surface on which engravings are incised. Carved trees were used as markers for ceremonial and symbolic purposes, including burials. Although, carved trees were relatively common in NSW in the early 20th century, vegetation removal has rendered this site type extremely rare. Modified trees, where bark was removed for often domestic use are less easily identified. Criteria for identifying modified trees include: the age of the tree; type of tree (the bark of many trees is not suitable, also introduced species would be unlikely subjects); axe marks (with the need to determine the type of axe - stone or steel – though Aborigines after settlement did use steel); shape of the scar (natural or humanly scarred); height of the scar above the ground (reasonable working height with consideration given to subsequent growth).

Fish Traps

Fish traps comprised arrangements of stone, branches and/or wickerwork placed in watercourses, estuaries and along coasts to trap or permit the easier capture of sea-life.

Grinding Grooves

Grinding grooves are elongated narrow depressions in soft rocks (particularly sedimentary), generally associated with watercourses, that are created by the shaping and sharpening of ground-edge implements. To produce a sharp edge the axe blank (or re-worked axe) was honed on a natural stone surface near a source of water. The water was required for lubricating the grinding process. Axe grinding grooves can be identified by features such as a narrow short groove, with greatest depth near the groove centre. The grooves also display a patina developed through friction between stone surfaces. Generally a series of grooves are found as a result of the repetitive process.

Isolated Finds

An Isolated find describes a site where only one artefact is visible. These finds are not found in apparent association with other evidence for prehistoric activity or occupation. Isolated finds occur anywhere and may represent loss, deliberate discard or abandonment of an artefact, or may be the remains of a dispersed artefact scatter. Numerous isolated finds have been recorded within the Study Area. An isolated find may flag the occurrence of other less visible artefacts in the vicinity or may indicate disturbance or relocation after the original discard.

Middens

Shell middens comprise deposits of shell remaining from consumption and are common in coastal regions and along watercourses. Middens vary in size, preservation and content, although they often contain artefacts made from stone, bone or shell, charcoal, and the remains of terrestrial or aquatic fauna that formed an additional component of Aboriginal diet. Middens can provide significant information on land-use patterns, diet, chronology of occupation and environmental conditions.

Mounds

Aboriginal mounds are places where people lived and reflect a record of that living space. Mounds may be places where Aboriginal people lived over long periods of time. Mounds often contain charcoal, burnt clay or stone heat retainers from cooking ovens, animal bones, shells, stone tools and occasionally Aboriginal burials.

Mythological / Traditional Sites

Mythological and traditional sites of significance to Aboriginal people may occur in any location, although they are often associated with natural landscape features. They include sites associated with dreaming stories, massacre sites, traditional camp sites and contact sites. Consultation with the local Aboriginal community is essential for identifying these sites.

Ochre quarries

Ochre, iron oxide may in colours through brown, yellow to red. Ochre may have been used dry for colouring hair or skin or ground to a fine powder and mixed with mediums such as water, blood, fat, etc as a fixative. Ochre was used for decorating the body, artefacts and rock shelters. Quality deposits provided a valuable resource with evidence of wide spread trade of the substance.

Rock Shelters may contain Art and / or Occupation Deposit

Rock shelters occur where geological formations suitable for habitation or use are present, such as rock overhangs, shelters or caves. Rock shelter sites generally contain artefacts, food remains and/or rock art and may include sites with areas of potential archaeological deposit, where evidence of rock-art or human occupation is expected but not visible. The geological composition of a Study Area will indicate the likelihood for rock shelters to occur.

Stone Arrangements

Stone arrangements include lines, circles, mounds, or other patterns of stone arranged by Aboriginal people. These may be associated with bora grounds, ceremonial sites, mythological or sacred sites. Stone arrangements are more likely to occur on hill tops and ridge crests that contain stone outcrops or surface stone. Preservation of those sites is dependent on minimal impact from recent land use practices.

Stone Quarries

A stone quarry is a place at which stone resource exploitation has occurred. Quarry sites are only located where the exposed stone material is suitable for use either for ceremonial purposes (e.g. ochre) or for artefact manufacture.

Appendix 3

Items listed on the National Heritage List

Items listed on the National Heritage List

Name of Item	Address	Heritage Listing
Catherine Hill Bay Heritage Conservation Area	Pacific Hwy, Catherine Hill Bay, NSW	National Heritage List
Rathmines Park	Dorrington Rd, Rathmines, NSW	National Heritage List

Appendix 4

Items listed on the Register of the National Estate

Items listed on the Register of the National Estate

Name of Item	Address	Heritage Listing
Awabakal Nature Reserve	105-117 Burwood Rd, Whitebridge, NSW	Register of the National Estate
Burwood Colliery Managers residence and staff housing (former)	105-117 Burwood Rd, Whitebridge, NSW	Register of the National Estate
Cooranbong Post Office (former)	41 Martinsville Rd, Cooranbong, NSW	Register of the National Estate
Cottage	29 Thomas St, Dudley, NSW,	Register of the National Estate
Cottage	31 Thomas St, Dudley, NSW	Register of the National Estate
Dobell House	47 Dobell Dr, Wangi Wangi, NSW	Register of the National Estate
Edgeworth Public School Buildings	7 Minmi Rd, Edgeworth, NSW	Register of the National Estate
Fennell Bay Reserve (Public Reserve R 38237)	Narara St, Blackalls Park, NSW	Register of the National Estate
Glenrock Ornithological Area	Burwood Rd, Whitebridge, NSW	Register of the National Estate
Hillsborough Canine Showground	80 Hillsborough Rd, Hillsborough, NSW	Register of the National Estate
Indigenous Place	Swansea Heads, NSW	Register of the National Estate
Lambton Colliery Structures and Buildings	999A Collier St, Redhead, NSW	Register of the National Estate
Little Pelican Cottages	Pacific Hwy, Little Pelican, NSW	Register of the National Estate
Moon Island Nature Reserve	Swansea Heads, NSW	Register of the National Estate
Morisset Showground	Ourimbah St, Morisset, NSW	Register of the National Estate
Mulbring Valley Landscape Conservation Area	Morisset Rd, Mulbring, NSW	Register of the National Estate
Nissen Type Residence	16 Arlington St, Belmont North, NSW	Register of the National Estate
Ocean View Hotel	Ocean St, Dudley, NSW	Register of the National Estate
Pensioners Hall	Ocean St, Dudley, NSW	Register of the National Estate
Public School	122 Ocean St, Dudley, NSW	Register of the National Estate
Pulbah Island Nature Reserve	Swansea, NSW	Register of the National Estate
Rathmines Seaplane Base (former)	Overhill Road, Rathmines, NSW	Register of the National Estate
Reserve R 81914 Tingira Heights Fossil Insect Beds	Burton Rd, Tingira Heights, NSW	Register of the National Estate
Residence	167 Ungala Rd, Blacksmiths, NSW	Register of the National Estate
The Bennals	45 Walter St, Belmont, NSW	Register of the National Estate
The Five Islands & Adjacent Land	Five Islands Rd, Teralba, NSW	Register of the National Estate
The Gables	87 Redhead Rd, Redhead, NSW	Register of the National Estate
Toronto Hotel	74 Victory Pde, Toronto, NSW,	Register of the National Estate

Name of Item	Address	Heritage Listing
Toronto Railway Station and Masters Room	Victory Pde, Toronto, NSW	Register of the National Estate
Toronto to Fassifern Rail Corridor	Victory Pde, Toronto, NSW	Register of the National Estate
War Memorial	Ocean St, Dudley, NSW	Register of the National Estate
Yarragee	23 Bellevue Rd, Belmont, NSW	Register of the National Estate
Catherine Hill Bay Heritage Conservation Area	Pacific Hwy, Catherine Hill Bay, NSW	National Heritage List
Rathmines Park	Dorrington Rd, Rathmines, NSW	National Heritage List

Appendix 5

Items listed on the NSW Heritage Inventory

Items listed on the NSW Heritage Inventory

Name of Item	Address	Level of Significance
Catherine Hill Bay Cultural Precinct	Flowers Drive , Catherine Hill Bay	State
Glenrock early coalmining sites	Glenrock State Recreation Area	State
Morisset Hospital Precinct	Morisset Park Road, Morisset	State
Rathmines Park, former RAAF Seaplane Base	Dorrington Road, Rathmines	State
Wangi Power Station Complex	Wangi Wangi	State
WWII RAAF Radar Station 208 (former)	Catherine Hill Bay	State

Appendix 6

Items listed in the Lake Macquarie Local Environmental Plan (LEP)

Items listed in the Lake Macquarie Local Environmental Plan (LEP)

Name of Item	Address	Lot Number	Heritage Listing/Significance
Newcastle Mines Rescue Station	533 Lake Rd	Lot 2, DP 599235	LEP-Local
Former Cockle Creek Railway Bridge	2 (over) Cockle Creek		LEP-Local
Cockle Creek Railway Bridge	3 (over) Cockle Creek		LEP-Local
Church Hall and Anglican Church	477 Lake Rd	Lot 1, DP 125686	LEP-Local
Speers Point Tram Route	Frederick St		LEP-Local
Gatekeeper's Cottage	1 Wilton Rd	Lot 1, DP 817297	LEP-Local
Johnston Family Cemetery	14A Taylor Ave	Lot 100, DP 630296	LEP-Local
Former Barnsley Public School	91 Appletree Rd	Lot 2, DP 1001812	LEP-Local
House "Yarragee"	23 Bellevue Rd	Lot 1, DP 881605	LEP-Local
Captain Bain's House	15 George St	Lot 2, DP 13715	LEP-Local
House "The Bennals"	45 Walter St	Lot D, DP 402085	LEP-Local
Former Ferry Wharf	55 Brooks Pde	Belmont Wharf	LEP-Local
Former John Darling Colliery	14 John Darling Ave	Lot 100, DP 1136505	LEP-Local
Former Staff Houses, Colliery Row	3 Maranatha Cl	Lot 12, DP 848941	LEP-Local
Railway Bridges	2 (over) Mudd Creek and 2 (over) Stony Creek		LEP-Local
Railway Station	26 South Pde		LEP-Local
Group of 4 Cottages	8 Creek Reserve Rd	Lot 11, DP 616785	LEP-Local
Former Boolaroo Post Office	91 Main Rd	Lot 2, DP 809177	LEP-Local
Former Motor Garage	19 Main Rd	Lot 1, DP 125272	LEP-Local
Commercial Hotel	2 Main Rd	Lot 1, Section A, DP 3494, Lot 2, Section A, DP 3494	LEP-Local
House "Alida"	Lakeview Rd	Lot 4, Section M, DP 3494	LEP-Local
Former Laboratory building on the former Pasminco site	Part of 13A Main Rd	Part of Lot 2, DP 1127713	LEP-Local
Colliery Relics	155 Old Main Rd	Lot 33, DP 858667	LEP-Local
House "Awaba Park"	18 Marmong St	Lot 120, DP 855520	LEP-Local
Quigley Grave	24 Park Pde	Pt Lot 468, DP 774186	LEP-Local
Lord of the Manor Cams Cottage	13 Cams Wharf Rd	Lot 2, DP 616354	LEP-Local
Row of 4 Shops with Cottages	275 Main Rd	Lot 21, DP 544989	LEP-Local
Brick Shops	281 Main Rd	Lot 4, DP 10789	LEP-Local
Former Doctor's Surgery	8 Michael St	Lot 2, DP 214463	LEP-Local
House	6 Michael St	Lot 1, DP 214463	LEP-Local
Cardiff Masonic Hall	4 Margaret St	Lot 12, Section B, DP 8186	LEP-Local
House	309 Main Rd	Pt Lot 34, DP 755233	LEP-Local
St Kevin's Cottage	230 Main Rd	Lot 1, DP 1015805	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
St Kevin's Church	226 Main Rd	Lot 3, Section A, DP 4143	LEP-Local
Former Miner's Cottage	251 Main Rd	Lot 1, DP 303203	LEP-Local
Former Colliery Tramway	14a Almora Cl	Lot 38, DP 827464	LEP-Local
Police Station and Lock Up	23–27 Clarke St	Lot 1, Section F, DP 163, Lot 3, Section F, DP 163, Lot 5, Section F, DP 163	LEP-Local
Wallarah Hotel	24 Clarke St	Lot 1, Section D, DP 163	LEP-Local
Cottages	10 Clarke St	Lot 71, DP 222717	LEP-Local
Cottages	21 Clarke St	Lot 78, DP 222717	LEP-Local
Cottage	17 Clarke St	Lot 80, DP 222717	LEP-Local
Cottages	9 Clarke St	Lot 84, DP 222717	LEP-Local
Cottage	3 Lindsley St	Lot 54, DP 222717	LEP-Local
Cottage	11 Lindsley St	Lot 58, DP 222717	LEP-Local
Coal Loader Jetty	Southern end of the beach	Lot 104, DP 1129872	LEP-Local
House and 4 Norfolk Pines	38 Flowers Dr	Lot 22, DP 593154	LEP-Local
Anglican Church	71 Flowers Dr	Lot 21, DP 593154	LEP-Local
Group of cottages	27 Flowers Dr	Lot 14, DP 222943	LEP-Local
Hall	1 Northwood Rd	Lot 1, DP 407474	LEP-Local
House	26 Flowers Dr	Lot 1, DP 1107593	LEP-Local
House	38 Flowers Dr (off Colliery Rd)	Lot 22, DP 593154	LEP-Local
Cemetery	8 Northwood Rd	Lot 7079, DP 1029250	LEP-Local
Miners' Cottages	300 Charlestown Rd	Lot 2, DP 33470	LEP-Local
Cottage	32 Smith St	Lot 1, DP 213865	LEP-Local
Brick Cottage	36 Smith St	SP 43904	LEP-Local
Threlkeld's Mine	359 Coal Point Rd	Lot 172, DP 1037893	LEP-Local
Grave "Frost's Rest"	1 Frost Rd	Lot 1, DP 919600	LEP-Local
Catholic Church and Cemetery	6 Martinsville Rd	Lot 1, DP 197852	LEP-Local
Former Post Office	41 Martinsville Rd	Lot 120, DP 755223	LEP-Local
House	9 Kings Rd	Lot 3, DP 549007	LEP-Local
House	85 Kings Rd	Lot 1, DP 798409	LEP-Local
North Corrumbung Cemetery	200 Martinsville Rd	Lot 7300, DP 1145113	LEP-Local
Suspension Footbridge	Off Victory St—Crosses Dora Creek		LEP-Local
Water Tower	15 Central Rd	Lot 20, DP 3534	LEP-Local
Bethel Hall	50 Central Rd	Lot 18, DP 129134	LEP-Local
College Hall	50 Central Rd	Lot 18, DP 129134	LEP-Local
Science Hall	50 Central Rd	Lot 18, DP 129134	LEP-Local
House "The Laurels"	50 Central Rd	Lot 18, DP 129134	LEP-Local
Auditorium	50 Central Rd	Lot 9, Section 7, DP 3533	LEP-Local
Sanitarium Health Foods Factory	70 Central Rd	Lots 6, 7 and 8, Section 1, DP 3533	LEP-Local
Sanitarium Dairy Farm	15 Central Rd	Lots 18 to 23, Section 3, DP 3533	LEP-Local
House "Three Bells"	597 Freemans Dr	Lot 201, DP 1059478	LEP-Local
Cottage	661 Freemans Dr	Lot A, DP 416525	LEP-Local
House "Sunnyside"	27 Avondale Rd	Lot 2, DP 204207	LEP-Local
House	16 Dora St	Lot 11, DP 533825	LEP-Local
Holmes Store	3 Watt St	Lot 38, DP 528601	LEP-Local
Cast Iron Reservoir	147 Ocean St	Lot 1, 446723	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Two Miner's Cottages	125 and 127 Ocean St	Lots 1, 2 and 3, Section D, DP 2657	LEP-Local
Dudley Public School	124 Ocean St	Lot 145, DP 755233	LEP-Local
Pensioners Hall	98 Ocean St	Lot 1, DP 931771	LEP-Local
Ocean View Hotel	85 Ocean St	Lot 20, Section A, DP 2304	LEP-Local
Royal Crown Hotel	94 Ocean St	Lot 18, Section B, DP 2304	LEP-Local
Former Miner's Cottage	31 Thomas St	Lot 9, Section D, DP 2657	LEP-Local
Former Miner's Cottage	29 Thomas St	Lot 11, Section D, DP 2657	LEP-Local
School Teacher's Residence	7 Minmi Rd	Lot 106, DP 755262	LEP-Local
Eraring Power Station	4 Cross St	Lot 10, DP 1050120	LEP-Local
Fassifern Railway Cottage	Wallsend Rd	Lot 1, DP 854050	LEP-Local
Toronto Railway Overbridge	(over) Fassifern Rd		LEP-Local
Fassifern Railway Station	29 Fassifern Rd		LEP-Local
Headframe Former Mining Museum	890A Freemans Dr	Lot 80, DP 610602	LEP-Local
Cardiff Railway Workshops	460 Main Rd	Lot 100, DP 1100258	LEP-Local
Brick House	47 Appletree Rd	Lot 3, Section B, DP 4479	LEP-Local
Brick House	54 Appletree Rd	Lot 22, DP 740832	LEP-Local
House	20 William St	Lot 14, Section E, DP 5432	LEP-Local
Former Police Station	20 Charlotte St	Lot 15, Section E, DP 5432	LEP-Local
Post Office Store	18 George St	Lot 1, Section L, DP 3442	LEP-Local
Holmesville Hotel	21 George St	Lot 20, Section M, DP 3442	LEP-Local
House	32 Seaham St	Lot 42, Section B, DP 4479	LEP-Local
Railway Station	Killingworth Rd		LEP-Local
Elcom Newcastle Substation	101 Killingworth Rd	Lot 1, DP 619513	LEP-Local
Former Killingworth Hotel	39 Killingworth Rd	Lot 13, Section E, DP 4339	LEP-Local
Soldier's Memorial	26 The Broadway	Lot 1, Section D, DP 4339	LEP-Local
South Waratah Colliery	31 Kirkdale Dr	Lot 132, DP 243393	LEP-Local
Little Pelican cottages and site		Lot 7036, DP 1030788	LEP-Local
House	15 Haddon Cr	Lot 1, DP 124241	LEP-Local
Public School	495 Martinsville Rd	Lot 157, DP 823773	LEP-Local
House "Woodside"	32 Wilkinson Rd	Lot 1, DP 741192	LEP-Local
Dora Creek Bridge	Owens Rd		LEP-Local
Farm House "Wonga Hill"	324 Owens Rd	Lot 63, DP 661760	LEP-Local
Stationmaster's House	58 Dora St	Pt Lot 1, DP 1002965	LEP-Local
Community Hall	77 Dora St	Lot 2, DP 590896	LEP-Local
Mullard Chambers building	71 Dora St	Lot 1, DP 215590	LEP-Local
Morisset High School	33 Bridge St	Lot 3, Section 40, DP 758707	LEP-Local
Tree—Morisset's Campsite	147 Macquarie St	Lot 7045, DP 93593	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Former Guesthouse "Kurrawilla"	127 Marine Pde	Lot 4 to 9, DP 23483	LEP-Local
"Nords Wharf"	43c Nords Wharf Rd	PO 1970/126	LEP-Local
Cabbage Trees	5 Soldiers Rd	Pt Lot 135, DP 755233	LEP-Local
West Wallsend Steam Tram Line	West Wallsend to Newcastle via Wallsend, Holmesville, Estelville, Edgeworth and Glendale		LEP-Local
Speers Point Steam Tram Line	Newcastle to Speers Point via West Wallsend		LEP-Local
Great Northern Railway	Line passes through Lake Macquarie from Garden Suburb to Wyee		LEP-Local
Belmont Railway	Adamstown to Belmont, the New Redhead Estate and Coal Company Railway		LEP-Local
Branch Lines from the Belmont Railway	Burwood No 3 Colliery, Whitebridge, Dudley Colliery, Dudley, Lambton Colliery, Redhead, John Darling Colliery, Belmont North, Belmont Colliery Sidings, Belmont	Lots 1, 2 and 9, DP 1038830	LEP-Local
Raspberry Gully Line Railway	Opposite Dalpura Lane to the Main Northern Railway Line, near Adamstown along Styx Creek		LEP-Local
Seaham, West Wallsend, Fairley and Killingworth Railway	Cockle Creek to Seaham No 1 Colliery at Seahampton with branches to Fairley and Killingworth		LEP-Local
Rhondda Colliery Railway	From West Wallsend railway on the northside of Stockton Borehole Colliery to the Rhonda Colliery south of Rhonda Rd, Teralba		LEP-Local
Fassifern to Toronto Branch Railway Line	Fassifern Railway Station to Toronto Railway Station and then Toronto Wharf		LEP-Local
Wyee Coal Conveyor Railway Loop	North of Wyee to Vales Point Power Station		LEP-Local
Cardiff South Colliery Tramway	Macquarie Rd, Cardiff South		LEP-Local
Catalina Memorial Nursing Home	171 Dorrington Rd	Lot 2, DP 226531	LEP-Local
Community Hall	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Catamaran Club	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Christadelphian School	2 Stilling St	Lot 5, DP 226534	LEP-Local
Flying Boat Ramps	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Rathmines Bowling Club	1 Stilling St	Lot 4, DP 226533	LEP-Local
Catalina War Memorial	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Rathmines Holiday Camp	3 Stilling St	Lot 1, DP 226530	LEP-Local
Brick Store	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Boat Slip	1 Overhill Rd	Lot 64, DP 596913	LEP-Local
Emergency Radio Bunkers	115 Wangi Rd	Lot 446, DP 1138964	LEP-Local
Lambton Colliery	1 Geraldton Dr	Lot 68, DP 878840	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Under-Manager's House	17 Geraldton Dr	Lot 7, DP 878840	LEP-Local
"The Gables"	87 Redhead Rd	Lot 4, DP 737493	LEP-Local
Mine Manager's House	21 Elsdon St	Lot 100, DP 609787	LEP-Local
House	10 Council St	Lot 1, DP 518527	LEP-Local
House	8 Council St	Lot 1, DP 521920	LEP-Local
House	18 Alley St	Lot 11, DP 525378	LEP-Local
House	37 Alley St	Lot 1, DP 587774	LEP-Local
Cottage	64 Speers St	Lot 1, DP 348879	LEP-Local
House	66 Speers St	Lot 3, DP 562487	LEP-Local
House	41 Albert St	Lot 1, DP 962726	LEP-Local
House	74 Speers St	Pt Lot 1, DP 956798	LEP-Local
House	214 The Esplanade	Lot 1, DP 108865	LEP-Local
House "The Knoll"	374 The Esplanade	Lot 3, DP 786053	LEP-Local
House	332 The Esplanade	Lot 4, DP 350608	LEP-Local
House	302 The Esplanade	Lot 32, DP 564214	LEP-Local
House	282 The Esplanade	Lot 145, DP 558308	LEP-Local
Former Lake Macquarie Council Chambers	143 Main Rd	Lot 13, DP 810700	LEP-Local
House	141 Main Rd	Lot 1, DP 368588	LEP-Local
Speers Point Garage	155 Main Rd	Lot 12, Section A, DP 4063	LEP-Local
House "Shangrila"	157 Main Rd	Lot 11, Section A, DP 4063	LEP-Local
House	159 Main Rd	Lot 10, Section A, DP 4063	LEP-Local
Lakeview Street Theatre	81 Lakeview St	Lot 14, Section B, DP 4063	LEP-Local
Shelter Shed	15 Park Rd	Lot 1, DP 998238	LEP-Local
Minenwerfer (or German Mortar)	15 Park Rd	Lot 1, DP 998238	LEP-Local
The Swansea Hotel	196 Pacific Hwy	Lot 12, DP 1101804	LEP-Local
Coast Guard Station	3a Lambton Pde	Lot 548, DP 39981	LEP-Local
Reid's Mistake, Head and Channel	7a Lambton Pde	Pt Reserve 88033	LEP-Local
Shop	10 Anzac Pde	Lot 1, DP 999965	LEP-Local
House "Moria"	59 York St	Lot 17, DP 816302	LEP-Local
Teralba Public School	57 York St	Lot 2, DP 795123	LEP-Local
Great Northern Hotel	2 Anzac Pde	Lot 7, Section A, DP 447469	LEP-Local
House "AS"	101 Railway St	Lot 261, DP 554269	LEP-Local
Station Master's Cottage	150 Railway St	Lot 3, DP 831957	LEP-Local
Teralba Cemetery Billygoat Hill	20 Pitt St	Lot 31, DP 858667	LEP-Local
Gartlee Mine	159 Railway St	Lot 1, DP 780614	LEP-Local
Rhondda Colliery	282 Rhondda Rd	Lot 101, DP 1073163	LEP-Local
House "Manuka"	182 Excelsior Pde	Lot 461, DP 589541	LEP-Local
House "The Moorings"	2 Jarrett St	Lot A, DP 368417	LEP-Local
Toronto Cemetery	354 Awaba Rd	Lots 7044 to 7046, DP 1052029 and Lot 7058, DP 1052031	LEP-Local
Toronto Hotel	74 Victory Pde	Lot 201, DP 549239	LEP-Local
Former Railway Station	16 Victory Row	Lot 220, DP 1021925	LEP-Local
Frith's Store	66 The Boulevarde	Lot B, DP 390795	LEP-Local
Building Restaurant	24 Victory Pde	Lot 1, DP 301366	LEP-Local
Royal Motor Yacht Club Annexe	8 Arnott Ave	Lot 12 to 15, DP 456286	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Building Restaurant	6 Arnott Ave	Lot X, DP 406274, Pt Lot 424, DP 823708, Lot 1, DP 917503	LEP-Local
Boatman's Cottage Lakefront	4 Arnott Ave	Lot 1, DP 950464	LEP-Local
Boathouse and Winches Lakefront	4 Arnott Ave	Lot 1, DP 950464 PO 65/60	LEP-Local
House	4 Arnott Ave	Lot 1, DP 950464	LEP-Local
House "Burnbrae"	32 Renwick St	Lot 1, DP 122786	LEP-Local
Station Master's Cottage	98 Brighton Ave	Lot 1, DP 125979	LEP-Local
House "McGeachie's"	109 Brighton Ave	Lot 2, DP 515029	LEP-Local
Convent of Mercy	26 Renwick St	Lot 2122, DP 1116609	LEP-Local
House	23 Renwick St	Lot 2, DP 350492	LEP-Local
Cottage	6 Renwick St	Lot 21, Section 7, DP 4236	LEP-Local
House	16 Hunter St	Lot 111, DP 596414	LEP-Local
Winn's House	19 Hunter St	Lot 100, DP 717511	LEP-Local
House "Dobell House"	47 Dobell Dr	Lot 13, DP 8840	LEP-Local
Gun emplacements	24 Reserve Rd	Lot 526, DP 662836	LEP-Local
House "Ali's Palace"	6 Fairfax Rd	Lot 2, DP 20222, Lot 34, DP 20222, Pt Lot 1, DP 20222	LEP-Local
First Orange Orchard	The slope with north eastern aspect falling from crest of hill at corner Beryl and Mills Sts down to creek and tramway	(WB-03)	LEP-Local
Mine Pithead and Coal Tramway to Lake	Follows creek from below Barbara St, to Lake between Howard and James Sts		LEP-Local
Cottage	17 Daydawn Ave	Lot 10, DP 651218	LEP-Local
West Wallsend Football Club Ground	3 Laidley St, Johnson Park	Lot 1, DP 421411	LEP-Local
West Wallsend (No 1) Colliery	off Wilson St	Pt Lot 106, DP 1000408	LEP-Local
Cottage	12 Carrington St	Lot 6, Section Z, DP 3809	LEP-Local
Cottage	15 Carrington St	Lot 15, Section D, DP 2252	LEP-Local
House "Earsdon Cottage"	20 Carrington St	Lot A, DP 370073	LEP-Local
Former Shop and Doctors surgery	47 Carrington St	Lot 16, Section C, DP 2252	LEP-Local
House	47 Carrington St	Lot 16, Section C, DP 2252	LEP-Local
Former Shop and House	52 Carrington St	Lot 2, Section G, DP 2252	LEP-Local
Post Office and Residence	54 Carrington St	Lot 1, Section G, DP 2252	LEP-Local
Catholic Church and Convent	5 Hyndes St	Lot 15, Section G, DP 2255, Lot 16, Section G, DP 2252, Lot 1, DP 500232, Lot 2, DP 500232	LEP-Local
Soldiers' Memorial and Park	49 Carrington St	Lot 1, DP 301342	LEP-Local
Workers' Club	51 Carrington St	Lot 11, DP 863266	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Clyde Inn Hotel	57 Carrington St	Lot 12, Section B, DP 2252	LEP-Local
House	59 Carrington St	Lot A, DP 382915	LEP-Local
Former School of Arts	65 Carrington St	Lot 21, DP 875161	LEP-Local
West Wallsend Co-Op	76a Carrington St	Lot 7, Section E, DP 2252	LEP-Local
West Wallsend Public School	49a Wallace St	Lot 5, Section J, DP 2252, Lot 6, Section J, DP 2252, Lot 7, Section J, DP 2252, Lot 8, Section J, DP 2252, Lot 9, Section J, DP 2252, Lot 10, Section J, DP 2252, Lot 11, Section J, DP 2252, Lot 12, Section J, DP 2252, Lot 1, DP 415746, Lot 1, DP 103681, Lot 1, DP 203314, Lot 1, DP 418805	LEP-Local
Miners' Memorial	49a Wallace St	Lot 8, Section J, DP 2252	LEP-Local
Presbyterian Church	48a Wallace St	Lot 1, Section O, DP 2253	LEP-Local
Baptist Church	49 Wallace St	Lot 15, Section K, DP 2252	LEP-Local
Former Northumberland Hotel	1 Hyndes St	Lot 11, DP 565278	LEP-Local
Cottage	53 Wilson St	Lot B, DP 315094	LEP-Local
Cottage	8 Laidley St	Lot B, DP 319636	LEP-Local
Museum Hotel	70 Wilson St	Lot 21, DP 700424	LEP-Local
Mt Sugarloaf and the Sugarloaf Range	Mt Sugarloaf Rd	Lot 1, DP 231108, Lot 2, DP 231108, Lot 21, DP 223395, Lot 1, DP 207238, Lot 1, DP 338999, Lot 121, DP 755262	LEP-Local
Mt Sugarloaf No 1 Colliery	Mt Sugarloaf Rd	Lot 7, DP 813135	LEP-Local
West Wallsend Cemetery	Cemetery Rd	Lots 980 and 981, DP 589701	LEP-Local
West Wallsend Valve House and Underground Reservoir	30a George Booth Dr, Estelville	Lot 1, DP 923587	LEP-Local
Anglican Church	11 Wallsend Rd	Lot 81, DP 1143907	LEP-Local
Whitebridge Cemetery	132a Dudley Rd	Lots 1697, 1698 and 1731, DP 755233	LEP-Local
House	105 Burwood Rd	Lot 7, DP 800730	LEP-Local
Railway Cutting and Bridge	Old Dudley Rd		LEP-Local
Captain Bulls Garden	76 Bulls Garden Rd	Lot 10, DP 220823	LEP-Local
Wyee Channel	Extending north, from the Wyee Dam, passing under Summerhayes Rd		LEP-Local
Cottage	8 Laidley St	Lot B, DP 319636	LEP-Local
Museum Hotel	70 Wilson St	Lot 21, DP 700424	LEP-Local

Name of Item	Address	Lot Number	Heritage Listing/Significance
Mt Sugarloaf and the Sugarloaf Range	Mt Sugarloaf Rd	Lot 1, DP 231108, Lot 2, DP 231108, Lot 21, DP 223395, Lot 1, DP 207238, Lot 1, DP 338999, Lot 121, DP 755262	LEP-Local
Mt Sugarloaf No 1 Colliery	Mt Sugarloaf Rd	Lot 7, DP 813135	LEP-Local
West Wallsend Cemetery	Cemetery Rd	Lots 980 and 981, DP 589701	LEP-Local
West Wallsend Valve House and Underground Reservoir	30a George Booth Dr, Estelville	Lot 1, DP 923587	LEP-Local
Anglican Church	11 Wallsend Rd	Lot 81, DP 1143907	LEP-Local
Whitebridge Cemetery	132a Dudley Rd	Lots 1697, 1698 and 1731, DP 755233	LEP-Local
House	105 Burwood Rd	Lot 7, DP 800730	LEP-Local
Railway Cutting and Bridge	Old Dudley Rd		LEP-Local
Captain Bulls Garden	76 Bulls Garden Rd	Lot 10, DP 220823	LEP-Local
Wyee Channel	Extending north, from the Wyee Dam, passing under Summerhayes Rd		LEP-Local
Glenrock Railway and Mine Entrance and early coal mining sites	Glenrock State Recreation Area	Lot 1, DP 523208 and Lot 21, DP 575387	LEP-State
Morisset Hospital Wards 5 and 6	84 Bridge Street, Morisset	Lot 1, DP 880557	LEP-State
Morisset Hospital Ward 9, Clinical Dept	84 Bridge Street, Morisset	Lot 1, DP 880557	LEP-State
Morisset Hospital Ward 10	84 Bridge Street, Morisset	Lot 1, DP 880557	LEP-State
Morisset Hospital The Chapel	84 Bridge Street, Morisset	Lot 1, DP 880557	LEP-State
Morisset Hospital Recreation Hall	84 Bridge Street, Morisset	Lot 1, DP 880557	LEP-State
Morisset Hospital The Main Store	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Residence No 1	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Ward 17, General Psychiatry	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Ward 12	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Residence No 3	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Maximum Security Division	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Cottage Row Residence Nos 16, 17, 18, 19, 20 and 21	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Morisset Hospital Water Supply Dam—Pourmalong Creek	69a Fishing Point Rd, Bonnells Bay	Lot 1 DP 880557	LEP-State
Wangi Power Station	80 Donnelly Rd	Lot 101, DP 880089	LEP-State

Appendix 7

AHIMS Search Results for Generic Study Area

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref Number : 109115

Client Service ID :56759

Note: This Excel report shows the sites found in AHIMS on the 18/11/2011. If this date is not the same as the original date of the Search Results letter obtained during the Basic Search, then the search results might be different. The PDF version of this report will always coincide with the Basic Search Results letter.

SiteID	SiteName	Contact	Datum	Zone	Easting	Northing	Context	SiteStatus	SiteFeatures	SiteTypes	Permits	Reports	Recorders
45-7-0005	Awaba Railway Stn;Toronto;		AGD	56	364374	6346257	Closed	Valid	Artefact : -,	Axe			Australian
45-7-0259	LEA 9 (Swansea)		GDA	56	366685	6346040	Closed	Valid	Artefact : -				RPS
45-7-0260	LEA 10 (Swansea)		GDA	56	365425	6345450	Open	Valid	Grinding Groove				RPS
45-7-0261	Stockyard Creek AS with PAD (Swansea)		GDA	56	365653	6343871	Open	Valid	Potential		3095,319		Mr.Alan
45-7-0313	RPS NEWST 20		GDA	56	363978	6346050	Open	Valid	Artefact : -				RPS
45-7-0304	RPS NEWST 11		GDA	56	365537	6343813	Open	Valid	Artefact : -				RPS
45-7-0305	RPS NEWST 12		GDA	56	365658	6343764	Open	Valid	Artefact : -				RPS
45-7-0306	RPS NEWST 13		GDA	56	364478	6343664	Open	Valid	Artefact : -				Mr.Roger
45-7-0309	RPS NEWST 16		GDA	56	364857	6345409	Open	Valid	Artefact : -				RPS
45-7-0310	RPS NEWST 17		GDA	56	364953	6345699	Open	Valid	Habitation				RPS
45-7-0295	RPS NEWST 2		GDA	56	365245	6345771	Open	Valid	Artefact : -				RPS
45-7-0296	RPS NEWST 3		GDA	56	365499	6344513	Open	Valid	Artefact : -				RPS
45-7-0297	RPS NEWST 4		GDA	56	365501	6344486	Open	Valid	Artefact : -				Mr.Roger
45-7-0298	RPS NEWST 5		GDA	56	365524	6344433	Open	Valid	Artefact : -				Mr.Roger
45-7-0299	RPS NEWST 6		GDA	56	365445	6344870	Open	Valid	Artefact : -				RPS
45-7-0303	RPS NEWST 10		GDA	56	365471	6344111	Open	Valid	Artefact : -				RPS

Report generated by AHIMS Web Service on 18/11/2011 for Cheng-Yen Loo for the following area at Datum :GDA, Zone : 56, Eastings : 363635 - 366742, Northings : 6343561 - 6347102 with a Buffer of 0 meters.Additional Info : For SMP assessment. Number of Aboriginal sites and Aboriginal objects found is 16

Appendix 8

AHIMS Site #45-7-0005 Information held at Australian Museum

From: Allison Dejanovic [Allison.Dejanovic@austmus.gov.au]
Sent: Friday, 18 November 2011 9:10 AM
To: Laraine Nelson
Subject: Aust Museum registered site
Attachments: 2332_001.pdf

Dear Laraine,

Please find attached a scanned image of the card/information the Australian Museum hold regarding your enquiry.

The archive section found the following information also; I'm afraid it is not much.

"I have checked the correspondence files we have received from Anthropology and there is no reference to this matter.

The Australian Museum's register of correspondence received notes that a letter was received on 14/9/54 from H Barton re Aboriginal Middens – letter 199. I cannot find Barton's letter it is not in the extant letters or files. "

Yours sincerely,

Allison

Allison Dejanovic
Collections Officer Indigenous Archaeology
Cultural Collections and Community Engagement
Monday - Wednesday - Friday
Australian Museum
6 College Street Sydney NSW 2010 Australia
t 61 2 9320 6209 m 0409 348 787 f 61 2 9320 6040
email: allison.dejanovic@austmus.gov.au

Visit: http://www.australianmuseum.net.au
Like: http://www.facebook.com/australianmuseum
Follow: http://www.twitter.com/austmus
Watch: http://www.youtube.com/austmus

Australian museum

Inspiring the exploration of nature and cultures

From: scanner@austmus.gov.au [mailto:scanner@austmus.gov.au]
Sent: Monday, 14 November 2011 2:02 PM
To: Allison Dejanovic
Subject: Attached Image

Dear Patricia

Many thanks for your assistance. I have attached a copy of the site card. We are trying to establish a management plan for this site and need to find it – it's not in the location recorded on AHIMS.

I work with Tessa Boer-Mah who worked with AMBS until recently and we think the site card quite old.

We were hoping that we may be able to obtain the report noted in the Site Card or after that any information could be useful.

Best regards

The Australian Museum.

AWABA (LAKE MACQUARIE).

Rock-shelters (numerous) east of the railway station and north of the State coal mine, toward the head of a gully leading towards Toronto, about the base of a mass of conglomerate near the horizon of the Great Northern Coal Seam.

Informant : H.Barton, L1/54/199.

Appendix 9

Correspondence with OEH Regarding Deregistering AHIMS Site #45-7-0005

RPS

Newcastle Office
Ground Floor, 241 Denison Street, Broadmeadow, NSW Australia 2292
PO Box 428, Hamilton, NSW Australia 2303
T +61 2 4940 4200 F +61 2 4961 6794 E newcastle@rpsgroup.com.au W rpsgroup.com.au

Our Ref: PR 110457-1
Date: 5th December 2011

Attn: Ms Cheryl Brown
Aboriginal Heritage Systems Unit
Office of Environment and Heritage
Department of Premier and Cabinet

Via: email: Cheryl.Brown@environment.nsw.gov.au

Dear Ms Brown

RE: REQUEST TO DEREGISTER SITE #45-7-0005

RPS (Newcastle) was commissioned to produce a Heritage Subsidence Management Plan (SMP) for the proposed longwall area within Centennial Newstan Colliery. As part of the assessment, all known sites within the area of possible subsidence were assessed to determine their level of sensitivity and the likelihood of being affected by proposed works. The SMP area was previously surveyed by RPS personnel in 2010 – 2011 where we made attempts to locate AHIMS Site #45-7-0005. According to the site description provided by OEH, AHIMS Site #45-7-0005 is a rockshelter and grinding groove recorded by H. Barton (Figure 1). However, it is unknown when this site was recorded and very little information was contained in the site description to assist RPS in finding the shelter.

The contents of the site description only provide a vague idea of where the site may be located, being east of the Awaba railway station and north of the State Coal Mines (Figure 1). No maps or pictures of the site were available. The method by which the site was originally located is also unknown, although it would appear that it took place more than 30 years ago (based on the age of the site number). The grid co-ordinates of the site were provided in spherical co-ordinates (longitude/latitude) and appear to be incorrect, as RPS personnel undertook a thorough inspection of the co-ordinates as well as the surrounding vicinity in February, 2011 and were unable to locate the site. The survey inspection was undertaken on the 14th February, 2011 by RPS personnel (Roger Mehr) together with representatives of the Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC), Awabakal Traditional Owners Aboriginal Corporation (ATOAC) and the Wonnarua National Aboriginal Corporation (WNAC) (Figure 2). The area was found to be an alluvial flat associated with a creek line. As shown in Plate 1-6, the landform features in this area do not contain rockshelters, steep gullies or escarpments, which are benchmark features for rockshelter formations (Figure 2).

On the 14th November, 2011, RPS contacted Ms Vanessa Finney of the Australian Museum to determine whether they had any information about AHIMS Site #45-7-0005.The only information the Museum possessed was the same site description as on the OEH site card. This information did not assist us any further in our investigation (Figure 1).

In an attempt to cover all possibilities, RPS converted the spherical co-ordinates (longitude/latitude) on the original AHIMS Site # 45-7-0005 site card into geographical co-ordinates (eastings/northings). This put the site 390m south of its original location and 500m north of AHIMS #45-7-0310.

On the 25th November, 2011, AHIMS #45-7-0005 was reinvestigated by ground truthing the area between the new possible location and AHIMS #45-7-0310 (Figure 2). Unfortunately, no rockshelter was located as the new co-ordinates were set in a relatively flat area to low slope with no landform features deemed suitable for rockshelter outcrops. AHIMS #45-7-0310 (Plate 7-9) was also reinvestigated and was assessed to be the same site as AHIMS #45-7-0005 due to the following reasons:

1) Rockshelter #45-7-0310 is located in the same vicinity as that described on site card AHIMS #45-7-0005;

2) Site card AHIMS #45-7-0005 described the presence of grinding grooves, and AHIMS#45-7-0310 is associated with an expansive sandstone pediment which would have offered a suitable platform for stone grinding activity (Plate 10-12). However, no groove marks were identified during the inspection; and

3) The shelter floor of AHIMS #45-7-0310 contained a reasonable deposit similar to that described in the AHIMS #45-7-0005 site card (Plate 13-16).

Based on the information gathered, RPS is confident that rockshelter #45-7-0005 may have been erroneously plotted when it was originally recorded, especially since the site was recorded when traditional mapping techniques were employed. Based on the amount of research undertaken to relocate AHIMS #45-7-0005, we feel that it should be deregistered from AHIMS and reinstated as AHIMS site #45-7-0310.

Yours sincerely
RPS

for

Cheng Yen Loo
(Archaeologist)

Figure 1: Original AHIMS #45-7-0005 Site Description and correspondence with Australian Museum

From: Allison Dejanovic [Allison.Dejanovic@austmus.gov.au]
Sent: Friday, 18 November 2011 9:10 AM
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Allison

Allison Dejanovic
Collections Officer Indigenous Archaeology
Cultural Collections and Community Engagement
Monday - Wednesday - Friday
Australian Museum
6 College Street Sydney NSW 2010 Australia
t 61 2 9320 6209 **m** 0409 348 787 f 61 2 9320 6040
email: allison.dejanovic@austmus.gov.au

Visit: http://www.australianmuseum.net.au
Like: http://www.facebook.com/australianmuseum
Follow: http://www.twitter.com/austmus
Watch: http://www.youtube.com/austmus

Australian museum

Inspiring the exploration of nature and cultures

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AWABA (LAKE MACQUARIE).

Rock-shelters (numerous) east of the railway station and north of the State coal mine, toward the head of a gully leading towards Toronto, about the base of a mass of conglomerate near the horizon of the Great Northern Coal Seam.

Informant : H.Barton, L1/54/199.

waba SYDNEY Locality S AXE GRINDING GROOVES

Arch. deposit and.

45-3A-5

Military map/other reference 33°01' S 151°33' E (town)

Syd 1:250,000 4560.9195 L. Macquarie 1:63,360

Pastoral or other property, park c562.196.

Description of site Grooves E. of Awaba railway station and N. of State Coal Mine. Around base of a mass of conglomerate neat the horizon of the Great Northern Coal Seam, and towards the head of a gully leading towards Toronto. Numerous rockshelters there.
Informant: H. Barton, 11/54/199 (A.M. file)

45-7-0005

Length of site Width

Nearest water supply

Kind of rock

Number of grooves REGISTER COPY

Size of grooves

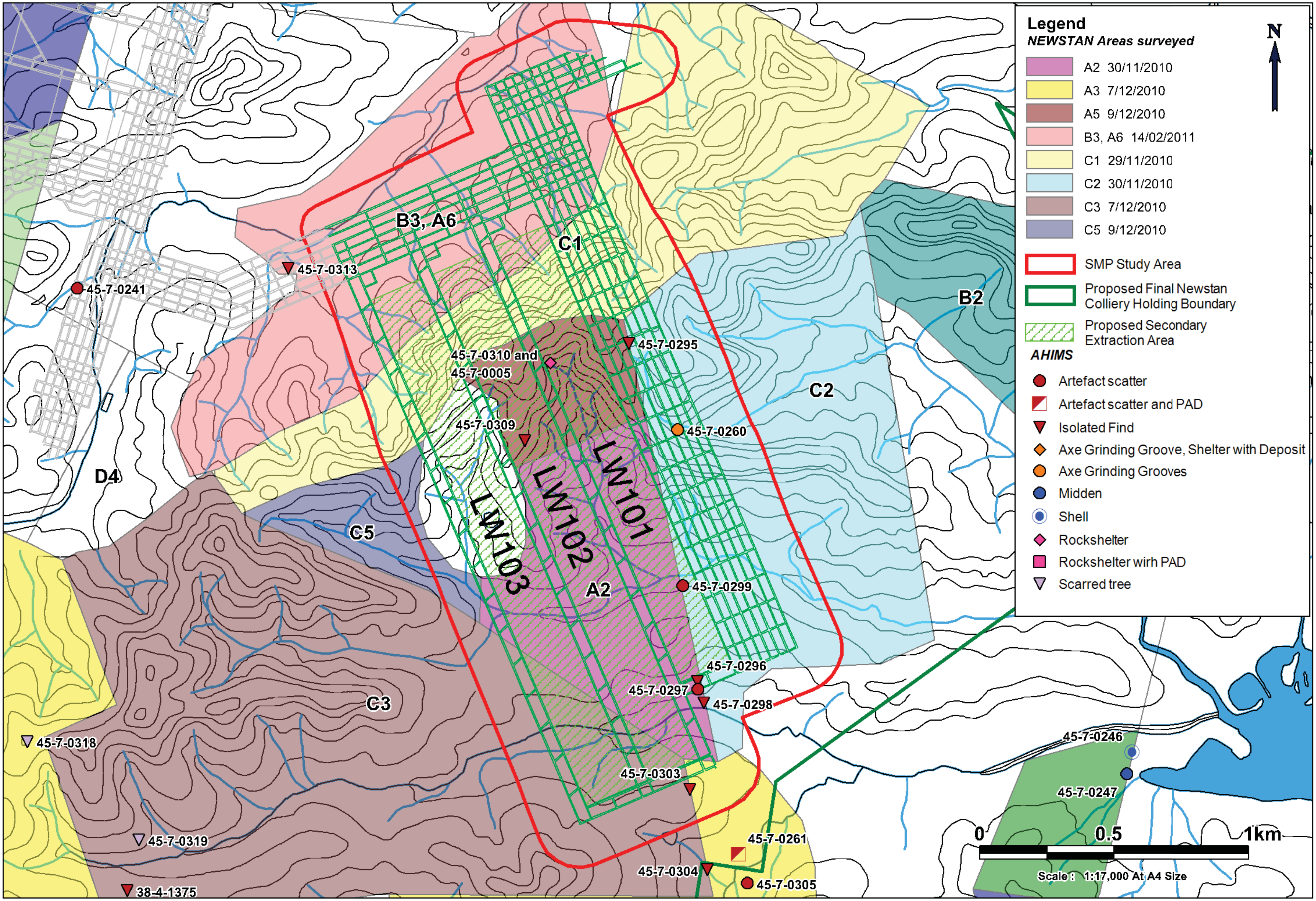
Associated with rock engravings, rock paintings, carved trees, stone arrangements, quarry, campsite, other relics

AUST. MUS. INDEX.

From:

0

Figure 2: Areas Surveyed to determine the whereabouts of AHIMS #45-7-0005



J:\JOBS\Centennial\All Jobs\110457 Newstan SMP\110457-1 Arch\10. Drafting\MapInfo Workspaces\110457 Figure for letter A4

Plate 1: Landscape features in Survey Unit B3, A6 (14.02.2011)-Flat plain

Plate 2: Landscape features in Survey Unit B3, A6 (14.02.2011)-Swamp country

Plate 3: Landscape features in Survey Unit B3, A6 (14.02.2011)-Open woodland on gentle slope

Plate 4: Landscape feature in Survey Unit B3. A6 (14.02.2011)-Flat country

Plate 5: Landscape feayire in Survey Unit B3, A6 (14.02.2011)-Swamp Country

Plate 6: Landscape features in Survey Unit B3, A6 (14.02.2011)-Swamp country

RPS

Plate 7: Rockshelter AHIMS #45-7-0310

Plate 8: Rockshelter AHIMS #45-7-0310

Plate 9: Rockshelter AHIMS #45-7-0310

Plate 10:Sandstone Pavement infront of AHIMS #45-7-0310

Plate 11: Sandstone Pavement infront of AHIMS #45-7-0310

Plate 12:Sandstone Pavement infront of AHIMS #45-7-0310

 **Plate 13: Rockshelter AHIMS #45-7-0310 Sediment deposits**	 **Plate 14: Rockshelter AHIMS #45-7-0310 Sediment deposits**
 **Plate 15: Rockshelter AHIMS #45-7-0310 Sediment deposits**	 **Plate 16: Rockshelter AHIMS #45-7-0310 Sediment deposits**

Appendix 10

Response from OEH about AHIMS Site #45-7-0005

Cheng Yen Loo

From: Cheng Yen Loo
Sent: Friday, 9 December 2011 3:23 PM
To: 'Cheryl.brown@environment.nsw.gov.au'; 'Carlos.Torres@environment.nsw.gov.au'
Cc: Laraine Nelson; Tessa Boer-Mah; Darrell Rigby
Subject: RE: AHIMS site #45-7-0005

Hi Cheryl and Carlos

Thanks for your assistance in this matter.

Regards

Cheng Yen Loo
Archaeologist
RPS
RPS Australia/SE Asia

T +61 2 4940 4200 | F +61 2 4961 6794 |
Please consider the environment before printing this email.

From: Vanessa Dwyer
Sent: Friday, 9 December 2011 3:20 PM
To: Cheng Yen Loo
Subject: FW: AHIMS site #45-7-0005

FYI below. Can you please respond?

Thanks

Vanessa Dwyer
Business Support Manager
RPS
RPS Australia/SE Asia

T +61 2 4940 4200 | F +61 2 4961 6794 | M 0402 236 321 |
Please consider the environment before printing this email.

From: Torres Carlos [mailto:Carlos.Torres@environment.nsw.gov.au]
Sent: Friday, 9 December 2011 3:14 PM
To: Vanessa Dwyer
Cc: Brown Cheryl
Subject: RE: AHIMS site #45-7-0005

Hi Vanessa,

Thank you for your e-mail. We have made the corrections to the coordinates of 45-7-0005 to be the same of 45-7-0310 with a note advising that they are the same site. This is the only way to solve the problem as we cannot de-register or delete sites.

Kind Regards

Carlos

ARAM Development Coordinator | Information Systems and Assessment Section | Policy, Information and Research Branch | Country, Culture and Heritage Division | Office of Environment and Heritage | Department of

Premier and Cabinet | Phone (02) 62297073

Please consider the environment before printing this email

From: Brown Cheryl
Sent: Friday, 9 December 2011 12:30 PM
To: Torres Carlos
Subject: FW: AHIMS site #45-7-0005

Hey Carlos

Can you assist me with this request below, well issue raised!

Cheers

Cheryl Brown
A/Head, Aboriginal Heritage Systems Unit
Information Systems and Assessment Section
Policy, Information and Research Branch
Country, Culture and Heritage Division
Office of Environment and Heritage
Department of Premier and Cabinet
PH: (02) 95856470 or 0448 831 241
Fax: (02) 95856094

Email: Cheryl.Brown@environment.nsw.gov.au

From: Vanessa Dwyer [mailto:Vanessa.Dwyer@rpsgroup.com.au]
Sent: Wednesday, 7 December 2011 2:41 PM
To: Brown Cheryl
Cc: Cheng Yen Loo
Subject: AHIMS site #45-7-0005

Dear Cheryl

Please find attached an letter with regard AHIMS site #45-7-0005.

Best regards

Chengyen Loo
Cheng.yen.loo@rpsgroup.com.au

RPS

Vanessa Dwyer
Business Support Manager
Australia Asia Pacific
http://rpsgroup.com.au
Vanessa.Dwyer@rpsgroup.com.au

PO Box 428, Hamilton,
NSW, Australia, 2303

241 Denison St, Broadmeadow, NSW, 2292 | T +61 2 4940 4200 | F +61 2 4961 6794 | M 0402 236 321

Appendix 11

Aboriginal Consultation Log

Newstan SMP

Consultation Log

Prepared by:

RPS AUSTRALIA EAST PTY LTD

241 Denison Street
Broadmeadow NSW 2292

T: +61 2 4940 4200
F: +61 2 4961 6794
E: newcastle@rpsgroup.com.au

Prepared for:

CENTENNIAL

PO Box 1000
Toronto NSW 2283

Client Manager: Ms Tessa Boer-Mah
Report Number: PR110457
Version / Date: Final June 2012

Date	Consultation Description	Method of Contact	Outcomes
29/06/2010	Identification of interested Aboriginal groups for land in the East Lake Macquarie region	Mail	Identification of interested Aboriginal groups for land in the East Lake Macquarie region
29/06/2010	Native Title Services Corporation Limited	Mail	Identification of interested Aboriginal groups for land in the East Lake Macquarie region
29/06/2010	National Native Title Tribunal	Mail	Identification of interested Aboriginal groups for land in the East Lake Macquarie region
29/06/2010	Heritage Officer, Lake Macquarie City Council	Mail	No response
29/06/2010	West Lakes Aboriginal Community (Koompahtoo LALC)	Mail	No response
29/06/2010	Hunter Central River Catchment	Mail	No response
29/06/2010	OEH	Mail	No response
7/07/2010	Office of the Registrar	Mail	Search result response-No Aboriginal people identified
8/07/2010	Lakes Mail	Newspaper	Advertisement published in the Lakes Mail
15/07/2010	OEH	Mail	DECCW sent their search results and 7 groups were identified: Awabakal Newcastle Aboriginal Co -op (ANAC), Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC), Awabakal Traditional Owners Aboriginal Corporation (ATOA), Awabakal Local Aboriginal Land Council (ALALC), Yamuloong Group Initiatives Ltd (YGIL), Arwarbukarl Cultural Resources Assoc (ACRA), Cacatua Culture Consultants (CCC)
16/07/2010	Awabakal Newcastle Aboriginal Co-Kevin McKenny	Mail	EOI Invitation
16/07/2010	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Mail	EOI Invitation
16/07/2010	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Mail	EOI Invitation
16/07/2010	Yamuloong Group Initiative Ltd-Sean Gordon	Mail	EOI Invitation
16/07/2010	Arwarbukarl Cultural Resource Association- Darren McKenny	Mail	EOI Invitation
16/07/2010	Cacatua Culture Consultants-Donna and George Sampson	Mail	EOI Invitation
16/07/2010	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Mail	EOI Invitation
16/07/2010	Wonnarua Nation Aboriginal Corporation (WNAC)	Email	EOI Response
16/07/2010	West Lakes Aboriginal Community (Koompahtoo LALC)	Phone	EOI Response
16/07/2010	Culturally Aware	Email	EOI Response-to advert
20/07/2010	Culturally Aware	Email	EOI Response-outside their area
22/07/2010	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	EOI Response
24/07/2010	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	EOI Response
30/07/2010	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Mail	Methodology letter
30/07/2010	West Lakes Aboriginal Community (Koompahtoo LALC)	Mail	Methodology letter
30/07/2010	Cacatua Culture Consultants-Donna and George Sampson	Mail	Methodology letter
30/07/2010	Wonnarua Nation Aboriginal Corporation-Laurie Perry	Mail	Methodology letter
25/08/2010	Awabakal Traditional Owners Aboriginal Corporation	Email	Field Work Invitation Letter

Date	Consultation Description	Method of Contact	Outcomes
25/08/2010	West Lakes Aboriginal Community (Koompahtoo LALC	Email	Field Work Invitation Letter
25/08/2010	Wonnarua Nation Aboriginal Corporation (WNAC	Email	Field Work Invitation Letter
25/08/2010	West Lakes Aboriginal Community (Koompahtoo LALC	Email	Field Work Invitation Letter- Response
27/08/2010	Awabakal Traditional Owners Aboriginal Corporatio	Email	Methodology Feedback/Reply
28/08/2010	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Methodology Feedback/Reply
31/08/2010	Wonnarua Nation Aboriginal Corporation (WNAC	Email	Reponses to Aboriginal stakeholders regarding the methodology
31/08/2010	West Lakes Aboriginal Community (Koompahtoo LALC	Email	Reponses to Aboriginal stakeholders regarding the methodology
31/08/2010	Awabakal Traditional Owners Aboriginal Corporation	Email	Reponses to Aboriginal stakeholders regarding the methodology
31/08/2010	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Reponses to Aboriginal stakeholders regarding the methodology
1/9/2010	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
20/9/10	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Provision of draft Main West heritage assessment report for comment
20/9/10	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Provision of draft Main West heritage assessment report for comment
20/9/10	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Letter	Provision of draft Main West heritage assessment report for comment
20/9/10	West Lakes Aboriginal Community - Koompahtoo LALC	Letter	Provision of draft Main West heritage assessment report for comment
20/9/10	Cacatua Culture Consultants-Donna and George Sampson	Letter	Provision of draft Main West heritage assessment report for comment
30/9/10	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Invitation to attend project update meeting
30/9/10	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Invitation to attend project update meeting
30/9/10	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Letter	Invitation to attend project update meeting
30/9/10	West Lakes Aboriginal Community - Koompahtoo LALC	Letter	Invitation to attend project update meeting
30/9/10	Cacatua Culture Consultants-Donna and George Sampson	Letter	Invitation to attend project update meeting
3/10/10	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Comments on draft Main West heritage assessment
15/10/10	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost and Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Meeting	Project update meeting
26/10/10	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost		Comments on draft Main West heritage assessment
29/11/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
30/11/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
6/12/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area

Date	Consultation Description	Method of Contact	Outcomes
7/12/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
8/12/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
9/12/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
10/12/10	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
14/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
15/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
16/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
17/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
18/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
25/2/11	Attended by various representatives from the registered Aboriginal stakeholder groups.	Survey	Pedestrian survey over proposed Newstan mining area
7/1/11	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Provision of revised recommendations and commitments to be incorporated into the Main West heritage assessment
7/1/11	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Provision of revised recommendations and commitments to be incorporated into the Main West heritage assessment
7/1/11	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Letter	Provision of revised recommendations and commitments to be incorporated into the Main West heritage assessment
7/1/11	West Lakes Aboriginal Community - Koompahtoo LALC	Letter	Provision of revised recommendations and commitments to be incorporated into the Main West heritage assessment
7/1/11	Cacatua Culture Consultants-Donna and George Sampson	Letter	Provision of revised recommendations and commitments to be incorporated into the Main West heritage assessment
27/1/11	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Comments and acceptance on revised Main West heritage assessment recommendations
31/1/11	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Comments and acceptance on revised Main West heritage assessment recommendations
14/6/11	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Invitation to attend project update meeting
14/6/11	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Invitation to attend project update meeting
14/6/11	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Letter	Invitation to attend project update meeting
14/6/11	West Lakes Aboriginal Community - Koompahtoo LALC	Letter	Invitation to attend project update meeting
14/6/11	Cacatua Culture Consultants-Donna and George Sampson	Letter	Invitation to attend project update meeting

Date	Consultation Description	Method of Contact	Outcomes
28/6/11	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost and Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Meeting	Project update meeting
12/7/11	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Provision of meeting presentation material and additional information requested
12/7/11	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Provision of meeting presentation material and additional information requested
12/1/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Letter	Invitation to attend project update meeting
12/1/2012	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Letter	Invitation to attend project update meeting
12/1/2012	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Letter	Invitation to attend project update meeting
12/1/2012	West Lakes Aboriginal Community - Koompahtoo LALC	Letter	Invitation to attend project update meeting
12/1/2012	Cacatua Culture Consultants-Donna and George Sampson	Letter	Invitation to attend project update meeting
22/2/12	Only attended by the Awabakal Traditional Owners Aboriginal Corporation – Kerrie Brauer and Dene Hawken	Meeting	Project update meeting
22/2/12	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Provision of meeting presentation slides
22/2/12	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Provision of meeting presentation slides
22/2/12	Awabakal Traditional Owners Aboriginal Corporation – Dene Hawken	Email	Provision of possible meeting dates for ACHMP inception meeting
28/2/12	Awabakal Traditional Owners Aboriginal Corporation – Dene Hawken,	Email	Confirmation of suitable date for ACHMP inception meeting on behalf of ATOAC, CCC and ADTOAC
7/3/12	Attended by the Awabakal Traditional Owners Aboriginal Corporation – Kerrie Brauer, Dene Hawken and Amanda Hawken, Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost, and Wonnarua Nation Aboriginal Corporation (WNAC) – Arthur Fletcher. Other registered Aboriginal stakeholders for other Centennial operations were also in attendance.	Meeting	ACHMP initiation meeting
8/3/12	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Provision of meeting presentation slides
8/3/12	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Provision of meeting presentation slides
8/3/12	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Email	Provision of meeting presentation slides
8/3/12	West Lakes Aboriginal Community - Koompahtoo LALC	Email	Provision of meeting presentation slides
8/3/12	Cacatua Culture Consultants-Donna and George Sampson	Email	Provision of meeting presentation slides
08/03/2012	Cacatua Culture Consultants-Donna and George Sampson	Email	Invitation to provide a statement of significance for report
08/03/2012	West Lakes Aboriginal Community (Koompahtoo LALC	Email	Invitation to provide a statement of significance for report

Date	Consultation Description	Method of Contact	Outcomes
08/03/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Invitation to provide a statement of significance for report
08/03/2012	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Invitation to provide a statement of significance for report
08/03/2012	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Email	Invitation to provide a statement of significance for report
9/3/12	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Invitation to attend Cultural Risk Ranking workshop
9/3/12	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Invitation to attend Cultural Risk Ranking workshop
9/3/12	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Email	Invitation to attend Cultural Risk Ranking workshop
9/3/12	West Lakes Aboriginal Community - Koompahtoo LALC	Email	Invitation to attend Cultural Risk Ranking workshop
9/3/12	Cacatua Culture Consultants-Donna and George Sampson	Email	Invitation to attend Cultural Risk Ranking workshop
09/03/2012	West Lakes Aboriginal Community (Koompahtoo LALC	Email	Margaret Harvey provided a statement of cultural significance
12/03/2012	Cacatua Culture Consultants-Donna and George Sampson	Phone	Invitation to provide a statement of significance for report-No response
12/03/2012	Wonnarua Nation Aboriginal Corporation (WNAC)-Laurie Perry	Email/Phone	Invitation to provide a statement of significance for report-said he will provide a statement
21/3/12	Wonnarua Nation Aboriginal Corporation – Laurie Perry	Meeting	Meeting to discuss Cultural Heritage Assessment for ILUA area.
23/03/2012	Awabakal Traditional Owners Aboriginal Corporation-Kerrie Brauer	Email	Kerrie provided a statement of cultural significance
23/03/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	In Person	Requested the cultural significance statement for the report. –Still considering.
23/3/12	Attended by Attended by the Awabakal Traditional Owners Aboriginal Corporation – Kerrie Brauer, Dene Hawken and Amanda Hawken and Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Meeting	Cultural risk ranking workshop (other stakeholder groups outside of Newstan Project attended as observers)
26/03/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email/phone	Follow up request for the cultural significance statement. No response.
28/03/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Email	Shane provided a cultural significance statement.
30/07/2010	Awabakal Descendants Traditional Owners Aboriginal Corporation-Shane Frost	Mail	Methodology letter
17/04/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Phone/Email	Discussions about registering restricted site (RPS Newstan 24)
17/04/2012	Awabakal Traditional Owners Aboriginal Corporation	Mail/Email	Invitation to review and make comments about the Newstan SMP report
17/04/2012	Cacatua Culture Consultants	Mail/Email	Invitation to review and make comments about the Newstan SMP report
17/04/2012	Westlakes	Mail/Email	Invitation to review and make comments about the Newstan SMP report
20/04/2012	Awabakal Traditional Owners Aboriginal Corporation	Email	Kerrie contacted CYL to request that they have a word version doc of Newstan SMP report so they could add their comments. DR replied that we can only issue a PDF version

Date	Consultation Description	Method of Contact	Outcomes
30/04/2012	Awabakal Traditional Owners Aboriginal Corporation	In person	Kerrie spoke to James Wearne regarding her concerns about the Newstan SMP report. Kerrie's concerns were essentially that the document did not address impacts to cultural values although there was a bit of confusion what these concerns actually were. James Wearne requested that Kerrie put her concerns in writing as James did not understand exactly what she expected in the report to address.
3/05/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Phone	Shane Frost contacted RPS (Cheng Yen Loo) to provide the name and phone number of the archaeologist that recorded the three scarred trees near the Awaba waste disposal area. Shane also wanted to give opinions and comments about the Newstan SMP report. Cheng Yen Loo informed Shane to write it down and send it to RPS before the due date. Shane Frost claimed that the copy of the report sent to him had written text missing. CYL explained this could be due to a technical problem with sending the email.
3/05/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Cheng Yen Loo immediately sent another version of the Newstan SMP report to Shane Frost
9/05/2012	Cacatua Culture Consultants	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due on the 15th May 2012. (Emailed as high importance).
9/05/2012	Westlakes Aboriginal Community	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due on the 15th May 2012. (Emailed as high importance).
9/05/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due on the 15th May 2012. (Emailed as high importance).
9/05/2012	Awabakal Traditional Owners Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due on the 15th May 2012. (Emailed as high importance).
9/05/2012	Wonnarua Nation Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due on the 15th May 2012. (Emailed as high importance).
14/05/2012	Cacatua Culture Consultants	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due tomorrow (15th May 2012). (Emailed as high importance).
14/05/2012	Westlakes Aboriginal Community	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due tomorrow (15th May 2012). (Emailed as high importance).
14/05/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due tomorrow (15th May 2012). (Emailed as high importance).
14/05/2012	Awabakal Traditional Owners Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due tomorrow (15th May 2012). (Emailed as high importance).

Date	Consultation Description	Method of Contact	Outcomes
14/05/2012	Wonnarua Nation Aboriginal Corporation	Email	Reminded all registered stakeholders that submission for comments regarding the Newstan SMP report is due tomorrow (15th May 2012). (Emailed as high importance).
15/05/2012	Wonnarua Nation Aboriginal Corporation	Email	Laurie was happy with everything in the report
15/05/2012	Cacatua Culture Consultants	Email	Replied to request for comments. Their comment was to refer to Kerrie Brauer and Shane Frosts Comments
15/05/2012	Awabakal Descendants Traditional Owners Aboriginal Corporation	Email	Shane provided a response.
15/05/2012	Awabakal Traditional Owners Aboriginal Corporation	Email	Kerrie emailed RPS to request an extension of time to submit comments for Newstan SMP report.
15/05/2012	Centennial agreed to provide ATOAC of time to provide comments-extension till 21 May 2012	Email via RPS	Kerrie never provided her comments or responses.

Centennial Coal

Public Notice

Aboriginal Stakeholder Consultation Newstan Colliery

Centennial Newstan Pty Limited is seeking to identify Aboriginal Stakeholders who wish to be consulted in regards to Aboriginal heritage assessments for mining operations associated with the Newstan Colliery. The study area is located to the east of Lake Macquarie, in the vicinity of the township of Awaba (Lake Macquarie LGA).

Interested stakeholders are requested to register their interest in writing to:

Anna Nardis
RPS Australia East P/L
PO Box 428, Hamilton NSW 2303
Tel: 02 4940 4200
Newcastle@rpsgroup.com.au

Expressions of interest should include current contact details. The closing date for registration is COB 22 July 2010. Newstan Colliery Community Information line is 1800 247 662.

7847-83

Cheng Yen Loo

From: Laurie Perry [l.perry@optusnet.com.au]
Sent: Tuesday, 15 May 2012 6:19 AM
To: Cheng Yen Loo
Cc: James Wearne; Tessa Boer-Mah
Subject: Re: Calls for comments-Newstan SMP report (Wonnaru Nation Aboriginal Corporation)

Importance: High

Hi Cheng Yen

I have no issues with the current Newstan SMP report and ACHCR process.

Cheers

Laurie Perry
CEO
Wonnarua Nation Aboriginal Corporation
Ground Floor 254 John St Singleton NSW
PO BOX 3066
Singleton Delivery Centre 2330
Ph: 02 6571 8595
Fax: 02 6571 8551
Mob : 0412 593 020
Email: wonnarua@bigpond.com.au
Home : l.perry@optusnet.com.au
Website: www.wonnarua.org.au

From: Cheng Yen Loo
Sent: Monday, May 14, 2012 3:57 PM
To: l.perry@optusnet.com.au
Cc: James Wearne ; Tessa Boer-Mah
Subject: Calls for comments-Newstan SMP report (Wonnaru Nation Aboriginal Corporation)

Hi Laurie

I hope you are well. As part of Part 4 of the ACHCR process, the Newstan SMP report was sent to you on the 17 April for review. Deadlines for receiving comments is **TOMORROW** (15th May 2012) 5pm close of business.

If you have any comments to make about the report, please send your comments back to me in writing.

My address is:

Cheng Yen Loo
RPS Australia East Pty Ltd
PO Box 428, Hamilton NSW 2303

Email: chengyen.loo@rpsgroup.com.au

Kind regards

Cheng Yen

RPS

Cheng Yen Loo
Archaeologist
RPS Australia Asia Pacific
PO Box 428, Hamilton, NSW, Australia, 2303
241 Denison St, Broadmeadow, NSW, 2292
Tel: +61 2 4940 4200
Fax: +61 2 4961 6794
Email: ChengYen.Loo@rpsgroup.com.au
www: http://rpsgroup.com.au

No virus found in this message.
Checked by AVG - www.avg.com
Version: 2012.0.2171 / Virus Database: 2425/4997 - Release Date: 05/13/12

Cheng Yen Loo

From: cacatua@resetdsl.net.au
Sent: Tuesday, 15 May 2012 1:14 PM
To: Cheng Yen Loo
Subject: Re: Calls for Comments-Newstan SMP Report (CCC)

Importance: High

> Cheng Yen

Thank you for the copy of the information with regards to Newstan.

we have read and discussed this information and are in support of any changes the shane or Kerrie would like to have implemented as we feel that this is their country to speak on.

Thank you
Donna Sampson
Reports Manager

From: Cheng Yen Loo
Sent: Tuesday, 15 May 2012 1:40 PM
To: 'kerrie@awabakal.com.au'
Subject: RE: Calls for Comments-Newstan SMP Report (Awabakal Traditonal Owners Aboriginal Corporation)-Request for extension

Dear Kerrie

I am sorry to hear that there has been a death in the family. I hope you are ok.

I have spoken to James Wearne about whether it is possible to give you an extension on providing comments. Centennial can only extend the submission date till Monday (21st May 2012) close of business 5pm because they have tight timeframes to keep to.

If you would like to provide comments, please do so by close of business next Monday (21st May 2012)

Take care

CY

RPS

Cheng Yen Loo
Archaeologist
RPS Australia Asia Pacific
PO Box 428, Hamilton, NSW, Australia, 2303
241 Denison St, Broadmeadow, NSW, 2292
Tel: +61 2 4940 4200
Fax: +61 2 4961 6794
Email: ChengYen.Loo@rpsgroup.com.au
www: http://rpsgroup.com.au

From: kerrie@awabakal.com.au [mailto:kerrie@awabakal.com.au]
Sent: Monday, 14 May 2012 6:52 PM
To: Cheng Yen Loo
Cc: 'James Wearne'; Tessa Boer-Mah
Subject: RE: Calls for Comments-Newstan SMP Report (Awabakal Traditonal Owners Aboriginal Corporation)
Importance: High

Dear Cheng,

Please accept my apologies but due to a death in the family I am unable to send through our comments for the Newstan SMP report by the 15th May 2012.

I would appreciate if we were given an extension to send our comments through at this time.

Kind regards,
Kerrie Brauer.

ATOAC
Kerrie Brauer | Director | Administration | Awabakal Traditional Owners Aboriginal Corporation
M: 04 12 86 63 57 | E: kerrie@awabakal.com.au | www.awabakal.com.au
PO Box 253 Jesmond NSW 2299 Australia

From: Cheng Yen Loo [mailto:ChengYen.Loo@rpsgroup.com.au]
Sent: Monday, 14 May 2012 3:50 PM
To: kerrie@awabakal.com.au
Cc: James Wearne; Tessa Boer-Mah
Subject: Calls for Comments-Newstan SMP Report (Awabakal Traditonal Owners Aboriginal Corporation)
Importance: High

Dear Kerrie

I hope you are well. As part of Part 4 of the ACHCR process, the Newstan SMP report was sent to you on the 17 April for review. Deadlines for receiving comments is **TOMORROW** (15th May 2012) 5pm close of business.

If you have any comments to make about the report, please send your comments back to me in writing.

My address is:

Cheng Yen Loo
RPS Australia East Pty Ltd
PO Box 428, Hamilton NSW 2303

Email: chengyen.loo@rpsgroup.com.au

Kind regards

Cheng Yen

RPS

Cheng Yen Loo
Archaeologist
RPS Australia Asia Pacific
PO Box 428, Hamilton, NSW, Australia, 2303
241 Denison St, Broadmeadow, NSW, 2292
Tel: +61 2 4940 4200
Fax: +61 2 4961 6794
Email: ChengYen.Loo@rpsgroup.com.au
www: http://rpsgroup.com.au

"From the Mountains to the Sea"
AWABAKAL
Descendants Traditional Owners
Aboriginal Corporation
20402046601

PO BOX 86
CLARENCE TOWN
NSW 2321

Date: 10 May 2012

Attention: Cheng Yen-Loo
RPS Australia East Pty Ltd
PO Box 428 Hamilton
NSW 2303

Re: Comments/Response-Draft Report-Aboriginal and European Cultural Heritage Assessment-*Newstan Colliery SMP*.

ALLA Cheng Yen,

This letter is in response to the correspondence we received asking if we, the Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC) would like to provide comments/feedback regarding the contents of the **Draft Report- Aboriginal and European Cultural Heritage Assessment-*Newstan Colliery SMP*.**

We would like to take up your offer to provide some comments that we believe can only serve to protect the integrity of our Cultural Heritage. These comments are set out below in the following dot-points;

- On page 3 of the draft report under heading ***Summary*** there is a statement which *'acknowledges the Traditional Custodians of the Lake Macquarie region'.*

    a. This statement fails to name the Awabakal People as the Traditional Custodians of the area that Centennial Newstan Colliery operations are located in. Yet further into the draft report on page 32 it states that *'the Awabakal were the largest clan in the Lake Macquarie region…Awabakal became the name which represented the entire group'*. If this is the case, then why have you failed to mention this fact up front in the very first statement?? If Centennial is so adamant in recognising the Traditional Custodians of the area, then why leave out who they are??

    This oversight needs to be corrected and clarified within this statement to afford the appropriate attention to the true custodians of the area and as documentation from early and more modern ethnographic records show (as on pages 32 of this very draft) that the Awabakal People are the Traditional Custodians of the area.

- Also on page 4 of the draft report in the first paragraph, it states that *'All the registered stakeholder groups have a strong cultural and spiritual connection to the Country...'*

    a. It would be a perfect world if this was the case but unfortunately this is not the situation. There are several reasons for this not being correct.

        - First, can we say that we are appalled and quite offended that this has been written in such a way! It does create some concern and indicate that the author does not grasp an understanding of the Cutlural Heriatge of our People.

        - Secondly, the level of actual connectedness/association that the Traditional Custodians/Owners, the Awabakal People have to this area should be considered as a primary association due to this being our Ancestral lands. All aspects of the Cultural Heritage of our People are intertwined with this very area and have been for thousands of years. The landforms and such contained within the landscape are unique and therefore this uniqueness is mirrored in the stories and beliefs that make up the distinctive Cultural Heritage of our People.
        Therefore the Cultural Heritage of the Awabakal People cannot be intermingled and interchanged with the stories or spirituality of the Cultural Heritage of other Aboriginal People/groups that are born out of other landscapes and beliefs from all over Australia. To suggest this is a certain sign that whoever is making these statements (such as the one highlighted in this instance), does not understand the uniqueness and individuality of specific Aboriginal People groups (Traditional Custodians/Owners) that make up the overall picture of Aboriginal People in Australia.

- Thirdly, for those Aboriginal People who have moved to this area in more recent times for many and varied reasons and who's Ancestors are not from this particular area, they have a different association with this region. With this not being their Traditional Country they have what many consider to be a secondary association. Many bring their own specific Cultural beliefs with them or have been told their own unique stories and spiritual beliefs which originate in their own Traditional areas and are specific to them. This does not mean they cannot (like other people in the community) care about the area they live in, but they do not have that primary role as Traditional Custodians/Owners when it comes to attachment/association regarding the unique spiritual beliefs and Cultural Heritage of the Awabakal.

- Therefore to make such a blanket statement as *'All the registered stakeholder groups have a strong cultural and spiritual connection to the Country...'* is utterly ridiculous and needs to be clarified to contain actualities rather than baseless and misinformed assumptions. As stated above, for someone to make such a blanket statement as this suggests they do not yet have an understanding of or comprehend how individual, unique and specific our Cultural Heritage is.

- We would like to see this statement amended to reflect what is Culturally appropriate and provide correct content which does not cause offense to those who read this in the future.

➢ Table 1-3 page 22 needs amending.

  a. The name of our corporation is incorrect. It needs to be shown as *Awabakal Descendants Traditional Owners Aboriginal Corporation.* At the moment, you have omitted the <u>Aboriginal Corporation</u> part from the end.

➢ Table 1-4 page 22 needs amending.

  a. We had two (2) representatives present on some of the days of the assessment. The name on the second line of this table 1-4 opposite Awabakal Descendants Traditional owners Aboriginal Corporation should be James Frost.

  b. Again, on page 40 section 5.1.4 and page 44 third paragraph, the name of our representatives should be Shane Frost and James Frost instead you have duplicated the one (1) name.

➢ Page 40 section 5.1.5 of the draft report, what looks like to be the second paragraph on the bottom of the page does not correspond to the content of section 5.1.5 (Isolated Find AHIMS #45-7-0295 RPS Newst 2). This second paragraph should be included in section 5.1.9 on page 41-42 Rockshelter with possible grinding groove (AHIMS #45-7-0310/45-7-0005 RPS Newst 17). This section needs to be amended and inserted into the related subject content for the Rockshelter.

➢ Page 42 of the draft report, first paragraph should be amended to state that *'...was recorded on the 9th December, 2010 by RPS personnel with the assistance of Aboriginal Stakeholders Mr Shane Frost and Mr James Frost (ADTOAC).'* The fact of the matter is that James and I were the ones who located this site. The only other person to visit this site on the day was the archaeologist who I notified of the location of the shelter about 1 hour after James and I had initially found it.

  - Again the same mistake has been made on page 44 of the draft report third paragraph which needs to be amended to say Shane Frost and James Frost (ADTOAC)

➢ Section 7.1.3 page 48 third paragraph and continuing onto page 49 and also on page 57 second paragraph of the draft report should be amended to withdraw Culturally sensitive information from being available to others. This information was given on the basis that it would not be made public but unfortunately it now has been by being included into this draft report. This information needs to be retracted immediately!!

  - We would expect that RPS provide an alternative section to this draft report so as to issue this information within this section considered as Sensitive Cultural Information in consultation with us. We agree that this Culturally sensitive information needs to be recorded but should only be made available to others with our permission.

➢ Table 7-8 AHIMS 45-7-0309 Isolated Find, we would have to disagree with your comments for this particular artefact in relation to its *Rarity*, *Integrity* and *Educational Potential*.

  a. First to *Rarity*, your comments refer to *'this site type'* as being common but in reality it is very seldom that you find an artefact of this type. Are you referring to the site as being common (being an Isolated Find) or are you inferring that the particular artefact that was found as being common?? We would suggest that if you are referring to the site being an Isolated Find as common then this is not truly representing the artefact in its true light by making this general comment apply to it!!

What is not being exposed here is the fact that this artefact is not common and the comments in Table 7-8 should reflect this fact. Unfortunately anyone reading this table would (if not knowing better) think this artefact is a dime a dozen if they were to believe the comment in reference to this artefact.

b. Also, under the heading of *Integrity*, you have made a statement that indicates that *'The integrity of the site is likely to be low given that it was located in an access corridor subject to light vehicle movement.'*

This statement can be no further from the truth as this artefact was not found on an access road/corridor. Also there are not many light or heavy vehicles that could traverse the landform that this artefact was located on because it was about twenty (20) metres off the roadway (which ran along the ridgeline) over quite a steep embankment that was covered with scrub, rock and large trees (Please see photos which show terrain where artefact was found in Figure 1 and 2).

c. *Educational Potential* is another area that you have indicated that this *'site type is not rare'.* Again we would have to disagree with this statement*.* Are you again referring to the *'site'* or the artefact itself as being not rare?? This artefact being an adze (chopper) has the ability to provide a source of educational potential that many would consider being of great importance and a valuable resource.

- On page 58 section 8.1.2 under the heading of *Sites Subject to Low-Moderate Risk of Impact* you have made a statement that says *'Due to the subsidence predicted, there is a small possibility that cracking of the surface soils may occur (MSEC2012:102) and artefacts may drop into them…In the event that artefacts fall through the cracks, the tools would be provided greater protection from surface disturbance, although the integrity of the overall site may be harmed.'*

a. This is a ridiculous statement '*In the event that artefacts fall through the cracks, the tools would be provided greater protection from surface disturbance'*. If this is the case, then it would be due to surface disturbance (subsidence) that the artefacts would ultimately find themselves falling into the cracks (produced by subsidence). This would then be considered disturbance of an Aboriginal object under the current legislation.

b. How this statement could even make it into a draft report belies comprehension. Or to consider this to be an acceptable outcome or even an excuse used to demonstrate the practicality and probable protection and preservation for the longevity of our Cultural Heritage is beyond us. Whatever happened to the idea of Intergenerational Equity and leaving behind for those to come some of what we now appreciate so they have the same experience that we ourselves have had the opportunity to encounter through our lifetime?? Can someone PLEASE EXPLAIN!!!!

- The paragraph which appears on page sixty (60) of the draft report does not correspond or make sense to the previous page fifty nine (59) which is describing sites subject to high risk of impact notably that being the rock shelter. The paragraph on page sixty (60) is the same content as that written in the third paragraph on page fifty nine (59) of the draft report. This needs to be amended to actually deal with the subject at hand.

- Shown in figures 4 & 5 is an artefact that was found in the same location as Artefact Scatter AHIMS #45-7-0297-RPS Newst 4 but somehow has not been recorded or showing up in the draft report. This needs to be rectified.

- Also there was a great deal of shell deposits (See Figures 6-12) found during this assessment in the area that this draft report covers. Why has it not been mentioned or recorded in this draft report??

- We do not agree with recommendations 2 and 3 on page 62 of the draft report. We cannot consent to the possible outcome of destruction to these two sites or any others. Therefore we believe there should be ***NO IMPACTS*** to any of our Cultural Heritage sites.

- We hope that it has been shown here that these sites are significant to us as Awabakal People and there is a great need to protect and preserve what is left of the Cultural Heritage of our People. We all need to regard the question of Intergenerational Equity as being of the utmost importance so that future generations are not disadvantaged in relation to what has or has not been left for them to appreciate and learn from. This again is why it is imperative to make sure appropriate decisions are made and suitable management and mitigation processes are put in place so as to provide the most appropriate protection and preservation for our Cultural Heritage that still exists (as already shown) within the area proposed for mining.

- What is intergenerational Equity?? We see ***Intergenerational Equity*** as a provision for future generations to benefit from what has transpired in the past and to have been left as much as the previous generation.

  Below are provided three (3) examples we have included, quoted from international organisations/standards from around the world, which explain what ***Intergenerational Equity*** represents;

  a. ***Intergenerational equity:*** *A core proposition is that future generations have a right to an inheritance (capital bequest) sufficient to allow them to generate a level of well-being no less than that of the current generation. Also refers to fairness in the treatment of different members of the same generation.*[1]

  b. ***Intergenerational equity:*** *Meeting the needs of the present without compromising the ability of future generations to meet their own needs.*[2]

  c. ***Intergenerational equity:*** *The principle of equity between people alive today and future generations. The implication is that unsustainable production and consumption by today's society will degrade the ecological, social, and economic basis for tomorrow's society, whereas sustainability involves ensuring that future generations will have the means to achieve a quality of life equal to or better than today's.*[3]

- Intergenerational Equity is an issue that has not been satisfactorily addressed within this ***draft report***. We believe this is an important objective which can help to preserve and protect our Cultural Heritage and it is our concern that if this is not adequately addressed at this preliminary stage of the process then it may be overlooked as this project progresses, subsequently leaving our Cultural Heritage vulnerable.

Unfortunately it must be said, that reviewing this draft report has been a very unpleasant experience. It seems to have been thrown together and in some ways our Cultural Heritage has been treated dismissively within its content. It displays many inconsistencies and errors and we are of the opinion that this draft does not present the appropriate significance it should to our Cultural Heritage and Cultural sites. In its current form it can only be described as disappointing, lacking and unacceptable in regard to what should be expected.

As can be seen on page 5 of the draft report our ***Statement of Aboriginal Cultural Significance*** sets out what has been for our Ancestors and is still today the tremendous importance this area signifies in the lives of our people. We would hope that our Cultural Heritage will be afforded the appropriate level of significance by Centennial and others that it deserves. For the simple fact is that we only have one chance to get things right in regard to the preservation and protection of our Cultural Heritage sites when considering the possible outcomes of this project.

Thank you for the opportunity to respond to this draft report. We would appreciate it if you could forward to us a copy of the final document at your earliest convenience. If further information is required please don't hesitate to contact us ASAP. Our contact details are as follows.

NGI NOA
Shane Frost-Managing Director: Awabakal Descendants Traditional Owners Aboriginal Corporation
Email:shanefrost@bigpond.com Phone: 49964362 Fax: 49964325 Mobile: 0428320671

***Cultural Heritage Sites** - Physical reminders of our Ancestors; once they are gone, they are gone forever and impossible to bring back!! THINK first and make WISE decisions last!!*

PLEASE NOTE: Next page contains photos of sites.

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[1] ***From Website 'www.traditionalknowledge.info/glossary.php'***

[2] ***From Website'www.konsult.leeds.ac.uk/public/level1/sec17/index.htm'***

[3] ***From Website'www.ic.gc.ca/eic/site/ee-ee.nsf/eng/h_ef00016.html'***

Above: Figure1-Note terrain where Isolated Find 45-7-0309 was located

Above: Figure2-Note terrain where Isolated Find 45-7-0309 was located no road present!!

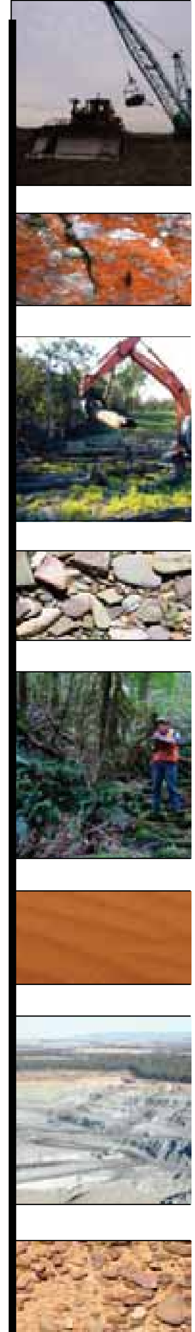
Above: Figure3-Note large sandstone platform in front of Rock Shelter AHIMS#45-7-0310/45-7-0005 that may contain grinding grooves but covered by debris. Shelter can just be seen as dark area in trees to the right of James.

Above: Figures 4 & 5-Note artefact in these pictures is an artefact that has not been recorded in draft. This artefact was found within the same location as Artefact Scatter AHIMS #45-7-0297 by Shane & James Frost on the 30th November 2010. This needs a site card for this artefact.

Above: Figures 6, 7, & 8 Just a couple of photos showing the Shell deposits found during this assessment. Some of the deposits were found close to AHIMS #45-7-0297 Artefact Scatter

Above: Figure 9-Showing an area where Figure seven is located. Shell covered the grassed area on the bank also and to the right of picture out of view.

Above: Figure 10 Oyster Shell and **Above Right**: Figure 11 and **Below Right**: Figure 12 Oyster and Cockle Shell eroding out of soil.



Surface Water Impact Assessment

APPENDIX 10

Centennial Coal

GHD

SURFACE WATER IMPACT ASSESSMENT

Newstan
Subsidence Management Plan LW 101-103

May 2012

Centennial Coal
Environment Matters

Executive Summary

The objective of this surface water impact assessment was to examine both the existing geomorphic condition and surface water quality of watercourses located within the Subsidence Management Plan for Longwalls LW101 to 103 for Newstan Colliery.

The geomorphic investigation was based upon a series of field investigations which looked at existing waterway type and condition. This was accompanied by a desktop assessment which determined stream order and significance to the environment. Geomorphic condition was categorised across the project as good, moderate or poor. A total of 11 waterway types were identified during the field investigations which predominately focused on third and fourth order streams, with the exception of Kilaben Creek which was a second order stream.

To support the geomorphic investigation a hydraulic assessment was undertaken on a regional and individual creek scale. A flood model was developed to assess the regional flooding characteristics of the project area. This formed a baseline for which impacts of the project could be identified. This was supported with a detailed hydraulic assessment, at an individual creek scale, to quantify the water surface elevation and velocity down each of the watercourses assessed.

An assessment of items of infrastructure within the study area was undertaken. This included the identification of two public and one private roads, several culverts and two electrical easements.

The assessment of existing surface water quality was undertaken in order to determine background baseline values for watercourses within the Subsidence Management Plan project area. In undertaking this assessment, the water quality at a number of water monitoring locations associated with Kilaben and Stony Creek were reviewed. These Water Monitoring Points included:

- WMP 27, 28, 29, 30, 31, 32, 33 and 34.
- Sampling locations from the Centennial Awaba Colliery Water Quality Management Plan known as Upstream and Downstream.

Typically a period of at least 6 months of monthly sampling was available for assessment for each of the monitoring points. Samples have generally been analysed for pH, Electrical Conductivity (EC), Total Suspended Solids (TSS), oil and grease, turbidity and total metals. The sampling data set was compared against the ANZECC (2000) default trigger values and discussed for each analyte.

From the assessment of water quality results, it was found that for some of the key parameters that the results were above default trigger values. This was determined to be due to the influence of the natural geology and catchment properties. Catchments that surround the Subsidence Management Plan Study Area, where sampling sets were available, were investigated to enable a comparative test for these influences. Many of the key parameters above the default trigger values of the Subsidence Management Plan Study Area were also found to be above in the surrounding catchments.

Prior to mining commencing in 2014, it is expected that a more comprehensive set of data from an estimated network of 24 water quality monitoring points will exist to determine site specific trigger values. Therefore from this assessment it was determined that site specific triggers would be more appropriate.

From the assessment of the predicted maximum subsidence impacts, changes are likely to occur in both natural features and specific public utilities. These were discussed with respect to surface water aspects and flooding impacts. Waterways within the study area were assessed indicating that subsidence may vary the alignment of minor drainage channels within the upper catchment positions, but catchment boundaries are unlikely to change.

The assessment of impacts on existing infrastructure was assessed with respect to roads, culverts and the electrical easements within the study area. Also discussed was the subsidence impact of Awaba Waste Management Facility and any risks posed to water quality levels within the study area. It was determined that though items of surface infrastructure will subside by some distance, the impact on the appropriate management of surface water and flooding characteristics are minimal. Some areas of infrastructure that are currently in a poor condition, such as the Access Tracks of the Electrical Easements, indicate that with subsidence their condition is exacerbated.

It was determined that, under post mining subsidence conditions, that the Awaba Waste Management Facility, as discussed by MSEC (2012), would not be an element of risk in the degradation of surface water quality within the Subsidence Management Plan study area. This was the conclusion based on the MSEC discussion of Awaba's surface water and leachate management infrastructure currently present within their waste management facilities.

Areas of increases in waterway gradient and flow velocities were observed in two watercourses. The increases observed in waterway gradient due to subsidence, resulted in flow velocity increases in the order of 0.4 m/s for the 2 year Average Recurrence Interval event. The hydraulic modelling also indicated instances of reduction in waterway gradients and subsequent flow velocity. From the geomorphic investigation of the subsided results, flow velocities were found to be maintained above 0.2 m/s for the flow events modelled. Given that the waterways traversing the project area are typically fine-grained systems that predominantly transport suspended sediments, it is unlikely that any aggradation of sediment along waterways will occur due to the subsidence impacts.

The impact on flood depth, due to predicted subsidence, was found to be greatest in the 2 year ARI event. This indicated that the flooding inundation had a maximum increase of 3.7% within the subsidence project area. The areas indicating the greatest impact were identified as Kilaben Creek and the unnamed creek. The greatest increase in flood depth was in the order of 0.5 m for the 100 year ARI and 0.35 m for the 2 year ARI.

Flood velocities were assessed for change between the existing and subsided model. Velocities remained consistent in the subsided surface with some instances of increases and decrease in velocity. Change in velocity was greatest within Kilaben Creek and the unnamed watercourse. These instances are both attributed to the presence and effect of the Electrical Easement and Access Track along the Eastern Branch.

A number of mitigation measures have been recommended for the potential impacts on the natural features and items of infrastructure within the Subsidence Management Plan Study Area. These include:

- Reporting, assessment of water quality results, an evaluation of trends and any need for management actions.
- Monitoring measuring and recording, visually and through field survey cross sections.

It is recommended that the water quality monitoring should continue to identify any potential changes in the defined baseline quality levels. It is additionally recommended that monthly monitoring of major ions continue to be included in the data set.

Contents

Table Index

Figure Index

Appendices

Glossary

Angle of Draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20 mm.
Aquifer	The layer of rock that holds water and allows water to flow slowly through it.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as or larger than the selected event.
Bord and pillar	A mining system whereby coal is extracted leaving ‘pillars’ of untouched coal to support the strata above.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Community	Anyone who is interested in or affected by subsidence issues associated with the proposed mining project.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Floodplain	Area of land which is subject to inundation by floods by up to the probable maximum flood event.
Floodplain management plan	The principal means of managing the risks associated with the use of the floodplain. A floodplain management plan needs to be developed in accordance with the principles and guidelines in this manual, and will usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Groundwater	Means water in a saturated zone or stratum or aquifer beneath the surface of the land.
Guideline	Numerical concentration or narrative statement supporting or maintaining a designated water use.
Headings	A roadway driven in to the coal seam for access to underground operations by personnel and machinery.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.

pH	Value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogenion concentration of the solution.
Potable water	Water of a quality suitable for drinking.
Risk	The chance of something happening that will have an impact upon objectives. It is measured in terms of consequence and likelihood.
Roadway	Underground tunnel constructed to enable access to working face.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Sediment-laden water	Water that has a high level of suspended solids.
Slope	A landform element inclined from the horizontal at an angle measured as degrees or as a percentage.
Strata	Geological layers below the ground surface.
Structure	The combination or spatial arrangement of primary soil particles (clay, silt, sand, gravel) into aggregates such as peds or clods, and their stability to deformation.
Subsidence	For the purposes of SMP approval process, subsidence is defined as mining-induced movements and deformations at the ground surface where (i) the vertical downward surface movements are greater than 20 mm, or (ii) the potential impacts on major surface infrastructure, structures or natural features may be significant, notwithstanding that the vertical downward surface movements are less than 20 mm.
Surface Water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Tailwater Level	Water level that forms the downstream boundary of the hydraulic modelling scenario. The water level present within Lake Macquarie provides a Tailwater condition for the hydraulic modelling of both the regional flood modelling and the hydraulic assessment for the geomorphology.
Vertical Subsidence	Vertical downward movements of the ground surface caused by underground coal mining.

Abbreviations

AHD	Australian Height Datum
AEMR	Annual Environmental Management Report
ARI	Average Recurrence Interval
BOM	Bureau of Meteorology
DA	Development Application
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
DTM	Digital Terrain Model
EIS	Environmental Impact Statement
GHD	GHD Pty Ltd
km	kilometre
IFD	Intensity-Frequency Duration
LEA	Life Extension Area
LGA	Local Government Area
m	metres
mm	millimetres
MOP	Mining Operations Plan
MTpa	Millions Tonnes per annum
NOW	NSW Office of Water
ROM	Run of Mine
SMP	Subsidence Management Plan
WC	Water Course

1. Introduction

Newstan Colliery (Newstan) is an underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan). Newstan Colliery is located approximately 25 km south-west of Newcastle and approximately 140 km north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan Colliery pit top and surface facilities are located approximately 4 km north of the township of Toronto on the western side of Lake Macquarie (site locality is shown in Figure 1-1).

Mining operations at Newstan first commenced in 1887 and has since undertaken extensive mining within the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole coal seams. Mining at Newstan is currently undertaken using a combination of modern longwall retreat and bord and pillar mining methods. Newstan has approval to produce up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal which is transported by private haul road to Eraring Power Station for domestic power production and by rail to the Port of Newcastle for export market.

The objective of current mining operations is to produce coal safely and efficiently to meet market demands, whilst satisfying the environmental management expectations of Centennial's internal standards, regulatory authorities and the local community.

