Centennial Coal

CENTENNIAL COAL
AWABA COLLIERY
ANNUAL REVIEW

March 2018

Centennial Coal
Environment Matters

Name of Operation	Awaba Colliery
Name of Operator	Centennial Newstan Pty Ltd
Development Consent/ Project Approval #	10_0038
Mining Lease #	CCL746, MPL327, MPL 328
Name of Holder of Mining Lease	Centennial Newstan Pty Ltd
Water License #	20BL173577, 20BL173582, 20BL173586
Name of Holder of Water License	Centennial Newstan Pty Ltd
MOP/RMP Start Date	August 2015
MOP/RMP End Date	August 2018
Annual Review Start Date	January 2017
Annual Review End Date	December 2017

I, Mick Cairney, certify that this audit report is a true and accurate record of the compliance status of Awaba Colliery for the period January 2017 – December 2017 and that I am authorized to make this statement on behalf of Centennial Newstan Pty Ltd.

Note:

a) *The Annual Review is an 'environmental audit' for the purposes of s122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion) in an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.*

b) *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (intention to defraud by false or misleading statement – maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents –maximum penalty 2 years imprisonment or $22,000,or both).*

Name of Authorised Reporting Officer	MICHAEL CAIRNEY
Title of Authorised Reporting Officer	MD + CEO
Signature of Authorised Reporting Officer	M Cairney
Date	28.3.18

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1. STATEMENT OF COMPLIANCE

Table 1: Statement of Compliance

Were all conditions of the relevant approval(s) complied with?	
PA 10_0038	Yes
EPL 443	Yes
CCL 746	Yes
MPL 327	Yes
MPL 328	Yes

Table 2: Non-Compliances

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Section addressed in Annual Review
Nil non-compliances					

Note: Compliance Status Key for Table 3

Risk Level	Colour Code	Description
High		Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Medium		Non-compliance with: • Potential for serious environmental consequences, but is unlikely to occur; or • Potential for moderate environmental consequences, but is likely to occur
Low		Non-compliance with: • Potential for moderate environmental consequences, but is unlikely to occur; or Potential for low environmental consequences, but is likely to occur
Administrative		Only to be applied where the non-compliance does not result in any risk of environmental harm (eg submitting a report to government later than required under approval conditions)

2. INTRODUCTION

Awaba Colliery was an underground coal mine operated by Centennial Newstan Pty Ltd (Centennial Newstan), within the Newstan Colliery Holding producing coal by the bord and pillar method, using continuous miners. The mine was operational from 1947 - 2012. During this time over 35 million tonnes of coal has been produced from the Great Northern Seam using a combination of first workings development, pillar extraction, pillar quartering, and pillar stripping.

An application for a Part 3A Project Approval was lodged in March 2010 by Centennial Newstan for the Awaba Colliery Mining Project (the "Project"), which sought approval from the Minister for Planning to allow ongoing and extended underground mining and associated surface operations. The project was declared by NSW Department of Planning as a Major Project under Part 3A of the EP&A Act, with Director General's Requirements (DGRs) issued on 22nd April 2010 (DA10_0038) for assessment under Section 75F of the Environmental Planning and Assessment Act (1979). The Environmental Assessment was submitted to the Department in September 2010. The Planning and Assessment Commission of New South Wales granted conditional approval to Centennial Newstan for their Part 3A Application on the 13th of May 2011.

The mine entry and primary surface facilities are located approximately 1 km south of Awaba Township and 5.5 km south west of Toronto on Wilton Road. The mine extends from the western extremity of Lake Macquarie to the eastern foothills of the Watagan Mountains.

In March 2012 the Awaba Colliery ceased mining operations as the available coal reserves were exhausted. All mine entries were decommissioned in 2012, removing access to the underground workings.

This AEMR has been developed in accordance with condition 3 of Schedule 5 of the Project Approval 10_0038.

Figure 1: Aerial photograph of Awaba Colliery surface facilities

Table 3: Awaba Colliery Environmental Contact Details

Name	Position	Email	Phone
Grant Watson	Mine Manager	Grant.Watson@centennialcoal.com.au	02 49560205
Nerida Manley	Environment & Community Coordinator	Nerida.Manley@centennialcoal.com.au	02 49560206

3. APPROVALS

Table 4: Environmental Approvals held by Awaba Colliery

Name	Description	Issued By	Expiry Date	Renewal Procedure
CCL746	Area above underground workings, within Crown Land.	Dept. Primary Industry (Mineral Resources)	31/12/2028	Manager Title and Property-North

Name	Description	Issued By	Expiry Date	Renewal Procedure
MPL327	Awaba Nitrogen Plant	Dept. Primary Industry (Mineral Resources)	05/08/2036	Manager Title and Property-North
MPL328	Part Awaba Stockpile	Dept. Primary Industry (Mineral Resources)	05/08/2036	Manager Title and Property-North
Mine Operations Plan (MOP)	Summary of Mining and Processing Activities – Newstan and Awaba	NSW Trade & Investment – Division of Resources & Energy	2018 - 2020	MOP approved for the period March 2018 – July 2020
Awaba Colliery Project Approval PA 10_0038	Permits development and works to occur as described in the EIS	NSW Department of Planning & Environment	31/12/2015	Permits development and works to occur as described in the EIS
Environmental Protection Licence 443	Permits scheduled activity "coal mining" and discharge of water from licensed discharge points.	Environment Protection Authority	Perpetual	Requires payment and Annual Return February each year

4. OPERATIONS SUMMARY

There was no mining undertaken during the reporting period. Previously mined areas can be found on Plan AW2245. The mine ceased underground operations in 2012, and the mine entries were sealed.

The Newstan Awaba Complex Mining Operations Plan was approved by DRE in March2015 and is approved until August 2018.

4.1. EXPLORATION

No exploration drilling occurred on CCL 746 within the reporting period. Drilling is undertaken in accordance with the *Awaba East Exploration Project Review of Environmental Factors* dated August 2008, approved on the 1/9/08, and *Stage 2 Awaba East Exploration Project Review of Environmental Factors* (REF) May 2009, approved on the 13/7/09. Modifications were made to the 2008 REF and approved on the 15/12/08, & 9/4/09, and a third modification to both REF's was approved on the 4/11/09.

4.2. LAND PREPARATION

No land preparation on the Awaba lease was undertaken for Awaba operations. Works completed for subsidence rehabilitation are included in Section 6.3 below.

4.3. CONSTRUCTION

No additional mine infrastructure for Awaba operations were constructed during the report period. Works onsite were limited to necessary maintenance of existing plant, or demolition and rehabilitation of existing infrastructure.

4.4. MINING

No mining activities were undertaken in the reporting period.

5. ACTIONS REQUIRED FROM PREVIOUS ANNUAL REVIEW

The DPE in a letter dated 19 July 2017 requesting additional information to be provided within the 2015 Annual Review as detailed in **Table 5**. The DPE confirmed acceptance of the additional information on 30 June 2016.

The DRE in a letter dated 19 July 2017 considered the 2016 Annual Review to be to the satisfaction of the Secretary.

Table 5: Actions from previous Annual Review

Action Required	Requested By	Action Taken	Where addressed in Annual Review
Provide sinkhole rehabilitation management plan (with maps of the sinkholes	Division of Resources and Energy	Sinkhole management plan updated and attached to AEMR	Appendix 2
Reseed the turn off area. The first seeding was not successful	Division of Resources and Energy	Re seeding scheduled for turn off area.	NA
Provide information regarding volume discharged and the ecological assessment	Division of Resources and Energy	Provided to DRE as part of the ongoing Awaba seepage investigation	NA
Provide native mix composition used for rehabilitation	Division of Resources and Energy	Provided to DRE July 2017	NA

Action Required	Requested By	Action Taken	Where addressed in Annual Review
Install sediment controls in the Awaba dam to avoid sediment back filling	Division of Resources and Energy	Completed August 2017	NA
Provide a Mine Closure Plan Jan 2019	Division of Resources and Energy	MOP approved for 2018 – 2020. Will undertake this closer to the end of the new MOP period	

6. ENVIRONMENTAL PERFORMANCE

Table 6: Summary of Monitoring Requirements

Monitoring Type	Status	Report Section
Noise Monitoring	Quarterly	**Section 6.1**
Air Quality Monitoring	Ongoing	**Section 6.2**
Meteorological Monitoring	Ongoing	**Section 6.7**
Surface Water Monitoring Groundwater Monitoring	Ongoing Ongoing	**Section 7.1** **Section 7.2**

6.1. NOISE

A Noise Management Plan for Awaba Colliery was developed in October 2011 as per Condition 2 of Schedule 3 and was approved by the Department of Planning and Infrastructure in November 2011.

Attended noise monitoring commenced in November 2011 at two locations identified within the Noise Management Plan and the Project Approval. The operator attended survey consists of a daytime period (7am – 6pm), an evening (6pm – 10pm) and two night surveys (10pm – 7am) for each of the monitoring locations.

Quarterly noise monitoring was undertaken in February, May, July and December 2015. The 2015 quarterly monitoring showed that the noise emissions from Awaba Colliery showed full compliance during each of the quarterly surveys with the noise criteria set out within Condition 1 of Schedule 3 along with the predictions made within the Environmental Assessment.

EPL443 dated 16 December 2015 requires that attended noise monitoring be undertaken one month prior to commencement of any mining activities and surface activities associated with mining for coal on the premises, once mining or surface activities have commenced a specific attended noise monitoring regime must be implemented as specified in Condition M8.2.

No attended noise monitoring was required during 2017 due to no operational activities occurring at Awaba during the reporting period and no potential for noise contribution from the Awaba Colliery.

The Northern Region Noise Management Plan has been developed to ensure that operational and construction noise impacts on the local community are minimised and appropriate management measures are identified and response protocols detailed should noise criteria be exceeded and to comply with statutory approval conditions. The plan was submitted to the DPE for approval in July 2016 and was approved in November 2017.

6.2. AIR QUALITY

6.2.1. Dust Deposition Gauges

An Air Quality & Greenhouse Gas Management Plan was established at Awaba in October 2011 in accordance with Condition 7 of Schedule 3 of the Project Approval and approved by the Department of Planning & Infrastructure in November 2011. The Northern Region Air Quality and Greenhouse Gas Management Plan has been developed to ensure that operational and construction air quality impacts on the local community are minimised, appropriate management measures identified and response protocols detailed should air quality criteria be exceeded and to comply with statutory approval conditions. The plan was submitted to the DPE for approval in July 2016.

In order to determine the effectiveness of the colliery's dust control measures, a network of dust depositional monitoring gauges have been established. Depositional gauges are located within the Colliery perimeter as well as adjoining areas. A total of four depositional gauges are utilised, all located within the Colliery boundary.

Samples are taken from the depositional gauges every 28 (±2) days as per Approved Methods for the Sampling and Analysis of Air Pollutants in NSW as administered by the Environment Protection Authority. As predicted with in the Environmental Assessment for the Awaba Colliery Mining Project dust deposition levels were below the Project air quality criteria at all surrounding dwellings. The following graph Figure 2 displays Awaba's monthly dust results.

The Awaba Colliery Mining Project EA for DG's 1-4 found the monthly averages and annual averages were below 2.4 g/m2/month, which is within the development consent limit of 4 g/m2/month annual average. The EA states that the results indicated that total annual average dust deposition levels at all receptors surround the Project are predicted to be below the Project criterion of 4 g/m2/month when using a conservative background level of 2 g/m2/month.

Table 7: Summary of depositional dust results between January 2017 and December 2017 surrounding Awaba Colliery

	Insoluble Solids (Combustible Matter + Ash) g/m^2/month			
	DG1	DG2	DG3	DG4
Long Term Average	0.6	1.2	3.5	1.1
Average 2017 (Reporting Period)	0.9	1.0	1.5	1.0
Air Quality Criteria	4	4	4	4

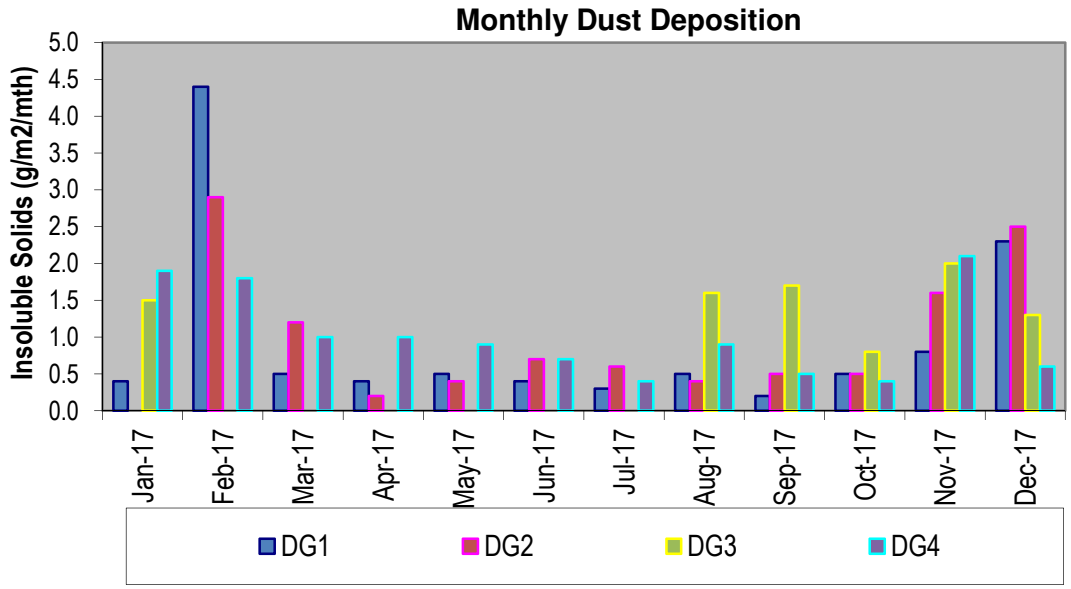

Figure 2: Awaba Monthly Dust Deposition 2017

6.2.2. High Volume Dust Sampling

A requirement of the Project Approval and the EPL was to install a high volume air sampler to evaluate the performance of the project. This was installed in 2014/2015 at the location known as the Nitrogen Plant.

High volume dust sampling was undertaken to monitor dust deposition rates and concentrations of Total Suspended Particulates (TSP) and Suspended Particles PM10.

Table 8: Annual Average PM10 and TSP

Annual Average PM10 (ug/m3) and TSP (ug/m3)		
Year	**PM10**	**TSP**
2017	10.6	19.2

The rolling annual average results for both locations were below the criteria for TSP of 90 µg/m3 (annual average), and PM10 of 30 µg/m3 (annual average), and the results were also below the PM10 24 hour limit of 50 µg/m3 during the 2017 reporting period.

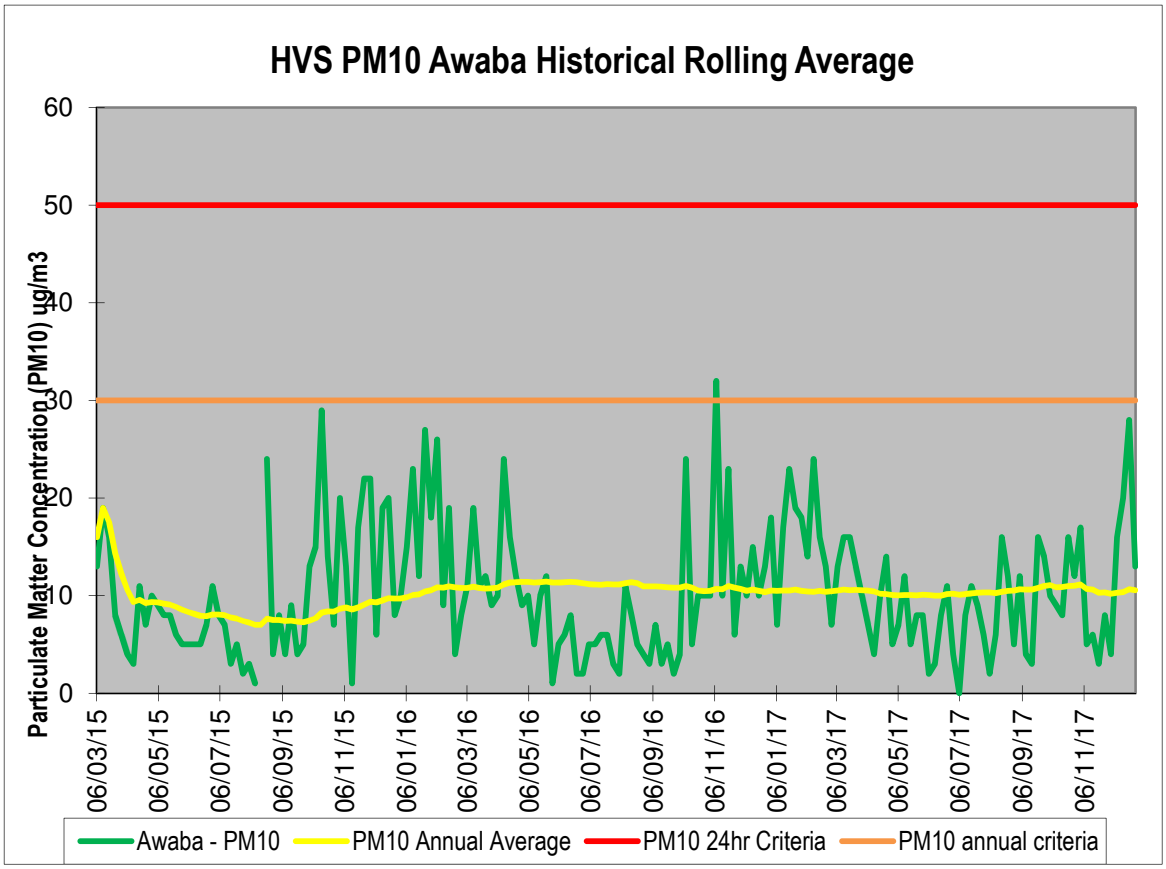

Figure 3: Awaba Rolling Annual Average and 24 hour results for High Volume Dust Sampling for PM10

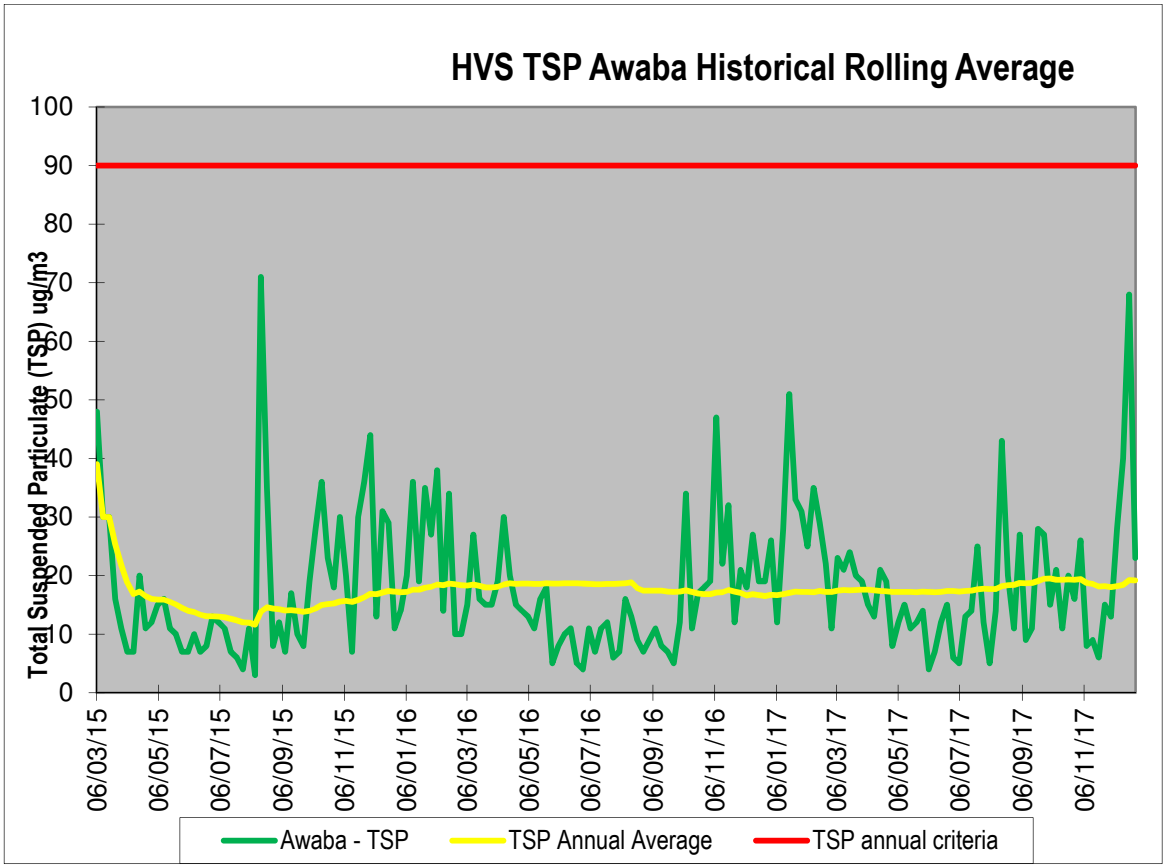

Figure 4: Awaba Rolling Annual Average and 24 hour results for High Volume Dust Sampling for TSP

6.2.3. Greenhouse Gas Monitoring

Awaba ceased operations and sealed the shafts and portals in 2012. The minimal usage & greenhouse gas information (electricity) is included within Newstan Colliery Annual Review Report.

6.3. SUBSIDENCE

Monitoring in the reporting period was conducted in accordance with the Subsidence Management Plan (SMP), SMP approval conditions and the Extraction Plan (as required by Condition 11 of Schedule 3 of the Project Approval) and the associated subsidence monitoring program. Table briefly outlines the subsidence monitoring and results conducted in accordance with the relevant SMP conditions.