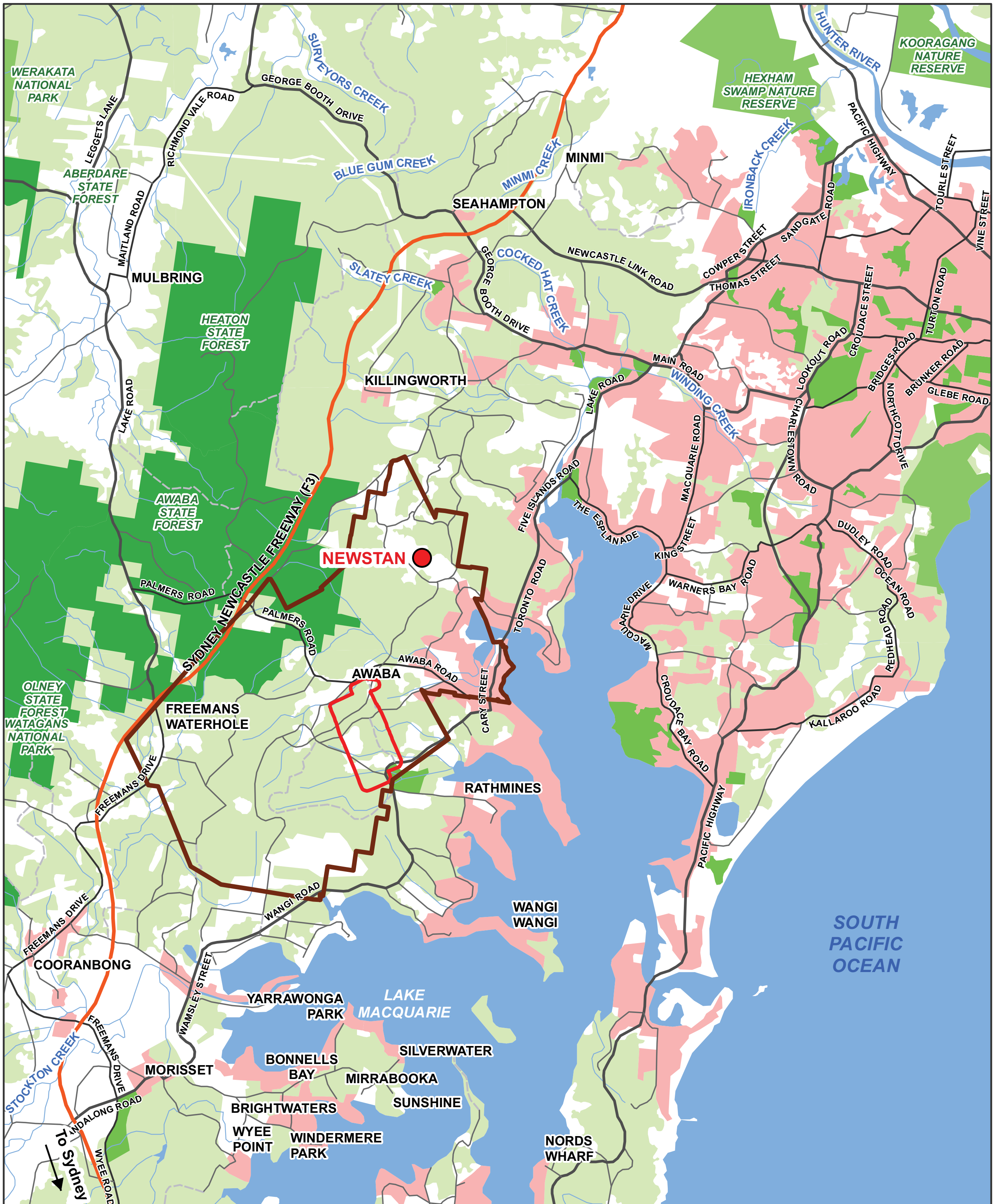
In May 1999, Development Consent (DA73-11-98) was granted under Part 4 of the Environmental Planning and Assessment Act (EP&A Act) to extend the life of the colliery in accordance with an Environmental Impact Statement (EIS) prepared in 1998, which defined the Life Extension Area (LEA). Following modifications to the approval, the mine currently operates under DA73-11-98 MOD 4 and the following approvals relevant to this SMP Application:

- Mining Lease ML1452.
- Mining Operations Plan (MOP) (2005 -2012).
- Environment Protection Licence (EPL) 395.

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a *Subsidence Management Plan (SMP)* prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103, which are located wholly within ML1452 and DA 73-11-98.

The SMP Study Area is described in detail in Section 1.1 and is shown in Figure 1-2. The SMP Application has been prepared in accordance with the *'Guideline for Applications for Subsidence Management Approvals'* (DPI-MR (now DTIRIS-DRE), December 2003), herein referred to as the 'SMP Guidelines'.

GHD Pty Ltd were engaged by Centennial Newstan to undertake an assessment of potential subsidence impacts to Surface Water Impacts in accordance with the SMP Guidelines and relevant statutory conditions, and provide this specialist report in support of the SMP Application for Longwalls LW101, 102 and 103. The scope of this report is detailed further in Section 1.5 and 1.6.



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0 625 1,250 2,500 3,750 5,000
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Newstan Colliery
- SMP Study Area
- Proposed Final Newstan Colliery Holding Boundary
- Freeway
- Principal Road
- Secondary Road
- Minor Road
- Track
- Watercourse
- Water Body
- Built Up Areas
- Forest Or Shrub
- Nature Conservation Reserve
- State Forest

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

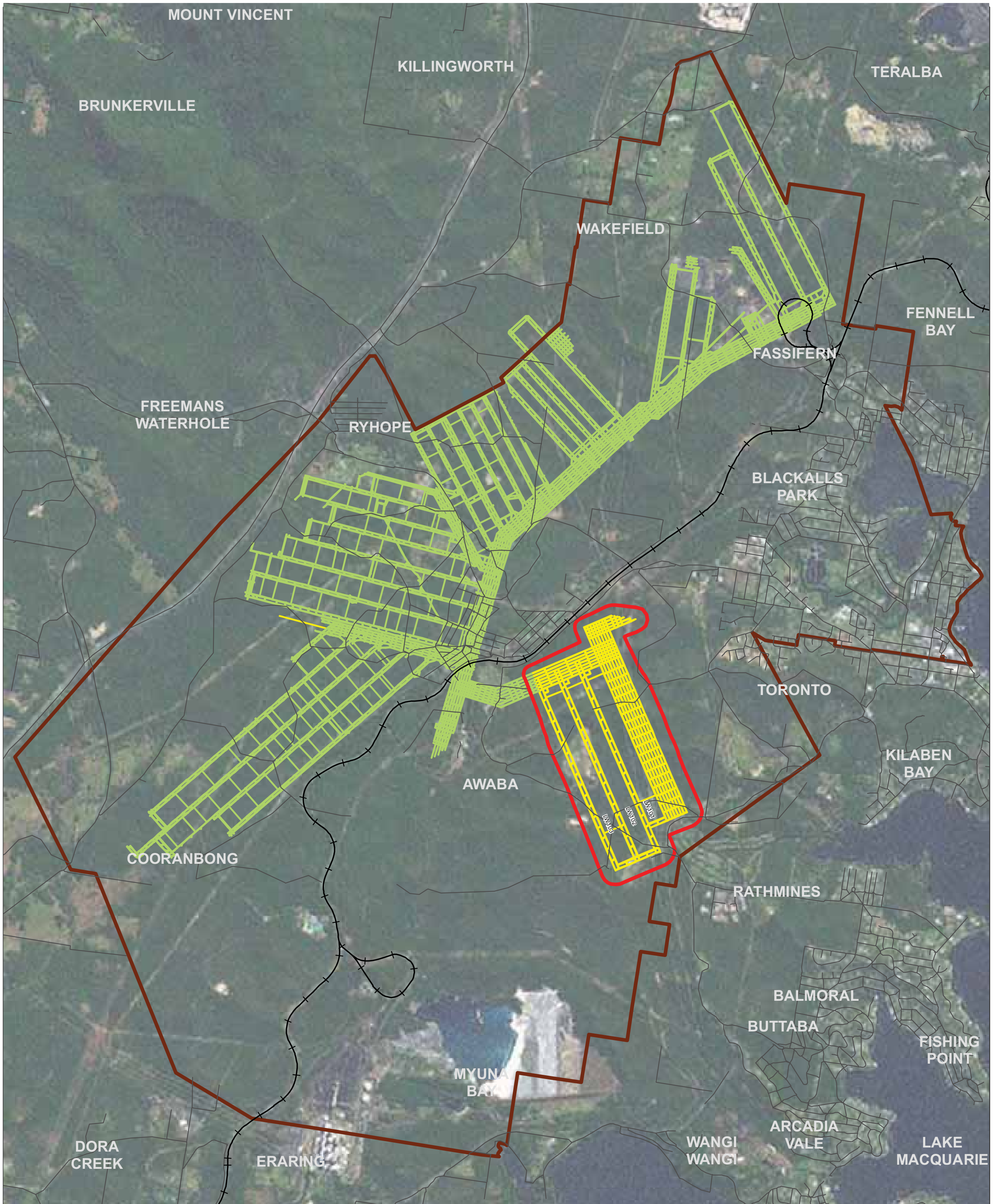
Newstan
Subsidence Management Plan
Surface Water Impact Assessment
Locality Plan

Centennial Newstan

DATE: 17/04/2012

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_001_Figure1-1_LocalityPlan.mxd



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Railway
- Roads
- Proposed Final Newstan Colliery Holding Boundary
- SMP Study Area
- Existing / Proposed Approaved Underground Workings
- SMP Longwalls

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Newstan Lochiel Holding Boundary

Centennial Newstan

DATE 14-04-2012

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_013_Figure1-2_NewstanLochielHoldingBoundary.mxd

A risk-based approach has been undertaken during the development and preparation of the SMP application, which has conservatively included subsidence predictions and assessments for both the expected mining scenario as well as an unpredicted scenario of increased subsidence conditions, as considered further in Section 7 of this report. A specialist subsidence impact assessment has been carried out by Mine Subsidence Engineering Consultants (MSEC), (2012) which has been referenced and summarised, where appropriate, throughout this report to provide the basis for potential impact assessment. The full report by MSEC can be found in Appendix A to the SMP Written Report for the SMP Application.

1.1 SMP Study Area

The study area for this report (herein referred to as the SMP Study Area) has been conservatively defined beyond the minimum requirements of the SMP Guidelines (2003) and is illustrated in Figure 1-2 (NS2846). The SMP Study Area incorporates the areas bounded by the following limits:

- A 26.5 degree angle of draw from the panel edge (limit of proposed extraction) of the proposed Longwalls LW101, 102, 103 for the depth of cover (as per Section 6.2 of the SMP Guidelines).Additionally, the study area also conservatively includes a 26.5 degree angle of draw from associated first workings (mains headings and associated mine development roads) adjacent to the longwalls, acknowledging these areas do not significantly contribute to subsidence but have been conservatively included.
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour resulting from the extraction of the proposed longwall panels (as per Appendix A of the SMP Guidelines). Additionally, the footprint of potential direct impact by subsidence parameters for tilt, strain and curvature has also been considered in establishing the SMP Study Area.

The proposed longwall panels have been designed to target the Young Wallsend (which comprises the Nobby's and Dudley seams) and Yard seams of the Newcastle Coal Fields. Depth of cover within the SMP Study Area ranges from a minimum of 200 m in the north-west to over 400 m in the south-east. LW101-LW103 are generally aligned in a north-south direction with mining proposed to occur from the south-east (outbye) retreating to the north-west back to the main headings.

1.2 Project Overview

Newstan Colliery is an existing underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan). Newstan Colliery is regionally located approximately 25 km south-west of Newcastle and 140 km north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan Colliery Surface Site is located approximately 4km north of the township of Toronto. Newstan Colliery began mining operations in 1887 and has since undertaken extensive mining within the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole coal seams.

The Newstan Colliery produces both a semi soft coking coal and thermal coal for the domestic and export markets. In 2009 the Newstan Colliery temporarily ceased underground mining production however continued to operate the Newstan Colliery surface site for the handling and processing of coal from other Centennial operations. Underground mining recommenced at the Newstan Colliery in July 2011.

1.3 Project Description

1.3.1 Mining Area

The majority of the proposed Newstan Colliery extension of mining area is located under undulating, unpopulated bushland. Lake Macquarie and the surrounding residential suburbs of Toronto and Rathmines border the Project Area to the east. To the south lies the Eraring Power Station and associated infrastructure including the Eraring Power Station ash dam. To the west lies the F3 freeway. The Main Northern Railway traverses the Project Area in a north-south direction. The proposed mining area is bordered by previous Newstan Colliery mine workings to the north and northwest while the western area of the proposed mining area is overlaid with mine workings from the Awaba Colliery in the Fassifern and Great Northern coal seams.

1.3.2 Mining Methods

Newstan Colliery has previously undertaken underground mining using a combination of continuous miner and longwall mining methods. These methods range from first workings development to secondary extraction. A range of ancillary equipment was also utilised in the underground workings including equipment for the transport of men and materials underground.

In addition to the underground mining equipment, Newstan Colliery utilises a variety of other equipment, for its operation of the existing Surface Facilities Area and CPP. The current equipment used in the operation of Newstan Colliery includes equipment for: coal handling; coal processing; coal loading and product coal haulage.

1.3.3 ROM Coal Production Limits

An extraction of up to 4 Mtpa of ROM coal from within the Newstan Colliery Life Extension Area is currently granted under Development Consent DA 73-11-98.

1.3.4 Coal Transport

Domestic coal is delivered by conveyor from the CPP to the 2000 tonne truck loading bin prior to being loaded onto trucks and transported to Eraring Power Station via the Newstan-Eraring private haul road.

Export coal product produced from the Newstan Colliery CPP is stockpiled within the central portion of the existing rail loop. Coal is then loaded by front end loaders onto the trains for transportation north along the Main Northern Railway to Port Newcastle or south to Port Kembla.

1.3.5 Coal Handling

ROM coal produced from the Newstan Colliery is transported underground from the working face to the surface and delivered to the Newstan CPP by a high capacity conveyor system. ROM coal may be temporarily stored in the existing 80,000 tonne ROM coal storage area, near the CPP, prior to being conveyed to the CPP via a 4,000 tonne feed bin. Coal products from the CPP are either delivered to:

- The truck loading bin for trucking of domestic thermal coal via the Newstan-Eraring private haul road to Eraring Power Station.
- The stockpile areas within the Newstan Colliery rail loop for train loading and transport to Port Newcastle, Port Kembla or the Vales Point Power Station.

1.3.6 Mine Access and Surface Facilities

The proposed Project will utilise the existing infrastructure of both the Newstan and Awaba Collieries. Upgrades to the existing Awaba Colliery buildings, including administration buildings, bathhouse facilities and workshop will be undertaken to support the workforce required for the Project when they relocate to the Awaba Surface Site from the Newstan Colliery Surface Site.

A new men and materials drift is proposed to be constructed as part of the Project at the Awaba Colliery Surface Site to provide an alternative access to the Newstan Colliery underground workings. The ongoing use of infrastructure at the Newstan Colliery once the workforce relocates to Awaba will be considered and assessed within the Northern Coal Services Coal Logistics Project EIS.

Ventilation shafts at both the Newstan and Awaba Collieries will continue to be utilised for the Project. The Awaba Colliery Surface Site will be the site of the approved but yet to be constructed upcast shaft and surface fans. A new downcast shaft is required to be constructed as part of the Project. The exact location of the new downcast shaft will be determined during the preparation of the EIS however is currently proposed for an area of Crown land located adjacent to an industrial area at Rathmines.

Additional infrastructure for gas drainage, greenhouse gas capture and abatement, ventilation, electrical reticulation, water reticulation, water management, communications and other services will also be required. Removal of all associated coal handling infrastructure at the Awaba Colliery Surfaces Site will commence in 2012.

Any additional infrastructure required to support the Newstan Colliery surface operations will be considered as part the Northern Coal Services – Coal Logistics Project currently being considered by Centennial. As such, any new surface coal handling infrastructure that may be required is not considered part of this Project.

1.4 Study Area

The study area for the surface water assessment encompasses the full extent of the Project Area as indicated on Figure 1-1.

1.5 Objectives of this Report

The objective of this surface water management plan is to assess the potential impacts of subsidence on the surface water systems of hydrology, and hydraulics, stream health including geomorphic impacts and water quality.

This report provides information that will support the SMP Application to the Department of Trade and Investment, Regional Infrastructure and Services (DTRIS), in accordance with the SMP Guideline (DPI; 2003), as summarised in Table 1-1.

Table 1-1 Information Provided in Support of the SMP Application (DPI; 2003)

Requirement	Where Addressed in this report
Section 6.2, The Application Area	Section 1, Figure 1-2
Section 6.4, Site Conditions of the Application Area	Section 4, Section 5

Requirement	Where Addressed in this report
Section 6.6.1 - Identification of Surface Features	Section 4, Section 5
Section 6.6.2 - Characterisation of Surface Features	Section 4, Section 5
Section 6.8 - Community Consultation	Section 1.7
Section 6.9 - Statutory Requirements	Section 2
Section 6.10 - Subsidence Impacts	Section 7
Section 7 - Proposed management plans	Section 8
Appendix B – Surface features that may be affected by Underground coal mining.	Section 4

To undertake an assessment of potential surface water impact, a number of assessment elements were completed as part of this report. These are outlined in Section 2 and were obtained from Guidelines for Application for Subsidence Management Approvals (2003). These assessment elements are specific to this surface water impact assessment.

1.6 Scope of Work

The scope of works for the investigation included:

- Review of existing surface water assessments.
- Undertake an ANZECC assessment based on existing water quality data and assess the impact of the Project on water quality.
- Assessment and documentation of surface water system within the extent of the lease boundary for the existing conditions and subsequent impact of the Project on the surface water system.
- Subsidence impact assessment on the geomorphology of waterways and surface water ponding for the SMP.
- Development of impact mitigation recommendations.

1.7 Stakeholder and Community Consultation

Centennial Newstan has undertaken consultation for the SMP application in accordance with the Newstan Colliery Stakeholder Engagement Plan. Consultation to date has included detailed discussions regarding the project with the Newstan Colliery Community Consultative Committee, interested landowners and relevant government agencies.

A briefing Session with all relevant government agencies was held on 20 March 2012 at which the SMP application was discussed. No issues regarding water quality relating to subsidence from underground mining activities were raised. Centennial Newstan is currently liaising with Lake Macquarie City Council in regards to the proposed SMP application and its potential impacts to the Awaba Waste Management Facility and subsequent impacts to water quality. These discussions are continuing.

2. Relevant Legislation and Policies

The following section provides a brief overview of the legislation and policies relevant to this surface water impact assessment.

2.1 Water Act 1912

The Water Act 1912 governs access, trading and allocation of licences associated with both surface and underground water for water sources where a water sharing plan has not been put in place. The elements to which the Water Act 1912 applies include extraction of water from a river, extraction of water from underground sources, aquifer interference and capture of surface runoff in dams.

2.2 Water Management Act 2000

The Water Management Act 2000 is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources commenced in August 2009 and regulates the interception and extraction of surface water and alluvium within the defined water sharing plan area. The alluvium within the project area is covered by this water sharing plan and is specifically within the North Lake Macquarie water source area. Centennial Newstan currently holds a number of water licences issued under the Water Act 1912.

2.3 NSW Department of Mineral Resources, Guideline for Applications for Subsidence Management Approvals

The Subsidence Management Approvals process was developed to identify all mining-induced subsidence impacts and mitigation measures prior to approval being granted under the conditions of an existing Mining Lease. This process requires that a SMP be prepared and approved by the DTIRS Manager Environmental Operations prior to approval being granted under Section 239(2) of the *Mining Act 1992*.

The SMP must outline:

- Affected Area.
- Subsidence Predictions.
- Assessment of subsidence impacts on the area.
- Prevention, mitigation and or rehabilitation of subsidence impacts.

The identification of major natural features, items of surface infrastructure and areas of environmental sensitivity was required under the *Guideline for Application for Subsidence Management Approv*als.

A summary of the natural features and items of surface infrastructure within the SMP Study Area is provided in Table 2-1. The descriptions, impacts and mitigation measures for the natural features and items of surface infrastructure are provided in Section 4, 5 and 7. The characterisation of the surface infrastructure was based on information provided by MSEC.

Table 2-1 Natural Features and Surface Infrastructure within the SMP Study Area

Elements	Within SMP Study Area	Where addressed in this Report
Natural Features		
Rivers and Creeks	✓	Section 7.1
Land Prone to Flooding or Inundation	✓	Section 7.3
Public Utilities		
Roads	✓	Section 7.3.4
Culverts	✓	Section 7.3.5
Electricity Transmission Lines	✓	Section 7.3.6
Industrial, Commercial and Business Establishments		
Waste Storages or Associated Plants	✓	Section 7.4.1

In some cases, the report will refer to other sources for information on specific items of surface infrastructure.

A summary of the features identified as *"Areas of Environmental Sensitivity"*, as defined in SMP Guideline (DPI; 2003), is provided in Table 2-2. It is not considered that the surface watercourses within or close to the SMP Study Area are classified as 'significant', although they have been identified and assessed for impact from mining.

Table 2-2 Areas of Environmental Sensitivity within the SMP Study Area

Elements	Within SMP Study Area	Where addressed in this Report
Significant surface watercourses, identified through consultation with relevant government agencies	×	×

3. Methodology

3.1 Desktop Study

For the desktop component of the assessment a number of tasks were undertaken including:

- Identification of waterways and drainage lines within the study area based on the Department of Lands topographic information, in accordance with the *Water Management Act 2000.*
- Review of previous Geomorphic Assessment for Subsidence Tolerance (GHD; 2010).
- Review of previous Surface Water Quality Assessment (GHD; 2010a).
- Review of Environmental Protection Licence 395 (Newstan) and Environmental Protection Licence (EPL) 443 (Awaba).
- Review of the Annual Environmental Management Report (AEMR) for 2011.
- Review of available water quality data and assessment of water quality data in relation to background ambient and ANZECC trigger values.

3.2 Waterway Field Assessments

A field assessment was undertaken for the Project within the Newstan Lease area to identify stream type, geomorphic condition and any areas of geomorphic interest. The assessment covered selected second order, and all third and fourth order streamlines within and adjacent to the SMP Study Area. The included identifying such features as bed controls, headcuts and other sites that may increase bed and bank instability. These were identified as culverts, sinkholes and informal track crossings. The geomorphic field investigation assessed and recorded key information concerning the morphology of each waterway including:

- Channel form and instream morphology.
- Bed and bank stability.
- Nature of bed and bank sediments.
- Channel controls.
- Adjoining landuses.
- Features indicative of flow levels (eg debris).
- Nature and location of any existing infrastructure.

An additional desktop assessment based on imagery and topographic information was also undertaken to classify all other streams (primarily first order) to define Stream Order, river style and condition.

3.2.1 Stream Order

Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler, 1952). Figure 3-1 indicates the Strahler stream ordering process. Numbering begins at the top of a catchment with headwater ('new') flow paths being assigned the number one. Where two flow paths of order one join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on.

Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the area downstream of the junction will retain the higher.

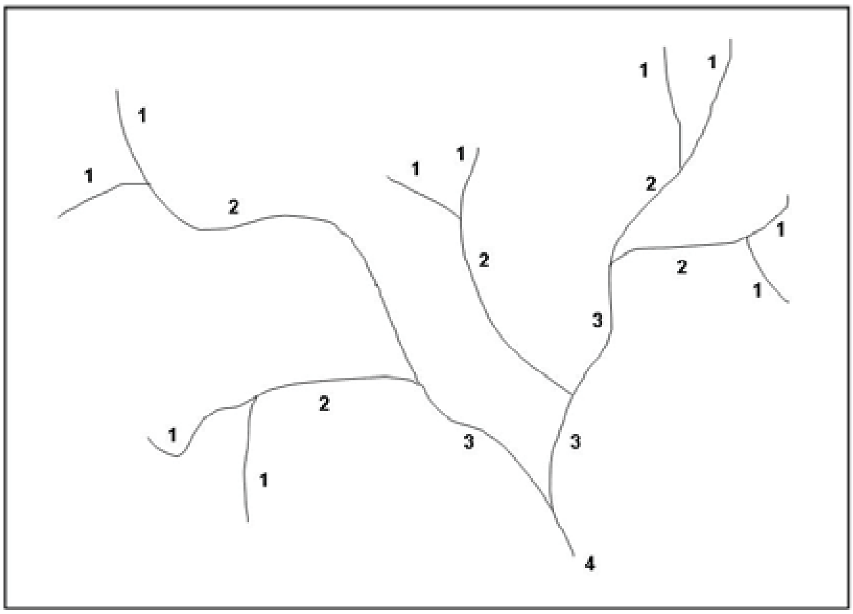


Figure 3-1 Stream Order for a Fictitious Catchment using Strahler (1952) Method

3.2.2 Waterway Types

The assessment of stream physical form and function is broadly based on the methods and principles of the River Styles™ framework (Brierley and Fryirs, 2005). Analysis and interpretation of maps and aerial photography were used to identify the extent and distribution of stream types within the Study Area. Determination of stream types is largely based on the following parameters:

- Degree of valley confinement and bedrock influences.
- Presence and continuity of a channel.
- Channel planform (number of channels, sinuosity).
- Channel and floodplain geomorphic features.
- Nature of channel and floodplain sediments.

3.2.3 Geomorphic Condition

Observable indicators of river geomorphic condition and change were identified and recorded during the field investigation. These indicators include:

- Bed and bank stability (extent and severity of erosion).
- Riparian vegetation associations.
- Geomorphic features such as bars, pools, riffles and benches.
- Evidence of channel lateral migration, expansion, incision and/or straightening.
- Evidence of excessive sediment deposition.

From these observations, a qualitative assessment of the indicative geomorphic condition of the streamlines was made. Assessment of geomorphic condition was based on (Outhet and Cook; 2004) who describe a rapid method of condition assessment that frames geomorphic condition in the context of natural and human induced variability and divide stream condition into three broad categories.

The characteristics of each condition category are described in Table 3-1. These categories provide an indication of the degree of alteration a reach has experienced from its expected natural form.

Table 3-1 Geomorphic Condition Category Descriptions

Indicative condition	Characteristics
Good	Geomorphic structure is largely unchanged from the pre-disturbance state such that only minor cases of localised instability occur. Relatively intact and effective vegetation coverage dominated by native species, giving resistance to natural disturbance and accelerated erosion. There is minimal alteration to catchment controls such as sediment supply and the hydrological regime allowing fast recovery from natural disturbance. There is also a high potential for ecological diversity.
Moderate	Geomorphic structure is moderately altered such that a reduced diversity of river features exist and floodplain connectivity is somewhat limited. Localised degradation of river character and behaviour, typically marked by modified patterns of geomorphic units. Patchy effective vegetation coverage allowing some localised accelerated erosion. The river has not fully adjusted to prevailing conditions and is experiencing ongoing changes.

Indicative condition	Characteristics
Poor	Considerable geomorphic alteration to the functioning and structure of the system when compared with the pre-disturbance condition. Type, extent and rate of processes are radically altered. Floodplain connectivity may be significantly altered. Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and/or inappropriate patterns or rates of planform change and/or bank and bed erosion). Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity. Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

3.3 Regional Hydrology and Hydraulics

An assessment was undertaken to assess the potential changes to the subsidence affected catchments hydrology and hydraulics. A full report of this assessment in included in Appendix B with a summary of the investigation and outcomes detailed below.

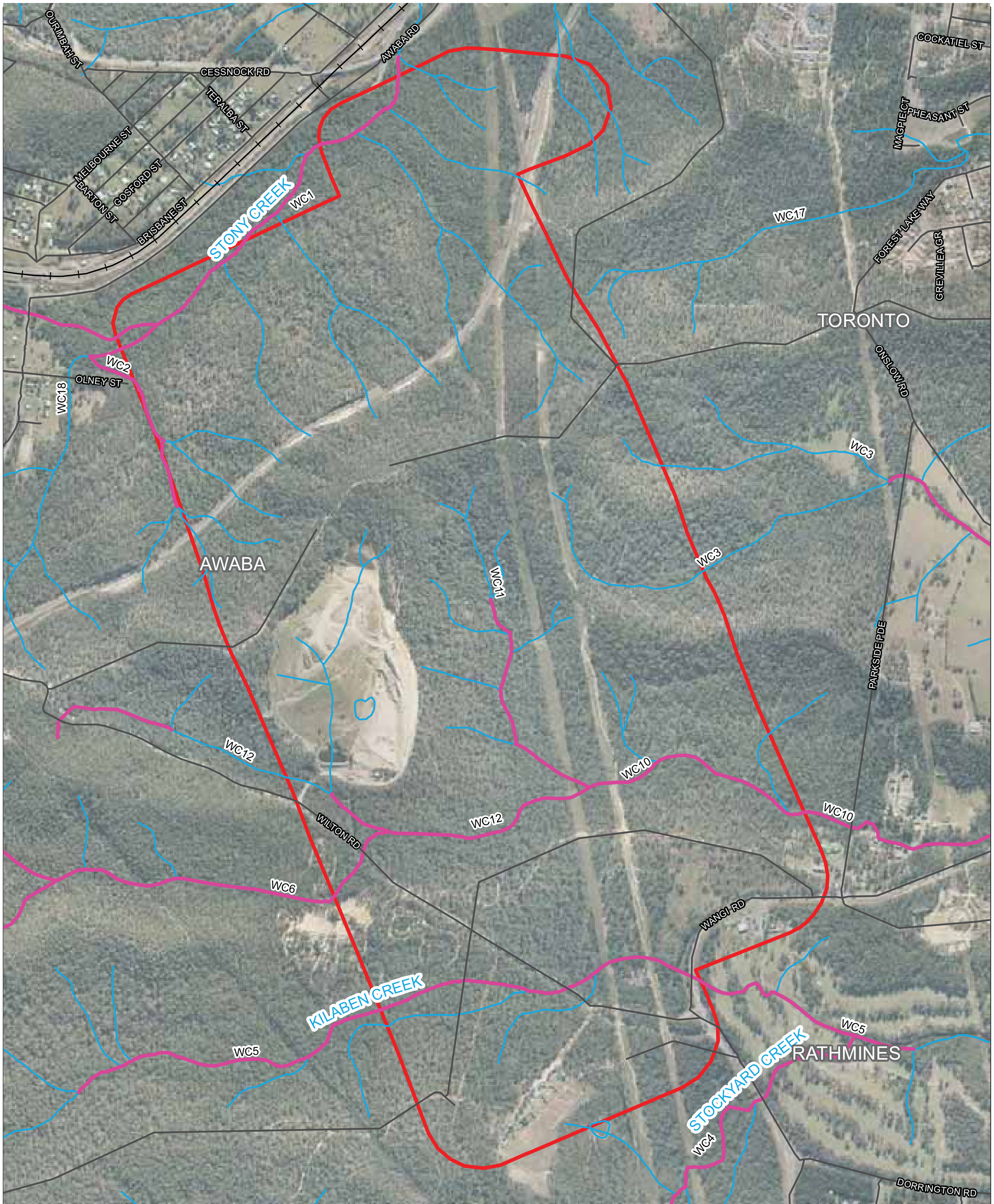
The hydraulic modelling incorporated in this assessment is provided for a comparative assessment of the investigation area. It is not intended to provide accurate flood extents for any other purpose aside for the stated purpose of this investigation. This includes (and not limited to) the provision of flood planning levels for Centennial Newstan or any 3rd party.

3.3.1 Modelling Methodology

The catchment was modelled using both XP-RAFTS (Version 7) to derive the rainfall and runoff, and TUFLOW (Ver. 2011-09-AE-iDP-w64) to model and assess the hydraulics of the catchment. The modelling assessed a catchment of over 2160 ha and included:

- The full catchment of Kilaben Creek (WC5).
- The full catchment of Stockyard Creek (WC4).
- The full catchment of Two un-named creeks consisting of WC6, WC10, WC11, WC12 & WC3 all of which discharge into Kilaben Bay.
- Stony Creek consisting of WC1, WC2 and WC7 upstream of Cessnock Road.

Details of the assessment area and watercourses assessed are depicted in Figure 3-2 and Figure 3-3.



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Assessed Creeks
- Roads
- Railway
- Waterways
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Assessed Creeks During Field Works

Centennial Newstan

DATE 17/04/2012 Figure 3-2

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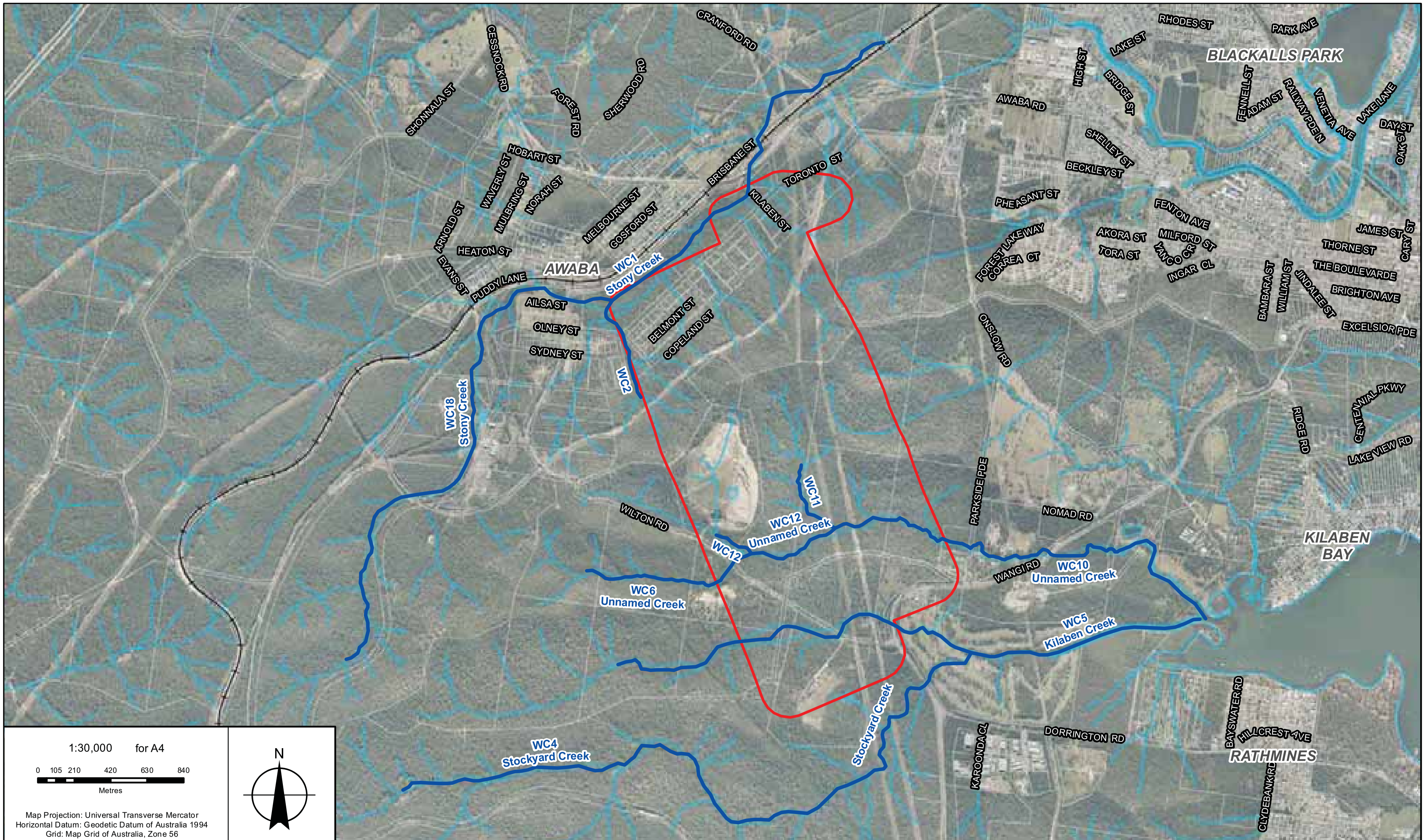

LEGEND

- Modelled Creeks
- SMP Study Area
- Railway
- Cadastre

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment
Hydraulic Geomorphic Assessment Extents

Centennial Newstan

DATE 17/04/2012

Figure 3-3

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A number of model runs were performed to assess the potential impacts of the estimated subsidence which included both the existing and proposed surface levels coupled with varying ARI events as summarised in Table 3-2. For each ARI event, a number of standard storm durations were assessed including:

- The short duration, high intensity but low volume 10 minute storm.
- The long duration, low intensity but high volume, 72 hour storm.

Typically the upper, smaller catchments are more responsive to the shorter duration storms whereas the larger low-lying catchments are more influenced by the longer duration events. Consequently the assessment covers a wide range of storm events which would assess a ranging spread of flood events. For each ARI the reported flood level or extent is taken as the widest flow or deepest level for that ARI, regardless of duration.

Table 3-2 TUFLOW Model Assessment

Estimated Flood Event	100 yr ARI	20 yr ARI	10 yr ARI	2 yr ARI
Existing Conditions	✓	✓	✓	✓
Subsided Conditions	✓	✓	✓	✓
Existing Conditions – with lake level rise	✓	×	×	×
Subsided Conditions – with lake level rise	✓	×	×	×

3.4 Hydraulic Geomorphic Assessment

The hydraulic geomorphic assessment focused on a change in flooding conditions due to subsidence for storm events of 3 months to the a 2 year ARI interval. Specifically this included the investigation of flood levels, depths and velocities for each storm event for the existing conditions and predicted subsided surface.

A hydraulic assessment of each of the creeks was undertaken using HEC-RAS (version 4), a one dimensional depth averaged model developed by the US Army Corp of Engineers.

The HEC-RAS geometry data was derived from LIDAR data supplied from Centennial Newstan in December of 2011. From the developed digital terrain model (DTM) surface, model cross sections were cut at a maximum spacing of 50 m depending on topography and creek conditions. For the predicted subsidence area, the subsidence contours, provided by MSEC (2012), were inserted into the existing surface. The model cross sections were recut to develop the proposed impact surface.

A literature review for Manning's values appropriate for various channel conditions was undertaken. Through this it was determined that Chow (1959) provided comprehensive documentation of the roughness associated within channels and the overbank portion of the natural flow path.

Table 3-3 Channel Conditions

Channel Type	Chow (1959)
Channel Base	Sluggish reaches, weedy, deep pools: 0.05 - 0.08
Overbank	Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches: 0.08 - 0.12

For the hydraulic assessment, Mannings n values of 0.07 and 0.1 were adopted for the channel and overbank areas of the hydraulic assessment. This was based on site inspections and the values typically reflect a sluggish and weedy creek with comparatively deep pools and overbank flows through dense brush.

This model differs from the regional hydraulic assessment (Section 3.3) in that the waterway form is defined. The regional hydraulic model, discussed in Section 5.2, focuses on the 2 year ARI to the 100 year ARI flows and the broad floodways with the details of the channels not modelled explicitly.

Flows for the HEC-RAS model were obtained from the XP-RAFTS model prepared for the catchment (Refer to Appendix C for details) for the 3 month, 1 year and 2 year ARI events.

4. Site Description

4.1 Land Uses

The location of the Project Area is within the Lake Macquarie Catchment situated between Toronto to the east and Awaba to the west. The area currently has a number of existing uses including the Awaba Waste Management Facility and the Newcastle Clay Pigeon Club wholly within the SMP boundary. Other uses include power easement, and roads infrastructure. The remainder of the land is forested.

4.2 Existing Infrastructure

Existing infrastructure located within the SMP Study Area includes:

- Wilton Road
- Wangi Road
- Mine Haul Road
- Approximately Seven Significant Drainage Culverts
- Two Power Easements

Each one of these items of surface infrastructure has the potential to be impacted by the project and require an assessment of their existing purpose and current condition. The following sections below will provide a brief background into these areas.

4.2.1 Roads

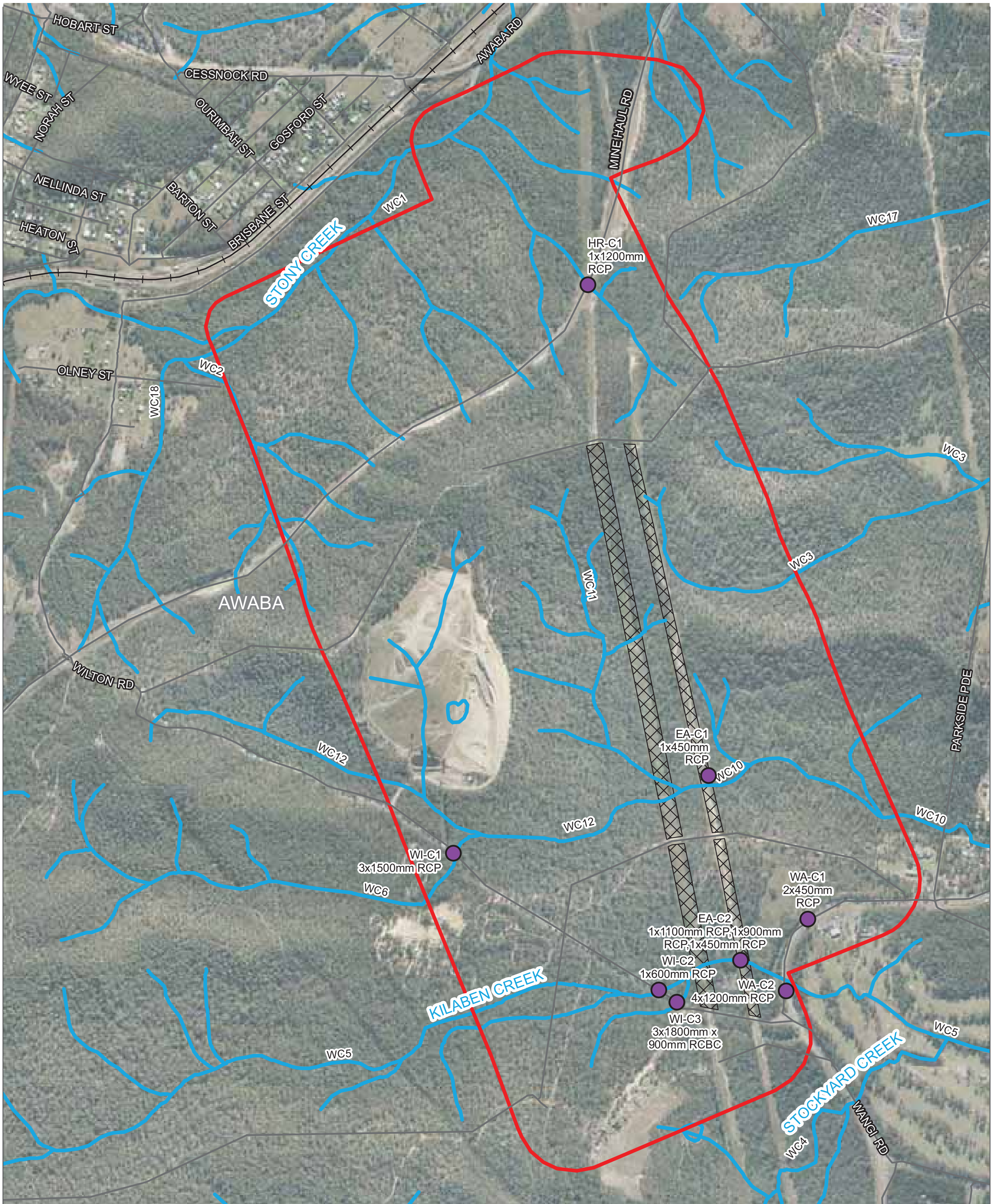
There are three major roads within the SMP Study Area. Wilton Road is located within the southern section of the SMP Study Area and has approximately 0.8 km of road directly above the proposed Longwalls LW102 and 103. The road is maintained by Lake Macquarie City Council (LMCC) and is bitumen with grass verges (MSEC; 2012).

Wangi Road is also located within the southern portion of the SMP Study Area though will not be directly mined beneath, and is situated approximately 0.1 km to the south of Longwall LW101. The road is maintained by Roads and Maritime Services (RMS), and is bitumen with concrete kerb and guttering in parts.

The most significant road infrastructure within the SMP Study Area is the Mine Haul Road which is used for road coal haulage between the Eraring Power Station and Newstan and Mandalong Mines. The road crosses over Longwall LW101, 102 and 103 within the northern portion of the SMP Study Area with approximately 0.8 km of the road directly mined beneath. The road is bitumen with grass verges as well as a number of large fill embankments and several cuttings. The cuttings include a number of road side table drains to convey water out, into the culverts and out to the creeks within the area.

4.2.2 Culverts

A total of seven culverts have been identified within the SMP Study Area for assessment. The seven culverts are predominantly in place to service the drainage requirements of roads present within the SMP Study Area. The culverts assessed are shown on Figure 4-1.



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0 50 100 200 300 400
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND
- Assessed Culverts
- Railway
- Roads
- Waterways
- SMP Study Area
- Electrical Easements Assessed

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Existing Infrastructure

Centennial Newstan

DATE 18/04/2012

Figure 4-1

GIS Filename: N:\AU\Newcastle\Projects\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_018_Figure4-1_ExistingInfrastructure.mxd

Each of the culverts have been assessed with the findings summarised in Table 4-1, (MSEC;2012).

Table 4-1 Culvert Assessment

Road Located On	Culvert Reference	Type	Location
Wilton Road	WI-C1	3 x 1500 mm Circular Concrete Culverts	Unnamed Creek, WC6
	WI-C2	1 x 600 mm Circular Concrete Culvert	Kilaben Creek Tributary, WC5
	WI-C3	3 x 1800 mmW x 900 mmH Concrete Box Culverts	Kilaben Creek Tributary, WC5
	WI-C4	1 x 375 mm Circular Concrete Culvert	Minor Drainage Line
Wangi Road	WA-C1	2 x 450 mm Circular Concrete Culvert	Minor Drainage Line
	WA-C2	4 x 1200 mm Circular Concrete Culvert	Kilaben Creek, WC5
Mine Haul Road	HR-C1	1 x 1200 mm Circular Concrete Culvert	Minor Drainage Mine, Stony Creek Tributary,

The culverts identified in Table 4-1 have been discussed due to their significance on the project. There are more culverts within the SMP Study Area though these are less significant in the assessment of surface water impact.

4.2.3 Electrical Infrastructure

Two power easements were identified to exist within the SMP Study Area (MSEC; 2012). These can be described as two parallel 132 kV transmission lines owned by AusGrid. The lines are orientated such that they run almost north to south through the SMP Study Area. These two lines have been identified as the Western Branch and Eastern Branch. The applicability of these easements to this assessment is the suitability of access to the lines as required.

Associated with the Eastern Branch easement is an unsealed access track which follows the electrical infrastructure as it traverses the Study Area. This access track crosses the waterways of WC10 and Kilaben Creek (WC5) in two culvert crossings. The typical waterway crossing construction, for this form of easement, is a concrete causeway though in some instances culverts may be used, dependent upon the frequency and volume of flow received.

The Western Branch did not contain an access track and hence no crossings were found to exist.

The existing condition of the two identified crossings was deemed appropriate for the temporary and rarely used nature of the access track, with heavily vegetated waterways present up and downstream of the easement crossing.

Table 4-2 has been prepared summarising each crossing with a reference name, type and condition. The crossings have been included on Figure 4-1.

Table 4-2 Existing Electrical Easement Waterway Crossings

Branch	Crossing Reference.	Type	Condition
Eastern	EA-C1	1 x 450mm Circular Concrete Culvert	Minimum cover, deteriorated culvert with significant vegetation up and downstream.
	EA-C2	1 x 1100mm Circular Concrete Culvert, 1 x 900mm Circular Concrete Culvert, 1 x 450mm Circular Concrete Culvert	Existing 1100mm Culvert slumping. Each culvert is located at different inverts with approximately 1 to 2 meters of cover.

Photographs of the crossings at EA-C1 and EA-C2 where the Electrical Easement access track crosses WC10 and Kilaben (WC5) are shown in Figure 4-2.

Figure 4-2 Photographs of Electrical Easement Waterway Crossings EA-C1 (left) and EA-C2 (right)

4.3 Landforms and Topography

Figure 4-4 provides a portion of a 1:25,000 scale topography map for the Project Area. This figure indicates that the proposed works extend in a Northwest to south east alignment and that the proposed works will cross three watercourses being Stony Creek (WC1), Kilaben Creek (WC5) and an un-named creek consisting of WC6, WC12, WC10.

Site levels within the SMP Study Area range from over 100 m AHD down to 0 m AHD along the lower reaches of Kilaben Creek. The area has significant slopes ranging from 50% along the ridge lines down to less than 0.5% along the estuarine creek lines.

4.4 Climate

While rainfall data was made available by Newstan Colliery, this data only extended from approximately July 2011 to March 2012 (Current) and subsequently not sufficient for a historical average.

Data was obtained from Silo based on the site coordinates. The period of data used in this assessment extended from January 1901 through to December 2011 and is presented in Figure 4-3. The statistics for this rainfall data set were:

- Minimum annual rainfall – 528 mm in 1944.
- Average annual rainfall – 1117 mm.
- Median annual rainfall – 1071 mm.
- Maximum annual rainfall – 2012 mm in 1950.

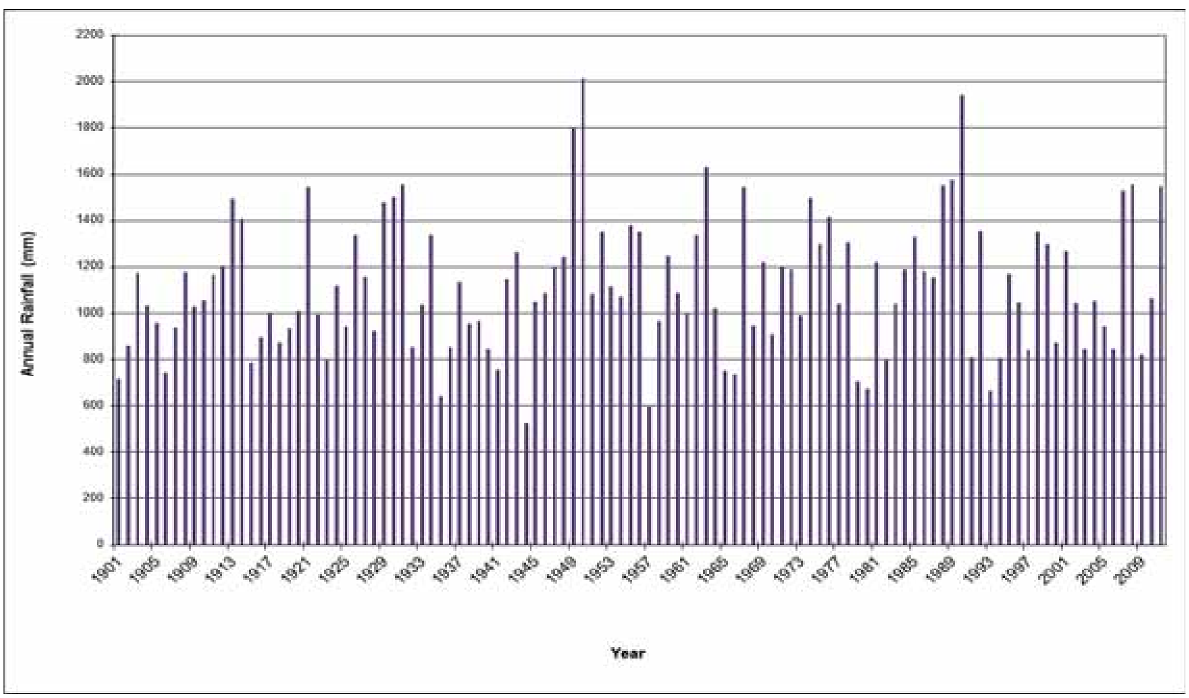
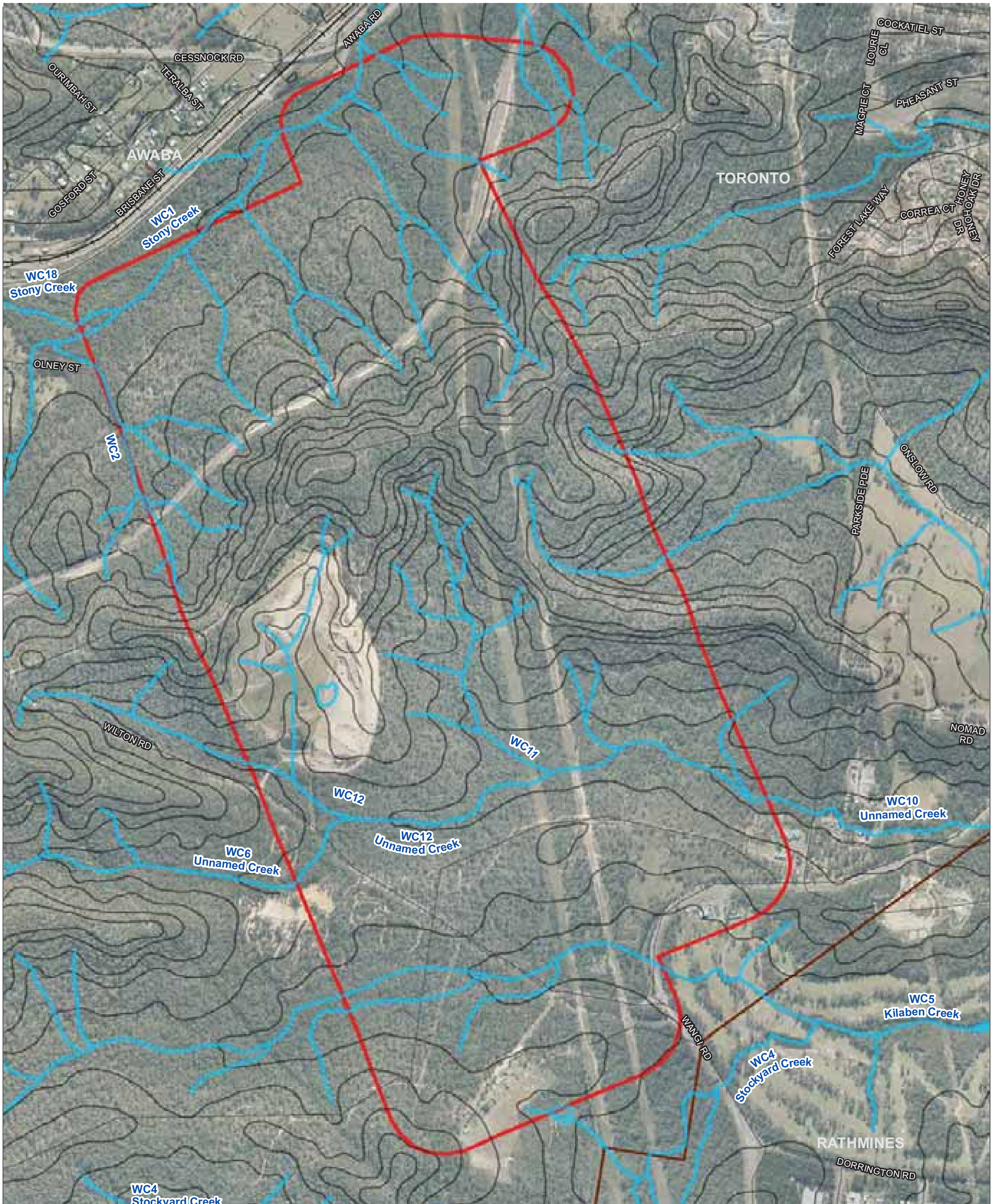


Figure 4-3 Annual Rainfall at Newstan Colliery (1901-2011; SILO Data)



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0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- 10m Contours
- Railway
- Roads
- Proposed Final Newstan Colliery Holding Boundary
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment

Project Area Topogrpahy

Centennial Newstan

DATE 17/04/2012

Figure 4-4

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_015_Figure4-2_ProjectAreaTopography.mxd

The monthly rainfall statistics were also determined for the period of record and selected statistics are provided in Figure 4-5. The average monthly rainfalls were observed to vary from a low of approximately 61 mm in August to a high of approximately 127 mm in February. Figure 4-5 shows a significant variation in the maximum recorded monthly rainfalls with the maximum monthly value being approximately 630 mm in February to a lowest maximum monthly value of approximately 221 mm in September.

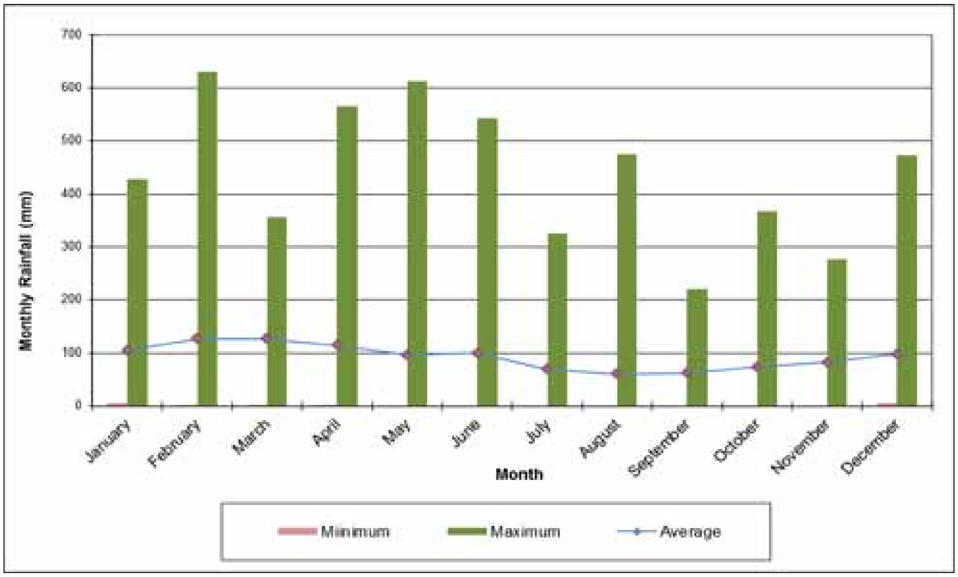

Figure 4-5 Monthly Rainfall Statistics, (1901-2011; SILO Data)

An analysis of the rainfall data was undertaken to enable an understanding of the likely rainfall patterns at the site. For various intervals of daily rainfall (rainfall depths), the average number of days per year which fall within each interval are presented in Figure 4-6. The graph also presents the cumulative days per year as a percentage against the same rainfall intervals.

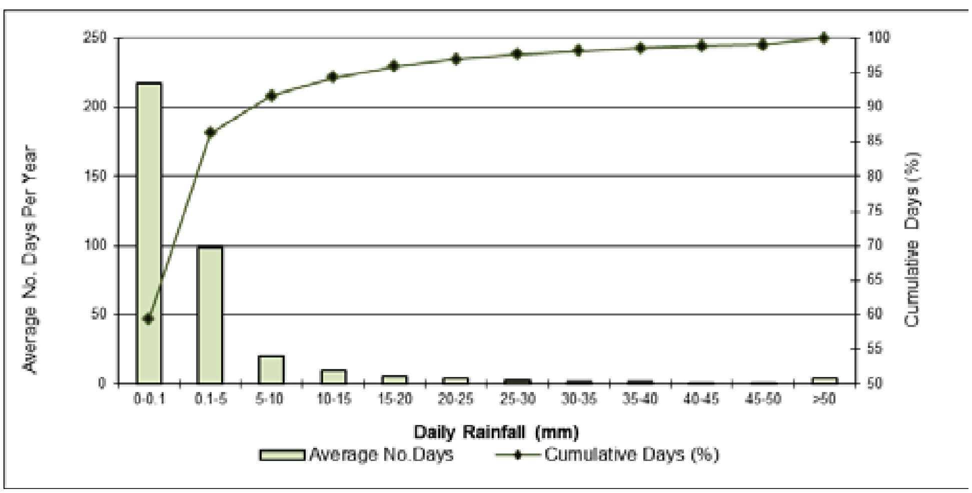

Figure 4-6 Number of Rain Days of Various Magnitudes

As presented in Figure 4-6, the average number of non- rainfall days per year is approximately 217 which is approximately 60% of days in a year. 27% of days per year receive between 0.1 and 5 mm of rainfall.

The data presented in Figure 4-6 was amended to exclude days without recorded rainfall. This enables a more detailed view of the statistical distribution of rainfall depths on rainy days. As shown in Figure 4-7, daily rainfall depths are greater than 10 mm, approximately 8% (or 30 days per year), on average, with approximately 3% of days in the year (or 11 days) receiving greater than 25 mm of rain.

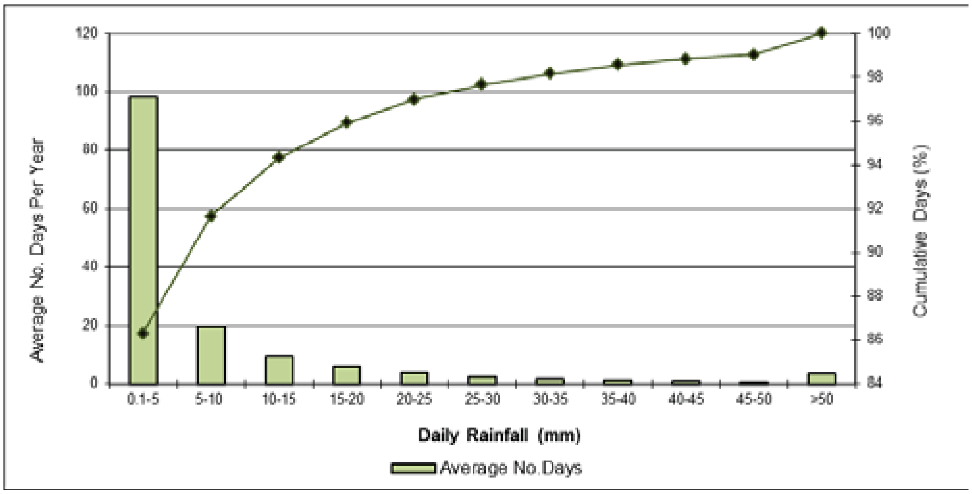

Figure 4-7 Number of Rain Days of Magnitudes, greater than 0 mm.

4.5 Geology and Soils

The SMP Study Area soil types, as identified by Murphy (1992) *Soil Landscapes of the Gosford-Lake Macquarie*, are the Awaba, Doyalson Warners Bay and Wyong soil types. A summary of the soil types are included below.

Awaba Soils are characterised by steep and low rolling hills on predominantly coarse-grained or hard setting soils. The Awaba consist of shallow Lithosols on the steeper slopes and transition to a moderate to deep Soloths on the gentler slopes. In the drainage lines Yellow and Gleyed Podzolic Soils are formed on fine grained substrates. These soils are considered to be a very high erosion hazard and are prone to rill and sheet erosion with a moderate erodibility for non-concentrated flows and a high erodability for concentrated flows. The soils are strongly acidic with typically a low fertility.

Doyalson Soils have similar properties of the Awaba soil landscape with these soils located on the higher elevations in the area. The Doyalson soils are moderately deep Yellow Earths, Yellow Podzolic and Soloths overlaying the Conglomerate Sandstone and Yellow Leached Earths, Grey Earths, Gleyed Podzolic. These soils are occurring on the drainage lines and they typically have a high erosion hazard with a high erodability for both non-concentrated and concentrated flows. The soils are strongly Acidic and have low fertility and are prone to seasonal waterlogging.

Warners Bay soils are moderately deep to deep Grey and Yellow Podzolic soils and structured loams. The soils are predominantly located on steep slopes and have potential for mass movement. These soils are considered a high erosion hazard which is prone to rill and sheet erosion with a moderate erodibility for non-concentrated flows and a moderate to high erodability for concentrated flows. They are strongly Acidic and low fertility.

Wyong Soils are poorly drained deltic soils of the floodplain and alluvial flats. The soils are predominately deep Yellow Podzolic , Brown Podzolic Soils with Soloths and Humus Podzols around the Lake edges. The soils are prone to waterlogging and are strongly acidic with low fertility.

5. Existing Environment

5.1 Waterways Conditions

The following sections outline the outcomes of the assessment of the existing geomorphology of waterways within and surrounding the SMP Study Area. The waterways inspected for the purpose of this assessment were predominately set within unpopulated bushland with a smaller area around mine related surface infrastructure as well as some areas of private land. The Awaba waste facility is also situated within the subsidence management plan project area. Most waterways within the project area are ephemeral in nature however significant flows were observed at some of the creeks due to substantial rain in the days and weeks before the site inspections.

The waterways assessed in the field were predominantly third and fourth order streams, however, although a second order creek, Kilaben Creek (WC5) was also inspected due to its relative large catchment area upstream of the SMP Study Area. All other waterways that were not assessed were identified as first and second order streams, as displayed in Figure 3-2. As most waterways in the project area are unnamed, the streamlines for higher order waterways have been attributed with a waterway identifier as shown in Figure 5-1.

Within the project area, third and fourth order streamlines include:

- WC1 (Stony Creek).
- WC2 (Tributary to Stony Creek).
- WC11, WC12 and WC10 which comprise reaches of an unnamed waterway catchment that drains to Kilaben Bay.

In addition, Kilaben Creek has been considered a significant second order stream and has been attributed with the identifier WC5.

5.1.1 Waterway Types

A total of four (4) different stream types (not including the “highly modified” drainage lines existing on the Awaba Waste Management Facility) were identified during the field assessment of the waterways within the SMP Study Area.

The stream types identified included:

- The Confined Valley Setting (CVS) types of Headwater and Floodplain Pockets Gravel.
- The Partly Confined Valley Setting (PCVS) type of Planform Controlled Low Sinuosity Fine Grained.
- The Laterally Unconfined Valley Setting (LUVS) type of Low Sinuosity Fine Grained.
- The Swampy Meadow Group (SMG) types of Swamp, Valley Fill and Chain of Ponds.

The distribution of stream types within the Study Area is displayed in Figure 5-2 and their characteristics are described in Table 5-1.

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0 50 100 200 300 400
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- 1st
- 2nd
- 3rd
- 4th
- Roads
- Railway
- Waterways
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

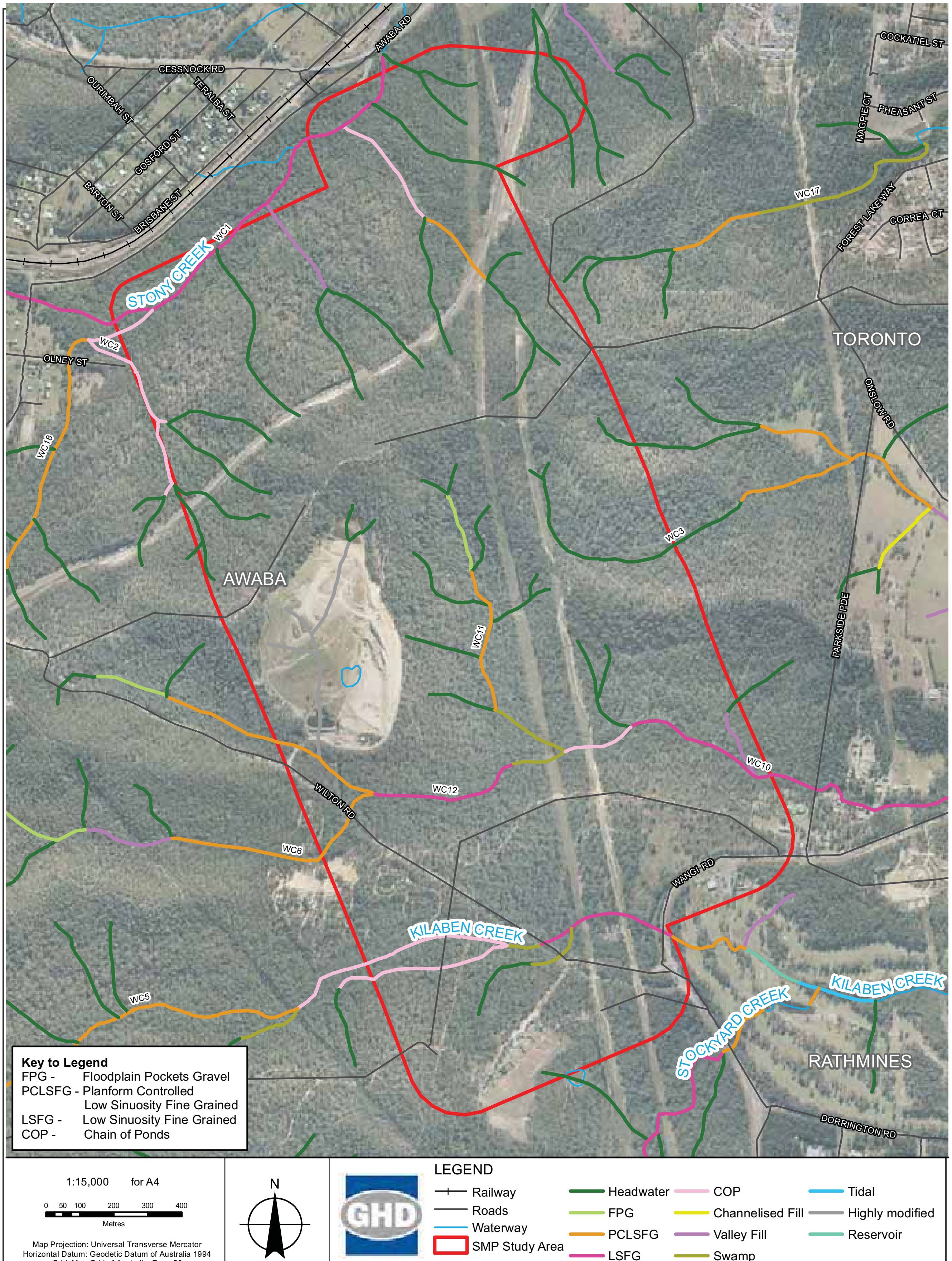
Strahler Stream Order Assessment

Centennial Newstan

DATE 17/04/2012

Figure 5-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_009_Figure5-1_StrahlerStreamOrderAssessment.mxd



LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Waterway Types

Centennial Newstan

DATE 17/04/2012

Figure 5-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_008_Figure5-2_WaterwayTypes.mxd

For the most part, waterways of third and fourth order streamlines and Kilaben Creek are fine-grained systems and do not transport bed load sediments (sand and gravel) in any significant quantity. As a result, channels (where they exist) do not exhibit a defined pool riffle sequence and bed controls are limited to vegetated zones comprised of alluvial sediments separating long pool sections. Vegetation is therefore considered the key control on channel form of the waterways within the project area.

Table 5-1 Riverstyle Characteristics within the SMP Study Area

Riverstyle	Characteristics	Photo
Headwater	Headwaters consist of steep gradient channels that are bedrock dominated and have limited deposits of sediments within the channel. Floodplains are non-existent. The channel may slowly erode the valley wall if it consists of weathered bedrock or colluvium. • All of the headwater systems are unnamed drainage lines in upper catchment positions. • Generally in good condition. • Majority are first order streams with some being second order streams with small catchment areas.	
Floodplain Pockets Gravel	Single, bedrock or terrace confined, channel with low sinuosity. Small floodplains occur at isolated wider sections of the valley. Channel bed is dominantly composed of bedrock with forced pools and runs separated by short, steep riffles of bedrock steps. Bed loads are usually dominated by cobble or gravel dependent on local geology. • Only one Floodplain Pockets Gravel exists within the SMP Study Area along an unnamed watercourse. • Exists in moderate to good condition and is a second order stream.	

Riverstyle	Characteristics	Photo
Planform Controlled, Low Sinuosity, Fine Grained	Single, trench-like, symmetrical low sinuosity channel set within a partly confined valley. Low width to depth ratio channel flows through valleys up to 300 m wide at valley floor. The channel is moderately laterally stable with slow rates of lateral migration through concave bank erosion. Cohesive fine-grained sediments dominate bed and alluvial banks. • Located along four reaches within the SMP Study Area. • Exists mainly in good condition with some moderate to good reaches. • Located along unnamed second and third order streams.	
Low Sinuosity Fine Grained	This waterway type exhibits a low sinuosity channel with wide, continuous floodplains and relatively stable, cohesive banks due to the fine-grained material. The bed consists of fine-grained sediments with some sand and gravel sections creating moderate hydraulic diversity. The channel itself is of low gradient and usually low energy allowing a build-up of fine-grained sediment. • Found in the SMP Study Area at lower catchment positions. • Kilaben and Stony Creek contain Low Sinuosity Fine Grained reaches. • Exist in moderate and good conditions. • Located along second, third and fourth order streams.	

Riverstyle	Characteristics	Photo
Chain of Ponds	These waterways display a series of symmetrical (occasionally irregular) ponds that occur at irregular intervals along a drainage line. The bank of the ponds and the bed in which they exist is composed of fine sand, mud and organic material. Ponds tend to retain water throughout the year and during high flows, sands and finer material are transported downstream. This waterway type is often associated with lower gradients and lower flow velocity. Typically a Chain of Ponds system can be prone to channelisation between the ponds forming a continuous channel. This reduces the water retention capacity of the ponds with associated loss of aquatic habitat. Once incised, recovery back to a chain of ponds system is limited. • Found in the SMP Study Area in middle to lower catchment positions. • Kilaben Creek has a large chain of ponds reach. Other reaches are located on unnamed waterways. • All chain of ponds within the SMP Study Area exist in good condition. • Located along first, second, third and fourth order streams.	

Riverstyle	Characteristics	Photo
Valley Fill	These systems are characterised by a relatively flat, unincised valley floor surface that lacks a continuous, well-defined channel. Substrates are comprised of alluvial fine silts and muds. Such features are typically formed by flows that lose their velocity and competence as they spread over an intact valley floor and deposit their sediment load. This allows a large proportion of sediment derived from upstream reaches to be trapped and stored within these reaches. Hence, these stream types act as long term sediment accumulation zones. The valley floors of these systems are heavily vegetated with a range of water dependant vegetation types. Degradation of these systems generally occurs through incisional processes such that a continuous channel forms within the valley floor sediments. Once incised, recovery back to an intact valley system is limited. • Found in limited locations within the SMP Study Area along first and second order waterways. • Reaches are in good condition.	

Riverstyle	Characteristics	Photo
Swamp	These systems are geomorphically similar to valley fills in that they exhibit an unchannelised valley floor surface. The main difference is that swamps are generally permanently inundated with water. As a result, swamp systems exhibit vegetation indicative of wet conditions such as melaleuca, sedge and tussock. Material eroded from the catchment is not transported through the reach, which is often on a relatively flat longitudinal grade. • Found in limited locations within the SMP Study Area. • Most reaches are located on unnamed waterways however a section of Kilaben Creek has been defined as Swamp. • Swamp reaches exist as first, second and third orders and are all in good condition.	

5.1.2 Gradients

Based on this assessment and other assessments of waterways in the area, the gradient associations for waterway types found in the SMP Study Area are displayed in Table 5-2. This indicates that Confined Valley Setting types generally have relatively moderate to high gradient associations, while the other groups generally have low to moderate gradient associations. The exception to this is that Swamp and Valley Fill both have associations with relatively higher gradients. A review of the higher gradient Swamp and valley Fill waterway types indicates that they were typically located upstream of existing rail and road embankments. As a result, they are considered to have developed from the construction of the embankment, in response to a poor flow conveyance through the embankment, causing flow back-up and sediment deposition.

Table 5-2 Relationship between Gradient and Waterway Type

Group	River Styles	Gradient Range (m/m)
Confined Valley Setting	Floodplain Pockets Gravel	0.043 – 0.137
	Headwater	0.017 – 0.200
Partly Confined and Laterally Unconfined Valley Settings	Planform Controlled Low Sinuosity Fine Grained	0.001 – 0.035
	Low Sinuosity Fine Grained	0.003 – 0.014

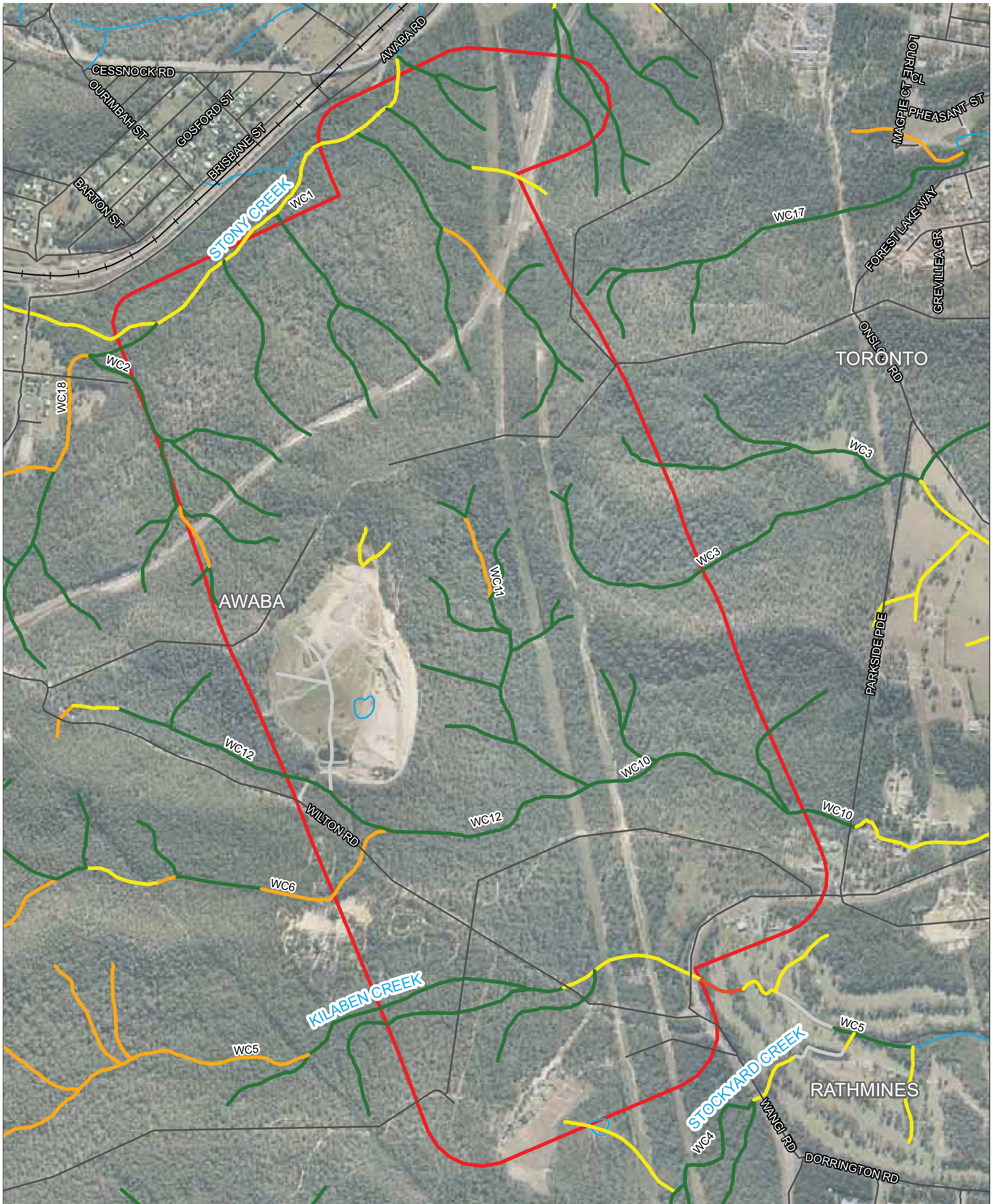
Group	River Styles	Gradient Range (m/m)
Swampy Meadow Group	Swamp	0.002 – 0.092
	Chain of Ponds	0.008 – 0.025
	Valley Fill	0.005 – 0.091

5.1.3 Waterway Existing Condition

The geomorphic condition of the assessed streamlines in the Study Area is displayed in Figure 5-3. Due to the relatively undisturbed nature of the SMP Study Area, most of the streamlines assessed were in good condition (54.2% of the assessed waterway length).

Moderate condition reaches (42.7% of the assessed waterway length) generally exhibited moderate channel instability in the form of localised bank erosion. These reaches are typically associated with degraded riparian vegetation conditions and generally display evidence of past channel incision and ongoing localised lateral instability.

Only one poor condition reach (3.1% of the assessed waterway length) was identified along WC5 where this waterway ran through the golf course at Toronto Country Club. This waterway was in a poor condition as a result of an existing headcut (~1 m high) situated approximately halfway along the assessed length of the waterway. The ongoing progression of the headcut generated an incised channel with unstable banks and this is likely releasing sediments downstream.



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0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Good
- Moderate to Good
- Moderate
- Poor
- None
- Roads
- Railway
- Waterways
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Assessed Stream Condition

Centennial Newstan

DATE 17/04/2012

Figure 5-3

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_010_Figure5-3_AssessedStreamCondition.mxd

Dammed waterways and the modified waterways crossing the Awaba Waste Management Facility were assessed as having no condition as fluvial geomorphic processes no longer operate along these waterways.

5.1.4 Waterway Stability

Most third and fourth order waterways and Kilaben Creek in the study area were considered to be relatively geomorphologically stable. This was a reflection of the densely vegetated nature of the waterways and the cohesive, fine grained alluvial soil landscape that they flow through.

Nevertheless, some waterways displayed localised instabilities in the form of either headward erosion or bank erosion. These instabilities and their locations are discussed in detail within the following sections.

5.1.5 Bed Instability – Headward Erosion

Headward erosion (‘headcut’) is erosion which occurs along a channel in the opposite direction to flow. This causes down cutting or incision of the bed of a stream and can alter the longitudinal profile of the waterway. Erosion can result in increased rates of sediment to be transported downstream.

Evidence of headward erosion in the SMP Study Area was limited to a section of WC11 Based on this assessment and other waterway assessments in the area, headward erosion along waterways did not usually result in a reduction of overall creek condition. Generally the headcuts are minor (less than 0.5 m high) and waterways rapidly return to their existing condition following passage of the headcut. This is evidenced by the extent of visible bank disturbance, generally limited to be within 5 m downstream of the headcut. This indicated that most observed headcuts were migrating upstream at relatively slow rates, allowing vegetation to recolonise and re-stabilise the disturbed channel banks before the headcut has retreated much further upstream.

5.1.6 Bank Instability

Bank instabilities were evident in some localised sections of waterways assessed however most creek banks within the study area are generally stable under the current flow regimes. This is due partly to the waterways being well-vegetated and partly to the cohesive nature of the silty alluvial soils.

5.2 Regional Flooding Conditions

Existing Catchment Conditions

The existing catchments within the SMP Study Area had varying flow depths and velocities for all of the ARI events assessed with very little change in the magnitude of the velocities between the 2 year ARI event and 100 year ARI events for identical locations. The range of velocities on the identified watercourses vary from a high of approximately 6 m/s on WC11 (a tributary of the unnamed creek) where the slopes are 50% down to less than 0.5 m/s in the estuarine reaches of WC5 (Kilaben Creek).

The regional flooding assessment can be referenced in detail within Appendix B. A discussion on the subsided results are summarised in Section 7.

5.3 Water Quality

In reviewing the existing water quality associated with the Newstan SMP Study Area, consideration was given to ten (10) water monitoring points (WMP). These locations are referred to as:

- WMP27
- WMP28
- WMP29
- WMP30
- WMP31
- WMP32
- WMP33
- WMP34
- Upstream
- Downstream

The locations referred to as Upstream and Downstream are sampling locations specific to the Centennial Awaba Colliery Water Quality Management Program. These two locations have been included in the assessment as they are located close to the SMP Study Area, and contain a slightly larger dataset. All the water quality sampling locations are indicated spatially on Figure 5-4.

5.3.1 Period of Data

The period of data reviewed for each of the monitoring locations is provided in Table 5-3. These locations have been sampled monthly and analysed for pH, EC (Electrical Conductivity), TSS (Total Suspended Solids), oil and grease, turbidity and total metals. A sample of the data assessed is provided in Appendix A.

Table 5-3 Water Monitoring Points Data Period

Monitoring Location	From Date	To Date
WMP27	June 2011	January 2012
WMP28	June 2011	December 2011
WMP29	June 2011	January 2012
WMP30	June 2011	January 2012
WMP31	June 2011	December 2011
WMP32	June 2011	December 2011
WMP33	June 2011	January 2012
WMP34	June 2011	December 2011

Monitoring Location	From Date	To Date
Upstream	March 2011[(a)]	February 2012
Downstream	March 2011[(a)]	March 2012

(a) The complete datasets for monitoring locations Upstream and Downstream commence in 2007, however it was considered that only the most recent data be considered for this assessment to minimise the effects of previous mining at Awaba Colliery.

An investigation into the availability of a comparative set of water quality monitoring data of a longer period was undertaken. Sampling locations within the surrounding Lords and Stockyard Creeks were investigated separately with comparisons made to the results indicated for the sampling locations specific to the SMP Study Area. This investigation is discussed in Section 5.3.4.

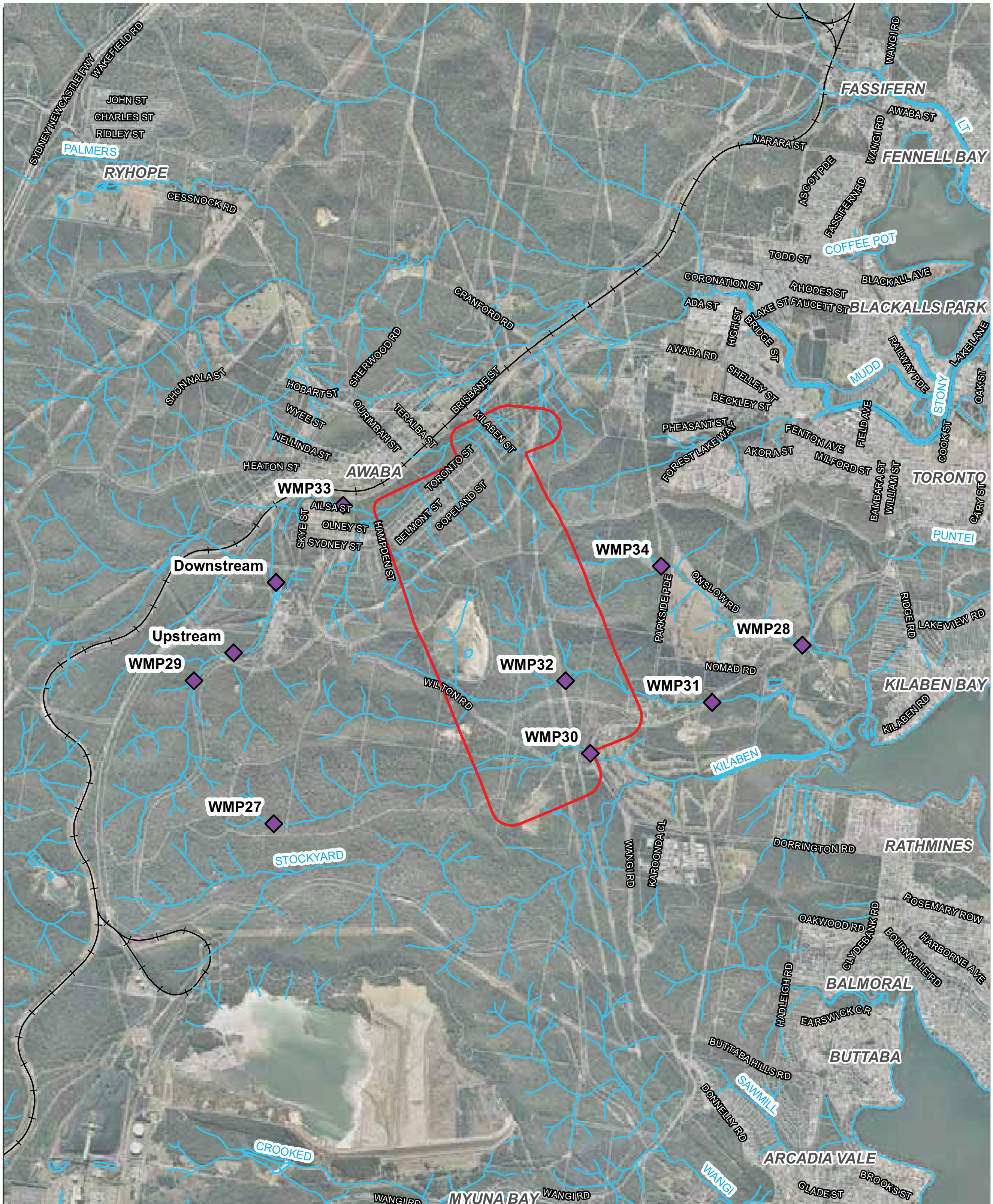
Water Quality Default Trigger Values

Australian and New Zealand Environment and Conservation Council (ANZECC) / Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) default trigger values that apply to this site are outlined in Table 5-4. They include stressor trigger values for Lowland or Coastal Rivers and default Freshwater and Coastal trigger values for the protection of 95% of aquatic species. Note that default trigger values for heavy metals apply to dissolved concentrations.

Table 5-4 ANZECC/ARMCANZ (2000) Default Trigger Values

Parameter	Freshwater / Lowland Rivers	Estuaries / Coastal Rivers	Comment
pH	6.5-8.0	7.0-8.5	Lowland river, SE Australia (Table 3.3.2, ANZECC/ARMCANZ 2000).
Electrical Conductivity (EC)	< 2200 µS/cm	-	Lowland river, SE Australia (Table 3.3.3, ANZECC/ARMCANZ 2000), NSW coastal rivers typically 200-300 µS/cm.
TSS	< 50 mg/L	6 mg/L	Lowland river, NSW (Table 8.2.12, ANZECC/ARMCANZ 2000), NSW coastal rivers 6 mg/L.
Turbidity	< 50 NTU	0.5-10 NTU	Lowland river, SE Australia (Table 3.3.3, ANZECC/ARMCANZ 2000). NSW coastal rivers 6 NTU.
Aluminium	0.055 mg/L	-	Applies for pH > 6.5.
Arsenic	0.013 mg/L	-	Guideline for As(V).
Boron	0.37 mg/L	-	
Cadmium	0.0002 mg/L	0.0055 mg/L	
Chromium	0.001 mg/L	0.0044 mg/L	
Cobalt	-	0.001 mg/L	

Parameter	Freshwater / Lowland Rivers	Estuaries / Coastal Rivers	Comment
Copper	0.0014 mg/L	0.0013 mg/L	
Iron	0.3 mg/L	-	Due to insufficient data, the Canadian guideline level is used as an interim indicative working level, as recommended by ANZECC/ARMCANZ (2000).
Lead	0.0034 mg/L	0.0044 mg/L	
Manganese	1.9 mg/L	-	
Nickel	0.011 mg/L	0.07 mg/L	
Zinc	0.008 mg/L	0.015 mg/L	



1:40,000 for A4 0 160 320 640 960 1,280 Metres Map Projection: Universal Transverse Mercator Horizontal Datum: Geodetic Datum of Australia 1994 Grid: Map Grid of Australia, Zone 56	N	LEGEND SMP Study Area Waterways Surface Water Quality Monitoring Points

	LOCATION	Newstan	Newstan Subsidence Management Plan Surface Water Impact Assesment Surface Water Quality Monitoring Points	Centennial Newstan	
	SEAM				
	DRAWN	M.B.			
	CHECKED				
	APPROVED				
	SCALE	refer to scalebar		DATE 27/04/2012	Figure 5-4

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_014_Figure5-4_WaterQualityMonitoringPoints_.mxd

Existing Surface Water Quality Data for Centennial Newstan

ANZECC (2000) procedure for the establishment of site specific trigger values involves the calculation of an 80th percentile concentration of background and baseline data. A statistical summary of available data for the WMPs within the Project Area are provided in Table 5-5.

Table 5-5 Statistical Summary of Water Quality Monitoring

Parameter		Range of Valves									
		WMP27	WMP28	WMP29	WMP30	WMP31	WMP32	WMP33	WMP34	Upstream	Downstream
pH	Range	5.1-5.7	6.1-7.4	5.5-6.3	4.6-6.7	6.5-7.8	6.5-7.5	6.2-7.0	4.8-5.4	6.5-7.0	3.1-7.2
	80%	5.7	6.7	6.3	6.6	6.9	7.2	7.0	5.3	6.9	6.8
EC (µS/cm)	Range	70-140	71-560	63-242	151-622	442-2910	538-3020	227-1430	129-248	143-179	55-3120
	80%	133	516	196	534	817	1262	1044	226	172	762
TSS (mg/L)	Range	7-11	5-30	6-640	5-74	6-28	10-232	7-100	5-8	6-21	6-118
	80%	8	18	166	18	18	143	40	7	14	32
Oil and Grease (ppm)	Range	0	0	0	0	0	0	0	0	0	0-4
	80%	0	0	0	0	0	0	0	3	0	0
Turbidity (NTU)	Range	18-44	12-100	38-509	16-203	17-79	7-123	14-93	17-34	36-57	1-148
	80%	38	40	82	61	49	62	33	27	54	31

Parameter		Range of Valves									
		WMP27	WMP28	WMP29	WMP30	WMP31	WMP32	WMP33	WMP34	Upstream	Downstream
Aluminium (mg/L)	Range	1.380-2.640	0.400-2.250	2.200-11.700	0.410-6.800	0.740-2.330	0.360-3.320	0.050-2.320	0.980-2.490	2.470-4.360	0.180-20.000
	80%	2.178	1.220	4.420	3.026	1.780	2.096	1.274	1.250	3.880	1.990
Arsenic (mg/L)	Range	0.000-0.001	0.000-0.011	0.000-0.002	0.000-0.002	0.000-0.004	0.000-0.007	0.000-0003	0.000-0.002	0.000-0.004	0.000-0.011
	80%	0.000	0.004	0.001	0.001	0.002	0.002	0.002	0.000	0.002	0.003
Boron (mg/L)	Range	0.000-0.000	0.000-0.000	0.000-0.060	0.000-0.000	0.130-0.580	0.180-1.030	0.000-0.070	0.000	0.000-0.070	0.000-0.190
	80%	0.000	0.000	0.050	0.000	0.300	0.502	0.040	0.000	0.060	0.072
Cadmium (mg/L)	Range	0.000-0.004	0.000-0.001	0.000-0.000	0.000-0.000	0.000-0.001	0.000-0.000	0.000-0.000	0.000-0.007	0.000-0.000	0.000-0.012
	80%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Chromium (mg/L)	Range	0.001-0.002	0.000-0.002	0.002-0.010	0.000-0.006	0.001-0.026	0.003-0.020	0.000-0.002	0.000-0.002	0.002-0.004	0.000-0.029
	80%	0.002	0.002	0.004	0.002	0.006	0.007	0.002	0.001	0.003	0.002
Cobalt (mg/L)	Range	0.000-0.000	0.000-0.000	0.000-0.002	0.000-0.000	0.000-0.014	0.000-0.012	0.000-0.002	0.000-0.002	0.000-0.000	0.000-0.264
	80%	0.000	0.000	0.0001	0.000	0.002	0.003	0.000	0.002	0.000	0.013
Copper (mg/L)	Range	0.000-0.001	0.000-0.010	0.000-0.007	0.000-0.21	0.000-0.005	0.000-0.012	0.000-0.007	0.000-0.002	0.002-0.006	0.002-0.118
	80%	0.000	0.003	0.004	0.002	0.003	0.006	0.007	0.002	0.005	0.014

Parameter		Range of Valves									
		WMP27	WMP28	WMP29	WMP30	WMP31	WMP32	WMP33	WMP34	Upstream	Downstream
Iron (mg/L)	Range	0.44-2.15	1.28-7.07	1.250-7.780	1.5-4.2	1.56-4.1	0.47-16.5	0.57-3.66	1.240-4.760	1.480-3.100	0.090-22.100
	80%	1.9	2.26	3.350	3.7	2.9	5.132	3.384	4.000	2.896	4.416
Lead (mg/L)	Range	0.000-0.001	0.000-0.010	0.000-0.008	0.000-0.008	0.001-0.003	0.000-0.007	0.000-0.008	0.000-0.003	0.001-0.002	0.000-0.138
	80%	0.001	0.002	0.003	0.005	0.002	0.003	0.005	0.002	0.002	0.006
Manganese (mg/L)	Range	0.010-0.022	0.017-0.105	0.026-0.124	0.030-0.220	0.012-0.339	0.013-0.268	0.005-0.987	0.028-0.052	0.023-0.094	0.015-12
	80%	0.018	0.086	0.083	0.200	0.059	0.071	0.097	0.047	0.066	1.302
Nickel (mg/L)	Range	0.000-0.001	0.000-0.002	0.001-0.004	0.000-0.002	0.002-0.038	0.004-0.033	0.001-0.004	0.000-0.004	0.002-0.003	0.001-0.295
	80%	0.001	0.001	0.003	0.002	0.059	0.011	0.003	0.002	0.003	0.035
Zinc (mg/L)	Range	0.000-0.009	0.018-0.052	0.009-0.030	0.000-0.125	0.013-0.031	0.010-0.049	0.014-0.118	0.016-0.050	0.015-0.044	0.008-18.700
	80%	0.008	0.040	0.020	0.020	0.028	0.027	0.066	0.048	0.044	1.348

5.3.2 Results

The results reported for the monitoring locations were reviewed to identify the baseline conditions and how that compares with both the ANZECC/ARMCANZ (2000) default trigger value range for Freshwater/Lowland Rivers and that for Estuaries and Coastal Rivers.

From the results indicated in Table 5-5 the assessment of each analyte is provided below. Note that the horizontal broken lines in the Figures within the following sections indicate the ANZECC trigger values, to provide a visual comparison.

pH

The recommended ANZECC trigger range for pH is 6.5-8.0. Based on the monitoring data illustrated in Figure 5-5 obtained for the SMP, only WMP31 and WMP32 were fully within this range. The remainder of the WMPs were found to have a lower pH than that of the ANZECC trigger value. Based upon this data the surface water is generally considered to be slightly acidic.

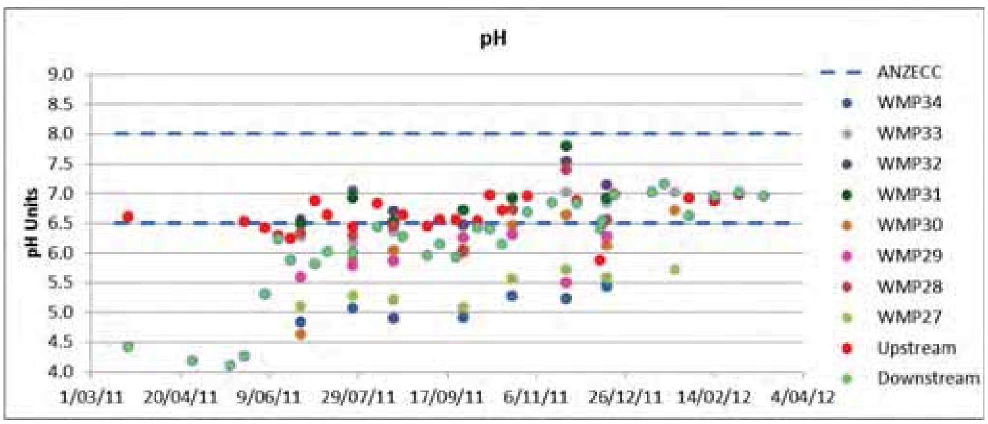


Figure 5-5 Water Quality Data – pH Levels

Electrical Conductivity (EC)

The ANZECC trigger value for EC is 2200 µS/cm. All of the reported results were below this value with the exception of three locations. The three sites exceeding this trigger value were WMP31, WMP32 and Downstream. These exceedences were two insistences occurring only on two occasions as shown in Figure 5-6. Based upon this data the surface water is generally considered to be fresh.