Table 9: Subsidence Monitoring Results

SMP Approval Condition No.	Requirement Summary	Comment / Description
22 (a) – Stage 1 23 (a) – Stage 2 24 (a) – Stage 3	***Summary of Subsidence and Environmental Monitoring Results***	The Following subsidence surveys and inspections have been completed: ***Surface Surveys –*** All scheduled subsidence surveys completed to December 31st, 2017. There were No Notifiable Subsidence Incidents in 2017. **Maximum subsidence** in **2017 period** – was in **Stage 2** - XLE17, -1.402m. **Stage 1** - Maximum subsidence was at XL40, -1.349m. **Stage 3** - Subsidence monitoring results in 2017 were well within predicted levels and continue to be relatively stable.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		Environmental inspections were carried out in January 2014. Traversing between transects involved walking along over a kilometre of Stony Creek, including part of a tributary. The 2014 survey found no impact on Stony Creek, and was the last Ecological Survey. ***Underground Surveys –*** All Awaba Mine entries (Drifts and Shafts) were sealed in August 2012 Underground workings are no longer accessible.
22 (b) – Stage 1 23 (b) – Stage 2 24 (b) – Stage 3	***Analysis of Subsidence and Environmental Monitoring Results***	After reporting greater than predicted subsidence in both Stage 1 and Stage 2 during 2014 – Monitoring Results for 2015, 2016 and **2017** were consistently relatively stable.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		January and March Surveys of **2014** found greater than predicted subsidence in Main South **Stage 1** Area. A report was prepared by a geotechnical consultant with regard to this event. The subsidence has had no adverse impact on surface infrastructure. Centennial Survey prepared a plan showing zones of subsidence along monitoring points in relation to surface features and underground workings to help bring perspective to results. A PDF of this plan was sent to relevant government departments and stakeholders. The significant increase in subsidence occurred approximately 175 to 300 metres from the Main Northern Railway Line. There is no subsidence impact on monitoring points nearer to the Main Northern Railway, Ulan Rail Loop, Haul Road, Haul Road Bridge, Telstra Tower or Railcorp and Ausgrid Power Poles. There have been no observed visual environmental impacts in Stage 1 Area.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		July 2014 Surveys found greater than predicted subsidence in Main South **Stage 2** Area. Centennial Survey prepared a plan showing zones of subsidence along monitoring points in relation to surface features and underground workings to help bring perspective to results. A PDF of this plan was sent to relevant government departments and stakeholders. The significant increase in subsidence occurred approximately 250 to 350 metres from the Main Northern Railway Line. There is no subsidence impact on monitoring points nearer to the Main Northern Railway, Ulan Rail Loop, Haul Road, Haul Road Bridge, Telstra Tower or Railcorp and Ausgrid Power Poles. Environmental impacts in Stage 2 - Cracking that was observed and reported, associated with the greater than predicted subsidence. The Sinkhole reported on 03/02/2015 near 8SW29-30. The sinkhole has been filled. The area is being rehabilitated in accordance with the sinkhole rehabilitation plan.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		No visual disturbance has been identified on tracks & trails. **Stage 3** Subsidence monitoring results in 2017 were within predicted levels and continue to be relatively stable. Environmental impacts in Stage 3 - have been confined to the previously reported and rehabilitated sinkhole.
22 (c) – Stage 1 23 (c) – Stage 2 24 (c) – Stage 3	***Trends in Monitoring Results***	In general - the trend in monitoring results shows that the majority of subsidence occurs during and shortly after mining extraction. In the following months the rate of subsidence decreases toward a stable environment. However after approximately 6 years of relative stability – there was greater than predicted subsidence in Main South **Stage 1** and **Stage 2** in **2014**. During 2014 – after the initial sudden increase in subsidence - results began to trend toward decreasing movement. In 2015, 2016 and **2017 -** surveys have consistently shown relatively stable results.

SMP Approval Condition No.	Requirement Summary	Comment / Description
22 (d) – Stage 1 23 (d) – Stage 2 24 (d) – Stage 3	***Management Actions of Potential Impacts***	In general - current Public Safety and Subsidence Management Plans are considered adequate. Following greater than predicted subsidence in **Stage 1** Main South Cross line / 8NE Centreline area in 2014; All relevant government agencies and stakeholders were notified as per condition 20, after results of January survey. Centennial Newstan conducted a follow up survey – including strain measurements in early March. The results were distributed to relevant government agencies and stakeholders. A visual inspection was carried out on 21/03/2014 - by a Geotechnical consultant accompanied by the Mine Manager and Mine Surveyor. No visual signs of subsidence were observed. The results were included in a geotechnical report. A meeting between Centennial Newstan and PSE was held on 25/03/2014 to discuss the mechanics and management of this occurrence. A report prepared by a geotechnical consultant with regard to this event was distributed to Transport NSW and the PSE on 27/03/2014. Further reports were distributed on 2/6/2014 and 23/6/2014. A meeting to discuss the increased subsidence in Stage 1 was held in Chatswood on 02/04/2014. It was attended by the Principal Subsidence Engineer (PSE), Centennial Newstan, an independent geotechnical consultant, and Transport NSW. During the Chatswood meeting – it was agreed to temporarily increase the

SMP Approval Condition No.	Requirement Summary	Comment / Description
		frequency of surveys until a trend of stable results was achieved. Note that as agreed during the meeting in Chatswood - subsidence of 50mm or greater observed within the Railway Protection Zone (RPZ) - will trigger further communication and review of the situation. Monitoring frequency was increased on 04/04/2014 to provide further data until the area became stable; and to monitor any possible increased subsidence moving toward the rail corridor. Following greater than predicted subsidence in **Stage 2** Main South Crossline Extension / 8SW Centreline area - All relevant government agencies and stakeholders were notified as per condition 21, after results of the July survey. A visual inspection carried out by the Mine Surveyor found evidence of minor surface impacts within these areas. Results were forwarded to PSE, relevant government departments and stakeholders on 14/07/2014. Agreement was reached with the PSE and Transport NSW - to increase monitoring frequency to provide further data until the area becomes stable; and to monitor any possible increased subsidence moving toward the rail corridor. Subsidence of 50mm or greater observed within the Railway Protection Zone (along 8SW) or the Railway Mining Barrier (along 6SW) - will trigger further communication and review of the situation. Monitoring frequency was increased on 16/07/2014. A meeting to discuss the trend of consistent relatively stable monitoring results in both **Stage 1** and **Stage 2** - was held in Burwood on 12/08/2015. It was attended

SMP Approval Condition No.	Requirement Summary	Comment / Description
		by the Principal Subsidence Engineer (PSE), Centennial Newstan, an independent geotechnical consultant, and Transport NSW. During the Burwood meeting – it was agreed to amend the frequency of surveys from fortnightly to monthly for a period of six months (commencing from August). If results continued to be stable during this period – agreement would be made to further reduce monitoring frequency. On October 7th, 2015, official approval was granted by PSE to vary this monitoring to monthly. A meeting between Centennial Newstan and PSE was held on 20/07/2016 to discuss the consistent relatively stable monitoring results in **Stage 1, 2, 3**. A report reviewing the recent subsidence data, prepared by a geotechnical consultant, was distributed to Transport NSW and the PSE on 25/08/2016. In addition, a letter requesting agreement from Transport NSW to amend the monitoring program to 2 monthly for 6SW points, and 6 monthly for other nominated **Stage 1,2,3** points was submitted on 25/08/2016. Agreement to amend the monitoring program was received from Transport NSW on 08/12/2016. Agreement to amend the monitoring program was received from PSE on 09/12/2016. A letter requesting agreement from Transport NSW to amend the monitoring program from 2 monthly to 6 monthly for 6SW points, was submitted on 21/09/2017.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		Following the reporting of the **Stage 2** localised sinkhole in February 2015, -The relevant government authorities and stake holders were informed within 24 hours of the discovery of the hole. The location of the sinkhole was plotted and is shown on the Stage 2 Face Position plan AW2075. The sinkhole has been filled. The area is being rehabilitated in accordance with the Sinkhole Rehabilitation Plan. Following the formation of the **Stage 3** Sinkhole in June 2011 -The relevant government authorities and stake holders were informed within 24 hours of the discovery of the hole. Rehabilitation of the site has since been completed. The location of the sinkhole was plotted, and is shown on the Stage 3 Face Position plan AW2176. Due to the partial reactivation of this hole - further minor rehabilitation works were carried out during 2015, in accordance with the Sinkhole Rehabilitation Plan.

6.4. BIODIVERSITY

Awaba Colliery has previously undertaken riparian surveys along Stony Creek as a requirement of Condition 23 of Schedule 3 of the Project Approval. As mining ceased in 2012 it has been deemed that this monitoring is no longer required.

Ecological monitoring conducted in regard to the Awaba Seepage is discussed in Section 7.2.

6.5. HERITAGE

In 2012 Centennial Coal developed the Centennial's Northern Holdings Aboriginal Cultural Heritage Management Plan. This document aims to provide a consistent approach to consultation between Centennial and the Aboriginal community as well as identify standard Aboriginal cultural heritage monitoring and management requirements. A revised Northern Region Aboriginal Cultural Heritage Management Plan was submitted to DPE in July 2016 and was approved on 15 September 2016.

Scarred Tree AHIMS#45-7-0318 (RPS ST 01) was identified in the northern portion of the Main South Mining area. This area was due to be undermined and thus the site was assessed for risk of harm by using observations of similar trees which had already been undermined in the southern portion of the Main South Mining area. The risk of harm identified was that the effects of subsidence may destabilise the tree resulting in tilting and potentially its collapse. Although this risk was assessed to be low; a monitoring program was commenced to ensure that the site was not harmed. This monitoring program began in 2010 when the site was first identified. It has been running for three years and has covered the pre-mining, mining and post mining phases. It was considered that tilting of greater than 10 degrees would pose a risk that the tree may fall over and consequently posed a risk of harming the site. During the course of monitoring, less than one degree of tilt was observed and thus there was no risk of harm to the site. The physical tree condition also had not changed as a result of subsidence. All subsidence effects in the vicinity of AHIMS#45-7-0318 have now occurred. There is no further risk to the site as a result of subsidence. Monitoring ceased in 2013.

European heritage items at the Awaba Colliery have been identified within the Proposed Schedule of Heritage Sites and Items. Each of these items has been proposed for heritage listing within the Lake Macquarie Local Government Area (LGA) Local Environmental Plan (LEP). It is important to emphasise that the items will not appear within the Lake Macquarie LGA LEP because they are only listed within the proposed/draft schedule.

The buildings including the Administration Office and the Workshop at the Awaba Colliery Pit Top area associated with the Awaba State Mine (AW-07) have been identified with local significance in the Lake Macquarie Inventory, in addition to the Awaba-Wangi Railway Line under the same item number (AW-07). The Water Pumping Station (AW-06) has also been identified in two previous reports as having a very high potential local heritage significance in term of representing extractive industries in the area (Suters Architects Snell 1993a; Suters Architects Snell 1996b).

Awaba Colliery also prepared and submitted a Post Mining Heritage Management Plan in accordance with Condition 31 of Schedule 3 of the Project Approval. This management

plan will include a study of the significance of the existing European heritage on the site, and was submitted to various stakeholders for consultation before being submitted to the Department of Planning & Infrastructure for Approval in 2012.

Identification of the approval requirements for the long term management options of Awaba Colliery is still being decided. No changes will be made to the site until consideration has been made to whether or not the site will be maintained, renovated for future use or demolition of the site.

6.6. WASTE

Waste production from the Colliery is negligible since mine closure. The waste management system is maintained, however now only includes minimal general waste.

6.7. RAINFALL MONITORING RESULTS

The total monthly rainfall data is shown below in Table 10.

Table 10: Rainfall at Awaba Colliery for the Period January 2017 to December 2017

2017 Month	Awaba Colliery Total Rainfall (mm)
January	74
February	141
March	336
April	49.83
May	18.5
June	135.5
July	7
August	6
September	1
October	190.5
November	11
December	46
Total	1016.33

A total of 1016.33 mm of rainfall was recorded at Awaba Colliery during the reporting period. The total annual rainfall for 2017 was less than the total rainfall recorded in 2016 (1141.4mm). The wettest period was in March 2017 recording 336mm.

7. WATER MANAGEMENT

7.1. SURFACE WATER

Water monitoring is undertaken in accordance with the approved Water Management Plan, Project Approval and Environment Protection Licence 443 requirements. There were no discharges from licenced discharge points during the reporting period. Water was also transferred from 10 South bore to the Eraring Ash Dam during the reporting period. Surface monitoring locations are provided in on Plan AW1040.

The Water Management Plan for Awaba Colliery was developed in October 2011 as per Condition 17 - 22 of Schedule 3 of the Project Approval and was approved by the Department of Planning and Infrastructure in November 2011. The surface water risk assessment (failure modes and effects analysis) was reviewed for the Awaba Colliery in 2012.

Upgrades to the pumping system at the Awaba Pollution Control Dam (PCD) were undertaken in 2014 to reduce the likelihood of discharge. Plans for the expansion of the PCD have been put on hold.

Upstream and downstream sampling has continued along Stony Creek to establish natural background concentrations, along with the introduction of an additional reference site in the Jigadee Creek catchment area as recommended in the surface water assessment completed for the Environmental Assessment.

7.2. GROUND WATER

Water underground is generated from groundwater which is released from the strata into underground mine workings. The collected water gravitates through an extensive goaf/underground dam system that allows filtration and settlement. The water can then be pumped from the mine via licensed discharge point LDP004, and via the 10 South Borehole into the Eraring Ash Dam. Pumping from LDP004 during the report period is discussed in Section 7.1.

In October 2011, a Groundwater Monitoring Program was developed in accordance with Condition 21 of Schedule 3 of the Project Approval (10_0038) and approved by the Department of Planning and Infrastructure in November 2011.

In August 2013 an inspection of an unnamed watercourse which flows to Muddy Lake identified an area of sodden ground which resulted in a water flow. This visual inspection indicated clear water with iron staining in the sediment.

The area affected is approximately 160m to the South of the nearest Awaba workings. The seepage area has shown results of low pH, high conductivity and other analytes.

Awaba Colliery workings have slowly been filling with water over several years. This rise in water level in the underground workings has occurred as a result of rainfall events infiltrating subsidence cracks and sinkholes, and groundwater infiltration. Awaba had also been receiving water under the EPL from Newstan Colliery of up to 4 ML/Day from 15 October 2011 to 27 June 2013. Ongoing monitoring is currently being undertaken at this location. The level within the workings was at 17.6m RL at the end of the reporting period.

In identification of the seepage area the following actions were undertaken:

- Initial water quality monitoring & establishment of monitoring points to determine water quality at the seepage area & downstream. After water quality returned unfavourable results, the following actions were undertaken;
- An assessment of water quality within the unnamed creek including a comparison against the Awaba Colliery underground water quality to determine if there are similarities.
- A preliminary Terrestrial Ecology Assessment.
- A preliminary Aquatic Ecology Assessment.
- Ongoing Monthly water quality monitoring & review of data.
- Monthly borehole water dipping and water quality analysis.
- Annual Terrestrial Ecology Assessment & establishment of permanent quadrats in spring 2014.
- Commencement of Biannual Aquatic Ecology Assessments in spring 2014. This has been developed to align with assessments carried out for Cooranbong Services Site.

The results of monitoring and change to the wetting regime and water quality within the seepage area has had or has the potential to have the following impacts on terrestrial and aquatic ecology:

- In the long term, an increase in the degree of waterlogging and inundation in the groundcover and changes to the flow within the creek may lead to a change in the vegetation community at the seepage area
- Changes in water quality as a result of the seepage are likely to result in the site being unable to support Swamp Sclerophyll Forest
- Changes in vegetation community that result in a loss of understory shrubs, leaf litter, hollow logs and mature trees (including Swamp Mahogany) would decrease the available foraging habitat for reptiles, ground-dwelling and arboreal mammals, bats and forest birds.
- Changes in water quality as a result of the seepage are likely to render the area unable to support threatened and migratory fauna through both loss of forage habitat and changes in water quality and chemistry resulting in an undrinkable water source.
- There is a high risk of impact to a Groundwater Dependent Ecosystem (Swamp Sclerophyll Forest).
- There was a notable decrease in the levels of macroinvertebrate taxa richness, EPT richness and SIGNAL 2 at SP5 (SW013) since the July 2012 monitoring events. The macroinvertebrate community at SP5 (SW013) is no longer considered a non impacted site.
- If the acidic seepage continues on a long term basis the site will be unable to support a diverse aquatic system and will affect aquatic fauna recruitment rates into the system.

In January 2015 a consultation session was held with the relevant government departments and the Rehabilitation Works Plan is being developed in consultation the DRE, OEH, NOW, EPA & LMCC in accordance with the Section 240 Notice from the DRE. This Rehabilitation Works Plan will include the following:

- Details of the ongoing Water Quality Monitoring,
- Details of the ongoing Macro-invertebrate Monitoring,
- Details of the ongoing Terrestrial Ecology Monitoring,
- Completing an options assessment, which will include the feasibility of rehabilitation options, and any other options which may result from consultation,

- On selection of a preferred option, a review Rehabilitation Works Plan is to be completed, with additional information with regards to the final rehabilitation completion criteria.

The Awaba Seepage Rehabilitation Works Plan period ended in January 2016. A Clean-Up Notice in regard to the Awaba Seepage was issued by the EPA on 8 April 2016 requiring the completion of environmental site investigations, evaluation of management options and the development of a design and implementation works program. An environmental site investigations report was submitted to the EPA in July 2016 and a management options report submitted to the EPA in September 2016. Centennial is continuing to consult with the relevant government departments to address the issue.

In February 2016, a bore CA13 was installed to investigate the geochemistry of the overburden strata above the mine workings and to monitor water quality in the Awaba workings adjacent to the seepage area.

In September 2017 Centennial Newstan was issued with a Clean Up Action 1553877 to undertake further monitoring along with a Treatment and Investigation Report. This information was provided to the EPA and DRE on the 28th of February 2018. A response has not yet been received from the departments.

7.3. WATER BALANCE

The water balance completed for the Awaba Colliery Water Management Plan and for the Awaba Colliery Mining Project predicted that the annual average discharge (ML/year) from the Awaba underground workings would be 278.1 ML per annum.

No discharges through licenced discharge points occurred within 2017.

8. REHABILITATION

8.1. BUILDINGS AND INFRASTRUCTURE

No additional buildings were undertaken during the report period at Awaba. No buildings were removed during the reporting period.

8.2. SUBSIDENCE

Sinkhole Rehabilitation was undertaken during the reporting period in accordance with the Sinkhole Rehabilitation Management Plan. Two sinkholes were rehabilitated between August and September 2017 in the areas MR7 – 18 and 20. All sinkholes were located within close proximity of each other.

The following occurred during the rehabilitation process:

- Each hole when finished was raised up in height and crowned off / re-shaped to shed water into diversion drains cut in around each hole;
- Sediment controls were installed in diversion drains including gabion baskets, rock check drains and boulders. A geosynthetic clay liner was installed in the diversion drain to prevent water ingress and reactivation of erosion.
- Trees and vegetation cleared were spread over rehabilitated areas;
- Rehabilitated areas were hand seeded with native mix as specified

Sinkhole rehabilitation is planned to continue in 2018. Rehabilitation monitoring and any additional maintenance and weed management will occur on previously rehabilitated sinkholes as required.

8.3. REHABILITATION OF DISTURBED LAND

The Newstan and Awaba MOP Complex was approved in March 2018 for the period March 2018 – July 2020.

Table 12 displays a rehabilitation summary for the Newstan and Awaba Collieries.

Table 11: Newstan Awaba Rehabilitation Summary

Domain	Area Affected / Rehabilitated (ha)	
	Total Area at MOP start (Plan 3A)	Total Area at end of MOP (Plan 3A)
Mine Lease Area		
Mine Lease(s) Area	3989.9	3989.9
Domain 1: Infrastructure Area		
Active Mining Area	102	102
Decommissioning	-	-
Landform Establishment	-	-
Growth Medium Development	-	-
Ecosystem and Land Use Establishment	-	-
Ecosystem and Land Use Sustainability	-	-
Relinquished Lands	-	-
Total	102	102
Domain 2: Tailings Storage Facility		
Active Mining Area	56.2	54.1
Decommissioning	-	-
Landform Establishment	7.0	7.0
Growth Medium Development	-	-
Ecosystem and Land Use Establishment	11.7	13.8
Ecosystem and Land Use Sustainability	20.8	20.8
Relinquished Lands	-	-
Total	95.7	95.7

Domain	Area Affected / Rehabilitated (ha)	
	Total Area at MOP start (Plan 3A)	Total Area at end of MOP (Plan 3A)
Domain 3: Water Management Area		
Active Mining Area	11.8	11.8
Decommissioning	-	-
Landform Establishment	-	-
Growth Medium Development	-	-
Ecosystem and Land Use Establishment	-	-
Ecosystem and Land Use Sustainability	-	
Relinquished Lands	-	-
Total	11.8	11.8
Domain 5: Stockpiled Material		
Active Mining Area	12.0	12.0
Decommissioning	-	-
Landform Establishment	-	-
Growth Medium Development	-	-
Ecosystem and Land Use Establishment	-	-
Ecosystem and Land Use Sustainability	-	-
Relinquished Lands	-	-
Total	12.0	12.0-
Domain 8: Underground Mining Area		
Active Mining Area	0 (Area above workings is 5088 ha)	0
Decommissioning	-	-
Landform Establishment	-	-
Growth Medium Development	-	-
Ecosystem and Land Use Establishment	-	-

Domain	Area Affected / Rehabilitated (ha)	
	Total Area at MOP start (Plan 3A)	Total Area at end of MOP (Plan 3A)
Ecosystem and Land Use Sustainability	-	-
Relinquished Lands	-	-
Total	-	-

8.4. REHABILITATION TRIALS AND RESEARCH

No rehabilitation trials occurred during the reporting period.

9. COMMUNITY

9.1. COMPLAINTS

There were no complaints made during the 2017 reporting period regarding Awaba Colliery operations.

Table 12: Awaba Complaints Summary 2010 - 2017

Record of Complaints	
Year	Total
2010	0
2011	0
2012	0
2013	0
2014	0
2015	0
2016	0
2017	0

9.2. COMMUNITY CONSULTATION

A Community Consultative Committee (CCC) has been in place at Newstan since 1999. In 2011 Awaba Colliery was joined into the Newstan Colliery CCC. The Committee generally meets quarterly to review the environmental performance of the mine and other relevant matters. Minutes of the meeting are kept and distributed by the independent Chairman. The minutes are also available on the Centennial Newstan website. Meetings of the Newstan and Awaba Colliery CCC were held in March, July and December during the reporting period.

9.3. COMMUNITY SPONSORSHIP

Newstan and Awaba Collieries continues to support the local community through various sponsorship avenues in 2017.

10. INDEPENDENT AUDIT

There is no requirement for Awaba Colliery to undertake an external Independent Environmental Audit.

11. INCIDENTS AND NON-COMPLIANCES DURING THE REPORTING PERIOD

There were no non-compliances during the reporting period.

12. ACTIVITES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

Activities proposed for the 2018 reporting period include;

- Maintenance of the Awaba Colliery pit top and remaining buildings
- Rehabilitation of sink holes in accordance with the Sinkhole Rehabilitation Plan.
- Ongoing consultation with the EPA with regard to the seepage and Clean-Up Notice requirements.