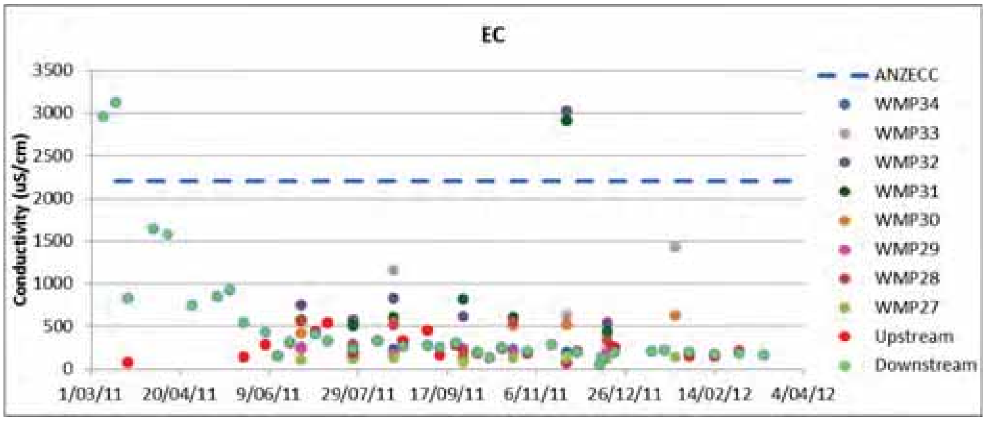


Figure 5-6 Water Quality Data - Conductivity Levels

Total Suspended Solids (TSS)

The ANZECC trigger level for TSS is defined as 50mg/L. The reported monitoring results indicate that 10% of the reported concentrations were above the trigger level. Sites WMP 27, 28, 31 and 34 had all sample concentrations below the trigger level.

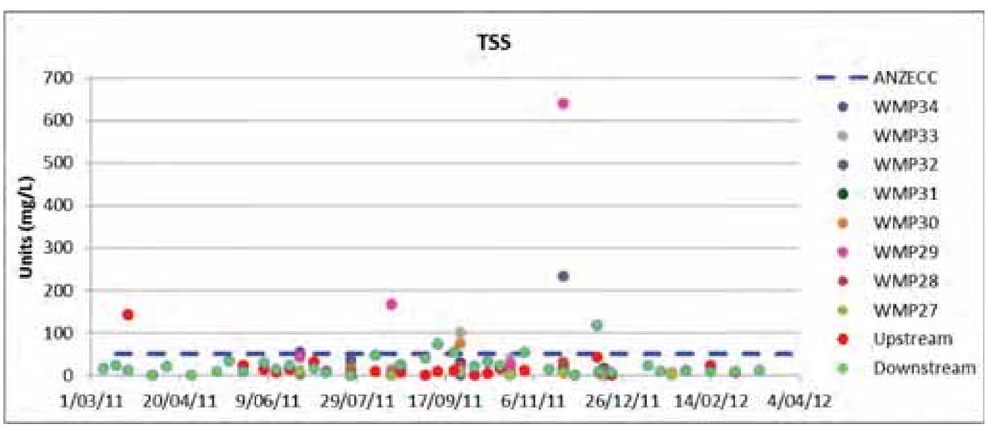


Figure 5-7 Water Quality Data – TSS Levels

Turbidity

The ANZECC trigger level for Turbidity is 50 NTU. From the monitoring results of the sites, 21% of the readings exceeded the ANZECC trigger value. Readings for WMP 27 and 34 were all below the ANZECC values.

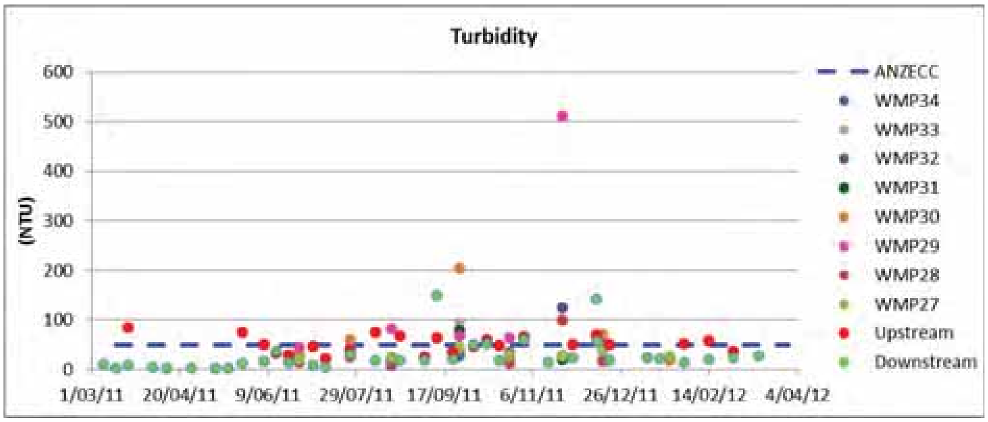


Figure 5-8 Water Quality Data - Turbidity

Oil and Grease

All results from the WMPs for Oils and Grease were below the recommended guideline concentration of 10 mg/L. This is an appropriate result given the current catchment land use types and the location of the monitoring points.

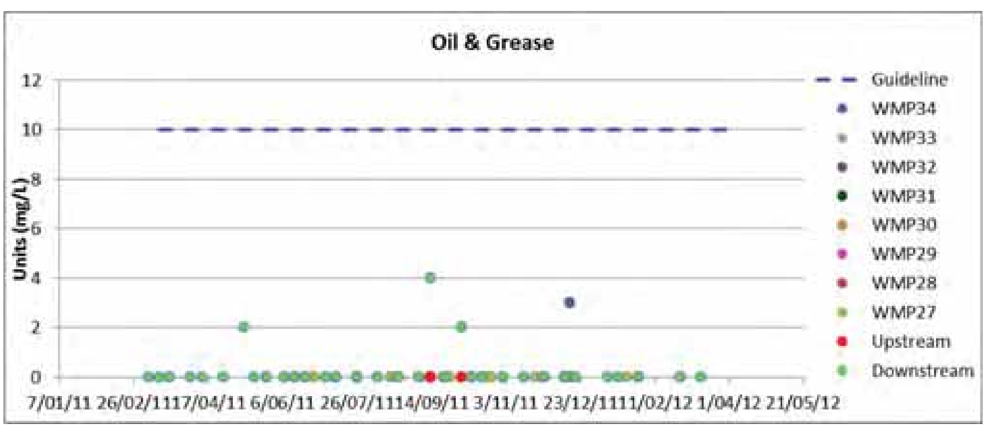


Figure 5-9 Water Quality Data – Oil and Grease

Heavy Metals

An assessment of the total concentration of heavy metals was undertaken for the monitoring locations listed in Table 5-3. The metals assessed included Aluminium, Arsenic, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, and Zinc. Each of these are discussed in the following Sections.

Aluminium

The ANZECC trigger level for Aluminium is 0.055 mg/L. From the samples collected, 91% were found to be above this level.

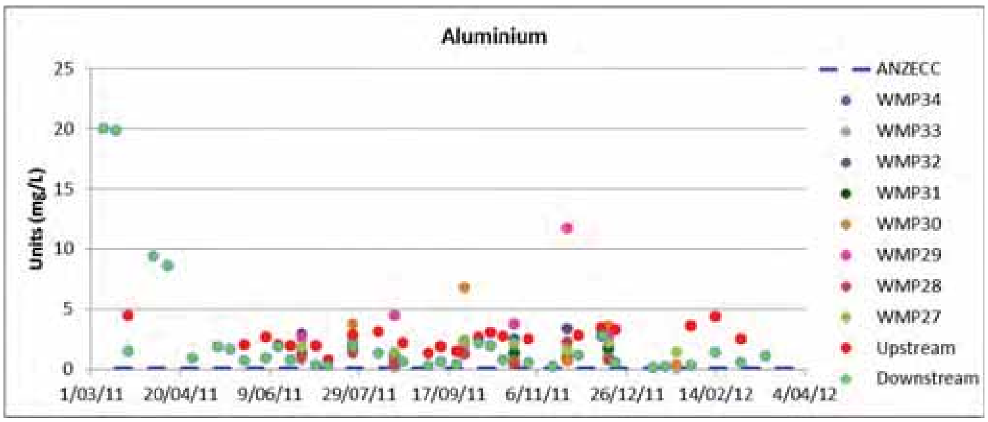


Figure 5-10 Water Quality Data – Aluminium

Arsenic

The ANZECC trigger level for Arsenic is 0.013 mg/L. All recorded concentrations for all WMPs were found to be below this trigger value.

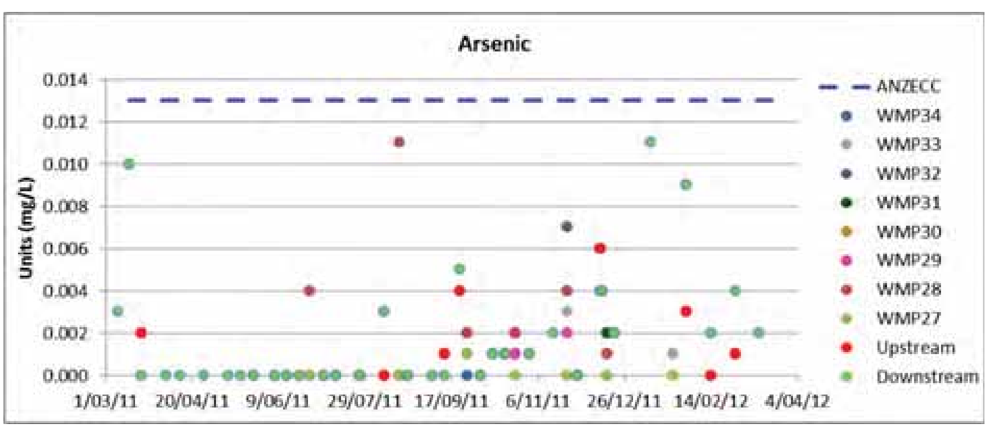


Figure 5-11 Water Quality Data – Arsenic

Boron

The reported concentrations of Boron were generally below the ANZECC guidelines of 0.37 mg/L with the exception of one result which exceeded the trigger value. This result was at WMP32 and this site was found to be consistently higher than the other sites sampled.

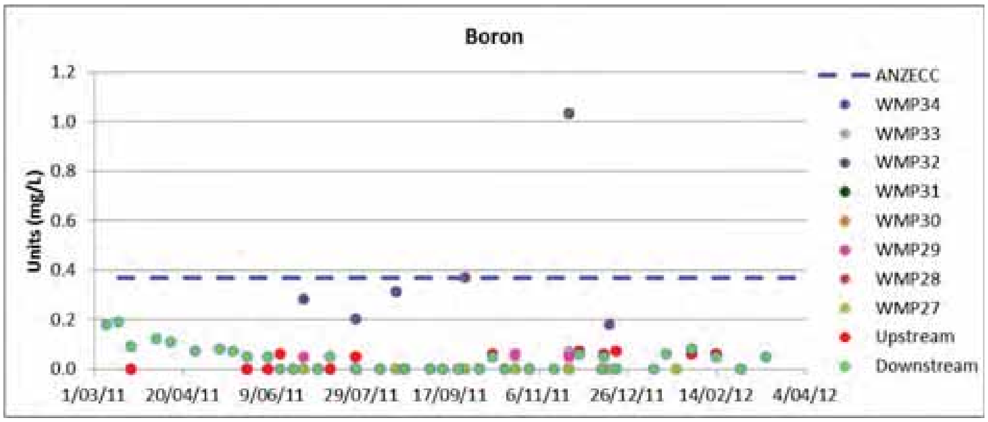


Figure 5-12 Water Quality Data – Boron

Cadmium

From the samples recorded 13% of the Cadmium concentrations were found to exceed the recommended ANZECC trigger guideline of 0.0002 mg/L for Freshwater/Lowlands levels. Of these samples five reported concentrations were found to be above the Estuaries/Coastal value of 0.0055 mg/L with a maximum concentration of 0.012 mg/L at Downstream.

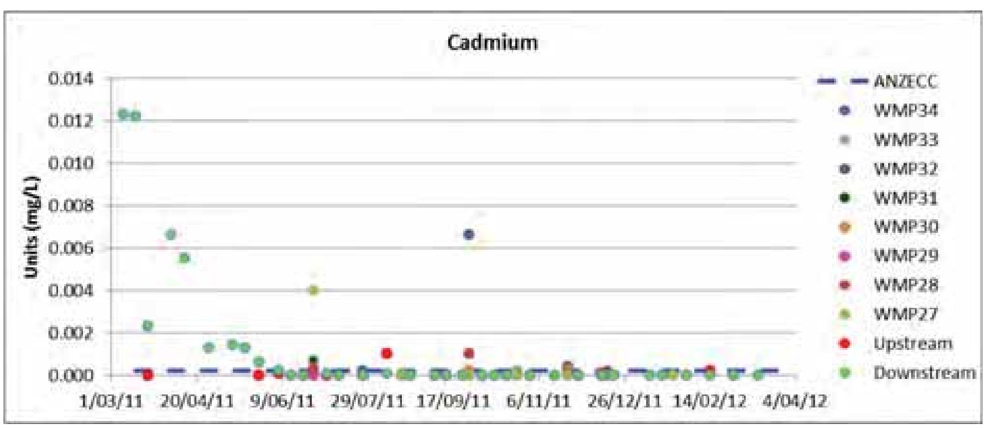


Figure 5-13 Water Quality Data – Cadmium

Chromium

The recorded concentrations of Chromium sampled indicated that 50% of these exceeded the recommended trigger value for ANZECC Lowlands of 0.001 mg/L.

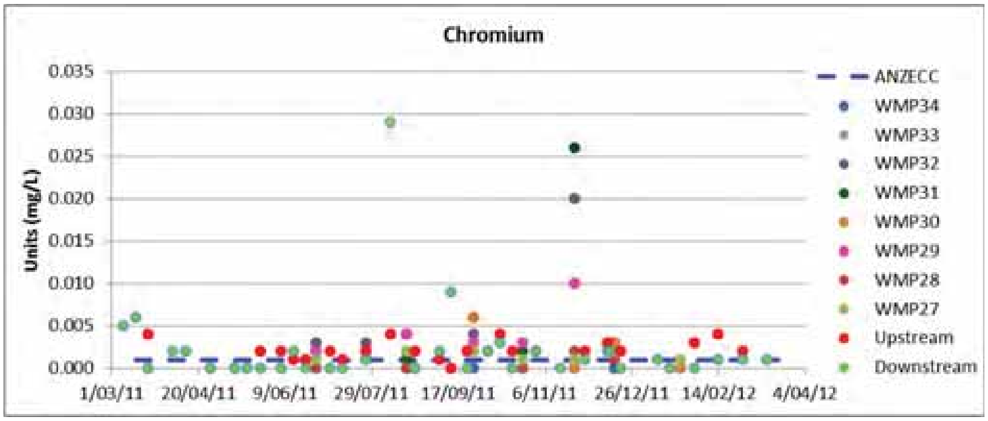


Figure 5-14 Water Quality Data – Chromium

Cobalt

There are no guideline levels for Cobalt within the ANZECC guidelines for Freshwater however the ANZECC trigger level for Estuarine/Coastal rivers is 0.001 mg/L. From the recorded concentrations, 20% of the values exceeded the recommended guideline.

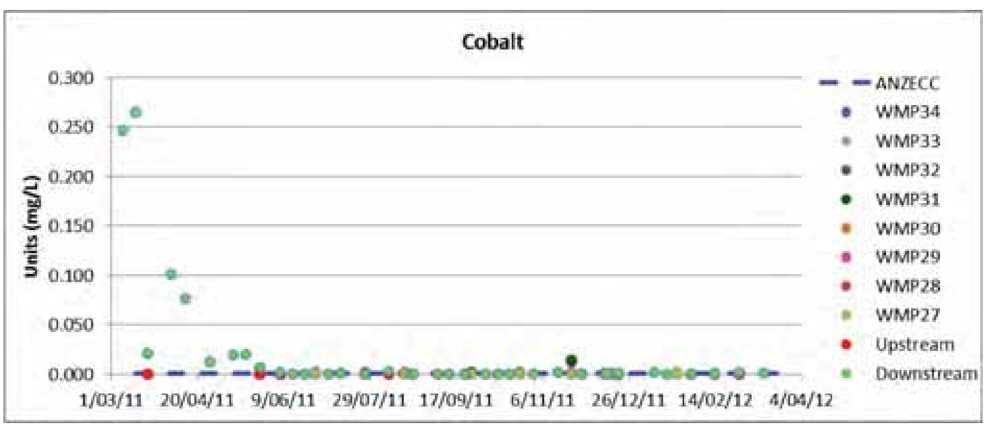


Figure 5-15 Water Quality Data - Cobalt

Copper

The Copper levels within the water quality monitoring records showed that 69% of samples exceeded the ANZECC Guideline for both Lowland/Freshwater and Estuarine/Coastal Waters of 0.0014 mg/L and 0.0013 mg/L respectively.

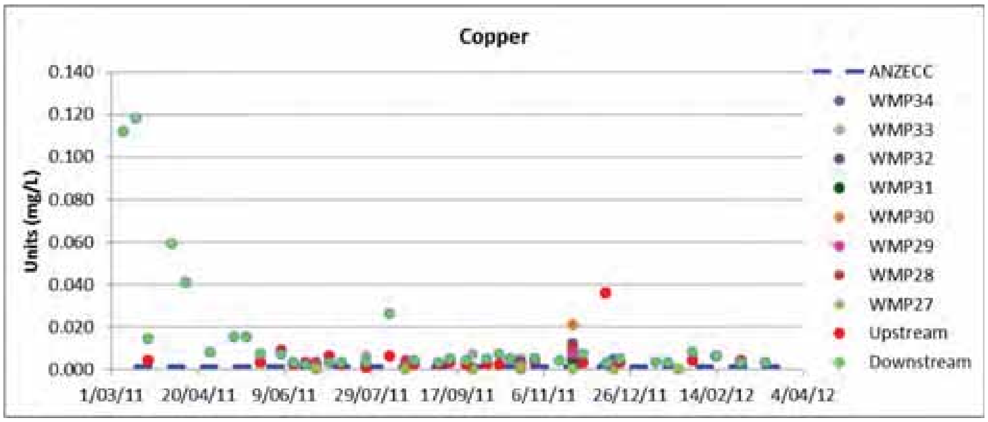


Figure 5-16 Water Quality Data - Copper

Iron

The monitoring results for Iron indicated that all of the samples exceeded the Canadian Guidelines (used in the absence of Australian data) level of 0.3 mg/L. WMP27 recorded the lowest average of 1.145 mg/L for all of the WMPs, however this concentration was still above the adopted Canadian trigger level.

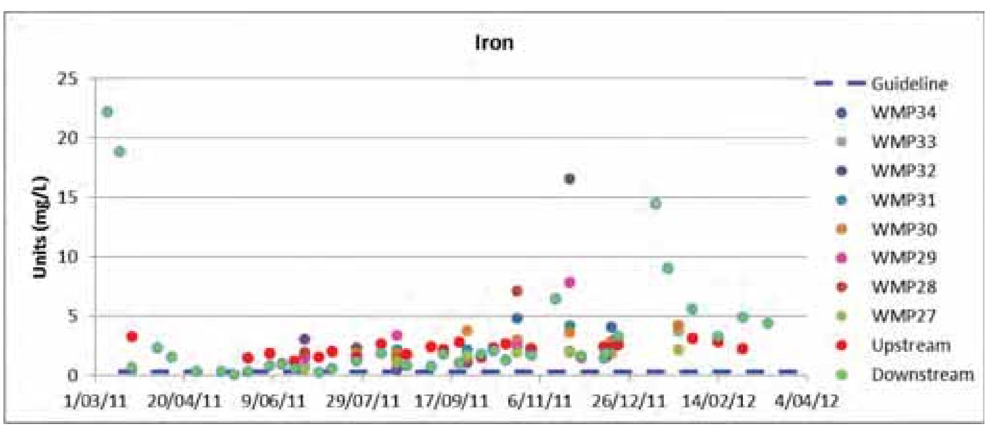


Figure 5-17 Water Quality Data - Iron

Lead

The ANZECC Trigger level for Lead within Lowland/Freshwater systems is 0.0034 mg/L. Of the recorded concentrations, 19% were found to be above this trigger level.

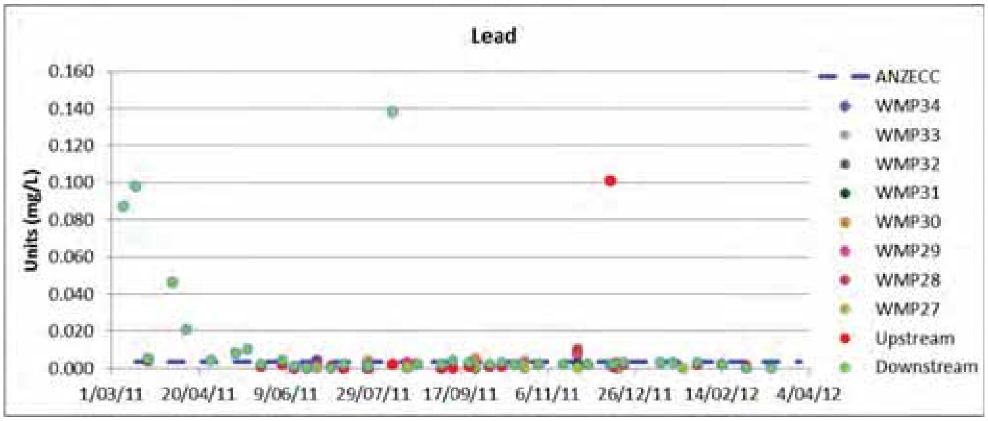


Figure 5-18 Water Quality Data - Lead

Manganese

All reported Manganese concentrations were found to be below the ANZECC Lowland/Freshwater trigger value of 1.90 mg/L with the exception of five samples collected at Downstream.

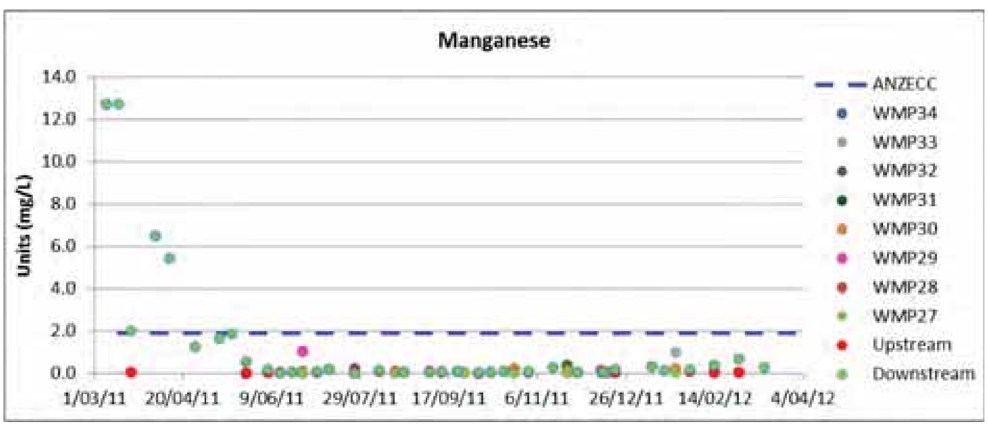


Figure 5-19 Water Quality Data - Manganese

Nickel

The recommended trigger level for ANZECC Lowland/Freshwater is 0.011 mg/L for Nickel. All concentrations were found to be below this trigger level with the exception of WMP32, WMP34 and Downstream. WMP32 and WMP34 had one sample each above this level, recorded on the same day whereas Downstream had 29% of its results found to be above the trigger level.

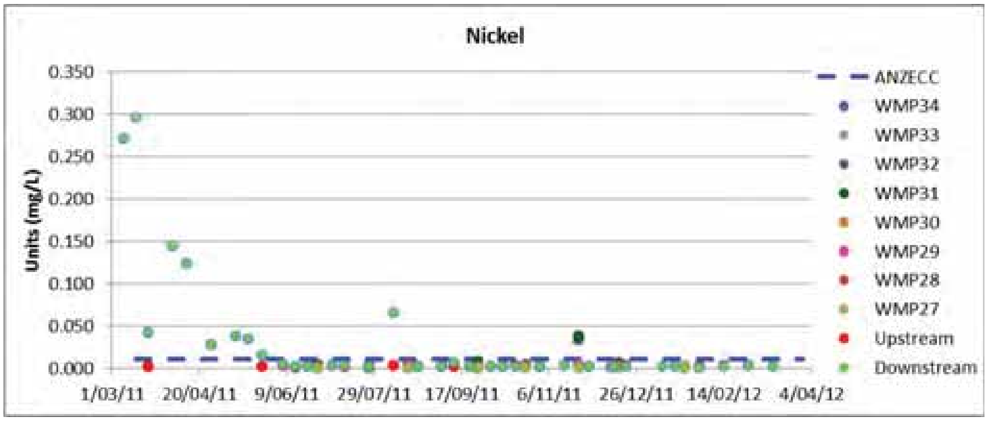


Figure 5-20 Water Quality Data - Nickel

Zinc

The recommended trigger value for ANZECC Lowland/Freshwater is 0.008 mg/L for Zinc. From the recorded results 84% exceeded this value. WMP27 was found to have the least number of exceedances with only one result above the trigger level with a concentration of 0.009 mg/L.

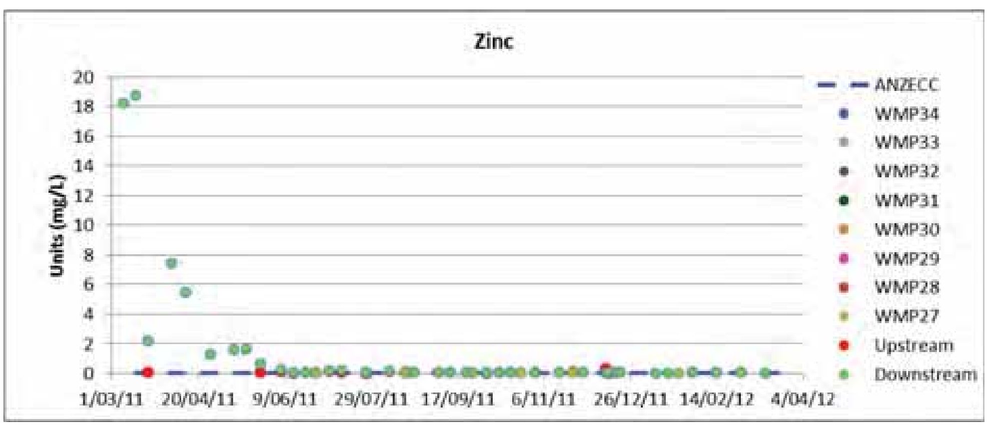


Figure 5-21 Water Quality Data - Zinc

Piper Diagram

Major cation and anion concentrations for each sampling location were plotted in a Piper Diagram. Piper Diagrams can be used to make tentative conclusions on the origin of water as represented by major ion analysis. A Piper Diagram is a trilinear diagram, where the apices of each diagram represent 100% of a component and the opposite end represents 0% of that component. The major ions are plotted as ratios. Only those samples with a full suite of major cation and anion concentrations results could be plotted.

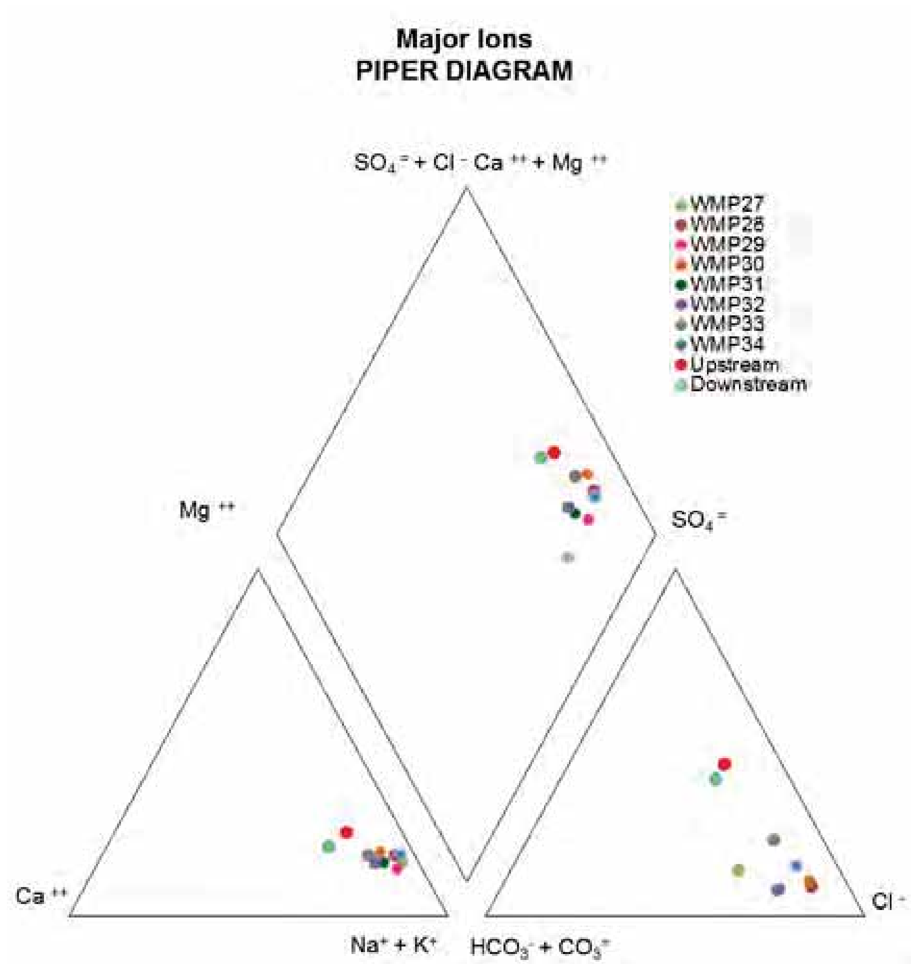


Figure 5-22 Major Ions Piper Diagram

Figure 5-22 shows that the samples taken are all similar and the water quality is a sodium-chloride type of water (Na-Cl).

5.3.3 Waterway Quality

Kilaben Creek

Kilaben Creek has two water monitoring points which are located upstream (WMP27) and downstream (WMP30) of the proposed subsidence area.

The pH results indicate that Kilaben Creek has slightly acidic water, with the average pH recorded at WMP27 being pH 5.4 and increasing to pH 6.1 at WMP30. In the investigation of EC at Kilaben Creek it was found to increase notably between the two water monitoring points. At WMP27, the average EC recorded was 119 µS/cm, whereas, the EC recorded at WMP30 was approximately four times higher with an average level of 399 µS/cm. These EC levels, however, are all within the recommended trigger levels for ANZECC Lowland/Freshwater.

Similarly, there was a 25% increase in total aluminium concentrations between WMP27 and WMP30 with all samples exceeding the recommended ANZECC trigger levels. It is noted that WMP30 recorded concentrations of approximately forty-four times higher than the trigger value, although this is likely to be attributed to non-bioavailable aluminium associated with suspended sediment.

Turbidity showed an increase from an average of 33 NTU at WMP27 to 69 NTU at WMP30. Levels recorded at WMP27 were found to be below ANZECC Lowland/Freshwater guidelines, whereas levels recorded at WMP30 are above. There was a notably higher turbidity recording at WMP30 of 203 NTU. This level is three times the next highest value recorded on the 26 September 2011 (Figure 5-8). If this sample was excluded, it would result in a lower average similar to that of WMP27.

Analysis of concentrations for total arsenic, boron, and nickel found that average levels at the two water monitoring points were within the recommended ANZECC trigger level guidelines.

Stony Creek

Stony Creek has two water monitoring points located upstream of the proposed subsidence area. These are WMP29 and WMP33. Collected samples of pH indicate that Stony Creek has slightly acidic water with average pH at WMP29 of pH 5.9 increasing to a pH 6.6 at WMP33.

As with Kilaben Creek, EC increased notably between the two water monitoring points. The average EC recorded at WMP29 was 165 µS/cm whilst at WMP33 an EC of approximately four times higher was observed (635 µS/cm). All recorded levels of EC, however, were below recommended ANZECC trigger levels.

The average concentration of total aluminium reported at WMP29 was 5.04 mg/L which is well above the ANZECC Lowland/Freshwater trigger limits of 0.055 mg/L. Downstream at WMP33 concentrations are reduced to an average of 0.992 mg/L. These concentrations are still above the recommended ANZECC trigger levels. It is likely that reported total concentrations are largely associated with a non-bioavailable form of aluminium, associated with suspended sediment. Further monitoring will clarify this relationship.

Average concentrations of total arsenic, boron, cadmium, cobalt and nickel were all within the recommended ANZECC trigger levels.

5.3.4 Comparative Surrounding Water Quality Data

Surrounding the SMP Study Area, a number of creeks were sampled for water quality in conjunction with those specific to the SMP Study Area. These include the points WMP 18, 25, 26 and 35. Each of these points has a similar catchment type and land use to those points used in the assessment of water quality for the SMP Study Area. The length of data available from these sampling locations is summarised in Table 5-6.

Table 5-6 Water Monitoring Points Data Period for additional points

Monitoring Location	From Date	To Date
WMP18	January 2011	March 2012
WMP25	June 2011	January 2012
WMP26	June 2011	January 2012
WMP35	June 2011	January 2012

These four points, shown in Table 5-6, have been used as to compare different catchment water qualities to those assessed for the SMP Study Area. The sampling locations of WMP18 and 35 are located within the Lords Creek catchment, whereas WMP 25 and 26 are located within the Stockyard Creek. These are shown, spatially, on Figure 5-23.

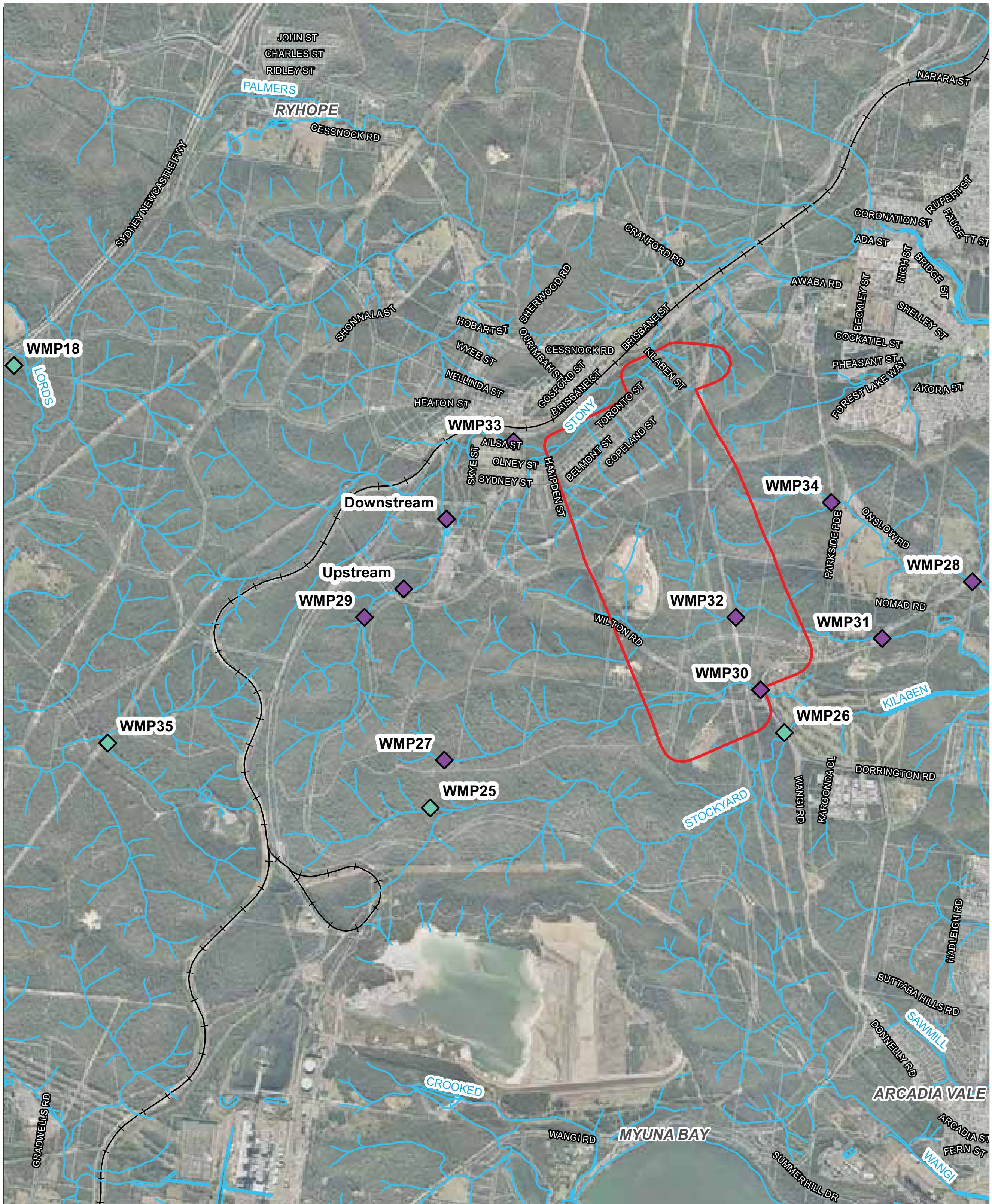
The additional water quality points were assessed for exceedances against the Estuarine/Coastal Waters ANZECC trigger values. The statistical results of the additional water quality point samples have been summarised in a briefer form then that for SMP Study Area, and are shown in Table 5-5, below.

Table 5-7 Comparative Water Quality Monitoring Locations

Parameter		Range of Valves			
		WMP18	WMP25	WMP26	WMP35
pH	Range	6.3-7.2	5.1-6	5.3-6.3	6.1-6.3
	80%	7.1	5.9	6.2	6.2
	Exceedences	20% (all below 6.5)	100% (all below 6.5)	100% (all below 6.5)	100% (all below 6.5)
EC (µS/cm)	Range	186-417	80-137	187-414	28-165
	80%	363	102	320	109
	Exceedences	0%	0%	0%	0%
TSS	Range	4-26	10-450	5-136	74-319

Parameter		Range of Valves			
		WMP18	WMP25	WMP26	WMP35
(mg/L)	80%	14	146	73	250
	Exceedences	0%	25%	25%	100%
Oil and Grease (ppm)	Range	0-0	0-0	0-0	0-4
	80%	0	0	0	2
	Exceedences	0%	0%	0%	0%
Turbidity (NTU)	Range	-	55-499	5-78	76-657
	80%	-	107	50	438
	Exceedences	-	88%	25%	100%
Aluminium (mg/L)	Range	0.170-2.090	3.030-8.250	0.660-2.430	0.910-10.400
	80%	1.238	6.012	1.086	6.752
	Exceedences	100%	35%	35%	100%
Arsenic (mg/L)	Range	0.000-0.003	0.000-0.002	0.000-0.001	0.000-0.003
	80%	0.001	0.001	0.000	0.002
	Exceedences	0%	0%	0%	0%
Boron (mg/L)	Range	0.000-0.060	0.000-0.070	0.000-0.000	0.000-0.000
	80%	0.050	0.040	0.000	0.000
	Exceedences	0%	0%	0%	0%
Cadmium (mg/L)	Range	-	0.000-0.001	0.000-0.005	0.000-0.002
	80%	-	0.000	0.000	0.000
	Exceedences	-	13%	38%	20%
Chromium (mg/L)	Range	-	0.002-0.007	0.000-0.002	0.000-0.010
	80%	-	0.004	0.002	0.006
	Exceedences	-	88%	38%	80%

Parameter		Range of Valves			
		WMP18	WMP25	WMP26	WMP35
Cobalt (mg/L)	Range	-	0.000-0.002	0.000-0.004	0.000-0.003
	80%	-	0.002	0.002	0.006
	Exceedences	-	38%	13%	80%
Copper (mg/L)	Range	0.000-0.003	0.000-0.004	0.000-0.002	0.000-0.011
	80%	0.002	0.003	0.001	0.009
	Exceedences	20%	75%	25%	80%
Iron (mg/L)	Range	1.380-3.680	1.680-7.940	1.280-6.220	0.850-8.800
	80%	3.074	4.314	3.400	5.542
	Exceedences	60%	88%	88%	100%
Lead (mg/L)	Range	0.000-0.002	0.002-0.006	1.280-6.220	0.001-0.009
	80%	0.002	0.003	0.003	0.008
	Exceedences	0%	13%	13%	60%
Manganese (mg/L)	Range	0.035-0.458	0.040-0.149	0.045-0.359	0.010-0.273
	80%	0.360	0.102	0.109	0.130
	Exceedences	0%	0%	13%	0%
Nickel (mg/L)	Range	-	0.001-0.002	0.000-0.002	0.001-0.005
	80%	-	0.102	0.002	0.003
	Exceedences	-	0%	0%	0%
Zinc (mg/L)	Range	0.006-0.013	0.007-0.024	0.008-0.026	0.011-0.036
	80%	0.010	0.014	0.018	0.034
	Exceedences	40%	75%	88%	100%



1:40,000 for A4

0 125 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- SMP Study Area
- Waterways
- Surface Water Quality Monitoring Points
- Comparable Surface Water Quality Monitoring Points

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment

Comparative Surrounding Catchments

Centennial Newstan

DATE 27/04/2012

Figure 5-23

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_019_Figure5-23_ComparativeSurroundingCatchments_.mxd

As indicated in Table 5-7, similarities can be drawn between the results indicated within the points located in the Lords and Stockyard Creek catchments and with the Kilaben and Stony Creek catchments.

The 80% values for pH, EC and Oil and Grease indicate water qualities that are fresh and slightly acidic and generally similar to those in the Kilaben and Stony Creek catchments.

When investigating the analytes indicating higher than trigger results, for example, high turbidity and TSS levels found within Lords Creek, similarities occurred with the results reported for Kilaben Creek. High turbidity and TSS can be linked to disturbance activities within the catchment. Disturbance activities are typically temporary in nature and are inherent in many catchments which include developments and quarries.

Concentrations of total aluminium within the comparative catchments of Lords and Stockyard Creeks were found to exceed the trigger values defined by ANZECC. This was similar to the levels identified for Kilaben and Stony Creeks. High levels of aluminium seem to be a typical catchment trait of the creek waters within this area, as many if not all results indicated higher levels of aluminium than the defined trigger values and there were no clear source for the high levels of pollutants. Further monitoring of total and dissolved heavy metal concentrations will clarify the proportion of metals in a non-bioavailable form.

Iron was another analyte that was shown to exceed the trigger values defined by ANZECC for the comparative catchment of Lords and Stockyard Creeks. No clear source for the iron could be determined from investigating the catchment land uses, and as with aluminium most of the results indicated higher levels of iron than the ANZECC trigger levels. This was similar to the levels identified for Kilaben and Stony Creeks.

Within the investigations of samples from Lords and Stockyard Creeks there were instances of where Chromium, Copper, Lead and Zinc exceeded the default trigger values. There was no firm understanding of the reasoning behind these exceedances from further investigation but they marry in with that of the Kilaben and Stony Creek investigation.

Further samples and investigation into Kilaben, Stockyard, Lords and Stockyard Creek will be undertaken to determine an understanding of the exceedances of the default trigger values. This will be undertaken prior to the extraction of coal and within future stages of the project.

6. Surface Water and Stream Health Assessment Criteria

6.1 Management of stream/aquifer systems in coal mining developments

GSS (2010) classified the watercourses found in the study area in accordance with the *Stream/Aquifer Guidelines – Management of Stream/Aquifer Systems in Coal Mining Developments*, *Hunter Region* DIPNR (2005).

The (DIPNR, 2005) guidelines were designed to assist the coal mining industry to manage risk in relation to impacts to stream systems. This is done through assessing the importance of streams and associated alluvial groundwaters, implementing protective mechanisms for critical river systems and developing monitoring and remedial procedures to address mining induced impacts to stream systems. The guidelines expect coal mining companies to comply with the legislative and regulatory frameworks under the *Environmental Planning and Assessment Act, 1979* (EPAA) and the *Water Management Act, 2000* (WMA).

6.1.1 Assessment Criteria

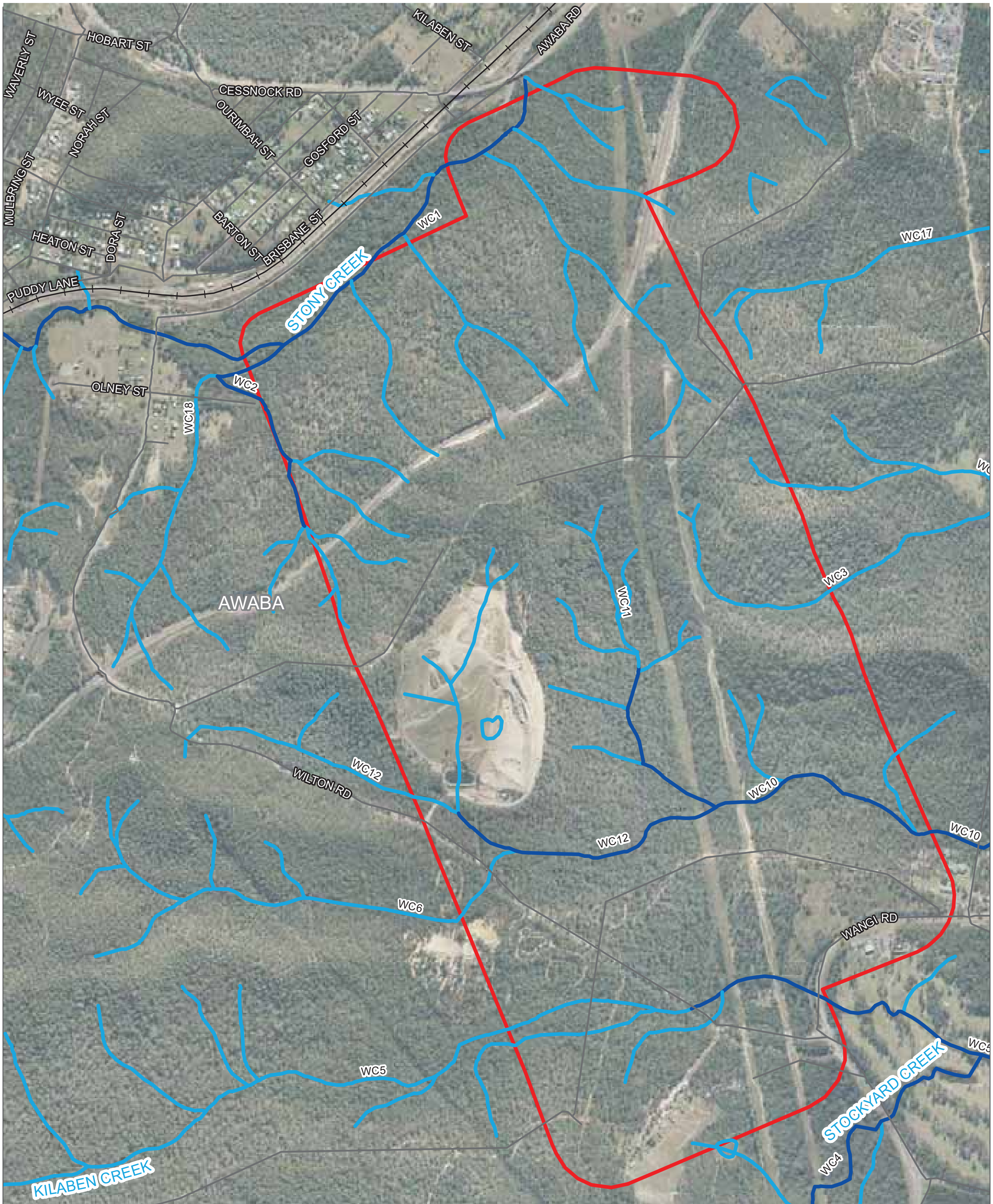
The assessment criteria for stream categories outlined in the *Stream/Aquifer Guidelines* (DIPNR, 2005) are as follows:

***'Schedule 1 Streams** – are streams classed as minor watercourses as defined in Schedule 1 of Section 5(1) of the Water Act, 1912. These streams are first and second order streams. They often have intermittent flow and discontinuous channels. Some segments may be short wetlands or swampy meadows. Any first or second order streams which carry overbank flows from defined rivers are not included in this schedule.*

***Schedule 2 Streams** – are termed notifiable streams, as notification to the department is required prior to any second workings proceeding. These streams are third order and higher, except for those listed under schedule 3.*

***Schedule 3 Streams** – are streams associated with mapped vulnerable alluvial groundwaters. These stream systems include the major river systems of the Hunter River, Goulbourn River and catchment tributaries flowing into it, Dart Brook, Glennies Creek, Pages River, Paterson River, Rouchel Brook, Williams River, Wollombi Brook and Wybong Creek.'*

Figure 6-1 displays the stream scheduling within the SMP Study Area as determined by GSS (2010). No Schedule 3 streams were identified by GSS (2010) in the Project Area.



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0 50 100 200 300 400
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Schedule 1 Stream
- Schedule 2 Stream
- Roads
- Railway
- SMP Study Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assessment

Stream Categories

Centennial Newstan

DATE 18/04/2012

Figure 6-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_017_Figure6-1_StreamCategories.mxd

6.1.2 Management Criteria

Schedule 1 Streams

Mining beneath these is generally acceptable provided that the environmental assessment can demonstrate minimal impacts. Schedule 1 Streams should be managed via the implementation of mitigation and remediation works where needed to ensure that:

- Stream stability is maintained where subsidence occurs.
- Stream fractures are minimised.
- Stream channels are maintained with minimal incision from bed grade change.
- Stream bed grade change minimised to provide stable stream length.

Where any stream stability controls are required, they will be designed in accordance with the Rehabilitation Manual for Australian Streams (Land and Water Resources Research and Development Corporation, 2000) and will be provided primarily by vegetation.

Schedule 2 Streams

The primary outcome required by the Guideline (DIPNR, 2005) is that 'geomorphic integrity of the stream will be maintained, the ecosystem habitat values of the stream will be protected and no significant alteration of the water quality will occur in the stream.'

Schedule 2 Streams should be managed so as to ensure that:

- They maintain pre-mining course, and maintain bed channel gradients which do not initiate erosion.
- Streams should maintain pool riffle sequences where they pre-existed.
- Connectivity to underground workings should be avoided.
- Flow loss to fracture zones should be limited to flow loads to groundwater similar to pre mining levels.
- Geomorphic integrity of the stream to be maintained.
- The ecosystem habitat values of the stream to be protected.
- No significant alteration of the water quality to occur in the stream.

Potential effects on site stream health will be identified by annual reviews of water quality data, and creek geomorphic conditions under the respective site environmental management and response plans.

6.2 Water Quality

Existing water quality monitoring results for waterways that traverse the SMP Study Area boundaries were reviewed and summarised in Section 5.3. It was found that some of the key parameters were above the default triggers. Subsequently the ANZECC freshwater guidelines trigger levels are not considered wholly applicable to these waterways. This is due to the influence of the natural geology and catchment and indicates that site specific triggers would be more appropriate.

Prior to mining commencing in 2014, it is expected that a more comprehensive set of data from an estimated network of 24 water quality monitoring points will exist to determine site specific trigger values. Subsequently, it is recommended that further water monitoring occur to provide a more robust baseline with each set of new data referred back to the historical readings and assessed if it is consistent with the previous sets of results.

6.3 Flooding

The key criteria for assessing flooding impact are:

- Minimise the impacts on downstream environment due to significant changes in the frequency, extent or depth of flooding.
- Identification of any change in the ability of flow to be conveyed through existing road and rail culverts.
- Minimise the impact of significant increases or decreases in waterway velocity.

7. Impact Assessment

Longwall mining generally results in the subsidence and deformation of the surface above the extracted seams. Subsidence predictions for the project area and the potential range of impacts resulting from the predicted subsidence have been assessed by MSEC (2012). Figure 7-1 displays the maximum predicted subsidence contours within the project area. The maximum vertical subsidence prediction is 1200 mm at the northern extent of Longwall LW103 following extraction of all longwalls.

Potential impacts on waterways as a result of surface subsidence include:

- Changes in drainage channel alignments and catchment boundaries.
- Changes in surface ponding.
- Capture of surface water to the underground goaf.
- Changes in peak flows and velocities within drainage channels resulting in increased scour potential.
- Changes in surface water quality.

The following Sections discuss each of the above potential impacts.

7.1 Waterway Stability and Ponding

There are several waterways within the predicted subsidence affectation zone (refer to Figure 7-1). As indicated in Section 5, the drainage lines occurring within the predicted subsidence affectation zone are generally first and second order. Third and fourth order streamlines also occur in the subsidence affectation zone and include:

- Stony Creek (WC1).
- The unnamed waterways of WC2, WC6, WC10, WC11, WC12.
- Kilaben Creek (WC5).

Stony Creek or WC1, is located some 300 m to the north of Longwall LW103. It is not directly mined beneath though it is within the subsidence affection and its general catchment is affected.

WC2 is located within 125 m west of Longwall LW103, though within the subsidence affection zone, it is not directly mined beneath it.

WC 6, WC10, WC11, and WC12 all are located in part above a Longwall of the SMP Study Area. WC6 has a majority of the stream length located to the west of Longwall LW103 and it includes less than 100 m of stream length located directly above Longwall LW103. WC10 is located directly over Longwall LW101 and has approximately 130 m of stream located above the longwall mining area. WC11 is located above both Longwalls LW101 and 102 with approximately 520 m of stream length located above the mining operations. In the last of the unnamed waterways within the SMP Study Area, WC12 is located above Longwalls LW101, 102 and 103 and has approximately 650 m of stream length above the mining operations, (MSEC; 2012)

Subsidence prediction by MSEC (2012) of the waterways of WC6, WC10, WC11 and WC12 were determined and the conventional subsidence and tilt are shown in Table 7-1.

Table 7-1 Maximum Predicted Total Conventional Subsidence and Tilt for WC6, WC10, WC11 and WC12.

Waterway	Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)
WC11	After LW101	700	4.5
	After LW102	825	2.0
	After LW103	850	2.0
WC12 (incl. WC6 and WC10)	After LW101	750	6.0
	After LW102	975	10.5
	After LW103	1075	10.5

Kilaben Creek or WC5, extends across the Longwalls LW101, 102 and 103 and directly mined beneath. It receives inflow from a number of 1st and 2nd order tributaries that are within the mining areas of Longwalls LW102 and 103. WC5 has approximately a total stream length of 860 m of likely subsidence, (MSEC; 2012)

Subsidence prediction by MSEC (2012) of Kilaben Creek (WC5) was determined and the conventional subsidence and tilt are shown in Table 7-2.

Table 7-2 Maximum Predicted Total Conventional Subsidence and Tilt for Kilaben Creek (WC5)

Waterway	Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)
WC5	After LW101	<20	<0.5
	After LW102	750	6.0
	After LW103	975	10.0

In summary of the results indicated in Table 7-1 and Table 7-2, the conventional predictions made for the waterways identified range in subsidence impacts of between <20 mm to 1075 mm. The most subsided of the waterways was determined to be the WC6, WC10 and WC12 combination whereby after Longwall LW103 is complete, a predicted subsidence of approximately 1075 mm is likely.

Predicted tilt results indicated a change in grade of between <0.5 mm to 10.5 mm per affected stream length metre. These tilts must be considered in conjunction with the existing waterway gradients defined in Section 5.1.2.

7.1.1 Potential Changes in Stream Hydraulics

To assess the potential for changes to the hydraulic regime within the waterways, a site specific 1-Dimensional HEC-RAS model of the waterways was created. The model focuses on the flows within the banks and for rainfall events less than the 2 year ARI specifically in and around the subsidence impact area.

Flows for the HEC-RAS model were obtained from the XP-RAFTS model prepared for the catchment (Refer to Appendix C for details) for the 1 year and 2 year ARI events. The three month flow was estimated based on the "rule of thumb" of 50% of the 1 year peak flow rate. These flow events were selected as they occur relatively frequently and are of sufficient magnitude to do work on channel boundaries.

Following modelling of the above flow events for existing conditions, a Digital Terrain Model (DTM) reflecting subsided conditions, was generated through subtracting the maximum subsidence predictions from the existing conditions DTM. The post subsidence DTM then provided the basis to develop a HEC-RAS hydraulic model to determine hydraulic conditions following subsidence.

The existing and post-subsidence HEC-RAS hydraulic modelling was undertaken for the following waterways in the subsidence affectation zone:

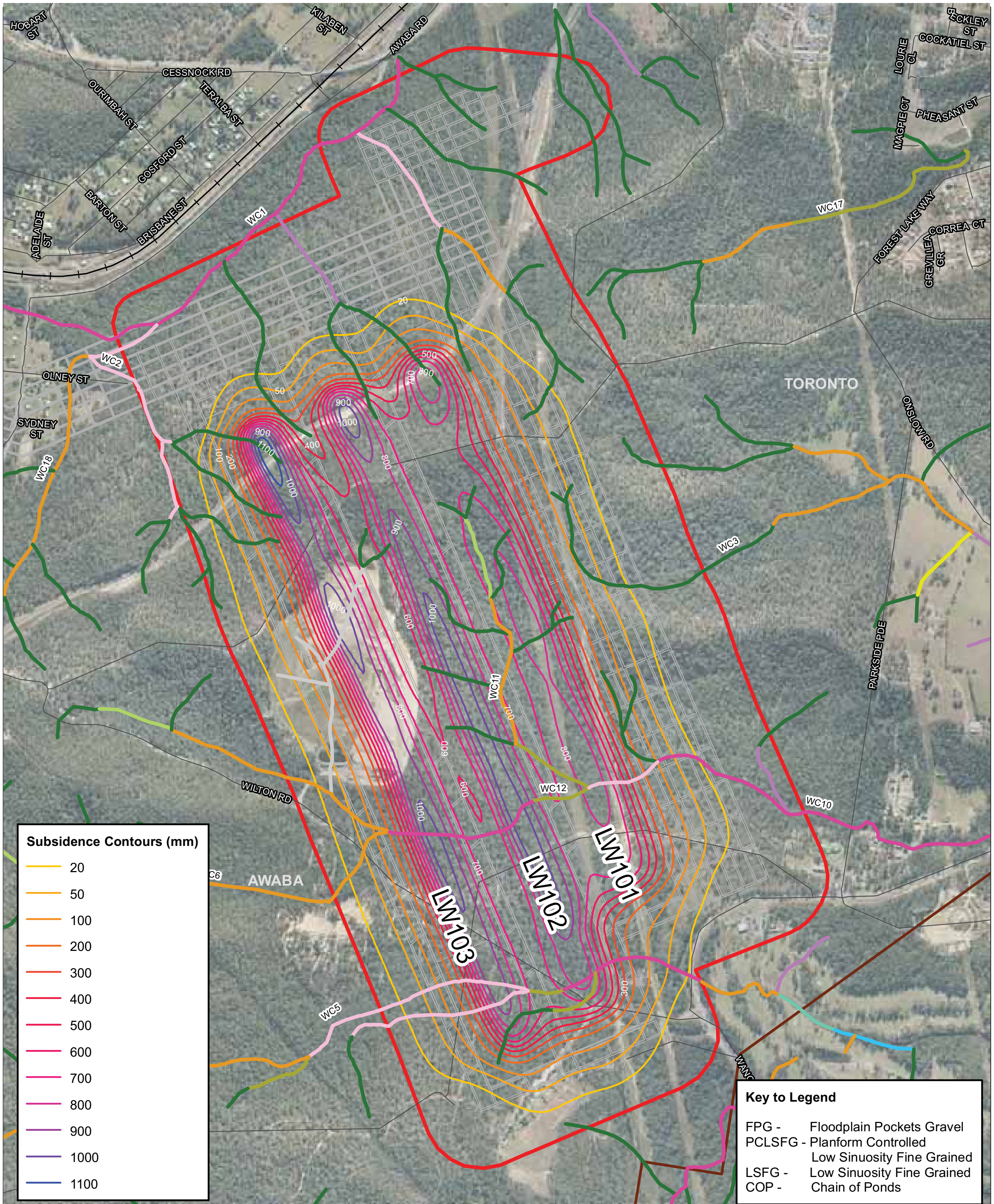
- WC1 – Stony Creek.
- WC5 – Kilaben Creek.
- WC6 – unnamed.
- WC12 and WC10 – unnamed.
- WC11 – unnamed.
- WC2 – unnamed.

The water level and velocity outputs for existing and subsided conditions for each of the above waterways are graphed in Appendix C on Figures C1 to C8. These indicate that hydraulic conditions following subsidence remain unchanged compared to existing conditions for WC1 (Stony Creek) and WC2.

For WC11, while the water levels drop for subsided conditions, the surrounding landscape will subside a similar amount and the water levels will remain unchanged relative to the immediate terrain. Flow velocities along WC11 remain unchanged following subsidence. This is due to the fact that WC11 runs parallel to the proposed underlying longwalls and will experience a uniform drop such that little to no change in stream grade are likely along its length as a result of subsidence.

The waterways WC5 and the combined reaches of WC6, WC10 and WC12 cross the subsidence affected area perpendicular to the underlying proposed longwall panels. In response to subsidence, these waterways exhibited an increase in gradient and flow velocity as they enter the subsidence affected area and a general reduction in gradient and flow velocity through the affected area.

The following Figure 7-2 and Figure 7-3 indicate the hydraulic section locations for referencing results against. The results of the hydraulic modelling can be found in Appendix C.



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0 50 100 200 300 400
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

Roads
Railway
Mine Plan
Proposed Final Newstan Colliery Holding Boundary
SMP Study Area
Headwater
FPG
PCLSFG
LSFG
COP
Channelised Fill
Valley Fill
Swamp
Tidal
Highly Modified
Reservoir

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment

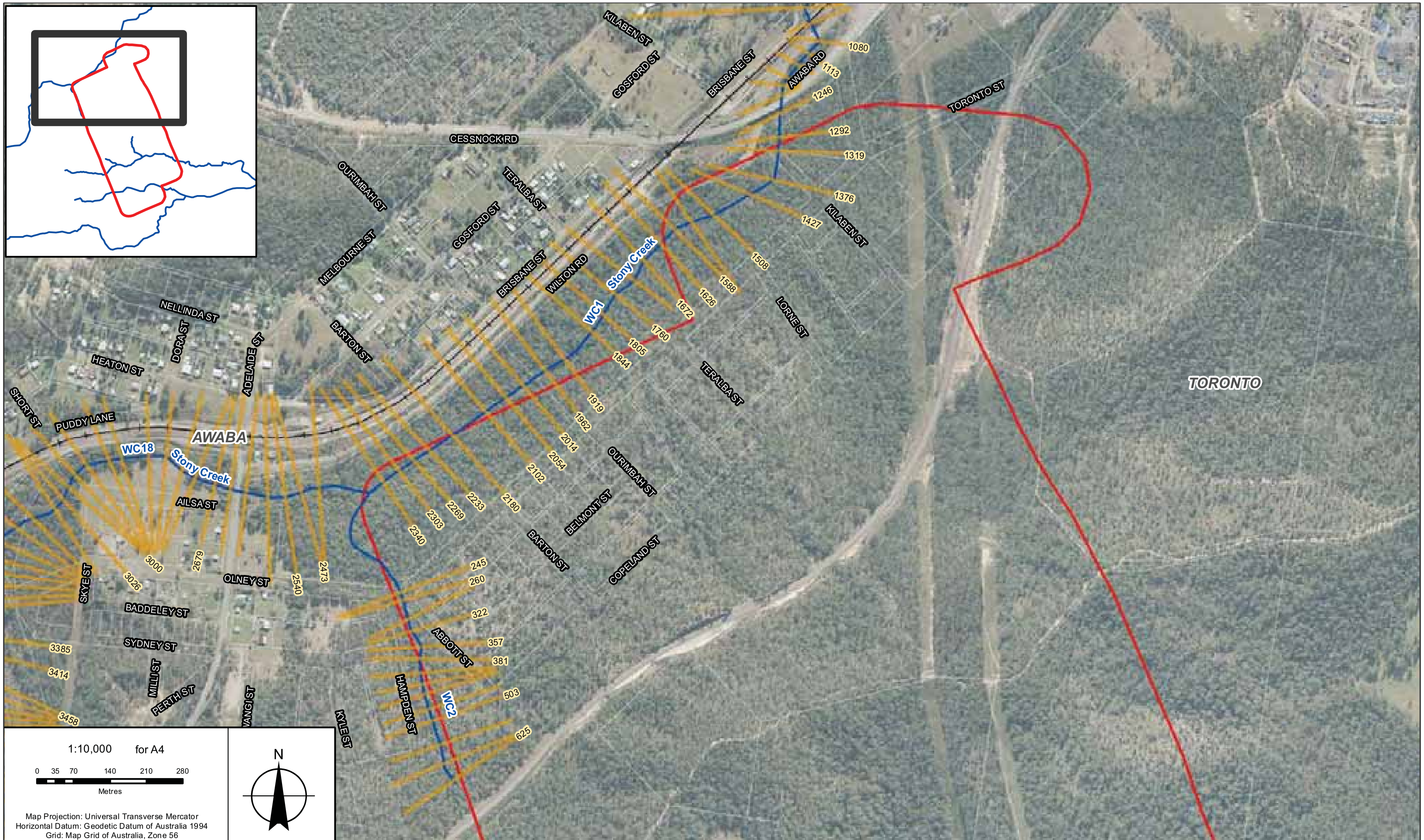
Subsidence Contours

Centennial Newstan

DATE 17/04/2012

Figure 7-1

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_012_Figure7-1_SubsidenceContours.mxd



GHD

LEGEND

- Modelled Creeks
- SMP Study Area
- Modelled Cross Sections and River Station
- Railway
- Cadastre

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

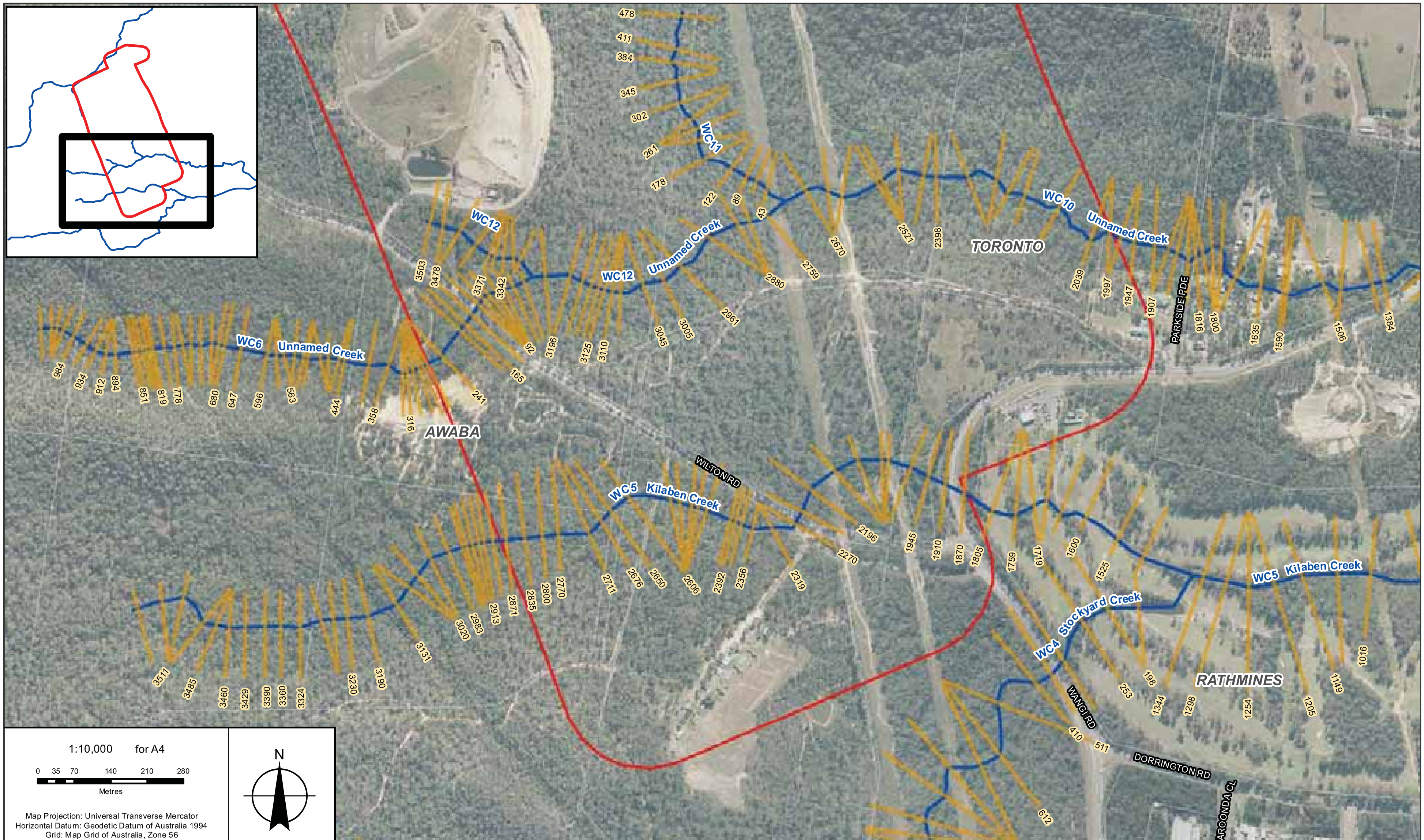
Newstan
Subsidence Management Plan
Surface Water Impact Assesment
Hydraulic Geomorphic Assessment
Section Locations - Stony Creek

Centennial Newstan

DATE 17/04/2012

Figure 7-2

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_006_Figure7-2_HydraulicGeomorphicSectionLocations_StonyCreek.mxd



LEGEND

- Modelled Creeks
- SMP Study Area
- Modelled Cross Sections and River Station
- Railway
- Cadastre

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment
Hydraulic Geomorphic Assessment
Section Locations-Unnamed & Kilaben Creeks

Centennial Newstan

DATE 17/04/2012

Figure 7-3

GIS Filename: G:\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\SurfaceWaterImpactAssessment\2215922_007_Figure7-3_HydraulicGeomorphicSectionLocations_Unnamed&KilabenCreek.mxd

© LPMA - Aerials, DCDB - 2007, DCDB - 2006; Centennial: SMP Study Area- 2009; GHD: Creek Flood data - 2012

7.1.2 Waterway Response to Increases in Gradient and Flow Velocities

The maximum estimated flow velocities along the waterways have been modelled. The maximum modelled flow velocities for waterways subject to gradient increases in response to the predicted maximum subsidence are as follows:

- Along WC5; the maximum flow velocity increases by 0.44 m/s from 0.52 m/s to 0.96 m/s under the 2 year ARI flow conditions in the vicinity of the Model Section 2605.6.
- Along WC12; the maximum flow velocity increases occur in the vicinity of the Model Section 3222.8, increasing by 0.4 m/s from 0.73 m/s to 1.13 m/s under the 2 year ARI flow conditions.
- Along WC6 the maximum flow velocity increases by 0.39 m/s from 0.4 m/s to 0.79 m/s under the 3 month ARI flow conditions in the vicinity of the Model Section 18.8.

Modelled post-subsidence velocities at these locations remain less than 1.2 m/s for flow events up to the 2 year ARI. Such velocities are below the maximum permissible velocity of 1.8 m/s for the erosion of waterways vegetated with long grasses (Fischenich, 2001).

Given the subject waterways are densely vegetated, particularly with the long native grass *gahnia sp*., the modelled flow velocity increases for subsided conditions are considered to be non-scouring. Hence, assuming riparian vegetation conditions are maintained, the potential for increased instability along the waterway sections subject to a gradient increase, is considered to be low.

Additionally the reach of WC5, which is subject to a gradient increase, is a chain of ponds system (refer to Figure 7-1). In the absence of a continuous, well defined channel, there is a risk that subsidence could initiate incision and the development of a continuous channel in response to an increase in gradient. The existing gradient along this waterway section was defined to be between 1.0% and 1.5% for the existing conditions. Under the subsided conditions, it was predicted that the gradient would likely increase up to 2.0%.

As discussed in Section 3, chain of ponds systems are known to exist within the area on gradients of up to 2.5%. Given the post subsidence gradients are lower than this value, it is not expected that the chain of ponds that reach along WC5 will be subject to incision as result of the predicted maximum subsidence if existing vegetation associations are maintained.

7.1.3 Waterway Responses to Gradient and Velocity Reductions

Analysis of the predicted subsidence indicates that it is likely that an increase in-channel surface water ponding will occur in waterway sections as a result of the subsided surface. This is most likely to occur along waterways WC5 and WC10 immediately upstream of where these waterways exit the subsidence affection zone. The modelled flow depth increases along these waterways are as follows:

- WC5 experiences a maximum depth increase of 0.2 m under the 2 year ARI flow conditions in the vicinity of Model Section 2196.2, with flow depth increases experienced between Model Sections 2269.8 to 2087.8.
- WC10 experiences a maximum depth increase of 0.1 m under the 2 year ARI flow conditions in the vicinity of Model Section 2624.2, with flow depth increases experienced between Model Sections 2880.3 to 2596.0.

This increase in depth can be correlated to the effect of the Western and Eastern Electrical Easements that traverse the SMP Study Area. These areas of clearing have resulted in a section of waterway that has a very low bed grade and is regularly disturbed by an access track crossing (as indicated within the Eastern Branch)These sections of waterway have their condition only exacerbated under a post mining subsidence scenario.

It is unlikely that any out-of-channel ponding will occur, as these waterways are channelised systems at these locations and the land surrounding the channels will subside an equal amount. As a result, if any out-of channel ponding was to occur, it is expected that flow will be directed back to the waterways causing no significant impact.

The waterways traversing the mine affected areas are fine-grained systems that predominantly transport suspended sediments. Under subsided conditions, flow velocities are maintained above 0.2 m/s for the flow events modelled, allowing sediment to remain in suspension. As a result, any aggradation of sediment along the waterways is expected to be minimal.

7.2 Surface Cracking

MSEC (2012) expects that fracturing of the uppermost bedrock layer will occur based on the predicted tensile and compressive strains. However, along the third and fourth order waterways and also Kilaben this fracturing is not expected to extend to the surface due to the coverage of alluvial soils associated with these waterways. If cracking does occur through the surface alluvial soil layers this cracking is likely to be self-healing as it is likely that fine grained material will gradually fill any cracks.

The upper reaches of the watercourses (i.e. first and second order, but excluding Kilaben Creek) have sandstone outcropping which forms a series of steps or drop downs. Fracturing of the exposed bedrock could result in spalling or dislodgement of rocks from the sandstone outcrops. There could also be some diversion of the surface water flows into the dilated strata beneath the beds, which could drain any ponded surface water upstream of the outcropping.

It is unlikely that there would be a net loss of water from the catchment, however, as the depth of dilation and fracturing is expected to be less than 10 m to 15 m and, because of the high natural grades, any diverted surface water is expected to re-emerge immediately downstream.

It is not expected that the surface water would be diverted into the mine workings because continuous cracking (i.e. the A Horizon) is not predicted to extend up to the surface. Vertical fracturing in the upper stratum is expected to be discontinuous and unlikely to result in increased hydraulic conductivity.

Surface cracking within creek beds will be monitored as part of ongoing subsidence monitoring (refer to Section 8).

7.3 Flooding

The Hydraulic Assessment as discussed briefly in Section 3.3 and detailed in full in Appendix B indicates that there will be minimal impacts on the identified watercourses.

7.3.1 Hydrology Impacts

The impact of the change in surface levels on the hydrology of the waterways is minor and not readily measurable due to the minor changes. The peak flow rates in the watercourses WC 10, WC4 and WC1 and WC3 remain unaltered for the subsided condition compared to the existing condition for all ARI events assessed.

The afflux for the flooding depth and level are shown within Figure 7-4 and Figure 7-5 for the 100 year ARI event. Flooding afflux results indicated that at the receiving waters of each of the creeks, as they exit the SMP Study Area, there is no change in flooding depths or velocities. This indicates the likelihood that flow volumes, for the 100 year ARI event, have remained constant between the existing and subsided flooding scenarios.

Catchment Boundaries

The predicted subsidence affectation zone is located within the catchments of Stony Creek (WC1), Kilaben Creek (WC5), Stockyard Creek (WC4), and two unnamed creeks identified as WC10 and WC3.

Analysis of the subsidence predictions indicates some change may occur in the alignment of minor drainage channels in upper catchment positions, though these changes are unlikely to change existing catchment boundaries.

The ridge line stretching across the SMP Study Area from east to west, just to the south of the Mine Haul Road, was determined to have not changed considering a post mining subsidence surface. Ridges that branch off this though heading to the north and south were shown to vary slightly when comparisons were made between existing and post mining subsidence surfaces. This was typical of the trends shown in the catchment analysis, while general changes in the ridge lines were very small they were more significant in the ridges running in a north or south direction.

Variation within these ridge lines were determined to be in the order of 1.5 to 2 m in a horizontal direction, within some specific instances, though this does not remain constant along the entire ridge line.

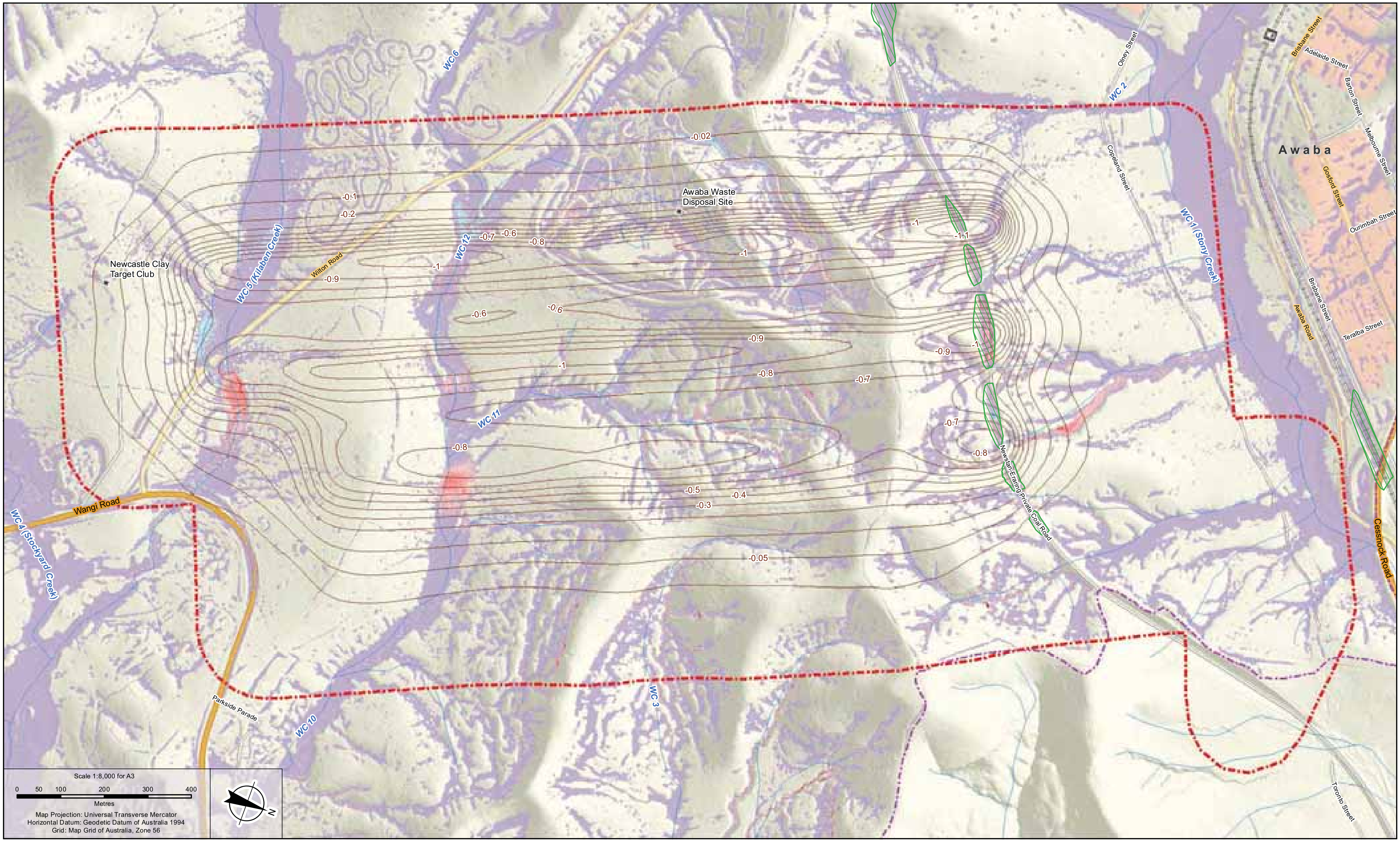
7.3.2 Hydraulic Impacts

The potential impacts caused by the subsidence may result in some minor changes to the catchment hydrology in both the extent and depth of the flood plain but also the associated flow velocities.

Flood Flow Depth and Extent

The subsidence assessment identified that there will be areas where there will be only a minor increase in flood extents and depths. Under the subsided conditions it was found that there were increases in the amount of flooding inundation for all of the assessed ARI events. The greatest was the 2 year ARI which had a maximum increase of approximately 3.7% within the SMP Study Area boundary with the 100 year ARI event having a similar increase of 3.4%. The increase in the area inundated, is a result of the change in depth within the waterways. This was primarily caused by a change in slope which in turn reduced flow velocity and therefore increasing the flow area. These changes in depth are illustrated in Figure 7-4, and the change in water level is also illustrated in Figure 7-5. Both Figures indicate the results for the 100 year ARI event.

The areas with the greatest impacts are located on Kilaben Creek (WC5) and the unnamed creek (WC12). These are positioned where the creeks cross the maximum subsidence and extend downstream to the approximate location of the 300 mm subsidence contour. The maximum increase in flood depth is of the order of 0.5 m for the 100 year ARI event and 0.35 m for the 2 year ARI.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m)

< -0.5, -0.50 - -0.35, -0.35 - -0.20, -0.20 - -0.10, -0.10 - 0.10, 0.10 - 0.20, 0.20 - 0.35, 0.35 - 0.50, >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Surface Water Impact Assessment

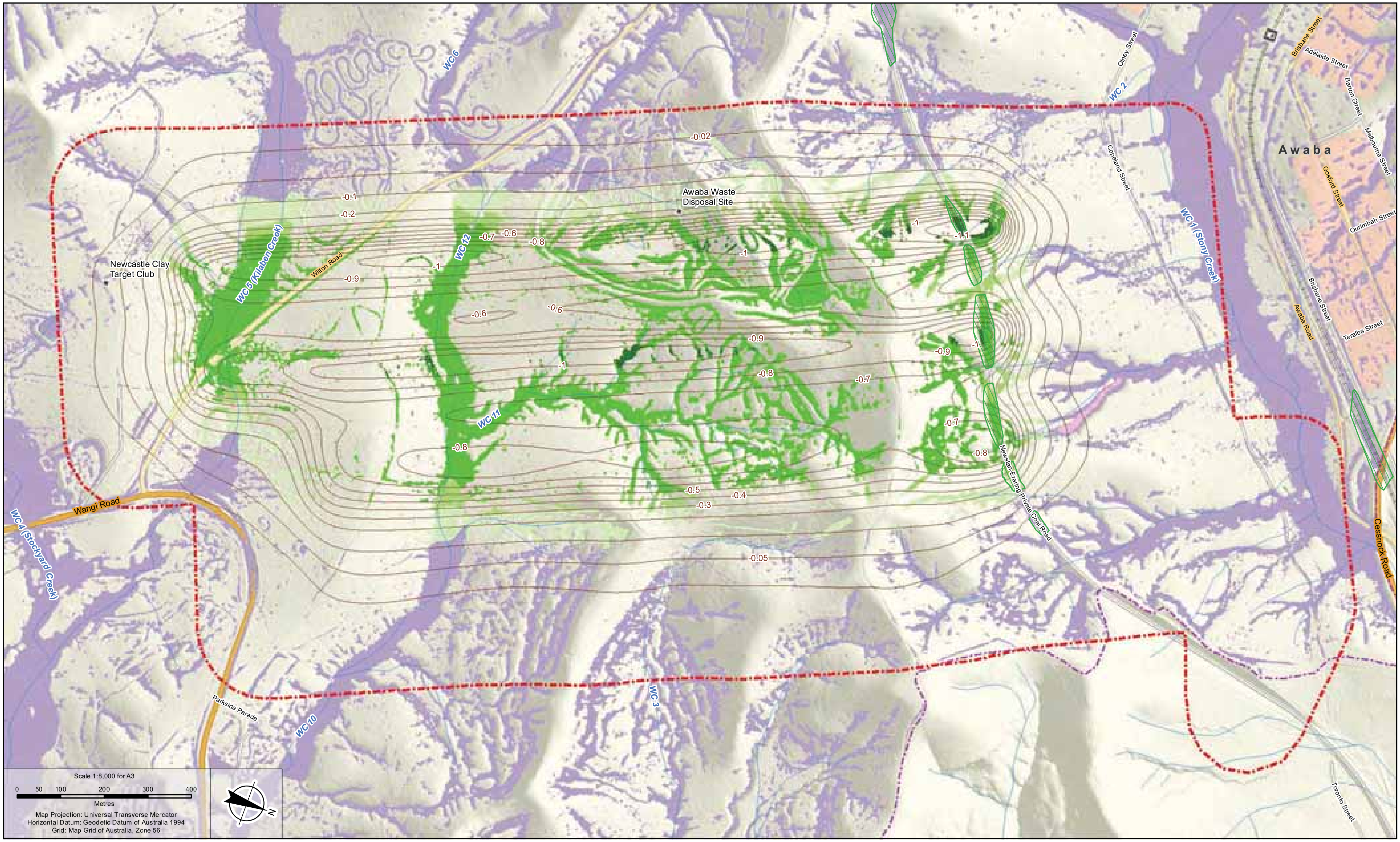
100 year ARI Depth Afflux Plot

Centennial Newstan

Date: 30/04/2012

Figure 7.4

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook_CODE5.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in water surface level (mAHD)

< -1.00; -1.00 - -0.50; -0.50 - -0.30; -0.30 - -0.10; -0.10 - 0.10; 0.10 - 0.30; 0.30 - 0.50; 0.50 - 1.00; > 1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Surface Water Impact Assessment

100 Year ARI Water Level Afflux Plot

Centennial Newstan

Date: 30/04/2012

Figure 7.5

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Table 7-3 provides details of the area inundated within the SMP Study Area boundary for both the existing and subsided scenarios and the resulting change as a percentage.

Table 7-3 Change of Area of Inundation due to Subsidence within the SMP Study Area Boundary

Event ARI	Area of Inundation (Depth > 100 mm)		
	Existing Case (km^2)	Subsided Case (km^2)	Change (%)
100	1.27	1.31	3.4%
20	1.22	1.26	3.7%
10	1.19	1.24	3.6%
2	1.13	1.17	3.7%
100 alternate Tailwater Level (TWL)	1.27	1.31	3.5%

Flow Velocity

The flow velocities within the catchment remain consistent or are reduced under the subsided conditions compared to the existing conditions as summarised in Section 5. Figure 7-6 illustrates that there is a 1.8% increase in areas with flow velocities between 0.0 and 0.5 m/s while an overall decrease in velocities that fall in the range between 0.5 and 5.0 m/s. There are some minor increases in velocities of over 5 m/s but this accounts for less than 0.1% in the SMP Study Area and located along the ridge lines.

The significant areas that show a change in velocity are generally as a result in the downstream reaches of Kilaben Creek (WC5) and the un-named watercourse, WC10 as illustrated in Figure 7-7. These locations have decreased bed grades which decrease velocity and therefore increase the flow depth in the creek. Areas that have an increased velocity are the upper reaches of these two creeks WC12 and WC5 have an increase in the order of 0.30 m/s. This increase in velocity corresponds to a slight steepening of the channel grade into the subsidence zone.

The flooding predictions shown in Figure 7-4, Figure 7-5 and Figure 7-7, indicate some limitations in the results. These limitations include areas of the model requiring further input data and detail. This input data and detail is currently being investigated and results will be further clarified in future stages of the project.

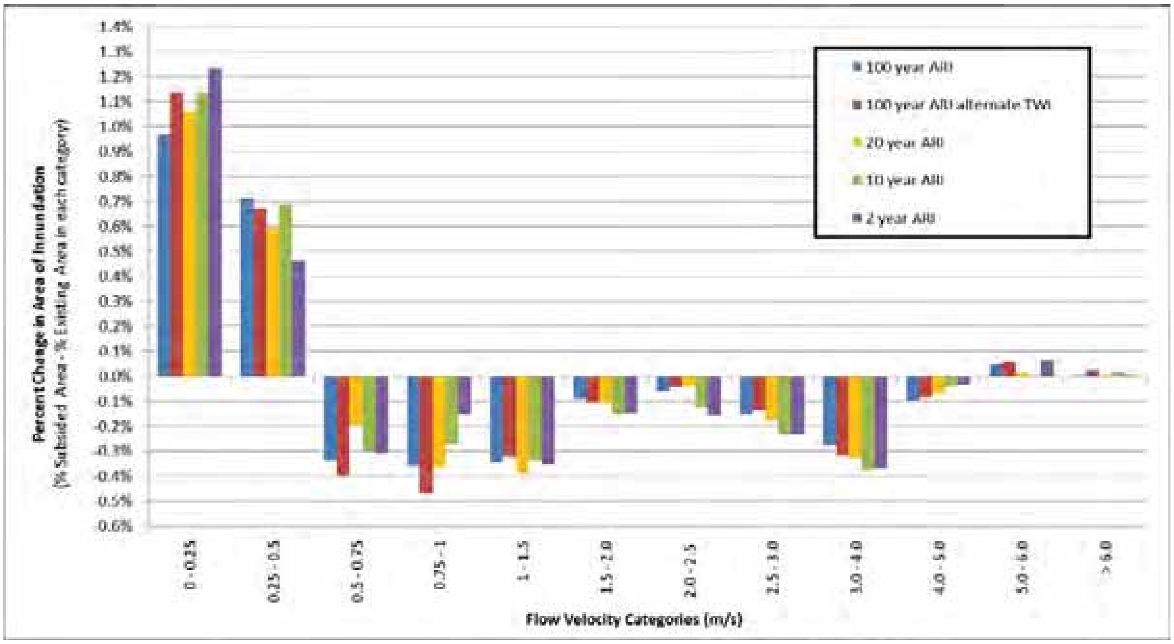
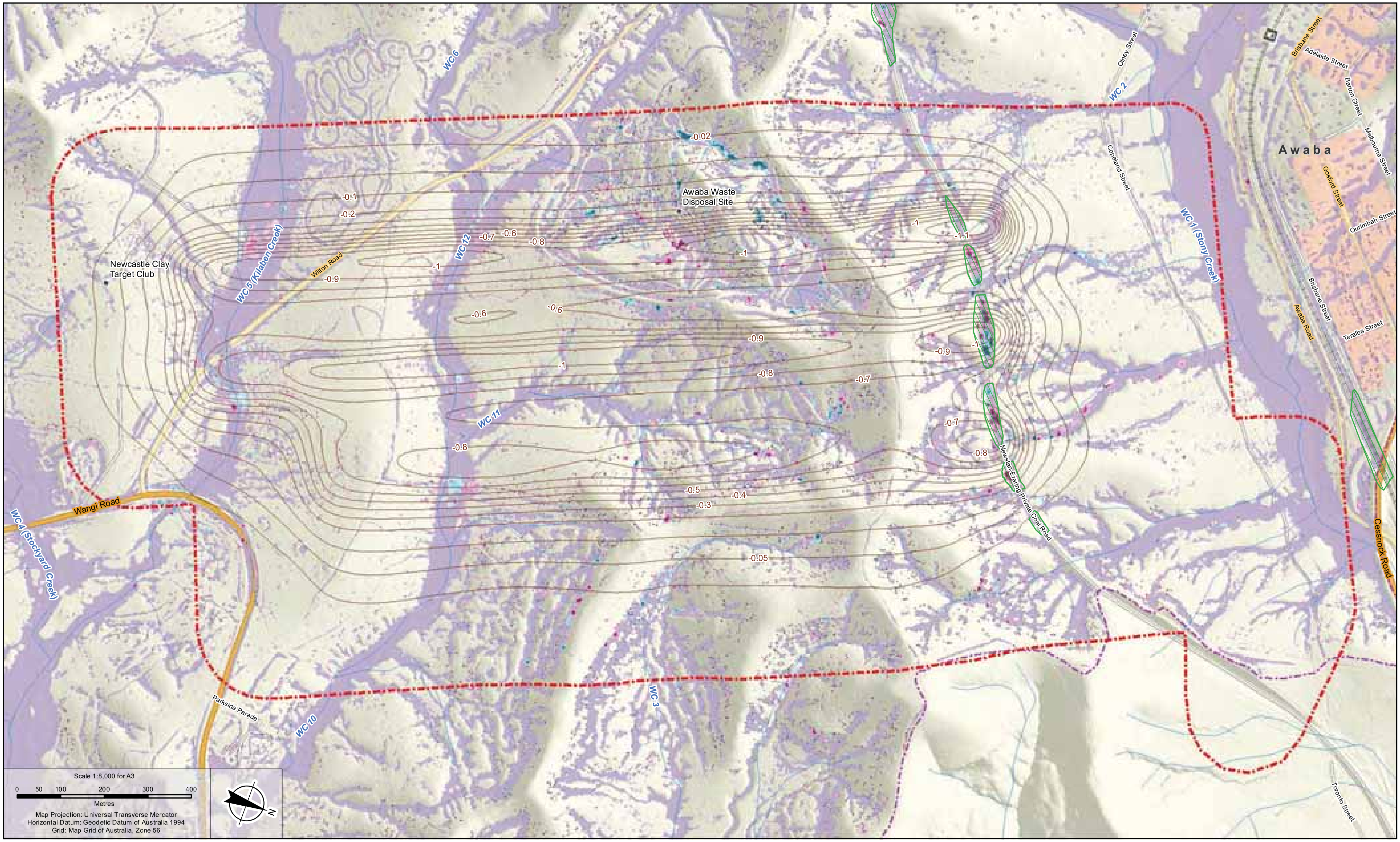


Figure 7-6 Change in SMP Study Area Velocities

7.3.3 Existing Infrastructure

The assessment of how subsidence is likely to impact existing infrastructure with respect to the effect of flooding and drainage was undertaken, for Roads, Culverts and Electrical Easements located within the SMP Study Area. Impacts associated with the existing infrastructure of the Awaba Waste Management Facility have also been discussed. This can be found within Section 7.4.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00 | -1.00 - -0.75 | -0.75 - -0.5 | -0.50 - -0.25 | -0.25 - 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Surface Water Impact Assessment

100 year ARI Velocity Afflux Plot

Centennial Newstan

Date: 30/04/2012

Figure 7.7

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook_CODE5.mxd

7.3.4 Roads

Of the roads assessed, the following maximum conventional subsidence and tilts have been determined by MSEC (2012).

Table 7-4 Predicted Subsidence and Tilt of Roads within SMP Study Area

Road Located On	Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt in any Direction (mm/m)
Wilton Road	After LW101	< 20	< 0.5
	After LW102	650	5.0
	After LW103	925	6.5
Wangi Road	After LW101	< 20	< 0.5
	After LW102	< 20	< 0.5
	After LW103	< 20	< 0.5
Mine Haul Road	After LW101	775	8.0
	After LW102	975	11.0
	After LW103	1175	13.0

As shown in Table 7-4, the maximum range of subsidence is 1175 mm on the Mine Haul Road. This is closely followed by Wilton Road with a maximum subsidence predicted of in the order of 925 mm. Both these roads are located directly above proposed longwalls.

The effect of the subsidence and tilt predictions on Wilton Roads was shown in longsections produced by MSEC which showed a similarity in existing and predicted post mining grades. In the vicinity of the Culvert WI-C3, subsidence predictions suggest a uniform change in surface with minimal increase in grades around the point at which the Culvert crosses Wilton Road.

Due to the nature of Wilton Road there are unlikely to be any specific points at which water can form areas of road side ponding. Ponding may occur on the surface of the road, in localised areas, but due to the significant grade of the road as it passes through the SMP Study Area it is unlikely that the road will be any more susceptible to flooding impacts.

Wangi Road is unlikely to be adversely effected as shown in the results in Table 7-4. A subsidence of less than 20 mm was predicted along Wangi Road with equally low tilt predictions.

The Mine Haul Road, similarly to Wilton Road, is undermined from longwalls located directly below it. The indicated change in grades between the existing and the predicted post mining grades indicated a minimal impact with a few areas indicating a steepening of grades. Generally the comparison of the longsection profile produced by MSEC indicates similarity over the majority of the affected road between the existing and predicted post mining grades.

Given that the Mine Haul Road contains a cut to fill profile for a large majority of the affected section of road, the table drain on the cut side must be assessed for increases in velocities with any steepening of road grade due to the predicted post mining grades. The estimated grade increase to approximately 50 mm/m from 40 mm/m is unlikely to cause a management issue, for what is typically a concrete table drain along the Mine Haul Roads.

7.3.5 Culverts

For the seven culverts investigated in Section 4.2.2, the following Table 7-5 shows the maximum conventional subsidence and tilt, as determined by MSEC (2012).

Table 7-5 Predicted Subsidence and Tilt of Culverts within SMP Study Area

Road Located On	Culvert Reference	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt in any Direction (mm/m)
Wilton Road	WI-C1	75	1.0
	WI-C2	800	3.0
	WI-C3	775	3.0
	WI-C4	< 20	5.0
Wangi Road	WA-C1	< 20	< 0.5
	WA-C2	25	< 0.5
Mine Haul Road	HR-C1	< 20	< 0.5

As the results in Table 7-5 indicate the maximum subsidence is likely to occur along Wilton Road and culverts WI-C2 and WI-C3, shown to subside by 800 mm and 775 mm respectively.

Culvert WI-C2 currently does not appear to provide a drainage function. Its location on the relatively steep longitudinal section of Wilton Road, the present vegetation, and the lack visual indicators of flow conveyance suggest that a majority of flow from day to day is conveyed by WI-C3. For this reason the impact on this culvert was not assessed.

The position of Culvert WI-C3, within the subsidence affection zone, indicates that it is unlikely that the drainage function of the Culvert is to be compromised. The scenario in this instance is that the Culvert would most likely have a uniform subsidence or a slight increase of grade in the direction of flow.

The tilts shown in the results of Table 7-5 were found to be greatest on Culvert WI-C3. As discussed by MSEC, a tilt of 5 mm/m is equal to a maximum change of grade of less than 1% and hence defined as a very minimal impact in terms of hydraulic function.

For each of the Culverts assessed within the SMP Study Area, an independent evaluation on the effect of subsidence on hydraulic operation was undertaken the results are shown in Table 7-6.

Table 7-6 Effect of Subsidence on Hydraulic Operation for Culverts within the SMP Study Area

Road Located On	Culvert Reference	Approximate Existing Culvert Grade (%)	Approximate Subsided Culvert Grade (%)	Culvert Exit Velocity under Subsided Conditions	Approximate Change between Existing Culvert Velocities and Subsided Culvert Velocities
Wilton Road	WI-C1	3.3	3.4	0.5 m/s	0.1 m/s
	WI-C3	5.0	5.5	3.5 m/s	0.9 m/s
	WI-C4	1.0	1.1	1.1 m/s	0.0 m/s
Wangi Road	WA-C1	6.3	6.3	3.6 m/s	0.0 m/s
	WA-C2	1.8	1.7	0.9 m/s	0.0 m/s
Mine Haul Road	HR-C1	4.3	4.3	4.3 m/s	0.0 m/s

The results in Table 7-6 show a good correlation with those Culverts with less than or equal to 25 mm subsidence indicating a negligible change in Culvert exist velocities under the predicted post mining subsided surface conditions. From the results summarised, changes in Culvert headwater depths were not included as all Culverts indicated a negligible change between the existing and the predicted post mining subsided surface condition headwater depths.