13. PLANS

AW2245 – Great Northern Seam Workings.

AW2260 – Location of Licenced Discharge Points and Surface Water Monitoring Points

AW2261 – Location of Air, Noise, Weather, Water – Monitoring points, and Water Management Devices

14. APPENDICES

Centennial Coal

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Centennial Newstan (Awaba) Colliery
2017 End of Year
Subsidence Status Management Report

Report Number: **10**

Reporting Period: **2017**

Distribution List:

- Director Environmental Sustainability
- Industry Coordination
- Subsidence Executive Officer
- District Inspector
- Principal Subsidence Engineer
- Subsidence Engineer
- NSW Department of Primary Industry | Water
- Office of Environment & Heritage
- Department of Planning & Environment
- Ausgrid
- RailCorp (Transport NSW),
- Subsidence Advisory NSW,
- Origin Energy,
- Telstra
- Newstan (Awaba) Mine Manager,
- Newstan (Awaba) Environmental Coordinator.

General Comments:

Stage 1:

- Approval to mine Stage 1 of Mine Subsidence Management Plan (MSMP) at Awaba Colliery was granted on 03/09/2007
- Mining completed on 26/06/2009.
- Monitoring variation from 3 to 6 monthly approved 28/06/2011.
- January and March 2014 resurveys recorded greater than predicted maximum subsidence along Main South Crossline between XL24 to XL66 – and 8NE Centreline between CL01 to CL16. Monitoring frequency was temporarily increased.
- Relatively stable results were achieved during the second half of 2014.
- Relatively stable results continued through 2015, 2016 and 2017.
- Monitoring variation from monthly to 6 monthly approved 09/12/2016.

Stage 2:

- Approval to mine Stage 2 of MSMP at Awaba Colliery was granted on 29/08/2008
- Mining completed on 08/03/2012.
- Monitoring variation from 3 to 6 monthly approved 31/05/2013.
- July 2014 resurvey recorded greater than predicted subsidence along Main South Crossline Extension between XLE01to XLE22 – and 8SW Centreline between 8SW22 to 8SW43. Monitoring frequency was temporarily increased.
- A Sinkhole was found and reported on 03/02/2015 near 8SW29-30. The sinkhole has been filled. The area is being rehabilitated in accordance with the sinkhole rehabilitation plan.
- Relatively stable monitoring results were achieved in 2015, and continued through 2016 and 2017.
- Monitoring variation from monthly - to 2 monthly for 6SW, and 6 monthly for all other points - approved 09/12/2016.

Stage 3:

- Approval to mine Stage 3 of MSMP at Awaba Colliery was granted on 15/12/2010
- A Sinkhole was found and reported following heavy rain over the June 2011 long weekend. The sinkhole was filled. The area was rehabilitated in accordance with the sinkhole rehabilitation plan.
- Mining Completed on 22/12/2011.
- Monitoring variation from 3 to 6 monthly approved 31/05/2013.
- Additional amendments to Stage 3 monitoring program in consultation with Principal Subsidence Engineer (PSE) and relevant stakeholders.
- Monitoring results show subsidence within predictions.
- 4NW monitoring was temporarily increased to Monthly – to match the frequency of Stage 1 and 2.
- 4NW Monitoring variation from monthly to 6 monthly approved 09/12/2016.
- There continues to be relatively stable monitoring results recorded from surveys.

Awaba Colliery Great Northern Seam Mining Ceased 08/03/2012.

- All Awaba Mine entries (Drifts and Shafts) were sealed in August 2012.
- Underground workings are sealed – and no longer accessible.

SMP Approval Condition No.	Requirement Summary	Comment / Description
22 (a) – Stage 1 23 (a) – Stage 2 24 (a) – Stage 3	**Summary of Subsidence and Environmental Monitoring Results**	The Following subsidence surveys and inspections have been completed: ***Surface Surveys –*** All scheduled subsidence surveys completed to December 31st, 2017. There were No Notifiable Subsidence Incidents in 2017. **Maximum subsidence** in **2017 period** – was in **Stage 2** - XLE17, -1.402m. **Stage 1** - Maximum subsidence was at XL40, -1.349m. **Stage 3** - Subsidence monitoring results in 2017 were well within predicted levels and continue to be relatively stable.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		Environmental inspections were carried out in January 2014. Traversing between transects involved walking along over a kilometre of Stony Creek, including part of a tributary. The 2014 survey found no impact on Stony Creek, and was the last Ecological Survey. ***Underground Surveys –*** All Awaba Mine entries (Drifts and Shafts) were sealed in August 2012 Underground workings are no longer accessible.
22 (b) – Stage 1 23 (b) – Stage 2 24 (b) – Stage 3	**Analysis of Subsidence and Environmental Monitoring Results**	After reporting greater than predicted subsidence in both Stage 1 and Stage 2 during 2014 – Monitoring Results for 2015, 2016 and **2017** were consistently relatively stable.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		January and March Surveys of **2014** found greater than predicted subsidence in Main South **Stage 1** Area. A report was prepared by a geotechnical consultant with regard to this event. The subsidence has had no adverse impact on surface infrastructure. Centennial Survey prepared a plan showing zones of subsidence along monitoring points in relation to surface features and underground workings to help bring perspective to results. A PDF of this plan was sent to relevant government departments and stakeholders. The significant increase in subsidence occurred approximately 175 to 300 metres from the Main Northern Railway Line. There is no subsidence impact on monitoring points nearer to the Main Northern Railway, Ulan Rail Loop, Haul Road, Haul Road Bridge, Telstra Tower or Railcorp and Ausgrid Power Poles. There have been no observed visual environmental impacts in Stage 1 Area.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		July 2014 Surveys found greater than predicted subsidence in Main South **Stage 2** Area. Centennial Survey prepared a plan showing zones of subsidence along monitoring points in relation to surface features and underground workings to help bring perspective to results. A PDF of this plan was sent to relevant government departments and stakeholders. The significant increase in subsidence occurred approximately 250 to 350 metres from the Main Northern Railway Line. There is no subsidence impact on monitoring points nearer to the Main Northern Railway, Ulan Rail Loop, Haul Road, Haul Road Bridge, Telstra Tower or Railcorp and Ausgrid Power Poles. Environmental impacts in Stage 2 - Cracking that was observed and reported, associated with the greater than predicted subsidence. The Sinkhole reported on 03/02/2015 near 8SW29-30. The sinkhole has been filled. The area is being rehabilitated in accordance with the sinkhole rehabilitation plan.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		No visual disturbance has been identified on tracks & trails. **Stage 3** Subsidence monitoring results in 2017 were within predicted levels and continue to be relatively stable. Environmental impacts in Stage 3 - have been confined to the previously reported and rehabilitated sinkhole.
22 (c) – Stage 1 23 (c) – Stage 2 24 (c) – Stage 3	**Trends in Monitoring Results**	In general - the trend in monitoring results shows that the majority of subsidence occurs during and shortly after mining extraction. In the following months the rate of subsidence decreases toward a stable environment. However after approximately 6 years of relative stability – there was greater than predicted subsidence in Main South **Stage 1** and **Stage 2** in **2014**. During 2014 – after the initial sudden increase in subsidence - results began to trend toward decreasing movement. In 2015, 2016 and **2017 -** surveys have consistently shown relatively stable results.

SMP Approval Condition No.	Requirement Summary	Comment / Description
22 (d) – Stage 1 23 (d) – Stage 2 24 (d) – Stage 3	**Management Actions of Potential Impacts**	In general - current Public Safety and Subsidence Management Plans are considered adequate. Following greater than predicted subsidence in **Stage 1** Main South Cross line / 8NE Centreline area in 2014; All relevant government agencies and stakeholders were notified as per condition 20, after results of January survey. Centennial Newstan conducted a follow up survey – including strain measurements in early March. The results were distributed to relevant government agencies and stakeholders. A visual inspection was carried out on 21/03/2014 - by a Geotechnical consultant accompanied by the Mine Manager and Mine Surveyor. No visual signs of subsidence were observed. The results were included in a geotechnical report. A meeting between Centennial Newstan and PSE was held on 25/03/2014 to discuss the mechanics and management of this occurrence. A report prepared by a geotechnical consultant with regard to this event was distributed to Transport NSW and the PSE on 27/03/2014. Further reports were distributed on 2/6/2014 and 23/6/2014. A meeting to discuss the increased subsidence in Stage 1 was held in Chatswood on 02/04/2014. It was attended by the Principal Subsidence Engineer (PSE), Centennial Newstan, an independent geotechnical

SMP Approval Condition No.	Requirement Summary	Comment / Description
		consultant, and Transport NSW. During the Chatswood meeting – it was agreed to temporarily increase the frequency of surveys until a trend of stable results was achieved. Note that as agreed during the meeting in Chatswood - subsidence of 50mm or greater observed within the Railway Protection Zone (RPZ) - will trigger further communication and review of the situation. Monitoring frequency was increased on 04/04/2014 to provide further data until the area became stable; and to monitor any possible increased subsidence moving toward the rail corridor. Following greater than predicted subsidence in **Stage 2** Main South Crossline Extension / 8SW Centreline area - All relevant government agencies and stakeholders were notified as per condition 21, after results of the July survey. A visual inspection carried out by the Mine Surveyor found evidence of minor surface impacts within these areas. Results were forwarded to PSE, relevant government departments and stakeholders on 14/07/2014. Agreement was reached with the PSE and Transport NSW - to increase monitoring frequency to provide further data until the area becomes stable; and to monitor any possible increased subsidence moving toward the rail corridor. Subsidence of 50mm or greater observed within the Railway Protection Zone (along 8SW) or the Railway Mining Barrier (along 6SW) - will trigger further communication and review of the situation. Monitoring frequency was increased on 16/07/2014.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		A meeting to discuss the trend of consistent relatively stable monitoring results in both **Stage 1** and **Stage 2** - was held in Burwood on 12/08/2015. It was attended by the Principal Subsidence Engineer (PSE), Centennial Newstan, an independent geotechnical consultant, and Transport NSW. During the Burwood meeting – it was agreed to amend the frequency of surveys from fortnightly to monthly for a period of six months (commencing from August). If results continued to be stable during this period – agreement would be made to further reduce monitoring frequency. On October 7th, 2015, official approval was granted by PSE to vary this monitoring to monthly. A meeting between Centennial Newstan and PSE was held on 20/07/2016 to discuss the consistent relatively stable monitoring results in **Stage 1, 2, 3**. A report reviewing the recent subsidence data, prepared by a geotechnical consultant, was distributed to Transport NSW and the PSE on 25/08/2016. In addition, a letter requesting agreement from Transport NSW to amend the monitoring program to 2 monthly for 6SW points, and 6 monthly for other nominated **Stage 1,2,3** points was submitted on 25/08/2016. Agreement to amend the monitoring program was received from Transport NSW on 08/12/2016. Agreement to amend the monitoring program was received from PSE on 09/12/2016.

SMP Approval Condition No.	Requirement Summary	Comment / Description
		A letter requesting agreement from Transport NSW to amend the monitoring program from 2 monthly to 6 monthly for 6SW points, was submitted on 21/09/2017. Following the reporting of the **Stage 2** localised sinkhole in February 2015, - The relevant government authorities and stake holders were informed within 24 hours of the discovery of the hole. The location of the sinkhole was plotted and is shown on the Stage 2 Face Position plan AW2075. The sinkhole has been filled. The area is being rehabilitated in accordance with the Sinkhole Rehabilitation Plan. Following the formation of the **Stage 3** Sinkhole in June 2011 -The relevant government authorities and stake holders were informed within 24 hours of the discovery of the hole. Rehabilitation of the site has since been completed. The location of the sinkhole was plotted, and is shown on the Stage 3 Face Position plan AW2176. Due to the partial reactivation of this hole - further minor rehabilitation works were carried out during 2015, in accordance with the Sinkhole Rehabilitation Plan.