The Culvert, HR-C1, is the only culvert to indicate a reduction in grade due to the subsidence predictions, as indicated in Table 7-6. This is likely to be minimal though with a maximum subsidence of less than 20 mm predicted.

7.3.6 Electrical Infrastructure

For the Western and Eastern Branches of Electrical Infrastructure located within the SMP Study area, the maximum conventional predicted subsidence was determined by MSEC.

Table 7-7 Predicted Subsidence and Tilt of the Electrical Easement within the SMP Study Area

Branch	Crossings	Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt in any Direction (mm/m)
Western	NA	After LW101	750	6.0
		After LW102	825	6.0
		After LW103	825	6.5
Eastern	EA-C1 and EA-C2	After LW101	650	6.5
		After LW102	725	7.0
		After LW103	725	7.0

As indicated in Table 7-7, the predicted subsidence conditions were determined to be, after completion of Longwall LW103, in the order of 825 mm and 725 mm for the Western and Eastern Branches respectively. Of these subsidence predictions, the maximum tilt in any direction was estimated at between 0.6 and 0.7 % (6 and 7mm/m, respectively).

The focus of these predictions was to determine the possible impact on the existing access track and waterway crossings present along the Eastern Branch. With an expected subsidence of 725 mm and a tilt of 0.7 % the existing crossings of EA-C1 and EA-C2 will likely be subsided uniformly. The crossing of EA-C2 is more likely to be able to contain flooding within the bank of the Creek, Kilaben Creek (WC5). The Access Track crossing EA-C1 was observed to contain minimal cover between the road and the creek invert. It is more than likely, in the event of significant rainfall, that the function of this crossing would be compromised. Regardless of this, the creek is able to contain flooding extents within its banks similar to EA-C2 though the banks are located at a greater width.

Under predicted post mining subsidence conditions, these two crossings indicate key areas where both depth and velocity afflux occur. The depth afflux in these areas was in the order of 0.2 to 0.35 m with a velocity decrease of up to 0.5 m/s for the 100 year ARI event. This is consistent with the results as discussed earlier in Section 7.3.2 and the complete study, attached in Appendix B. The significance of this impact is minor as these access tracks are private and rarely used by AusGrid. In addition to this, the existing condition and serviceability of these crossings are predicted to be poor. The indicated level of afflux in both depth and velocity can be defined as manageable in this case as flooding is maintained within the banks of the waterways.

7.4 Water Quality

The proposed subsidence impacts will cause a change in surface levels and minor alterations to the hydrology and hydraulics of the catchment. It is expected that there will be minimal impacts on the water quality. There is a potential for, with any destabilisation and movement of creeks that a minor increase in TSS, and Turbidity may occur from time to time due to areas of erosion.

Areas of disturbance currently exist within the Eastern Branch of the Electrical Infrastructure due to the presence of an unsealed Access Track. The amount of sediment transport likely from this area of disturbance alone would outweigh any impacts created from subsidence induced erosion of the waterways.

Ongoing monitoring should be undertaken to assess any potential changes that may occur within the subsidence zone. It is additionally recommended that monthly monitoring of major ions continue to be included.

It should be considered that Secondary Extraction of the proposed mining area will not commence until 2014. By this time a larger series of data will be available consisting of a total of 24 monitoring points. At this time a better understanding of site specific triggers will be available.

7.4.1 Awaba Waste Management Facility

The Awaba Waste Management Facility (AWMF) is located above Longwall LW103 and is expected to experience up to 1075 mm of subsidence (MSEC; 2012). The facility includes a waste disposal area, leachate collection systems, leachate ponds, sediment ponds, gas drainage systems, a gas powered generator, weigh bridges, and administration and storage structures. The original waste disposal area was unlined, while the newer cells were constructed with a liner (MSEC; 2012). The facility has also proposed to expand the waste emplacement area and to construct an Alternative Water Treatment Facility.

Wherever mining is undertaken underneath a waste disposal facility there are potential effects of subsidence on the water quality of the surrounding environment.

Firstly, the subsidence could cause surface cracking of the capping layer, which would allow surface water to flow through the waste area and collect pollutants. However, the AWMF has established procedures with the aim of maintaining the integrity of the capping layer which is subject to natural settlement of the waste. It is likely that this natural settlement would be larger than the mining related subsidence (MSEC; 2012). Therefore, subsidence impacts are unlikely to have a detrimental effect on water quality due to surface cracking of the capping layer.

Secondly, the extraction of the longwalls may result in fracturing and dilation of the topmost bedrock layers which will increase permeability of near surface strata layers (MSEC; 2012). As the original waste disposal areas are unlined there is potential for leachate to drain from the waste area and enter the groundwater system. However, MSEC concludes that continuous cracking would not extend from the seam up to the surface. For this reason leachate would be expected to be confined near the surface strata. Therefore, subsidence impacts are unlikely to have a detrimental effect on water quality due to increased permeability of the underlying strata.

Thirdly, there is potential for subsidence to affect above ground storages of polluted water such as leachate and sediment ponds. However, it is anticipated that these facilities could be managed with the implementation of suitable management plans such that subsidence does not have a detrimental effect on water quality.

7.5 Increased Subsidence Predictions

Using a scenario whereby an increased subsidence predictions of a factor of two times (MSEC; 2012) occurred, the impact of the project on, waterway stability, ponding and flooding were evaluated. These are discussed within the following Sections.

7.5.1 Impacts on Waterway Stability and Ponding

In the event that the maximum subsidence predictions were exceeded by a factor of two times, it is expected that gradients along reaches of WC5, WC6 and WC12 would increase to a maximum of 2.5% to 3.0% where they enter the subsidence affected area. Such a gradient increase is considered to increase the risk of incision and increased waterway instability from low to moderate. This higher risk, in the absence of hydraulic modelling of increased subsidence conditions, is primarily based on the analysis that the increased gradients match or exceed the maximum gradient of known chain of ponds systems in the area. Hence, there is the potential that incision and head cut erosion may be initiated along waterways WC5, WC6 and WC12 where they enter the subsidence affectation zone.

It is therefore recommended to monitor areas where potential ponding, channel instabilities or head cut erosion may occur. If such waterway impacts are observed, remediation works will need to be implemented to maintain channel grades, with consideration of channel stabilities and existing waterway characteristics.

MSEC (2012) discusses the impact on waterways of subsidence predictions exceeding estimates by a factor of 2 times. It was outlined that if the actual curvatures, strains or valley related movements exceeded those predicted, it would be expected that the extent of fracturing in the uppermost bedrock would increase along the sections of the watercourses located directly above the proposed longwalls. This depth of fracturing would still be expected to penetrate no greater than 10 m to 15 m. From this estimate, MSEC believed that given a fracturing of 15 m it is unlikely that any loss of surface water from the catchment would occur.

MSEC also identified in an increased subsidence prediction scenario that it would be likely that visible fracturing along the first and second order watercourses would increase while fracturing within lower reaches would still be unlikely.

In summary, the risk of ponding, channel instabilities or head cut erosion along waterways WC5, WC6, WC10 and WC12 is considered moderate in the event that the predicted subsidence is exceeded by a factor of two.

7.5.2 Impacts on Hydrologic and Hydraulic Conditions

The assessment indicated that there is a potential for stream reversal of Kilaben Creek (WC10) and the un-named creek WC12. With a potential grade reversal there is a possibility of ponding within the creek which would not have occurred previously. For the other watercourses assessed by MSEC, there would be changes to the grades but not to a level sufficient to change the hydrology or hydraulics.

Hydrologic Conditions

The impacts on the hydrologic conditions when considering an increased subsidence prediction, is likely to be minor given that there was minimal change with the current conditions. This was illustrated in the GHD (2012a) report comparing the peak flows at WC12 and WC10 for the pre and post models, which provided results that indicated only a minor change. It is anticipated that as a result of an increased subsidence prediction, and a shallowing or reversing of grade was to occur, the catchment runoff would take longer to leave the subsidence impacted area. This would most likely reduce the peak flow at Wangi Road.

Hydraulic Conditions

Considering an increased subsidence prediction, the impacts on the hydraulic operation of the watercourses within the project area, would likely consist of:

- An increase of flow depth due to a corresponding reduction in flow velocity.
- A reduction in flow depth and increase in flow velocity. Based on the MSEC report, the maximum grade for WC12 in the increased subsidence predictions scenario would be in the order of 3.5% which is an increase from 2.5%. The magnitude of this change on the velocity would be in the order of 20% based on the velocity being proportional to the square root of slope. As a guide, this would represent a worst case scenario velocity of 1.8 m/s for the 100 year ARI event on WC12, and an increase from 1.5 m/s in the 100 year ARI event.

8. Mitigation Measures

8.1 Reporting

Newstan currently develops an Annual Environmental Management Report (AEMR). This report typically includes the elements specific to Surface Water Management of:

- A detailed assessment of the water quality monitoring results collected over the course of the annual monitoring program.
- An evaluation of any trends occurring across the site.
- Any recommendations for management action.

It is recommended that this AEMR should report on the identified areas of potential impact during the course of the proposed longwall mining and report on any management actions taken. Management actions specific to surface water impacts may include:

- Alterations to water quality monitoring frequencies, parameter or locations.
- The initiation of remedial action.

As part of mitigating potential impacts of subsidence on waterways within the SMP Study Area, a Newstan Watercourse Management Plan will be developed. This management plan will include:

- Area of applicability.
- Recommendations for remediation actions including Trigger Action Response Plans (TARP's).
- Monitoring requirements.
- Aspects of ecological health, and groundwater interactions with the waterways.
- Reporting requirements.

The definitions of monitoring and remediation requirements that will be incorporated into the Watercourse Management Plan are further discussed in Section 0.

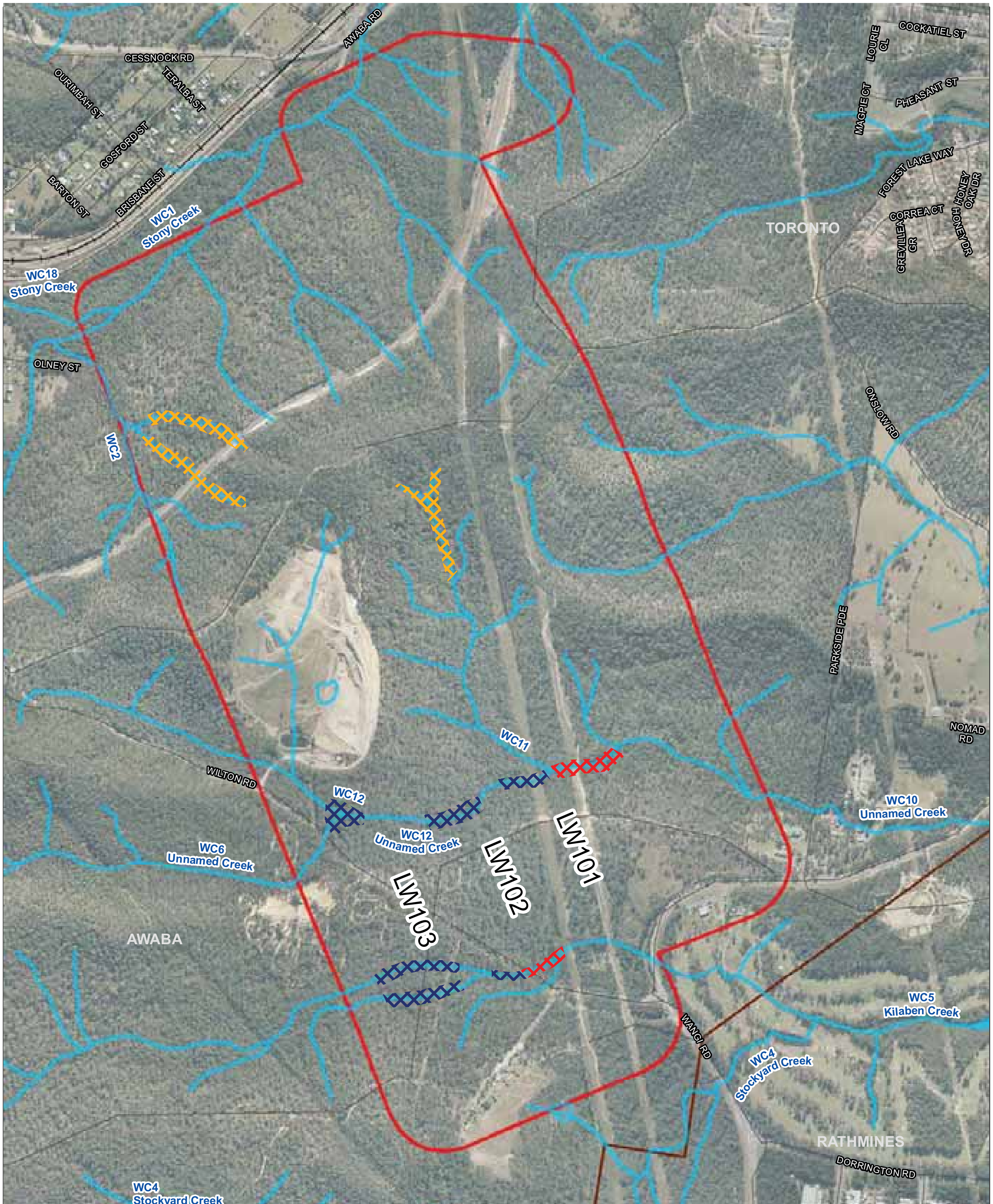
8.2 Monitoring and Remediation

- At Newstan, various inspections and monitoring are undertaken at regular intervals ranging weekly to monthly. During the proposed longwall mining of the SMP study, visual monitoring of the waterways discussed will be required. Specific areas of interest have been highlighted and are indicated on Visual inspection and recording (including photographic records at appropriate intervals) of stream bed and bank condition and riparian vegetation along waterways WC5, WC6, WC10 and WC12 through the subsidence affected area. These inspections are to focus on identifying any incision or head cut development along waterways.
- In the event incision or head-cut development is observed following subsidence, remediation works will need to be implemented to maintain channel grades, with consideration of channel stabilities and existing waterway characteristics. This will be achieved through the following points:
  - All Remediation works will be completed in accordance with developed a Watercourse Management Plan, covering;
    - (i) Installation of appropriate erosion and sediment controls where required.
    - (ii) Limiting access tracks into works areas by using existing access tracks as far as possible.
    - (iii) Avoid or limit the use of large machinery to minimise disturbance.
    - (iv) Where disturbance and vegetation clearance is required ensure that the disturbance is minimal.
    - (v) Prompt stabilisation and revegetation of disturbed areas.
- The Watercourse Management Plan will incorporate TARP's for instances of greater than predicted areas of subsidence.

Figure 8-1. It is recommended that these recommended areas of monitoring form part of a specific watercourse management plan set out to monitor and manage waterways identified within the SMP Study Area.

The monitoring and remediation procedures may include but not limited to:

- Monitoring, measuring and recording (e.g. photographic records) of the extent and magnitude of any surface cracking along first order and second order drainage lines in depths of cover less than 250 m. If works are required these may include self-healing of cracks and/or manual sealing of cracks, using approved methods.
  - Monitoring methods may include the development of a cross section across the waterway in locations likely to experience more significant impacts from the subsidence, where the section can be monitored visually and through detailed ground survey over a period of 6 to 12 months.
- Visual inspection and recording (including photographic records at appropriate intervals) of stream bed and bank condition and riparian vegetation along waterways WC5, WC6, WC10 and WC12 through the subsidence affected area. These inspections are to focus on identifying any incision or head cut development along waterways.
- In the event incision or head-cut development is observed following subsidence, remediation works will need to be implemented to maintain channel grades, with consideration of channel stabilities and existing waterway characteristics. This will be achieved through the following points:
  - All Remediation works will be completed in accordance with developed a Watercourse Management Plan, covering;
    - (vi) Installation of appropriate erosion and sediment controls where required.
    - (vii) Limiting access tracks into works areas by using existing access tracks as far as possible.
    - (viii) Avoid or limit the use of large machinery to minimise disturbance.
    - (ix) Where disturbance and vegetation clearance is required ensure that the disturbance is minimal.
    - (x) Prompt stabilisation and revegetation of disturbed areas.
- The Watercourse Management Plan will incorporate TARP’s for instances of greater than predicted areas of subsidence.



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0 50 100 200 300 400

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

- Railway
- Proposed Final Newstan Colliery Holding Boundary
- SMP Study Area
- Creek Stability Monitoring Area
- Monitoring of Exposed Areas of Rock
- Ponding Monitoring Area

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Surface Water Impact Assesment

Waterway Monitoring Locations

Centennial Newstan

DATE 17/04/2012

Figure 8-1

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8.3 Drainage of Roads and Culverts

It is recommended that during the proposed mining of the longwalls within the SMP Study Area, the roads and culverts identified as being within the SMP zone of affection be visually monitored regularly.

The visual monitoring should consider any signs of water ponding on the road surface or within road side table drains. Culverts and Access Track crossings, indicated within Table 4-1 and Table 4-2 should be also monitored periodically to determine whether cracking is observed or extended periods of water ponding on the upstream side of a culvert is occurring.

8.4 Water Quality Monitoring

Surface water quality monitoring will continue for the Newstan SMP project. The water monitoring points of this study have been incorporated into the existing Newstan Surface Water Quality Monitoring Program and will continue monitoring as per the location, analytes and duration summarised in Table 8-1.

Table 8-1 Proposed Monitoring Program

Location	Samples	Duration
WMP27, WMP28, WMP29, WMP30, WMP31, WMP32, WMP33, WMP34	• pH, EC Turbidity, Oil & Grease, TSS • Metals, Total and Dissolved: Aluminium, Arsenic, Boron, Cobalt, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Nickel, Zinc • Major Ions: Calcium, Magnesium, Potassium, Sodium, Chloride, Total Alkalinity • Total nitrogen, including ammonia	Monthly

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Appendix A

Water Quality Data Samples

Water Quality Data Samples

Date of Sample	Seam/other reference	pH	TSS	TDS	Ec (uS/cm)	Oil & Grease	Manganese (Filt)	Iron (Filt)	Turbidity (NTU)	Aluminium (Dissolved)	Aluminium (Total)	Antimony	Arsenic (Dissolved)	Arsenic (Total)	Barium
27/06/11	WMP27	5.16	11	138	109	0	0.007	0.48	17.9	0.77	1.9		0	0	0.026
26/07/11	WMP27	5.28	<5	74	120	0	0.012	1.15	30.8	1.77	2.64		0	0	0.024
18/08/11	WMP27	5.22	<5	120	123	0	0.012	0.71	24.1	1.2	1.4		0	0	0.025
26/09/11	WMP27	5.09	8	169	70	0	0.015	1.06	43.7	1.76	2.27		0	0.001	0.027
24/10/11	WMP27	5.56	<5	140	127	0	0.008	0.98	26.5	1.49	2.13		0	0	0.028
23/11/11	WMP27	5.72	7	131	140	0	0.022	1.19	27.3	0.75	1.57		0	0	0.03
16/12/11	WMP27	5.57	<5	186	121	0	0.009	0.52	40.8	0.53	2.19		0	0	0.026
23/01/12	WMP27	5.72	<5	182	135	0	0.019	1.23	26	0.69	1.38		0	0	0.028
27/06/11	WMP28	6.34	10	382	560	0	0.16	0.92	12.3	0.22	1.11		0.004	0.004	0.04
26/07/11	WMP28	6.29	5	192	275	0	0.027	1.07	24.3	1.12	1.33		0	0	0.025
18/08/11	WMP28	6.45	6	312	516	0	0.089	1.03	13.7	0.26	0.46		0.006	0.011	0.031
26/09/11	WMP28	6.05	15	174	211	0	0.034	0.86	40	0.96	1.22		0	0.002	0.023
24/10/11	WMP28	6.74	<5	368	549	0	0.04	1.44	11.6	0.25	0.4		0.001	0.002	0.04
23/11/11	WMP28	7.40	30	101	71	0	0.017	0.15	99.5	0.37	2.25		0.002	0.004	0.042
16/12/11	WMP28	6.56	8	242	322	0	0.012	2.32	15.5	0.14	0.80		0	0.001	0.025
23/01/12	WMP28														
27/06/11	WMP29	5.61	42	235	242	0	0.053	0.92	43.2	1.7	2.56		0	0	0.028
26/07/11	WMP29	5.79	<5	116	191	0	0.023	0.93	38.1	2	2.6		0	0	0.022
18/08/11	WMP29	5.86	166	228	172	0	0.058	1.21	81.6	2.28	4.42		0	0	0.038
26/09/11	WMP29	6.26	22	270	237	0	0.022	0.65	65.9	0.91	2.2		0	0.001	0.022
24/10/11	WMP29	6.31	24	240	196	0	0.051	1.46	63.5	2.38	3.72		0	0.001	0.03
23/11/11	WMP29	5.49	640	320	63	0	0.074	0.98	509	1.28	11.7		0	0.002	0.076
16/12/11	WMP29	6.28	6	210	180	0	0.039	0.59	52.1	0.77	2.55		0	0	0.025
23/01/12	WMP29														
27/06/11	WMP30	4.62	8	368	416	0	0.057	0.9	30.9	0.91	0.98		0	0	0.045
26/07/11	WMP30	5.88	14	136	184	0	0.027	1.14	59.0	2.11	3.76		0	0	0.028
18/08/11	WMP30	6.04	<5	330	540	0	0.085	0.91	17.3	0.43	0.61		0	0	0.056
26/09/11	WMP30	6.01	74	344	151	0	0.025	1.19	203	2.15	6.8		0	0.002	0.033
24/10/11	WMP30	6.47	18	350	500	0	0.134	1.32	31.1	0.56	0.63		0	0.001	0.07
23/11/11	WMP30	6.64	5	336	510	0	0.178	2.23	27.3	0.61	0.73		0	0	0.062
16/12/11	WMP30	6.13	11	227	211	0	0.042	1.06	68.9	0.78	3.60		0	0	0.037
23/01/12	WMP30	6.72	5	474	622	0	0.240	1.44	16.0	0.12	0.41		0	0	0.070

Date of Sample	Seam/other reference	Beryllium (Dissolved)	Beryllium (Total)	Boron	Cadmium (Dissolved)	Cadmium (Total)	Chromium (Dissolved)	Chromium (Total)	Chloride	Cobalt (Dissolved)	Cobalt (Total)	Copper (Dissolved)	Copper (Total)	Iron (Dissolved)	Iron (Total)	Lead (Total)	Lithium	Magnesium (Dissolved)	Manganese (Dissolved)	Manganese (Total)	Mercury	Nickel (Dissolved)	Nickel (Total)	Potassium	Selenium (Dissolved)	Selenium (Total)	Selenium
27/06/11	WMP27			0	0.0014	0.004	0	0.001	30	0	0	0	0		0.44	0		2		0.01	0	0	0		0	0	
26/07/11	WMP27			0	0	0	0.001	0.001	20	0	0	0.001	0.001		1.22	0		2		0.015	0	0	0		0	0	
18/08/11	WMP27			0	0	0	0.001	0.002	28	0	0	0	0		1.07	0			3	0.012	0	0	0		0	0	
26/09/11	WMP27			0	0	0	0	0.002	23	0	0	0	0		1.59	0.001		2		0.017	0	0	0		0	0	
24/10/11	WMP27			0	0	0	0.001	0.001	25	0	0	0	0.001		1.91	0.001		2		0.010	0	0	0.001		0	0	
23/11/11	WMP27			0	0	0	0	0.001	32	0	0	0	0		1.86	0		2		0.022	0	0	0		0	0	
16/12/11	WMP27			0	0	0	0	0.002	24	0	0	0	0		1.76	0.001		2		0.01	0	0	0.001		0	0	
23/01/12	WMP27			0	0	0	0	0.001	22	0	0	0.001	0		2.15	0		2		0.018	0	0	0		0	0	
27/06/11	WMP28			0	0	0.0003	0	0	130	0	0	0.001	0.002		1.86	0		10		0.105	0	0.001	0.001		0	0	
26/07/11	WMP28			0	0	0	0	0.001	56	0	0	0.002	0.002		1.42	0.001		5		0.029	0	0.001	0.001		0	0	
18/08/11	WMP28			0	0	0	0	0	127	0	0	0.002	0.003		1.36	0.002			10	0.09	0	0	0.001		0	0	
26/09/11	WMP28			0	0	0.001	0	0.002	49	0	0	0.002	0		1.28	0.001		4		0.038	0	0	0		0	0	
24/10/11	WMP28			0	0	0	0	0	157	0	0	0	0.001		7.07	0.002		10		0.086	0	0.001	0.001		0	0	
23/11/11	WMP28			0	0	0.0001	0	0.002	5	0	0	0.006	0.010		1.87	0.010		1		0.082	0	0	0.002		0	0	
16/12/11	WMP28			0	0	0	0	0.001	81	0.001	0	0.002	0.001		2.26	0		6		0.017	0	0	0.001		0	0	
23/01/12	WMP28																										
27/06/11	WMP29			0.05	0.0001	0	0.001	0.002	40	0	0	0.001	0.002		1.43	0.001		6		0.06	0	0.001	0.001		0	0	
26/07/11	WMP29			0	0	0	0.002	0.002	26	0	0	0.001	0.001		1.25	0		4		0.026	0	0.001	0.001		0	0	
18/08/11	WMP29			0	0	0	0.002	0.004	32	0	0.001	0.002	0.004		3.35	0.003			6	0.083	0	0.001	0.003		0	0	
26/09/11	WMP29			0	0	0	0	0.003	22	0	0	0.002	0		1.39	0.001		13		0.026	0	0.001	0.001		0	0	
24/10/11	WMP29			0.06	0	0	0.002	0.003	29	0	0	0.001	0.002		2.34	0.002		4		0.071	0	0.002	0.003		0	0	
23/11/11	WMP29			0.05	0.0001	0	0	0.010	10	0	0.002	0.002	0.007		7.78	0.008		1		0.124	0	0.001	0.004		0	0	
16/12/11	WMP29			0	0	0	0	0.002	22	0	0	0.001	0.002		1.78	0.002		5		0.046	0	0.001	0.002		0	0	
23/01/12	WMP29																										
27/06/11	WMP30			0	0	0.0002	0	0	95	0	0	0	0		1.49	0		8		0.064	0	0	0		0	0	
26/07/11	WMP30			0	0	0	0	0.002	35	0	0	0.001	0.001		1.83	0.002		4		0.03	0	0	0		0	0	
18/08/11	WMP30			0	0	0	0.001	0	134	0	0	0	0		1.82	0		11		0.075	0	0	0		0	0	
26/09/11	WMP30			0	0	0.0002	0.001	0.006	34	0	0	0.001	0		3.70	0.005		3		0.038	0	0	0.002		0	0	
24/10/11	WMP30			0	0	0	0	0	123	0	0	0	0		2.92	0		10		0.202	0	0	0.001		0	0	
23/11/11	WMP30			0	0	0.0002	0	0	102	0	0	0.012	0.021		3.58	0.008		9		0.190	0	0.001	0.002		0	0	
16/12/11	WMP30			0	0	0	0	0.003	47	0	0	0.001	0.002		2.85	0.003		4		0.053	0	0.001	0.002		0	0	
23/01/12	WMP30			0	0	0	0	0	144	0	0	0.001	0		4.20	0		12		0.220	0	0	0		0	0	

Date of Sample	Seam/other reference	pH	TSS	TDS	Ec (uS/cm)	Oil & Grease	Manganese (Filt)	Iron (Filt)	Turbidity (NTU)	Aluminium (Dissolved)	Aluminium (Total)	Antimony	Arsenic (Dissolved)	Arsenic (Total)	Barium	Beryllium (Dissolved)	Beryllium (Total)	Boron	Cadmium (Dissolved)	Cadmium (Total)
27/06/11	WMP31	**6.48**	6	**406**	566	0	0.018	1.08	22.1	0.61	**1.15**		0	0	0.046			0.15	0	0.0007
26/07/11	WMP31	6.92	16	**268**	504	0	0.009	0.82	32.5	0.7	**1.71**		0	0	0.046			0.16	0	0
18/08/11	WMP31	6.52	<5	**366**	603	0	0.033	1.46	17.3	0.58	**0.77**		0	0	0.052			0.13	0	0
26/09/11	WMP31	6.71	28	510	817	0	0.019	0.62	**78.6**	0.45	**2.33**		0	0.002	0.089			0.30	0.0002	0.0001
24/10/11	WMP31	6.93	7	**394**	600	0	0.041	1.55	26.6	0.77	**1.3**		0	0.002	0.06			0.16	0	0
23/11/11	WMP31	7.79	16	**1520**	2910	0	0.344	2.97	**19.6**	0.23	**0.74**		0.005	**0.004**	0.227			0.58	0.0002	0.0002
16/12/11	WMP31	6.93	15	**290**	442	0	0.012	0.87	**49.0**	0.32	**1.78**		0.001	**0.002**	0.052			0.13	0	0.0002
23/01/12	WMP31																			
27/06/11	WMP32	**6.56**	52	**496**	748	0	0.005	0.64	21.2	0.51	**2.96**		0	0	0.074			0.28	0.0003	0
26/07/11	WMP32	7.03	35	**300**	567	0	0.134	1.18	39.2	0.29	**2.14**		0.001	0	0.058			0.2	0	0
18/08/11	WMP32	6.70	<5	**546**	823	0	0.015	0.37	6.6	0.15	**0.36**		0.001	0	0.063			0.31	0	0
26/09/11	WMP32	**6.48**	10	422	618	0	0.014	0.47	41.2	0.41	1.25		0	0.001	0.06			0.37	0	0
24/10/11	WMP32																			
23/11/11	WMP32	7.54	232	**1560**	3020	0	0.218	1.97	123	0.15	3.32		0.004	0.007	0.260			1.03	0.0001	0.0004
16/12/11	WMP32	7.15	<5	**348**	538	0	0.011	0.68	46.4	0.28	1.79		0	0.001	0.062			0.18	0	0
23/01/12	WMP32																			
27/06/11	WMP33	**6.28**	<5	**322**	419	0	0.002	0.36	17	0.36	0.77		0	0	0.065			0	0	0
26/07/11	WMP33	6.16	<5	**218**	295	0	0.017	0.81	43.9	1.31	2.32		0	0	0.041			0.05	0	0
18/08/11	WMP33	6.36	14	**646**	1150	0	0.011	0.14	17.7	0.05	0.18		0.001	0	0.123			0	0	0.0001
26/09/11	WMP33	6.44	100	207	227	0	0.011	0.57	92.9	0.9	1.83		0.001	0.002	0.032			0	0.0002	0
24/10/11	WMP33	6.71	40	**366**	534	0	0.028	0.51	14.4	0.15	0.76		0	0.002	0.068			0.05	0	0.0002
23/11/11	WMP33	7.02	20	**388**	**622**	0	0.048	0.73	28.9	0.2	0.97		0.001	0.003	0.070			0.07	0	0
16/12/11	WMP33	6.85	<5	**144**	**362**	0	0.032	0.77	34.0	0.28	1.35		0.002	0.002	0.036			0	0	0
23/01/12	WMP33	7.01	7	**926**	**1430**	0	0.914	1.01	19	0.01	0.05		0.001	0.001	0.146			0	0	0
27/06/11	WMP34	**4.84**	5	**238**	**248**	0	0.049	1.19	20.3	1.43	1.37		0	0	0.029			0	0	0
26/07/11	WMP34	5.07	<5	**128**	**130**	0	0.027	1.25	24.6	1.8	1.81		0	0	0.019			0	0	0.0002
18/08/11	WMP34	4.89	<5	197	**227**	0	0.051	1.63	16.5	1.23	1.14		0.002	0	0.03			0	0.0001	0
26/09/11	WMP34	4.91	<5	170	**129**	0	0.038	1	26.7	1.07	1.23		0	0	0.021			0	0	0.0066
24/10/11	WMP34	5.28	<5	**284**	**226**	0	0.041	3.78	33.6	2.61	2.49		0.001	0.002	0.029			0	0	0.0001
23/11/11	WMP34	5.23	8	**182**	**191**	0	0.051	1.49	19.9	0.85	0.98		0	0	0.026			0	0.0001	0.0002
16/12/11	WMP34	5.43	<5	**219**	**166**	3	0.036	3.67	17.7	1.23	1.25		0.001	0	0.017			0	0.0001	0
23/01/12	WMP34																			

Date of Sample	Seam/other reference	Chromium (Dissolved)	Chromium (Total)	Chloride	Cobalt (Dissolved)	Cobalt (Total)	Copper (Dissolved)	Copper (Total)	Iron (Dissolved)	Iron (Total)	Lead (Total)	Lithium	Magnesium (Dissolved)	Manganese (Dissolved)	Manganese (Total)	Mercury	Nickel (Dissolved)	Nickel (Total)	Potassium	Selenium (Dissolved)	Selenium (Total)	Selenium
27/06/11	WMP31	0.001	0.002	120	0	0	0.002	0.002		1.82	0.001		10		0.023	0	0.002	0.002		0	0	
26/07/11	WMP31	0.002	0.002	80	0	0	0.002	0.002		1.56	0.002		8		0.012	0	0.003	0.003		0	0	
18/08/11	WMP31	0.002	0.001	149	0	0	0.002	0.002		2.14	0.001		11		0.032	0	0.003	0.003		0	0	
26/09/11	WMP31	0.002	0.006	170	0.002	0.002	0.003	0		2.10	0.003		16		0.033	0	0.007	0.008		0	0	
24/10/11	WMP31	0.001	0.002	150	0	0.001	0.002	0.003		2.90	0.002		11		0.059	0	0.003	0.004		0	0	
23/11/11	WMP31	0.024	0.026	518	0.014	0.014	0.004	0.005		4.10	0.002		42		0.339	0	0.036	0.038		0	0	
16/12/11	WMP31	0.001	0.003	99	0	0	0.002	0.003		2.42	0.002		7		0.023	0	0.003	0.004		0	0	
23/01/12	WMP31																					
27/06/11	WMP32	0.001	0.003	167	0	0	0.002	0.003		2.97	0.004		12		0.013	0	0.003	0.004		0	0	
26/07/11	WMP32	0.002	0.003	91	0	0.002	0.002	0.002		2.27	0.002		10		0.202	0	0.004	0.004		0	0	
18/08/11	WMP32	0.002	0.004	211	0	0	0.001	0.002		0.47	0		15		0.017	0	0.004	0.004		0	0	
26/09/11	WMP32	0.001	0.004	118	0.001	0.001	0.002	0		1.05	0.001		11		0.022	0	0.004	0.004		0	0	
24/10/11	WMP32																					
23/11/11	WMP32	0.020	0.020	624	0.013	0.012	0.007	0.012		16.5	0.007		33		0.268	0	0.036	0.033		0	0	
16/12/11	WMP32	0.002	0.003	127	0	0.001	0.003	0.004		2.29	0.002		9		0.021	0	0.004	0.006		0	0	
23/01/12	WMP32																					
27/06/11	WMP33	0	0	68	0	0	0.003	0.003		0.68	0.002		10		0.005	0	0.001	0.001		0	0	
26/07/11	WMP33	0.001	0.002	46	0	0	0.006	0.006		1.54	0.004		6		0.02	0	0.002	0.002		0	0	
18/08/11	WMP33	0	0	317	0	0	0.002	0.004		0.57	0.001		27		0.02	0	0.002	0.002		0	0	
26/09/11	WMP33	0	0.002	47	0	0	0.005	0.007		1.35	0.005		6		0.018	0	0.001	0.002		0	0	
24/10/11	WMP33	0	0.002	131	0	0	0.004	0.005		2.76	0.004		13		0.071	0	0.002	0.004		0	0	
23/11/11	WMP33	0	0.001	129	0	0	0.005	0.007		3.54	0.008		13		0.103	0	0.002	0.002		0	0	
16/12/11	WMP33	0	0.002	75	0	0	0.004	0.005		1.96	0.002		7		0.035	0	0.002	0.002		0	0	
23/01/12	WMP33	0	0	383	0.002	0.002	0.002	0		3.66	0		30		0.987	0	0.003	0.003		0	0	
27/06/11	WMP34	0.001	0	49	0.002	0.002	0.001	0.001		1.56	0.001		5		0.052	0	0.002	0.001		0	0	
26/07/11	WMP34	0.001	0.001	21	0	0	0.002	0.001		1.33	0.001		3		0.028	0	0	0		0	0	
18/08/11	WMP34	0.002	0.001	53	0.002	0.002	0.001	0.001		1.8	0.001		6		0.047	0	0.002	0.002		0	0	
26/09/11	WMP34	0	0	33	0	0	0.001	0.001		1.24	0		3		0.039	0	0.001	0.001		0	0	
24/10/11	WMP34	0.002	0.002	58	0.002	0.002	0.002	0.002		4.76	0.003		4		0.042	0	0.003	0.004		0	0	
23/11/11	WMP34	0	0	42	0.001	0.001	0.002	0.002		2.00	0.002		4		0.050	0	0.002	0.001		0	0	
16/12/11	WMP34	0.001	0	39	0.002	0	0.002	0		4.00	0.002		3		0.034	0	0.003	0.001		0	0	
23/01/12	WMP34																					

Samples cont/d…

Date of Sample	Seam/other reference	Silver	Sulphur Sulphate (Total)	Zinc (Dissolved)	Zinc (Total)	Nitrogen (Ammonia)	Nitrogen (Total)	Nitrogen Organic TKN	Phosphorous (Total)	Hardness (Total)	BOD	NOx	Fluoride (Total)	Cyanide (Total)	Barium (dissolved)	Boron (dissolved)	Lead (dissolved)	Mercury (dissolved)	Silver (dissolved)	Sodium (dissolved)	Hydroxide Alkalinity as Ca Co3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity asCaCO3	Total Anions	Total Cations	Ionic Balance	Dissolved Lithium	Dissolved Potassium	Dissolved Calcium
27/06/11	WMP27	0	8	0.005	0.007	<0.01	0	0	0.04	8	0	0.04	0	0	0.024	0	0	0	0	18	<1	<1	3	3	1.07	1			2	<1
26/07/11	WMP27	0	12	0.006	0.008	0.01	0.3	0.3	0	8	0	0	0	0	0.02	0	0	0	0	14	<1	<1	2	2	0.85	0.85			3	<1
18/08/11	WMP27	0	7	0.005	0.006	0	0	0	0	12	0	0.04	0	0	0.025	0	0	0	0	17	<1	<1	4	4	1.02	1.04			2	<1
26/09/11	WMP27	0	9	0.007	0	0	0.1	0.1	0	8	0	0.03	0	0	0.022	0	0	0	0	15	<1	<1	1	1	0.86	0.87			2	0
24/10/11	WMP27	0	3	0.006	0.009	0	0.5	0.5	0	8	0	**0**	0	0	0.024	0	0	0	0	18	<1	<1	4	4	0.85	1			2	<1
23/11/11	WMP27	0	<1	0.005	0.007	0.02	0.5	0.5	0.13	8	0	**0.01**	0	0	0.025	0	0	0	0	19	<1	<1	6	6	1.02	1.04			2	<1
16/12/11	WMP27	0	7	0.006	0.008	0	3.3	0.6	0.02	8	0	**2.68**	0	0	0.019	0	0	0	0	19	<1	3	12	15	1.12	1.04			2	<1
23/01/12	WMP27	0	<1	0.006	0.006	0	0.9	0.8	0.02	8	0	**0.10**	0	0	0.024	0	0	0	0	18	<1	<1	7	7	0.76	1			2	<1
27/06/11	WMP28	0	30	0.046	0.043	<0.01	0	0	0.07	76	0	0.04	0	0	0.04	0	0	0	0	72	<1	<1	24	24	4.77	4.86	0.9		8	14
26/07/11	WMP28	0	17	0.021	0.025	0.02	0.8	0.8	0.05	30	0	0	0	0	0.022	0	0	0	0	32	<1	<1	8	8	2.09	2.18			7	4
18/08/11	WMP28	0	21	0.035	0.04	0	0	0	0.05	66	0	**0.05**	0.2	0	0.031	0	0	0	0	73	<1	<1	32	32	4.66	4.65	0.1		6	10
26/09/11	WMP28	0	10	0.02	0.021	0	0.5	0.5	0.07	24	0	0.03	0	0	0.018	0	0	0	0	29	<1	<1	5	5	1.69	1.84			4	3
24/10/11	WMP28	0	14	0.015	0.020	0	0.7	0.7	0.16	59	0	**0**	0	0	0.032	0	0	0	0	87	<1	<1	26	26	5.24	5.11	1.26		6	7
23/11/11	WMP28	0	<1	0.015	0.052	0.03	0.5	0.5	0.06	24	0	**0.04**	0.1	0	0.014	0.4	0.002	0	0	4	<1	<1	18	18	0.5	0.66			<1	8
16/12/11	WMP28	0	11	0	0.018	0.01	0.3	0.3	0.07	32	3	**0.01**	0	0	0.023	0	0.002	0	0	48	<1	<1	13	13	2.77	2.86	1.51		5	3
23/01/12	WMP28																													
27/06/11	WMP29	0	40	0.021	0.02	<0.01	0.3	0.3	0.01	35	0	0.02	0	0	0.023	0	0	0	0	28	<1	<1	3	3	2.02	1.99			3	4
26/07/11	WMP29	0	30	0.01	0.009	0	0.4	0.4	0	24	0	0	0	0	0.018	0	0	0	0	19	<1	<1	4	4	1.44	1.36			2	3
18/08/11	WMP29	0	34	0.015	0.02	0.03	0	0	0.04	35	0	0.04	0	0	0.024	0	0	0	0	26	<1	<1	7	7	1.75	1.9			3	4
26/09/11	WMP29	0	105	0.017	0.018	0.04	0.4	0.3	0	96	0	0.05	0.01	0	0.017	0	0	0	0	26	<1	<1	11	11	3.03	3.1	1.2		2	17
24/10/11	WMP29	0	23	0.010	0.019	0	0.4	0.4	0.06	24	0	0.02	0	0	0.022	0.05	0	0	0	23	<1	<1	9	9	1.48	1.53			2	3
23/11/11	WMP29	0	<1	0.016	0.030	0.01	0.1	0.1	0.04	4	8	0	0	0	0.018	0.36	0.001	0	0	8	<1	<1	2	2	0.32	0.48			2	<1
16/12/11	WMP29	0	31	0.011	0.015	0.01	0.3	0.3	0.07	30	0	0	0	0	0.016	0.06	0	0	0	23	<1	<1	11	11	1.49	1.66			2	4
23/01/12	WMP29																													
27/06/11	WMP30	0	25	0.016	0.011	<0.01	0.1	0.1	0.05	48	0	0.03	0	0	0.042	0	0	0	0	56	<1	<1	15	15	3.5	3.47	0.44		3	6
26/07/11	WMP30	0	18	0.01	0.009	0	0.9	0.9	0.05	21	0	0	0	0	0.022	0	0	0	0	21	<1	<1	4	4	1.44	1.42			3	2
18/08/11	WMP30	0	27	0.007	0.008	0	0	0	0.02	68	0	0.02	0	0	0.062	0	0	0	0	77	<1	<1	26	26	4.86	4.78	0.85		3	9
26/09/11	WMP30	0	10	0.009	0.019	0	0.4	0.3	0	17	0	0.06	0	0	0.015	0	0.001	0	0	22	<1	<1	5	5	1.27	1.35			2	2
24/10/11	WMP30	0	23	0.021	0.013	0	0.5	0.5	0	61	0	0.01	0	0	0.056	0	0	0	0	73	<1	<1	32	32	4.59	4.47	1.27		3	8
23/11/11	WMP30	0	20	0.086	0.125	0.07	0.1	0	0.07	62	3	0.10	0.1	0	0.061	0.29	0.003	0	0	67	<1	<1	52	52	4.33	4.23	1.2		3	10
16/12/11	WMP30	0	8	0.010	0.020	0	0.6	0.6	0.04	24	0	0.02	0	0	0.024	0	0	0	0	29	<1	<1	7	7	1.63	1.79			2	3

Date of Sample	Seam/other reference	Silver	Sulphur Sulphate (Total)	Zinc (Dissolved)	Zinc (Total)	Nitrogen (Ammonia)	Nitrogen (Total)	Nitrogen Organic TKN	Phosphorous (Total)	Hardness (Total)	BOD	NOx	Fluoride (Total)	Cyanide (Total)	Barium (dissolved)	Boron (dissolved)	Lead (dissolved)	Mercury (dissolved)	Silver (dissolved)	Sodium (dissolved)	Hydroxide Alkalinity as Ca Co3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity asCaCO3	Total Anions	Total Cations	Ionic Balance	Dissolved Lithium	Dissolved Potassium	Dissolved Calcium
23/01/12	WMP30	0	22	0.005	0	0.01	0.6	0.4	0.04	77	0	0.15	0	0	0.065	0	0	0	0	84	<1	<1	43	43	5.38	5.27	1.07		3	11
27/06/11	WMP31	0	24	0.011	0.015	0.04	1.2	0.7	0.04	61	0	0.49	0	0	0.042	0.14	0	0.0001	0	75	<1	<1	38	38	4.64	4.74	1.02		10	8
26/07/11	WMP31	0	22	0.011	0.013	3.75	5.5	5.2	0.17	46	0	0.26	0	0	0.04	0.14	0	0	0	53	<1	<1	50	50	3.71	3.62	1.31		10	8
18/08/11	WMP31	0	18	0.013	0.016	0.22	1.8	1.2	0.03	65	0	0.63	0	0	0.052	0.12	0	0	0	88	<1	<1	43	43	5.44	5.41	0.23		11	8
26/09/11	WMP31	0	19	0.016	0.023	1.59	19.2	5.4	0.19	101	6	13.8	0	0	0.074	0.029	0	0	0	107	<1	<1	45	45	6.09	7.33	1.73		26	14
24/10/11	WMP31	0	14	0.012	0.018	0.05	1.4	1.0	0.81	65	0	0.35	0.1	0	0.055	0.16	0.001	0	0	90	<1	<1	48	48	5.48	5.53	0.39		12	8
23/11/11	WMP31	0	0	0.027	0.031	49.1	73.5	73.3	0.42	248	14	0.20	0.2	0	0.216	0.86	0.001	0	0	358	<1	<1	506	506	24.7	23.4	2.84		111	30
16/12/11	WMP31	0	14	0.009	0.028	0.04	3.6	1.7	0.10	46	4	1.92	0.1	0	0.038	0.16	0	0	0	58	<1	<1	34	34	3.76	3.81	0.56		14	7
23/01/12	WMP31																													
27/06/11	WMP32	0	37	0.011	0.018	0.03	2.1	1.2	0.02	74	0	0.92	0	0	0.053	0.26	0	0.0001	0	101	<1	<1	38	38	6.24	6.37	0.99		19	10
26/07/11	WMP32	0	24	0.013	0.019	3.49	5	4.8	0.1	76	8	0.16	0.1	0	0.049	0.18	0	0	0	61	<1	<1	76	76	4.59	4.53	0.58		14	14
18/08/11	WMP32	0	25	0.01	0.01	0.18	2.3	1.1	0.5	94	3	1.23	0	0	0.069	0.29	0	0	0	115	<1	<1	56	56	7.59	7.4	1.3		20	13
26/09/11	WMP32	0	16	0.008	0.01	1.41	28.2	5.5	0.06	65	10	22.7	0	0	0.052	0.38	0	0	0	87	<1	<1	17	17	4	5.8	1.58		28	8
24/10/11	WMP32																				<1	<1								
23/11/11	WMP32	0	0	0.018	0.049	40.7	55.4	42.0	0.43	193	14	13.4	0.2	0	0.168	1.09	0.002	0	0	392	<1	<1	396	396	25.5	23.8	3.48		113	23
16/12/11	WMP32	0	17	0.011	0.021	0.03	4.2	1.7	0.06	64	3	2.47	0.1	0	0.045	0.21	0	0	0	72	<1	<1	46	46	4.86	4.86	0		17	11
23/01/12	WMP32																													
27/06/11	WMP33	0	60	0.066	0.067	<0.01	0.4	0.4	0	76	0	0	0	0	0.064	0	0	0	0	44	<1	<1	12	12	3.41	3.51	1.51		3	14
26/07/11	WMP33	0	34	0.045	0.052	0	0.7	0.7	0.04	42	0	0	0	0	0.036	0	0.002	0	0	32	<1	<1	10	10	2.21	2.29			2	7
18/08/11	WMP33	0	86	0.103	0.118	0	0.5	0.5	0.05	174	5	0	0	0	0.12	0	0	0	0	157	<1	<1	16	16	11	10.4	2.92		5	25
26/09/11	WMP33	0	31	0.042	0.054	0	0.5	0.3	0.02	42	0	0.16	0.1	0	0.026	0	0.002	0	0	33	<1	<1	16	16	2.29	2.33			2	7
24/10/11	WMP33	0	40	0.054	0.067	0	0.8	0.8	0.11	88	0	0.03	0.1	0	0.067	0.05	0	0	0	80	<1	<1	38	38	5.29	5.33	0.34		3	14
23/11/11	WMP33	0	44	0.034	0.062	0	0.3	0.3	0.13	88	3	0.02	0.2	0	0.057	0.24	0.002	0	0	81	<1	<1	36	36	5.27	5.39	1.11		4	14
16/12/11	WMP33	0	34	0.031	0.037	0.01	0.6	0.5	0.08	49	3	0.07	0.1	0	0.03	0.05	0.001	0	0	52	<1	<1	20	20	3.22	3.31	1.38		3	8
23/01/12	WMP33	0	56	0.012	0.014	0.02	0.6	0.4	0.03	206	0	0.15	0.2	0	0.142	0	0	0	0	198	<1	<1	69	69	13.4	12.9	1.89		5	33
27/06/11	WMP34	0	26	0.05	0.049	<0.01	0.6	0.6	0.07	28	0	0	0	0	0.027	0	0	0.0001	0	29	<1	<1	2	2	1.96	1.9			3	3
26/07/11	WMP34	0	12	0.028	0.025	0	1.1	1.1	0.14	17	0	0	0	0	0.016	0	0	0	0	15	<1	<1	2	2	0.88	1.05			2	2
18/08/11	WMP34	0	15	0.052	0.05	0	0.3	0.3	0.05	32	0	0.01	0	0	0.029	0	0	0	0	29	<1	<1	2	2	1.85	1.98			3	3
26/09/11	WMP34	0	10	0.032	0.032	0	0.5	0.5	0.02	17	0	0.04	0	0	0.018	0	0	0	0	20	<1	<1	2	2	1.18	1.27			2	2
24/10/11	WMP34	0	<1	0.048	0.048	0	1.0	1.0	0.08	21	0	0	0	0	0.027	0	0.002	0	0	31	<1	<1	4	4	1.72	1.85			3	2
23/11/11	WMP34	0	12	0.037	0.036	0	0	0	0.12	21	0	0	0	0	0.023	0.19	0	0	0	25	<1	<1	2	2	1.47	1.57			2	2
16/12/11	WMP34	0	<10	0.040	0.016	0	0.8	0.8	0.15	15	3	0.05	0	0	0.019	0	0.002	0	0	24	<1	<1	7	7	1.24	1.39			2	1

Appendix B

Hydraulic Assessment

Report

Centennial Coal

HYDRAULIC ASSESSMENT REPORT

Newstan
Subsidence Management Plan LW 101-103

May 2012

Centennial Coal Environment Matters

Executive Summary

Newstan Colliery (Newstan) is an underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan), which is located approximately 25 km south-west of Newcastle in the Lake Macquarie Local government Area. Newstan Colliery currently operates under DA73-11-98 MOD4, a modified version of the Development Consent (DA73-11-98) granted in 1999 to extend the life of the colliery, and a number of other approvals including: Mining lease ML1452; Mining Operations Plan (2005 – 2012); and Environment Protection Licence 395.

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a *Subsidence Management Plan (SMP)* prior to commencing underground mining operations which will potentially lead to subsidence. An SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103, which are located wholly within ML1452 and DA 73-11-98.

Centennial Newstan engaged GHD to undertake an assessment of potential subsidence impacts on the current hydraulic characteristics of the area in the accordance with the '*Guideline for Applications for Subsidence Management Approvals'* (Department of Primary Industries - Mineral Resources, December 2003), and relevant statutory conditions, and provide this specialist report in support of the SMP Application for LW101, LW102 and LW103 – collectively known as the SMP study area.

Purpose of this Report

This report aims to provide Centennial Newstan Pty. Ltd. with a broad understanding of the 'existing' hydraulic situation and an assessment of the potential hydraulic implications of the predicted subsidence due to longwall mining in the SMP study area. This Report is subject to, and must be read in conjunction with, the scope, limitations, assumptions and qualifications contained within this Report.

Modelling Methodology

The hydraulic characteristics and potential impacts of the predicted subsidence of the study area were assessed by exploring and comparing the output from a 'rain-on-grid' hydraulic model pre- and post-predicted subsidence (i.e. the only change was the underlying terrain).

The models were run for the 100, 20, 10 and 2 year Average Recurrence Intervals (ARIs) and a sensitivity run for the 100 year ARI with an alternate downstream tailwater level. The results from these runs were post-processed to create a flood extent\depth plot and velocity plot for the pre- and post-subsidence scenarios, as well as afflux plots to identify areas of change and assist in the assessment of potential impacts.

Hydraulic Assessment

'Existing' scenario results indicate that there are five major flow paths that pass through or nearby the SMP study area, which are Stockyard Creek (WC4), Kilaben Creek (WC5), Stony Creek (WC1), and two unnamed creeks that drain to Kilaben Bay (WC3 and WC10/WC12). However, only Kilaben Creek (WC5) and one of the unmade creeks (WC10/WC12) pass directly through the area of predicted subsidence. Other general characteristics identified include the fact that:

- Flow paths are generally quite confined due to the steep terrain.

- Majority of flooding is relatively shallow.
- Velocities vary along the identified flow paths, which indicate changes in grade and/or pools.
- Higher velocities are generally found in locations with steep terrain, such as the upper parts of the catchments.

The existing flooding conditions at and adjacent to surface infrastructure were assessed as well as the impacts of subsidence on the flooding conditions. Surface infrastructure within the SMP application area potentially impacted by flooding includes public and private roads, easements, drainage lines and culverts.

The depth and velocity afflux results indicate that the impact of the predicted subsidence is likely to be minimal, with only minor changes to the depth of flooding, velocity and flow hydrographs within the study area between the 'subsided ' and 'existing' scenario. The study did identify the following general minor changes in the flood behaviour in the study area:

- An increase in ponding where the predicted subsidence causes a flattening or reversal of the slope, and a decrease in ponding where the predicted subsidence increases the slope – this resulted in an increase in the area of inundation of between 3.4 % and 3.7 %.
- A speeding up of flow where the predicted subsidence increases the slope, and a slowing of flow where there is increased ponding or reduced slope – this resulted in an increase in the proportion of flows at the two extremes of the velocity distribution.
- Some relatively minor changes in hydrograph peaks and timing due to the slope changes along a flow path and\or the relative timing of converging branches.
- A general isolation of the major changes to the two major flow paths through the SMP application area (which includes WC5, WC10, WC11, and WC12). Some of the minor flow paths out of the area of predicted subsidence to the north also experience moderate change.
- Flow velocities at waterways crossing the electrical infrastructure easements will decrease, while flood depths and frequency of inundation will increase.

Conclusion

Overall the hydraulic modelling indicates that the predicted subsidence will result in relatively localised changes to the 'existing' hydraulic characteristics, in terms of depth, velocity, and the shape of flow hydrographs within the study area.

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Glossary

Angle of Draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20 mm.
Aquifer	The layer of rock that holds water and allows water to flow slowly through it.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Average recurrence interval	The long term average number of years between the occurrence of a flood as big as or larger than the selected event.
Bord and pillar	A mining system whereby coal is extracted leaving 'pillars' of untouched coal to support the strata above.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Community	Anyone who is interested in or affected by subsidence issues associated with the proposed mining project.
Design Rainfall Event	A hypothetical rainfall event representing a specific likelihood of occurrence (for example the 100 year or 1% probability rainfall event).
Effluent	Something that flows out as liquid waste from industry, sewage works etc.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Floodplain	Area of land which is subject to inundation by floods by up to the probable maximum flood event.
Floodplain management plan	The principal means of managing the risks associated with the use of the floodplain. A floodplain management plan needs to be developed in accordance with the principles and guidelines in this manual, and will usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Groundwater	Means water in a saturated zone or stratum or aquifer beneath the surface of the land.
Guideline	Numerical concentration or narrative statement supporting or maintaining a designated water use.

Headings	A roadway driven in to the coal seam for access to underground operations by personnel and machinery.
Hydrograph	A graph which shows haw to discharge of stage/flood level at any particular location changes with time during a flood.
Infiltration	The downward movement of water into the soil. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.
Overland flow (sheet flow)	Water flowing in a thin layer over the land surface.
pH	Value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Potable water	Water of a quality suitable for drinking.
Probability	A statistical measure of the expected chance of flooding.
Probable maximum flood	The largest flood that could conceivably occur at a particular location. The PMF defines the extent of flood prone land, i.e. the floodplain.
Risk	The chance of something happening that will have an impact upon objectives. It is measured in terms of consequence and likelihood.
Roadway	Underground tunnel constructed to enable access to working face.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Sediment-laden water	Water that has a high level of suspended solids.
Slope	A landform element inclined from the horizontal at an angle measured as degrees or as a percentage.
Strata	Geological layers below the ground surface.
Structure	The combination or spatial arrangement of primary soil particles (clay, silt, sand, gravel) into aggregates such as peds or clods, and their stability to deformation.

Subsidence	For the purposes of SMP approval process, subsidence is defined as mining-induced movements and deformations at the ground surface where (i) the vertical downward surface movements are greater than 20 mm, or (ii) the potential impacts on major surface infrastructure, structures or natural features may be significant, notwithstanding that the vertical downward surface movements are less than 20 mm.
Surface Water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Tailings	Fine reject material produced as a result of the coal processing process.
Tailwater Level	Water level that forms the downstream boundary of the hydraulic modelling scenario. The water level present within Lake Macquarie provides a Tailwater condition for the hydraulic modelling of both the regional flood modelling and the hydraulic assessment for the geomorphology.
Vertical Subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
Wastewater	The used water of a community or industry, containing dissolved and suspended contaminants.

Abbreviations

AHD	Australian Height Datum
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DA	Development Application
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
DTM	Digital Terrain Model
EIS	Environmental Impact Statement
EPL	Environmental Protection Licence
GHD	GHD Pty Ltd
km	kilometre
IFD	Intensity-Frequency Duration
LEA	Life Extension Area
LGA	Local Government Area
LMCC	Lake Macquarie City Council
m	metres
MOP	Mining Operations Plan
MTpa	Millions Tonnes per annum
NOW	NSW Office of Water
ROM	Run of Mine
SMP	Subsidence Management Plan

1. Introduction

Newstan Colliery (Newstan) is an underground coal mine owned and operated by Centennial Newstan Pty Limited (Centennial Newstan). Newstan Colliery is located approximately 25 km south-west of Newcastle and approximately 140 km north of Sydney within the Lake Macquarie Local Government Area (LGA). The Newstan Colliery pit top and surface facilities are located approximately 4 km north of the township of Toronto on the western side of Lake Macquarie (site locality is shown in Figure 1.1).

Mining operations at Newstan first commenced in 1887 and has since undertaken extensive mining within the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole coal seams. Mining at Newstan is currently undertaken using a combination of modern longwall retreat and bord and pillar mining methods. Newstan has approval to produce up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal which is transported by private haul road to Eraring Power Station for domestic power production and by rail to the Port of Newcastle for export market.

The objective of current mining operations is to produce coal safely and efficiently to meet market demands, whilst satisfying the environmental management expectations of Centennial's internal standards, regulatory authorities and the local community.

In May 1999, Development Consent (DA73-11-98) was granted under Part 4 of the Environmental Planning and Assessment Act (EP&A Act) to extend the life of the colliery in accordance with an Environmental Impact Statement (EIS) prepared in 1998, which defined the Life Extension Area (LEA). Following modifications to the approval, the mine currently operates under DA73-11-98 MOD 4 and the following approvals relevant to this SMP Application:

- Mining Lease ML1452.
- Mining Operations Plan (MOP) (2005 -2012).
- Environment Protection Licence (EPL) 395.

Under the conditions of Mining Lease 1452, Centennial Newstan is required to prepare a *Subsidence Management Plan (SMP)* prior to commencing underground mining operations which will potentially lead to subsidence. Accordingly, an SMP Application has been prepared to seek approval from the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Division of Resources and Energy (DRE) for the development and extraction of longwall panels LW101, LW102 and LW103, which are located wholly within ML1452 and DA 73-11-98.

The SMP study area is described in detail in Section 1.1 and is shown in Figure 1.1 (NS2846). The SMP Application has been prepared in accordance with the *'Guideline for Applications for Subsidence Management Approvals'* (DPI-MR (now DTIRIS-DRE), December 2003), herein referred to as the 'SMP Guidelines'.

GHD Pty. Ltd. were engaged by Centennial Newstan to undertake an assessment of potential subsidence impacts on the current hydraulic characteristics of the area in accordance with the SMP Guidelines and relevant statutory conditions, and provide this specialist report in support of the SMP Application for LW101, 102 and 103. The scope of this report is detailed further in Section 1.2.

A risk-based approach has been undertaken during the development and preparation of the SMP application, which has conservatively included subsidence predictions and assessments for both the expected mining scenario as well as an unpredicted scenario of increased subsidence conditions, as considered further in Section 3.4.5 of this report. A specialist subsidence impact assessment has been carried out by Mine Subsidence Engineering Consultants MSEC (2012) which has been referenced and summarised, where appropriate, throughout this report to provide the basis for potential impact assessment. The full report by MSEC can be found in Appendix A to the SMP Written Report for the SMP Application.

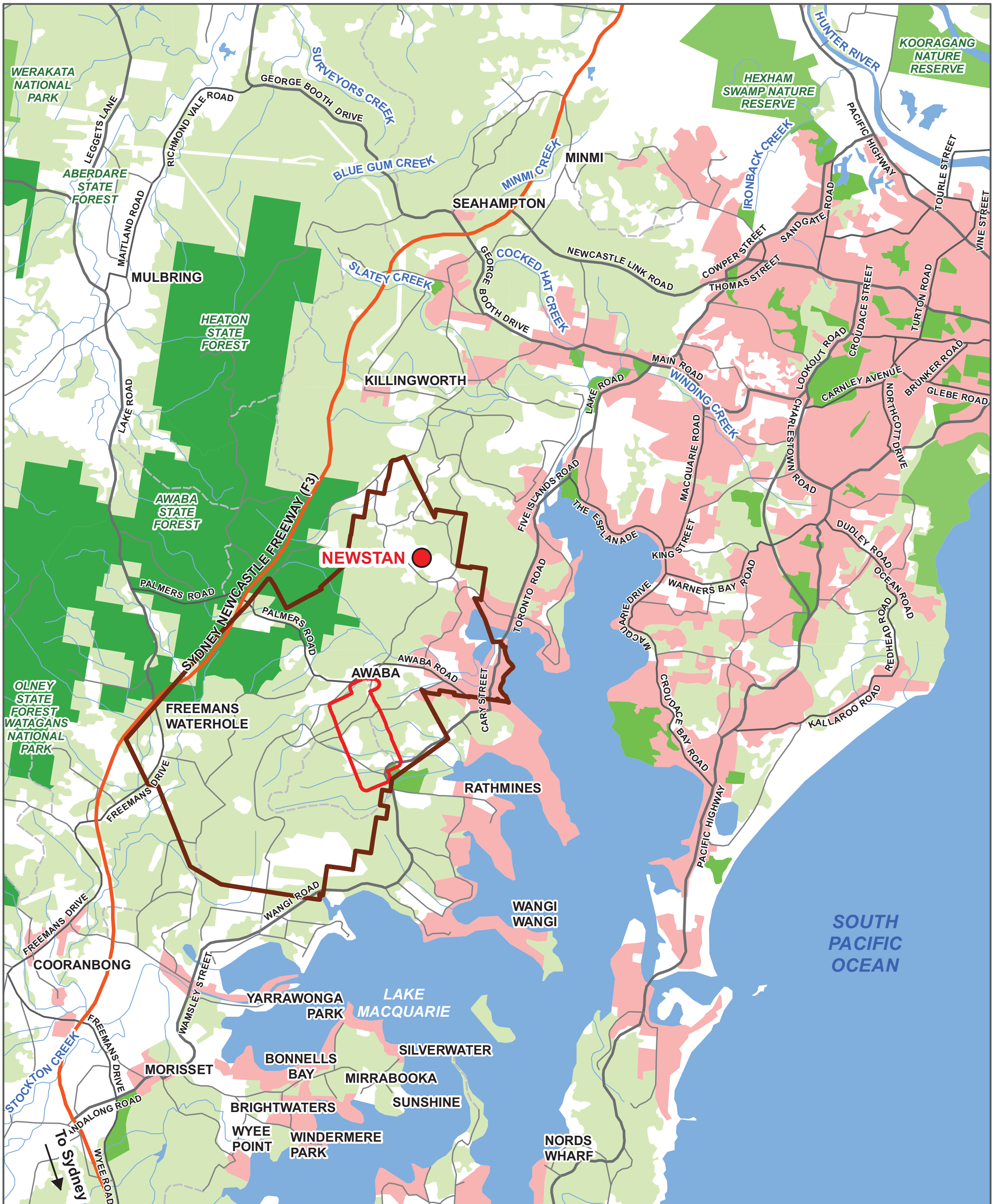
1.1 SMP Study Area

The study area for this report (herein referred to as the SMP Study Area) has been conservatively defined beyond the minimum requirements of the SMP Guidelines (2003) and is illustrated in Figure 1.2 (NS2846). The SMP Study Area incorporates the areas bounded by the following limits:

- A 26.5 degree angle of draw from the panel edge (limit of proposed extraction) of the proposed Longwalls LW101, 102, 103 for the depth of cover (as per Section 6.2 of the SMP Guidelines).Additionally, the study area also conservatively includes a 26.5 degree angle of draw from associated *first workings* (mains headings and associated mine development roads) adjacent to the longwalls, acknowledging these areas do not significantly contribute to subsidence but have been conservatively included.
- The predicted limit of vertical subsidence, taken as the 20mm subsidence contour resulting from the extraction of the proposed longwall panels (as per Appendix A of the SMP Guidelines). Additionally, the footprint of potential direct impact by subsidence parameters for tilt, strain and curvature has also been considered in establishing the SMP Study Area.

Further, whilst not predicted to be affected by subsidence, the project (and this report) also prudently identified surface features beyond the SMP Study Area potentially sensitive to far-field or valley related movements (more commonly applicable to built features), as detailed within the specialists subsidence report by MSEC (2012).

The proposed longwall panels have been designed to target the Young Wallsend (which comprises the Nobby's and Dudley seams) and Yard seams of the Newcastle Coal Fields. Depth of cover within the SMP Area ranges from a minimum of 200m in the north-west to over 400m in the south-east. LW101-LW103 are generally aligned in a north-south direction with mining proposed to occur from the south-east (outbye) retreating to the north-west back to the main headings.



1:150,000 for A4

0 625 1,250 2,500 3,750 5,000
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND
- Newstan Colliery
- SMP Study Area
- Proposed Final Newstan Colliery Holding Boundary
- Freeway
- Principal Road
- Secondary Road
- Minor Road
- Track
- Watercourse
- Water Body
- Built Up Areas
- Forest Or Shrub
- Nature Conservation Reserve
- State Forest

LOCATION	NEWSTAN
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

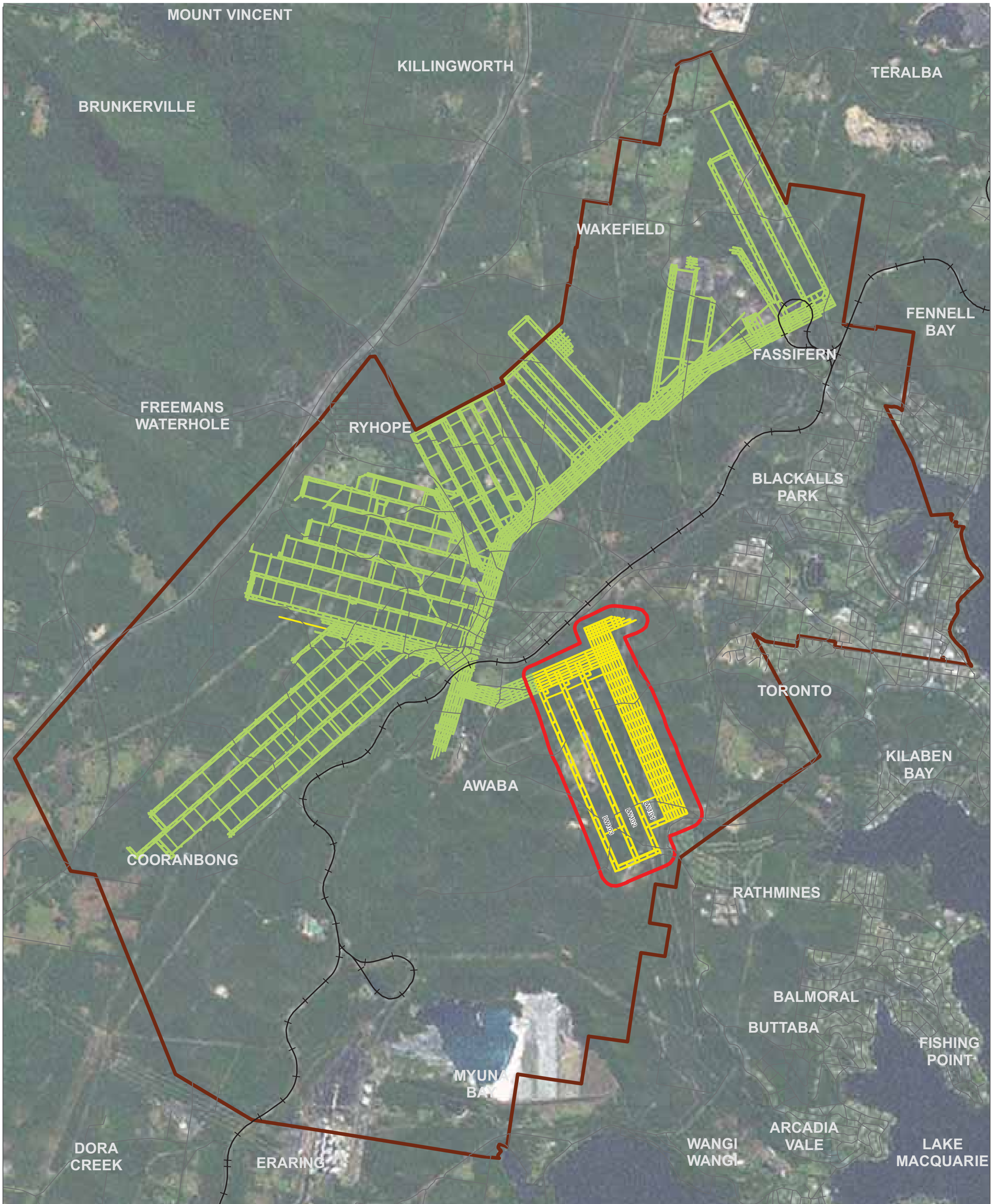
Newstan
Subsidence Management Plan
Hydraulic Assessment Report
Locality Plan

Centennial Newstan

DATE: 19/04/2012

Figure 1-1

GIS Filename: N:\AU\NEWCASTLE\PROJECTS\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\Flooding Assessment\2215922_004_Figure1-1_LocalityPlan.mxd



1:60,000 for A4

0 240 480 960 1,440 1,920
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

GHD

LEGEND

Railway
Roads
Proposed Final Newstan Colliery Holding Boundary
SMP Study Area
Existing / Proposed Approved Underground Workings
SMP Longwalls

LOCATION	Newstan
SEAM	
DRAWN	M.B.
CHECKED	
APPROVED	
SCALE	refer to scalebar

Newstan
Subsidence Management Plan
Hydraulic Assessment Report

Newstan Lochiel Holding Boundary

Centennial Newstan

DATE 14-04-2012

Figure 1-2

GIS Filename: N:\AU\NEWCASTLE\PROJECTS\22\0105001\GIS\Maps\Hunter\Newstan\Deliverables\2215922\Flooding Assessment\2215922_003_Figure1-2_NewstanLochielHoldingBoundary.mxd

1.2 Objectives of this Report

The objectives of this report was to provide Centennial Newstan with a broad understanding of the 'existing' hydraulic situation and an assessment of the potential hydraulic implications of the predicted subsidence due to longwall mining in the SMP application area.

This report provides information that will support the SMP Application to the Department of Trade and Investment, Regional Infrastructure and Services (DTRIS), in accordance with the SMP Guideline (DPI; 2003), as summarised in Table 1-3.

This Report is subject to, and must be read in conjunction with, the scope, limitations, assumptions and qualifications contained within this Report.

Table 1-1 Information Provided in Support of the SMP Application (DPI; 2003)

Requirement	Where Addressed in this report
Section 6.2 - The Application Area	Figure 2.1
Section 6.6.1 - Identification of surface features	Section 2.3.1
Section 6.6.2 - Characterisation of surface features	Section 2.3.2
Section 6.6.3 - Areas of Environmental Sensitivity	Section 3.3, Section 3.4
Section 6.10 - Subsidence Impacts	Section 3.4
Appendix B – Surface and Sub-surface features that may be affected by Underground coal mining.	Section 3.4.3

A discussion on existing site conditions, Community Consultation, Statutory Requirements, and Proposed Management Plans for the SMP Application area have been included within the Surface Water Impact Assessment Report (GHD; 2012). In addition to this a further discussion of the characterisation of surface features have been discussed in the Surface Water Impact Assessment Report.

To undertake an assessment of flooding, a number of assessment elements were completed as part of this report outlined in Table 1-2 and Table 1-2. These elements were obtained from Guidelines for Application for Subsidence Management Approvals (2003).

Table 1-2 Natural Features and Surface Infrastructure within the SMP Study Area

Elements	Within SMP Study Area	Where addressed in this Report
Natural Features		
Rivers and Creeks	✓	Section 3.3, Section 3.4
Land Prone to Flooding or Inundation	✓	Section 3.3, Section 3.4
Public Utilities		
Roads	✓	Section 3.3.3, Section 3.4.3
Culverts	✓	Section 3.3.3, Section 3.4.3
Electricity Transmission Lines	✓	Section 3.3.3, Section 3.4.3

As indicated in Table 1-2, a summary of the natural features and items of surface infrastructure within the SMP Study Area has been provided. The descriptions and predicted change for flooding in respect to the natural features and items of surface infrastructure are provided in Section 2 and 3.

A summary of the features identified as *"Areas of Environmental Sensitivity"* within the SMP Study Area, as defined in SMP Guideline (DPI; 2003), is provided in Table 1-3. It is not considered that the surface watercourses within or close to the SMP Study Area are classified as 'significant', although they have been identified and assessed for impact from mining.

Table 1-3 Assessment of Subsidence Impacts on Areas of Environmental Sensitivity within the SMP Area, (DPI; 2003)

Elements	Within SMP Area	Where addressed in this Report
Significant surface watercourses, identified through consultation with relevant government agencies	×	×

1.3 Scope and Limitations

The overall aim of this study was to identify the current hydraulic situation and then assess the hydraulic implications of the subsidence from underground mining operations. In order to achieve this, the project has involved the following:

- Reviewing and revising the hydrologic modelling for the area.

- Processing available terrain information to generate an updated model of the topography across the study area to improve physical representation for use in the hydraulic model.
- Preparing and analysing the 'existing' flooding situation.
- Preparing and analysing the 'subsided' flooding situation.
- Assessing changes in key hydraulic factors between the 'existing' and 'subsided' situation, namely depth and velocity.

This Report has been prepared by GHD for Centennial Coal and may only be used and relied on by Centennial Coal for the purpose agreed between GHD and Centennial Coal as set out in Section 1.2 of this Report.

GHD otherwise disclaims responsibility to any person other than Centennial Coal arising in connection with this Report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in the Report and are subject to the scope limitations set out in the Report.

The opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the date of preparation of the Report. GHD has no responsibility or obligation to update this Report to account for events or changes occurring subsequent to the date that the Report was prepared.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD described in this Report. GHD disclaims liability arising from any of the assumptions being incorrect.

1.4 Available Information

Information contained within previous reports was supplementing with other information to develop both the hydrologic and hydraulic models for this study. The following information was used:

- Bureau of Meteorology's Intensity-Frequency-Duration (IFD) program.
- General data regarding the study area from Centennial Newstan, including:
  - Aerial photography
  - A number of terrain data sets (LiDAR and various contour sources)
    - 2010 LiDAR (provided June 2011)
    - 2009 Contours (provided June 2011)
  - Mine layout plans (provided June 2011)
- Previous flood study reports of nearby or intersecting catchments, namely:
  - Stony Creek Flood Study, Report J2186/R2123/v2 September 2005 (Cardno Lawson Treloar Pty. Ltd.).
  - LT Creek Flood Study, Final Report R.N1355.001.03 April 2011 (BMT WBM).
  - Lake Macquarie Floodplain Management Plan – July 2001 (Webb, McKeown & Associates Pty. Ltd.).
  - Sea Level Rise Policy Fact Sheet (D02421916) – February 2012 (Lake Macquarie City Council).

- Subsidence predictions from external subsidence modelling by MSEC (provided February 2012).
- Photos from site inspection, which occurred on 4 October 2011.

1.5 Modelling Scenarios

As part of this study, the following two scenarios were modelled for each of the required Average Recurrence Intervals (ARIs):

- 'Existing' Conditions - scenario based on currently defined terrain and estimates of impervious fractions.
- 'Subsided' Conditions - same as above, with an altered terrain to reflect the potential impact of subsidence post-mining (based on data supplied by external subsidence modelling).

These scenarios will be modelled with the current estimated design lake levels and a 'lake level rise' scenario (as defined by LMCC, 2012) for one ARI as a form of sensitivity testing for the potential impacts of climate change.

2. Modelling Methodology

2.1 Overview

This study involved a combination of hydrologic and hydraulic modelling to provide an understanding of the 'existing' flooding situation and the potential impacts of subsidence due to long wall mining in the SMP application area. The study area is illustrated in Figure 2.1, which shows that the SMP application area does extend slightly outside the hydraulic model boundary in the north-east corner. This was considered acceptable because the subsidence impacts do not extend into this area.

Hydrologic modelling of the catchment containing the Centennial Newstan SMP application area was undertaken using the hydrologic modelling package XP-RAFTS (version 7.0). The XP-RAFTS model has been set up for the purposes of providing rainfall-excess hyetographs for input into an unsteady hydraulic model only and as such cannot be relied upon to provide total flow estimates for locations within or downstream of the hydraulic model. Rainfall-excess hyetographs were prepared for individual subareas within the hydraulic model for all standard storm durations (10 minutes to 72 hours) for the events and scenarios listed in Table 2.1.

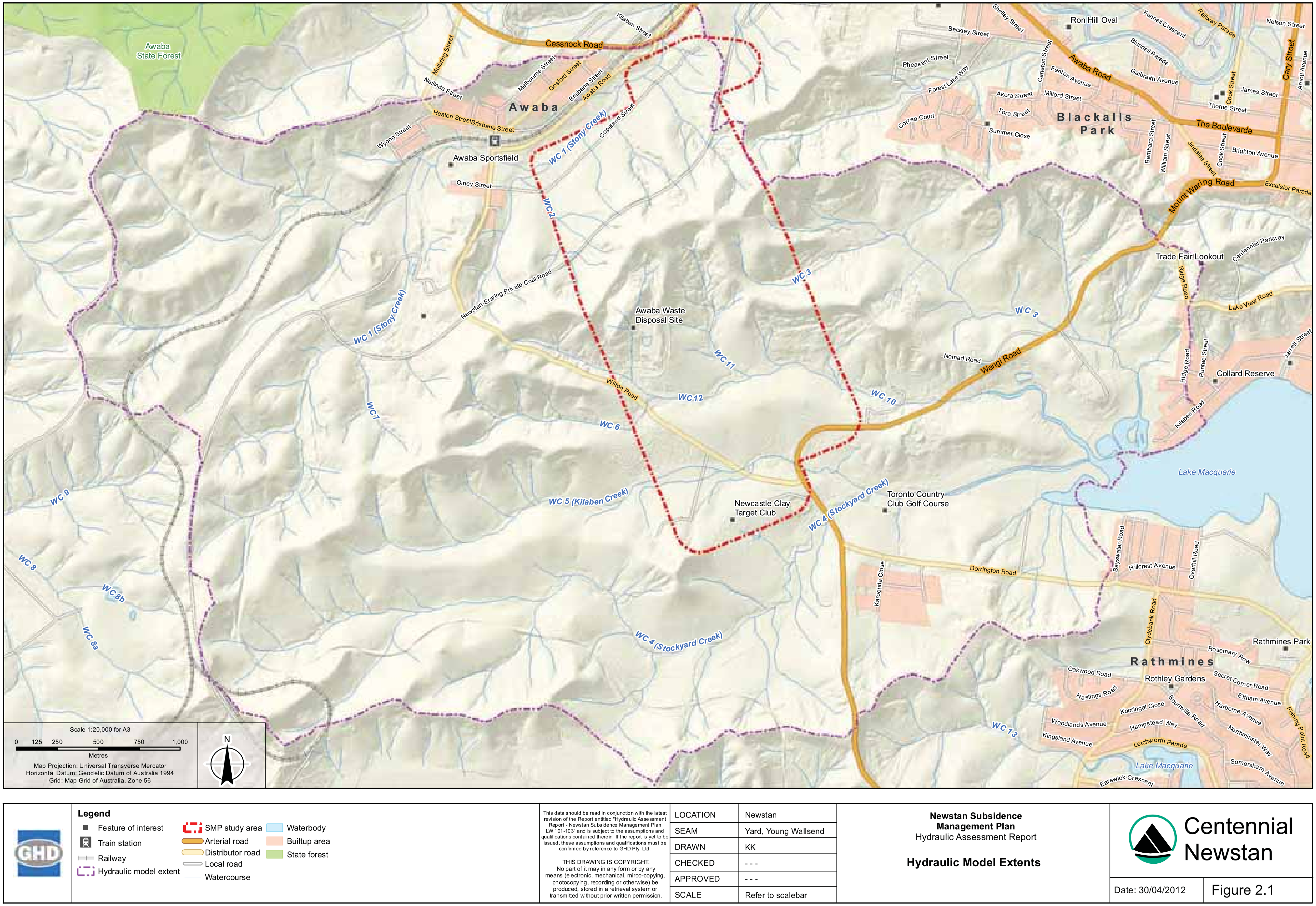
Table 2.1 Required XP-RAFTS Model Runs

Design Rainfall Event	100 yr ARI	20 yr ARI	10 yr ARI	2 yr ARI
Base Case	✓	✓	✓	✓

Hydraulic modelling of the SMP application area was undertaken using TUFLOW (version 2011-09-AE-iDP-w64). The TUFLOW model was created using the available drainage details and a variety of terrain data from Centennial Newstan. Rainfall-excess hyetographs from XP-RAFTS were applied directly to the 2D domain. The other major boundary conditions were fixed water levels at the downstream end of the model. The TUFLOW model was run to determine flood levels for the events and scenarios listed in Table 2.2. The results of the TUFLOW runs are post-processed to create a flood extent\depth plot and velocity plot for the pre- and post- mining scenarios. Afflux plots were also prepared to identify areas of change and assist in the assessment of potential impacts.

Table 2.2 Required TUFLOW Model Runs and Flood Extents

Estimated Flood Event	100 yr ARI	20 yr ARI	10 yr ARI	2 yr ARI
Existing Conditions	✓	✓	✓	✓
Subsided Conditions	✓	✓	✓	✓
Existing Conditions – with lake level rise*	✓	×	×	×
Subsided Conditions – with lake level rise*	✓	×	×	×
NB: * indicates that these scenarios are referred to as 'with alternate tailwater level' (or alt TWL)				



This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Hydraulic Model Extents

Centennial Newstan

Date: 30/04/2012

Figure 2.1

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd

2.2 Digital Terrain Model

A Digital Terrain Model (DTM) of the area being modelled for the SMP application area was created by GHD using thinned LiDAR grid points and contour information provided by Centennial Newstan. The DTM, which is presented in Figure 2.2, formed the basis of the two dimensional grid for use in the TUFLOW model and was produced using a combination of 12D, SAGA-GIS and ArcGIS. The TUFLOW model grid was also subject to some additional modifications to improve the representation of key topographic features (i.e. key drainage lines) and/or terrain features such as ridges and roads. The DTM was also used to estimate the flood depths and extents for comparison purposes.

Given the range of data sources used in the creation of the DTM and their inherent accuracies, there were some data mismatches at the boundaries between the sources. These boundary issues were generally minor and were overcome by allowing the GIS software to interpolate across an 8 m gap created at the interface of the data sources. There were however a few areas that had a more significant issue, these were addressed by incorporating a number of break lines to better reflect the general terrain across the boundary – details of these changes are presented in Appendix A.

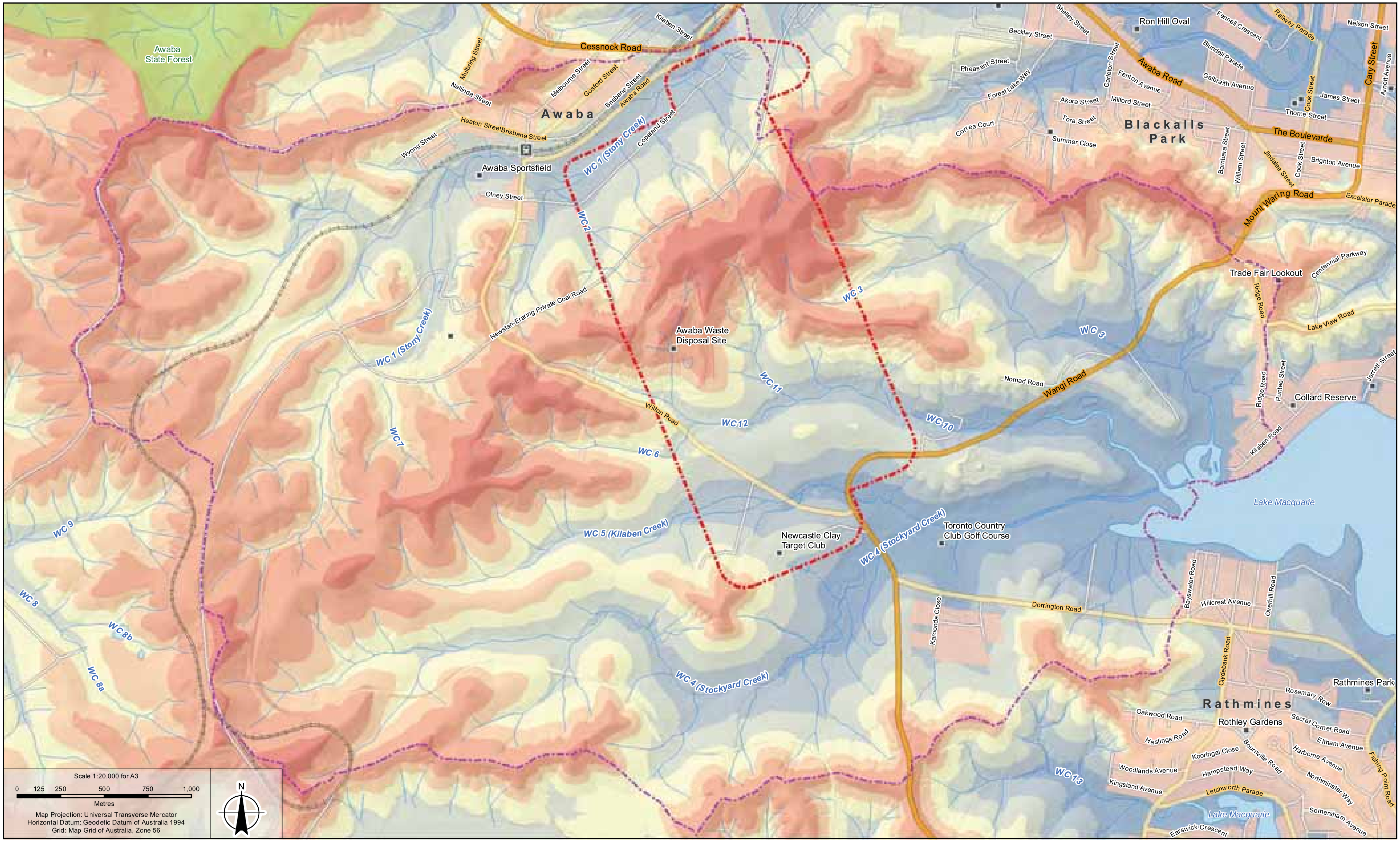
To simulate the post-mining terrain, a DTM of the predicted subsidence (MSEC, 2012) was created and used to create a modification grid for the 2D domain of the TUFLOW model (i.e. the two 2D domains were added together). The predicted subsidence DTM is illustrated in Figure 2.3.

2.3 Hydrologic Modelling

Hydrologic assessment of the area has been undertaken using XP-RAFTS a widely used non-linear runoff routing (hydrologic) model. The model was used to simulate the rainfall runoff process and generate rainfall-excess hyetographs for use in the hydraulic model. Design rainfall estimates were determined for the 2, 10, 20 and 100 year ARIs. Design rainfall was applied to the model using standard temporal patterns from Australian Rainfall and Runoff (AR&R) (IEAust, 2003).

2.3.1 Catchment Description and Delineation

Catchment delineation was undertaken via interrogation of contours from the DTM, which generated the catchments presented in Figure 2.4. The predominant land use within the catchment is either rural or Crown Land. In addition to the urban roads, there are a number of roads that divide the rural and forested areas throughout the catchment. The residential areas are comprised of part of the township of Awaba and the suburbs along the western shore of Lake Macquarie from Toronto to Arcadia Vale. Given the mining works in the area, it is worth noting the presence of some wastewater or tailings dams and/or spoil mounds. The upper portion of the catchment and valley sides are relatively steep, but the lower portions of the catchment and valleys are comparatively flat.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Elevation (mAHD): < 10, 10 - 20, 20 - 30, 30 - 40, 40 - 50, 50 - 75, > 75

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

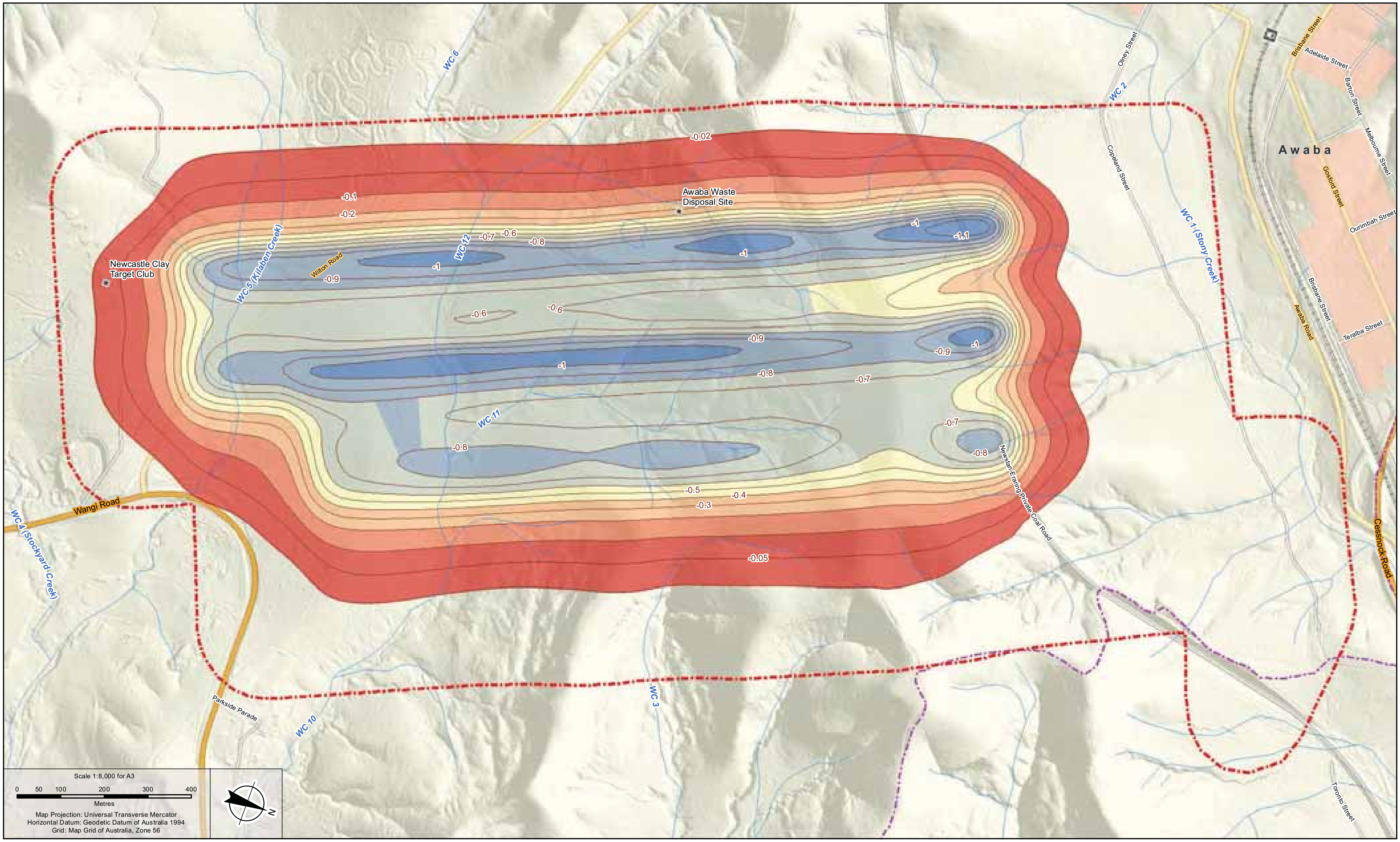
'Existing' Conditions Digital Terrain Model (DTM)

Centennial Newstan

Date: 30/04/2012

Figure 2.2

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Depth (m): > -0.1; -0.2 - -0.1; -0.4 - -0.2; -0.6 - -0.4; -0.8 - -0.6; -0.1 - -0.8; < -1

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

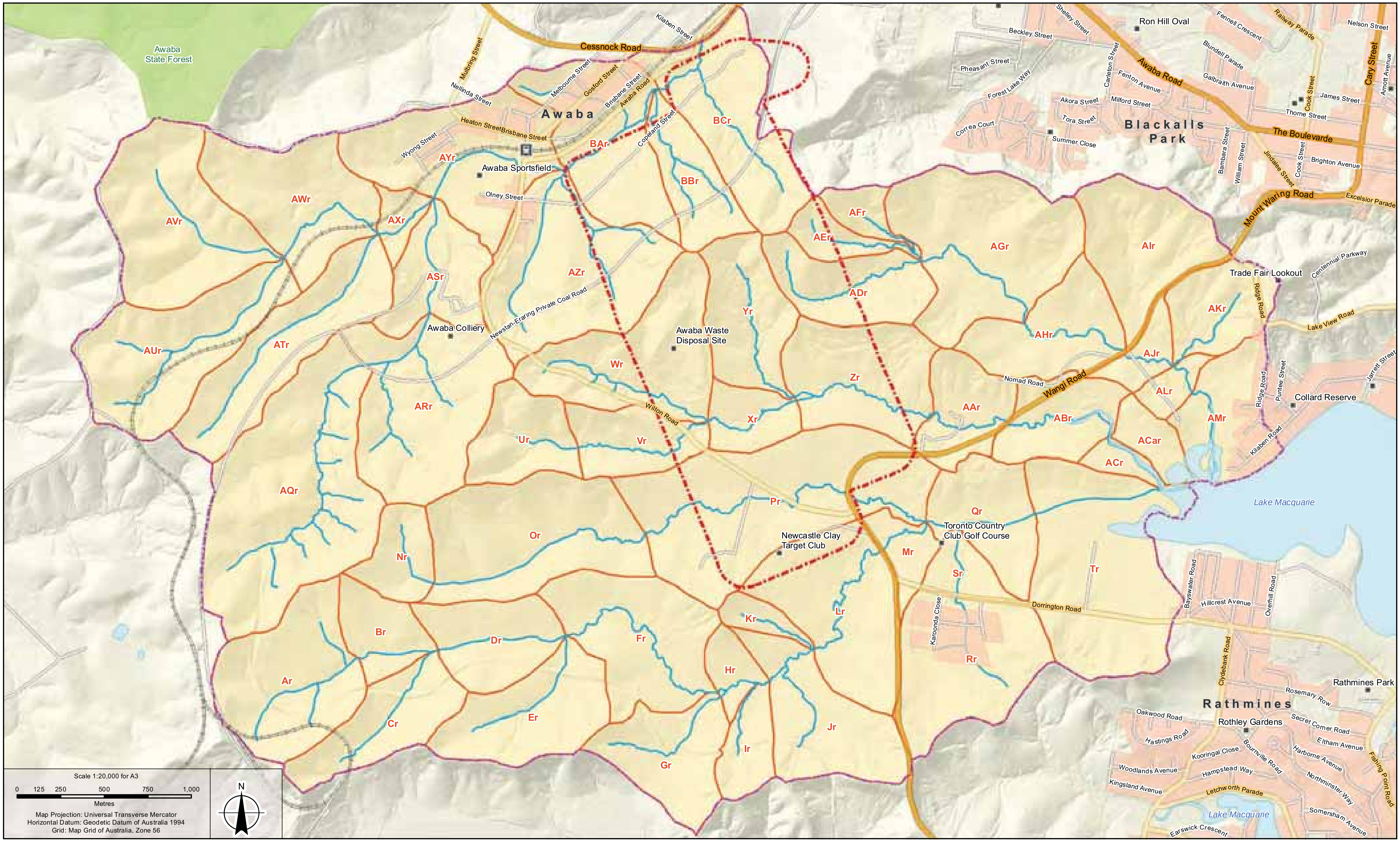
Predicted subsidence impacts as a result of longwall mining

Centennial Newstan

Date: 30/04/2012

Figure 2.3

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook_CODE4.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Waterbody
- Builtup area
- State forest
- Hydrologic sub-catchments
- Gully line for hydraulic model

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

XP-RAFTS Catchments and Model Setup

Centennial Newstan

Date: 30/04/2012

Figure 2.4

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd

2.3.2 Adopted Model Parameters

The following Sections outline the model parameters adopted for this study, which have been selected based on an assessment of the available information, including:

- Aaerial photography.
- Cadastre.
- Photos and notes from the site inspection.
- Values adopted from previous studies in the area.

As part of the study area forms part of the catchment for the Stony Creek Flood Study (Cardno, 2005), this was the main source of comparison for model parameters.

Catchment Properties

To assess the rainfall-runoff process, XP-RAFTS requires each catchment to be defined by an area, impervious fraction, vectored slope, and roughness (Manning's 'n'). For this study, these parameters were selected based on the following methods and assumptions:

- Area – obtained directly from GIS software based on subarea boundaries.
- Impervious fraction – assessed visually on a case by case basis from aerial photography, but with the guide of assuming the following impervious fractions for various land uses:
  - Fully forested areas 0 %
  - Other land use areas ≥ 5 %
- Vectored slope – obtained directly from terrain analysis conducted on DTM.
- Roughness – assessed visually on a case by case basis from aerial photography and site inspection (see Appendix B for example photos of the study area), but with the guide of assuming the following Manning's 'n' value for certain land uses:
  - Forested areas 0.100
  - Rural/open grass areas 0.050
  - Urban areas (including sealed roads) 0.020

The adopted catchment values are outlined in Appendix B. For modeling purposes in XP-RAFTS, the catchments with an impervious area are represented as two separate subareas with an impervious fraction of either 0 % or 100 %. The 100 % impervious subarea has the same parameters except for the roughness, which was assumed to be 0.020.

Loss Modeling Approach

As with similar studies in the area, an initial and continuing loss approach was adopted. The actual loss parameters used are outline below:

- 20 mm initial loss, 2.5 mm continuing loss for pervious areas.
- 1 mm initial loss, 0 mm continuing loss for impervious areas.

These values are within normal ranges and are consistent with AR&R and compare well to those used in the Stony Creek Flood Study (Cardno, 2005).

Intensity-Frequency-Duration (IFD) Parameters

The IFD parameters were selected using the Bureau of Meteorology's GIS based IFD program at a representative location in the catchment. The parameters used were as follows:

- ${}^{2}i_{1}$ (1 hr duration, 2 yr ARI) 33.64 mm\hr
- ${}^{2}i_{12}$ (12 hr duration, 2 yr ARI) 7.49 mm\hr
- ${}^{2}i_{72}$ (72 hr duration, 2 yr ARI) 2.5 mm\hr
- ${}^{50}i_{1}$ (1 hr duration, 50 yr ARI) 65.19 mm\hr
- ${}^{50}i_{12}$ (12 hr duration, 50 yr ARI) 15.35 mm\hr
- ${}^{50}i_{72}$ (72 hr duration, 50 yr ARI) 5.34 mm\hr
- G (skewness) 0.02
- F2 (2 yr ARI geographical factor) 4.31
- F50 (50 yr ARI geographical factor) 15.94

2.4 Hydraulic Modelling

Hydraulic modelling was undertaken using TUFLOW. TUFLOW is a hydrodynamic model used for simulating one-dimensional (1D) and two-dimensional (2D) flows. The model is based on the solution to the free-surface flow equations. It links 1D network (ESTRY) domains to 2D (TUFLOW) domains to represent the catchment terrain and its drainage system. The TUFLOW model consists of a 2D domain representing the catchment terrain, a combination of 1D and 2D elements representing the underground drainage system and a set of boundary conditions comprising the calculated XP-RAFTS hyetograph inflows and the downstream water levels.

TUFLOW modelling was undertaken to determine the peak water levels in the SMP application area before and after suspected subsidence as a result of longwall mining for the events and scenarios listed in Table 2.2. The model was initially run for twenty different 100 year ARI storm durations ranging from 10 minutes to 72 hours in order to determine the critical peak flood levels (i.e. 20 runs in total).

Plans showing the layout of the SMP application area TUFLOW model, as described below, are included in Appendix C.

2.4.1 2D Domain

The 2D domain represents the surface terrain of all major overland flow paths within the hydraulic model. A DTM was created from a range of data sources to represent the catchment topography (see Section 2.2 for more details). Using this terrain model, a grid comprising 8 m square cells was formed over the entire study area. An 8 m grid size was adopted as a suitable model resolution given the detail and accuracy of the survey data, and the size of the study area. This was considered appropriate after minimal differences in results were observed when testing a smaller grid size (i.e. 4 m grid). Each cell is made up of nine points, with the elevation for each point based on the DTM. The grid was orientated to minimise the domain size and align with the majority of the major topographic features within the catchment. The 2D domain was used to model all overland flow paths.

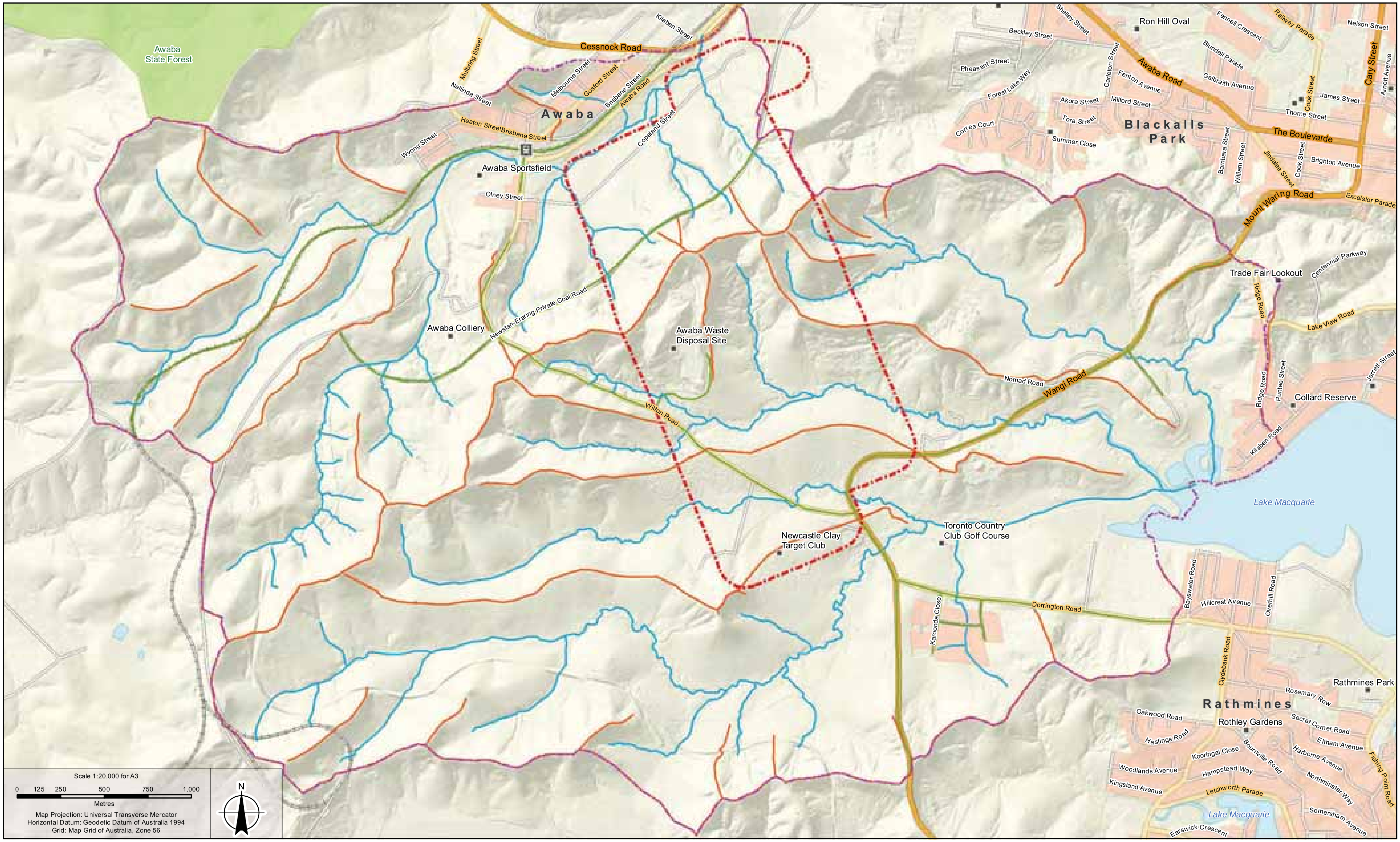
Some key topographic features or control structures, which may have appeared discontinuous or missed in the 8 m gridding process, were included in the 2D domain by modifying the elevations of cell points. The locations of these modifications are shown in Figure 2.5, which represent features such as:

- Key creeks and gullies
- Ridges
- A number of roads, especially around drainage structures.

The bed resistance was allocated to each cell as a Manning's n value based on land use type. Adopted Manning's n values are tabulated in Table 2.3, and can be seen graphically over the catchment in Appendix C.

Table 2.3 Bed Resistance Values for 2D domain

Material Number	Manning's n	Land Use
1	0.02	*Roads\Concrete Channels [Default Material]*
2	0.05	*Railway*
3	0.1	*Residential*
4	0.05	*Rural Residential (low-density residential with occasional trees)*
5	0.2	*Commercial*
6	0.2	*Industrial*
7	0.1	*Forest (dense trees)*
8	0.05	*Scrub (trees and scrub, some open grassy gaps)*
9	0.03	*Open grass*
10	0.07	*Creek*
12	0.05	*Lake*
13	0.07	*Bushy Residential (low-density residential with thick vegetation)*
14	0.05	*Power sub-station*
15	0.5	*Blocked out building*
16	0.03	*Coal stock piles*



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Ridge line for hydraulic model
- Waterbody
- Builtup area
- State forest
- Gully line for hydraulic model
- Road/rail for hydraulic model

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Location of terrain modification lines in TUFLOW

Centennial Newstan

Date: 30/04/2012

Figure 2.5

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd

2.4.2 Drainage Network

The drainage network comprises a combination of 1D and 2D elements to enable the modelling of a continuous drainage path for the majority of drainage lines in the study area. A combination of 1D and 2D elements were used to model the drainage network depending on the available information and location in the catchment.

The 1D elements of the drainage network were modelled as circular or rectangular culverts with an SX point or line connection to the 2D domain depending on the size of the culvert. This type of boundary transfers the net flow into/out of the 1D node to the connecting 2D cell(s), and does not transfer momentum. All these culverts were modelled with a Manning's n value of 0.013 and had typical entry and exit losses of 0.5 and 1 respectively.

Drainage elements where there was no data available, were modelled in the 2D domain as a one cell wide opening in the terrain to allow for some flow to pass the obstruction. These obstructions are primarily located on the roads in the study area. This representation may under or over estimate the actual opening through the obstruction, but without any other information was considered appropriate because it allows for some water to pass the obstruction and maintains a continuous path through the catchment. Considering that this modelling is only intended to compare the pre- and post- modelling scenario and not provide absolute flood level information, this assumption is considered appropriate.

At present there has been no explicit consideration of potential blockage of the modelled structures due to the comparative nature of the study.

2.4.3 Boundary Conditions

Boundary conditions in the TUFLOW model include inflow rainfall-excess hyetographs and downstream tailwater conditions.

Based on previous flood studies around Lake Macquarie, the values shown in Table 2.4 were adopted as a constant tailwater level for the downstream boundaries on the lake. These levels were applied in the TUFLOW model as head versus time boundary condition ("HT" boundary) across the 2D domain (in a 2d_bc layer), and remained constant throughout each simulation. The 'sensitivity' runs referred to in Table 2.4 were used to demonstrate the lack of sensitivity of the results to tailwater levels and assess the potential impact of climate change. Given the elevation and relative remoteness of the area of interest to Lake Macquarie it was considered appropriate to model these events assuming coincident flooding of both the stream and lake. If modelling results were required closer to the lake additional sensitivity runs with lower lake levels should be considered.

Table 2.4 Adopted Downstream Tail Water Levels for Lake Macquarie

Scenario		Water level
All Scenarios	100 yr ARI	1.38 m AHD
	20 yr ARI	0.97 m AHD
	10 yr ARI	0.80 m AHD
	2 yr ARI	0.45 m AHD
Sensitivity Scenario	100 yr ARI	1.38 m AHD + 0.9 m = 2.28 m AHD

The other two downstream boundaries in the model, which occur to the north of the study area on Stony Creek (WC1) and at the railway underpass of Cessnock Road (Figure 2.6), were also represented as head versus time boundaries ("HT" boundaries). Based on available data from previous studies and the steep terrain, these boundaries were set to have a tailwater just below the ground surface, which allows water to leave the model freely. This approach does result in some drawdown at the boundary, but this only affects the one or two cells at the models boundary, and as these are away from the area of interest this approach was considered appropriate.

The downstream tailwater levels in Table 2.4 were also applied as an initial water level throughout the model to prevent a wall of water rushing back up through the model.

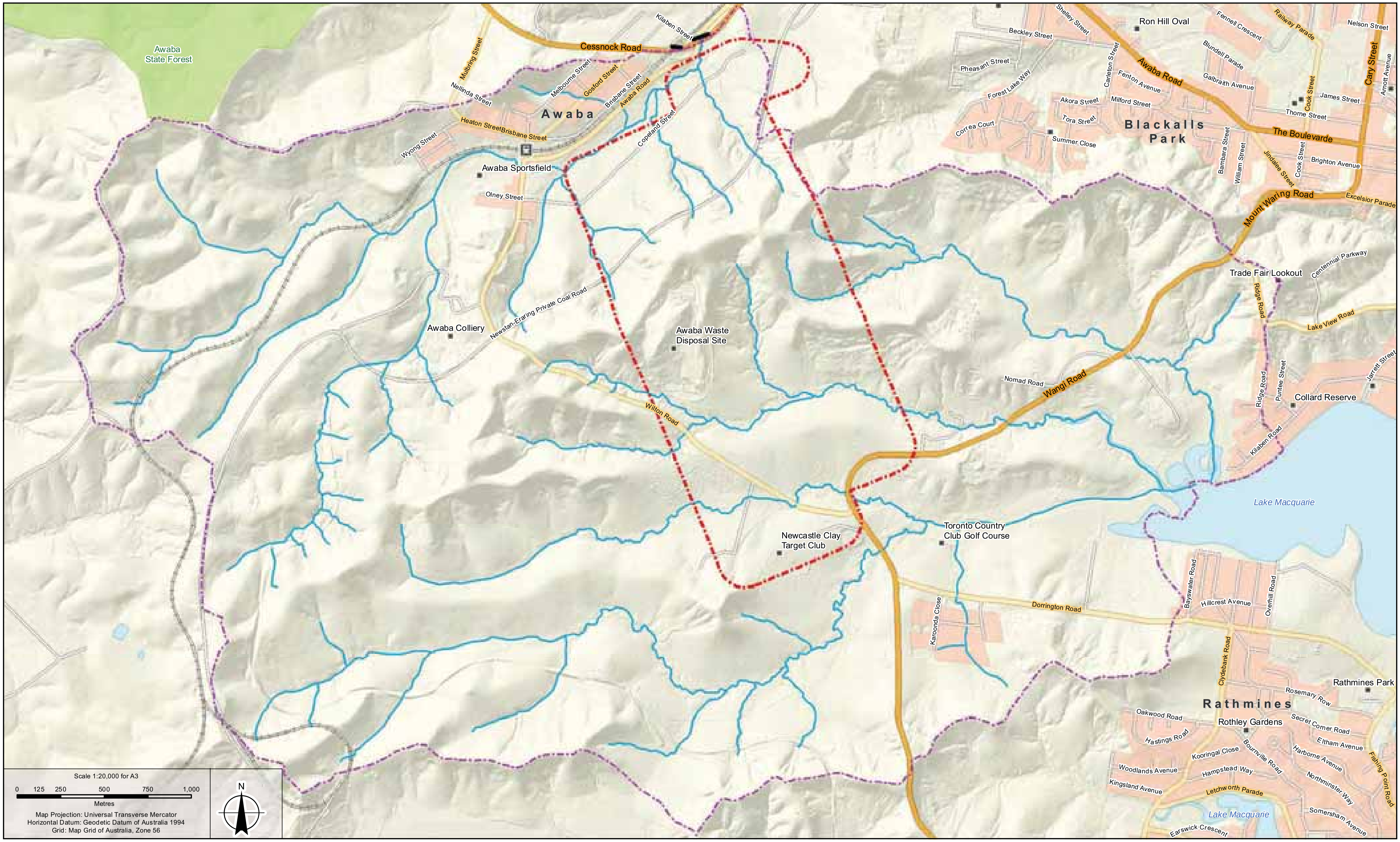
The rainfall-excess hyetographs generated using the XP-RAFTS model for the events and scenarios listed in Table 2.1 were adopted as rainfall depth boundary conditions ("RF" - rainfall depth versus time). For all events, these depths were distributed over the subareas (via a 2d_sa layer). To maintain the hyetograph shape and ensure only one rainfall time-series is applied to each cell the following commands were used in the TUFLOW model:

- Rainfall Boundaries == STEPPED
- Rainfall Gauges == One per Cell

2.4.4 Model and Run Parameters

Following several test runs trialling various parameters, the following parameters were found to achieve the most stable model runs across a wide range of storm durations, and have been adopted for all runs (unless otherwise specified):

- A time step of 0.5 seconds for the 2D domain and a time step of 0.5 seconds for the 1D domain.
- Model run times long enough for peak flood levels to occur throughout the study area. This can sometimes be considerably longer than the storm duration to allow enough time for flow to reach the outlet and for storage levels to peak.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Waterbody
- Builtup area
- State forest
- Gully line for hydraulic model
- Downstream tailwater boundary

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Location of downstream boundary conditions not on Lake Macquarie

Centennial Newstan

Date: 30/04/2012

Figure 2.6

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd

- An initial water level in the 1D and 2D domains equal to the downstream tailwater level (unless otherwise defined by an initial water polygon).
- "Manholes at All Culvert Junctions == OFF" command. This command turns off the automatic loss calculation approach for 1D elements in TUFLOW and adopts any user specified losses.
- "Taper Closed NA Table == ON" command. This command can improve model stability by reducing the sudden change in available storage as the water level reaches the obvert of closed 1D elements.
- "Mass Balance Corrector == ON" command. This command is intended to help reduce mass balance errors in problematic models, particularly those with steep and/or very shallow flow (both of which occur in this model).

No other special commands were required to stabilise the Centennial Newstan SMP application area model.

3. Hydraulic Assessment

3.1 Overview

The objective of the hydraulic assessment is to assess the potential impact of the subsidence due to extraction of the longwalls on the hydraulic conditions of surface water systems. This is best analysed by assessing afflux in terms of depth (and\or water surface level) and velocity. This study has defined this as the relative change in a variable between the ‘existing’ and ‘subsided’ situation (i.e. ‘Subsided’ result minus ‘Existing’ result). A positive afflux will be an increase in the variable in the ‘subsided’ case relative to the ‘existing’ case, and a negative afflux will be a decrease in the variable in the ‘subsided’ case relative to the ‘existing’ case. However, to provide an indication of the extent of the flooding and an improved understanding of flow paths through the study area depth and velocity results have also been presented.

Although the hydraulic model extends beyond the SMP application area, the discussion of results will focus on the area around the SMP application area (see highlighted area in Figure 3.1). This reduced area of focus is due to impacts being located primarily in and around the SMP boundary. Figure 3.1 also shows there is a small section of area within the SMP application area that is outside the hydraulic model as identified by the “study area extent”. The excluded area is not affected by predicted subsidence (see Figure 2.3) and does not contribute to flows within the model. For completeness results for the entire study area are included in Appendix D, Appendix E and Appendix F.

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Results discussion area

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Area of interest around SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.1

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd

3.2 Results Processing Discussion and Qualifications

In order to gain a more representative understanding of flooding behaviour in the area, the raw results from the two-dimensional hydraulic modelling software (TUFLOW) are post-processed on a finer grid so that the depth can be estimated using the more detailed topography from the Digital Terrain Model (DTM). As this study has used a “rain-on-grid” approach, the post-processing has also involved filtering the results on depth to define an extent and focus the assessment on the more significant flow paths within the study area. The post-processing methodology used for this study is outlined in Figure 3.2.

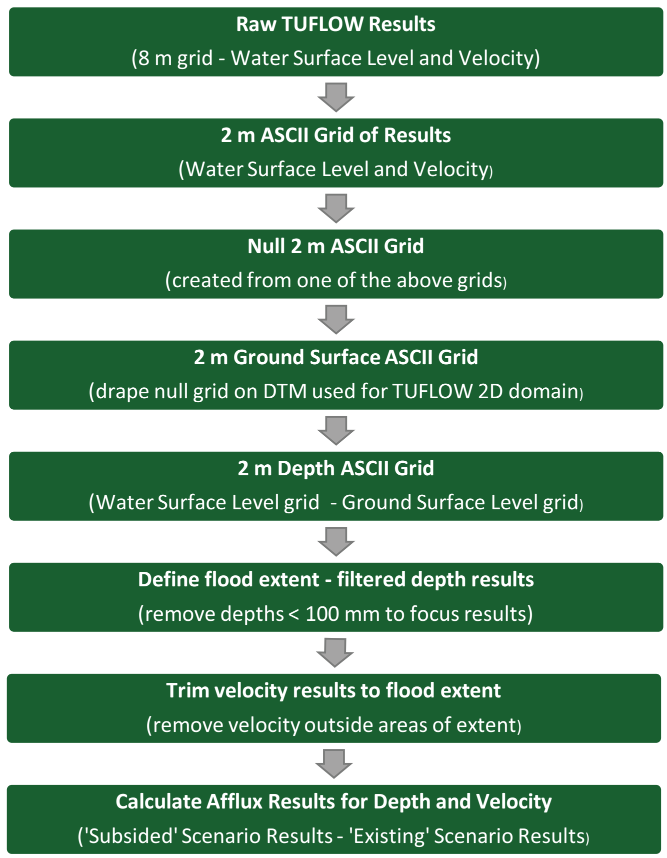


Figure 3.2 Post-Processing Methodology

Converting the raw TUFLOW results to 2 m ASCII grids to determine flood depths and extents enables the use of more detailed terrain from the DTM producing a more detailed interpretation of the hydraulic results from the 8 m grid. Given the steep terrain and gridded nature of the 2D domain in the hydraulic model, this conversion process can result in some speckling of the results due to numerical noise generated by the processing. This noise exists both within and external to the areas of predicted subsidence. This noise is generally easy to differentiate and not significant with respect to the real results however for some results which are indicating relatively minor changes such as many of the afflux results, some interpretation is needed to identify the ‘real’ results. In general, the results were considered ‘real’ if there was a significant cluster of similarly affected cells. This approach was considered appropriate because the project is focussed on identifying areas of change, and does not aim to define absolute levels or a definitive change in level.

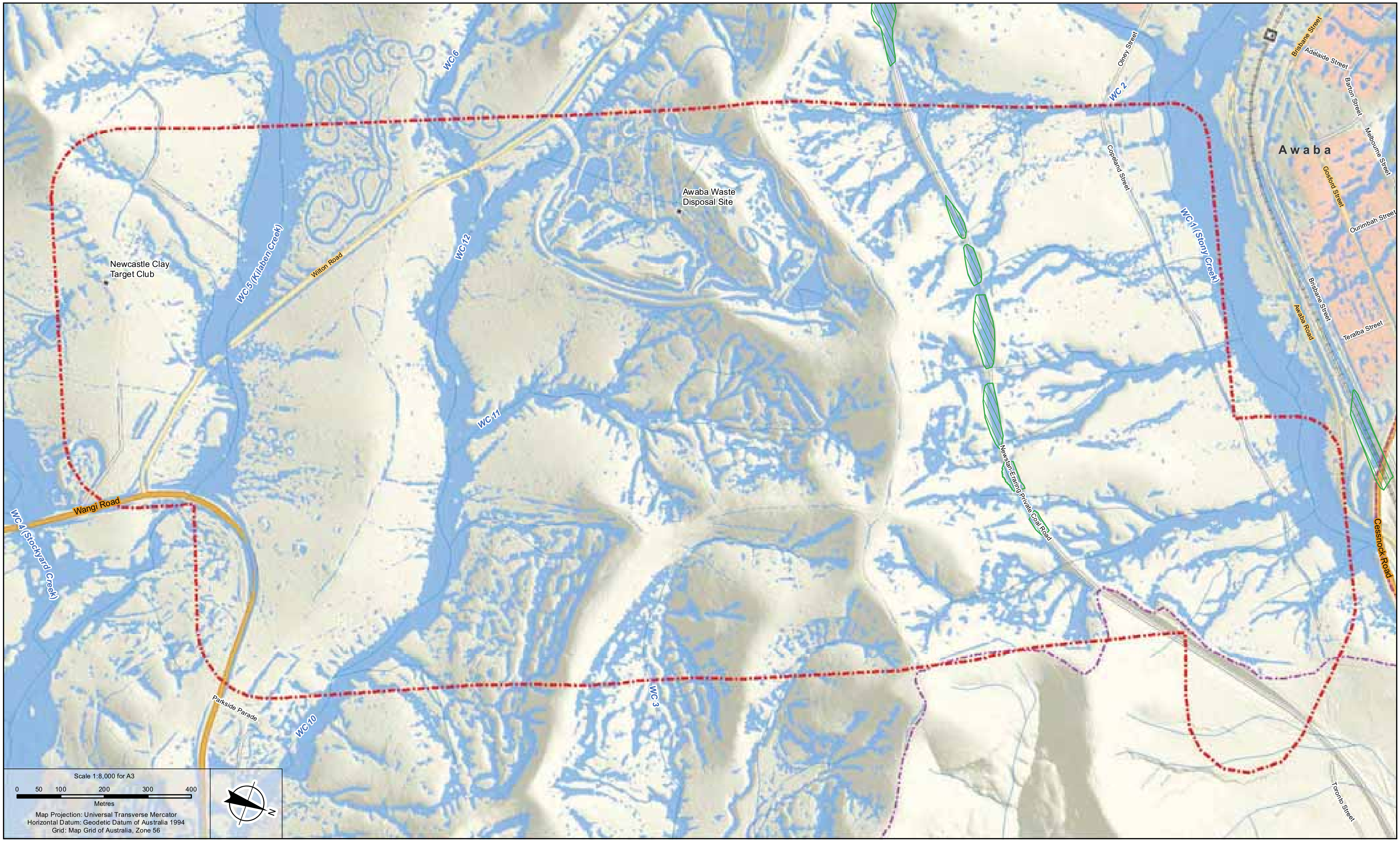
While the noise is generally small in magnitude and extent, there are examples where it is more significant, providing some insight into the mechanisms causing this effect. One clearly identifiable example is along the haul road where water levels from the top of the escarpment effectively bridge the finer resolution ground surface of the cutting producing apparent flood depths of several meters.

The process of filtering out depths less than 100 mm to estimate a flood extent does result in an extent that contains many isolated areas of flooding around the catchment. The small isolated patches can generally be ignored, but some of the larger ones should be considered as continuing on to join one of the defined flow paths (i.e. they are likely to be localised depression that are connected to the defined flow paths by flow of less than 100 mm depth). This depth filtering approach for defining the extent is widely adopted for “rain-on-grid” modelling.

Due to underlying workings and resolution of the model, there are some limitations in regards to the results at the bottom of steep valleys where the dominant flow is down the slope and not along the thalweg (i.e. areas of cut along roads). The limitation relates to the fact that the model represents the water surface level as a single value on a cell, which is output from the model as an interpolated value on the cell side. This interpolation can result in the reporting of artificially high depths due a 'bridging' of the cut area. The areas significantly affected by this have been highlighted on all the result figures as hatched polygons, and the results in these areas need to be interpreted appropriately.

3.3 ‘Existing’ Conditions Scenario

The ‘existing’ hydraulic situation for the study area is presented in Figure 3.3, which shows a flood extent for the modelled 100 year ARI event. This plot shows that there are five major flow paths that pass through or nearby the SMP application area, which are Stockyard Creek (WC4), Kilaben Creek (WC5), Stony Creek (WC1), and two unnamed creeks that drain to Kilaben Bay (WC3 and WC10/WC12). One of the unnamed creeks (WC10/WC12) and Kilaben Creek (WC5) pass directly through the SMP application area, and as such are the flow paths that are likely to be more subject to change as a result of the subsidence. In addition to these major flow paths, there are also numerous tributaries or minor flow paths that connect to the five major flow paths. A discussion on depth, velocity and existing infrastructure under ‘existing’ conditions is provided in Sections 3.3.3, 3.3.1 and 3.3.2 respectively.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- 100 year flood extent

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

100 year ARI 'Existing' Conditions Scenario - Flood Extent in SMP Study Area

Centennial Newstan

Date: 30/04/2012

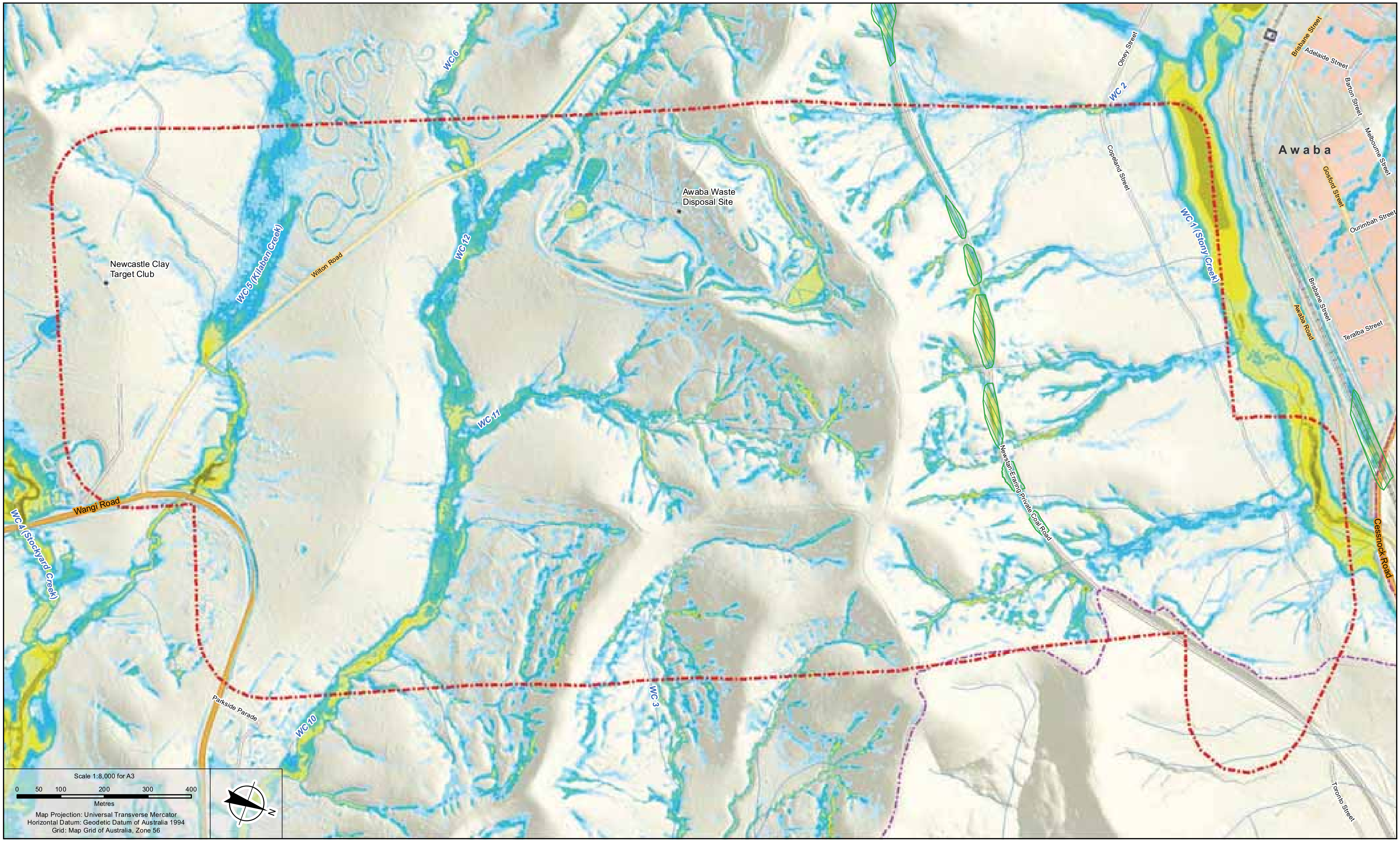
Figure 3.3

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

3.3.1 Depth Results

Table 3.1 and Figure 3.4 to Figure 3.8 outline the depth distribution for the modelled ARIs in the area of interest around the SMP application area (see Appendix D for a complete set of results for the modelled ARIs). These results indicate the following key hydraulic properties for this area:

- Flow paths are quite confined due to the steep terrain – there is only a 0.14 km^2 or 11 % change in the area of inundation between the 100 year and 2 year ARI.
- Majority of flooding is relatively shallow - between 58 % (100 year ARI) and 66 % (2 year ARI) of the flooding is less than 0.4 m deep, and between 87 % (100 year ARI) and 93 % (2 year ARI) is less than 1m deep.
- Areas of flooding greater than 1 m in depth are generally confined to the following areas:
  - The thalweg of the identified flow paths (both major and minor), especially Kilaben Creek (WC5) upstream of Wangi Road, the unnamed creek (WC10/WC12), and Stony Creek (WC1) upstream of Cessnock Road overpass.
  - Existing water bodies in the Awaba Waste Disposal Site.
- Results for the SMP area are relatively insensitive to the adopted tailwater level within the range assessed, as indicated by the consistent results between the standard 100 year ARI runs and the alternate tailwater 100 year ARI runs (sensitivity runs).



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

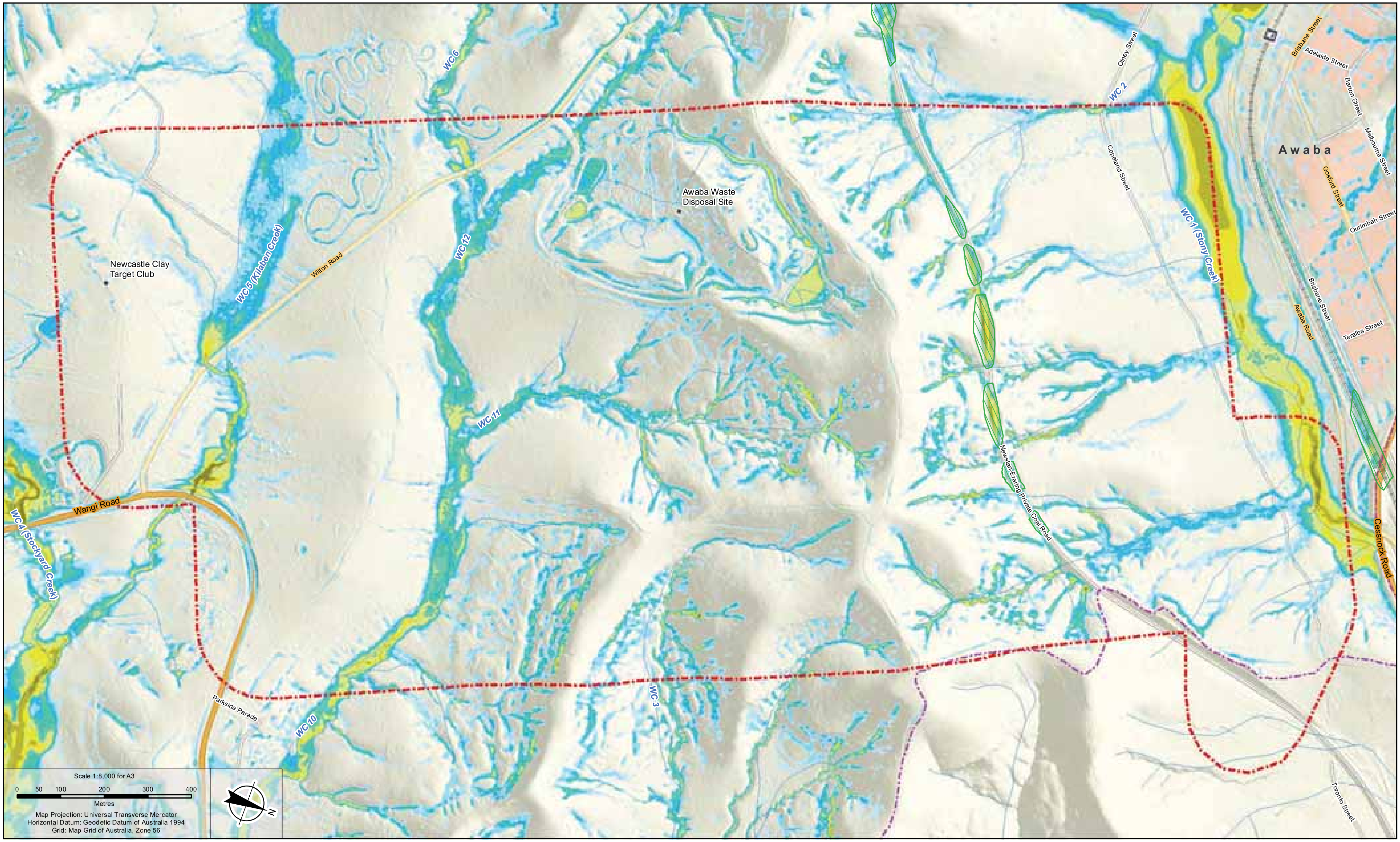
'Existing' Scenario 100 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.4

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

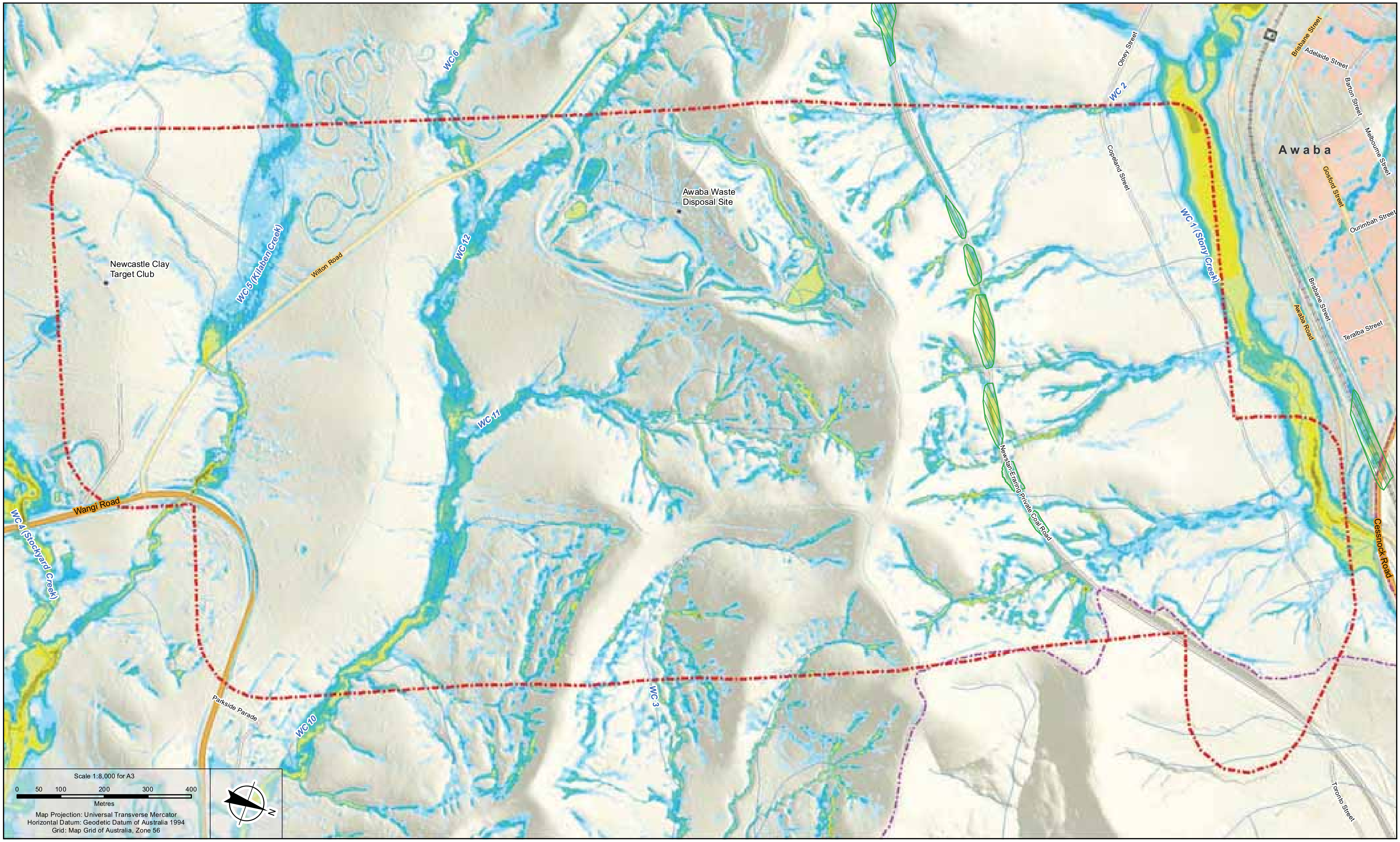
'Existing' Scenario 100 year ARI with alternate tailwater Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.5

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

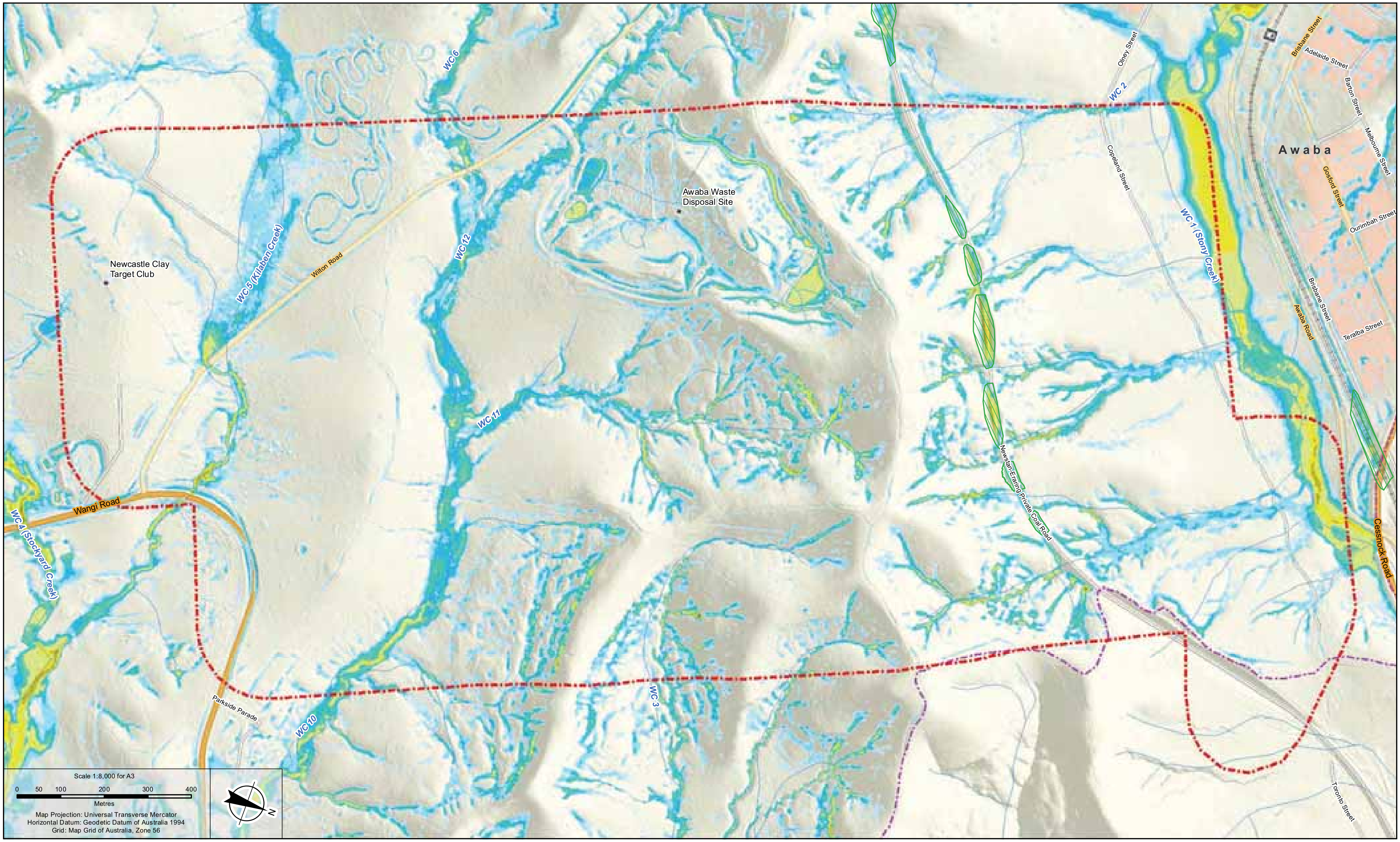
'Existing' Scenario 20 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.6

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



GHD

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m): < 0.20, 0.20 - 0.40, 0.40 - 0.60, 0.60 - 0.80, 0.80 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

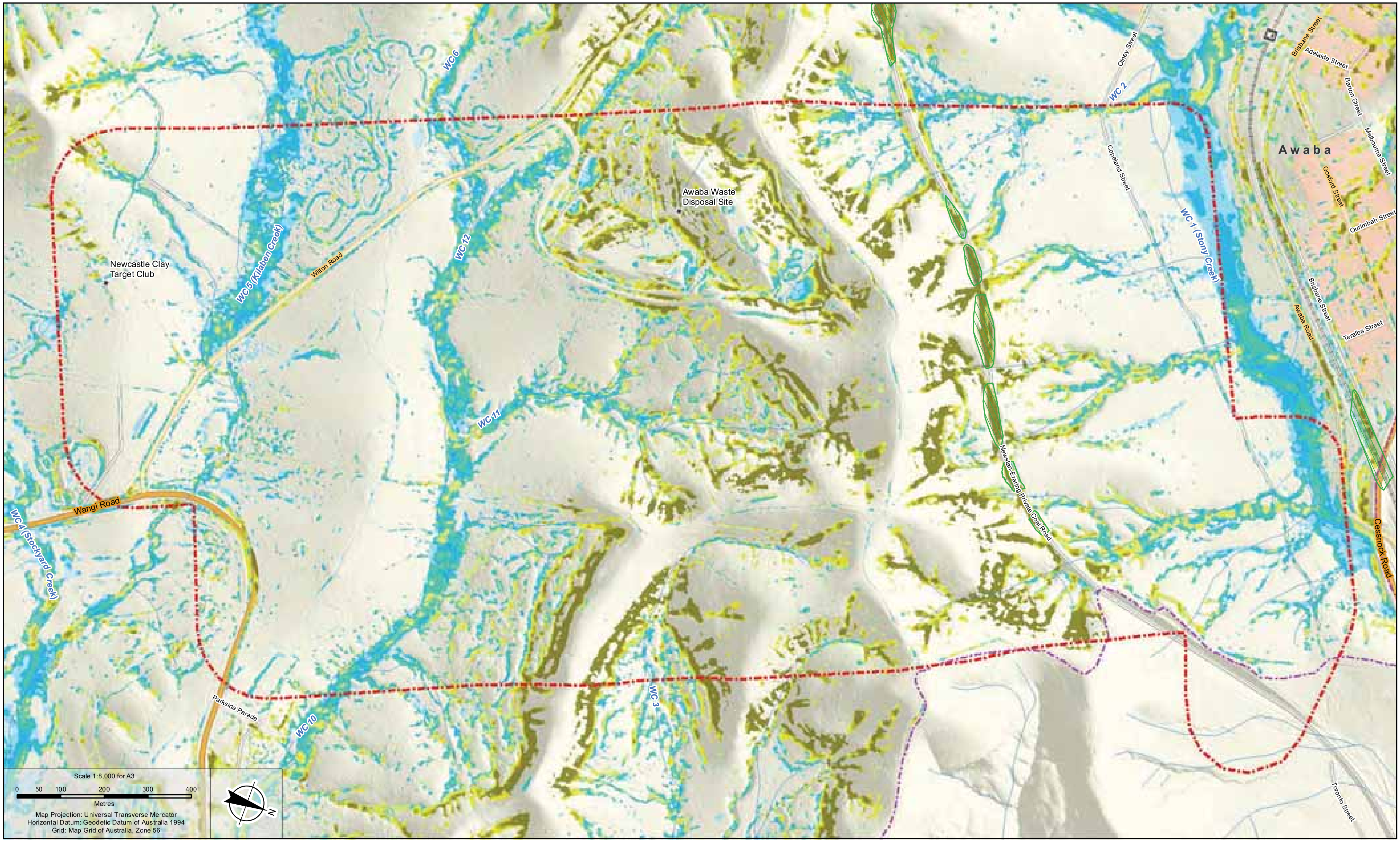
'Existing' Scenario 10 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.7

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 2 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.8

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

Table 3.1 'Existing' Conditions Scenario Depth Distribution for the Area of Inundation

Depth Ranges (m)	Scenario									
	100 year ARI		100 year ARI alt TWL		20 year ARI		10 year ARI		2 year ARI	
	Area of inundation (km^2)	% of Total Area	Area of inundation (km^2)	% of Total Area	Area of inundation (km^2)	% of Total Area	Area of inundation (km^2)	% of Total Area	Area of inundation (km^2)	% of Total Area
0.1 - 0.2	0.397	31.3%	0.397	31.3%	0.395	32.4%	0.394	33.1%	0.391	34.6%
0.2 - 0.4	0.343	27.0%	0.343	27.0%	0.350	28.7%	0.353	29.6%	0.356	31.5%
0.4 - 0.6	0.186	14.7%	0.186	14.7%	0.182	14.9%	0.178	14.9%	0.167	14.8%
0.6 - 0.8	0.110	8.7%	0.110	8.7%	0.104	8.5%	0.098	8.2%	0.088	7.8%
0.8 - 1	0.069	5.4%	0.069	5.4%	0.061	5.0%	0.058	4.9%	0.048	4.3%
1 - 1.2	0.045	3.6%	0.045	3.6%	0.040	3.3%	0.037	3.1%	0.032	2.9%
1.2 - 1.4	0.037	2.9%	0.037	2.9%	0.032	2.6%	0.029	2.4%	0.026	2.3%
1.4 - 1.6	0.027	2.1%	0.027	2.1%	0.020	1.7%	0.019	1.6%	0.013	1.2%
1.6 - 1.8	0.018	1.4%	0.018	1.4%	0.016	1.3%	0.015	1.2%	0.004	0.3%
1.8 - 2	0.015	1.2%	0.015	1.2%	0.012	1.0%	0.006	0.5%	0.002	0.2%
2 - 2.2	0.012	1.0%	0.012	1.0%	0.004	0.3%	0.002	0.2%	0.001	0.1%
2.2 - 2.4	0.007	0.5%	0.007	0.5%	0.002	0.1%	0.001	0.1%	0.001	0.1%
> 2.4	0.003	0.3%	0.003	0.3%	0.002	0.1%	0.001	0.1%	0.001	0.1%
Total	1.269	-	1.269	-	1.220	-	1.192	-	1.130	-

3.3.2 Velocity Results

Velocity distribution results for the area of interest around the SMP application area are provided in Table 3.2 and Figure 3.9 through to Figure 3.13 (see Appendix D for a complete set of results for the modelled ARIs). These results indicate the following key hydraulic properties:

- The majority of velocities, between 52 % and 65 % of the flow within the area of inundation, is travelling at less than 1 m/s.
- Velocities vary along the identified flow paths, which is typically due to changes in grade and/or pools.
- Higher velocities are generally found in locations with steep terrain, such as adjacent to ridges and through areas of cut.
- Results are relatively insensitive to the adopted tailwater level, as indicated by the consistent results between the standard and alternate tailwater 100 year ARI runs (sensitivity runs).

3.3.3 Existing Infrastructure

Surface infrastructure within the SMP application area potentially impacted by flooding includes public and private roads, easements, drainage lines and culverts. The 100-year ARI event is commonly used to represent large design storm events and often forms the basis of design criteria for hydraulic structures. As such it has been selected to analyse the hydraulic conditions at existing surface infrastructure within the SMP study area.

The public roads passing through the SMP area are Wilton Road and Wangi Road. Wilton Road passes through the SMP area from the Western boundary to the South-Eastern boundary with three major culvert groups conveying flows underneath the road. Wangi road passes through the South-Eastern corner of the site with two major culvert groups passing under the road.

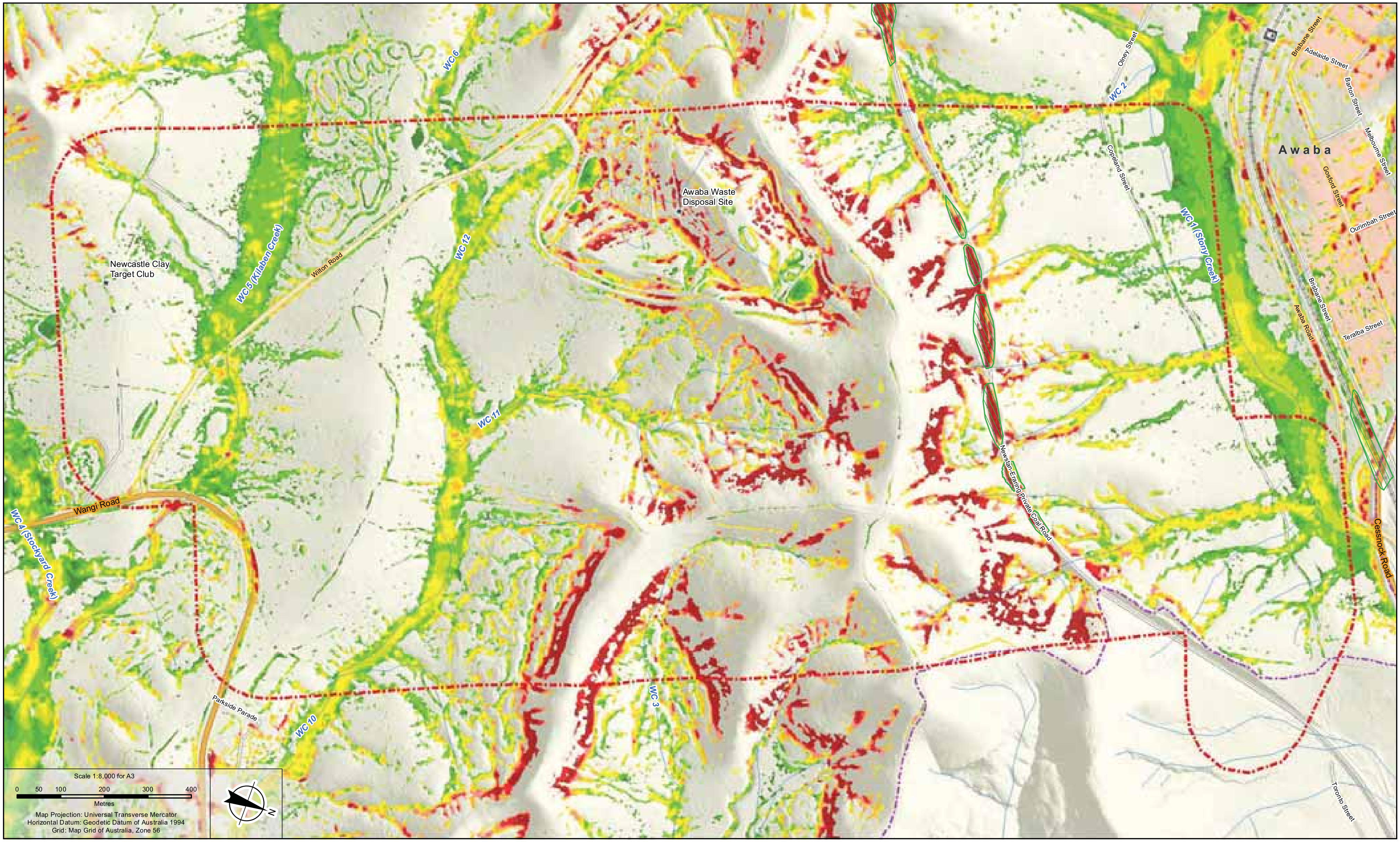
The results of the modelling show that for existing conditions during the 100-year ARI event the only location where a major drainage path flowing at a depth greater than 100 mm overtops Wilton or Wangi Roads is at Culvert WI-C3 passing under Wilton Road. At this location flows over the road are up to 1.5 m in depth and 1 m/s in velocity. The location of WI-C3 is detailed in MSEC (2012).

The private Mine Haul Road passes through the SMP area from the North-Western to the North-Eastern Boundary of the site. There are culvert groups at several locations conveying flows underneath the road.

During the design of the Haul Road major culverts were designed to convey the 100-year ARI design event with no overtopping of the road (AECOM,2009). Therefore it is expected that during the 100-year ARI event there will be no major instances of overland flow over the Haul Road.

There are two major Electrical Infrastructure Easements passing through the site from the North-Eastern boundary to the Southern boundary of the SMP Study Area. There is an unsealed access track along the length of the Eastern easement.

The results of the modelling show that for existing conditions during the 100-year ARI event major waterways flow across the Western and Eastern Easements at two locations. The largest 100-year ARI Event flow width is approximately 40 m upstream of the Eastern Easement and increases to approximately 100 m as it flows across the easement. The large flow width is due to the natural channel becoming wider and shallower as it passes across the easements. Across the easements there are large areas of low velocity with a narrow deeper section at the existing watercourse with higher velocities up to approximately 3.5 m/s and a flow depth up to 2 m. There are small culverts at several locations along the length of the low level access track. However, based on site inspection of their size and condition it is considered unlikely that they will convey significant quantities of water during large storm events and the access track will be inundated.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.50	1.500 - 2.00	2.000 - 2.50	2.50 - 3.00	>3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

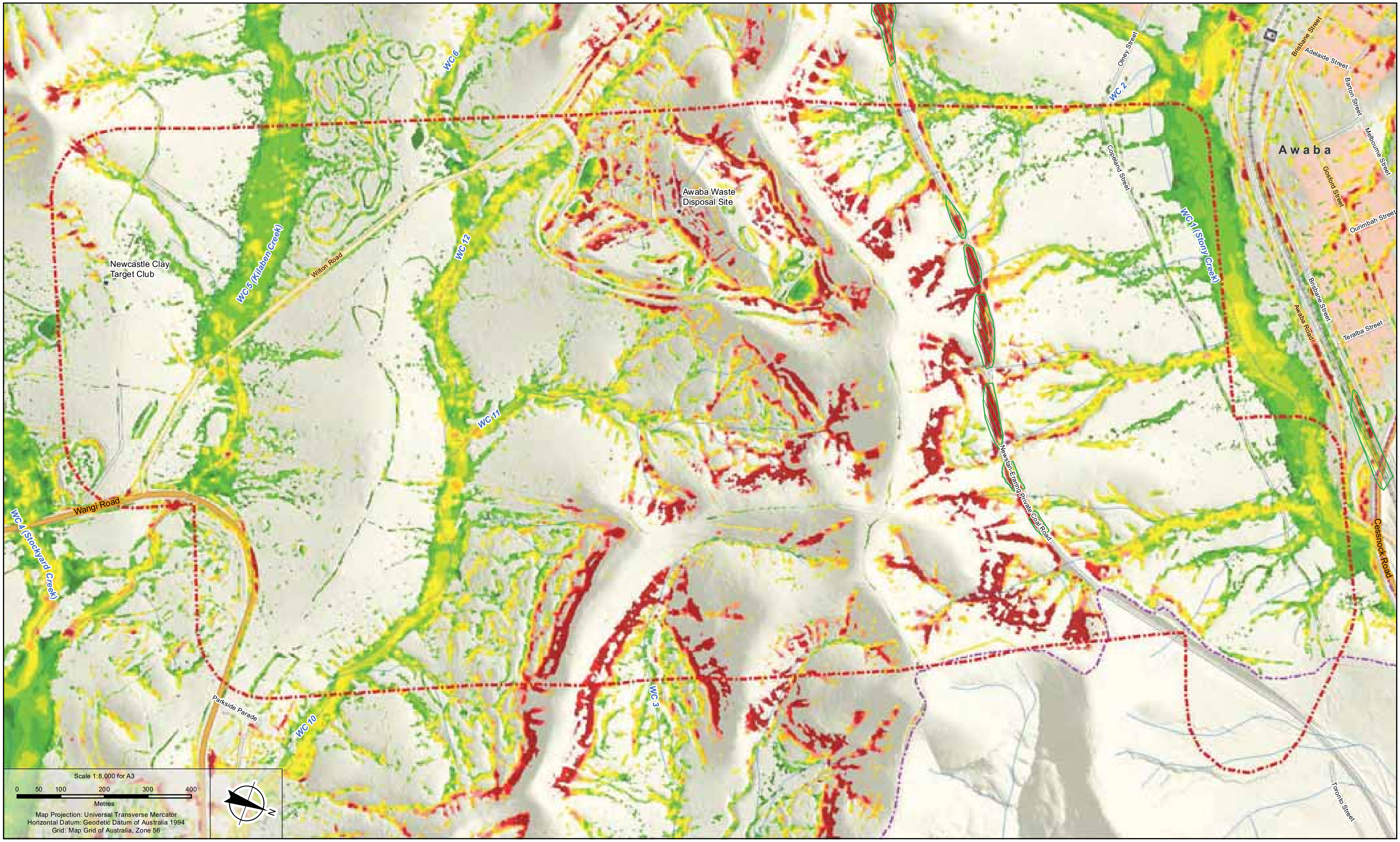
'Existing' Scenario 100 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.9

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

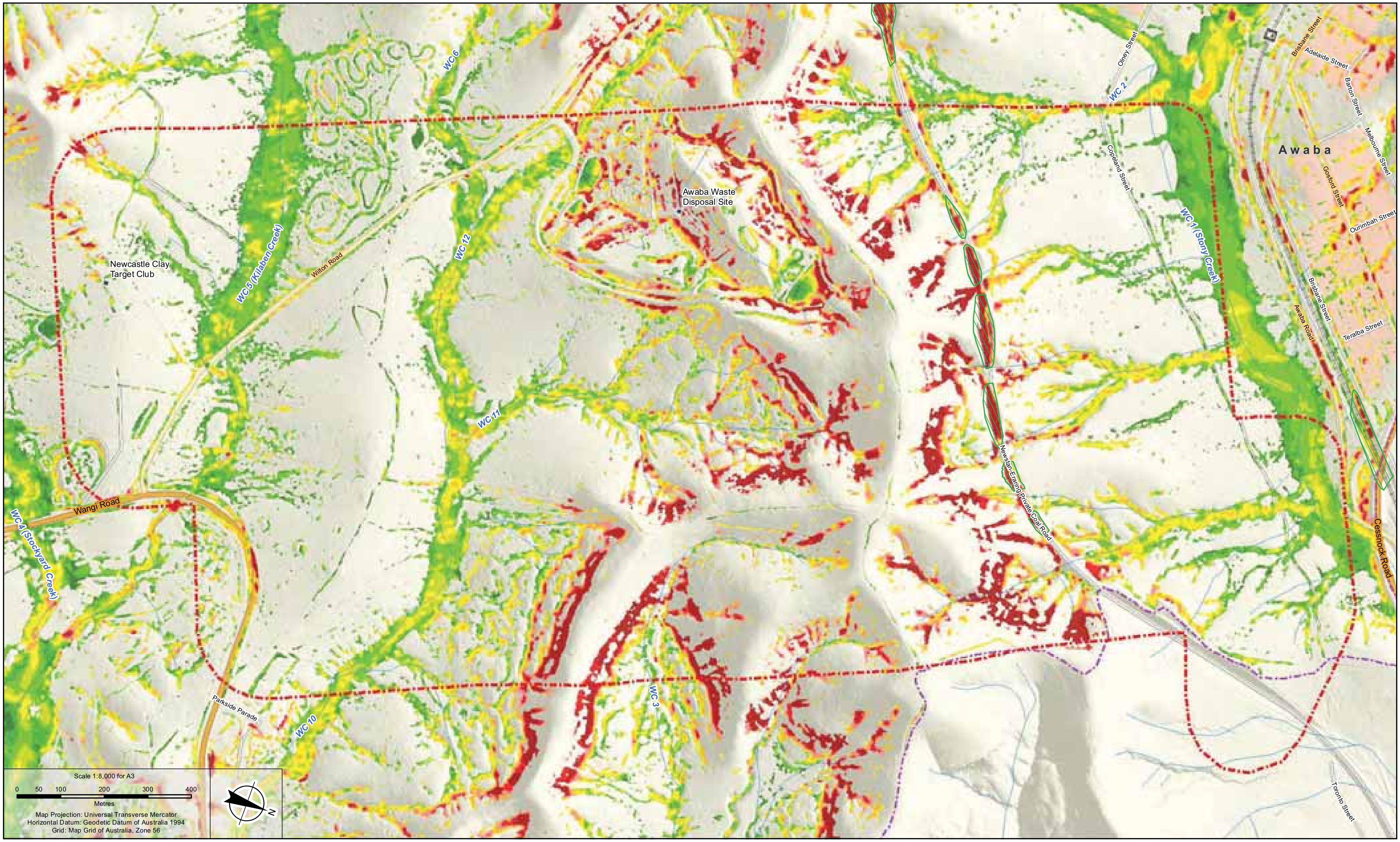
'Existing' Scenario 100 year ARI with alternate tailwater Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.10

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

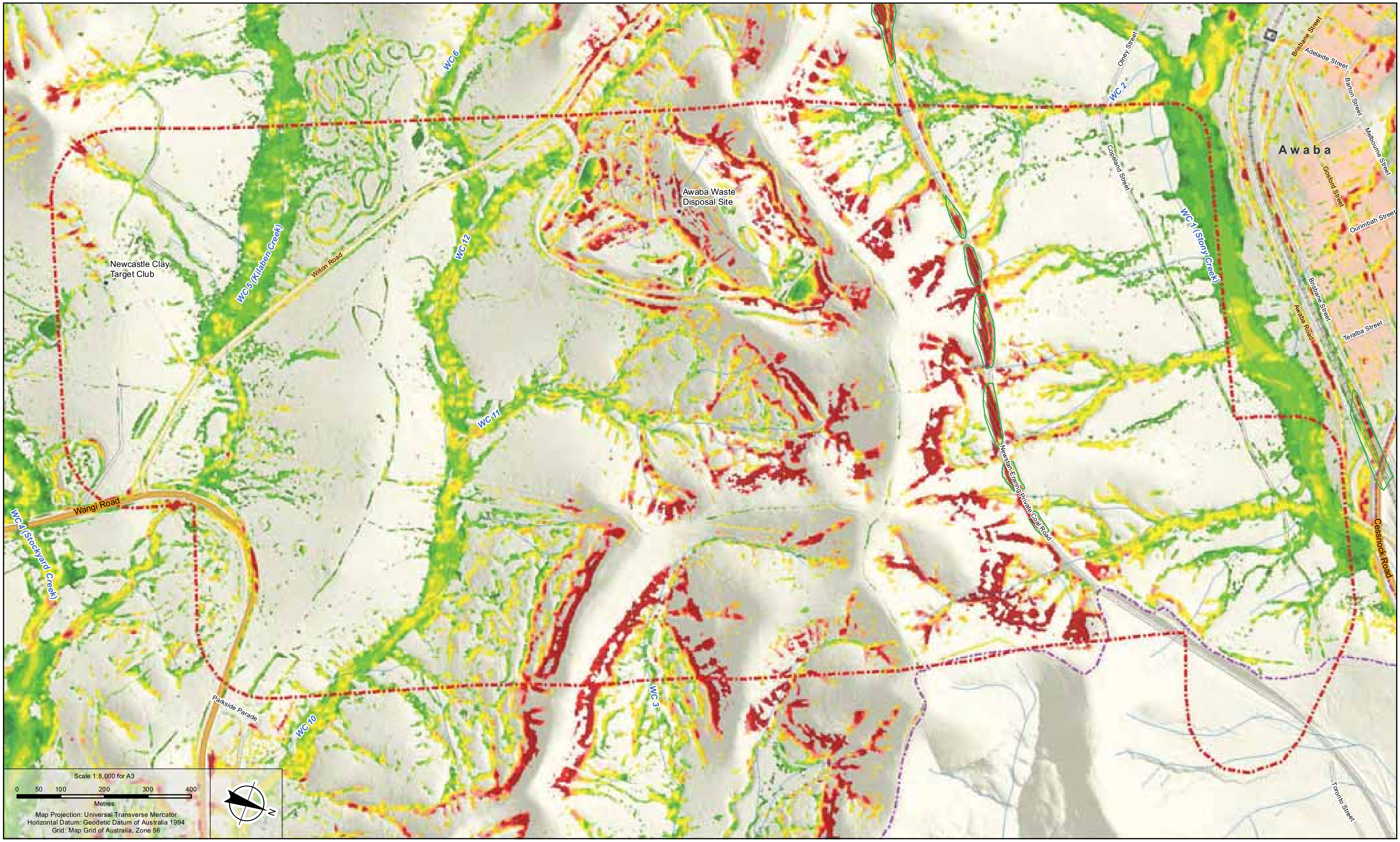
'Existing' Scenario 20 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.11

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 10 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.12

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.50	1.500 - 2.00	2.000 - 2.50	2.50 - 3.00	>3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 2 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.13

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

Table 3.2 ‘Existing’ Conditions Scenario Velocity Distribution for the Area of Inundation

Velocity Range (m/s)	Scenario									
	100 year ARI		100 year ARI alt TWL		20 year ARI		10 year ARI		2 year ARI	
	Area of inundation (km2)	% of Total Area	Area of inundation (km2)	% of Total Area	Area of inundation (km2)	% of Total Area	Area of inundation (km2)	% of Total Area	Area of inundation (km2)	% of Total Area
0 - 0.25	0.036	2.8%	0.036	2.8%	0.039	3.1%	0.042	3.3%	0.047	3.7%
0.25 - 0.5	0.177	13.9%	0.177	13.9%	0.186	14.6%	0.191	15.1%	0.200	15.8%
0.5 - 0.75	0.261	20.6%	0.261	20.6%	0.251	19.8%	0.238	18.7%	0.206	16.2%
0.75 - 1	0.205	16.1%	0.205	16.1%	0.180	14.2%	0.168	13.2%	0.142	11.2%
1 - 1.5	0.221	17.4%	0.221	17.4%	0.200	15.7%	0.192	15.1%	0.179	14.1%
1.5 - 2.0	0.115	9.0%	0.115	9.0%	0.112	8.8%	0.111	8.7%	0.107	8.4%
2.0 - 2.5	0.077	6.1%	0.077	6.1%	0.076	6.0%	0.075	5.9%	0.074	5.9%
2.5 - 3.0	0.060	4.7%	0.060	4.8%	0.060	4.7%	0.060	4.7%	0.059	4.6%
3.0 - 4.0	0.072	5.7%	0.072	5.7%	0.072	5.7%	0.072	5.7%	0.071	5.6%
4.0 - 5.0	0.030	2.4%	0.029	2.3%	0.029	2.3%	0.028	2.2%	0.029	2.3%
5.0 - 6.0	0.008	0.7%	0.008	0.7%	0.009	0.7%	0.009	0.7%	0.008	0.7%
> 6.0	0.007	0.6%	0.007	0.5%	0.007	0.6%	0.007	0.5%	0.006	0.5%
Total	1.269	-	1.268	-	1.220	-	1.192	-	1.130	-

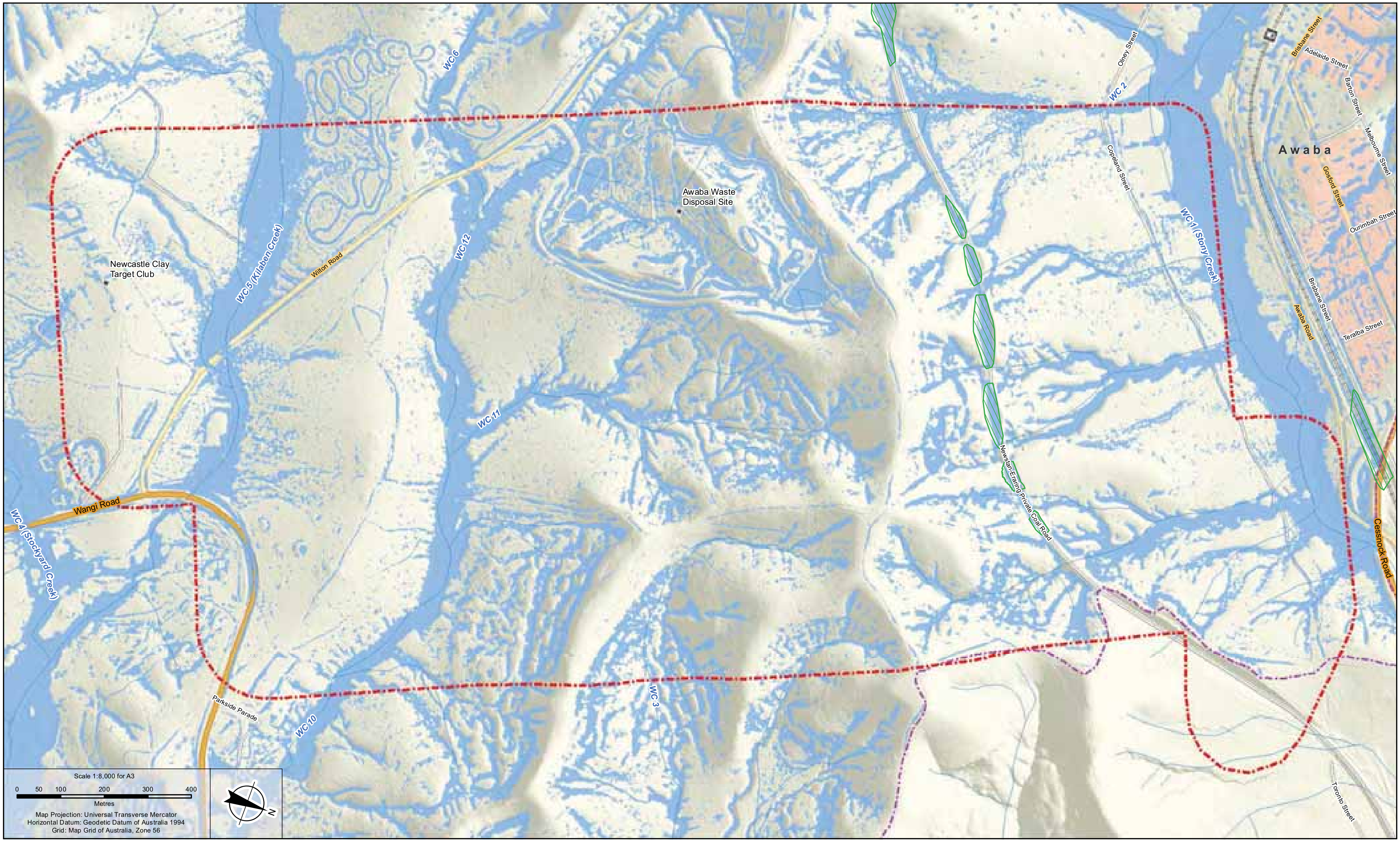
3.4 'Subsided' Conditions Scenario

The hydraulic situation for the study area in the 'subsided' scenario is presented in Figure 3.14, which shows a flood extent for the modelled 100 year ARI event (see Appendix E for a complete set of results for the modelled ARIs). These plots show a very similar situation to that in the 'existing' scenario, in that there are still the same flow paths through the area and the extent is very similar in most areas, apart from some broadening along the major flow paths through the SMP application area. These minimal changes are evidenced in Figure 3.15, which shows the change in water surface level (in m AHD) between the pre- and post- subsidence scenario. This also shows the area of change is generally confined to the SMP application area. Given the purpose of this study, a discussion of the changes in depth and velocity from the 'existing' conditions scenario is provided in Sections 3.4.1 and 3.4.2 respectively. A Section on the change in flooding characteristics of existing infrastructure and change in the flow hydrographs within the affected area is also provided in Section 3.4.3 and Section 3.4.4 respectively.

3.4.1 Depth Results

Figure 3.16 to Figure 3.20 outline the afflux in terms of depth for the modelled ARIs in the area of interest around the SMP application area (see Appendix E for zoomed in depth plots of the 'subsided' scenario). For these plots positive afflux (or an increase in depth) between the 'existing' and 'subsided' cases is shown as blue and negative afflux (or a reduction in depth) is shown as red. To better understand these changes, Figure 3.21 also summarises how the depth distribution for each ARI has changed between the 'Existing' conditions scenario and the 'Subsided' conditions scenario. These results indicate the following key changes in the hydraulic properties for this area:

- The overall flood extent has increased by between 3.4% and 3.7% due to the subsidence, with the higher increases occurring in the smaller ARIs (or the more frequent events).
- The predicted subsidence has caused more positive depth afflux (or comparatively deeper water) than negative depth afflux (or comparatively shallower water).
- Positive afflux has generally occurred where flow paths have been changed to have flatter and/or adverse grades as a result of subsidence, which generally occurs as subsidence estimates reduce between longwalls and on the downstream side of the predicted subsidence area.
- Negative afflux has generally occurred where the terrain has been made steeper, which occurs along the flow paths as they enter the area of predicted subsidence or more generally on the sides of the valley that run parallel to the predicted increasing subsidence.
- The areas of the most change are along the two major flow paths through the SMP application area (which include WC5, WC10, WC11, and WC12), and to a lesser extent two of the minor flow paths out of the centre of the area of predicted subsidence to the north.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- 100 year flood extent

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

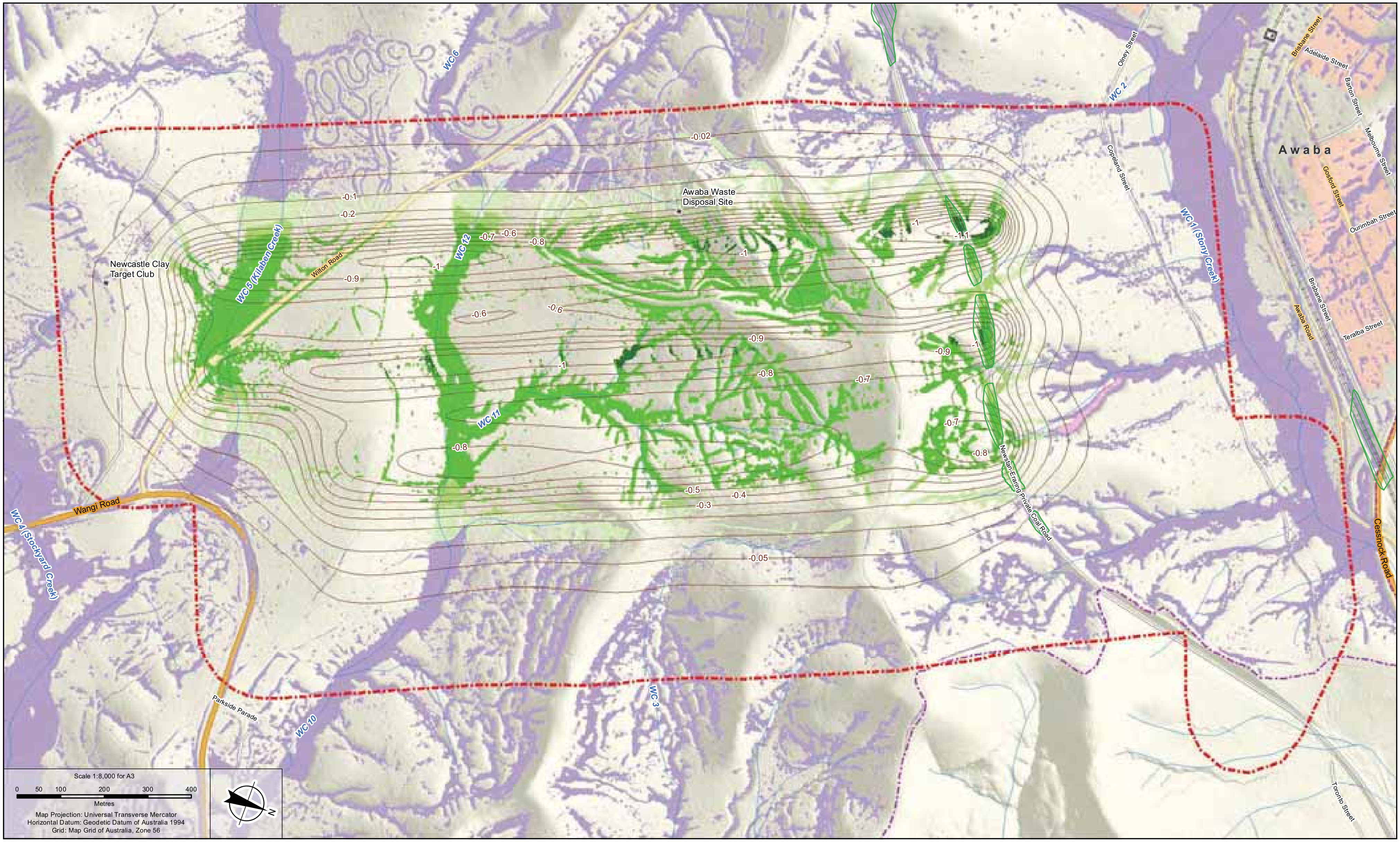
100 year ARI 'Subsided' Conditions Scenario - Flood Extent in SMP Study Area

Centennial Newstan

Date: 30/04/2012

Figure 3.14

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in water surface level (mAHD)

< -1.00 | -1.00 - -0.50 | -0.50 - -0.30 | -0.30 - -0.10 | -0.10 - 0.10 | 0.10 - 0.30 | 0.30 - 0.50 | 0.50 - 1.00 | > 1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

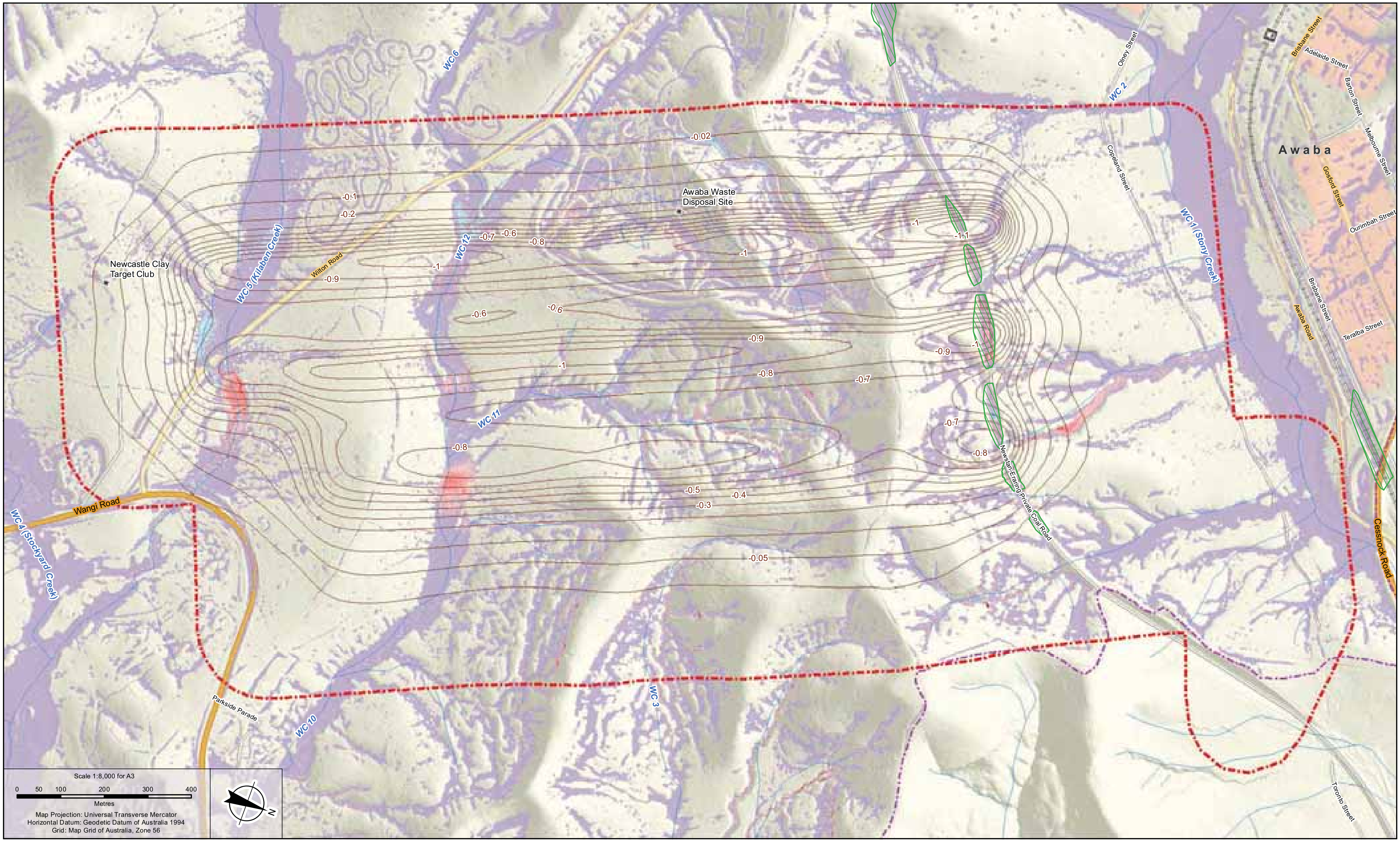
SMP Study Area 100 year ARI WSL Afflux Plot - 'Subsided' Scenario' - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.15

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m)

< -0.5; -0.50 - -0.35; -0.35 - -0.20; -0.20 - -0.10; -0.10 - 0.10; 0.10 - 0.20; 0.20 - 0.35; 0.35 - 0.50; >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

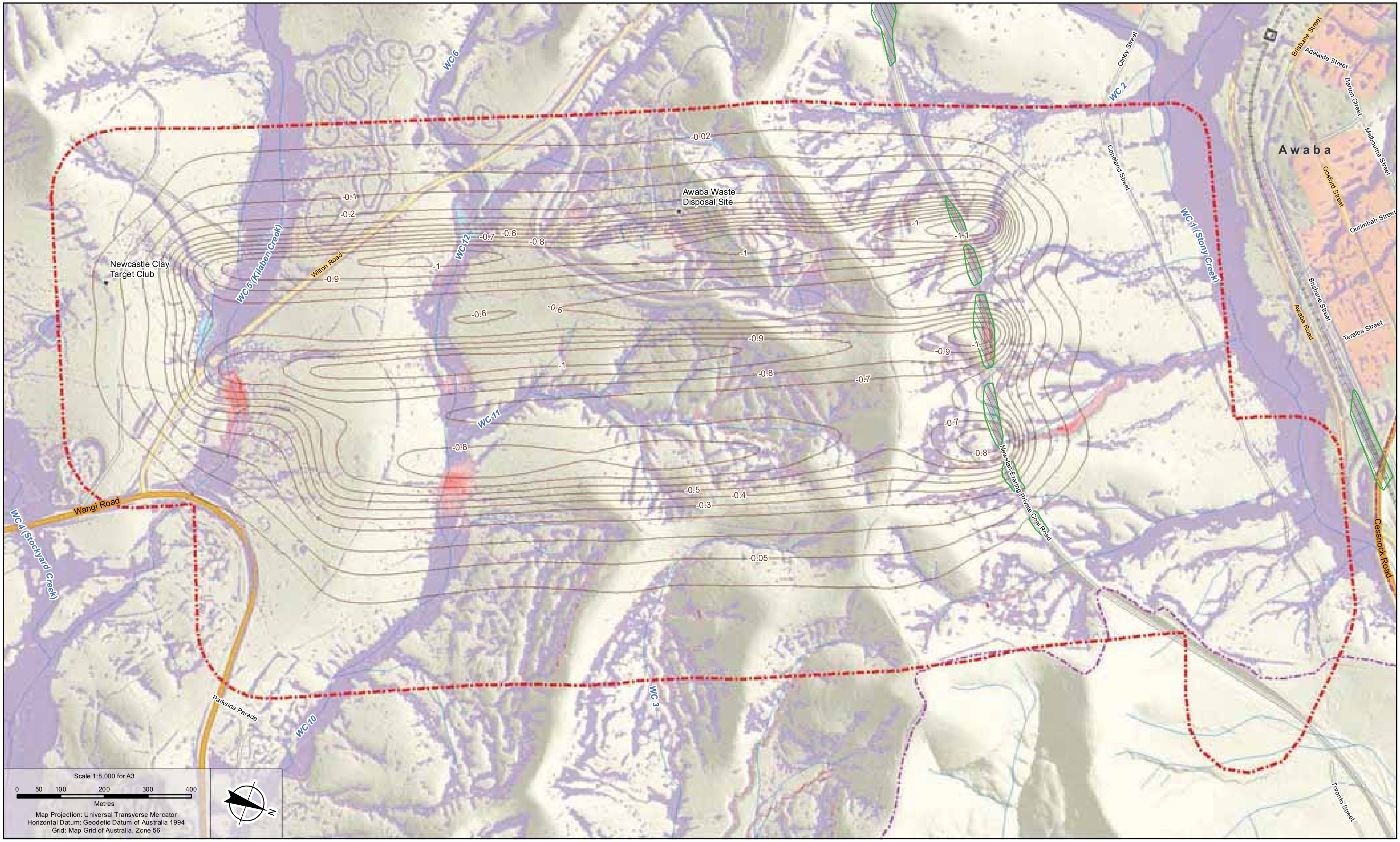
SMP Study Area 100 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.16

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m)

< -0.5 | -0.50 - -0.35 | -0.35 - -0.20 | -0.20 - -0.10 | -0.10 - 0.10 | 0.10 - 0.20 | 0.20 - 0.35 | 0.35 - 0.50 | >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

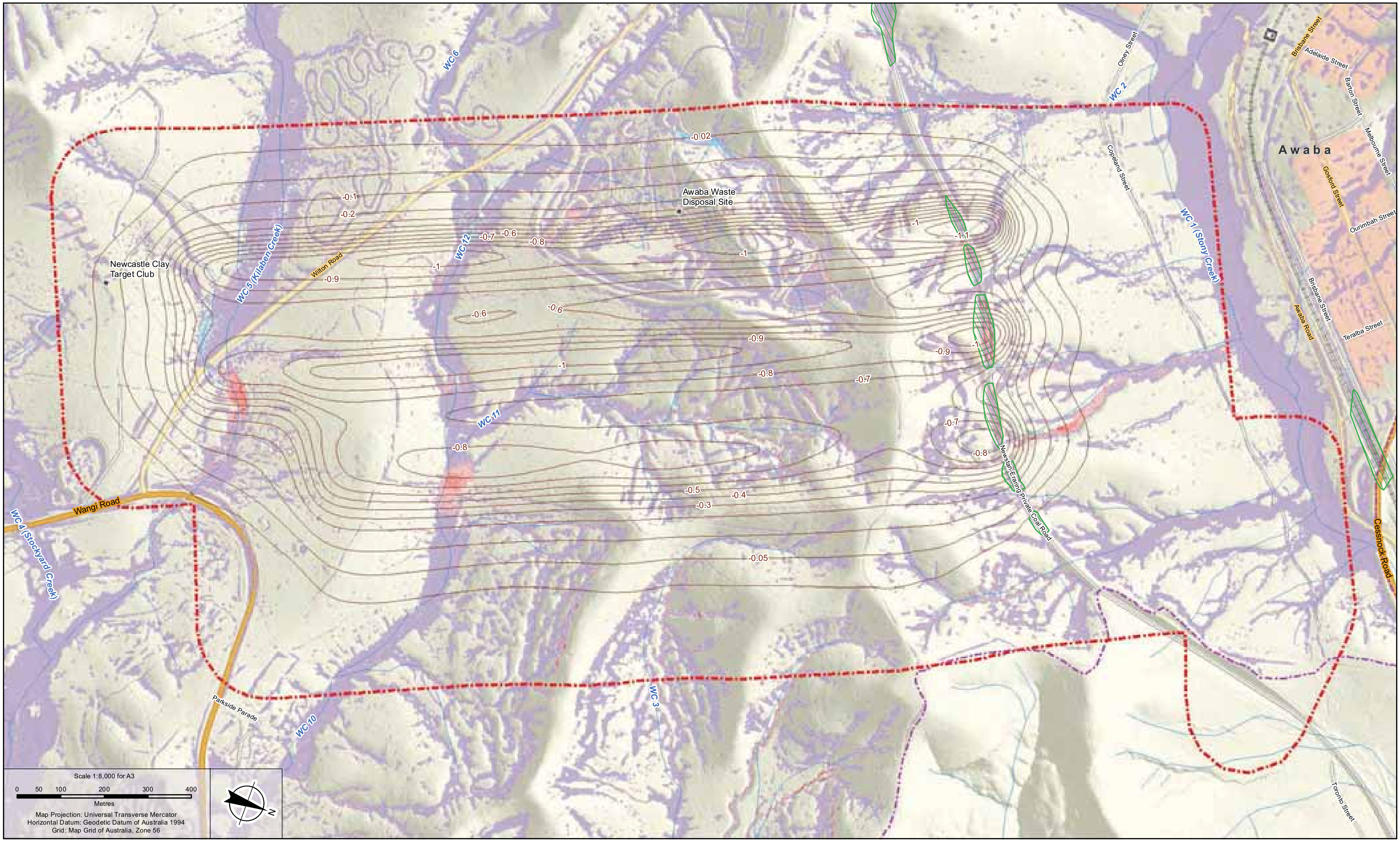
SMP Study Area 100 year ARI Depth Afflux Plot with alternate tailwater - 'Subsided' Scenario' - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.17

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m): < -0.5; -0.50 - -0.35; -0.35 - -0.20; -0.20 - -0.10; -0.10 - 0.10; 0.10 - 0.20; 0.20 - 0.35; 0.35 - 0.50; >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

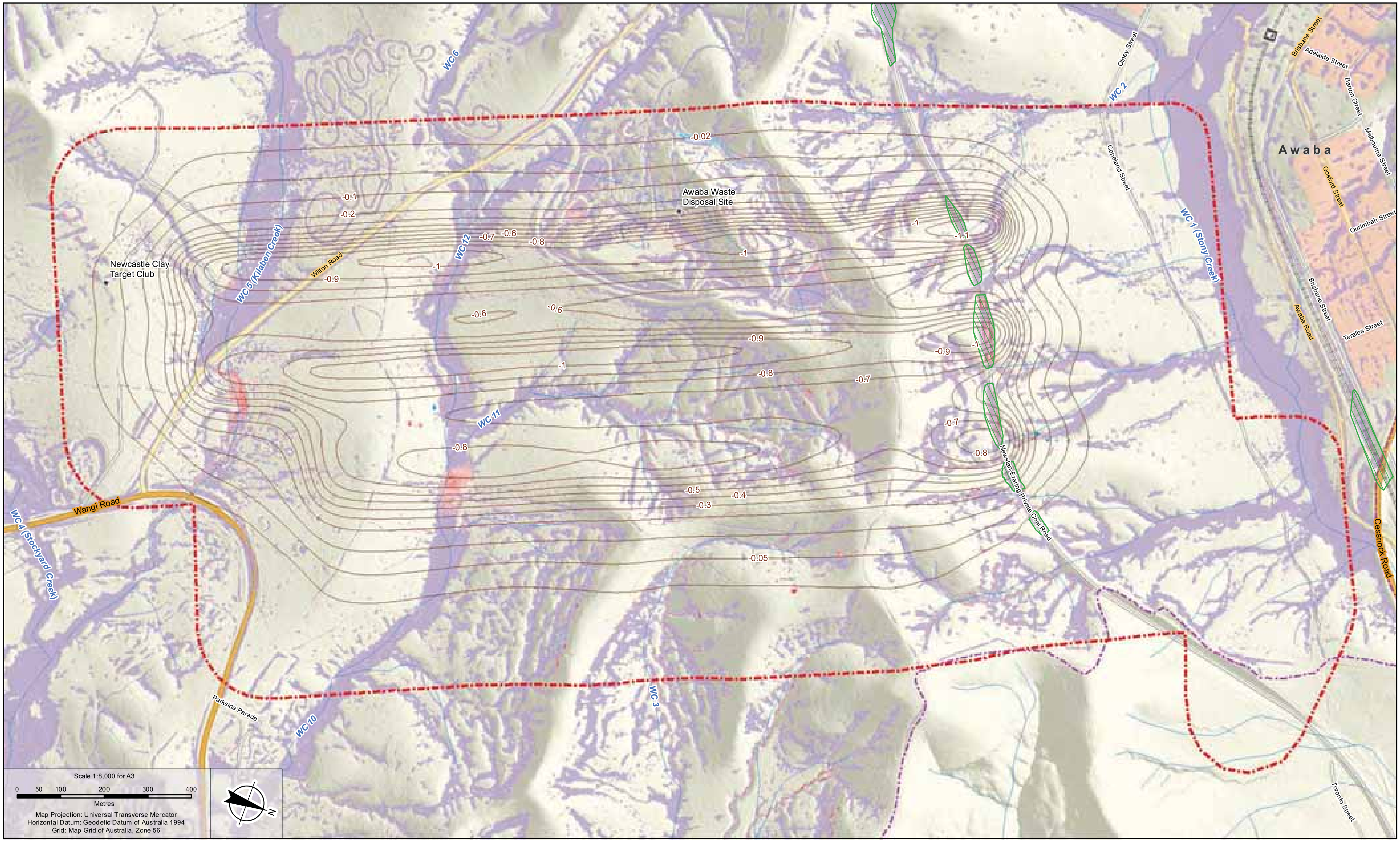
SMP Study Area 20 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.18

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m)

< -0.5 | -0.50 - -0.35 | -0.35 - -0.20 | -0.20 - -0.10 | -0.10 - 0.10 | 0.10 - 0.20 | 0.20 - 0.35 | 0.35 - 0.50 | >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

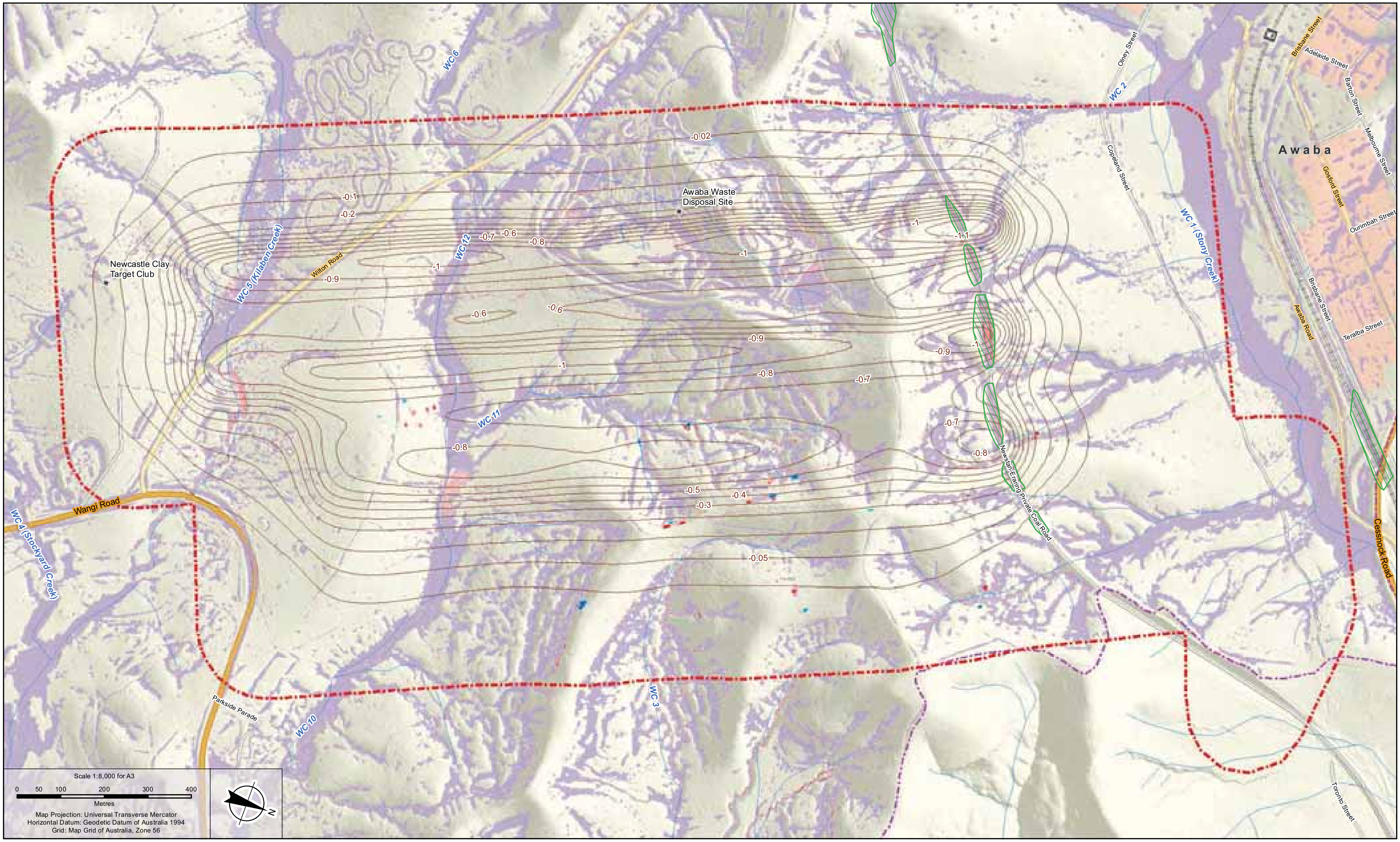
SMP Study Area 10 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