Grant Watson

Centennial Newstan (Awaba) Colliery – Mine Manager

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Centennial Coal

Newstan & Awaba Subsidence Rehabilitation Report

2017

1. Background

Newstan Colliery commenced mining operations in 1887, and is an underground mine owned and operated by Centennial Newstan Pty Ltd. Newstan Colliery has undertaken underground mining using both bord and pillar mining, and long wall mining methods. Mining has been undertaken in the Young Wallsend, Great Northern, Fassifern, Borehole and West Borehole seams.

Awaba Colliery is a small underground coal mine also owned and operated by Centennial Newstan Pty Ltd. Awaba Colliery commenced operations in 1947, and continued until 2012 when the mining operations ceased and the mine was sealed.

The Sinkhole Rehabilitation Plan (Appendix 1) was prepared following the formation of a number of sinkholes throughout the area of the former Western Underground at Awaba Colliery. These sites are associated with previous full pillar extraction and shallow depth of cover (<30m). The Sinkhole Rehabilitation Plan outlines a methodology for the effective rehabilitation and maintenance of sinkholes for reference by employees and contractors of Centennial Newstan.

2. Scope

This Newstan & Awaba Subsidence Rehabilitation Report is prepared to fulfil the requirement of the Sinkhole Rehabilitation Plan, the requirements under the Mining Operations Plans for Newstan & Awaba, and to provide a summary report to the DTIRIS-DRE as soon as practicable following the completion of field inspections and a schedule of works for rehabilitation. This report will provide details of the following:

- The identification of newly formed sinkholes or subsidence cracks;
- An assessment outlining the condition of newly formed sinkholes & subsidence cracks including the following;
    - Locality (including co-ordinates)
    - Site characteristics
    - Approximate dimensions
- An assessment outlining the condition of rehabilitated sinkhole areas; and
- Identify any erosion features (such as head cuts) within creek lines.

3. Location

The Subsidence and Rehabilitation Monitoring Plan (AW2248) is included in Appendix 2, and identifies the location of existing and historical sinkholes at Awaba Colliery.

The figure effectively demonstrates that sinkholes at the Colliery are concentrated within areas associated with low depth of cover (less than 30m) and drainage lines (where depth of cover is further reduced). These areas identified on the plan AW2248 by the highlighted creek line are the focus areas of the inspections, and are labelled from MR1 to MR13.

4. Monitoring Schedule

The Subsidence inspection is scheduled to be undertaken quarterly by the Environmental Co-ordinator or designated personnel in accordance with the Sinkhole Rehabilitation Plan. Each quarterly inspection will cover one to three of the focus areas.

5. Identified Subsidence

The following table provides any additional subsidence identified during inspections in 2016/2017 above the Awaba and Newstan Colliery workings, the location and the observations.

Table 1 Inspection Results

Area Inspected		Any Subsidence impacts found?			GPS Location	
	Site Number	Sinkholes, cracks, step change, ponding, etc	Dimensions L x W x D	Observations	Easting	Northing
MR7	MR7-8	Sinkhole	50m x 15m x 3m	Dense ground cover, in creek line, nil flow, ponding	E0361285	6344231
MR7	MR7-9	Sinkhole	1m x 1m x 0.5m	Dense riparian vegetation, in creek line, nil flow, ponding	E0361440	6344246
MR7	MR7-10	Sinkhole	4m x 3m x 1m	Dense ground cover, In creek line, Edge of track, nil flow, ponding	E0361452	6344258
MR7	MR7-11	Sinkhole	1m Dia.	Edge of access track, deep.	E0361344	6344177
MR7	MR7-13	Sinkhole	1.5m x 1.5m	Adjacent to power easement access track.	E0360500	6343958
MR7	MR7-15	Sinkhole	4m x 2.5m x 1m	Currently a minor depression in ground – with potential to worsen during a significant rainfall event / watercourse flow	E0361422	6344257
MR7	MR7-16	Sinkhole	2m x 2m x 1m	Sinkhole in close proximity to MR7-8	E0361353	6344224
MR7	MR7-18	Sinkhole	2m x 3m x 2m	Small sinkhole located upstream of the MR7 series	E361717	6344381
MR7	MR7-20	Sinkhole	1m x 4m x 2m	Area of wash out above MR7-18	E361763	6344406
MR11	MR11-1	Sinkhole	2m x 3m x 5m	Deep hole above the creek line	E0362885	6343452
MR11	MR11-2	3 Sinkholes	6m x 4m x 5m	3 sinkholes of similar size in close proximity. Possibly draining into mine	E0362857	6343403
MR11	MR11-3	Sinkhole	4m x 4m x 3m	In creek line	E0362770	6343359
MR11	MR11-4	Sinkhole	1m x 2m x 1m	20m from the creek line in dense vegetation	E0362743	6343294

Area Inspected	Site Number	Any Subsidence impacts found?			GPS Location	
		Sinkholes, cracks, step change, ponding, etc	Dimensions L x W x D	Observations	Easting	Northing
Stage 2	Stage 2	Sinkhole	5 x 4 x 3	Sinkhole within drainage line	E362159	6344085
Stage 3	Stage 3	Sinkhole	2 x 2 x 2	Small area located below original stage 2 sinkhole that had reopened	E362514	6345298

6. Rehabilitation Status

The below describes the rehabilitation status of previous sinkholes and subsidence cracks. If the subsidence is re-activated, then the point will be added back into the above table for additional work.

Table 2 Subsidence Rehabilitation Status

Rehabilitated Site		GPS Location		Rehabilitation Assessment						
Area	Site Number	Easting	Northing	Evidence of Subsidence	Erosion or Sedimentation	Crop establishment	Natural Regeneration	Weed Infestation	Integrity of banks, drains, Sediment control structures	General Stability

Rehabilitated Site		**GPS Location**		**Rehabilitation Assessment**						
Area	Site Number	**Easting**	**Northing**	Evidence of Subsidence	Erosion or Sedimentation	Crop establishment	Natural Regeneration	Weed Infestation	Integrity of banks, drains, Sediment control structures	General Stability
MR6	MR6-1	360166	6344245	No	No	No	No	No	N/A	Track on power line easement
MR6	MR6-4	360437	6344337	No	No	Yes	Yes	Minor	good	Good
MR6	MR6-10	360695	6344714	No	No	Yes	Yes	Minor	Good	Good
MR6	MR6-9	360695	6344714	Yes Crack	No	No	Yes	No	Good	Good
Aldon Crsct	23-25	367796	6348751	No	No	Yes	No	No	Good	Good
MR7	MR7-5	E0360771	6343919	No	No	Yes	No	Minor	Good	Good
MR7	MR7-1	E0362885	6343452	No	No	Yes	No	Minor	Good	Good

Rehabilitated Site		GPS Location		Rehabilitation Assessment						
Area	Site Number	Easting	Northing	Evidence of Subsidence	Erosion or Sedimentation	Crop establishment	Natural Regeneration	Weed Infestation	Integrity of banks, drains, Sediment control structures	General Stability
MR7	MR7-2	E0362857	6343403	No	No	Yes	No	Minor	Good	Good
MR7	MR7-3	E0362770	6343359	No	No	Yes	No	Minor	Good	Good
MR7	MR7-4	E0362743	6343294	No	No	Yes	No	Minor	Good	Good
MR7	MR7-13A	E0360477	6343951	No	No	Yes	No	No	Good	Good
Newstan Subsidence Crack (not on plan)	Newstan Crack			No	No	Yes	Yes	Minor	Good	Good
Stage 2	Stage 2	362159	6344085	No	No	Yes	Yes	Minor	Good	Good
Stage 3	Stage 3	362514	6345298	No	No	Yes	Yes	Minor	Good	Good

MR7-18 and MR7-20

Rehabilitation of the MR7-18 and MR7-20 sinkholes commenced in August 2017 and were done in conjunction with one another due to their close proximity. The sinkholes were cordoned off to restrict access, and sediment and erosion controls installed. Land clearing was restricted to the predetermined access route, subsidence area and the creek diversions. The base of the hole was filled with boulders and concrete followed by a layer of course rock, a layer of course sand, a layer of fine sand, a layer of clay and covered with soil excavated from the sink hole.

The below pictures provide before and after photos of the sinkhole.

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Centennial Awaba Colliery

FINAL

Sinkhole Rehabilitation Plan

Awaba Colliery

March 2012

CCC03-005

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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1.0 INTRODUCTION

1.1 Background

Awaba Colliery is a small underground coal mine operated by Centennial Newstan Pty Ltd, a wholly owned subsidiary of Centennial Coal Company Ltd (Centennial). The mine entry and primary surface facilities are located approximately one kilometre south of the Awaba village and 5.5km south west of Toronto on the western side of Lake Macquarie, near Newcastle NSW. Awaba Colliery has been producing coal by bord and pillar mining methods since 1947. The locality of the site is illustrated on **Figure 1.**

Awaba Colliery was a small operation which historically produced approximately 800,000 tonnes of thermal coal annually until the cessation of mining in early 2012. Since commencing mining operations in 1947, over 30 million tonnes of coal has been extracted from the Great Northern Seam using a combination of first workings development, pillar extraction, pillar quartering, and pillar stripping.

The old Western Underground workings are located directly to the west of the existing Awaba surface facilities and approximately 3km north of the Eraring Power Station. These mine workings are located beneath crown land and are very shallow (less than 30m) in certain areas. Mining within the Western Underground was undertaken through a combination of the full extraction and partial pillar extraction methods of mining.

Due to the shallow nature of the historic workings and the specific characteristics at the site, a number of sinkholes have developed above the old Western Underground workings (typically in drainage lines and creeks where the depth of cover is further reduced). A sinkhole is defined as an abrupt local depression at the surface which can be hazardous due to its tendency to occur without warning (Singh and Darh, 1997). These sinkholes cause safety and environmental issues that need to be managed appropriately.

1.2 Scope

This Sinkhole Rehabilitation Plan has been prepared in response to a request by Centennial Coal following the formation of a number of sinkholes throughout the area of the former Western Underground which were first detected in 2010. These sites are associated with previous full pillar extraction and shallow depth of cover (<30m). This Sinkhole Rehabilitation Plan outlines a methodology for the effective rehabilitation and maintenance of sinkholes for reference by employees and contractors of Awaba Colliery. It aims to fulfil the following objectives:

- Establish objectives for the rehabilitation of land at the Awaba Colliery that has been disturbed by sinkholes (also to be used for any future sinkholes that may be observed);
- Outline rehabilitation procedures for sinkholes and associated land preparation works;
- Establish required actions to ensure the safety of Awaba Colliery employees, contractors and the general public is maintained;
- Achieve acceptable post rehabilitation land use suitability;
- To create a stable post rehabilitation landform;
- To preserve downstream water quality;
- Re – establish habitat and landforms that will support fauna and flora communities;
- Outline procedures to ensure adherence with the relevant guidelines and legislative requirements relevant to this Sinkhole Rehabilitation Plan;
- Outline management measures to stabilise any upstream erosion impacts;
- Outline proposed contingency measures to address unpredicted impacts associated with sinkhole rehabilitation; and

- Provide all employees and contractors of Awaba Colliery with a clear description and understanding of responsibilities and requirements regarding sinkhole rehabilitation and monitoring.

1.3 Awaba Colliery Approvals

Mining operations commenced at the Awaba Colliery in 1947, well before the introduction of the NSW Environmental Planning and Assessment Act (EP&A Act) in 1979. Until recently, mining at Awaba Colliery has been carried out pursuant to continuing use rights afforded under the EP&A Act and State Environmental Planning Policy (Major Development) 2005. In May 2011, Project Approval PA 10_0038 for the *Awaba Colliery Mining Project* was granted by the NSW Minister of Planning under (the now repealed) Part 3A of the EP&A Act to allow a minor extension of underground mining and the ongoing use of associated surface facilities. Accordingly post-closure (care and maintenance) operations at Awaba Colliery are currently undertaken in accordance with the requirements of Project Approval PA 10_0038 and mining lease conditions.

Awaba Colliery is situated within the Newstan Colliery Holding and operates within the bounds of Consolidated Coal Lease 746 (CCL746), which was issued (as a renewal) pursuant to Section 114(1) of the Mining Act 1992. Current active mining within the Main South Area (Stage 2 and 3) and East B mining area are undertaken in accordance with Subsidence Management Plan (SMP) approvals received from the Department of Trade and Investment, Regional Infrastructure and Services – Division of Resources and Energy (DTIRIS - DRE) (formerly I&I) in 2005 and 2009 respectively.

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Location Plan
FIGURE 1

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2.0 PROJECT SITE CHARACTERISTICS

2.1 Land Use and Ownership

Identified sinkholes at Awaba Colliery are located within the previously mined Western Underground area and are located on Crown Land under lease from the NSW State Government to Centennial for the purposes of mining. The land surrounding the sinkholes is characterised by bushland. Land use in the area is predominantly of mining related activity including access and exploration activities.

2.2 Topography and Surface Hydrology

The local landscape is characterised by low, rolling ridges and gullies ranging from 25 to 60m in elevation Australian Height Datum (AHD) with slope gradients generally between 10 – 25%. The landscape comprises predominantly of open Sclerophyll forest with some riparian vegetation occurring around watercourses and within low lying areas.

Surface hydrology in the local area consists of a series of perennial first and second order water courses with semi-permanent ponds in various locations. Runoff from the area reports to natural drainage lines that eventually report to Jigadee Creek, a tributary of Dora Creek. The more established watercourses in the area are characterised by a narrow corridor of riparian vegetation consisting of Melaleuca and sedges. It is noted that the hydrology of some watercourses and drainage lines has been impacted by the presence of sinkholes at the Awaba Colliery, with observations indicating that flows are likely to be reporting to the mine workings as opposed to Jigadee Creek.

2.3 Soils and Geology

The identified sinkholes are located within the Awaba Hills soil landscape situated predominantly on coarse-grained sediments of the Narrabeen Group and Newcastle Coal Measures. The soils of this landscape tend to be shallow, hard setting and stony (Murphy, 1993).

Mining at the Awaba Colliery has been concentrated in the Great Northern Seam. The overlying formation is the Teralba Conglomerate (GSSE, 2010) which is thickly bedded with generally tightly packed, variable size, sub rounded to rounded, pebble and cobble clasts. The Teralba Conglomerate thins regionally from greater than 40m thick in the west of the site to approximately 20m in the east.

The formation underlying the seam is the Awaba Tuff. The Awaba Tuff is typically composed of inter-bedded very low to low strength (UCS of 5 to 15MPa) tuffaceous siltstone and sandstone beds. Thickness of these individual beds can vary significantly across the Awaba Colliery site. When exposed to water in the mine environment these units have the propensity to break down causing trafficability problems and floor heave.

2.4 Surrounding Infrastructure

There is no infrastructure within close proximity to the identified sinkholes; however, there are some infrastructure features in the general area of the sinkholes including:

- 330kv transmission lines;
- Transmission line easement;
- Unsealed access roads;
- Public roads; and
- The Main Northern Railway.

GSSE recommends that this surrounding infrastructure should be considered in any due diligence/risk assessments for the rehabilitation of future sinkholes at the site.

2.5 Aboriginal and European Heritage

An AHIMS search undertaken by RPS HSO in 2009 and documented in the *'Revised Stage 3 SMP Area Subsidence Management Plan Application'* (GSSE, 2009) indicates that no Aboriginal or European cultural heritage sites or areas of archaeological significance have been identified within the vicinity of identified sinkholes.

2.6 Ecology

2.6.1 Threatened Flora

The Awaba Colliery is surrounded by natural bushland, consisting of native tree species, Smooth Barked Apple and Scribbly Gum. Smooth-barked Apple and Scribbly Gum bushland is a preferred habitat for several threatened native flora species listed under the Threatened Species Conservation Act 1995 (TSC Act) and Environment Protection Biodiversity Conservation Act 1999 (EPBC Act). It is possible that threatened species may be present within the sinkhole rehabilitation and work area, therefore mitigation measures will need to be undertaken to minimise the potential impacts. This may include the internal Ground Disturbance Permit or by undertaking due diligence work ahead of the disturbance using a suitably qualified ecologist.

The Ecology Assessment undertaken by Hunter Eco in 2010 identified threatened species within close proximity of the identified sinkholes including:

- Black Eyed Susan (*Tetratheca juncea*); and
- Small-flower Grevillea (*Grevillea parviflora. subsp. parviflora*).

Black Eyed Susan is a small woody shrub that grows in open forest/woodlands, with a mixed shrub understorey. The shrub is native to the Upper Sydney Basin regions of Lake Macquarie and Wyong, and their main threat is land clearing. Small-flower Grevillea can be found in a variety of habitats and could be present within the sinkhole rehabilitation and work area.

2.6.2 Threatened Fauna

As mentioned previously, Awaba Colliery is surrounded by natural bushland, consisting of native tree species, Smooth Barked Apple and Scribbly Gum Eucalyptus trees. The natural bushland is a possible habitat for several threatened native fauna species listed under the TSC Act and EPBC Act. It is possible that threatened species may be present within the sinkhole rehabilitation and work area, therefore care should be taken to avoid contact with the local fauna during the remediation of the sinkholes.

Known threatened fauna species within close proximity of the sinkhole rehabilitation and work area, as identified in the Ecology Assessment undertaken by Hunter Eco in 2010, include:

- Glossy Black Cockatoo; and
- Little Lorikeet.

The Glossy Black Cockatoo is generally smaller than the average cockatoo, with distinct red tails. It lives within undisturbed coastal bushlands around Australia, and has been listed as a threatened species within the Lake Macquarie Local Government Area (LGA). The Little Lorikeet is an endemic Australian parrot, with a bright green body, and red forehead, which feeds upon flowering Eucalypts. They are known to occur within the Lake Macquarie LGA.

The threatened fauna species likely to be present at the subject site are highly mobile and would therefore not be impacted by the small surface changes associated with the remediation of sinkholes.

3.0 FORMATION OF SINKHOLES

3.1 General Sinkhole Formation

Sinkholes associated with underground mining generally occur in areas that have a shallow depth of cover (less than 50m), weak overburden and geological discontinuities. This type of subsidence forms abrupt local depressions at the surface which can be hazardous to life and property due to its tendency to occur without warning (Singh and Darh, 1997). Rainfall, water seepage and earthquakes all aggravate the occurrence of sinkholes.

Sinkhole subsidence can form in a number of ways above underground workings. Cavities may occur within the overburden following the inflow of sand and soil from the overlying weathered and friable strata through faults. These cavities eventually cave in and sinkholes appear at the surface. Alternatively, sinkholes can occur due to the failure of a mine roof which migrates through the overlying strata until the failure zone intercepts the unconsolidated overburden.

3.2 Current Condition of the Project Area

Subsidence events and sinkholes have occurred within the Awaba Colliery in historical mining areas (Western Underground) where shallow extraction was undertaken using bord and pillar methods. A monitoring program of the areas in the vicinity of the workings with the potential for such subsidence has been used by Awaba Colliery to identify these areas so that rehabilitation can occur in a timely manner (in accordance with the requirements of Consolidated Coal Lease (CCL) 746).

Awaba Colliery has experienced a number of sinkhole events caused by subsidence associated with the underground mines. The locations of identified sinkholes, creeks/drainage lines and the existing Awaba Colliery underground workings have been shown in **Figure 2**.

LEGEND

- Creek / drainage line
- Existing sinkhole
- Extent of existing / historical workings

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FIGURE 2

Sinkhole Conte□t Plan

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Project: Awaba Sinkhole Management

Client: Centennial Coal Company Pty Ltd

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3.3 Floor Heave/Subsidence Adjacent to Sinkholes

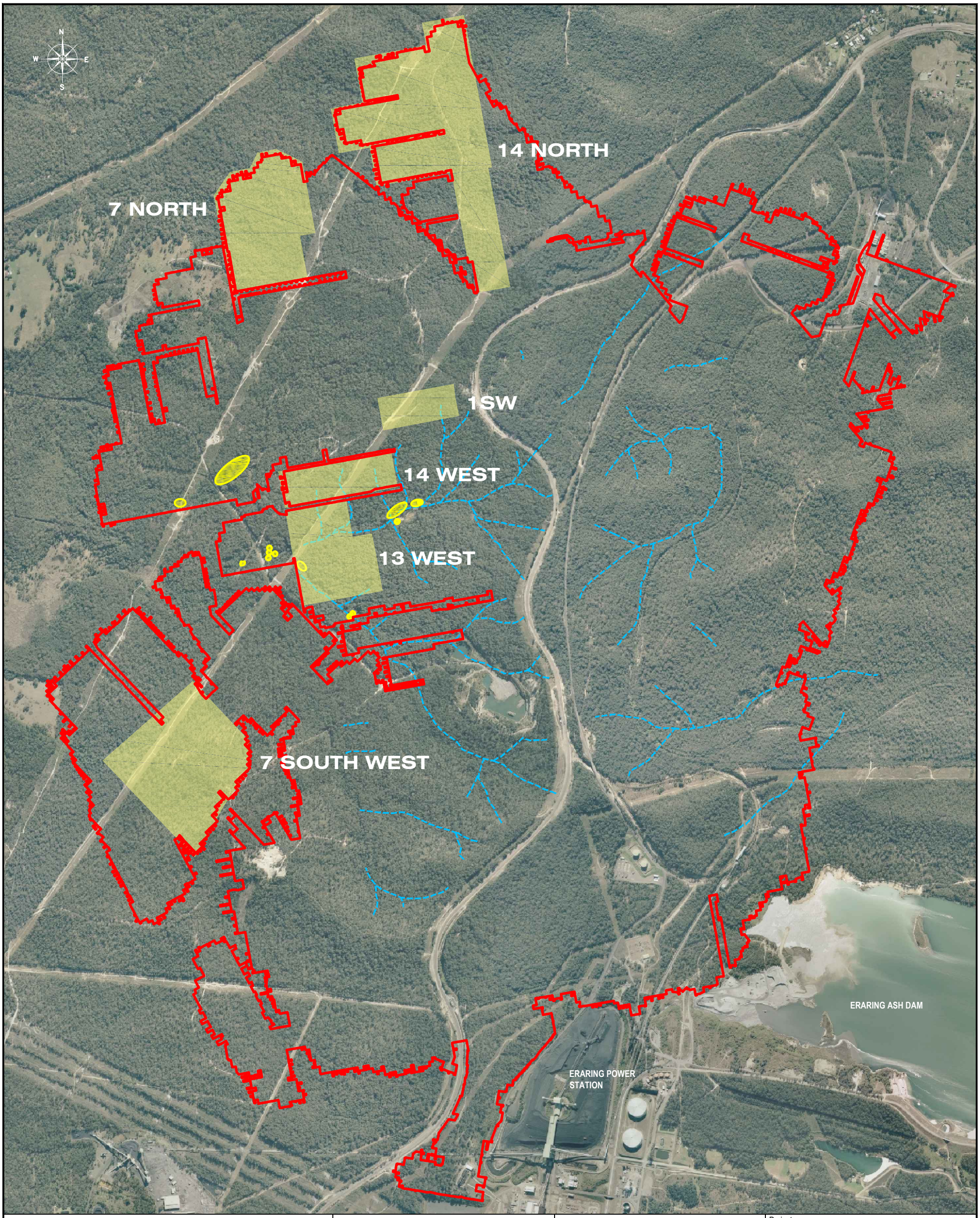
Figure 3 uses information provided by Centennial Coal to identify the locations of floor heave/subsidence events that have occurred in the immediate vicinity and adjacent to the sinkholes that have developed at the site. These subsidence events may be contributing to the formation of the sinkholes. The location of the floor heave/subsidence events with respect to the sinkholes are shown in **Figure 3**. All events have occurred on the west and north side of the railway, and at depths between 25m and 80m. No events have occurred east of the railway line. **Figure 3**, identifies panels that have experienced floor heave events, although it does not identify exactly what part of the panels did.