Figure 3.19

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in depth (m)

< -0.5, -0.50 - -0.35, -0.35 - -0.20, -0.20 - -0.10, -0.10 - 0.10, 0.10 - 0.20, 0.20 - 0.35, 0.35 - 0.50, >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 2 year ARI Depth Afflux Plot - 'Subsided' Scenario' - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.20

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

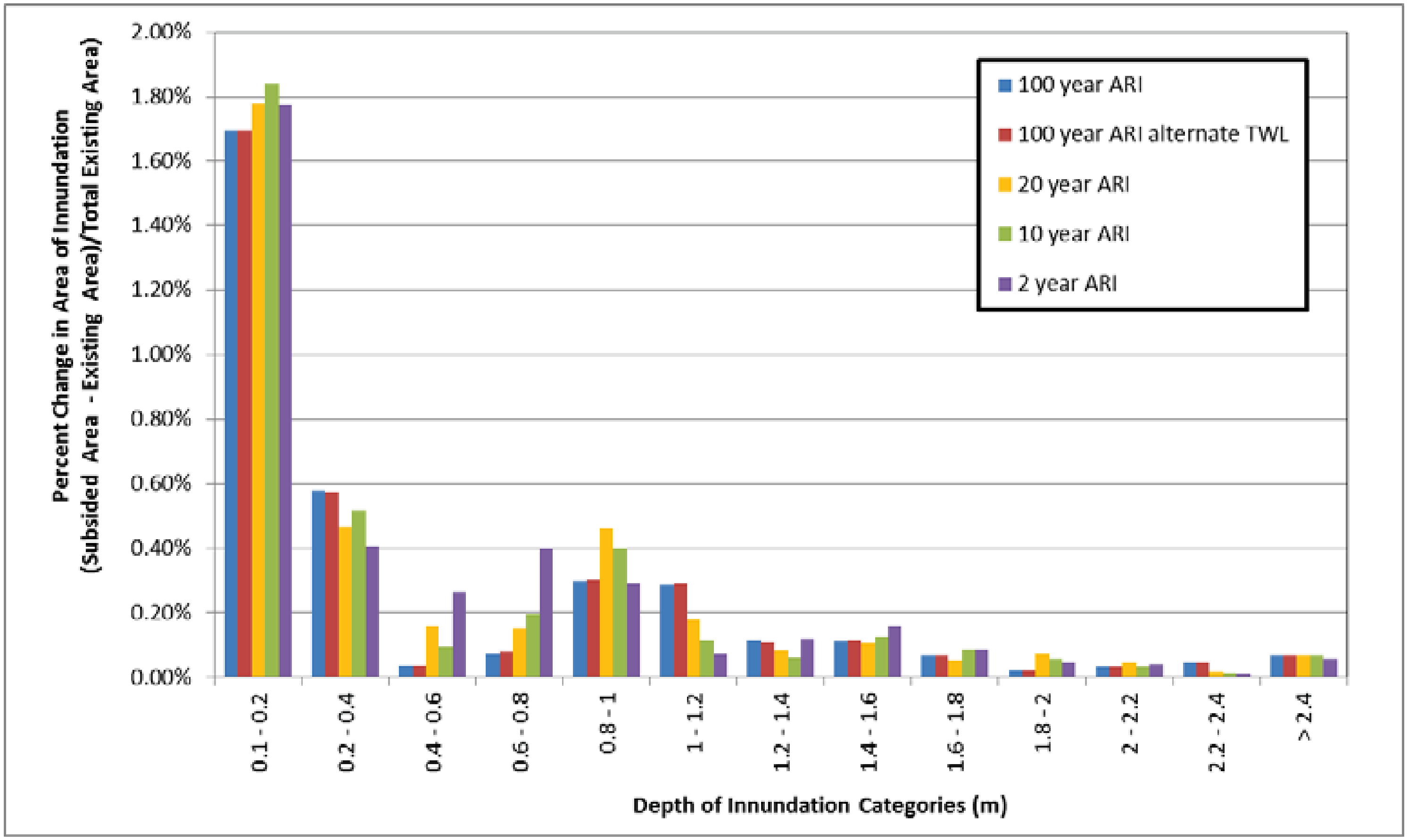
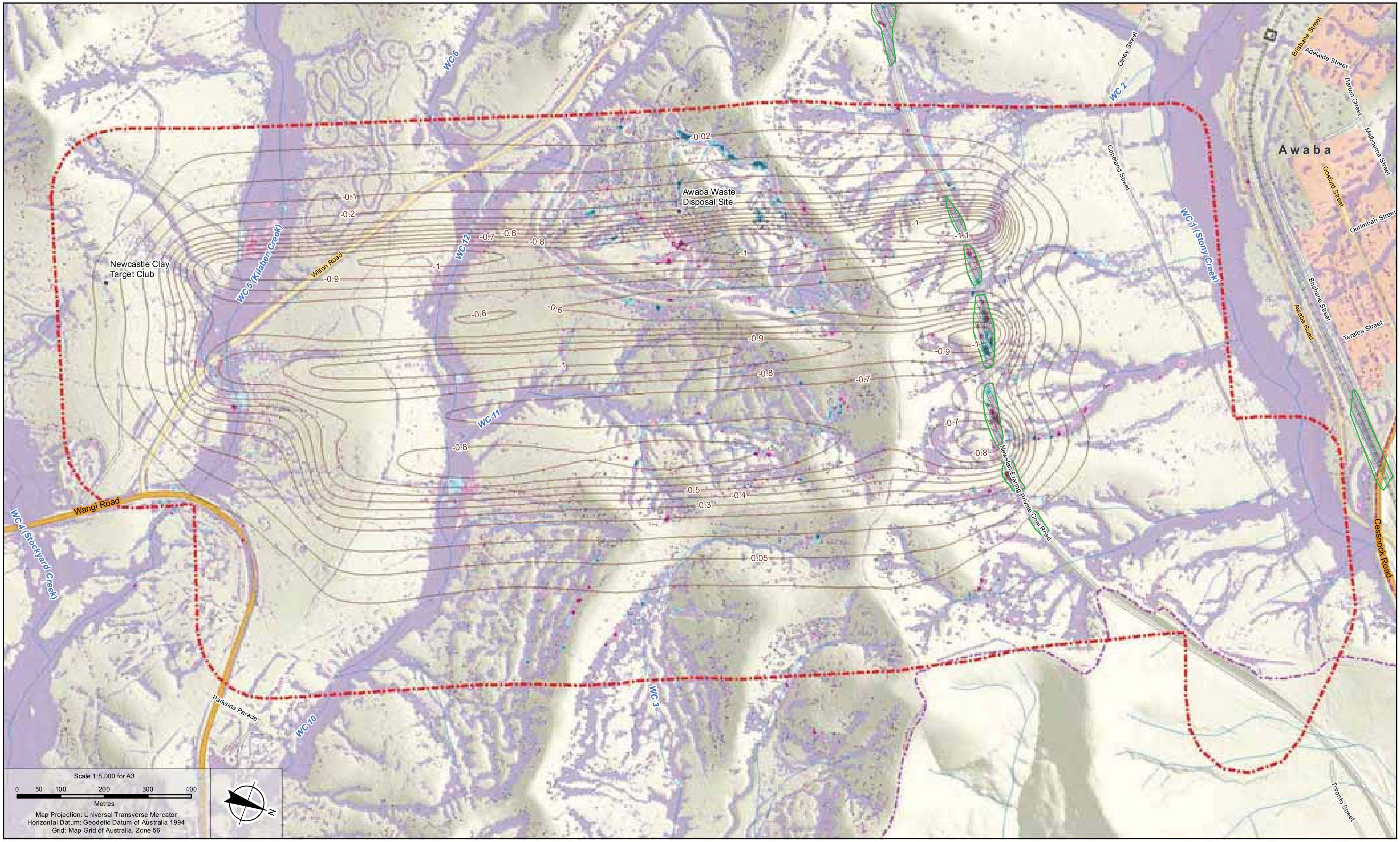


Figure 3.21 Change in Depth Distribution Between 'Existing' and 'Subsided' Conditions Scenarios

3.4.2 Velocity Results

The afflux in velocity is illustrated in Figure 3.22 through to Figure 3.26 for the modelled ARIs (see Appendix E for zoomed in velocity plots of the 'subsided' scenario). For these plots positive afflux (or an increased velocity) between the 'existing' and 'subsided' cases is shown as blue and negative afflux (or a reduced velocity) is shown as red. To better understand these changes, Figure 3.27 also summarises how the depth distribution for each ARI has changed between the 'Existing' conditions scenario and the 'Subsided' conditions scenario. These results indicate the following key changes in the hydraulic properties for this area:

- Apart from the increased area of inundation the velocity distribution between the pre- and post-predicted subsidence scenarios is relatively similar, with the biggest change in area of inundation in a velocity category being less than 1.2%.
- The predicted subsidence has generally caused increases in the area of inundation at the two extremes of the velocity distribution, with the biggest change in flows less than 0.5 m/s.
- The predicted subsidence has caused similar amount of negative velocity afflux (or comparatively slower water) and positive velocity afflux (or comparatively faster water).
- Positive afflux has generally occurred where the terrain has been steepened as a result of the predicted subsidence, which mainly occurs as the flow paths enter the area of predicted subsidence.
- Negative afflux has generally occurred where the predicted subsidence has caused ponding, which is likely the result of the terrain being altered to have flatter or adverse grade and as such mainly occurs as flow paths exit the area of predicted subsidence (or at the point where predicted subsidence decreases slightly between longwalls).
- Biggest changes have occurred on the two major flow paths that pass through the SMP application area (which include WC5, WC10, WC11, and WC12), and to a lesser extent two of the minor flow paths out of the centre of the area of predicted subsidence to the north.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00; -1.00 - -0.75; -0.75 - -0.5; -0.50 - -0.25; -0.25 - 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

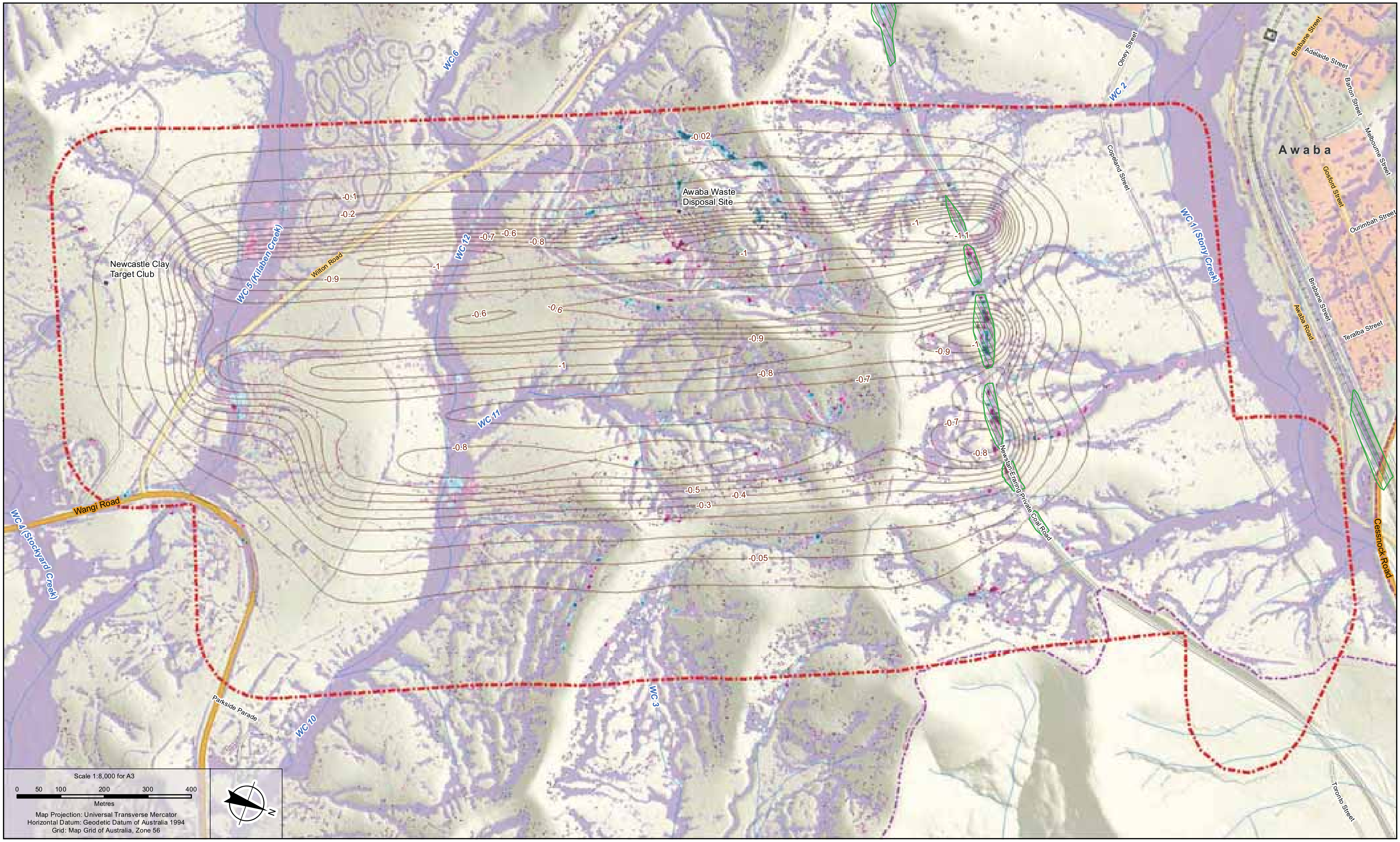
SMP Study Area 100 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.22

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00 | -1.00 - -0.75 | -0.75 - -0.5 | -0.50 - -0.25 | -0.25 - 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

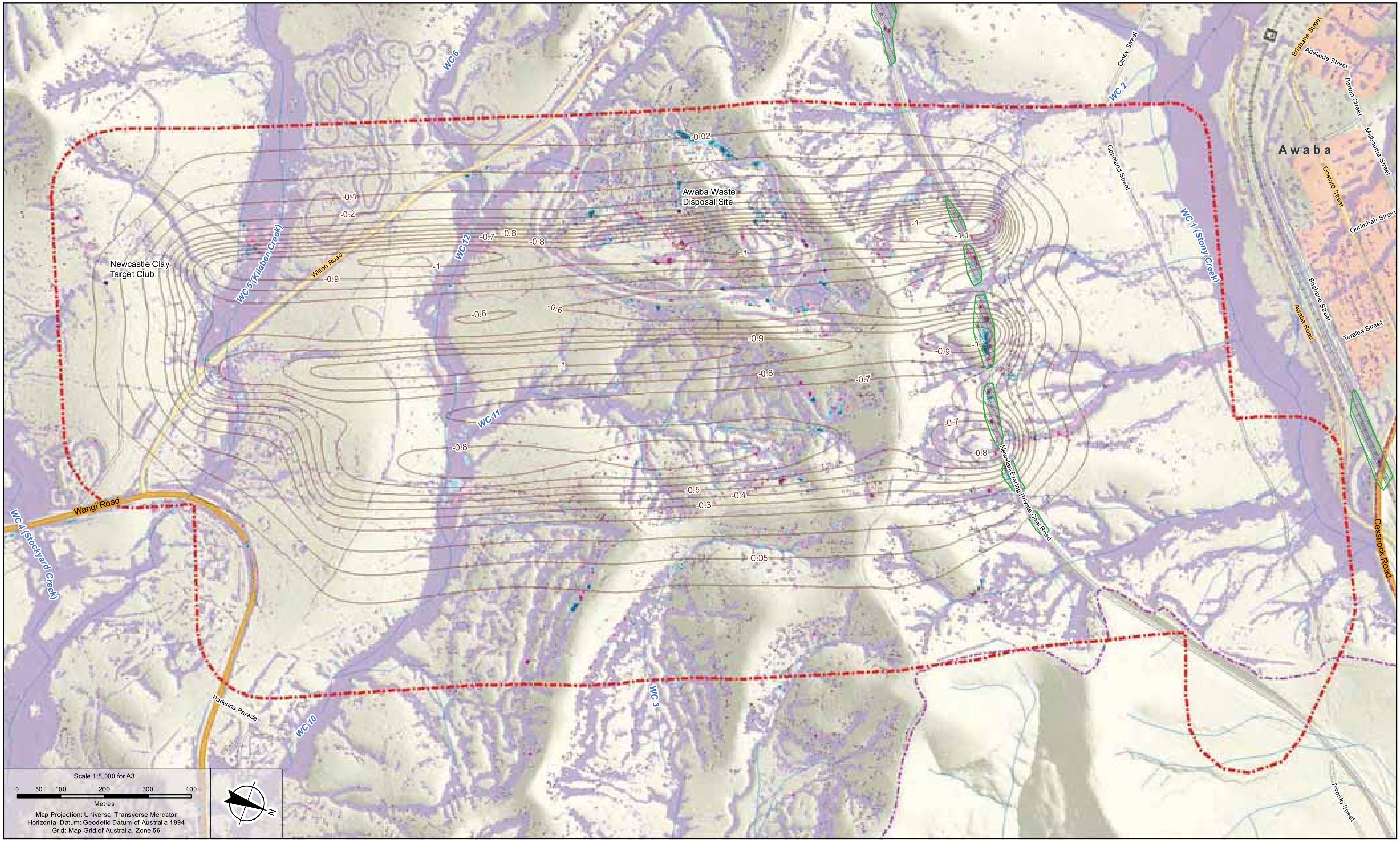
SMP Study Area 100 year ARI Velocity Afflux Plot with alternate tailwater - 'Subsided' Scenario' - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.23

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



GHD

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00; -1.00 - -0.75; -0.75 - -0.5; -0.50 - -0.25; -0.25 - 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

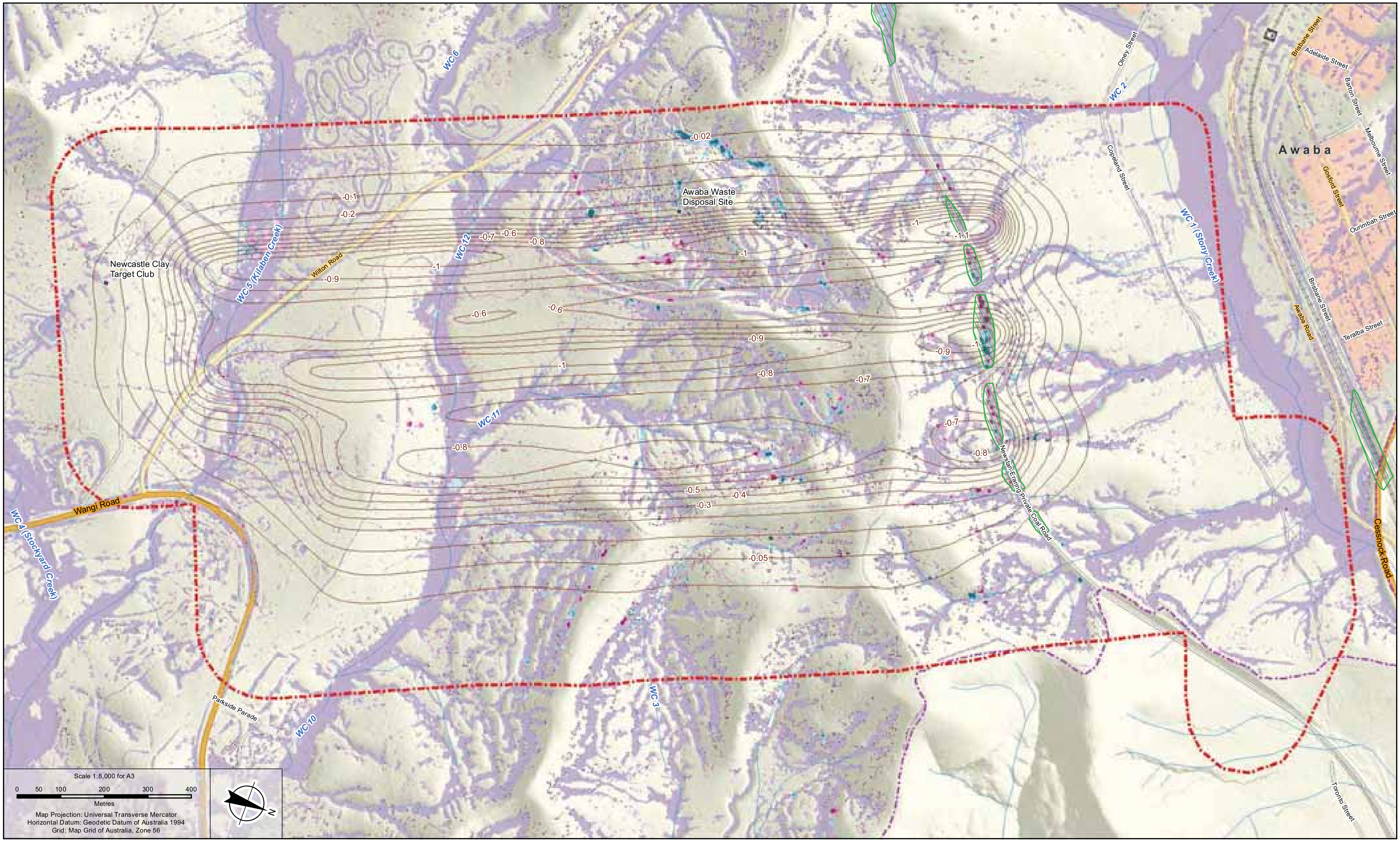
SMP Study Area 20 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.24

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00 | -1.00 - -0.75 | -0.75 - -0.5 | -0.50 - -0.25 | -0.25 - 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

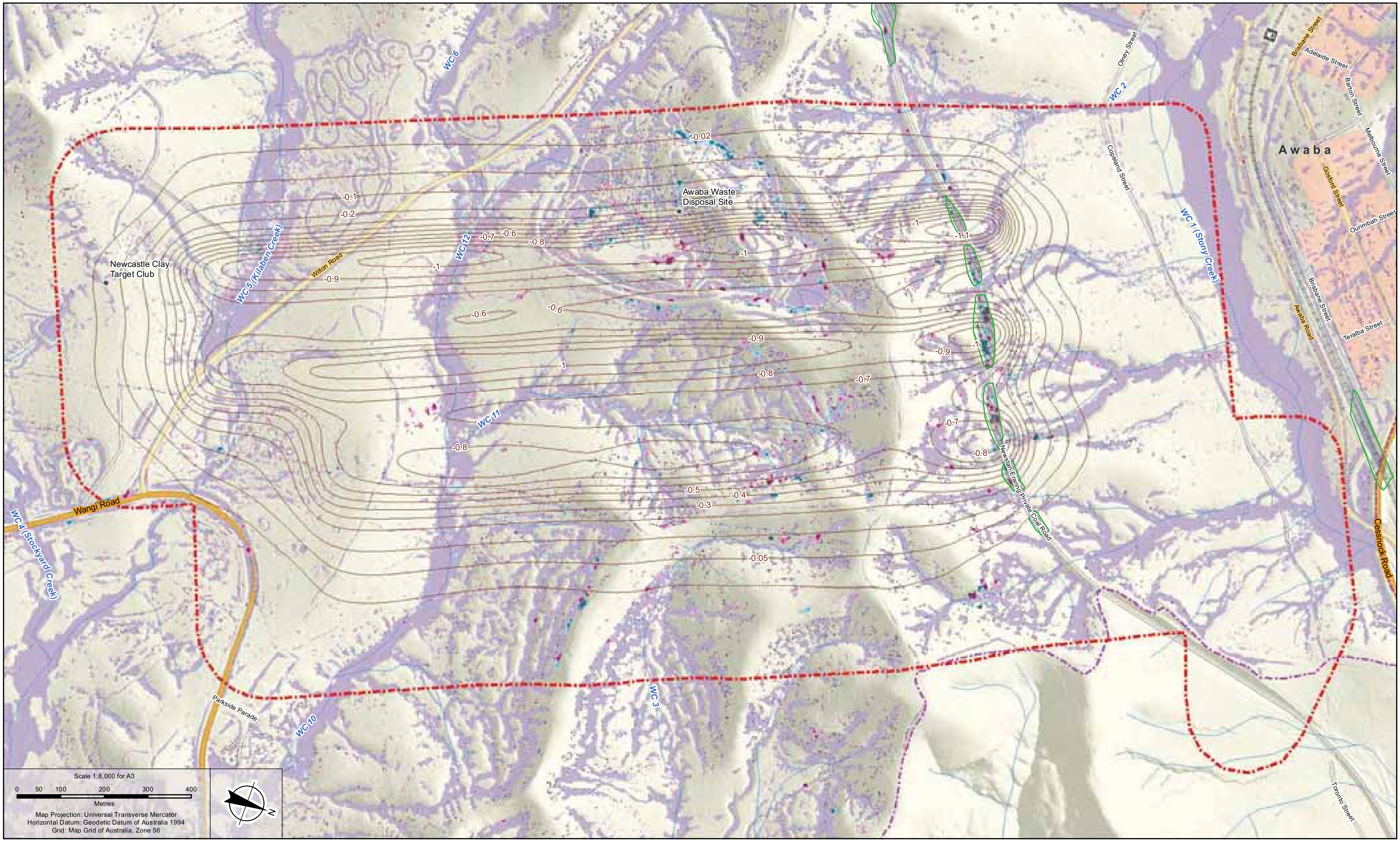
SMP Study Area 10 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.25

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area
- Subsidence contour

Change in velocity (m/s)

< -1.00; -1.00 - -0.75; -0.75 - -0.5; -0.50 - -0.25; -0.25 - 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 2 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario'

Centennial Newstan

Date: 30/04/2012

Figure 3.26

GIS Filename: G:\22\15922\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

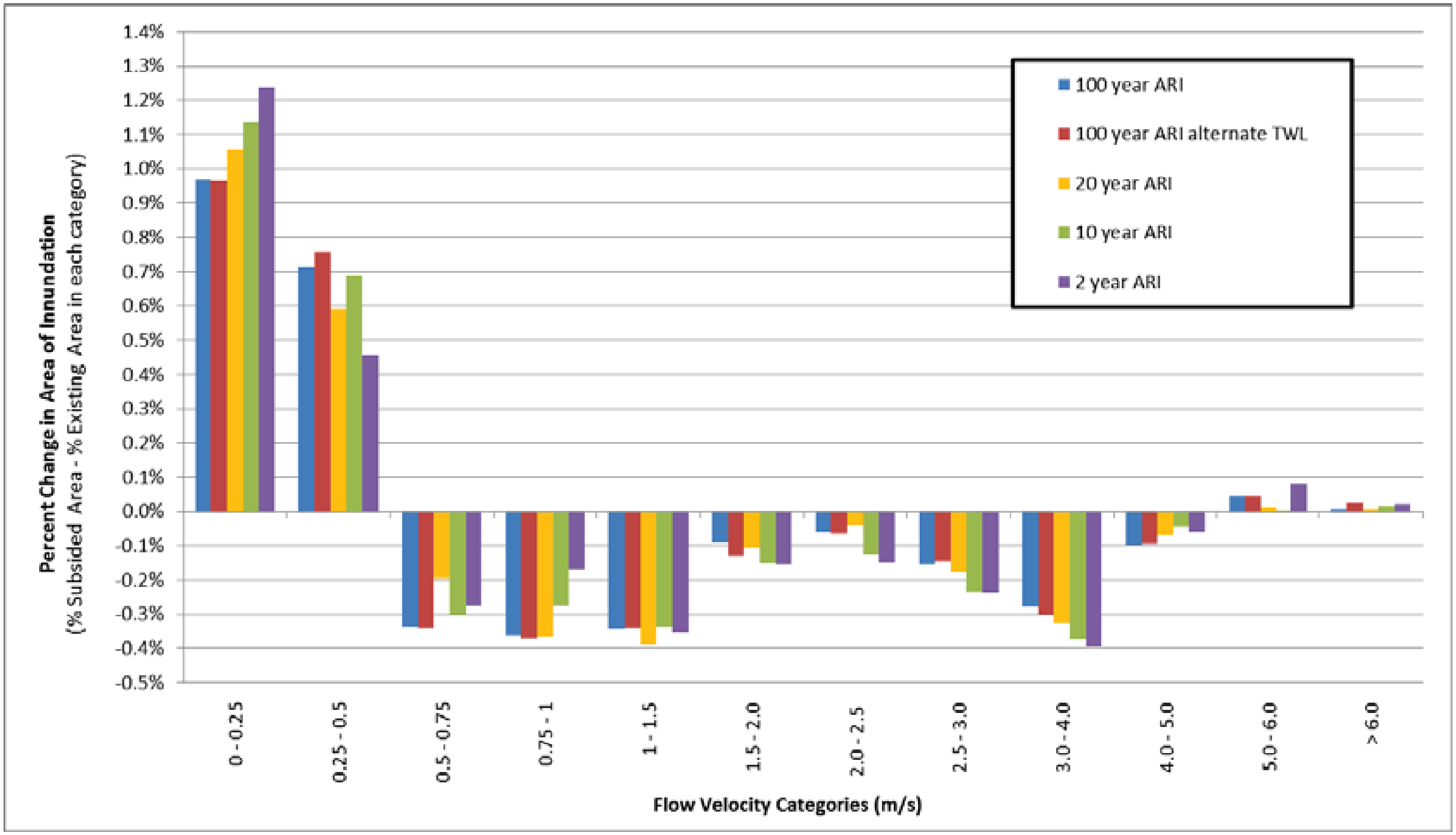


Figure 3.27 Change in velocity distribution between 'Existing' and 'Subsided' conditions scenarios

3.4.3 Existing Infrastructure

The existing flooding conditions experienced at or adjacent to existing surface infrastructure are detailed in Section 3.3.3.

For the post subsidence 100-year ARI event there is one location where a major drainage path flowing at a depth greater than 100 mm overtops Wilton or Wangi Roads. This location is at Culvert WI-C3 passing under Wilton Road and is the same location as where flow overtops under existing conditions. At the point of overflow there are no major and consistent increases or decreases in flood depths or velocities between existing and post-subsidence conditions. The location of WI-C3 is detailed in MSEC (2012).

Expected impacts of subsidence on existing culverts under public roads are discussed in *Surface Water Impact Assessment, Newstan Subsidence Management Plan LW 101-103,* GHD, (2012).

As discussed in Section 3.3.3 the major culverts passing under the Mine Haul Road are designed to convey the 100-year ARI event. Mine Subsidence is unlikely to result in major variations in flow volumes at the culverts. Therefore, if regular inspections and maintenance of the culverts are carried out throughout the subsidence period to ensure the culverts remain operational it is unlikely that any instances of major overland flow over the road will occur for the 100-year ARI event post-subsidence conditions.

In post-subsidence conditions the flow depth for waterways flowing across the Electrical Infrastructure Easements during the 100-year ARI event are up to 0.35 m greater than under existing conditions, and up to 0.2 m greater for the 2-year ARI Event. In general, velocities for the subsided case are less than for the existing case, up to 0.5 m/s for the 100-year ARI Event. It is unlikely that the change in hydraulic conditions will result in additional maintenance required for the easement as velocities on average have decreased and therefore erosion of the access track and scouring of the culverts is expected to reduce. However, due to the increase in flood depths the frequency of inundation is expected to increase. This can be attributed to a change in the grade of the waterway due to subsidence. This area is discussed in detail within the Surface Water Impact Assessment (GHD 2012)

3.4.4 Flow Hydrograph Results

Comparing flow hydrographs between the ‘Existing’ and ‘Subsided’ scenarios, indicates that the predicted subsidence will have little impact on the peak flow and/or timing of flow along the identified flow paths due to the steep terrain. Some localised minor changes include:

- Small increases in some peak flows.
- Small reductions in some peak flows.
- Minor changes to the timing of the peak flows (i.e. earlier or later peaks).

These minor changes, examples of which are shown in Figure 3.28 through to Figure 3.30, are possibly the result of one or more of the following physical mechanisms:

- Increased attenuation due to slower catchment response from a flattening of the catchment.
- Reduced attenuation due to faster catchment response times from a steepening of the catchment.
- Minor changes in catchment storage (the finite resolution of the model limits analysis of this effect although it is unlikely to be significant).
- Increases and or decreases in peak flows downstream of stream junctions as a result of different relative timings of the tributaries.

The observed changes in hydrographs are so small that in many instances it is possible that the changes are the result of modelling limitations rather than the potential physical mechanisms listed above.

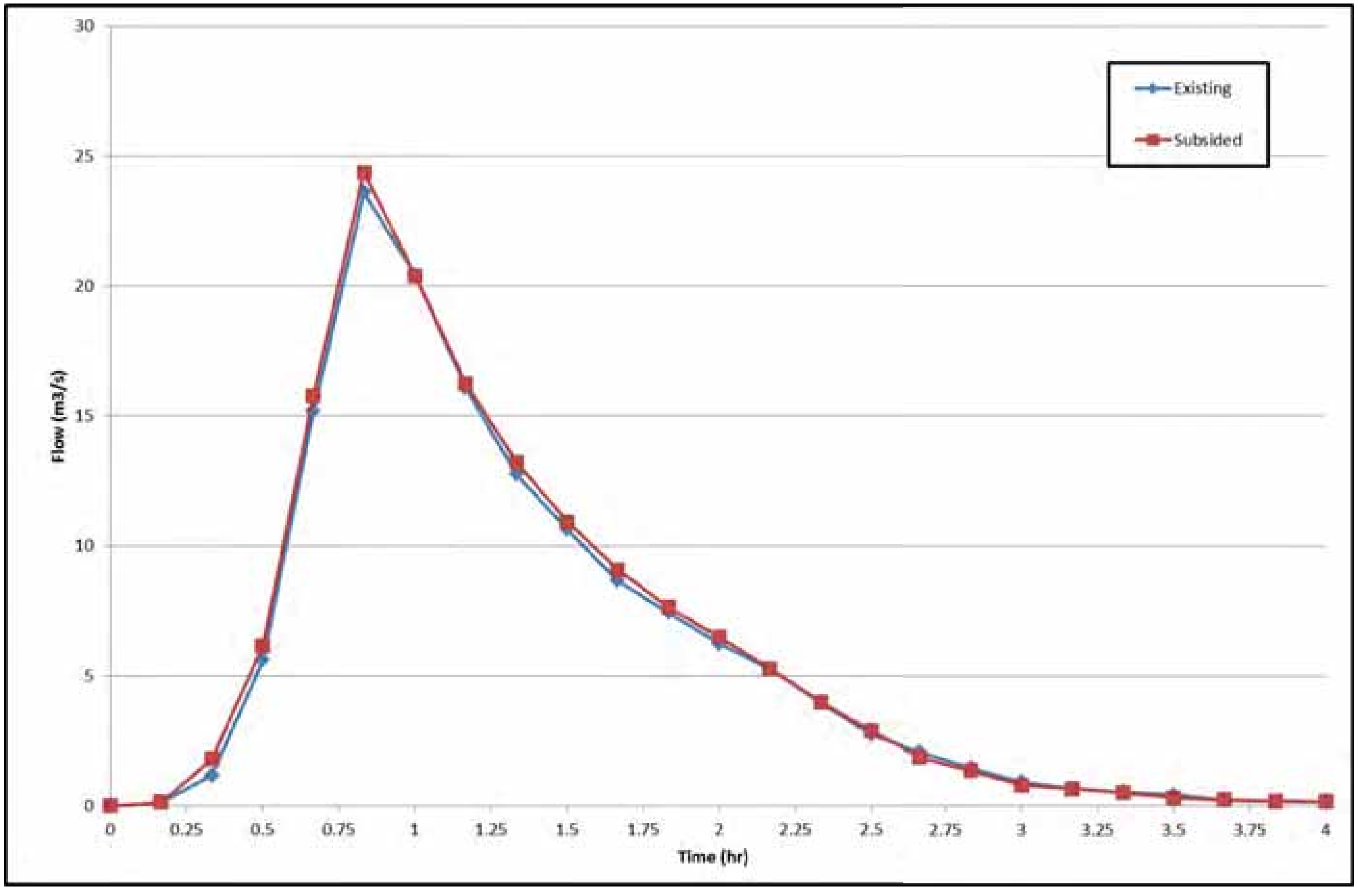


Figure 3.28 Example of Increased Peak Flow (Flow Results are from just Downstream of Junction WC6 and WC12)

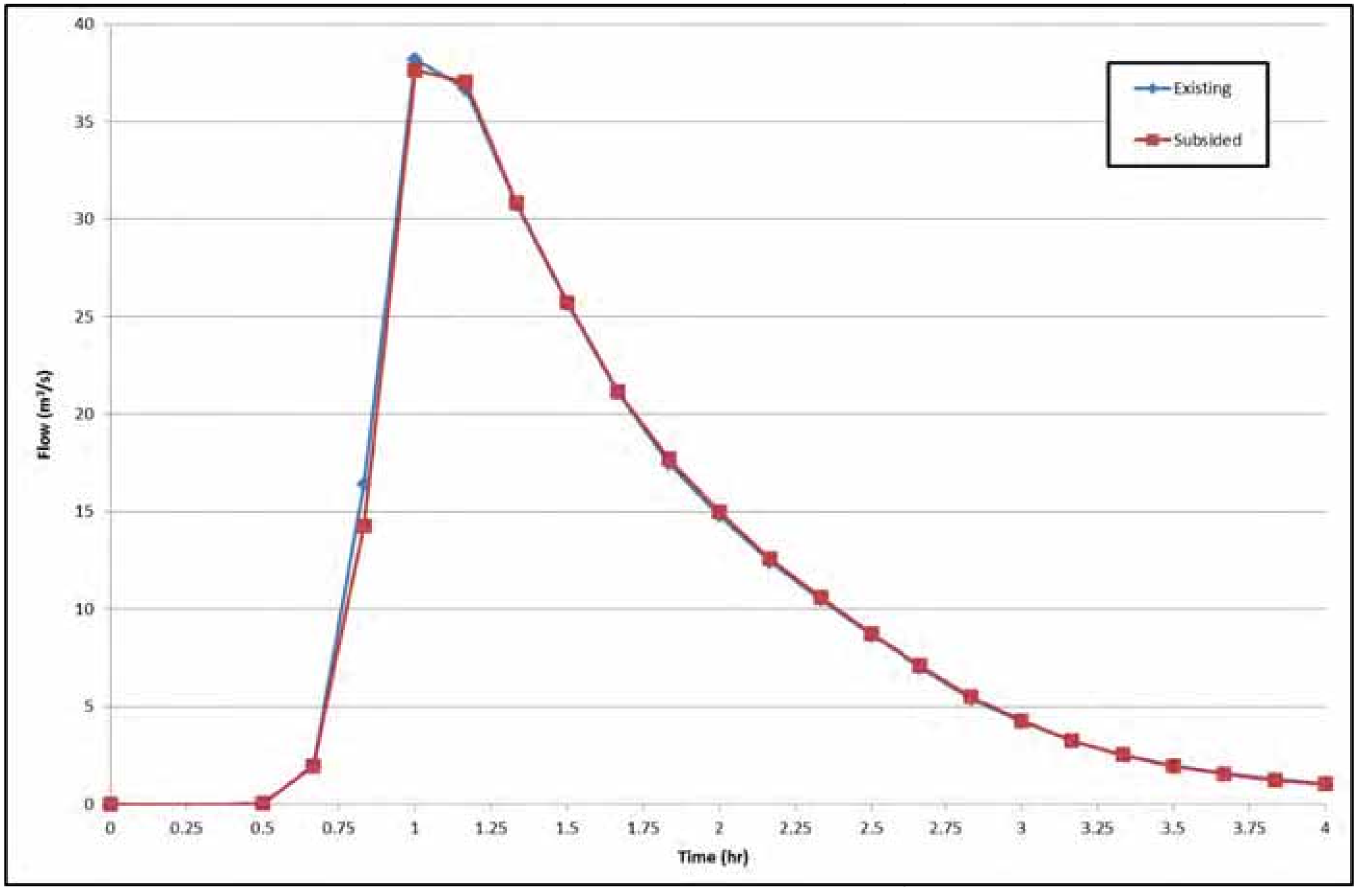


Figure 3.29 Example of Decreased Peak Flow (Flow Results are from WC10 at SMP Boundary Upstream of Wangi Road)

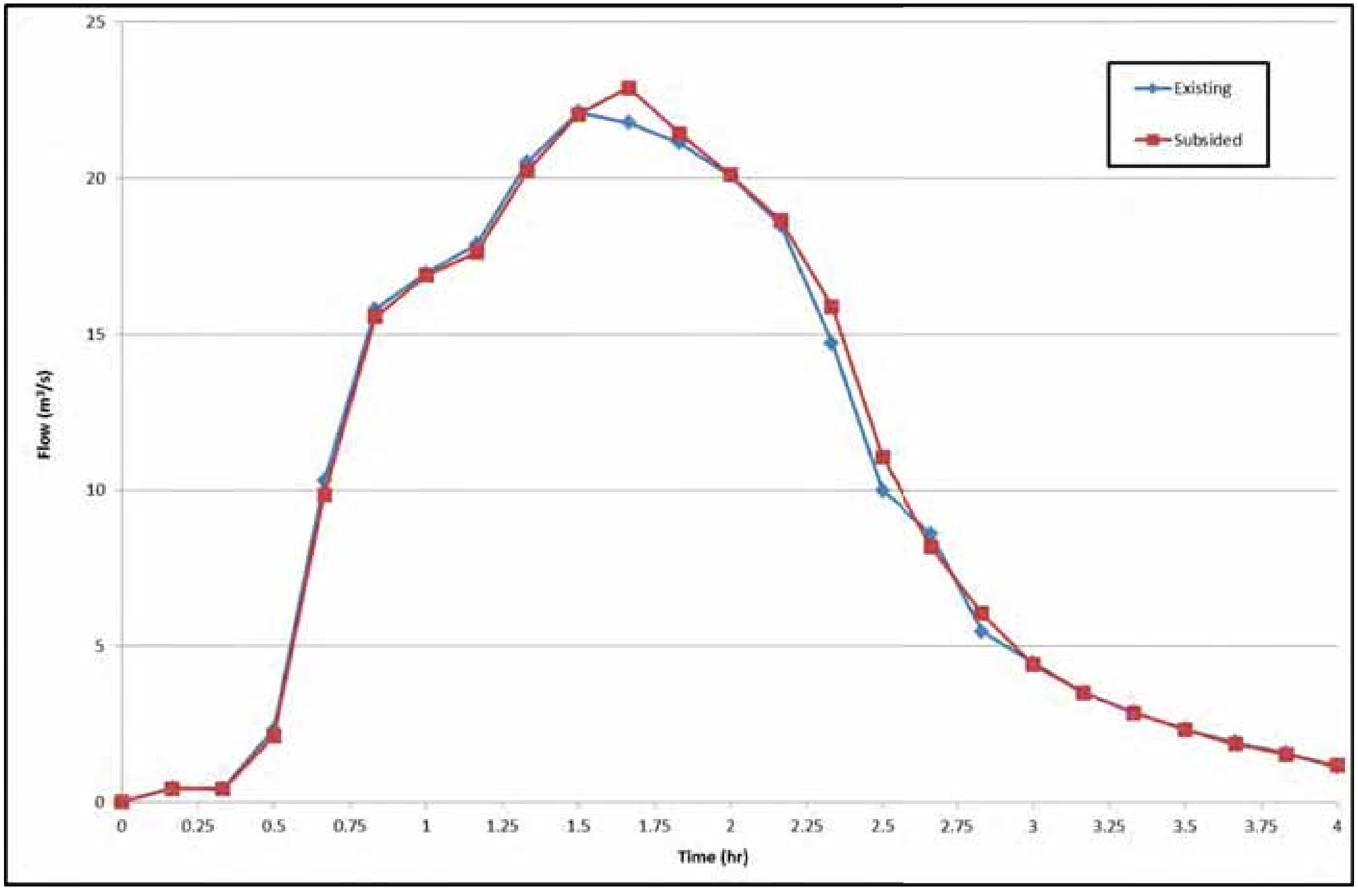


Figure 3.30 Example of Altered Hydrograph Timing (Flow Results are from Kilaben Creek or WC5 Just Downstream of Wangi Road)

3.4.5 Qualitative Assessment of Potential Increased Subsidence

In the case of increased subsidence conditions, it is likely that there will be an increase in the magnitude of the impacts identified in this report which include:

- An increase in ponding where the predicted subsidence causes a flattening or reversal of the slope, and a decrease in ponding where the predicted subsidence increases the slope.
- A speeding up of flow where the predicted subsidence increases the slope, and a slowing of flow where there is increased ponding or reduced slope.
- Subsequent changes in flow hydrograph peaks and timing.

The degree of change however will depend on the magnitude of change in the subsidence, and is likely to be relatively minor unless:

- There is a reversal of grade along a significant portion of one of the key identified flow paths. If this was to occur, the subsidence would likely form a storage that could alter the timing, magnitude and volume of flows leaving the area of subsidence.
- There is a significant steepening in grades, which may increase flow velocities and potentially reduce stream bed stability. Geomorphological assessment would be required to determine the effect of these physical changes on stream stability.

A sensitivity scenario of two times the predicted subsidence scenario modelled in this report is discussed in Section 5.2.4 of MSEC (2012), which indicates the potential significance of increased subsidence in terms of altered slopes and ponding in the SMP Study Area. This suggests that WC5, WC10, WC11 and WC12 are most likely to experience increased changes in grade, if not a grade reversal, and therefore would be expected to experience hydraulic changes as outlined above.

4. Conclusions

The hydraulic modelling indicates that the predicted subsidence will only have relatively minor impacts on the 'existing' hydraulic characteristics, which for the most part remain dominated by the steep terrain. This minimal change as a result of the predicted subsidence is evidenced in the following key changes in the flood behaviour:

- An increase in the area of inundation of only a 3.4 % to 3.7 % in the area of interest around the SMP application area for the modelled scenarios.
- The general isolation of major changes to the two major flow paths through the SMP application area (which includes WC5, WC10, WC11, and WC12) and moderate changes to some of the minor flow paths exiting the area of predicted subsidence to the north.
- The relatively minor changes in flow hydrograph peaks and timing.

Although the overall impact was minor, the study did identify the following two general changes in the flood behaviour in the study area:

- An increase in ponding where the predicted subsidence causes a flattening or reversal of the slope, and a decrease in ponding where the predicted subsidence increases the slope.
- A speeding up of flow where the predicted subsidence increases the slope, and a slowing of flow where there is increased ponding or reduced slope. This resulted in an increase in the proportion of flows at the two extremes of the velocity distribution, and a decrease for the others.

5. References

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Appendix A

Summary of Terrain Modifications

‘Existing Conditions’ Digital Terrain Model (DTM) Formation Overview

In order to model the pre- and post- mining scenario and identify changes in the hydraulics of the area, it was necessary to create a DTM of the entire hydrologic catchment(s) that contain the SMP application area. As a result the DTM covers an area of around 21.6 km^2 and utilises the following data sources to obtain complete coverage:

- Thinned LiDAR ground points provided by Centennial Coal.
- A combination of 0.5 m and 1 m contour information provided by Centennial Coal.

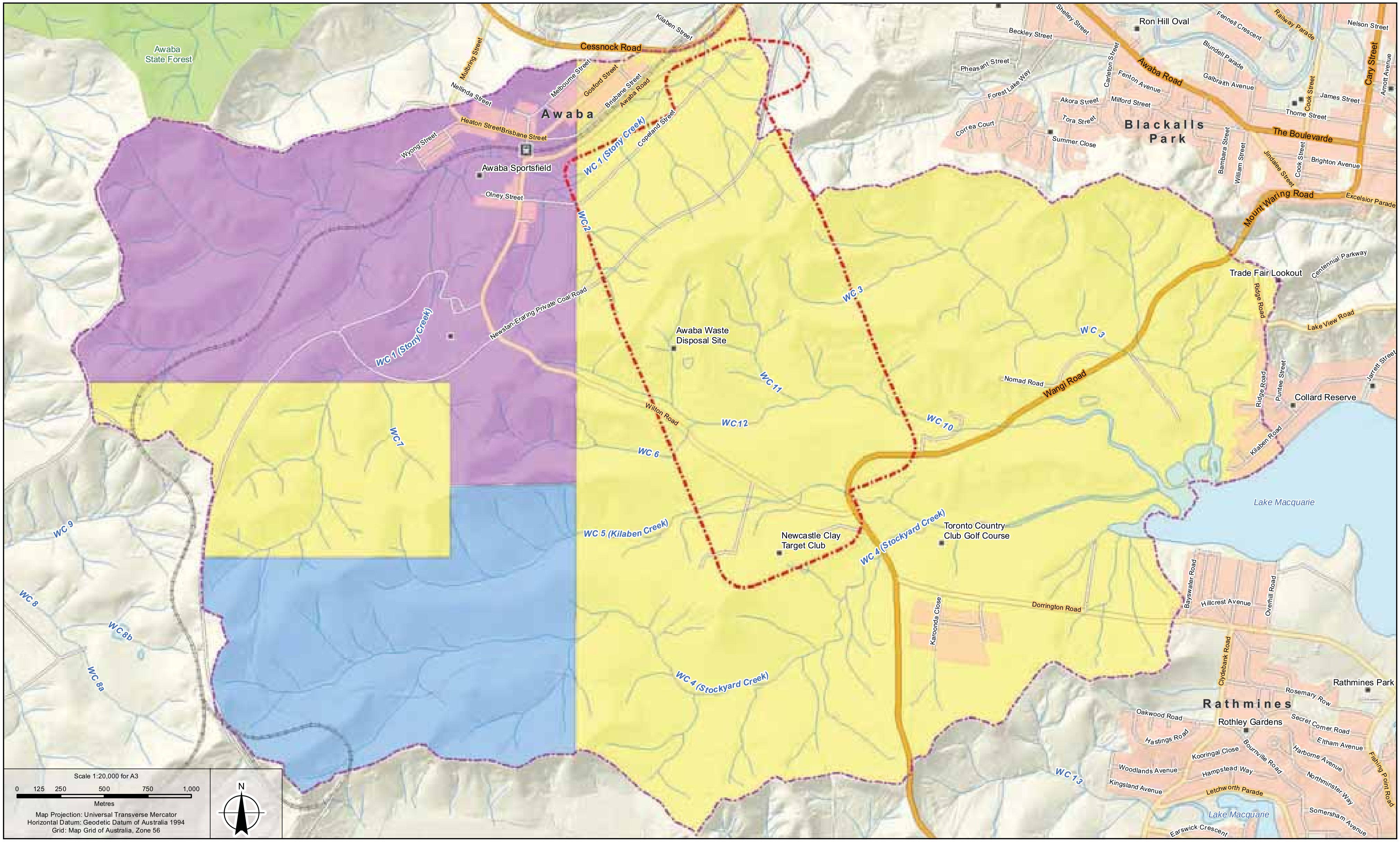
The extent of the DTM and the area covered by the various data sources is shown in Figure A1.

Due to the inherent differences in the level of detail and accuracy between the data sources, there were some features in the base terrain data that needed modification to better reflect the physical terrain in the study area. The features that were modified in the production of the DTM used to create the hydraulic model terrain were:

- Data mismatches at the boundaries between the various data sources.
- Flat or adversely graded areas along valleys due to the coarse base data.

Details of the modifications to the above features are detailed in the proceeding Section. In general, the ridges were not modified as these were deemed less important in determining the potential change in hydraulics of the area post-mining.

For the purpose of creating terrain for the hydraulic model, the terrain data was manipulated and used to create a 1 m DTM using a combination of 12D, Arc-GIS and SAGA-GIS. A plot of the final ‘Existing’ Conditions scenario DTM can be seen in Figure A2.



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- 0.5 m Contours (Centennial Coal - Area D)
- Area B - Centennial Coal Contours
- LiDAR

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

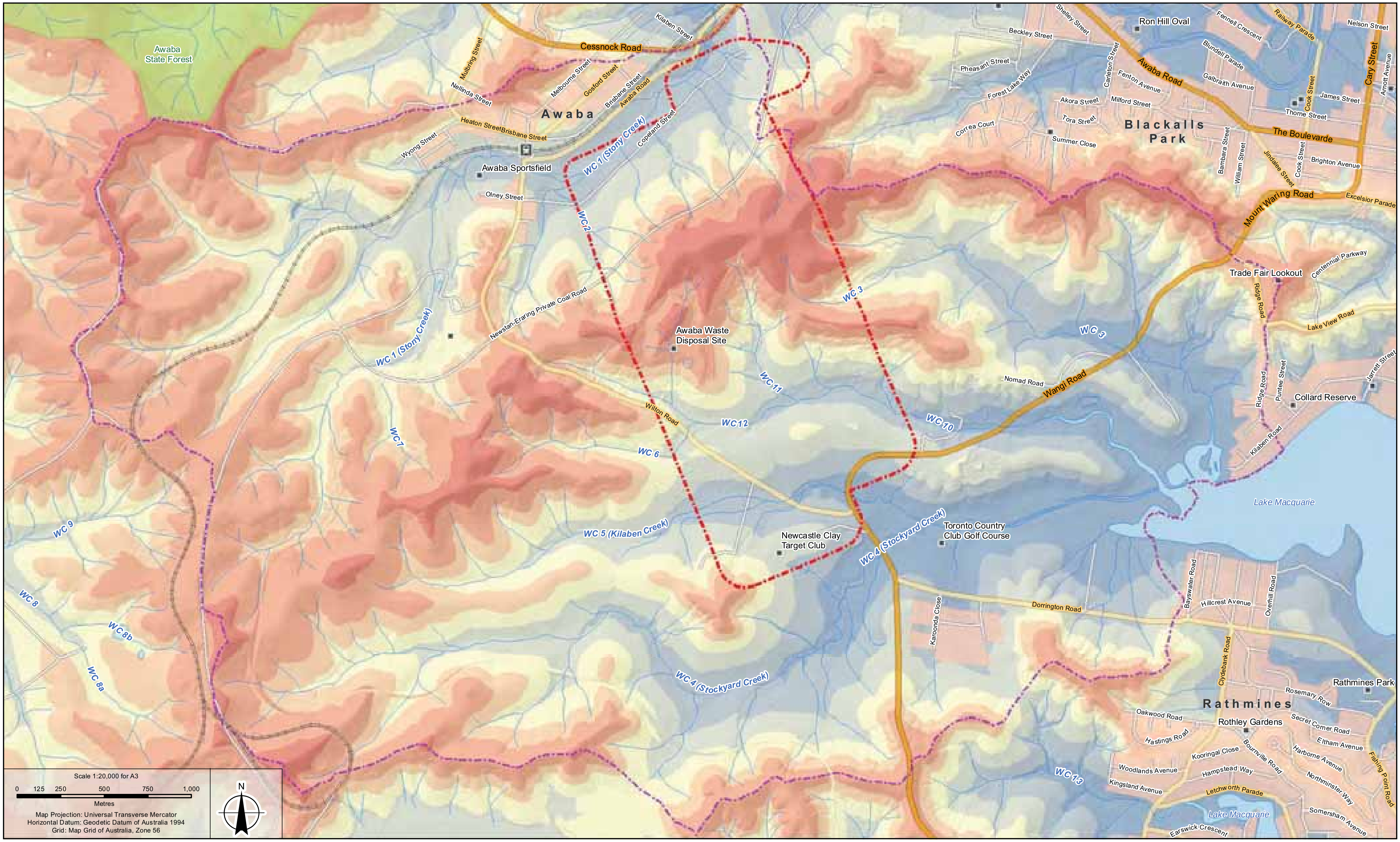
Data Source Contribution to Digital Terrain Model (DTM)

Centennial Newstan

Date: 30/04/2012

App. A1

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Elevation (mAHD)

< - 10, 10 - 20, 20 - 30, 30 - 40, 40 - 50, 50 - 75, > 75

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

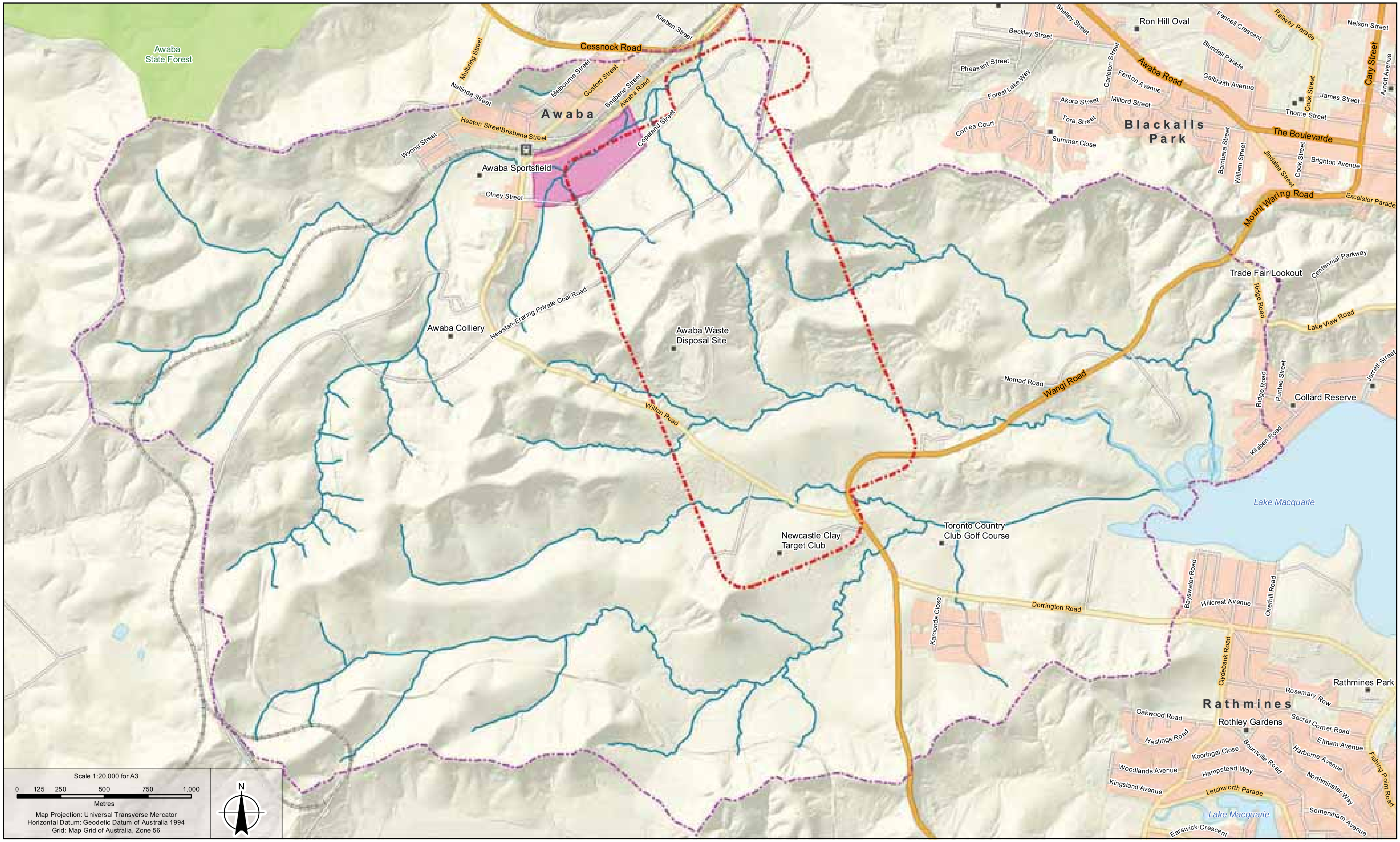
Final 'Existing' Scenario Digital Terrain Model (DTM) Plot

Centennial Newstan

Date: 30/04/2012

App. A2

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Waterbody
- Builtup area
- State forest
- Area of terrain modification
- Gully line for hydraulic model

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Digital terrain Model Terrain modification locations

Centennial Newstan

Date: 30/04/2012

App. A3

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd

Details of Terrain Modifications

- Flat or adversely graded areas along valleys due to the coarse base data, vegetation, ponding and or road embankments

  Using streamlines defined for the hydraulic model, in-built terrain processing mechanisms in Arc-GIS were used to ensure terrain data graded in the downstream direction. To minimise significant changes as a result of this process, an iterative process was used where the modified terrain was checked and if necessary used to revise the streamlines.

- Data mismatches at the boundaries between the various data sources

  The data mismatches at the boundary were generally minor and easily addressed, but there was one location were more significant terrain modifications were required due to a large difference in the valley invert at the interface of the LiDAR and contour information – this location is shown in Figure A4. The minor mismatches were overcome by creating an 8 m buffer between the data sources and allowing an inbuilt terrain modification process called “close gaps” in SAGA-GIS to interpolate across the gap between the data sources. The more significant modification on the other hand was addressed by removing a higher section of LiDAR data in the valley and manually extending contours through this area to match in with contours created from the LiDAR downstream of the high section (these changes are highlighted in Figure A5). The data was manipulated in this way due to the correlation between the data sources outside the valley and the fact that the area is covered in dense vegetation, which may cause errors in the LiDAR.

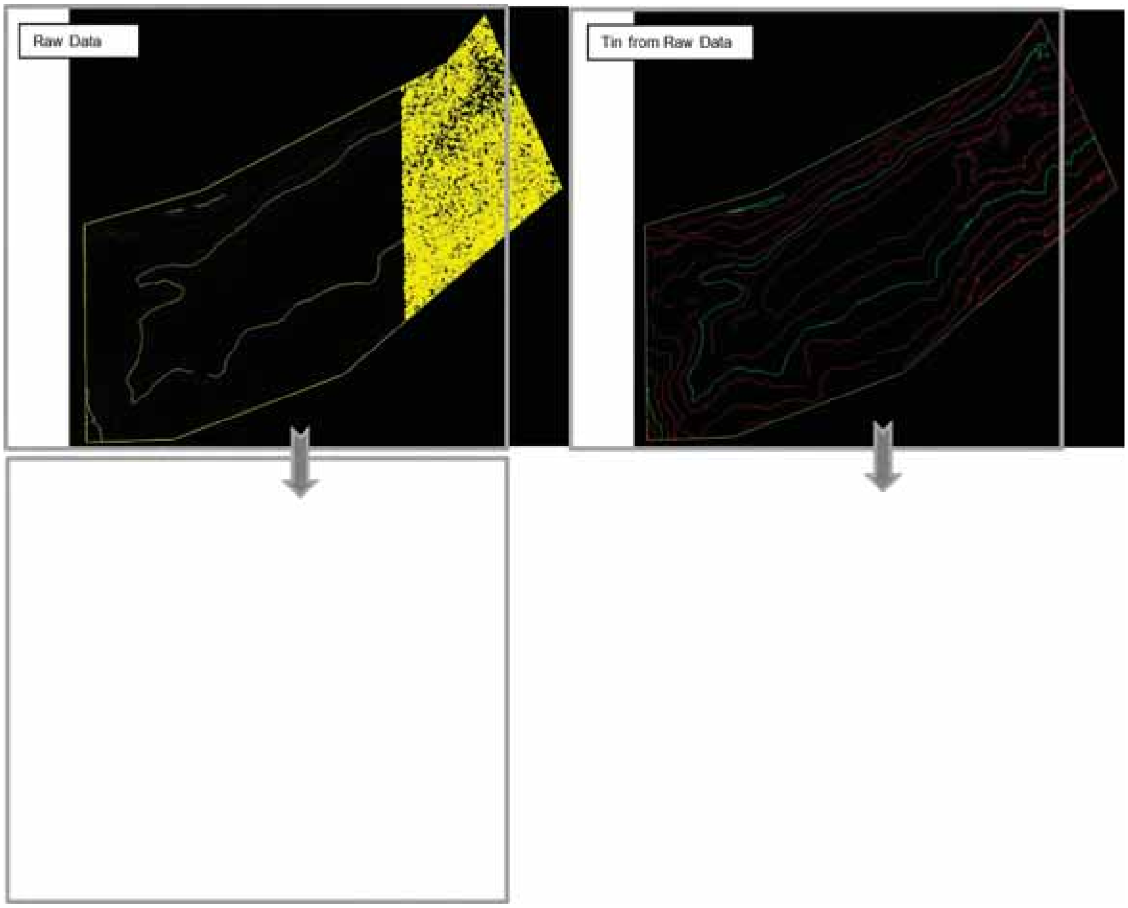


Figure A4 Digital Terrain Model (DTM) Terrain Modification Location

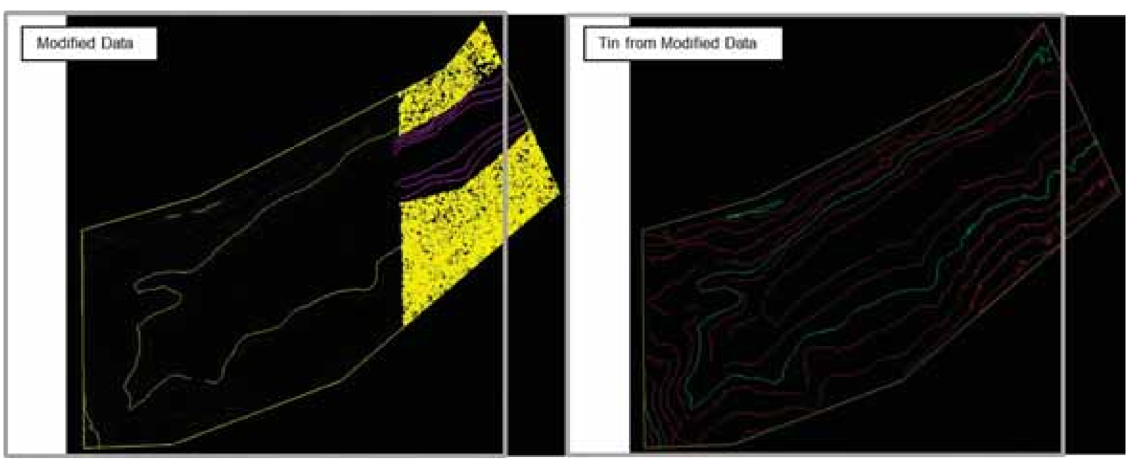


Figure A5 Terrain Modifications and Resultant Tin at Problem Area

Appendix B

Hydrologic Modelling – Catchment Parameter Plots and Site Inspection Photos

Table B1 Adopted Subarea Catchment Properties (Hydrology)

Subarea ID	Impervious Fraction	Area (ha)	Impervious Area (ha)	Pervious Area (ha)	Catchment Slope	Mannings 'n' Pervious Areas	Mannings 'n' Impervious Areas
AUr	0.05	64.27	3.21	61.06	13.47	0.1	0.02
AVr	0	67.87	0.00	67.87	16.90	0.1	-
AWr	0	53.37	0.00	53.37	13.02	0.1	-
ATr	0.05	55.75	2.79	52.97	13.01	0.1	0.02
AXr	0.1	8.48	0.85	7.63	12.33	0.1	0.02
ASr	0.15	31.41	4.71	26.70	11.83	0.1	0.02
ARr	0.1	72.13	7.21	64.92	15.01	0.1	0.02
Ur	0	27.43	0.00	27.43	23.30	0.1	-
Cr	0	34.86	0.00	34.86	14.54	0.1	-
Er	0	44.35	0.00	44.35	12.69	0.1	-
Gr	0	36.76	0.00	36.76	12.32	0.1	-
Ir	0	15.93	0.00	15.93	16.29	0.1	-
Hr	0	10.84	0.00	10.84	11.16	0.1	-
Nr	0	18.91	0.00	18.91	15.06	0.1	-
Or	0	73.81	0.00	73.81	14.13	0.1	-
Dr	0	33.40	0.00	33.40	10.04	0.1	-
Vr	0.05	26.06	1.30	24.75	16.51	0.1	0.02
Xr	0	17.26	0.00	17.26	8.81	0.1	-
Yr	0	36.94	0.00	36.94	21.67	0.1	-
Zr	0	49.65	0.00	49.65	15.33	0	-
Pr	0.05	104.58	5.23	99.35	9.30	0.1	0.02
ADr	0	34.98	0.00	34.98	20.94	0.1	-
AFr	0	9.46	0.00	9.46	23.75	0.1	-
AGr	0.05	76.67	3.83	72.83	17.10	0.075	0.02
AKr	0.05	27.39	1.37	26.02	17.11	0.1	0.02
AJr	0.05	11.37	0.57	10.80	11.39	0.1	0.02

Subarea ID	Impervious Fraction	Area (ha)	Impervious Area (ha)	Pervious Area (ha)	Catchment Slope	Mannings 'n' Pervious Areas	Mannings 'n' Impervious Areas
AZr	0.05	74.96	3.75	71.21	16.09	0.1	0.02
AYr	0.2	65.95	13.19	52.76	11.30	0.75	0.02
BBr	0.05	26.62	1.33	25.29	19.16	0.1	0.02
BAr	0.2	55.23	11.05	44.18	11.45	0.1	0.02
ALr	0.1	8.23	0.82	7.40	9.99	0.075	0.02
AHr	0.05	38.41	1.92	36.49	10.56	0.075	0.02
AIr	0.05	46.16	2.31	43.86	21.73	0	0.02
AOr	0	19.02	0.00	19.02	20.64	0.1	-
ANr	0	20.69	0.00	20.69	25.01	0.1	-
BGr	0.1	20.11	2.01	18.10	19.10	0.1	0.02
Kr	0	8.01	0.00	8.01	17.93	0.1	-
ACr	0	6.63	0.00	6.63	8.70	0.1	-
BE	0.025	29.53	0.74	28.80	5.32	0.1	0.02
BHr	0.2	31.17	6.23	24.93	10.80	0.075	0.02
BI	0.05	12.08	0.60	11.48	5.89	0.1	0.02
BF	0.025	28.81	0.72	28.09	3.84	0.1	0.02
AEr	0	11.87	0.00	11.87	25.13	0.1	-
Br	0	20.86	0.00	20.86	10.67	0.1	-
Wr	0.05	58.16	2.91	55.25	20.37	0.1	0.02
Lr	0.05	59.63	2.98	56.64	8.37	0.1	0.02
Jr	0	45.80	0.00	45.80	13.18	0.1	-
Mr	0.05	12.63	0.63	12.00	4.85	0.05	0.02
AQr	0	112.81	0.00	112.81	13.06	0.1	-
AAr	0.1	26.89	2.69	24.20	14.49	0.075	0.02
Ar	0	59.69	0.00	59.69	14.10	0.1	-
ABr	0.05	28.89	1.44	27.44	11.89	0.1	0.02
Fr	0	56.58	0.00	56.58	11.31	0.1	-
ACar	0.05	12.18	0.61	11.57	8.05	0.075	0.02

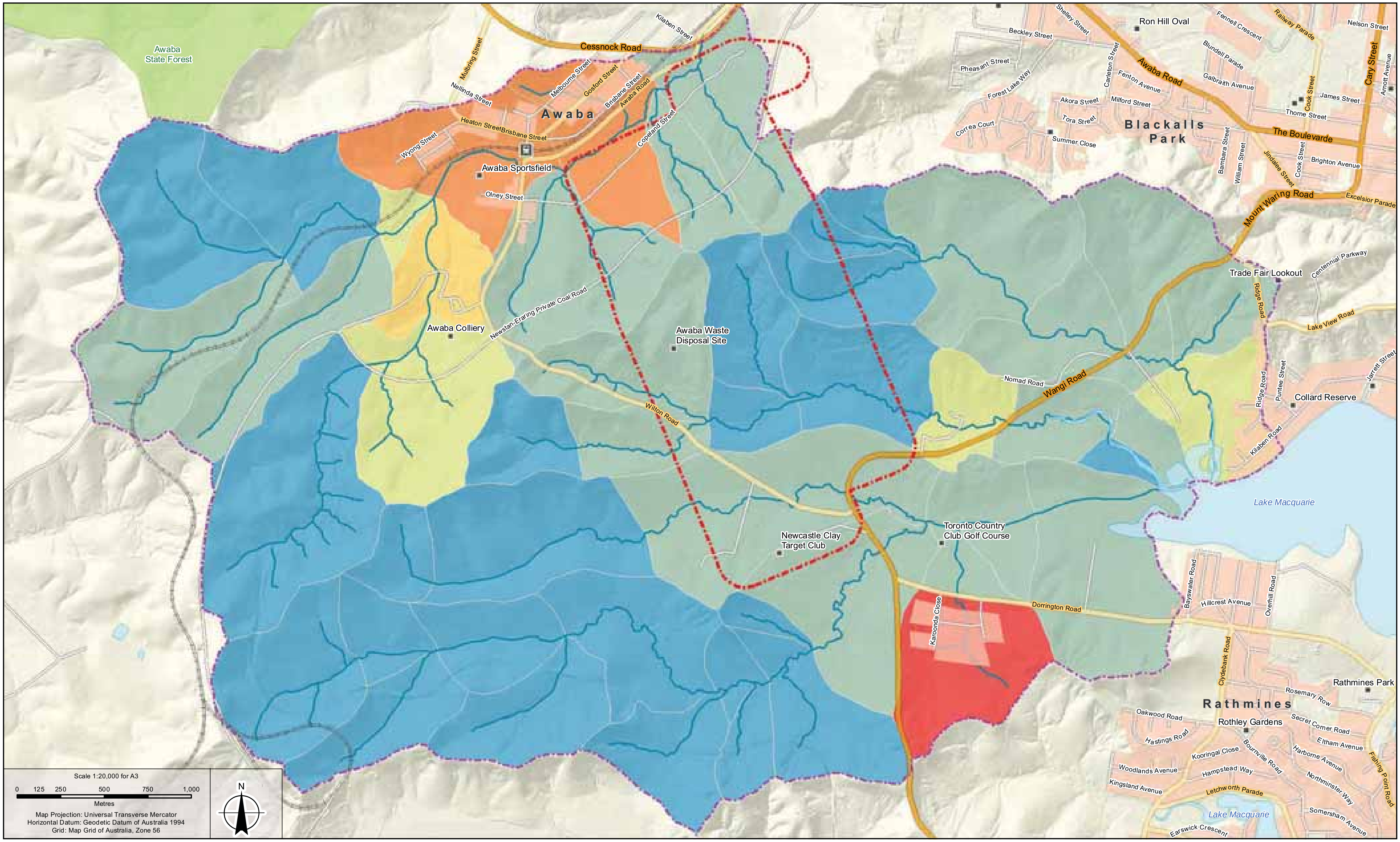
Subarea ID	Impervious Fraction	Area (ha)	Impervious Area (ha)	Pervious Area (ha)	Catchment Slope	Mannings 'n' Pervious Areas	Mannings 'n' Impervious Areas
BJr	0.05	9.64	0.48	9.16	12.33	0.075	0.02
BKr	0.8	13.01	10.41	2.60	14.48	0.075	0.02
APr	0.05	22.56	1.13	21.43	18.41	0.075	0.02
APa	0.5	72.31	36.16	36.16	15.06	0.075	0.02
CNr	0	162.36	0.00	162.36	17.53	0.1	-
CPr	0.05	124.01	6.20	117.81	13.44	0.1	0.02
AMr	0.1	34.61	3.46	31.15	8.28	0.075	0.02
BLr	0.3	23.09	6.93	16.16	8.84	0.05	0.02
Rr	0.3	58.97	17.69	41.28	11.01	0.025	0.02
Sr	0.05	12.25	0.61	11.63	6.15	0.05	0.02
Qr	0.05	33.37	1.67	31.71	8.75	0.05	0.02
BMr	0.35	24.65	8.63	16.02	8.08	0.1	0.02
Tr	0.05	89.21	4.46	84.75	9.11	0.075	0.02
BCr	0.05	55.97	2.80	53.17	15.68	0.1	0.02
BD	0.1	60.20	6.02	54.18	10.22	0.025	0.02

Site Inspection Photos	
Photo B1 - Valley Crossing Access Track through SMP Study Area (south of Newstan-Eraring Private Coal Road and West of Wilton Road)	
Photo B2 - Creek WC3 Looking Upstream from Wangi Road	
Photo B3 - Creek WC3 Looking Downstream from Wangi Road	

Site Inspection Photos	
Photo B4 - Creek WC10 Looking Upstream from Wangi Road	
Photo B5 – Kilaben Creek (WC5) Culverts under Wangi Road	
Photo B6 – Kilaben Creek (WC5) downstream Wangi Road - looking downstream	

Site Inspection Photos	
Photo B7 – Kilaben Creek (WC5) looking upstream from Wilton Road	
Photo B8 – Kilaben Creek (WC5) culverts under Wilton Road	
Photo B9 – Kilaben Creek (WC5) looking downstream from Wilton Road	

Site Inspection Photos	
Photo B9 – Creek WC6 looking downstream from Wilton Road	
Photo B10 – Stony Creek (WC1) looking upstream from Wilton Road towards Cessnock Road underpass	



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Waterbody
- Builtup area
- State forest
- Gully line for hydraulic model

Impervious fraction: 0, 0.05, 0.1, 0.15, 0.2, 0.3

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

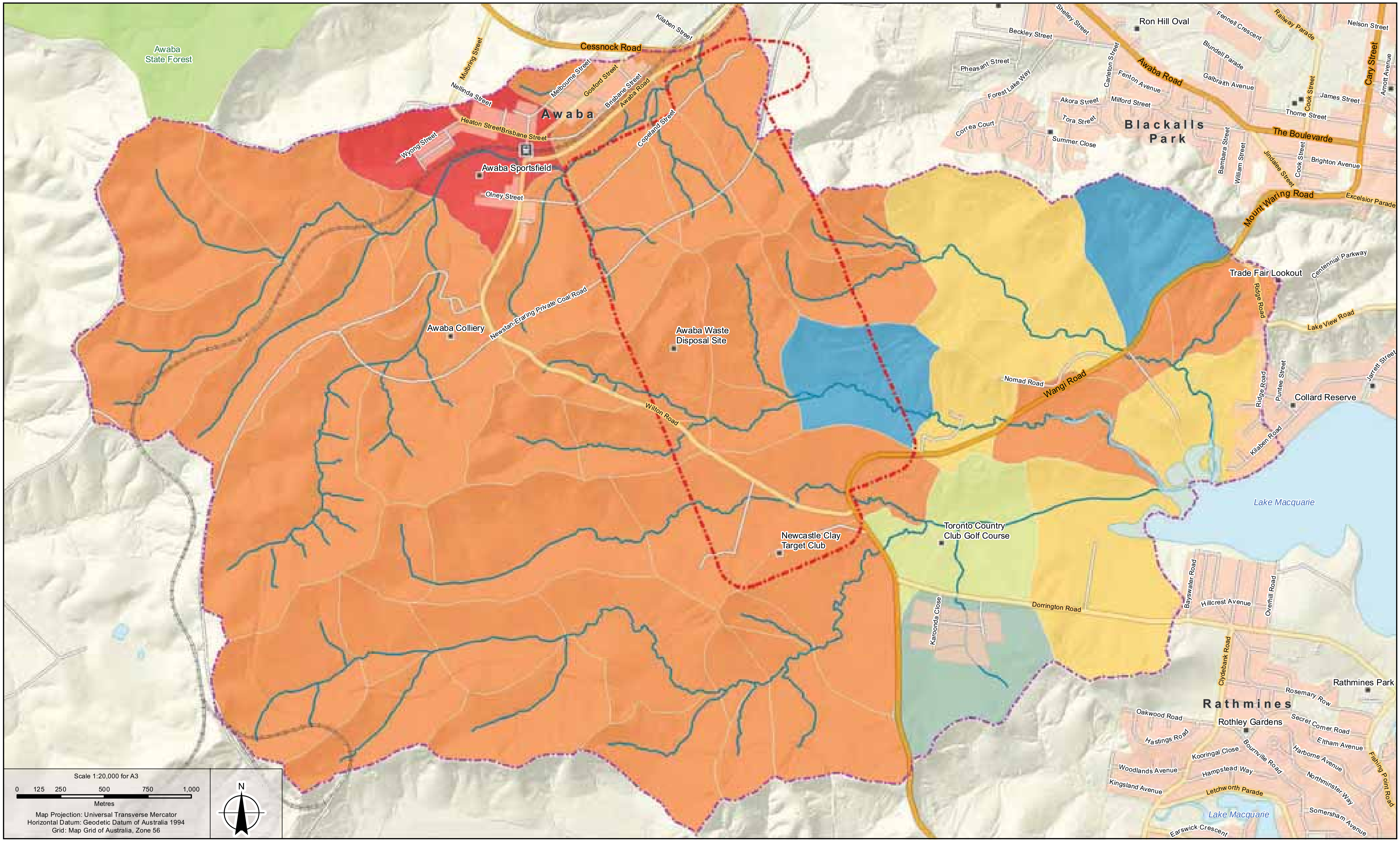
Hydrologic Model - Impervious Fraction Plot

Centennial Newstan

Date: 30/04/2012

App. B1

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Waterbody
- Builtup area
- State forest
- Gully line for hydraulic model

Mannings 'n' roughness: 0, 0.025, 0.05, 0.075, 0.1, 0.75

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Hydrologic Model - Manning's 'n' Catchment Roughness Plot

Centennial Newstan

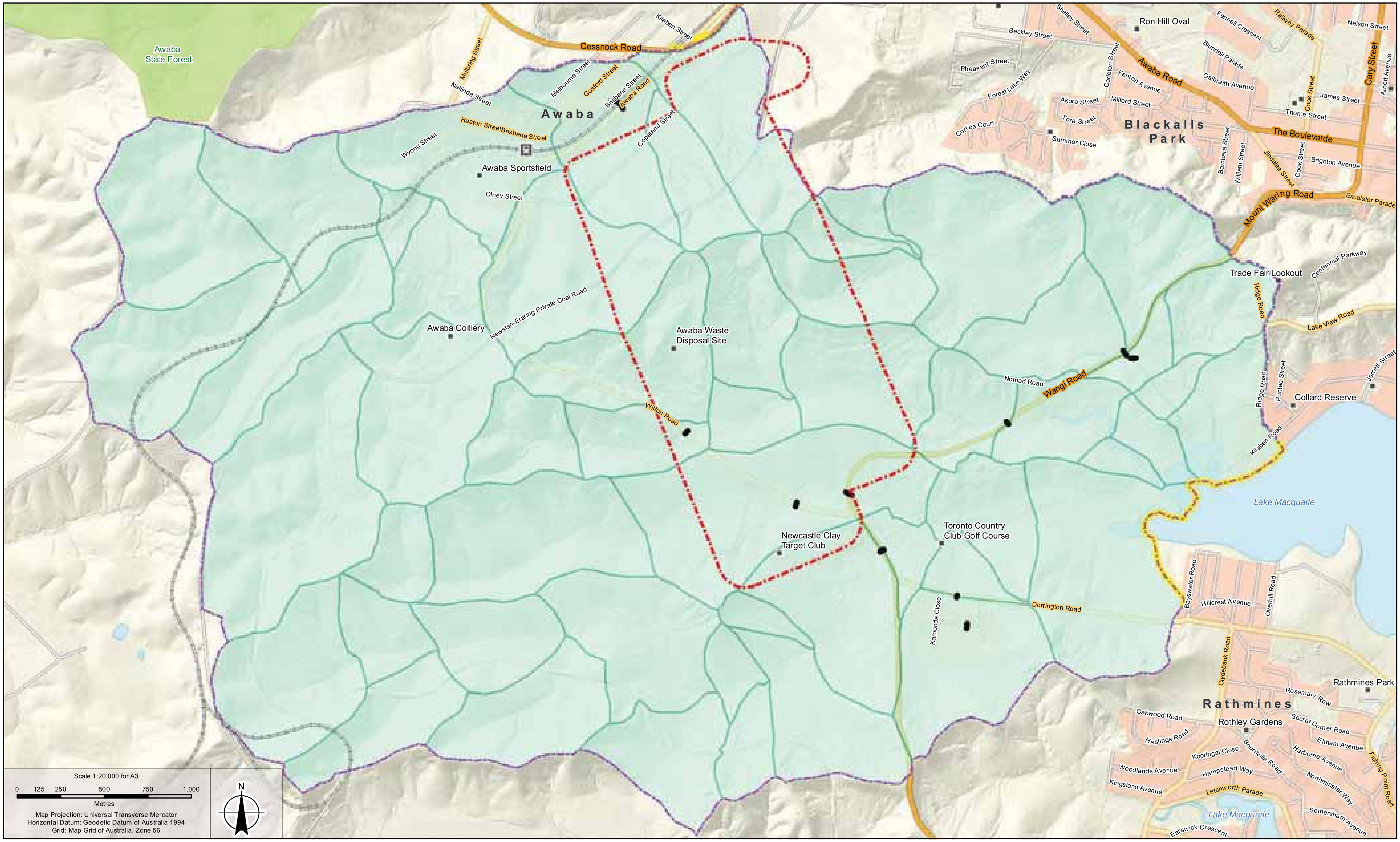
Date: 30/04/2012

App. B2

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd

Appendix C

Hydraulic Modelling – Model Layout and Parameter Plots



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Dowstream TWL
- Waterbody
- Builtup area
- State forest
- Inflows catchment
- 1d structures

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

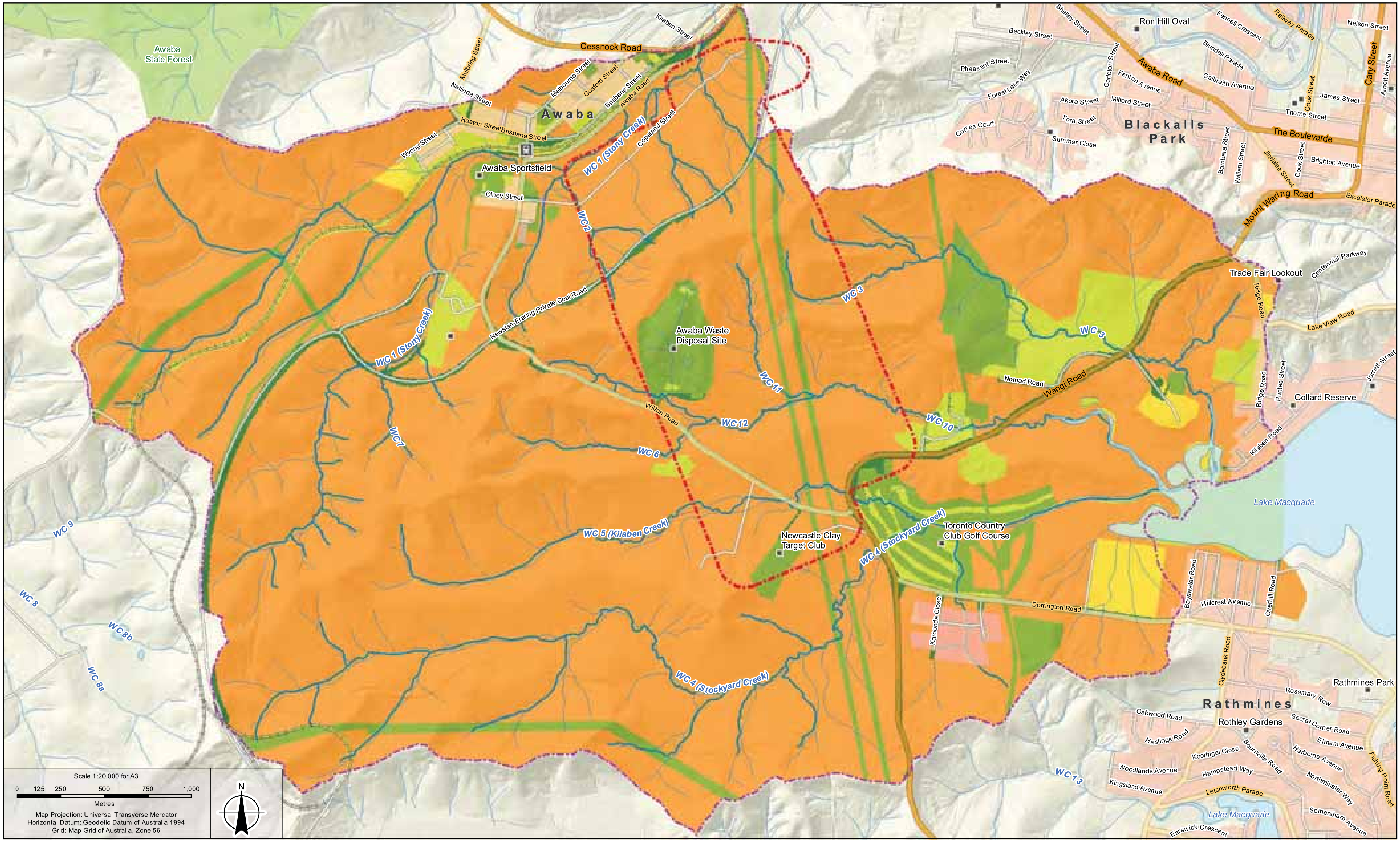
Hydraulic Model Setup

Centennial Newstan

Date: 30/04/2012

App. C1

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_Without_Watercourse.mxd



GHD

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Gully line for hydraulic model

Mannings 'n' roughness: 0.02, 0.03, 0.05, 0.07, 0.1, 0.2

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

Hydraulic model Manning's 'n' Catchment Roughness Plot

Centennial Newstan

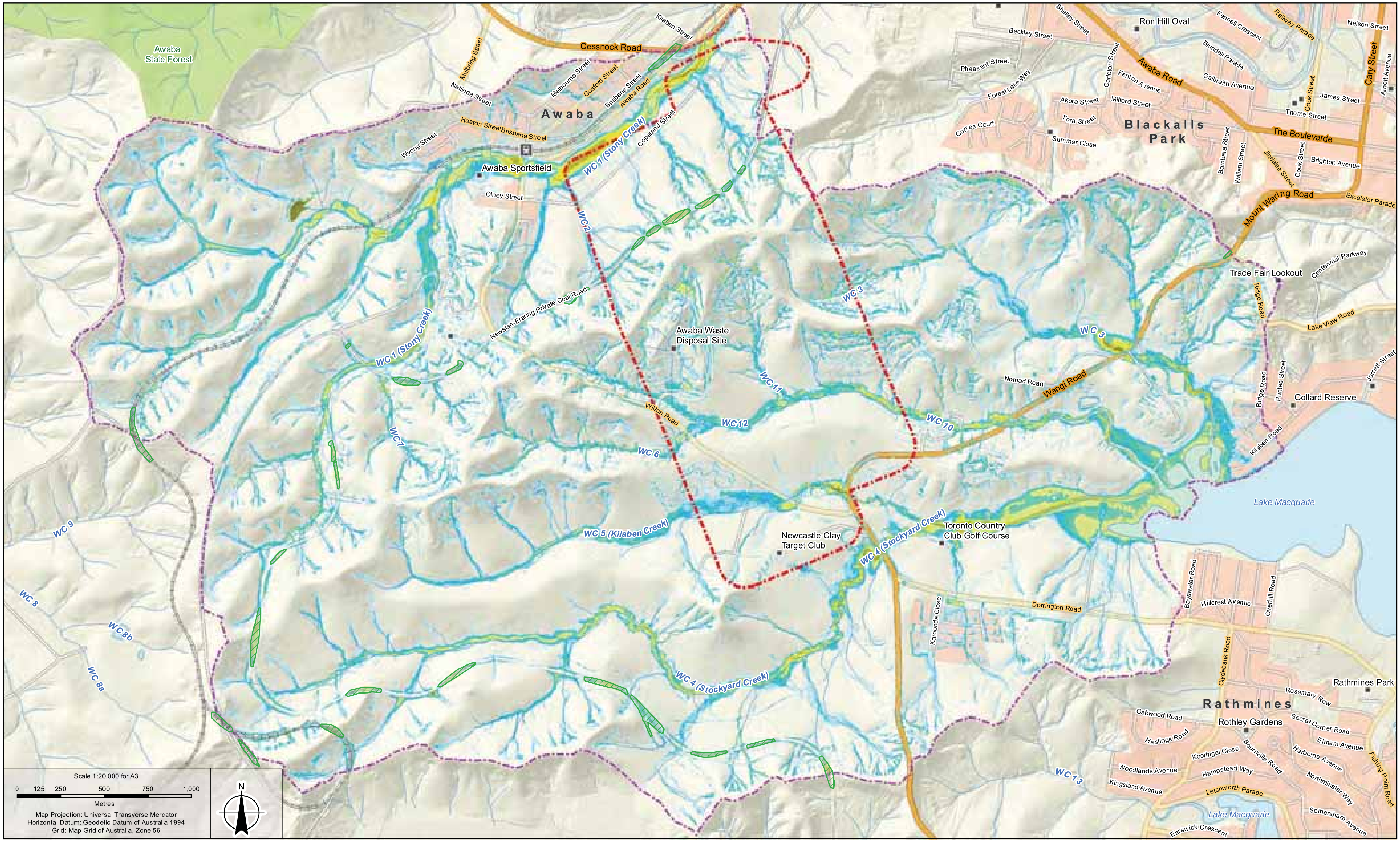
Date: 30/04/2012

App. C2

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook_CODE3.mxd

Appendix D

Hydraulic Modelling Results – Overall 'Existing' Conditions Scenario Plots



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m)

< 0.20	0.20 - 0.40	0.40 - 0.60	0.60 - 0.80	0.80 - 1.00	1.00 - 1.50	1.50 - 2.00	2.00 - 2.50	>2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

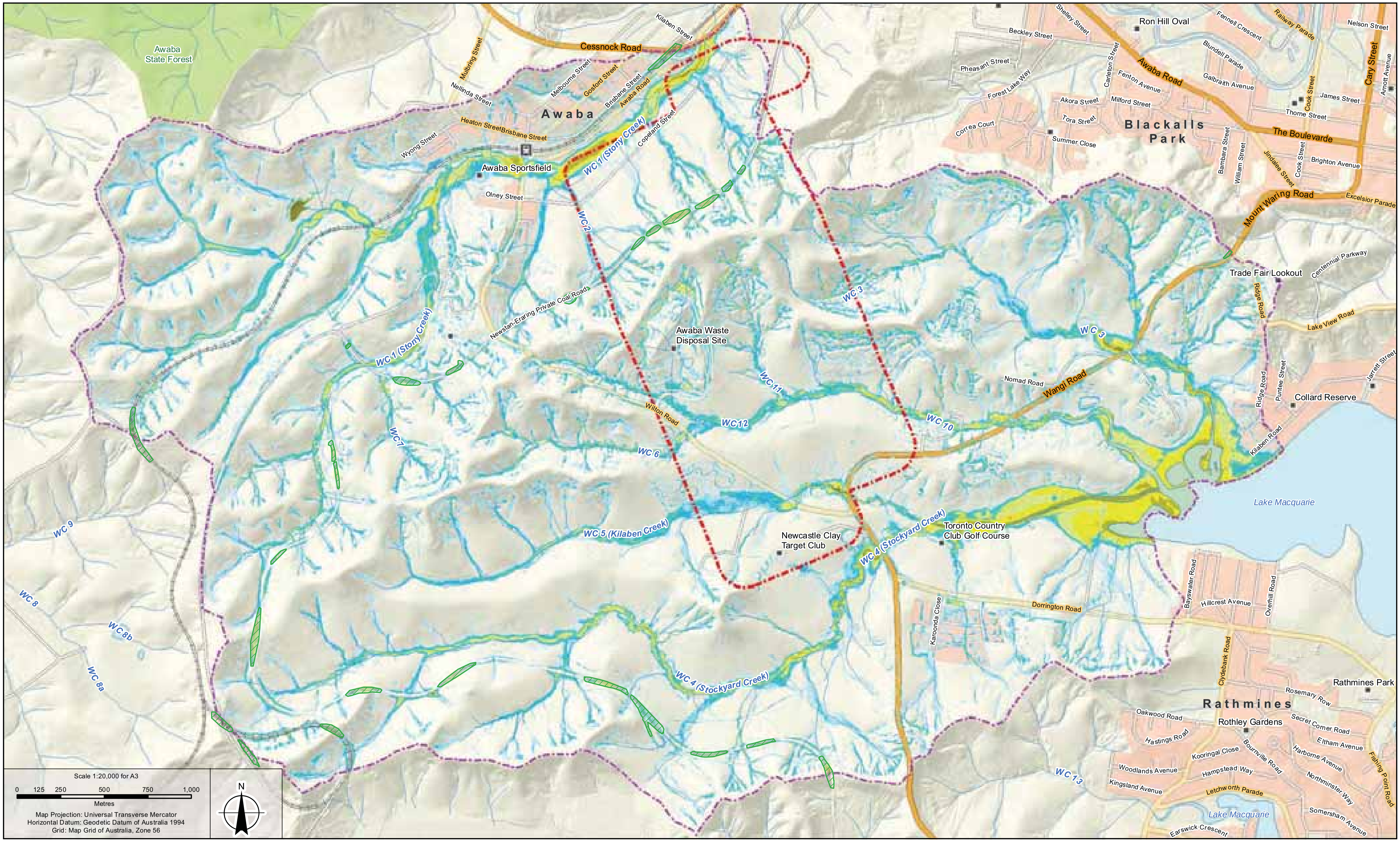
'Existing' Scenario 100 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. D1

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

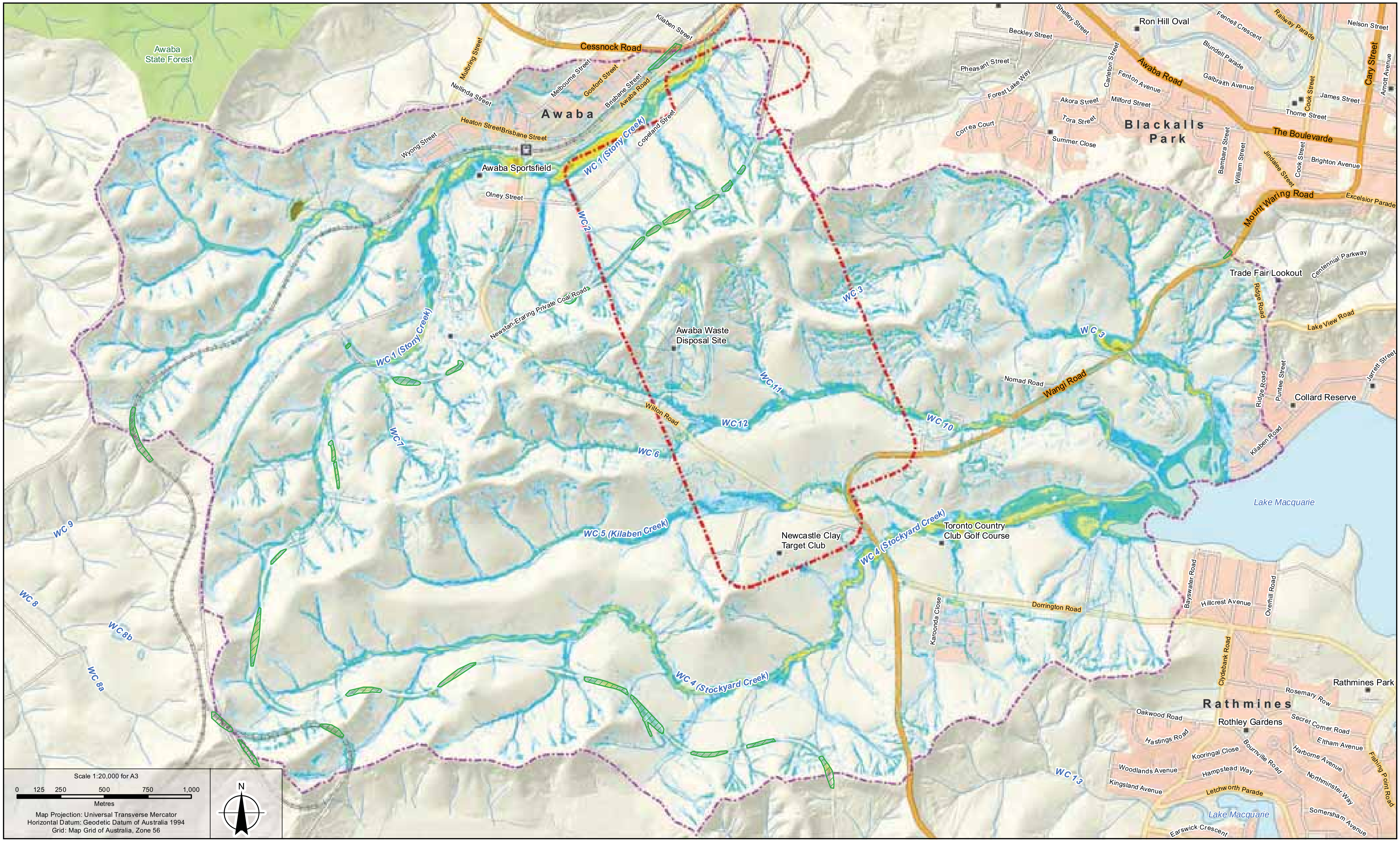
'Existing' Scenario 100 year ARI with alternate tailwater Depth Plot

Centennial Newstan

Date: 30/04/2012

App. D2

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

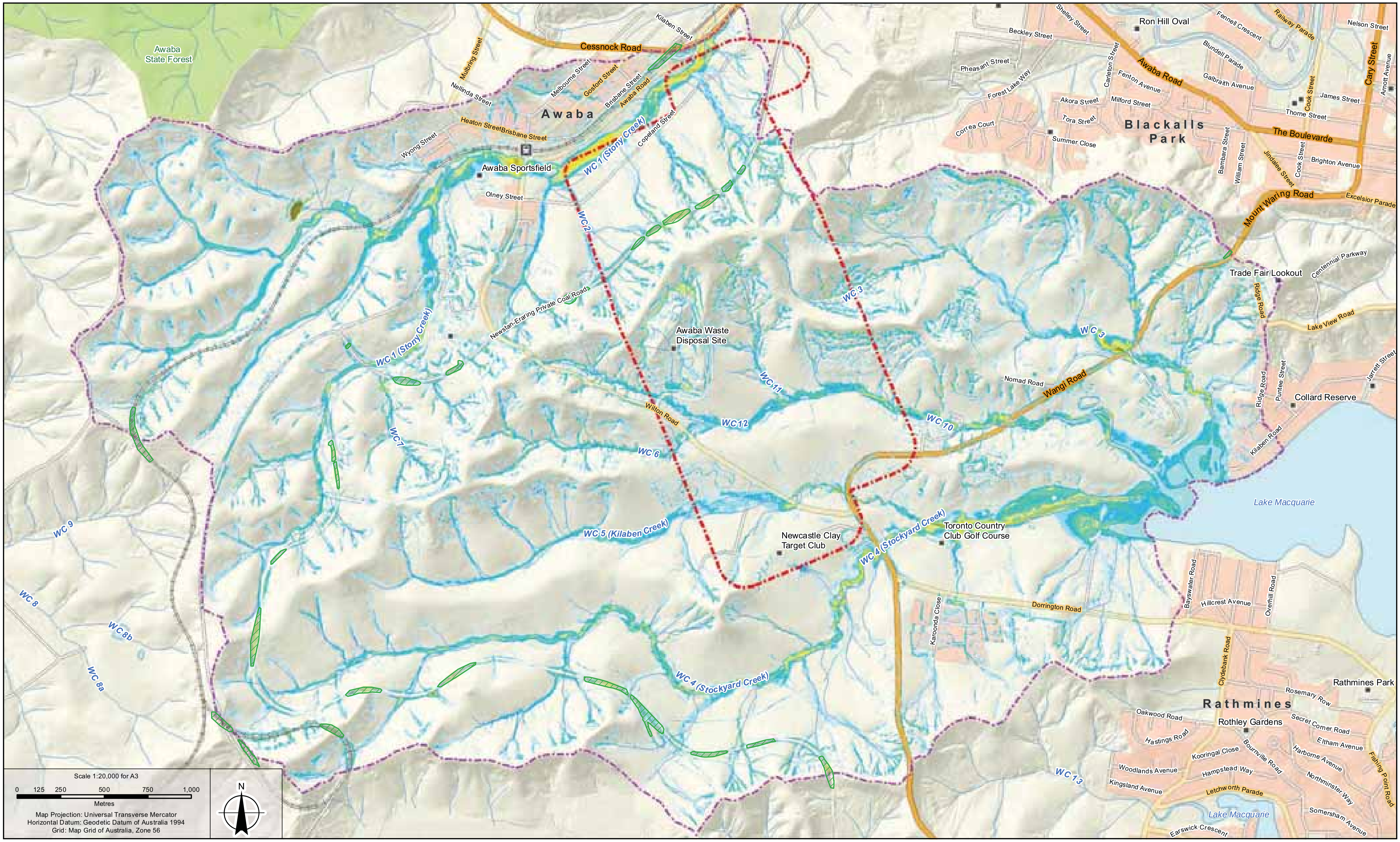
'Existing' Scenario 20 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. D3

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 10 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. D4

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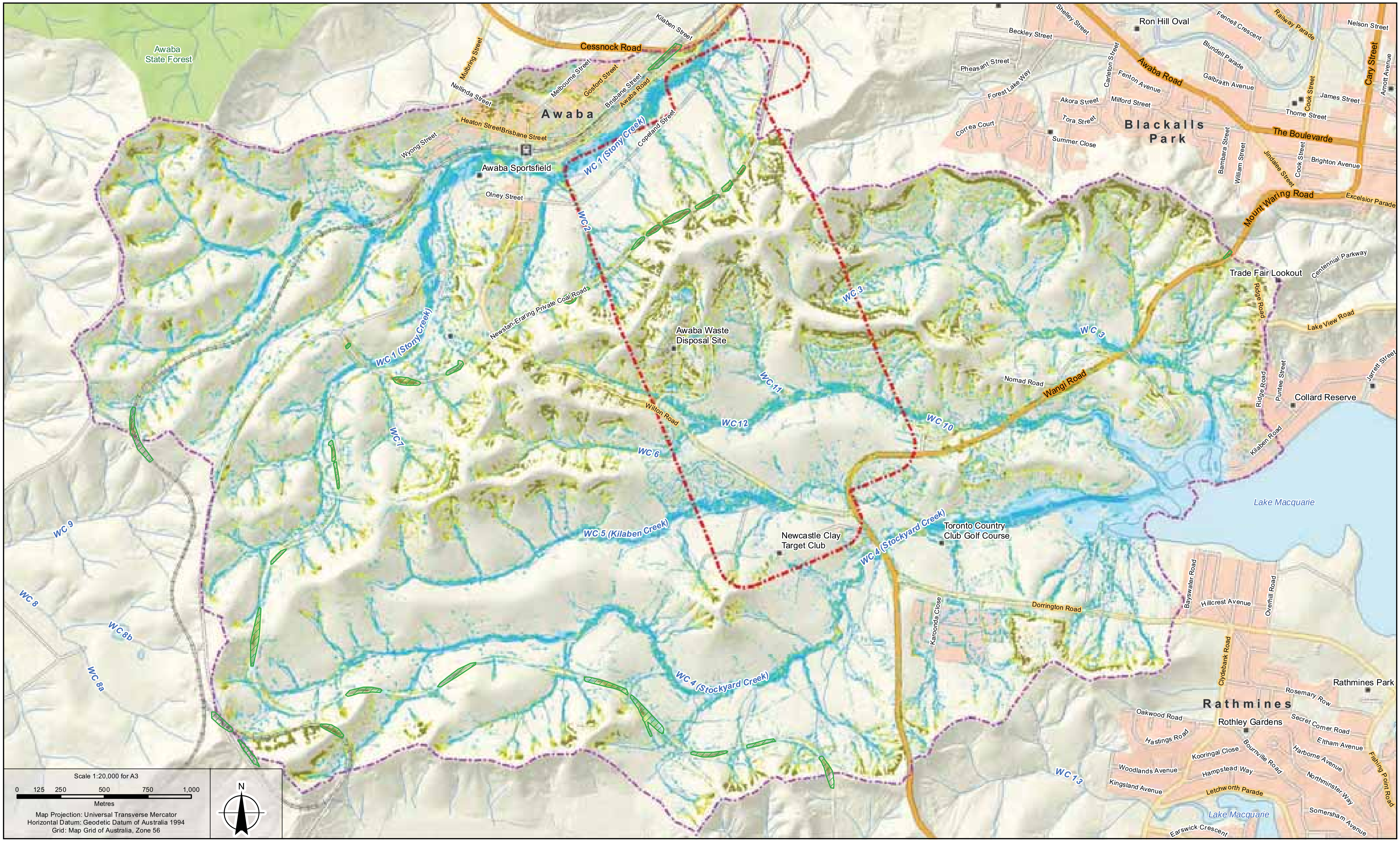

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20, 0.20 - 0.40, 0.40 - 0.60, 0.60 - 0.80, 0.80 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 2 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. D5

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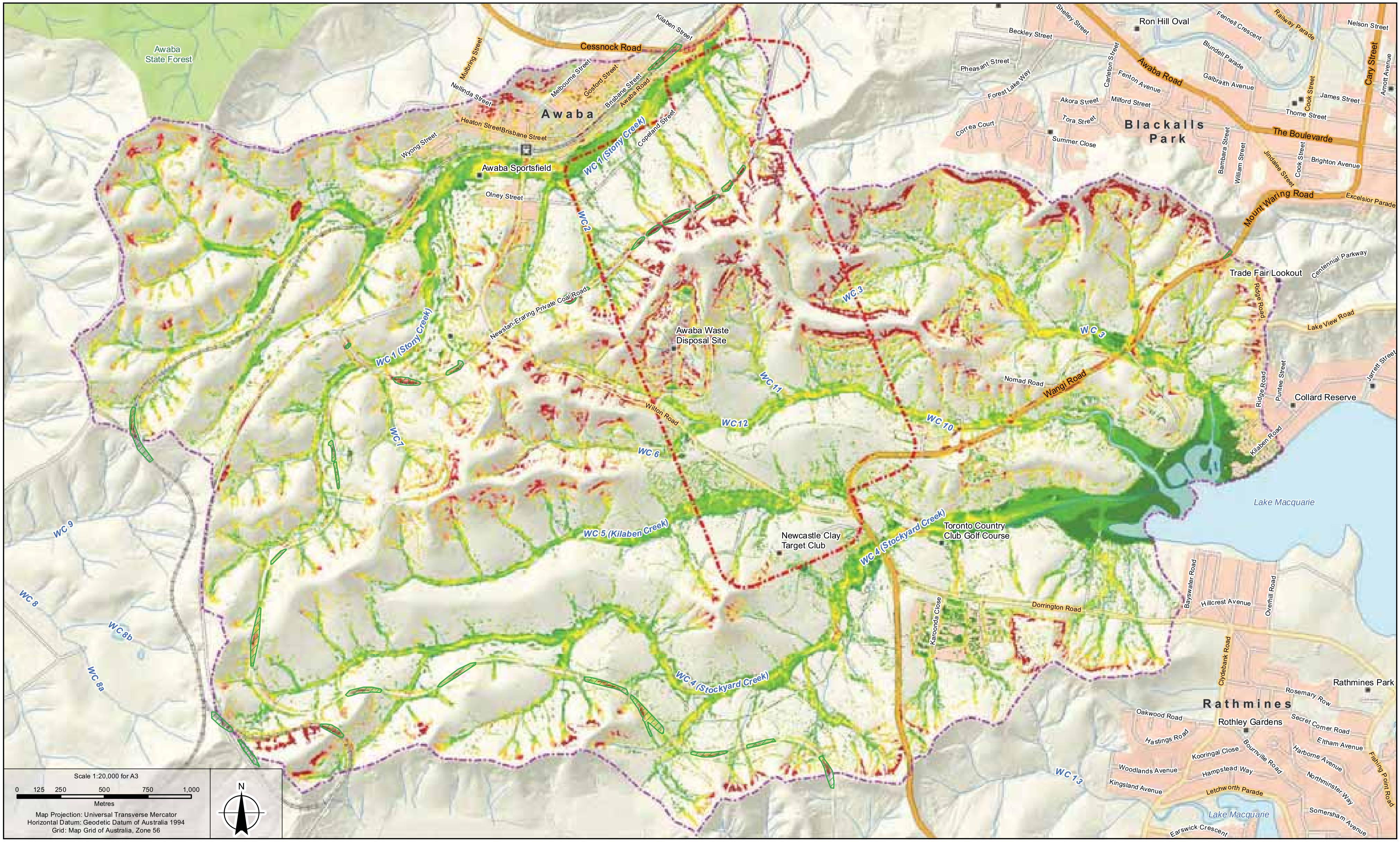

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 100 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. D6

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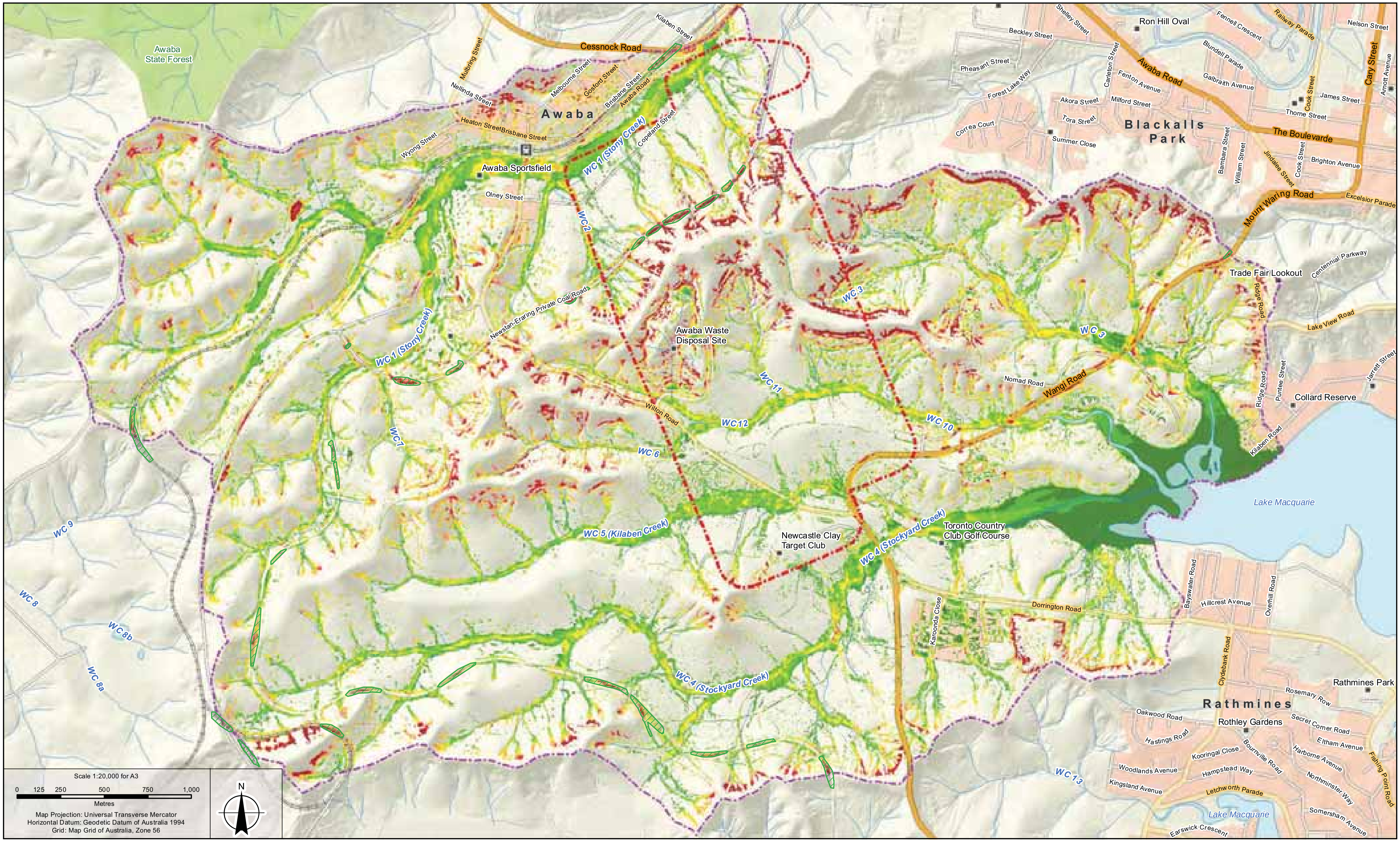


Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

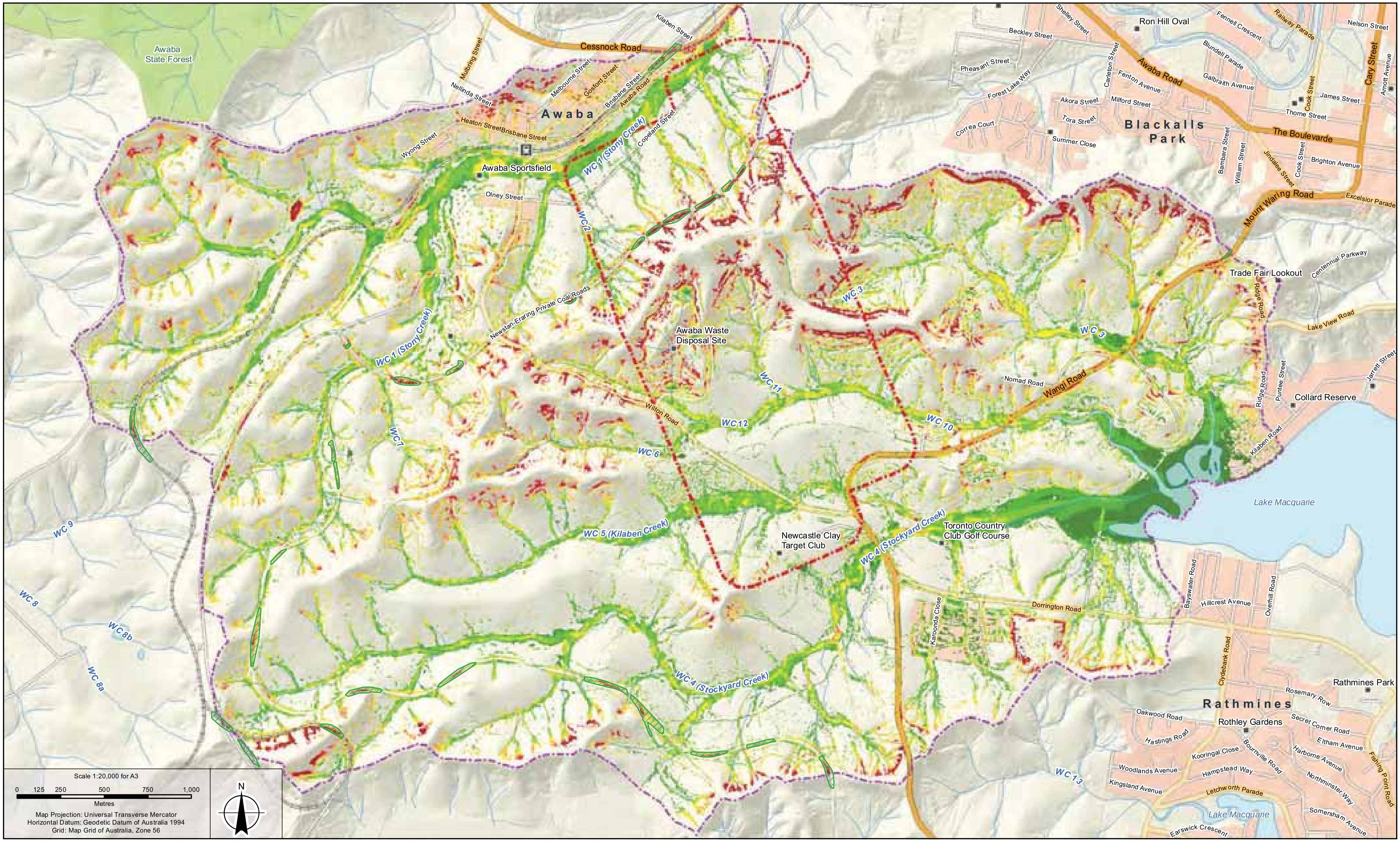
Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 100 year ARI with alternate tailwater Velocity Plot

Centennial Newstan

Date: 30/04/2012 App. D7

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 20 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. D8

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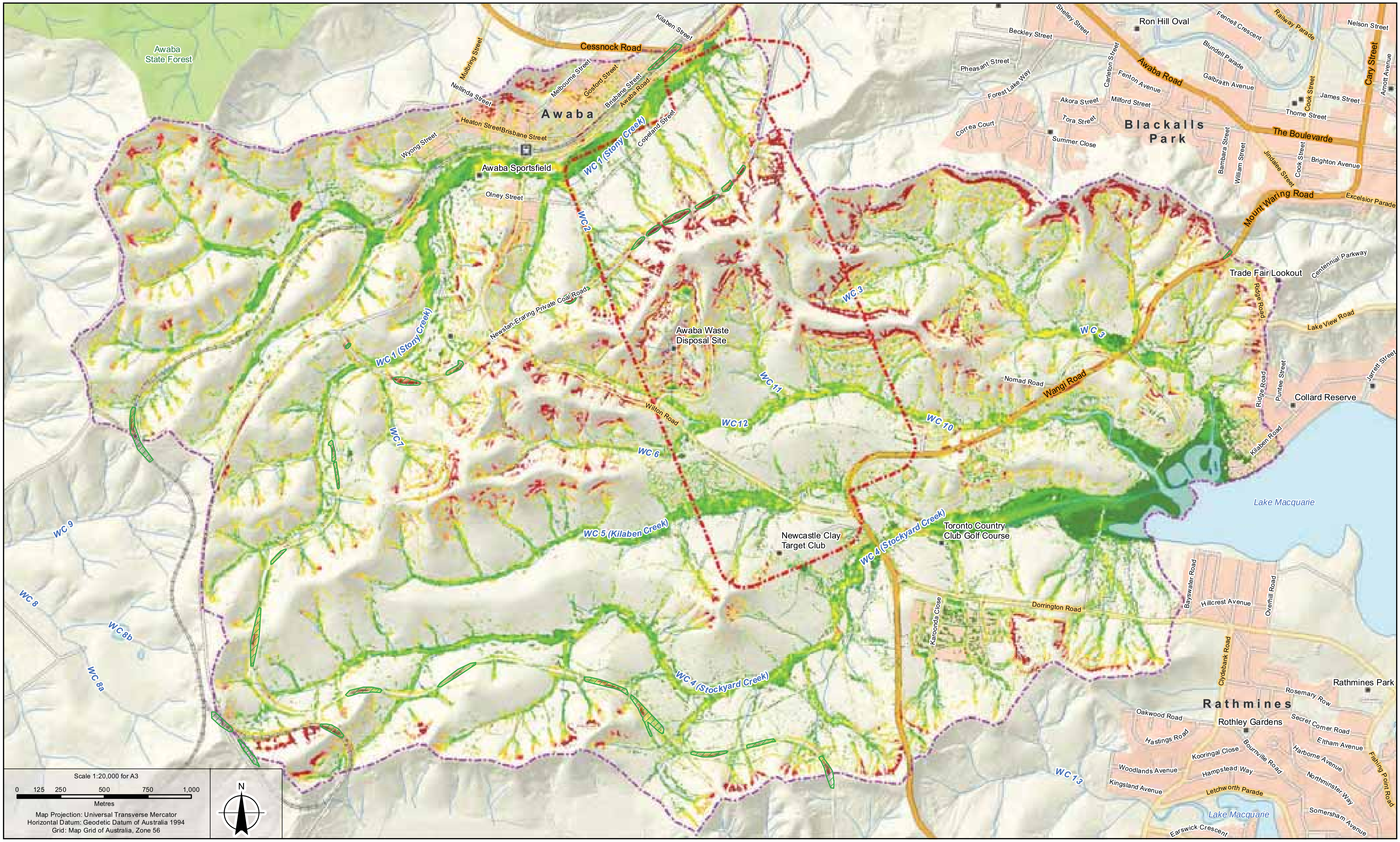


Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

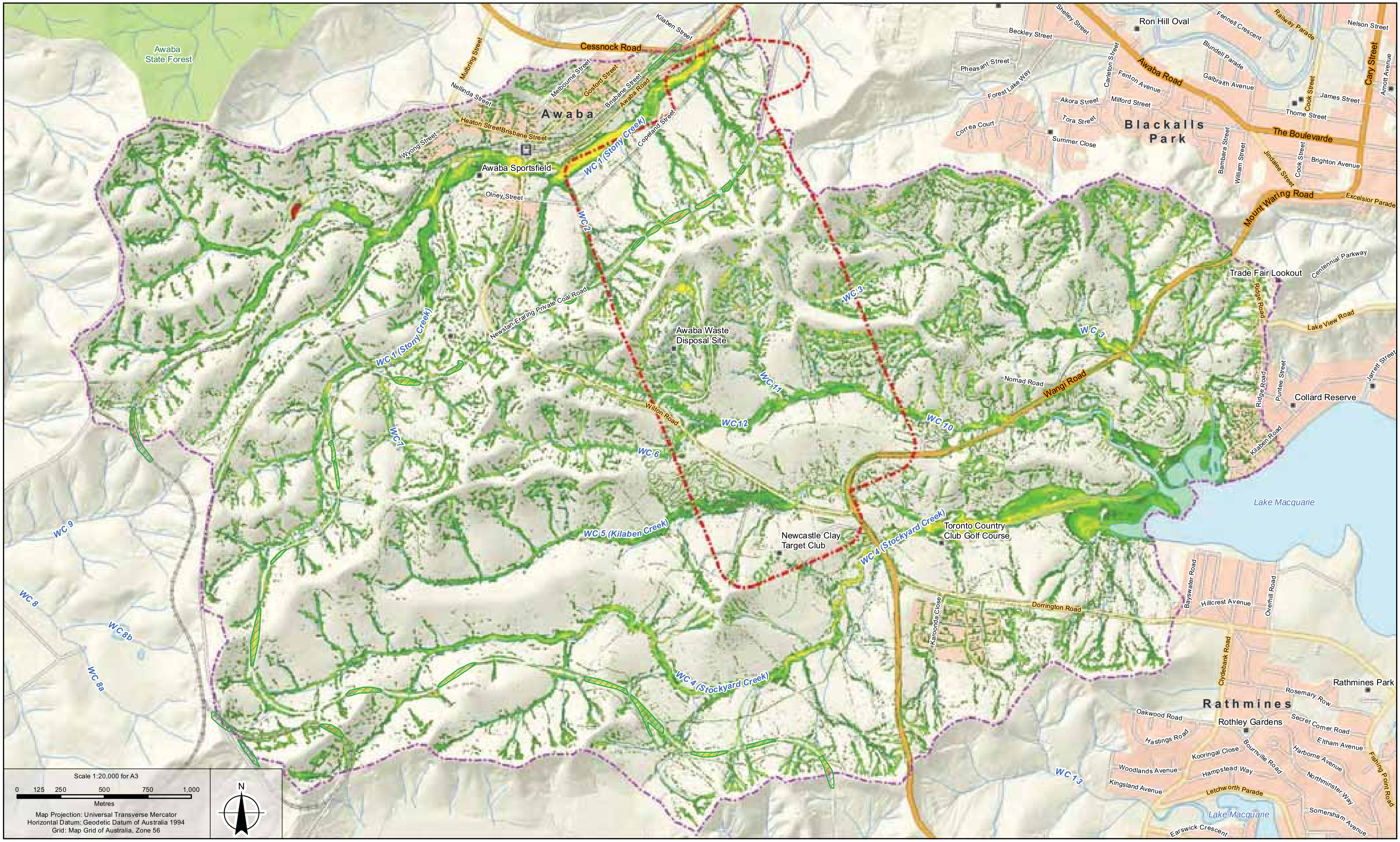
'Existing' Scenario 10 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. D9

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Existing' Scenario 2 year ARI Velocity Plot

Centennial Newstan

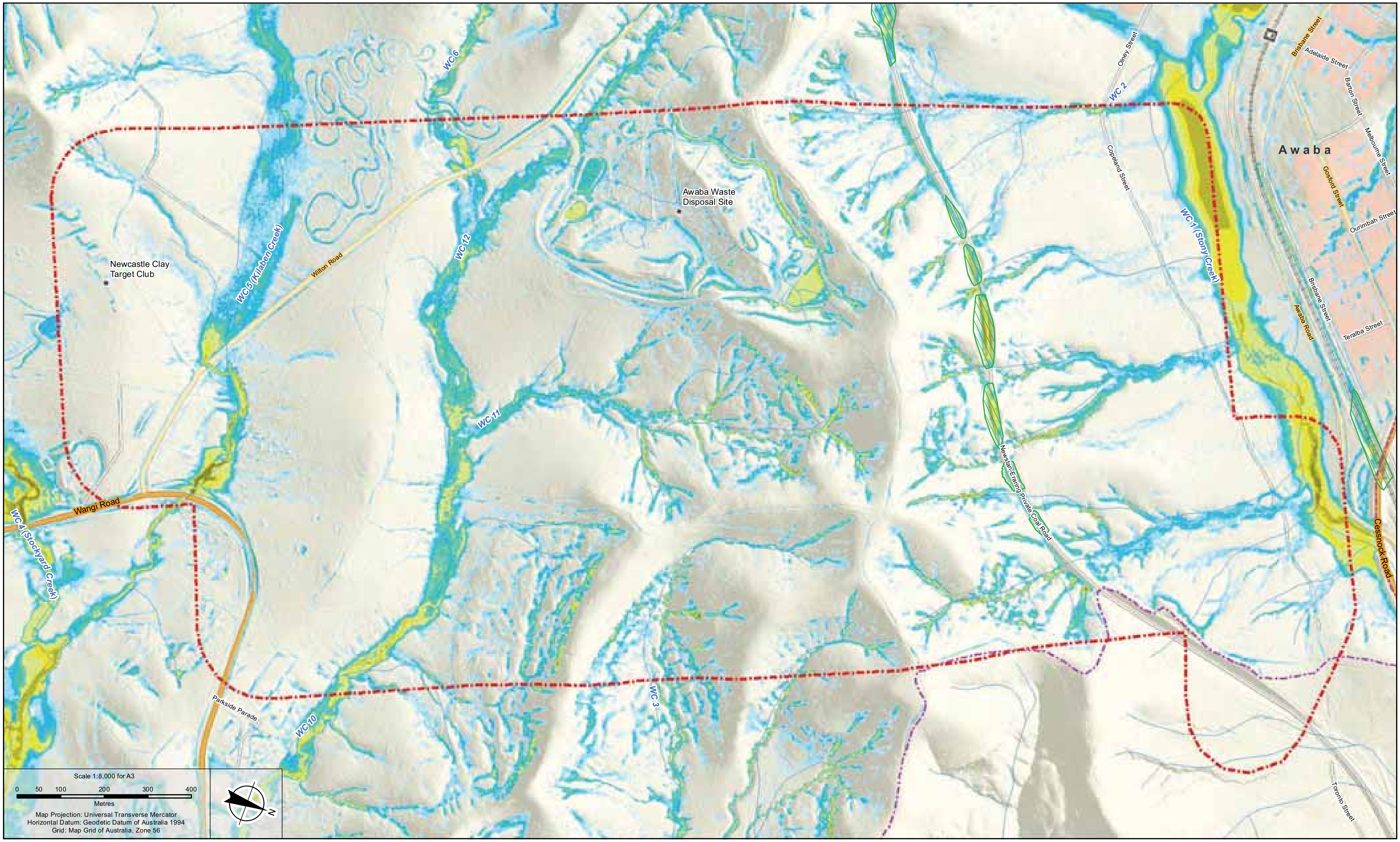
Date: 30/04/2012

App. D10

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd

Appendix E

Hydraulic Modelling Results – SMP Focus Area and Overall 'Subsided' Conditions Scenario Plots



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E1

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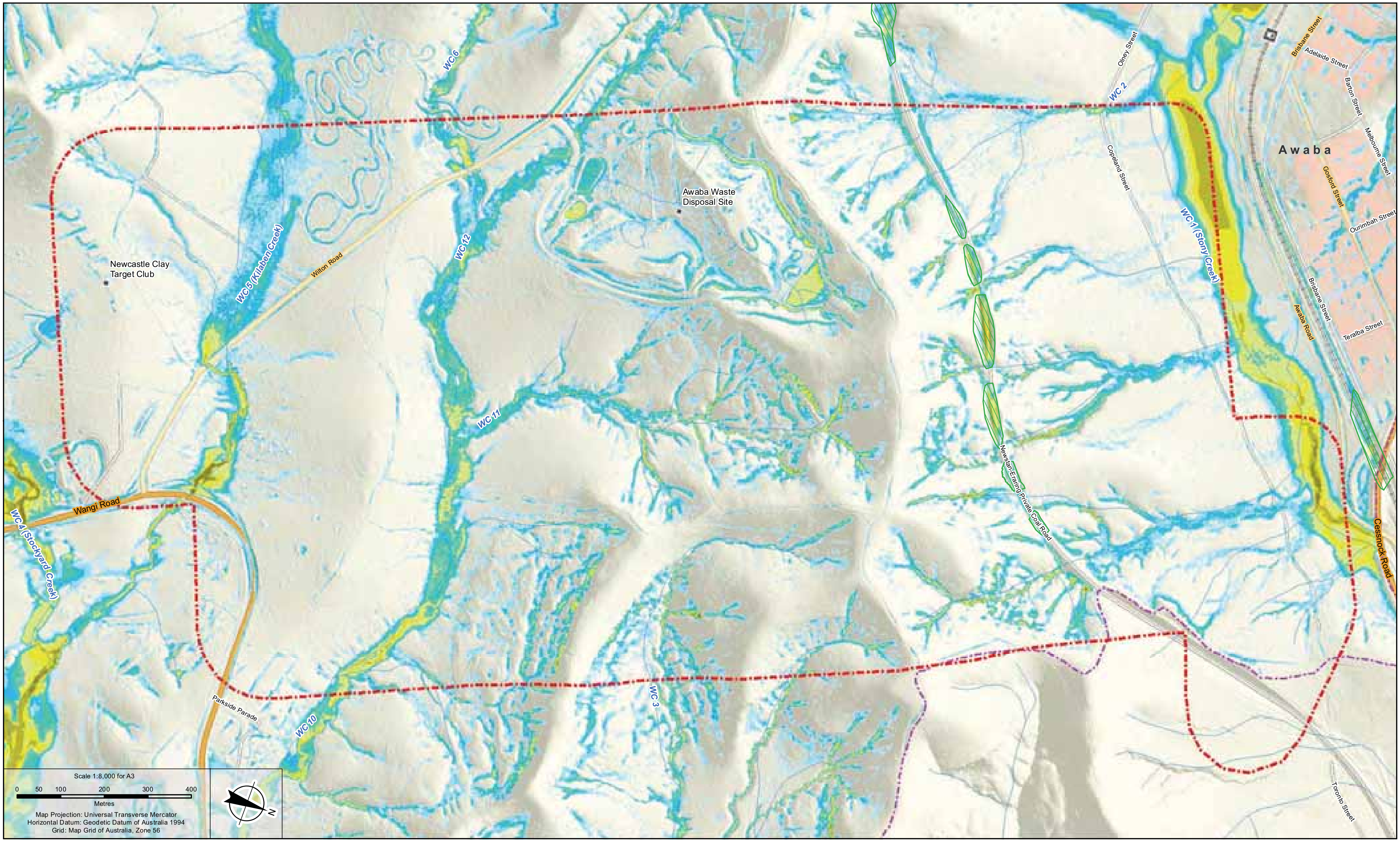

GHD

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI with alternate tailwater Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012 | App. E2

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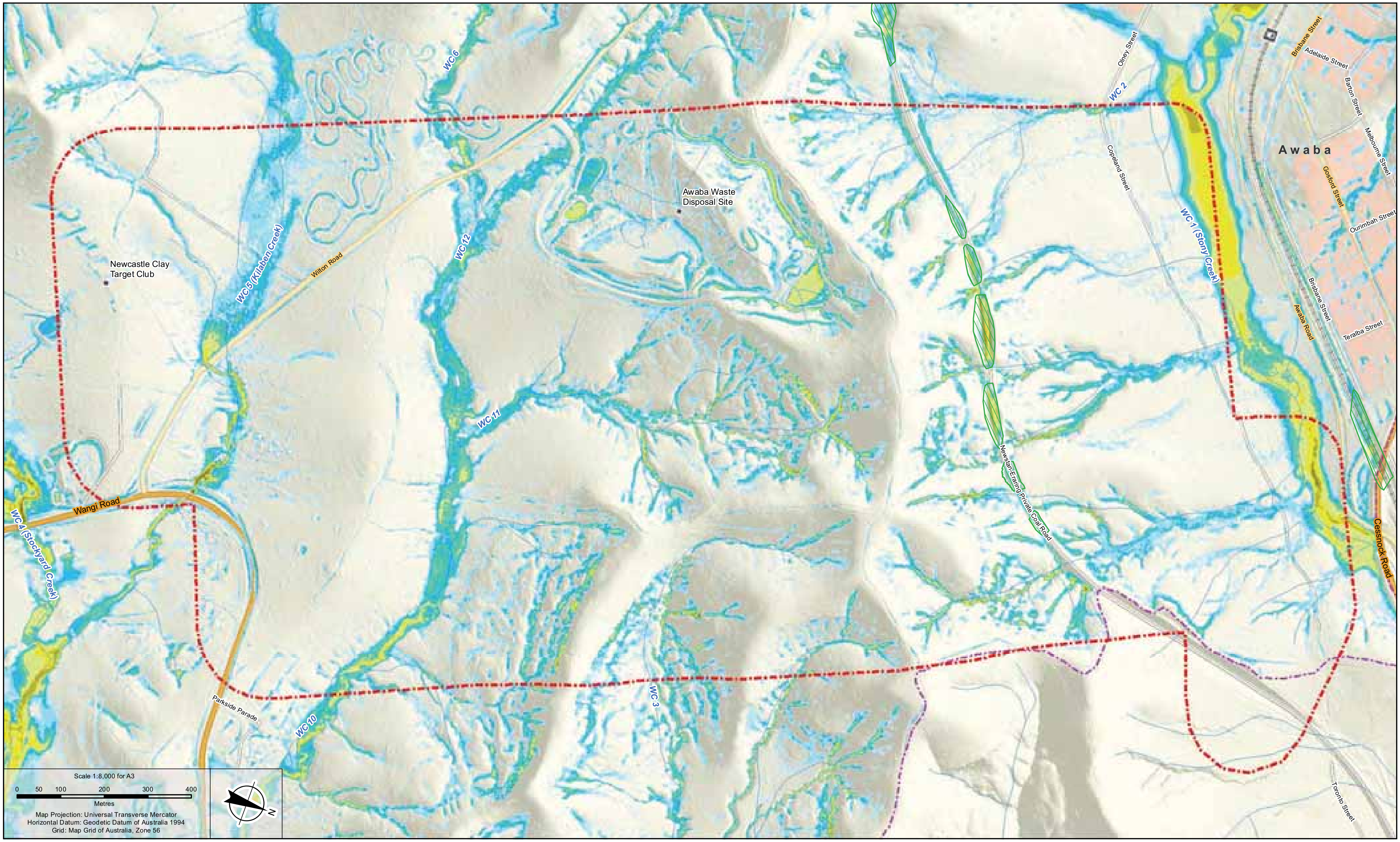

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 20 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E3

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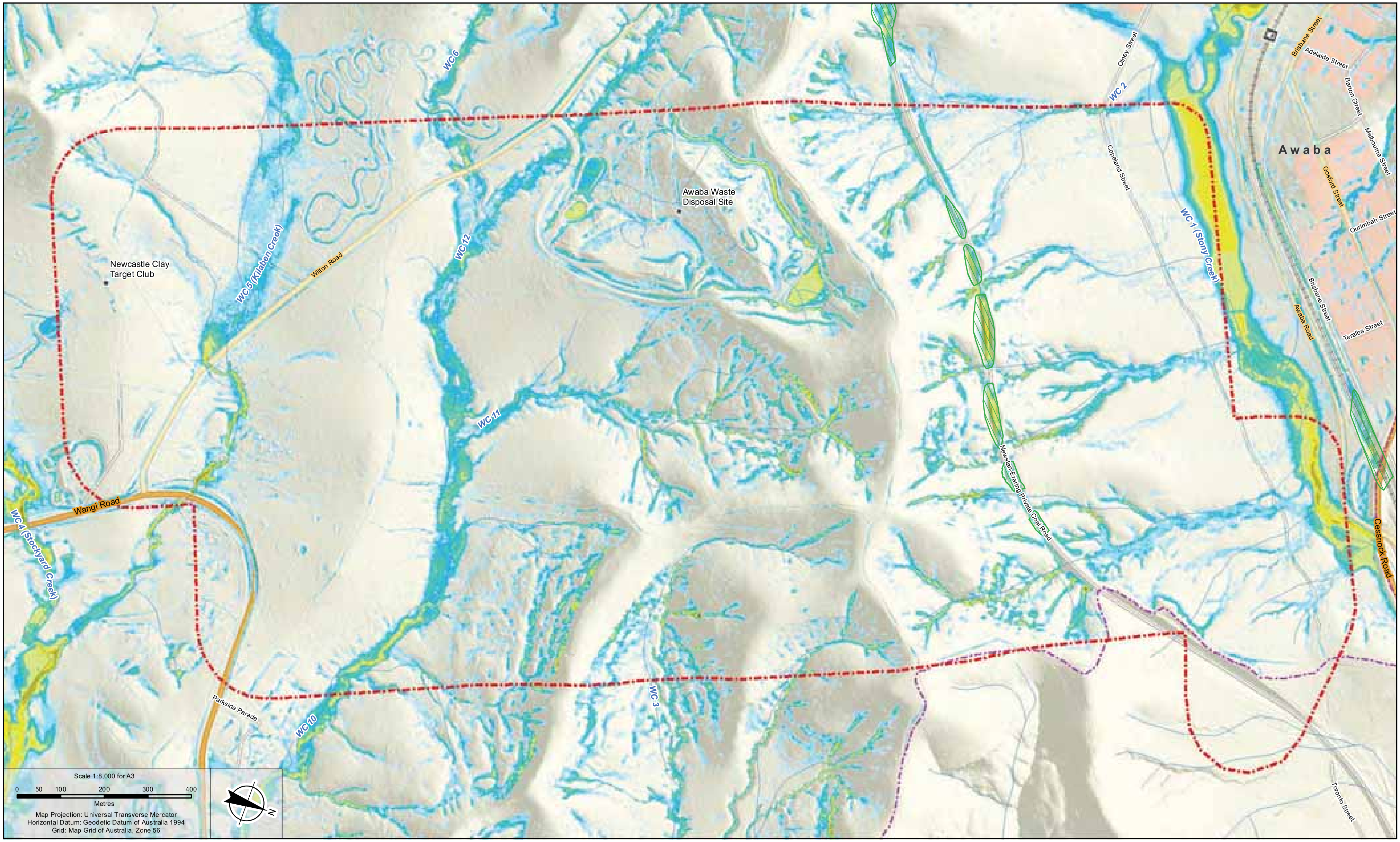

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 10 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E4

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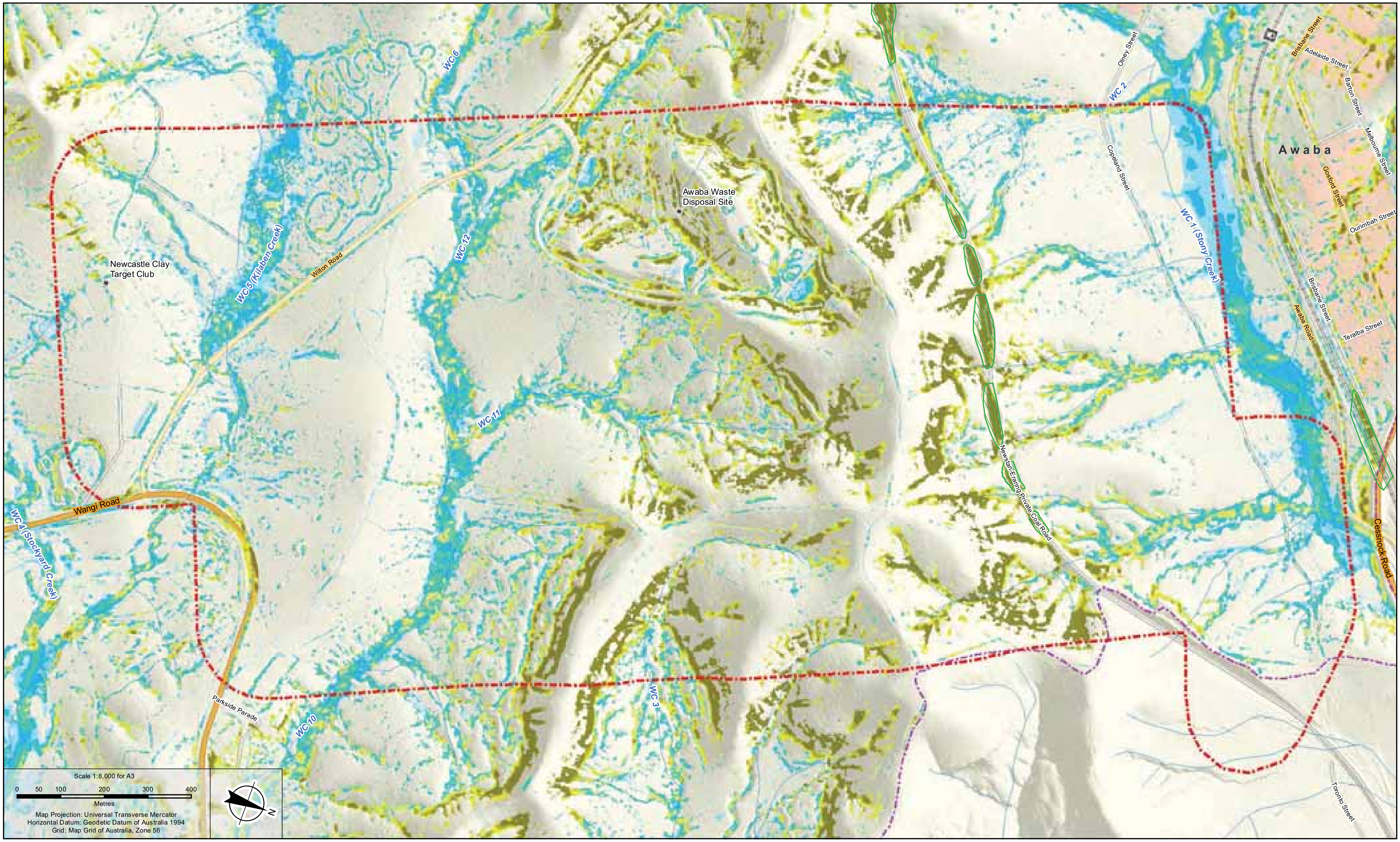

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 2 year ARI Depth Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E5

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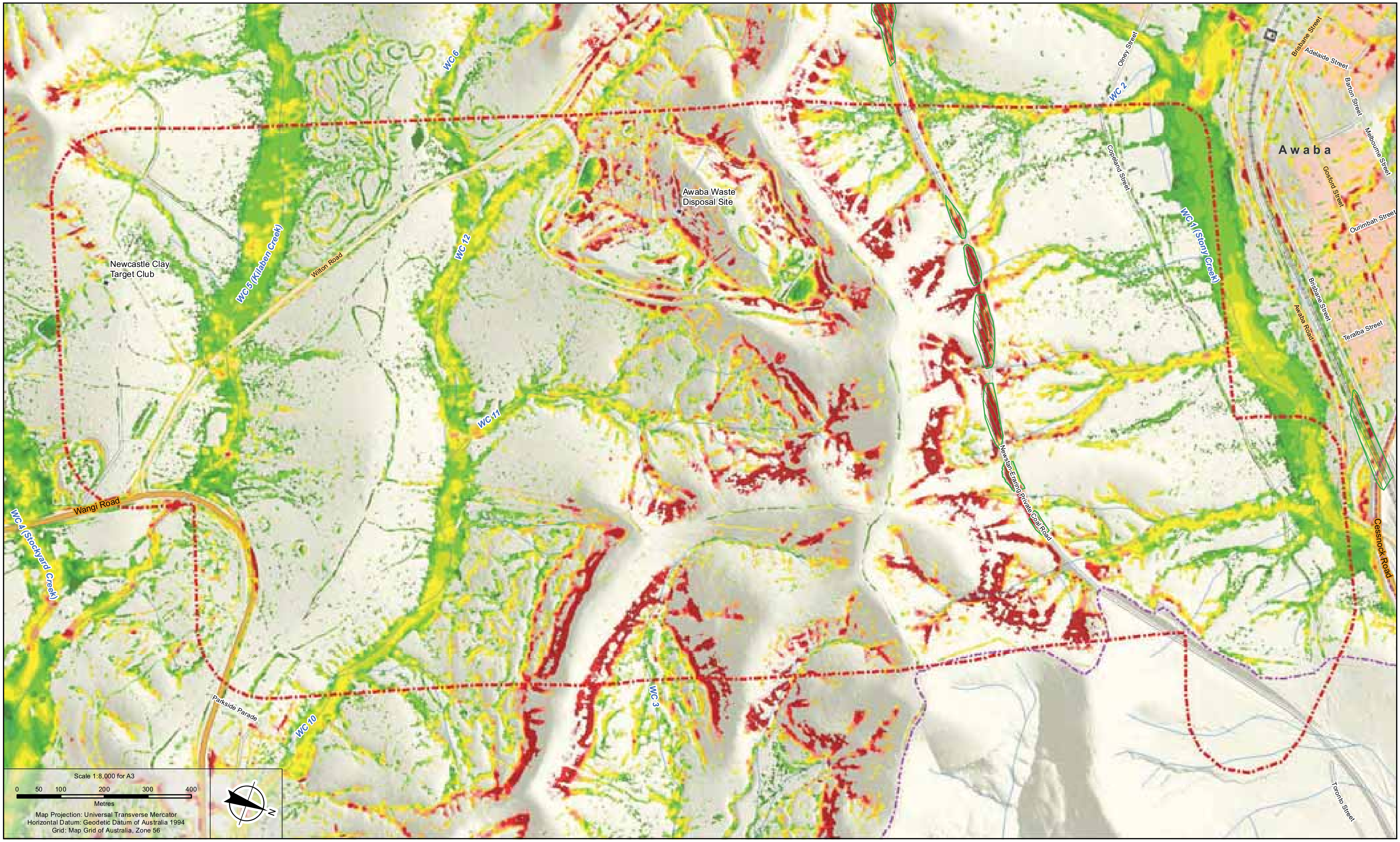

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E6

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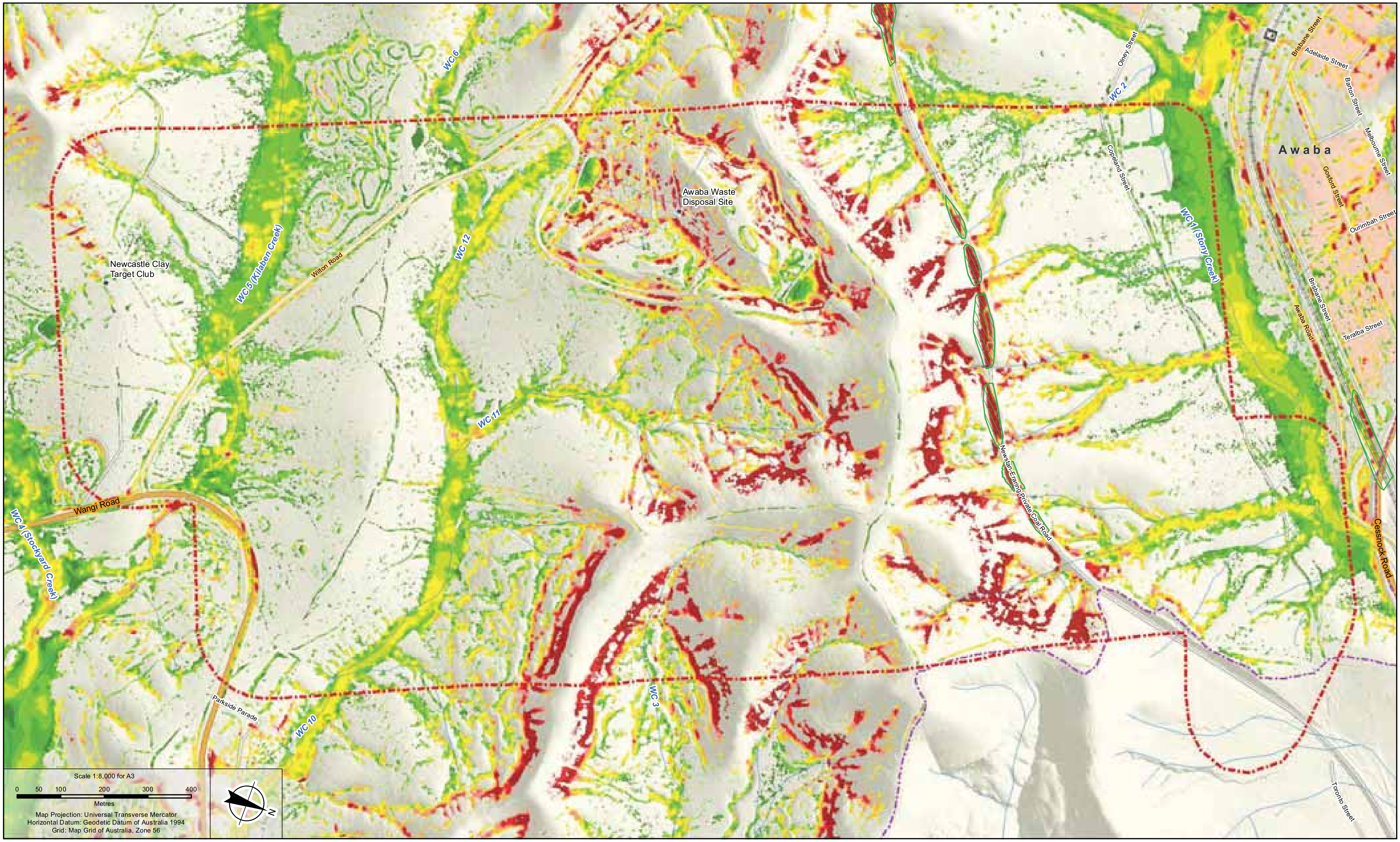

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI with alternate tailwater Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E7

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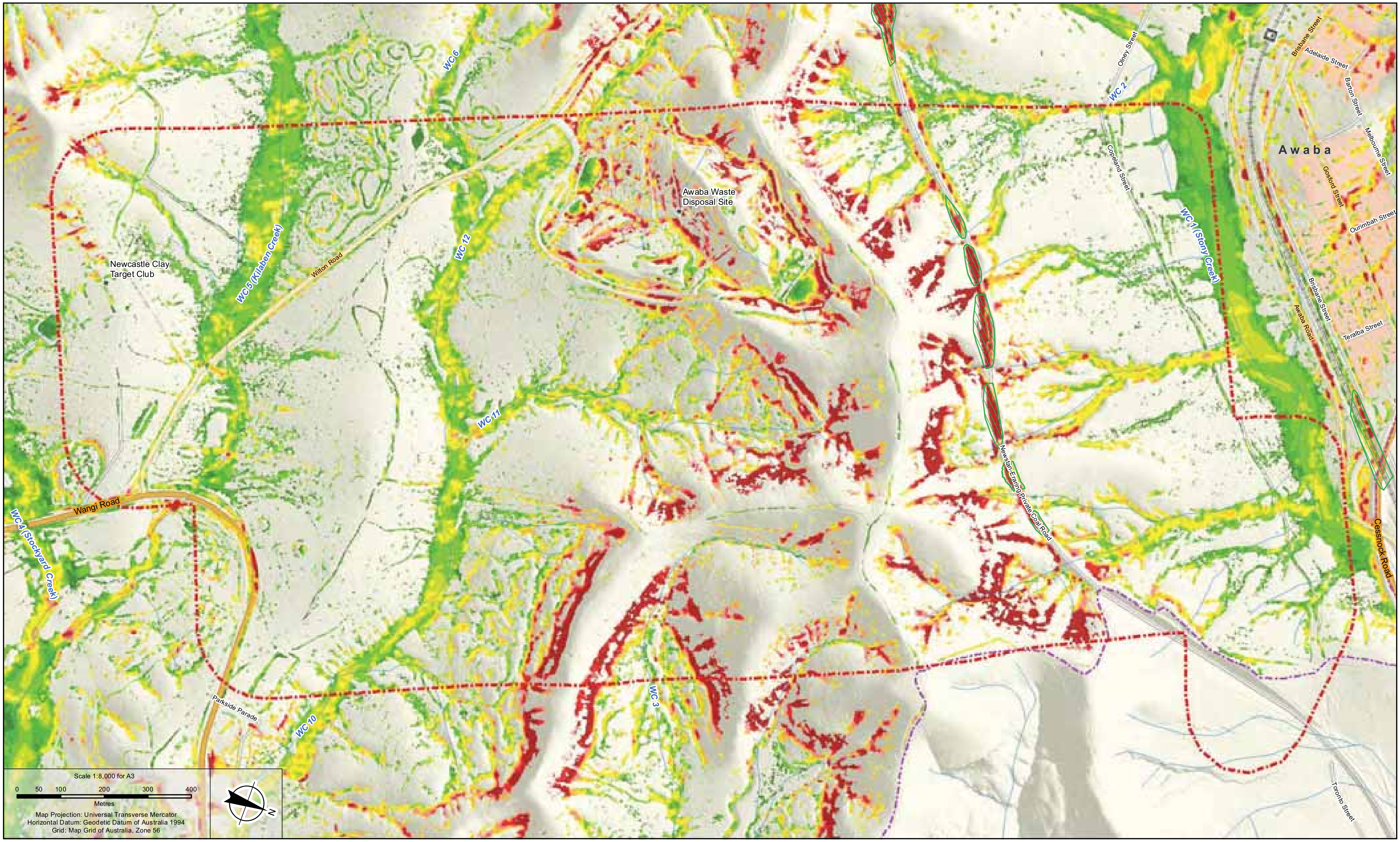

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.50	1.500 - 2.00	2.000 - 2.50	2.50 - 3.00	>3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 20 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E8

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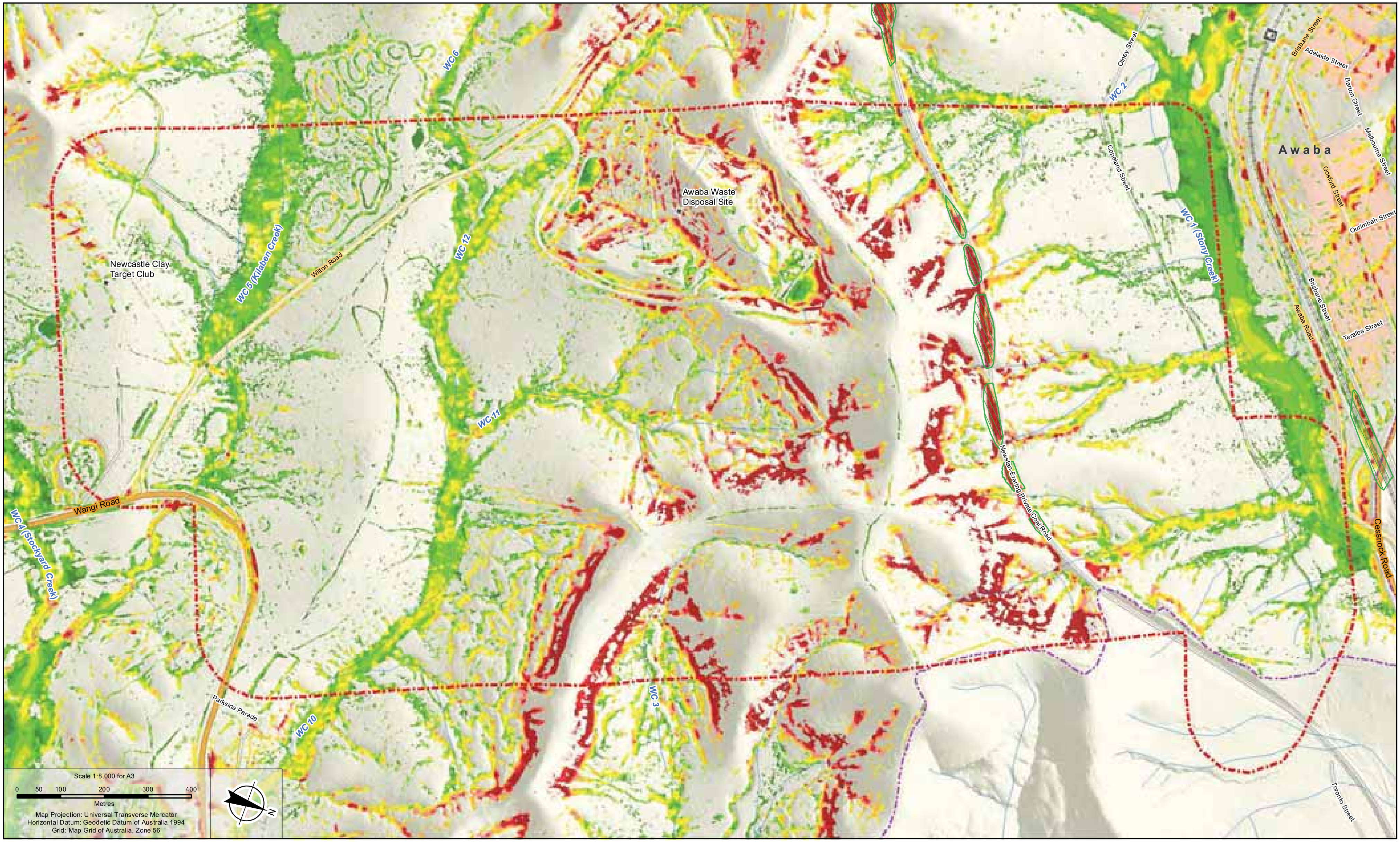

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 10 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E9

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\002_Newstan_Maps_8K_Mapbook.mxd

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- Arterial road
- Distributor road
- Local road
- Watercourse
- SMP study area
- Builtup area

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain.

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 2 year ARI Velocity Plot - zoomed in on SMP Study Area

Centennial Newstan

Date: 30/04/2012

App. E10

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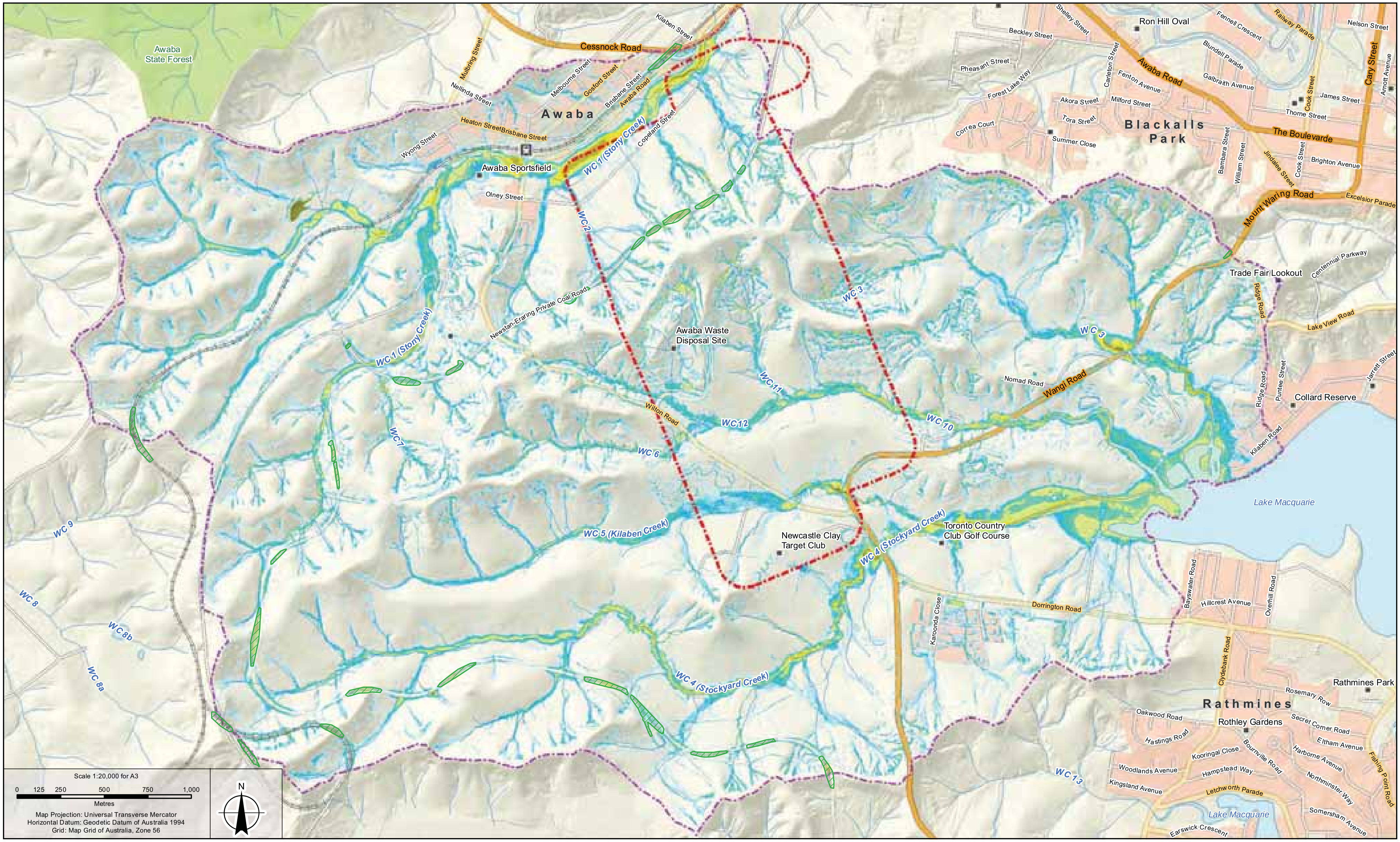

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. E11

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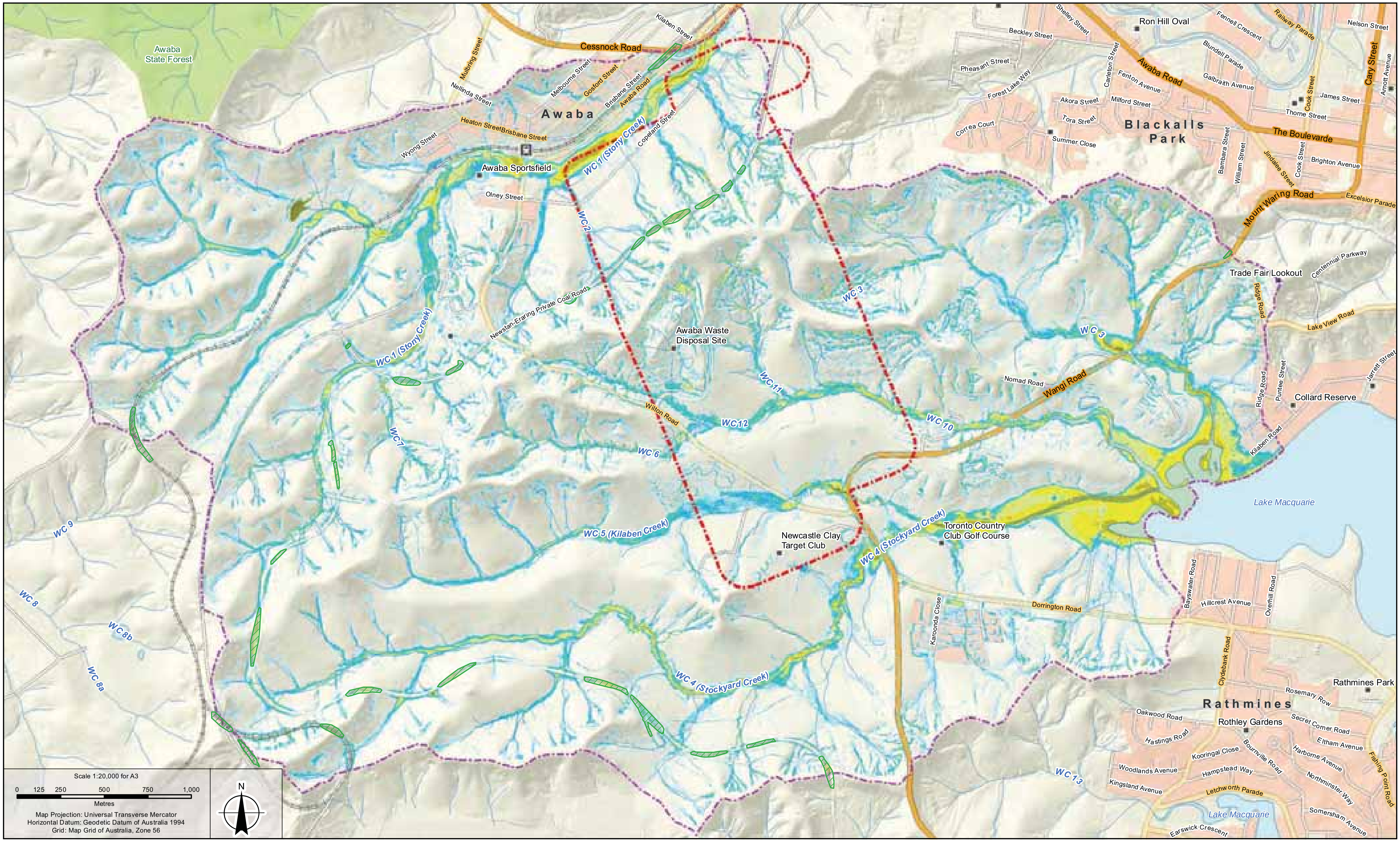

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20, 0.20 - 0.40, 0.40 - 0.60, 0.60 - 0.80, 0.80 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 100 year ARI with alternate tailwater Depth Plot

Centennial Newstan

Date: 30/04/2012

App. E12

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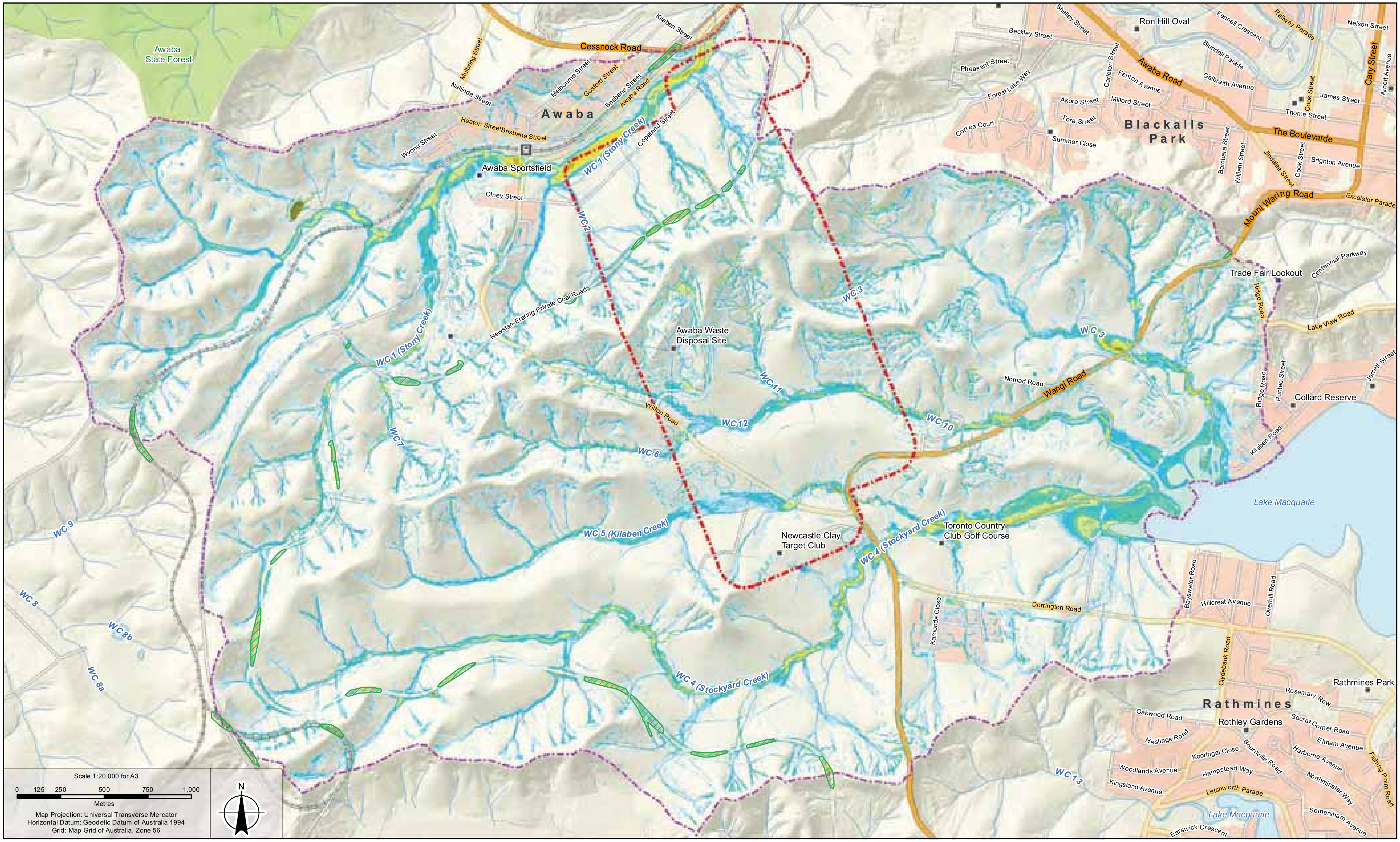

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 20 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. E13

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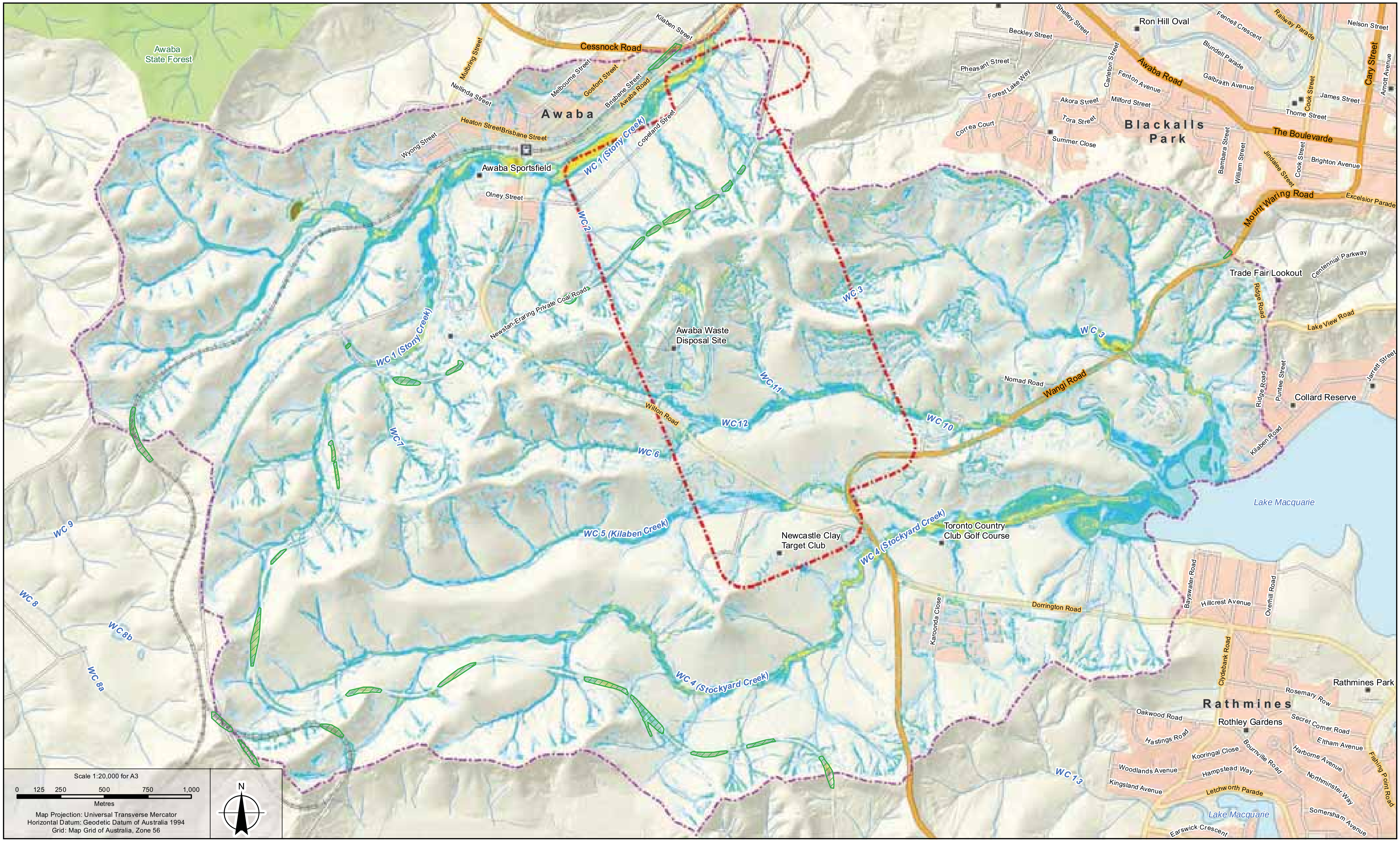

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m)

< 0.20 | 0.20 - 0.40 | 0.40 - 0.60 | 0.60 - 0.80 | 0.80 - 1.00 | 1.00 - 1.50 | 1.50 - 2.00 | 2.00 - 2.50 | >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 10 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. E14

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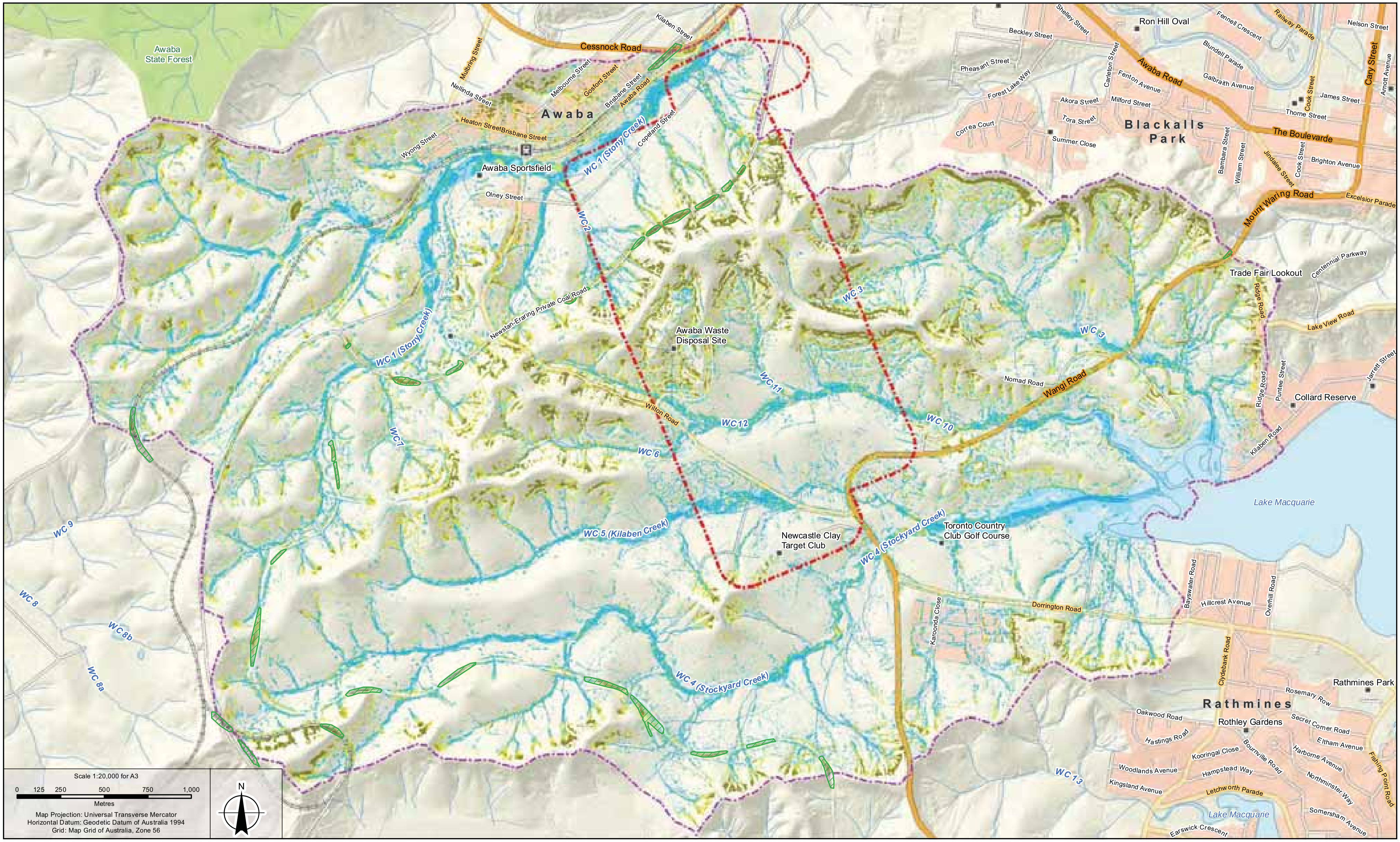

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Depth (m): < 0.20; 0.20 - 0.40; 0.40 - 0.60; 0.60 - 0.80; 0.80 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; >2.50

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

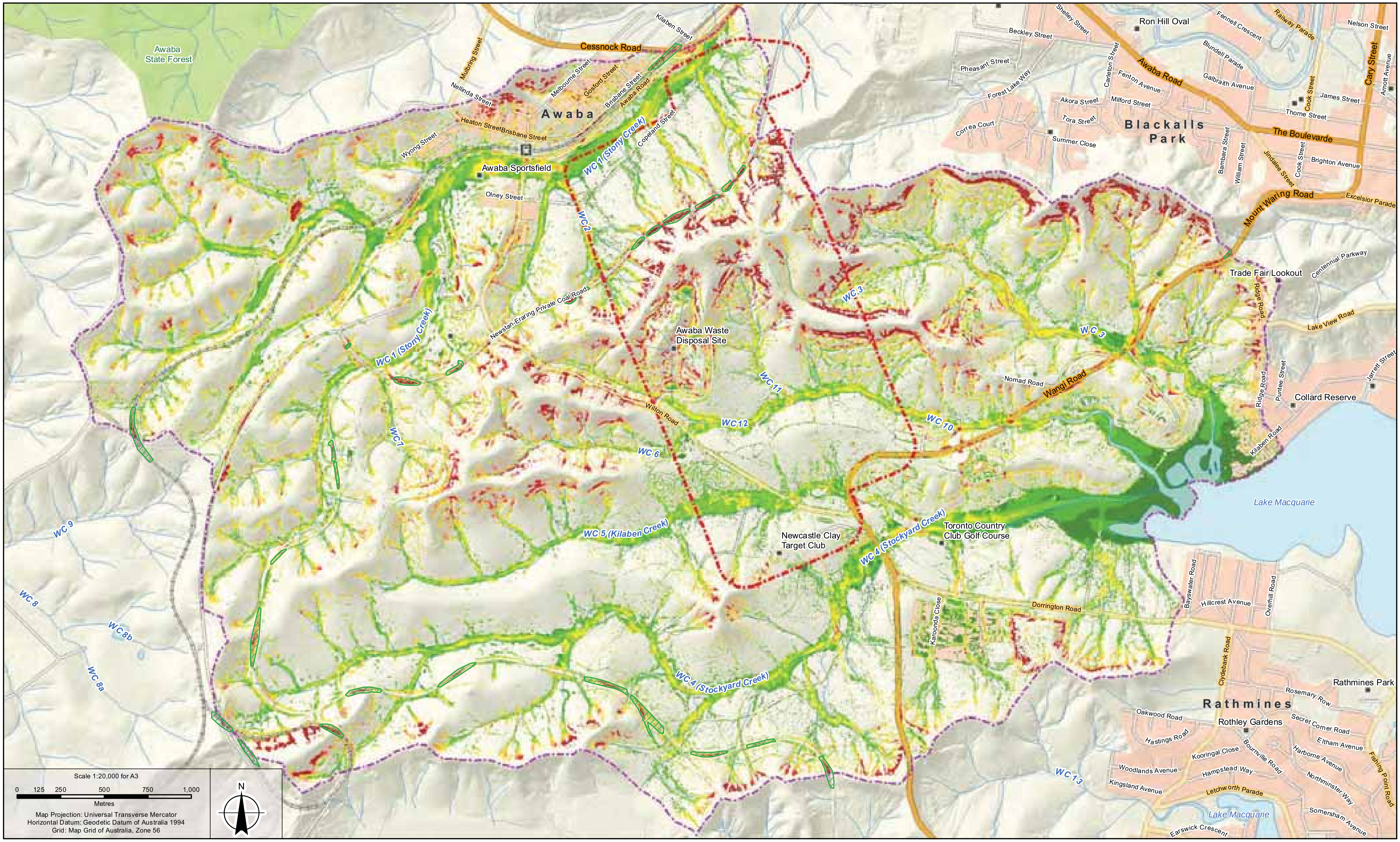
'Subsided' Scenario 2 year ARI Depth Plot

Centennial Newstan

Date: 30/04/2012

App. E15

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

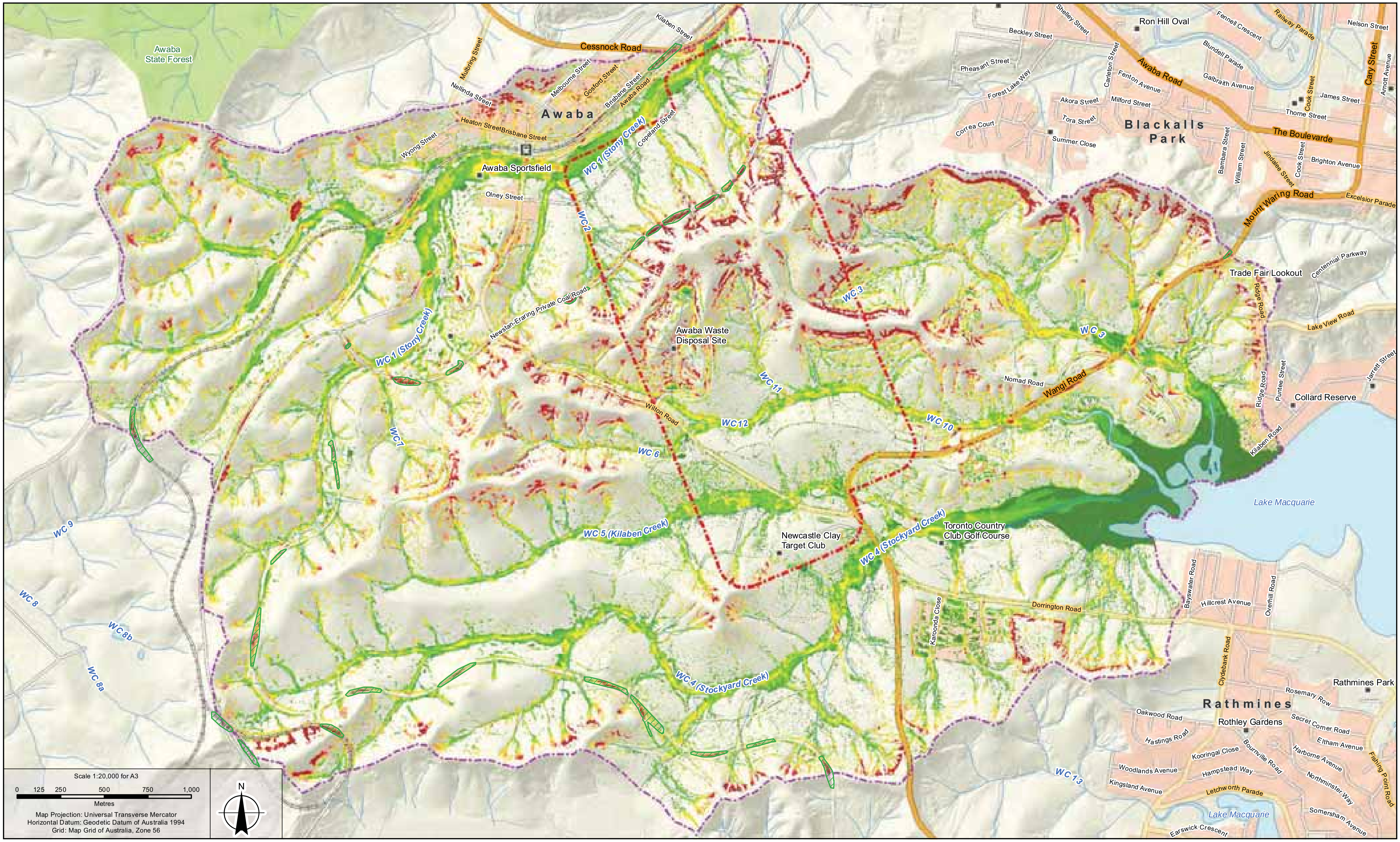
'Subsided' Scenario 100 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. E16

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

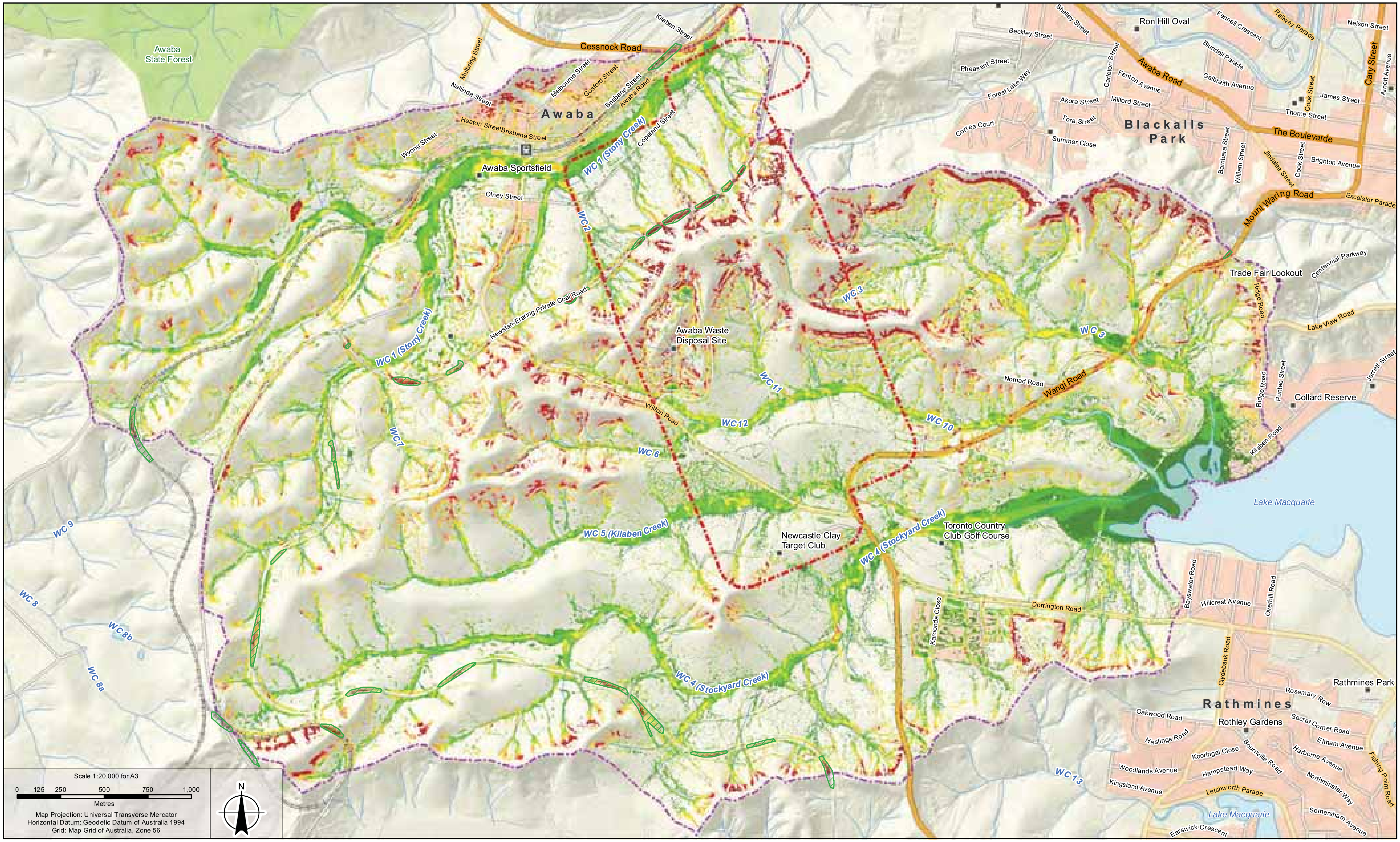
'Subsided' Scenario 100 year ARI with alternate tailwater Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. E17

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



GHD

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s)

< 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | 1.00 - 1.50 | 1.500 - 2.00 | 2.000 - 2.50 | 2.50 - 3.00 | >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

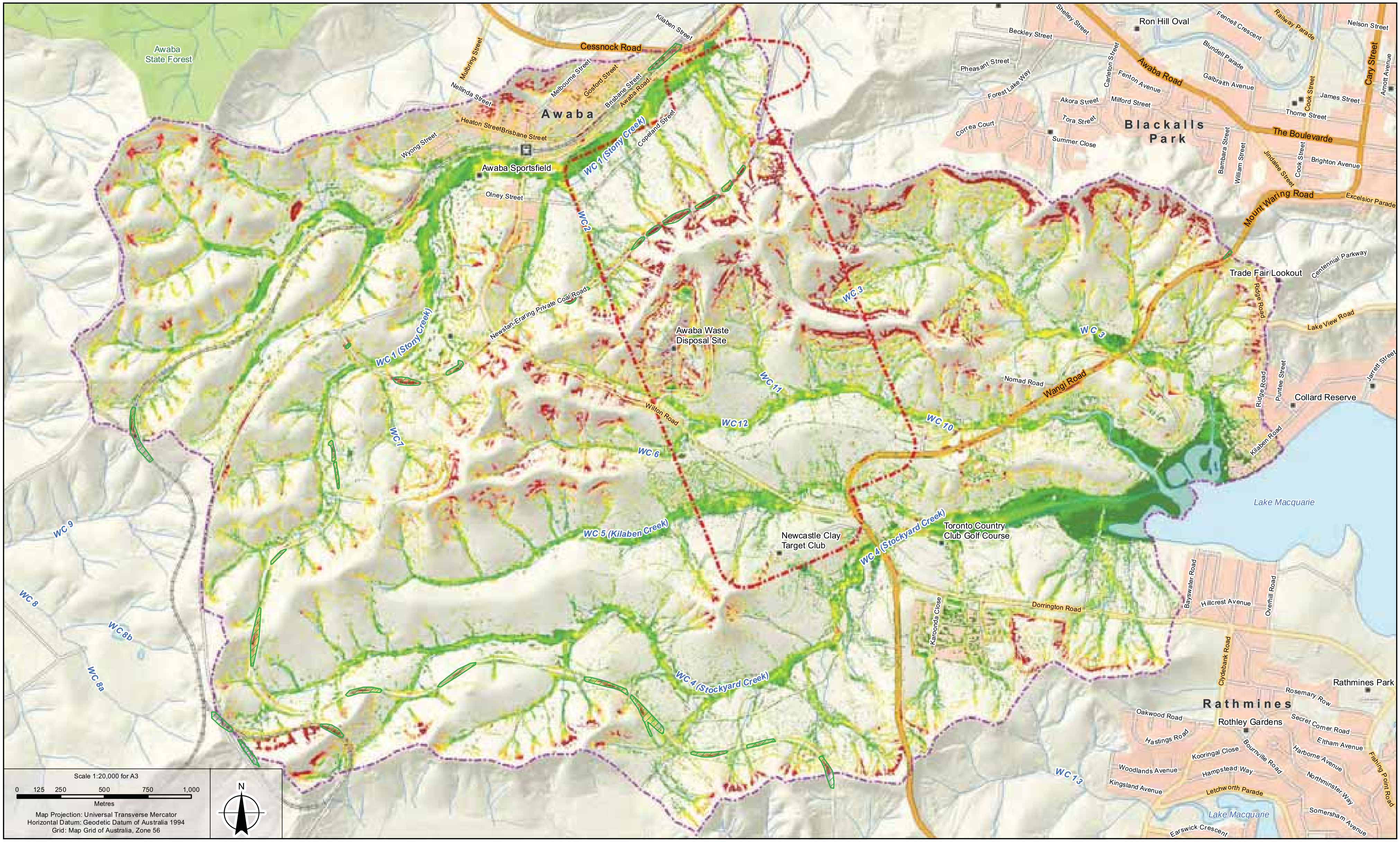
'Subsided' Scenario 20 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. E18

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

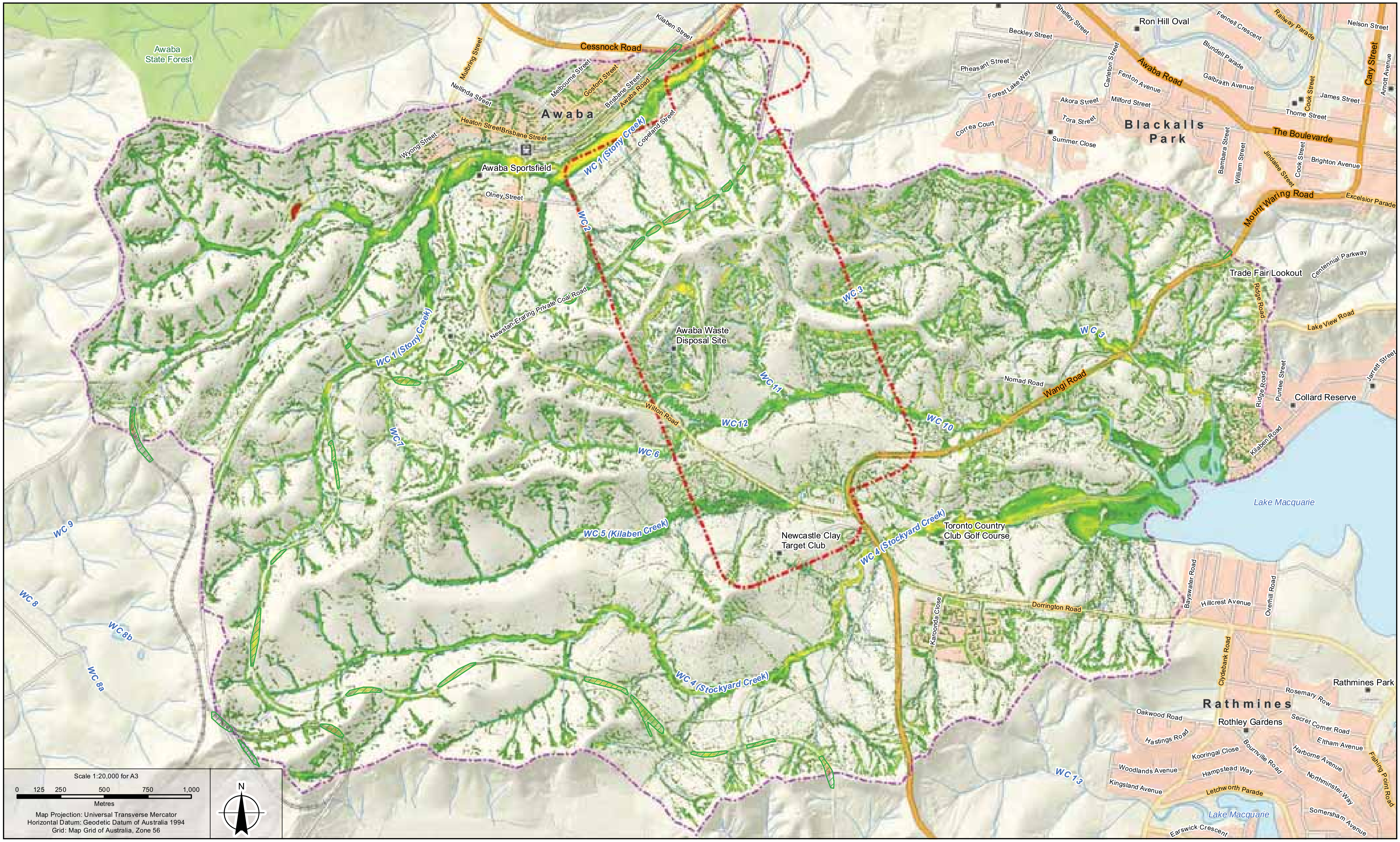
'Subsided' Scenario 10 year ARI Velocity Plot

Centennial Newstan

Date: 30/04/2012

App. E19

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest

Velocity (m/s): < 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; 1.00 - 1.50; 1.500 - 2.00; 2.000 - 2.50; 2.50 - 3.00; >3.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

'Subsided' Scenario 2 year ARI Velocity Plot

Centennial Newstan

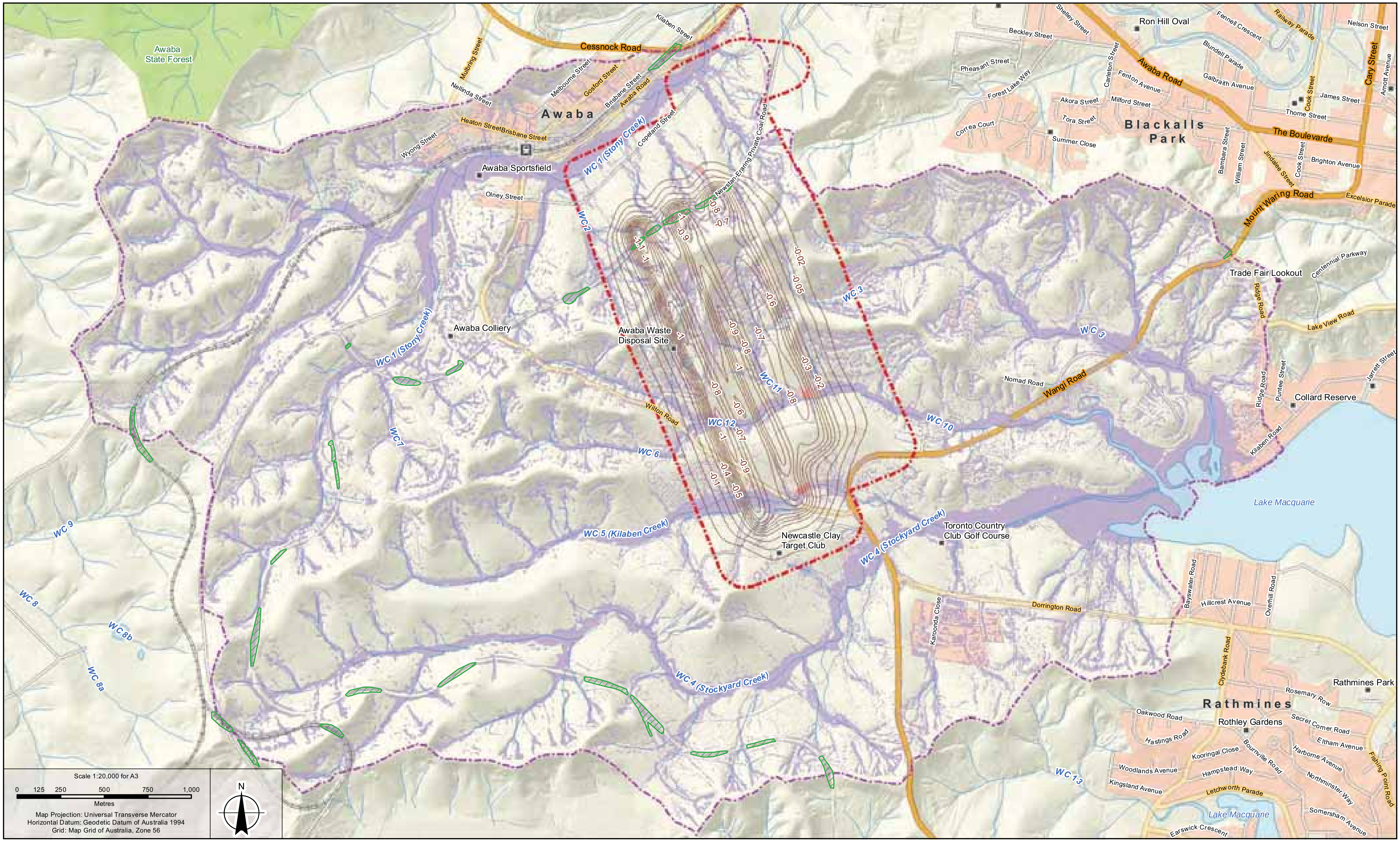
Date: 30/04/2012

App. E20

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd

Appendix F

Hydraulic Modelling Results – Overall Afflux Plots



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in depth (m)

< -0.5; -0.50 - -0.35; -0.35 - -0.20; -0.20 - -0.10; -0.10 - 0.10; 0.10 - 0.20; 0.20 - 0.35; 0.35 - 0.50; >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

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LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

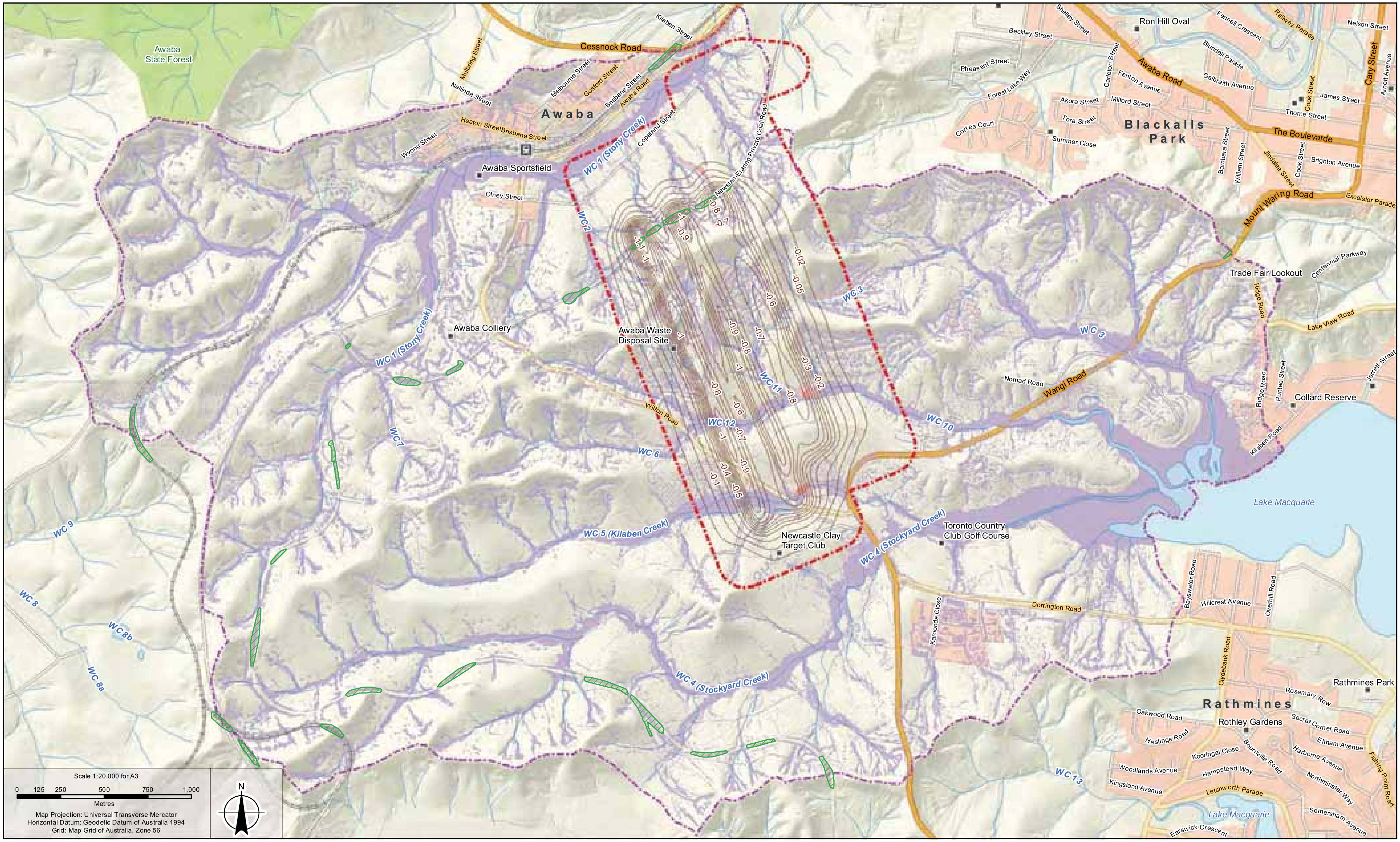
SMP Study Area 100 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F1

GIS Filename: G:\22\15922\00\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in depth (m)

< -0.5 | -0.50 - -0.35 | -0.35 - -0.20 | -0.20 - -0.10 | -0.10 - 0.10 | 0.10 - 0.20 | 0.20 - 0.35 | 0.35 - 0.50 | >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

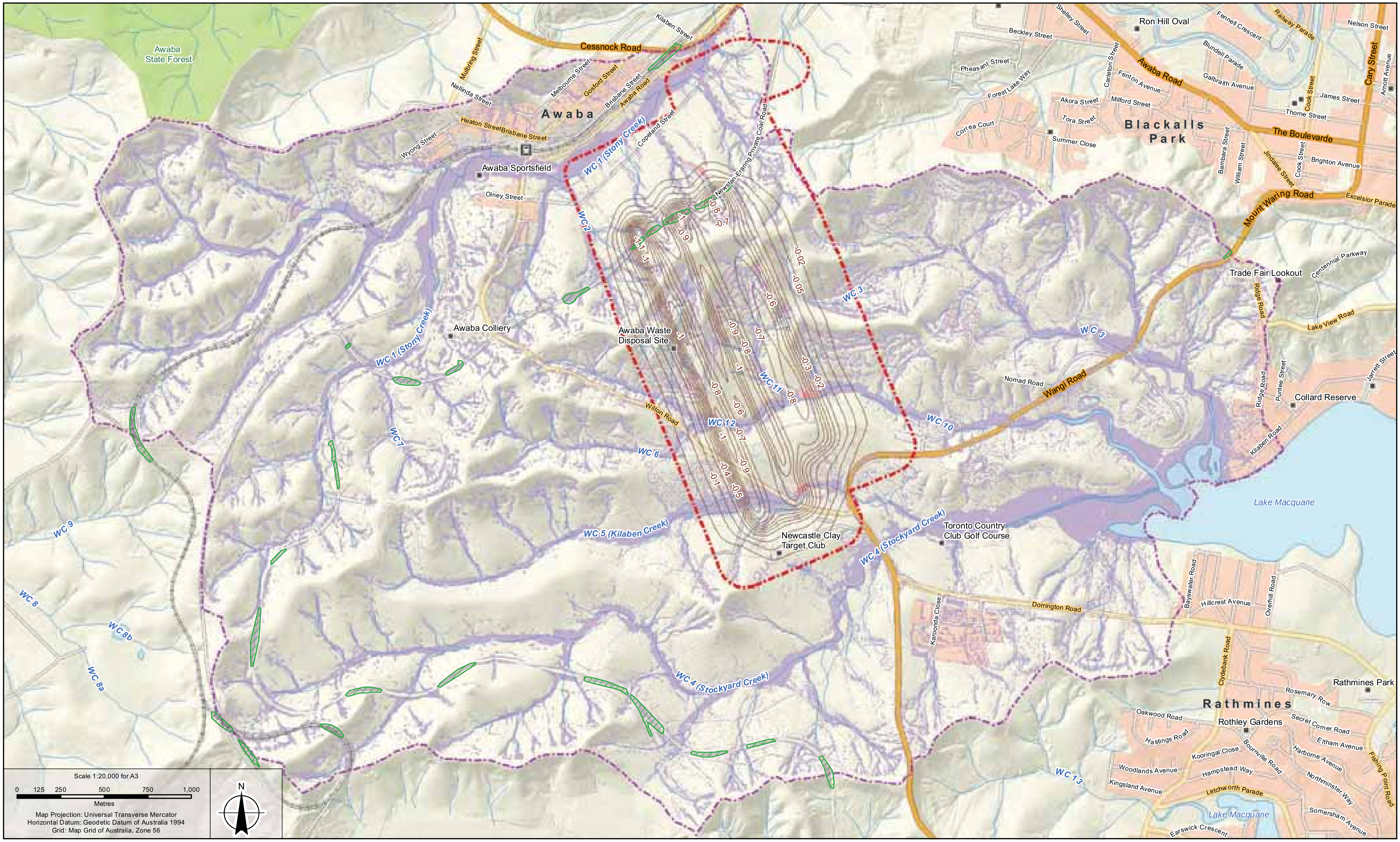
SMP Study Area 100 year ARI Depth Afflux Plot with alternate tailwater - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F2

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in depth (m)

< -0.5, -0.50 - -0.35, -0.35 - -0.20, -0.20 - -0.10, -0.10 - 0.10, 0.10 - 0.20, 0.20 - 0.35, 0.35 - 0.50, >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 20 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F3

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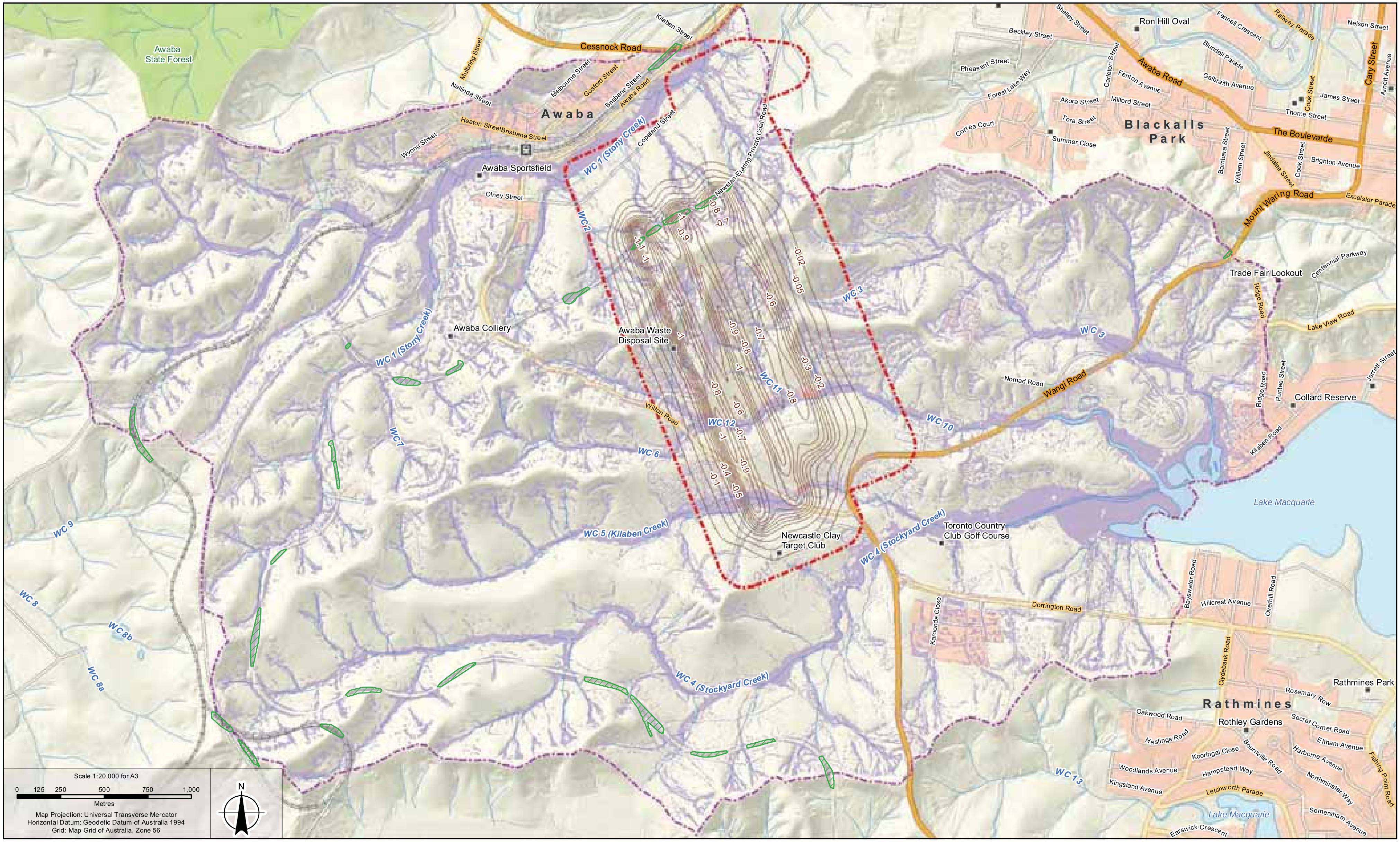

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in depth (m)

< -0.5; -0.50 - -0.35; -0.35 - -0.20; -0.20 - -0.10; -0.10 - 0.10; 0.10 - 0.20; 0.20 - 0.35; 0.35 - 0.50; >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 10 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F4

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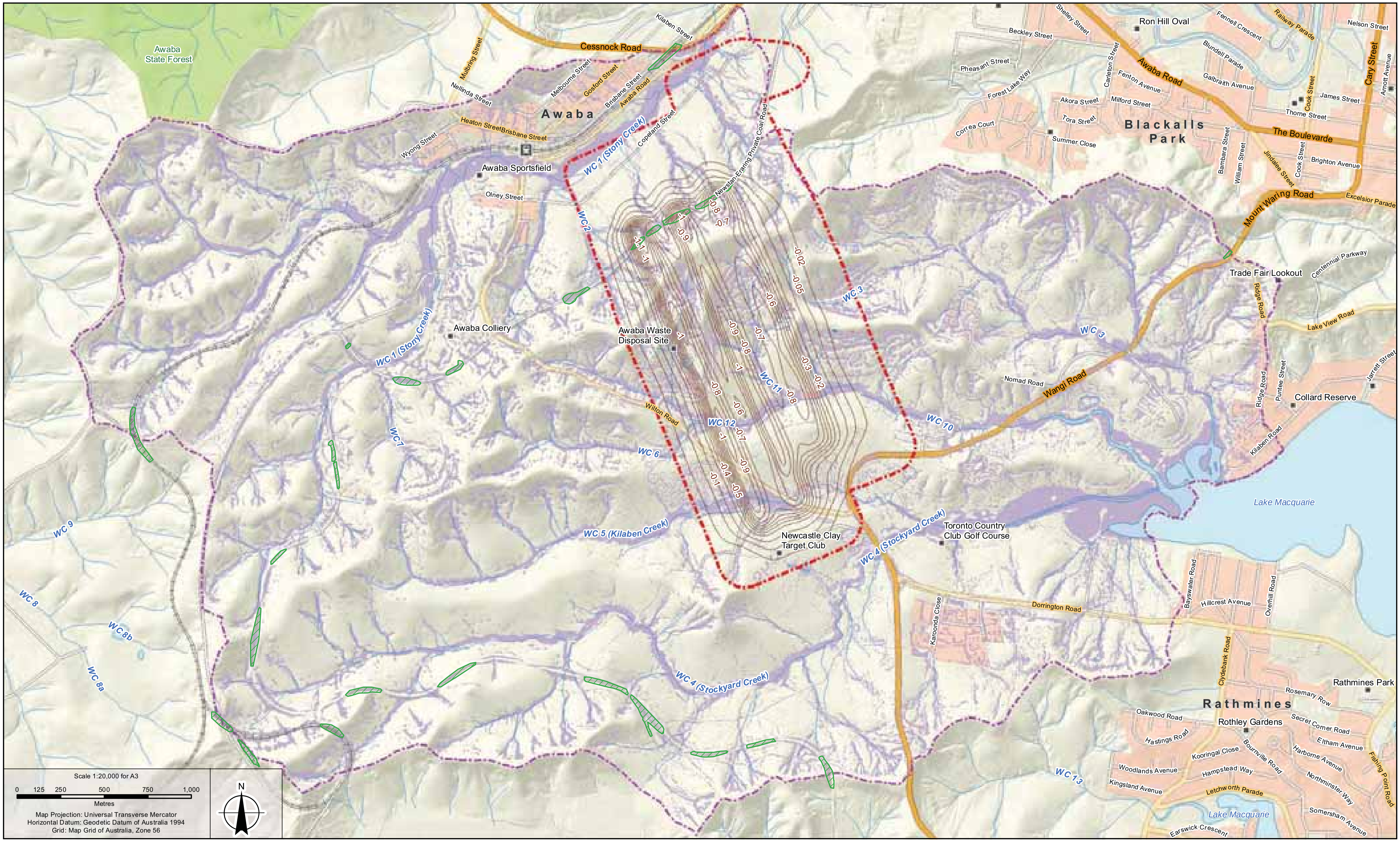

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in depth (m)

< -0.5, -0.50 - -0.35, -0.35 - -0.20, -0.20 - -0.10, -0.10 - 0.10, 0.10 - 0.20, 0.20 - 0.35, 0.35 - 0.50, >0.5

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 2 year ARI Depth Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F5

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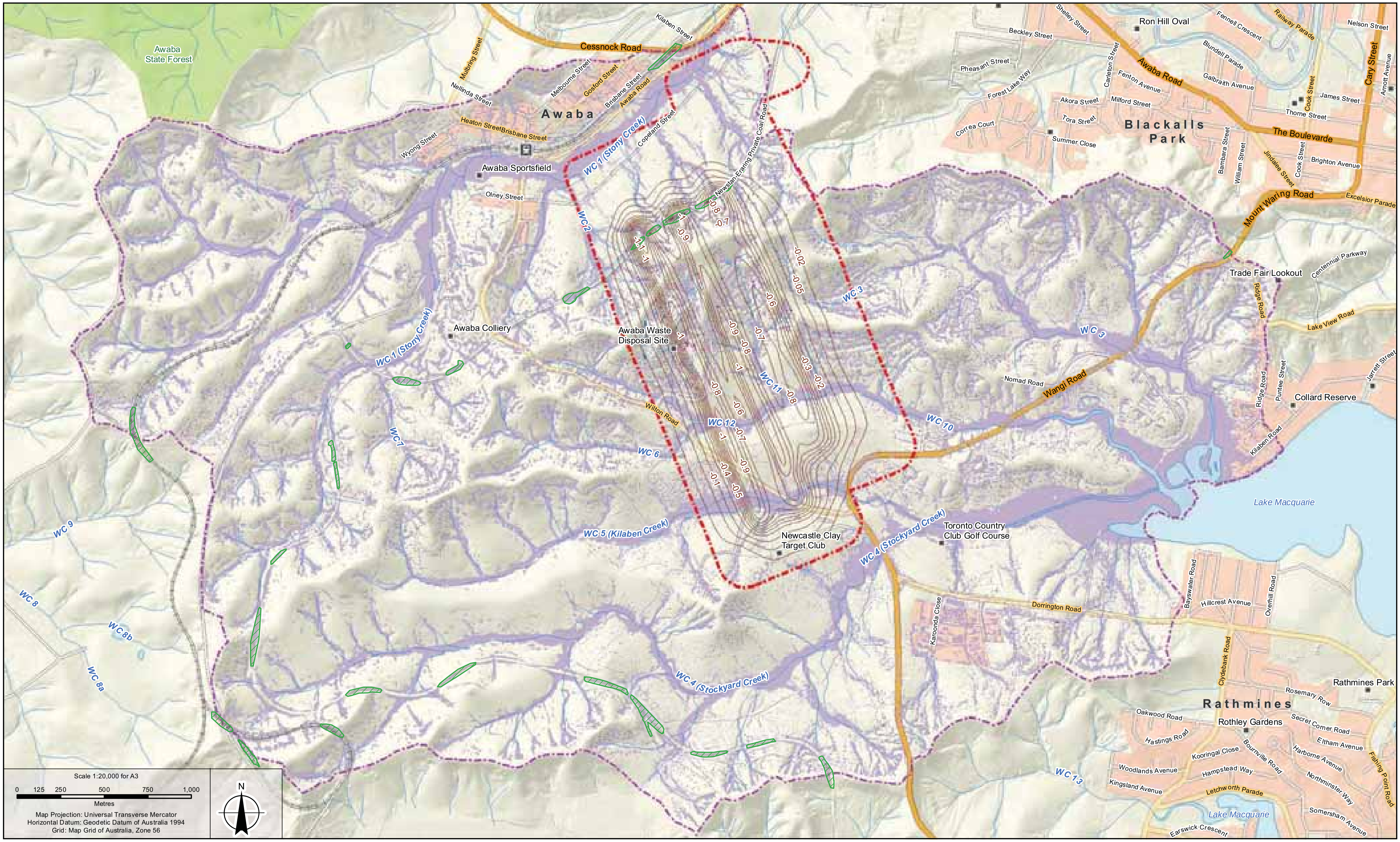


Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in velocity (m/s)

< -1.00 | -1.00 - -0.75 | -0.75 - -0.5 | -0.50 - -0.25 | -0.25 - 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

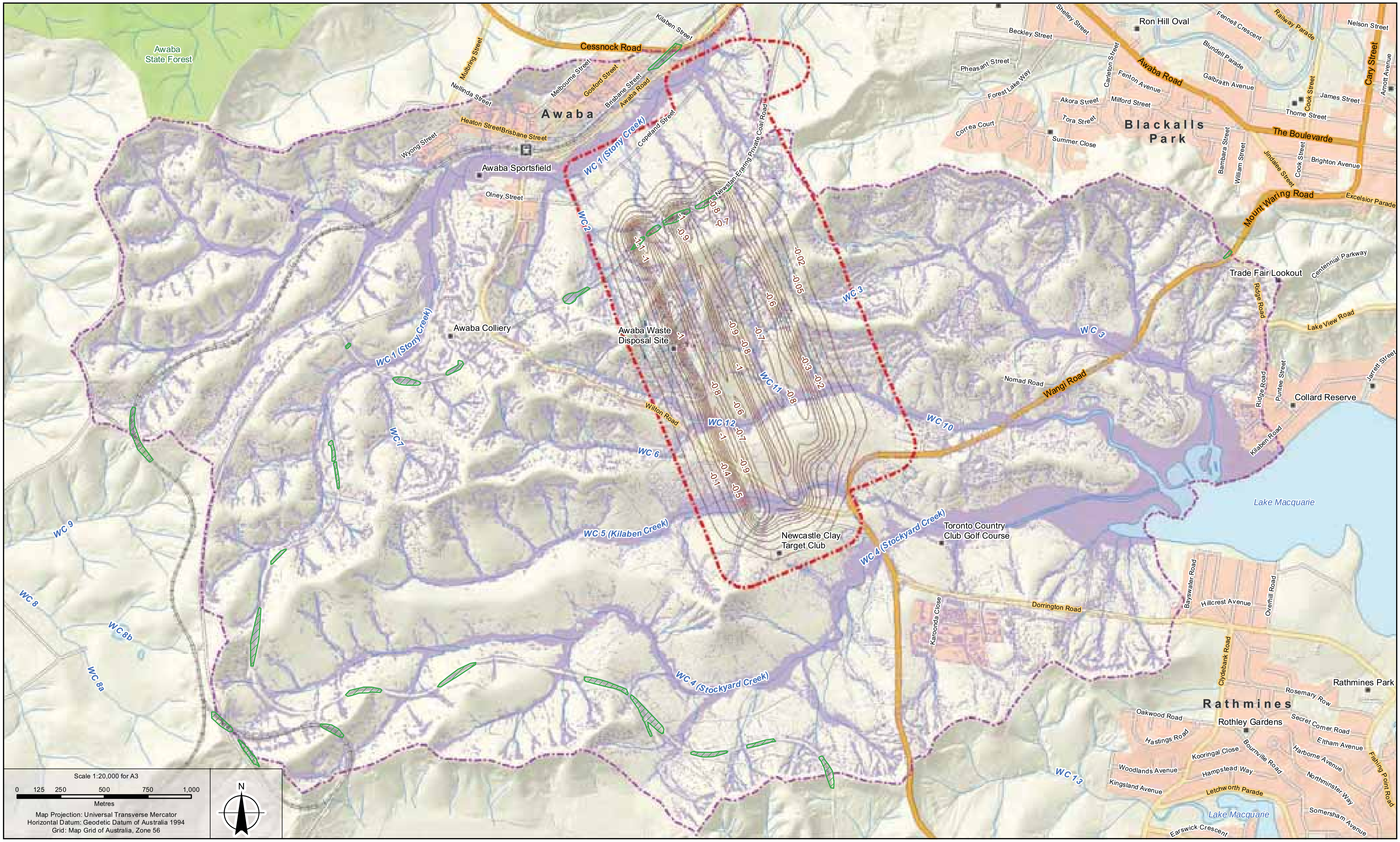
SMP Study Area 100 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F6

GIS Filename: G:\22\1592200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in velocity (m/s)

< -1.00; -1.00 - -0.75; -0.75 - -0.5; -0.50 - -0.25; -0.25 - 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 100 year ARI Velocity Afflux Plot with alternate tailwater - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F7

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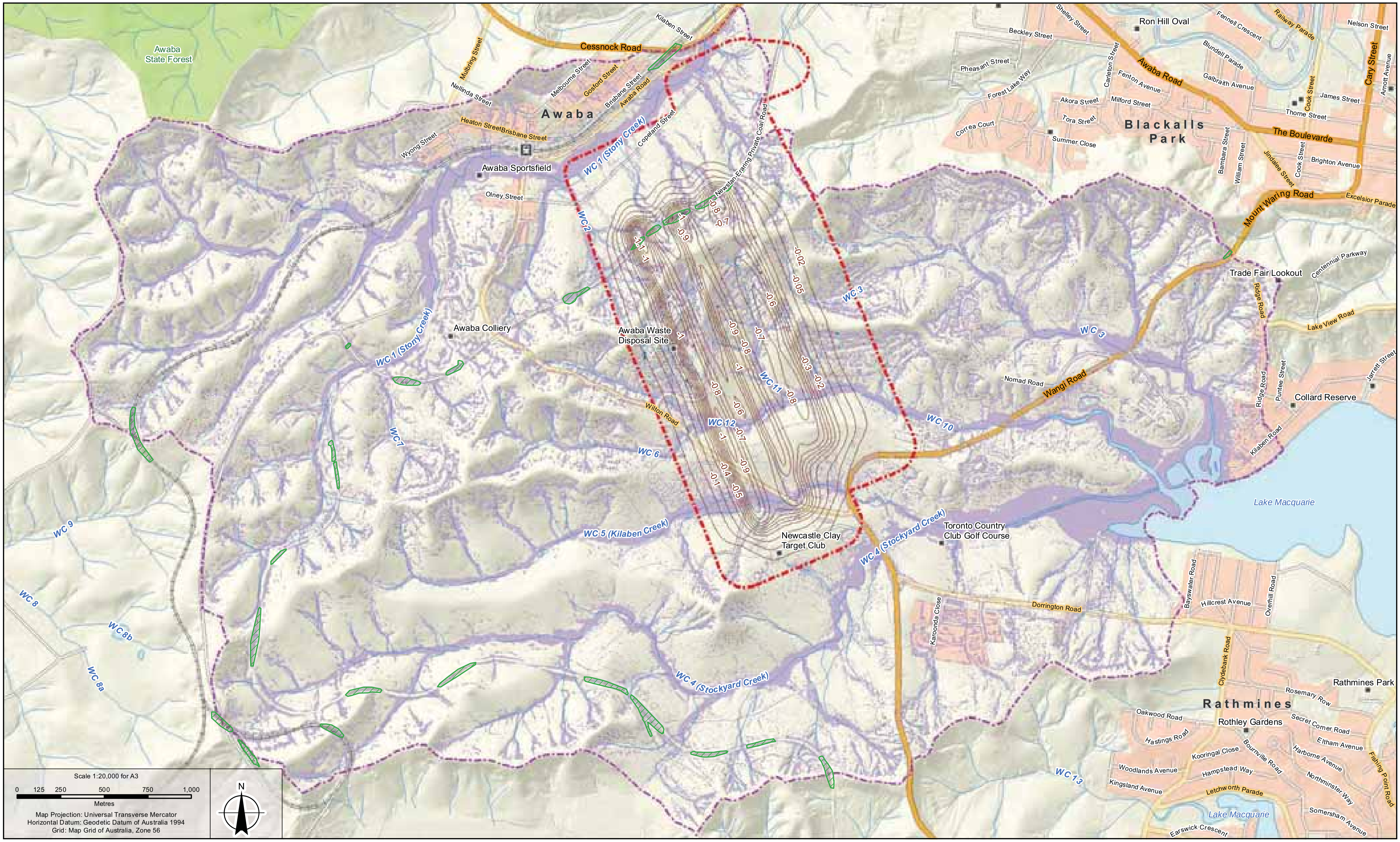

Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in velocity (m/s)

< -1.00; -1.00 - -0.75; -0.75 - -0.5; -0.50 - -0.25; -0.25 - 0.25; 0.25 - 0.50; 0.50 - 0.75; 0.75 - 1.00; >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 20 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F8

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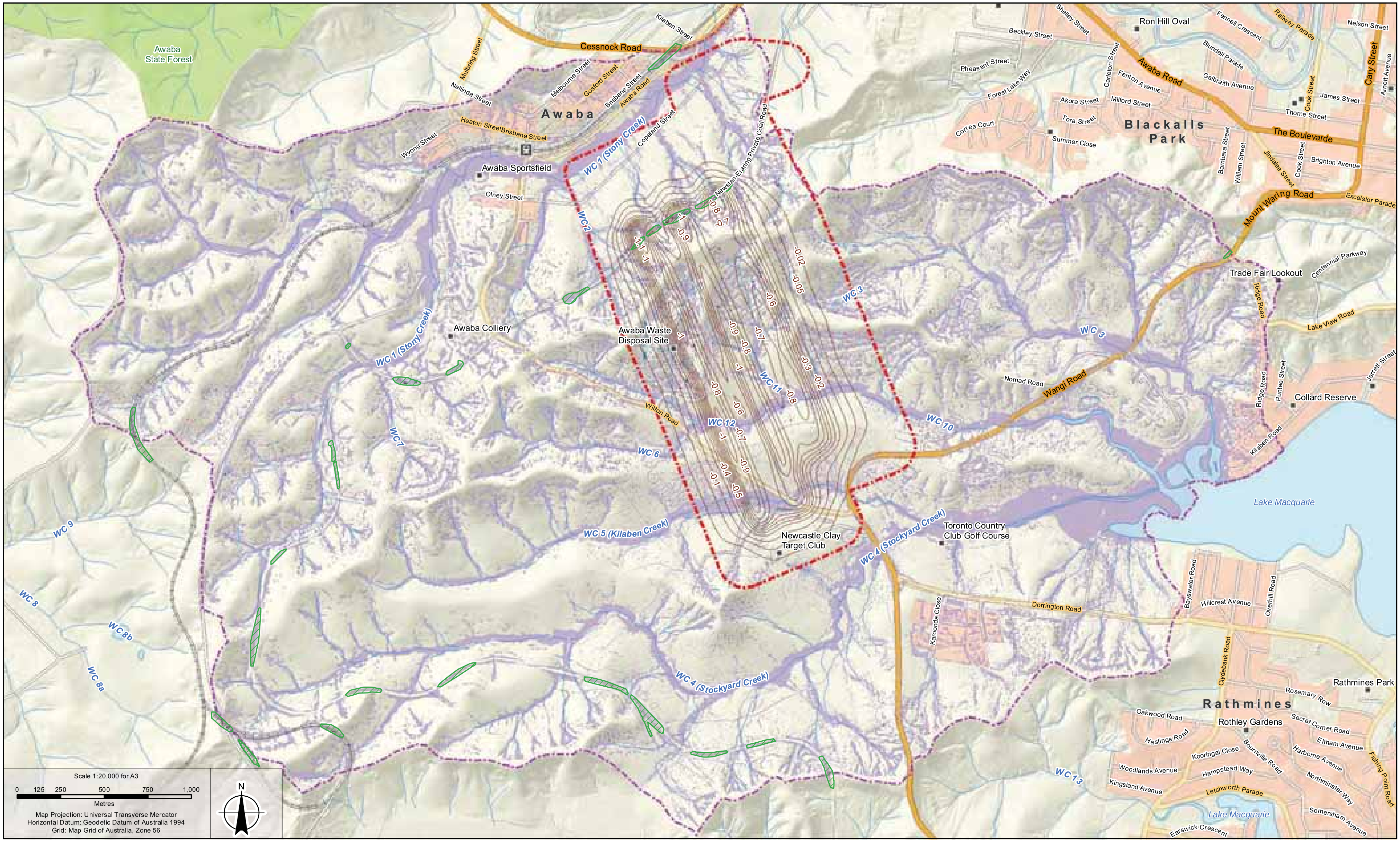


Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in velocity (m/s)

< -1.00, -1.00 - -0.75, -0.75 - -0.5, -0.50 - -0.25, -0.25 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

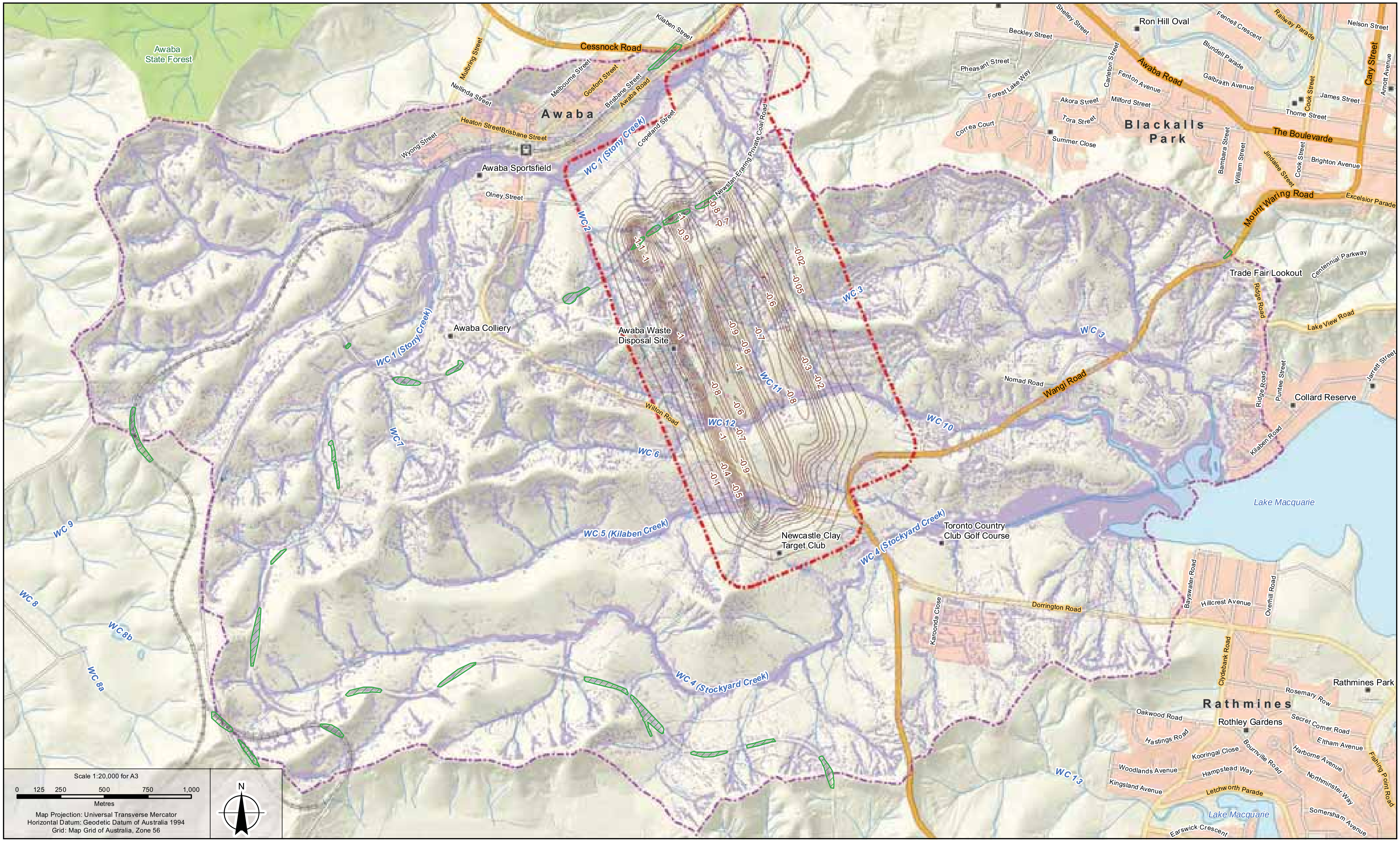
SMP Study Area 10 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F9

GIS Filename: G:\22\15922200\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd



Legend

- Feature of interest
- Train station
- Railway
- Hydraulic model extent
- Area of model limitation*
- SMP study area
- Arterial road
- Distributor road
- Local road
- Watercourse
- Waterbody
- Builtup area
- State forest
- Subsidence contour

Change in velocity (m/s)

< -1.00 | -1.00 - -0.75 | -0.75 - -0.5 | -0.50 - -0.25 | -0.25 - 0.25 | 0.25 - 0.50 | 0.50 - 0.75 | 0.75 - 1.00 | >1.00

* Results in this area are locally unreliable due to the underlying workings and resolution of the model and the steep terrain

This data should be read in conjunction with the latest revision of the Report entitled "Hydraulic Assessment Report - Newstan Subsidence Management Plan LW 101-103" and is subject to the assumptions and qualifications contained therein. If the report is yet to be issued, these assumptions and qualifications must be confirmed by reference to GHD Pty. Ltd.

LOCATION	Newstan
SEAM	Yard, Young Wallsend
DRAWN	KK
CHECKED	- - -
APPROVED	- - -
SCALE	Refer to scalebar

Newstan Subsidence Management Plan
Hydraulic Assessment Report

SMP Study Area 2 year ARI Velocity Afflux Plot - 'Subsided' Scenario - 'Existing' Scenario

Centennial Newstan

Date: 30/04/2012

App. F10

GIS Filename: G:\22\15922000\GIS\Maps\Deliverables\001_Newstan_Maps_20K_Mapbook.mxd

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GHD

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

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Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	P.Woodman	G.Hay	[signature]	M Williamson	[signature]	01/05/12

Centennial Coal

Centennial Coal Company Limited
P O Box 1000
Toronto NSW 2283
www.centennialcoal.com.au

Appendix C

Hydraulic Geomorphic Assessment

Longsections

Details

www.ghd.com.au
Tel. 02 4979 9999 Fax. 02 4979 9988
Level 3, 24 Honeysuckle Drive, Newcastle

Hydraulic Results

Refer to Figures 7-2 and 7-3 for hydraulic section locations

				3- Month ARI Event				1-Year ARI Event				2-Year ARI Event			
Watercourse	Hydraulic Section River Station	Minimum Channel Elevation (mAHD) Existing	Minimum Channel Elevation (mAHD) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided
WC5 (Kilaben Creek)	2871	16.27	16.26	16.74	16.73	0.41	0.41	16.84	16.83	0.48	0.48	16.90	16.89	0.56	0.56
WC5 (Kilaben Creek)	2835	16.13	16.11	16.36	16.34	0.43	0.43	16.43	16.41	0.41	0.42	16.48	16.46	0.43	0.43
WC5 (Kilaben Creek)	2800	15.62	15.60	15.94	15.91	0.35	0.36	16.03	16.00	0.41	0.41	16.09	16.06	0.46	0.47
WC5 (Kilaben Creek)	2770	15.43	15.39	15.76	15.71	0.27	0.29	15.82	15.77	0.30	0.32	15.87	15.81	0.33	0.35
WC5 (Kilaben Creek)	2711	14.82	14.73	15.03	14.95	0.44	0.41	15.08	15.00	0.45	0.41	15.12	15.04	0.46	0.43
WC5 (Kilaben Creek)	2676	14.16	14.05	14.47	14.34	0.45	0.48	14.57	14.43	0.47	0.49	14.64	14.48	0.44	0.50
WC5 (Kilaben Creek)	2650	13.89	13.71	14.31	14.08	0.30	0.35	14.37	14.15	0.35	0.36	14.41	14.20	0.40	0.39
WC5 (Kilaben Creek)	2606	13.59	13.05	13.68	13.08	0.78	0.80	13.75	13.12	0.59	0.86	13.80	13.15	0.52	0.96
WC5 (Kilaben Creek)	2524	12.26	11.34	12.70	11.81	0.33	0.28	12.80	11.90	0.42	0.37	12.87	11.98	0.46	0.41
WC5 (Kilaben Creek)	2505	12.24	11.33	12.64	11.77	0.27	0.21	12.72	11.85	0.32	0.26	12.78	11.91	0.36	0.29
WC5 (Kilaben Creek)	2481	12.35	11.49	12.50	11.69	0.31	0.25	12.56	11.76	0.37	0.30	12.61	11.81	0.41	0.32
WC5 (Kilaben Creek)	2469	12.05	11.28	12.38	11.61	0.25	0.23	12.44	11.67	0.31	0.27	12.49	11.73	0.35	0.31
WC5 (Kilaben Creek)	2451	11.75	11.05	12.01	11.31	0.68	0.58	12.07	11.35	0.65	0.63	12.10	11.38	0.77	0.74
WC5 (Kilaben Creek)	2402	10.98	10.28	11.45	10.76	0.24	0.24	11.54	10.85	0.26	0.27	11.60	10.91	0.30	0.30
WC5 (Kilaben Creek)	2392	11.02	10.33	11.35	10.69	0.76	0.57	11.43	10.76	0.73	0.65	11.48	10.81	0.68	0.65
WC5 (Kilaben Creek)	2380	10.92	10.26	11.17	10.51	0.31	0.34	11.24	10.59	0.38	0.36	11.29	10.64	0.42	0.41
WC5 (Kilaben Creek)	2356	10.37	9.76	10.59	10.01	1.04	0.67	10.67	10.05	1.01	0.89	10.73	10.11	0.96	0.89
WC5 (Kilaben Creek)	2319	9.89	9.26	10.20	9.53	0.28	0.33	10.33	9.68	0.33	0.34	10.46	9.81	0.35	0.34
WC5 (Kilaben Creek)	2270	9.49	8.79	9.90	9.31	0.57	0.40	10.08	9.49	0.65	0.50	10.24	9.65	0.67	0.55
WC5 (Kilaben Creek)	2242	8.29	7.53	8.57	7.95	0.46	1.54	8.84	8.10	1.90	1.78	8.90	8.21	2.48	1.98
WC5 (Kilaben Creek)	2196	7.10	6.29	8.11	7.48	0.35	0.25	8.36	7.76	0.44	0.31	8.55	7.94	0.51	0.38
WC5 (Kilaben Creek)	2138	7.06	6.52	7.58	7.33	1.64	0.68	7.91	7.60	1.19	0.68	8.15	7.78	0.98	0.69
WC5 (Kilaben Creek)	2088	6.15	5.92	7.32	7.20	0.48	0.41	7.47	7.34	0.78	0.65	7.62	7.49	0.96	0.79
WC5 (Kilaben Creek)	2041	6.03	5.90	7.29	7.17	0.21	0.20	7.39	7.27	0.36	0.35	7.48	7.36	0.48	0.47
WC5 (Kilaben Creek)	2029	7.03	6.92	7.22	7.11	0.89	0.91	7.27	7.16	1.13	1.13	7.32	7.20	1.30	1.30
WC5 (Kilaben Creek)	1984	4.41	4.34	5.47	5.45	0.48	0.44	5.76	5.74	0.63	0.58	6.00	5.98	0.73	0.69
WC5 (Kilaben Creek)	1945	4.41	4.36	5.41	5.40	0.36	0.34	5.68	5.67	0.47	0.45	5.92	5.91	0.54	0.51
WC5 (Kilaben Creek)	1910	4.47	4.45	5.35	5.35	0.47	0.45	5.59	5.59	0.64	0.61	5.81	5.82	0.75	0.73
WC5 (Kilaben Creek)	1870	4.32	4.30	4.78	4.76	0.59	0.59	4.96	4.95	0.74	0.73	5.10	5.08	0.85	0.85
WC12	3503	26.21	26.18	26.65	26.61	0.50	0.50	26.78	26.74	0.64	0.64	26.85	26.81	0.73	0.73
WC12	3478	26.07	26.02	26.39	26.33	0.49	0.52	26.49	26.43	0.58	0.60	26.55	26.50	0.63	0.65
WC12	3444	25.52	25.45	25.82	25.75	0.67	0.66	25.92	25.85	0.78	0.79	25.99	25.92	0.84	0.85
WC12	3403	24.93	24.86	25.28	25.19	0.46	0.47	25.37	25.28	0.61	0.61	25.43	25.34	0.69	0.71
WC12	3371	24.21	24.07	24.52	24.38	1.10	1.10	24.62	24.48	1.07	1.18	24.68	24.55	1.16	1.20
WC12	3359	23.38	23.22	24.15	23.98	0.59	0.61	24.31	24.14	0.77	0.81	24.40	24.23	0.87	0.91
WC12	3342	23.48	23.29	23.83	23.64	1.04	1.03	23.91	23.72	1.27	1.28	23.98	23.79	1.34	1.36
WC12	3323	22.60	22.31	23.36	23.01	0.61	0.76	23.50	23.15	0.68	0.90	23.58	23.24	0.75	0.93
WC12	3309	22.80	22.45	23.29	22.90	0.37	0.47	23.42	23.02	0.47	0.56	23.49	23.12	0.56	0.62
WC12	3245	22.08	21.35	22.53	21.80	0.88	0.97	22.63	21.90	0.90	1.03	22.73	21.95	0.73	1.13
WC12	3196	21.17	20.17	22.00	21.02	0.43	0.41	22.15	21.17	0.57	0.54	22.25	21.27	0.65	0.62
WC12	3170	21.31	20.34	21.88	20.92	0.46	0.41	22.01	21.06	0.54	0.47	22.09	21.14	0.59	0.53
WC12	3152	21.36	20.39	21.78	20.84	0.43	0.41	21.89	20.95	0.51	0.50	21.96	21.03	0.57	0.56
WC12	3138	21.22	20.30	21.48	20.57	0.96	0.97	21.55	20.65	1.16	1.17	21.61	20.70	1.27	1.29
WC12	3125	19.93	19.17	20.97	20.23	0.45	0.44	21.15	20.40	0.67	0.58	21.27	20.51	0.75	0.62
WC12	3110	20.67	19.87	20.85	20.14	0.88	0.71	21.02	20.28	0.83	0.73	21.11	20.38	0.83	0.73
WC12	3094	20.03	19.34	20.64	19.94	0.59	0.57	20.79	20.08	0.69	0.66	20.88	20.18	0.72	0.68
WC12	3045	19.73	19.08	19.98	19.32	0.57	0.53	20.08	19.41	0.61	0.59	20.15	19.48	0.64	0.62
WC12	3005	18.81	18.11	19.51	18.79	0.41	0.45	19.64	18.92	0.50	0.56	19.72	19.01	0.55	0.61
WC12	2961	18.80	17.98	19.20	18.34	0.44	0.54	19.31	18.43	0.53	0.69	19.39	18.51	0.59	0.73
WC12	2880	18.04	17.04	18.35	17.40	0.38	0.35	18.43	17.49	0.45	0.42	18.47	17.54	0.54	0.48
WC12	2819	17.28	16.53	17.64	16.93	0.46	0.36	17.74	17.03	0.45	0.38	17.82	17.09	0.45	0.40
WC12	2795	17.17	16.47	17.53	16.83	0.22	0.22	17.65	16.93	0.26	0.27	17.73	17.00	0.28	0.30
WC12	2759	17.01	16.28	17.32	16.53	0.48	0.65	17.47	16.66	0.54	0.70	17.56	16.75	0.59	0.75
WC10	2670	16.35	15.55	16.86	16.10	0.33	0.28	17.03	16.27	0.37	0.33	17.12	16.38	0.40	0.36
WC10	2624	16.12	15.38	16.60	15.94	0.55	0.41	16.75	16.09	0.66	0.51	16.84	16.20	0.72	0.57
WC10	2596	15.92	15.29	16.41	15.83	0.37	0.31	16.54	15.98	0.47	0.40	16.63	16.08	0.54	0.45
WC10	2521	15.28	15.06	15.48	15.26	0.81	0.73	15.58	15.37	0.86	0.76	15.64	15.44	0.92	0.80
WC10	2510	15.08	14.88	15.29	15.12	0.40	0.36	15.42	15.25	0.45	0.41	15.50	15.33	0.50	0.46
WC10	2471	14.47	14.36	14.91	14.80	0.43	0.41	15.00	14.91	0.54	0.51	15.07	14.97	0.60	0.57
WC10	2421	14.01	13.94	14.40	14.34	0.39	0.38	14.52	14.47	0.43	0.42	14.60	14.55	0.47	0.46
WC10	2398	13.69	13.65	14.18	14.13	0.48	0.47	14.33	14.29	0.52	0.52	14.42	14.38	0.56	0.56
WC10	2336	12.85	12.83	13.38	13.37	0.62	0.62	13.46	13.45	0.81	0.79	13.52	13.50	0.91	0.89
WC10	2273	11.67	11.67	12.29	12.29	0.63	0.63	12.48	12.48	0.69	0.69	12.61	12.61	0.73	0.73
WC10	2237	11.09	11.09	11.91	11.91	0.79	0.79	12.16	12.16	0.83	0.83	12.32	12.32	0.84	0.84
WC10	2204	10.91	10.91	11.77	11.77	0.53	0.53	12.02	12.02	0.70	0.70	12.17	12.17	0.79	0.79
WC10	2131	10.37	10.37	11.59	11.59	0.42	0.42	11.81	11.81	0.48	0.48	11.93	11.93	0.54	0.54
WC10	2039	10.75	10.75	11.16	11.16	0.61	0.61	11.33	11.33	0.74	0.74	11.42	11.42	0.84	0.84
WC10	1997	10.21	10.21	10.71	10.71	0.64	0.64	10.90	10.90	0.68	0.68	11.01	11.01	0.71	0.71

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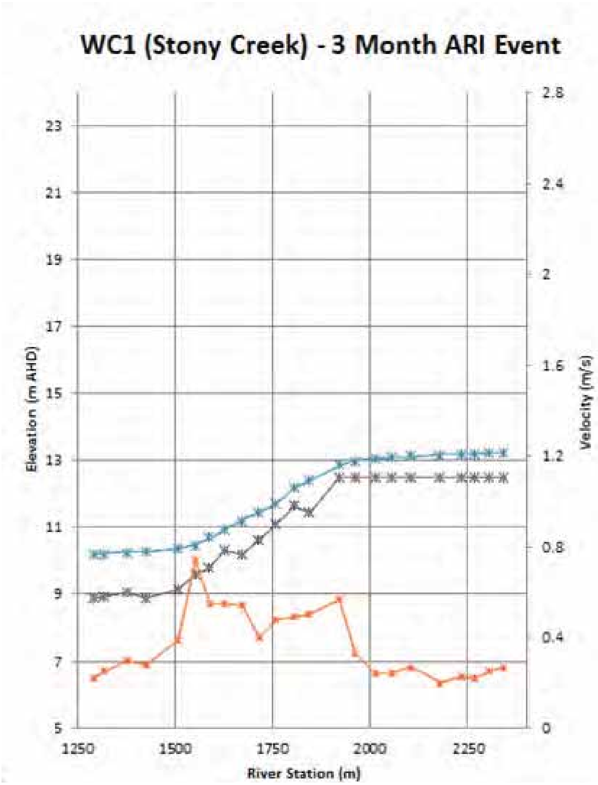
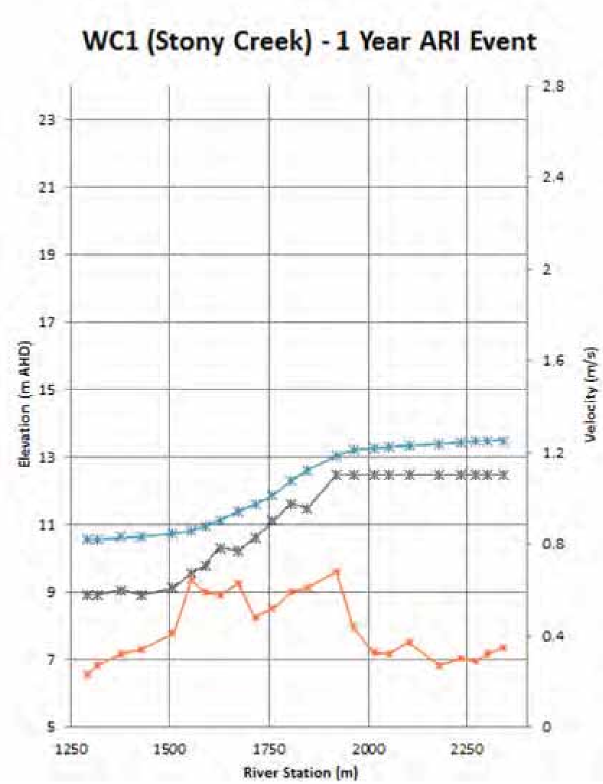
Tel. 02 4979 9999 Fax. 02 4979 9988
Level 3, 24 Honeysuckle Drive, Newcastle

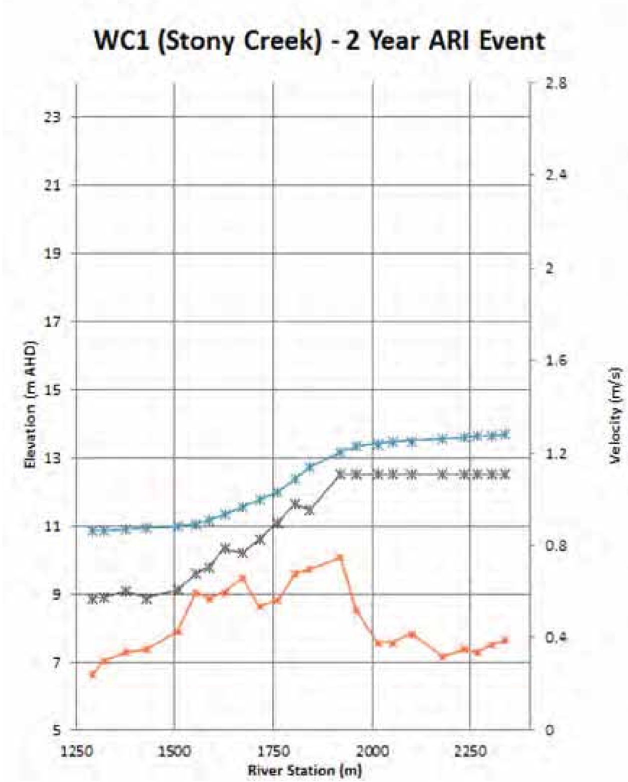
Hydraulic Results

Refer to Figures 7-2 and 7-3 for hydraulic section locations

				3- Month ARI Event				1-Year ARI Event				2-Year ARI Event			
Watercourse	Hydraulic Section River Station	Minimum Channel Elevation (mAHD) Existing	Minimum Channel Elevation (mAHD) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided	Water Level (mAHD) Existing	Water Level (mAHD) Subsided	Flow Velocity (m/s) Existing	Flow Velocity (m/s) Subsided
WC1 (Stony Creek)	2340	12.50	12.50	13.25	13.25	0.27	0.27	13.51	13.51	0.35	0.35	13.69	13.69	0.39	0.55
WC1 (Stony Creek)	2303	12.50	12.50	13.23	13.23	0.25	0.25	13.48	13.48	0.32	0.32	13.66	13.66	0.37	0.74
WC1 (Stony Creek)	2269	12.50	12.50	13.21	13.21	0.22	0.22	13.46	13.46	0.29	0.29	13.63	13.63	0.34	0.39
WC1 (Stony Creek)	2233	12.50	12.50	13.19	13.19	0.23	0.23	13.44	13.44	0.30	0.30	13.60	13.60	0.35	0.28
WC1 (Stony Creek)	2180	12.50	12.50	13.17	13.17	0.20	0.20	13.41	13.41	0.27	0.27	13.57	13.57	0.32	0.30
WC1 (Stony Creek)	2102	12.50	12.50	13.12	13.12	0.27	0.27	13.35	13.35	0.37	0.37	13.50	13.50	0.42	0.25
WC1 (Stony Creek)	2054	12.50	12.50	13.09	13.09	0.24	0.24	13.30	13.30	0.32	0.32	13.46	13.46	0.38	0.22
WC1 (Stony Creek)	2014	12.50	12.50	13.06	13.06	0.24	0.24	13.27	13.27	0.33	0.33	13.42	13.42	0.38	0.22
WC1 (Stony Creek)	1962	12.50	12.50	13.00	13.00	0.33	0.33	13.20	13.20	0.44	0.44	13.34	13.34	0.52	0.46
WC1 (Stony Creek)	1919	12.50	12.50	12.86	12.86	0.57	0.57	13.05	13.05	0.68	0.68	13.18	13.18	0.75	0.50
WC1 (Stony Creek)	1844	11.47	11.47	12.42	12.42	0.50	0.50	12.60	12.60	0.61	0.61	12.72	12.72	0.70	0.85
WC1 (Stony Creek)	1805	11.64	11.64	12.18	12.18	0.49	0.49	12.31	12.31	0.59	0.59	12.40	12.40	0.68	0.55
WC1 (Stony Creek)	1760	11.11	11.11	11.72	11.72	0.48	0.48	11.88	11.88	0.52	0.52	12.00	12.00	0.56	0.47
WC1 (Stony Creek)	1714	10.61	10.61	11.44	11.44	0.40	0.40	11.63	11.63	0.48	0.48	11.78	11.78	0.54	0.82
WC1 (Stony Creek)	1672	10.21	10.21	11.22	11.22	0.54	0.54	11.41	11.41	0.63	0.63	11.56	11.56	0.66	1.63
WC1 (Stony Creek)	1626	10.33	10.33	10.91	10.91	0.55	0.55	11.15	11.15	0.58	0.58	11.33	11.33	0.60	0.51
WC1 (Stony Creek)	1588	9.80	9.80	10.69	10.69	0.55	0.55	10.96	10.96	0.59	0.59	11.18	11.18	0.57	0.26
WC1 (Stony Creek)	1552	9.59	9.59	10.48	10.48	0.74	0.74	10.82	10.82	0.64	0.64	11.06	11.06	0.60	0.49
WC1 (Stony Creek)	1508	9.14	9.14	10.36	10.36	0.39	0.39	10.73	10.73	0.41	0.41	10.99	10.99	0.43	0.79
WC1 (Stony Creek)	1427	8.90	8.90	10.30	10.30	0.28	0.28	10.66	10.66	0.34	0.34	10.93	10.93	0.35	0.33
WC1 (Stony Creek)	1376	9.08	9.08	10.27	10.27	0.30	0.30	10.63	10.63	0.32	0.32	10.90	10.90	0.34	0.52
WC1 (Stony Creek)	1319	8.92	8.92	10.22	10.22	0.25	0.25	10.59	10.59	0.27	0.27	10.86	10.86	0.30	0.54
WC1 (Stony Creek)	1292	8.90	8.90	10.20	10.20	0.22	0.22	10.57	10.57	0.23	0.23	10.85	10.85	0.24	0.38
WC6	274	27.29	27.28	27.57	27.57	0.31	0.31	27.65	27.65	0.39	0.39	27.70	27.69	0.43	0.43
WC6	241	26.91	26.89	27.10	27.09	0.85	0.84	27.17	27.15	0.80	0.81	27.19	27.18	0.87	0.86
WC6	181	25.43	25.41	25.90	25.86	0.19	0.20	26.01	25.98	0.26	0.26	26.07	26.04	0.30	0.30
WC6	165	25.60	25.57	25.84	25.80	0.51	0.56	25.92	25.89	0.69	0.70	25.98	25.95	0.78	0.78
WC6	144	25.13	25.08	25.27	25.25	0.81	0.67	25.35	25.31	0.82	0.82	25.40	25.35	0.84	0.87
WC6	121	24.45	24.40	24.76	24.68	0.47	0.54	24.85	24.79	0.60	0.61	24.90	24.85	0.67	0.66
WC6	106	24.48	24.41	24.29	24.25	0.98	0.65	24.37	24.28	1.00	1.06	24.41	24.30	1.04	1.27
WC6	92	23.60	23.50	23.90	23.76	0.48	0.60	23.99	23.89	0.62	0.62	24.05	23.98	0.66	0.60
WC6	75	23.38	23.25	23.71	23.67	0.45	0.26	23.85	23.83	0.41	0.26	23.95	23.94	0.38	0.25
WC6	59	23.27	23.11	23.67	23.67	0.18	0.09	23.83	23.83	0.17	0.10	23.93	23.93	0.16	0.10
WC6	42	23.05	22.85	23.06	23.08	0.29	0.37	23.14	23.16	0.29	0.42	23.42	23.20	0.43	0.48
WC6	19	22.75	22.45	23.09	22.71	0.40	0.79	23.17	22.80	0.40	0.74	23.18	22.86	0.50	0.61
WC11	478	25.60	24.90	25.86	25.16	0.40	0.40	25.93	25.23	0.49	0.49	25.98	25.28	0.53	0.53
WC11	411	24.18	23.48	24.38	23.68	0.71	0.72	24.44	23.74	0.96	0.96	24.47	23.77	1.16	1.16
WC11	384	23.30	22.60	23.50	22.80	0.66	0.65	23.58	22.88	0.71	0.71	23.64	22.94	0.67	0.66
WC11	345	22.18	21.45	22.50	21.77	0.70	0.72	22.61	21.88	0.86	0.88	22.70	21.97	0.83	0.86
WC11	302	21.71	20.96	21.94	21.21	0.34	0.33	22.01	21.27	0.45	0.44	22.05	21.31	0.51	0.50
WC11	261	20.85	20.13	21.11	20.39	0.94	0.96	21.21	20.49	1.02	1.02	21.27	20.55	1.09	1.07
WC11	240	20.24	19.52	20.60	19.88	0.56	0.55	20.73	20.01	0.58	0.58	20.78	20.06	0.61	0.62
WC11	218	19.85	19.12	20.07	19.33	0.79	0.86	20.15	19.41	0.94	1.00	20.21	19.47	0.99	1.01
WC11	178	19.17	18.44	19.47	18.74	0.39	0.37	19.57	18.84	0.44	0.44	19.63	18.90	0.43	0.44
WC11	122	18.73	18.03	19.02	18.33	0.34	0.33	19.09	18.40	0.40	0.39	19.13	18.43	0.45	0.44
WC11	89	18.35	17.65	18.66	17.95	0.32	0.35	18.71	18.00	0.39	0.40	18.74	18.03	0.44	0.45
WC11	68	18.15	17.44	18.41	17.69	0.26	0.26	18.47	17.74	0.31	0.32	18.50	17.78	0.35	0.35
WC11	43	17.69	16.94	17.78	17.03	0.66	0.69	17.81	17.06	0.76	0.75	17.83	17.08	0.83	0.89
WC2	625	28.56	28.56	28.74	28.74	0.40	0.40	28.80	28.80	0.49	0.49	28.84	28.84	0.56	0.56
WC2	588	27.63	27.63	27.80	27.80	0.59	0.59	27.86	27.86	0.68	0.68	27.90	27.90	0.69	0.69
WC2	551	26.57	26.57	26.72	26.72	0.45	0.45	26.78	26.78	0.55	0.55	26.84	26.84	0.48	0.48
WC2	503	25.46	25.46	25.56	25.56	0.36	0.36	25.59	25.59	0.47	0.47	25.61	25.61	0.54	0.54
WC2	478	24.71	24.71	24.81	24.81	0.33	0.33	24.84	24.84	0.39	0.39	24.86	24.86	0.44	0.44
WC2	449	23.59	23.59	23.77	23.77	0.37	0.37	23.80	23.80	0.45	0.45	23.82	23.82	0.51	0.51
WC2	430	23.07	23.07	23.21	23.21	0.30	0.30	23.24	23.24	0.35	0.35	23.26	23.26	0.39	0.39
WC2	408	22.32	22.32	22.44	22.44	0.46	0.46	22.46	22.46	0.58	0.58	22.49	22.49	0.64	0.64
WC2	381	20.65	20.65	20.83	20.83	0.83	0.83	20.90	20.90	0.97	0.97	20.96	20.96	1.08	1.08
WC2	357	19.68	19.68	19.89	19.89	0.67	0.67	19.98	19.98	0.81	0.81	20.04	20.04	0.90	0.90
WC2	322	18.97	18.97	19.13	19.13	0.45	0.45	19.19	19.19	0.56	0.56	19.25	19.25	0.64	0.64
WC2	297	18.00	18.00	18.22	18.22	1.08	1.08	18.30	18.30	1.25	1.25	18.35	18.35	1.38	1.38
WC2	260	17.44	17.44	17.81	17.81	0.15	0.15	17.89	17.89	0.21	0.21	17.95	17.95	0.25	0.25
WC2	245	17.58	17.58	17.70	17.70	0.90	0.90	17.75	17.75	1.08	1.08	17.79	17.79	1.18	1.18







GHD

- Subsided Channel Invert Level (mAHD)
- Existing Channel Invert Level (mAHD)
- Subsided Flow Velocity (m/s)
- Subsided Water Level (mAHD)
- Existing Water Level (mAHD)
- Existing Flow Velocity (m/s)

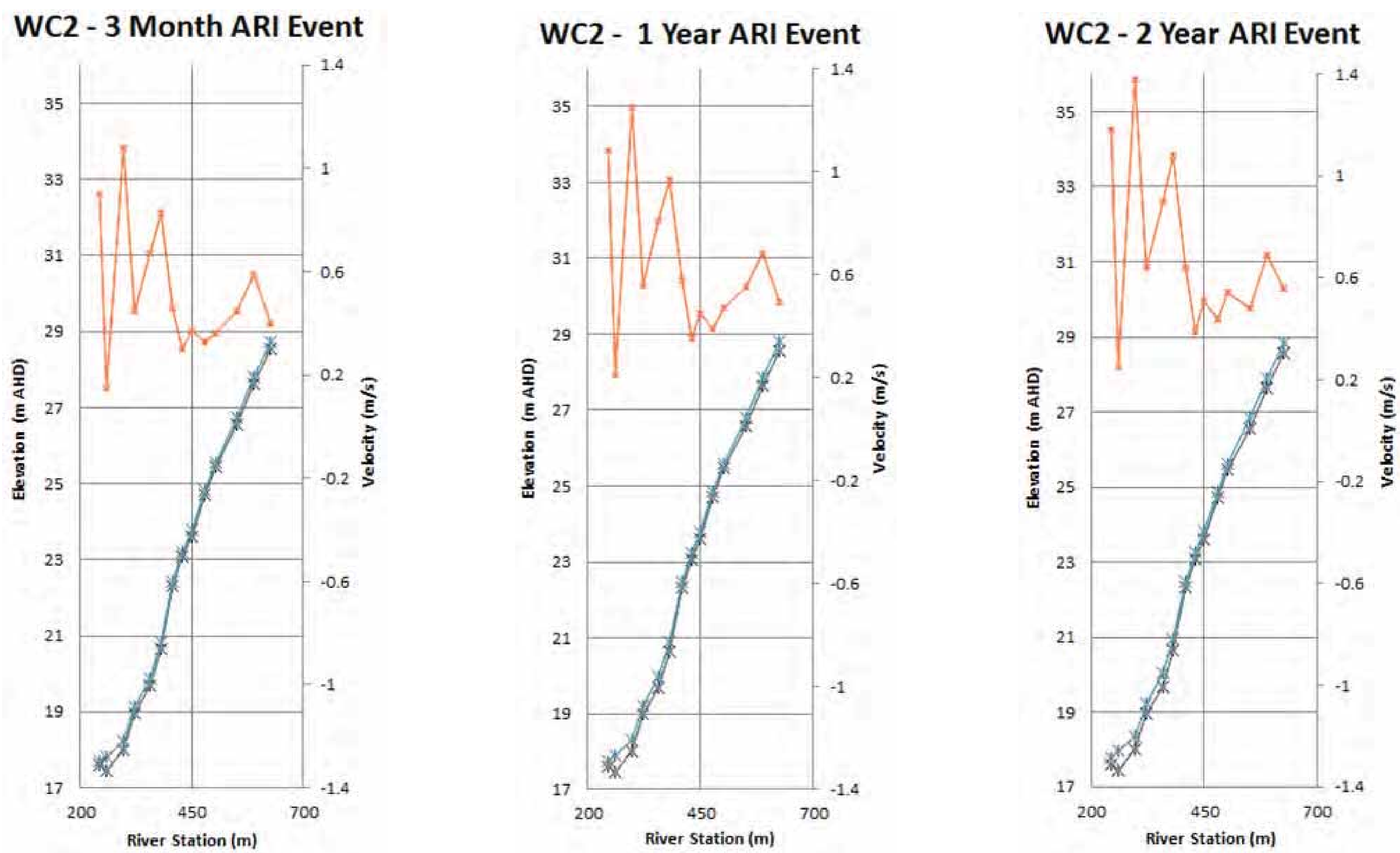
LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC1
ARI Events

Centennial Newstan

DATE April 2012

Figure C1



Subsided Channel Invert Level (mAHD)
Existing Channel Invert Level (mAHD)
Subsided Flow Velocity (m/s)
Subsided Water Level (mAHD)
Existing Water Level (mAHD)
Existing Flow Velocity (m/s)

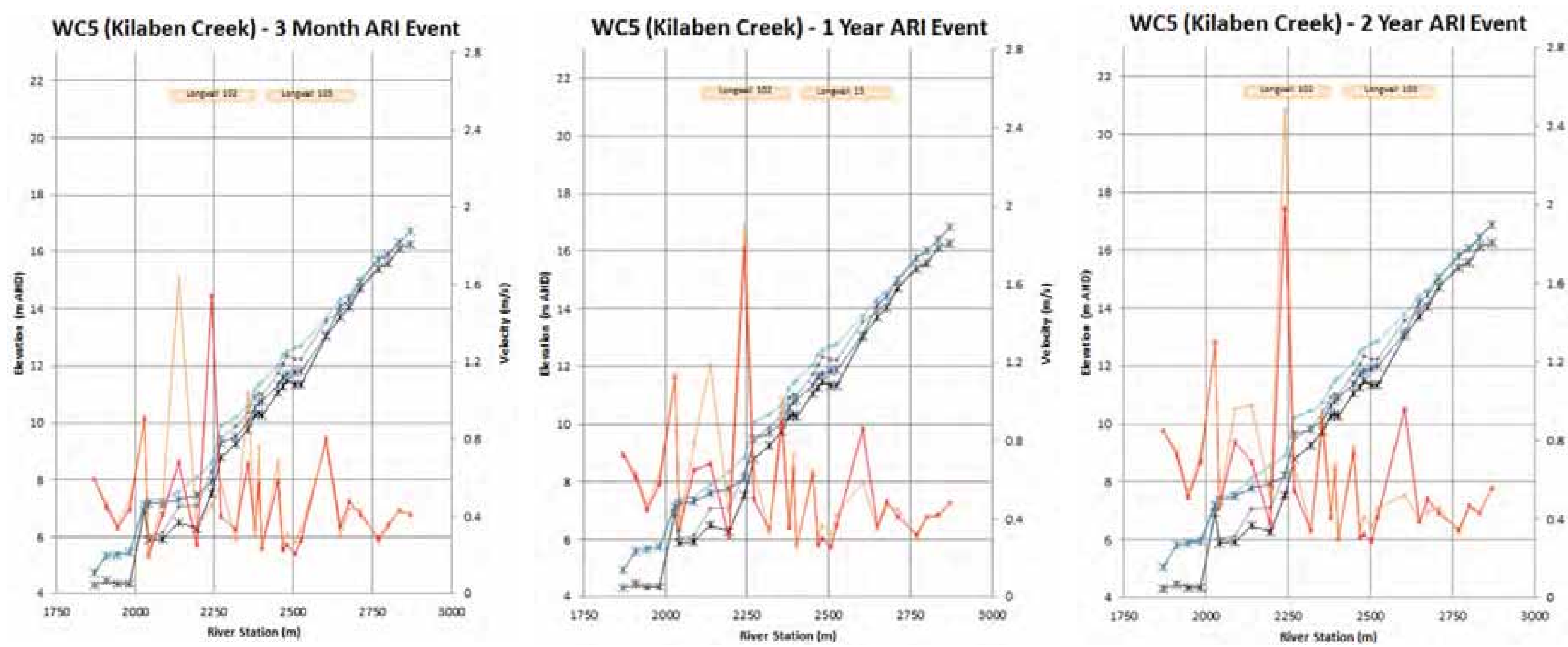
LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC2
ARI Events

Centennial Newstan

DATE April 2012

Figure C2



Subsided Channel Invert Level (mAHD)
Subsided Water Level (mAHD)
Existing Channel Invert Level (mAHD)
Existing Water Level (mAHD)
Subsided Flow Velocity (m/s)
Existing Flow Velocity (m/s)

LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC5
ARI Events

Centennial Newstan

DATE April 2012

Figure C3

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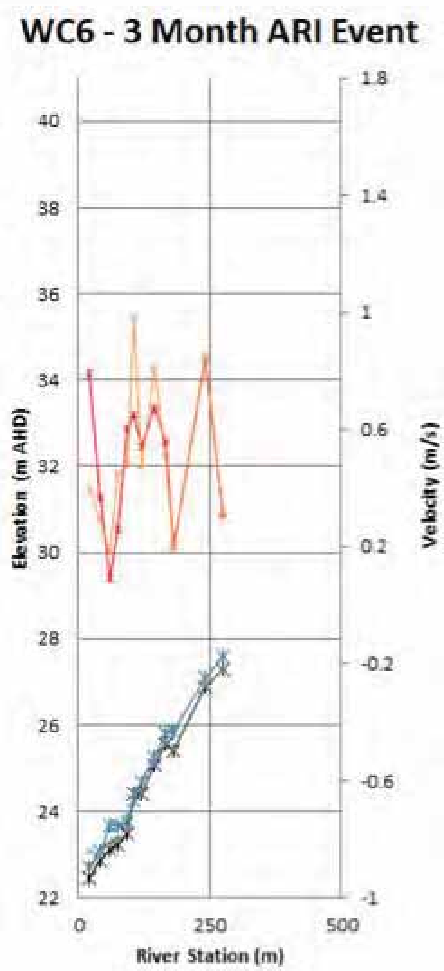
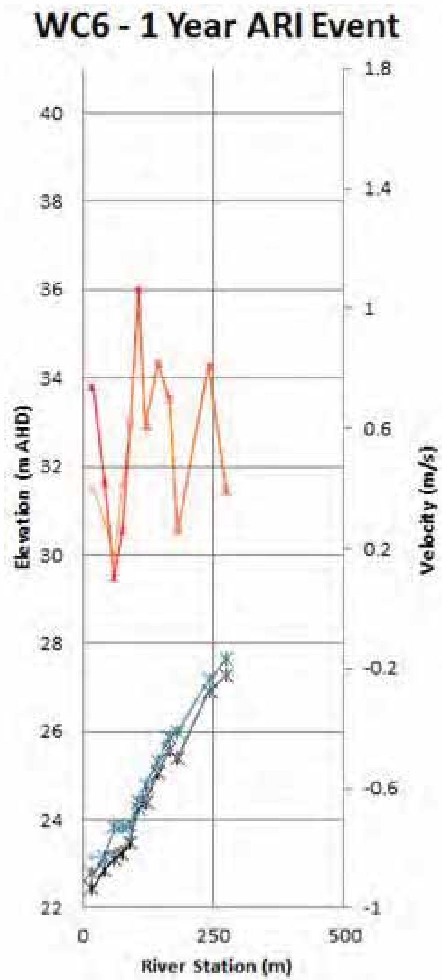
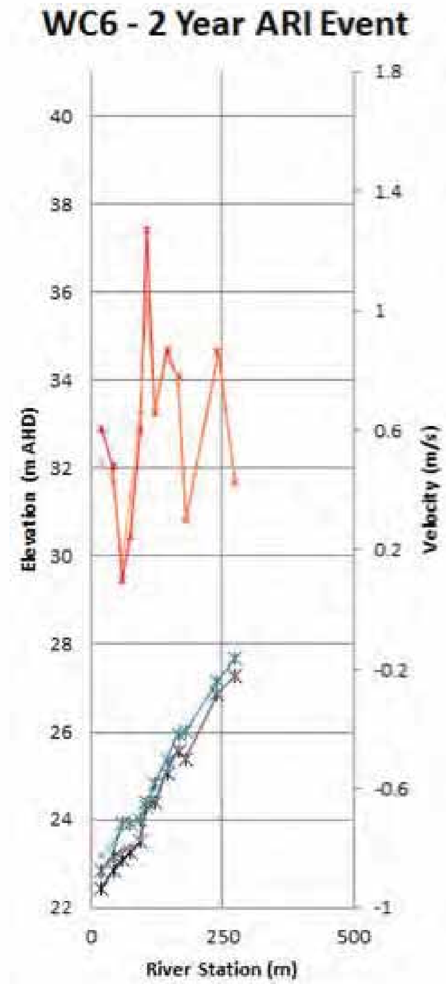






Subsided Channel Invert Level (mAHD)
Existing Channel Invert Level (mAHD)
Subsided Flow Velocity (m/s)
Subsided Water Level (mAHD)
Existing Water Level (mAHD)
Existing Flow Velocity (m/s)

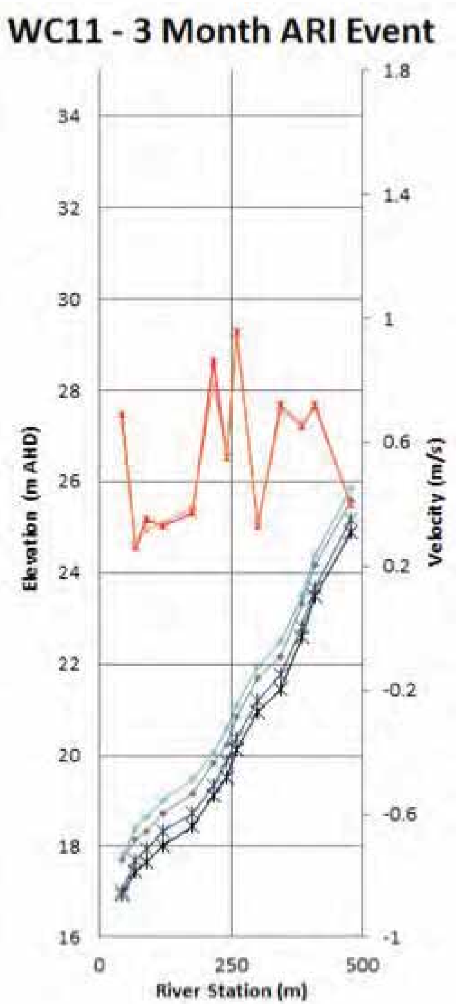
LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

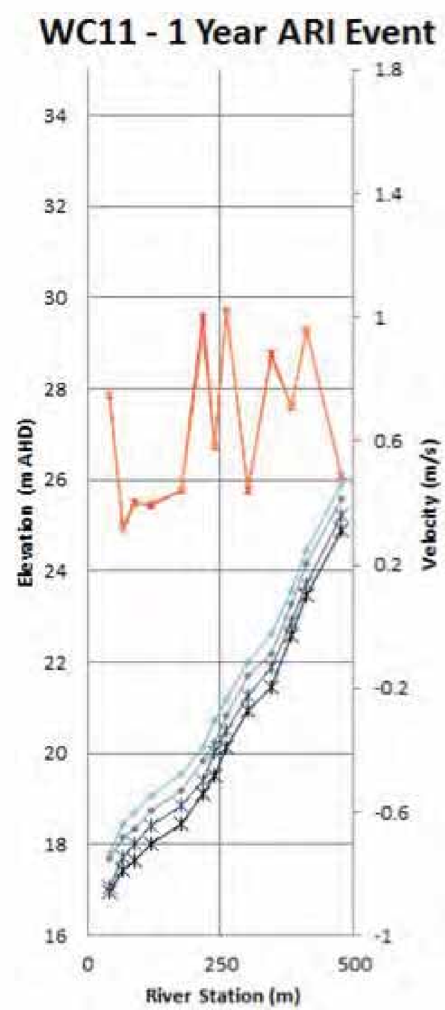
Stoney Creek WC6
ARI Events

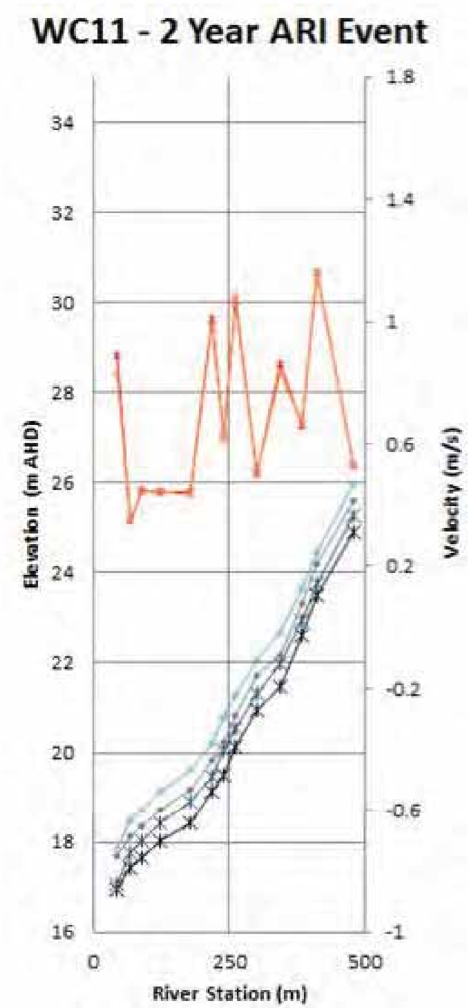
Centennial Newstan

DATE April 2012

Figure C4







GHD

Subsided Channel Invert Level (mAHD)
Existing Channel Invert Level (mAHD)
Subsided Flow Velocity (m/s)
Subsided Water Level (mAHD)
Existing Water Level (mAHD)
Existing Flow Velocity (m/s)

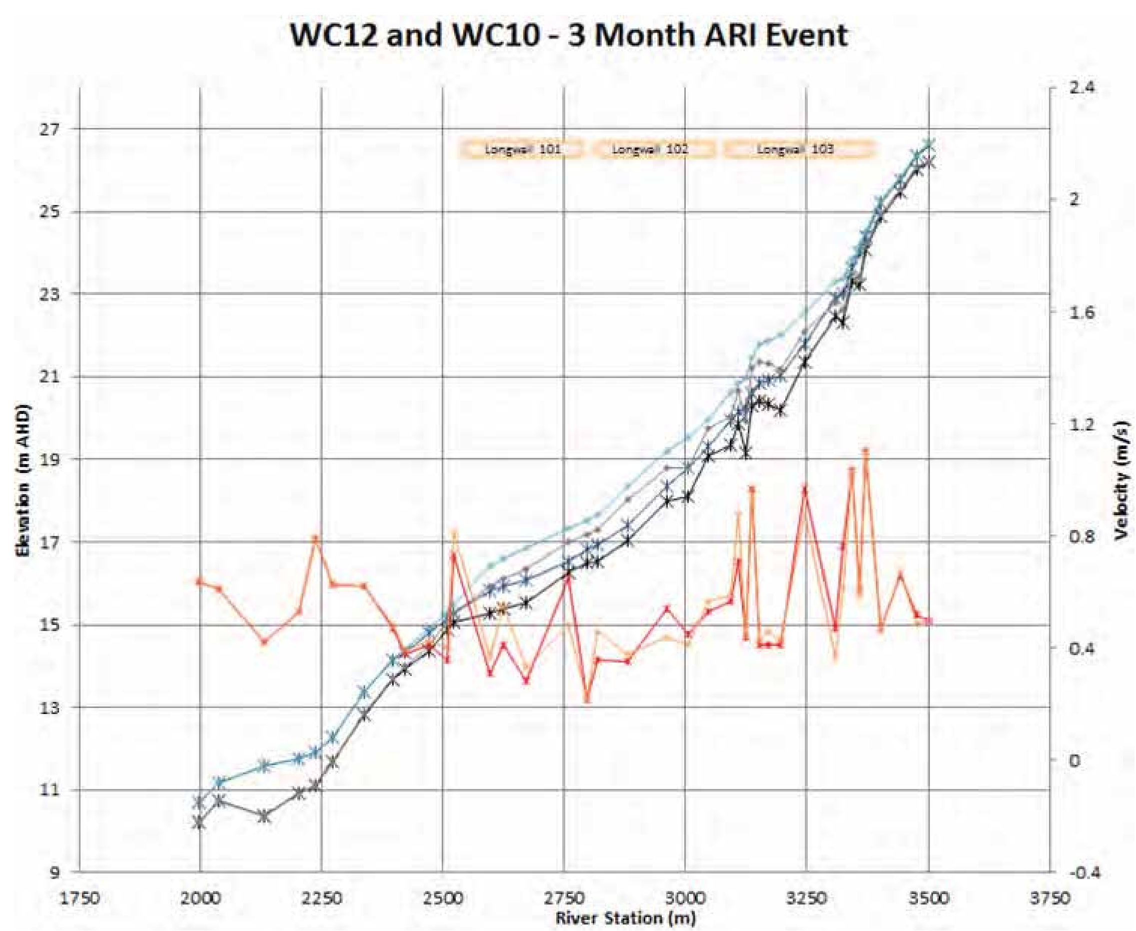
LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC11
ARI Events

Centennial Newstan

DATE April 2012

Figure C5



LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC10 & WC12
3 Month ARI Event

Centennial Newstan

DATE April 2012

Figure C6

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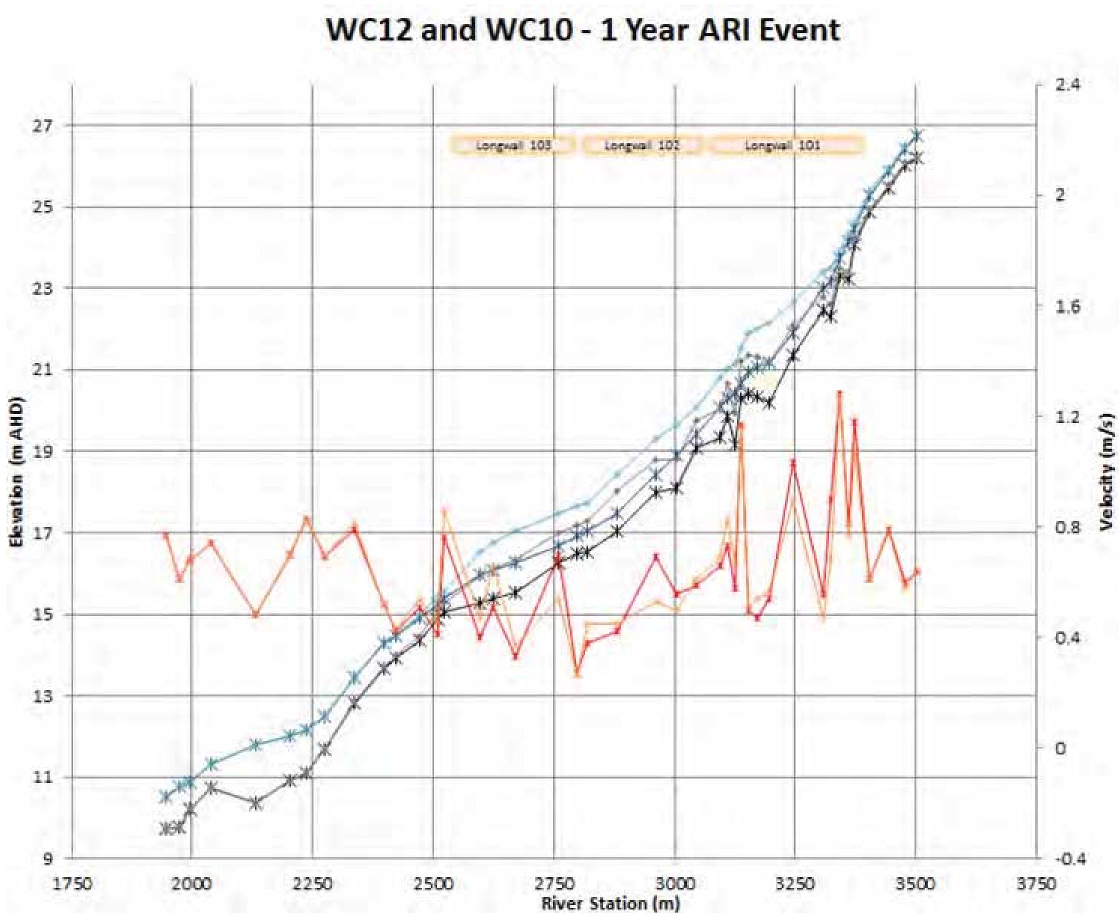

Subsided Channel Invert Level (mAHD)
Existing Channel Invert Level (mAHD)
Subsided Flow Velocity (m/s)
Subsided Water Level (mAHD)
Existing Water Level (mAHD)
Existing Flow Velocity (m/s)

LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC10 & WC12
1 Year ARI Event

Centennial Newstan

DATE April 2012

Figure C7

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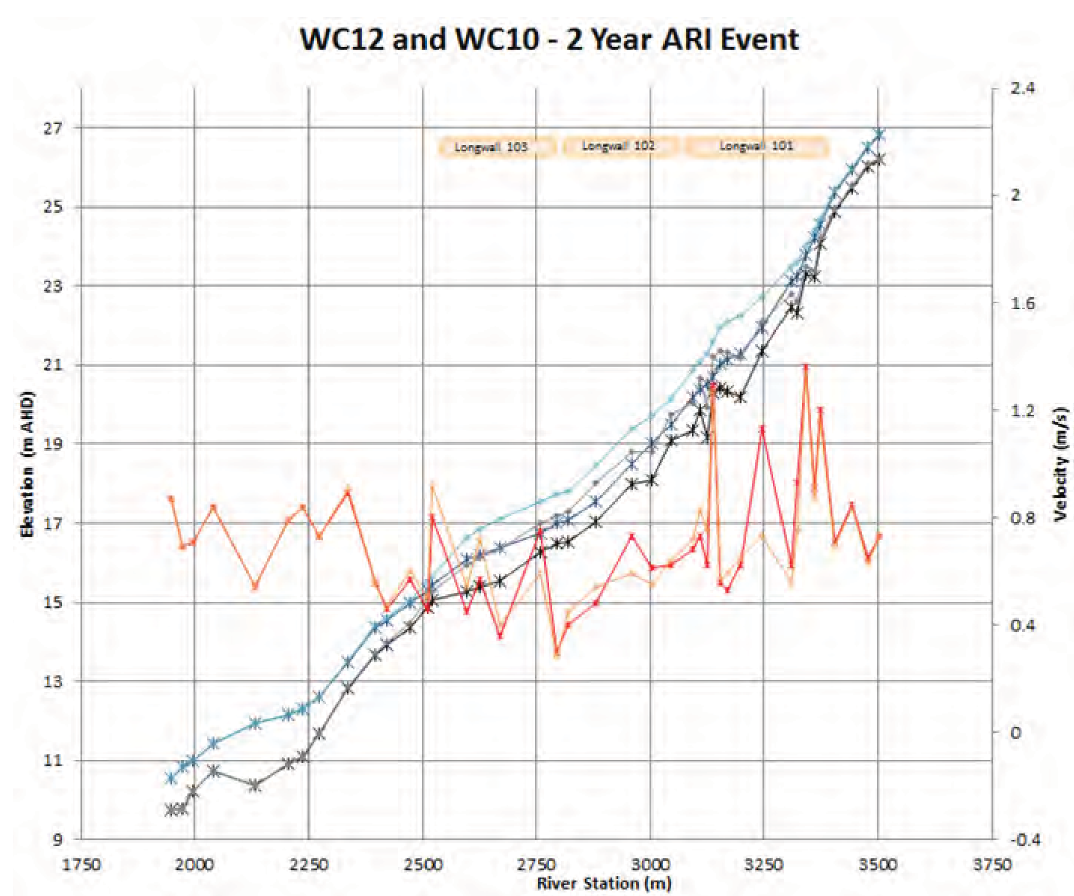

Subsided Channel Invert Level (mAHD) | Subsided Water Level (mAHD)
Existing Channel Invert Level (mAHD) | Existing Water Level (mAHD)
Subsided Flow Velocity (m/s) | Existing Flow Velocity (m/s)

LOCATION	Newstan
SEAM	Young Wall. & Yard
DRAWN	SM
CHECKED	LH
APPROVED	
SCALE	Not to scale

Stoney Creek WC10 & WC12
2 Year ARI Event

Centennial Newstan

DATE April 2012 | Figure C8

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GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com.au

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Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	L Hammersley	P Parker	Paul Parker	S Gray	[signature]	01/05/12

Centennial Coal

Centennial Coal Company Limited
P O Box 1000
Toronto NSW 2283
www.centennialcoal.com.au