Seedsman Geotechnics Pty Ltd state in the report Subsidence Assessment Part 3A Submission (Seedsman, 2010) that floor heave/subsidence events have not been formally or exhaustively studied. There appears to be two models proposed.

One model proposes that abutment stresses around the extraction panel generate failure in relatively large pillars and that this propagates through the first workings. This model requires elevated vertical stresses that are well in excess of tributary area loading and that these persist over large areas (Seedsman, 2010).

The adopted model is that the pillar floor foundations are unstable and will collapse once the panel is wide enough so that full loading is applied (refer to **Figure 4**). Due to the presence of low strength floor horizons, the bearing strength of the pillar foundation is significantly less than the strength of the coal component. The bearing strength is a function of the width of the pillar compared to the thickness of the low strength layer, so that wider pillars have higher bearing strength. The massive Teralba Conglomerate roof means that it can bridge across narrow panels and transfer more of the vertical stress to the abutments. As the panel increases in width, a condition develops where the conglomerate cannot span – the conglomerate then collapses and loads the pillars directly and the foundations fail; at the same time loads are reduced on the abutments. An implication of this model is that until the conglomerate beam fails there may be no indication of floor heave or other evidence of low strength floors (Seedsman, 2010).

The pillars involved had been formed on 20m centres and at depths from 25m to 80m such that the pillars themselves have had a very high factor of safety. There have also been reports of wind rush events in association with the failures. It is important to note that such events did not always develop with pillars of these dimensions – there are many areas of Awaba still standing with pillars formed on 20m centres (Seedsman, 2010).



LEGEND

- Creek / drainage line
- Existing sinkhole
- Extent of existing / historical workings
- Floor heave / subsidence

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FIGURE 3

Location o□Floor □ea□e□ Subsidence E□ents

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Client: Centennial Coal Company Pty Ltd

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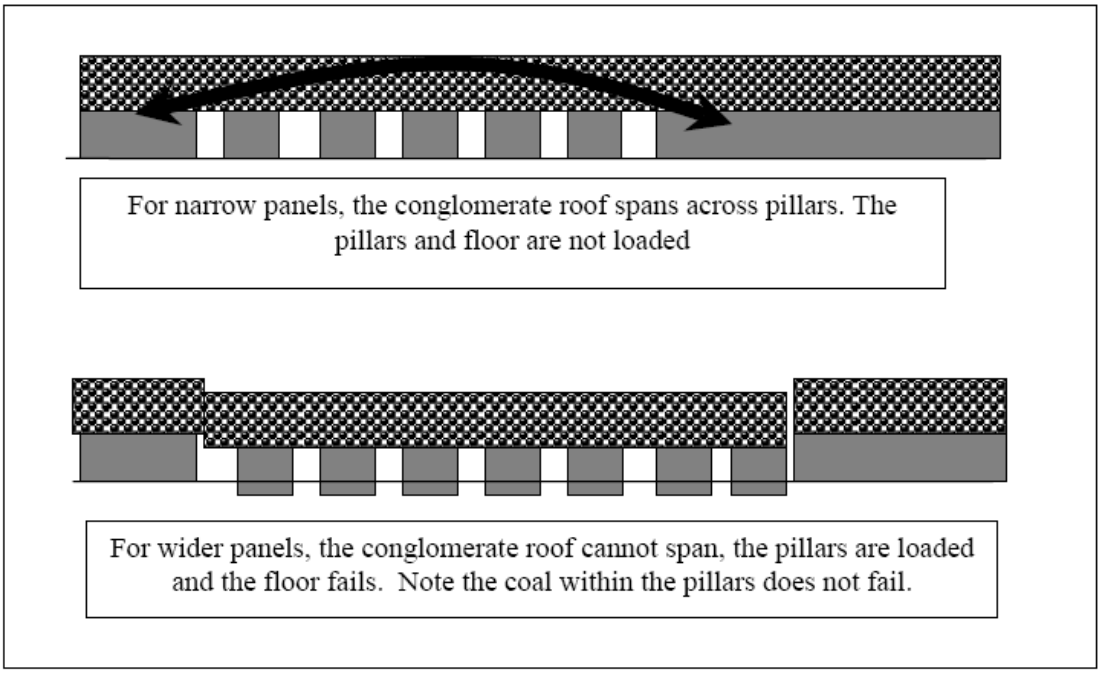

Figure 4 – Model for the Development Floor Heave/Subsidence Events

4.0 REHABILITATION STRATEGY

Rehabilitation activities at the Awaba Colliery are currently undertaken in accordance with the site's Rehabilitation and Environmental Management Plan, which is applicable until December 2015. This Sinkhole Rehabilitation Plan is intended to compliment this strategy by providing some specific advice on rehabilitation of the sinkholes at Awaba Colliery.

Once sinkholes have been identified in a specific location, an area will need to be established to enable rehabilitation activities to take place. This may require clearing an area greater than the actual area requiring rehabilitation. Sufficient room will typically be needed to enable the establishment of the water diversion works, provide a stockpile area for any fill material, vehicle park up areas, and access tracks. The existing sinkholes within the site vary significantly in size however the general rehabilitation strategy will be the same for each sinkhole.

Prior to the commencement of works a detailed schedule of works is to be prepared and submitted to the DTIRIS-DRE for comment.

4.1 Inspections

Visual field inspections will be undertaken at Awaba Colliery by the Environment and Community Coordinator or Environment and Community Officer on a quarterly basis for the following:

- Identify and assess the condition of newly formed sinkholes;
- Assess the condition of existing sinkholes (yet to be rehabilitated);
- Monitor the condition of rehabilitated sinkhole areas; and
- Identify any erosion features (such as headcuts) within creek lines.

Figure 5 identifies the location of existing sinkholes at Awaba Colliery in respect to depth of cover and drainage lines. This figure effectively demonstrates that sinkholes at the Colliery are concentrated within areas associated with low depth of cover (less than 30m) and drainage lines (where the depth of cover is further reduced). As a result of this knowledge and the large surface area associated with the Awaba Colliery, it is recommended that inspections focus on these areas**.**

As soon as practicable after the inspection, Awaba Colliery shall provide a report to the DTIRIS-DRE outlining the findings of the inspection as outlined in **Section 7.3**.

4.2 Establishing access to Sinkhole Rehabilitation Work Areas

During any rehabilitation works, the existing roads/tracks will be used wherever possible to access the sinkhole(s) at the site. Where additional access tracks are required to access the rehabilitation works area, they will be located and constructed in a manner to minimise the impact on the existing environment. New access tracks will be constructed with adequate erosion and sediment control (ESC) devices and appropriate drainage controls. The 'Blue Book' (Managing Urban Stormwater: Soils and Construction Vol. 1, 4th edition and Vol. 2E Mines and Quarries (Landcom, 2004 and DECCW, 2008)) will be used as a guide to the minimum standard applicable.

A due diligence/risk assessment (typically by using the Centennial Coal ground Disturbance Permit process) will be required for all new works to identify and effectively manage any safety or environmental risks associated with new access tracks. Works will also need to be undertaken in accordance with any Controlled Activity Permits (to be issued by the NSW Office of Water [NOW] where required).

Note: A Controlled Activity Permit will be required where the works are to be undertaken outside of an active Mining Lease.

In addition, all proposed tracks and roads will need to be assessed by a suitably qualified ecologist (particularly with respect to potential impacts to *Tetratheca juncea*) and an archaeologist to ensure that there are no Aboriginal sites within the proposed work area.

Access tracks crossing natural creeks should be avoided wherever possible; however, this may be required in isolated sinkhole areas where individual sinkholes are located on either side of a creek. Temporary creek crossings such as these can be installed provided that the appropriate approvals have been granted and that adequate upstream flow diversion structures are in place (discussed in **Section 4.3**). These temporary creek crossings should be constructed to minimise the impacts on the existing creek system. Where appropriate, access tracks within the rehabilitation works areas should remain in place for at least 6 months to allow for monitoring and maintenance of the rehabilitated sinkholes.

LEGEND

- Creek / drainage line
- Existing sinkhole
- Extent of existing / historical workings

Depth of Cover:

- Less Than 30m
- Less Than 40m
- Over 40m

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FIGURE 5

Depth o□Co□er

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Client: Centennial Coal Company Pty Ltd

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4.3 Site Surface Water Management

Appropriate surface water management is crucial to the success of the sinkhole rehabilitation program, especially where sinkholes are located within or immediately adjacent to existing creek systems. During the rehabilitation of these sinkholes the upstream runoff and creek flow will need to be diverted around the sinkholes to allow suitable access to the site. This is particularly important where the works are to be undertaken within the alignment of an existing creek or drainage line.

Upstream clean water diversion drains will be required wherever upslope water run-on is expected to have significant adverse effects on the sinkhole rehabilitation sites. Where these diversion drains are required to cross the access road a cross-bank shall be constructed. A typical configuration for cross-banks is provided in **Appendix A**.

Temporary creek diversion channels may need to be constructed (where practical) around sinkholes that are in the process of being rehabilitated and where they are located within creek lines. Where this is not feasible coffer/check dams may be constructed upstream of sinkholes with a pump or a gravity fed polypipe to divert flow around the site (refer to **Figure 6**). These dams may be constructed using a soil bund lined with rip rap rock material or alternatively can be made up of sandbags. The exact method of coffer dam construction will depend on the expected duration of the sinkhole rehabilitation works and the specific characteristics of individual sites. The size of the coffer dam should be large enough to contain and divert a 2 year average recurrence interval (ARI) storm event for the entire period of the works program.

Diverted runoff will need some form of scour protection where it re-enters the natural creek system. This scour protection will typically be in the form of rip rap rock material (e.g. ballast overlying geofabric material) to armour the creek and to mitigate high velocity flows caused by the concentration of runoff.

4.4 Erosion and Sediment Control

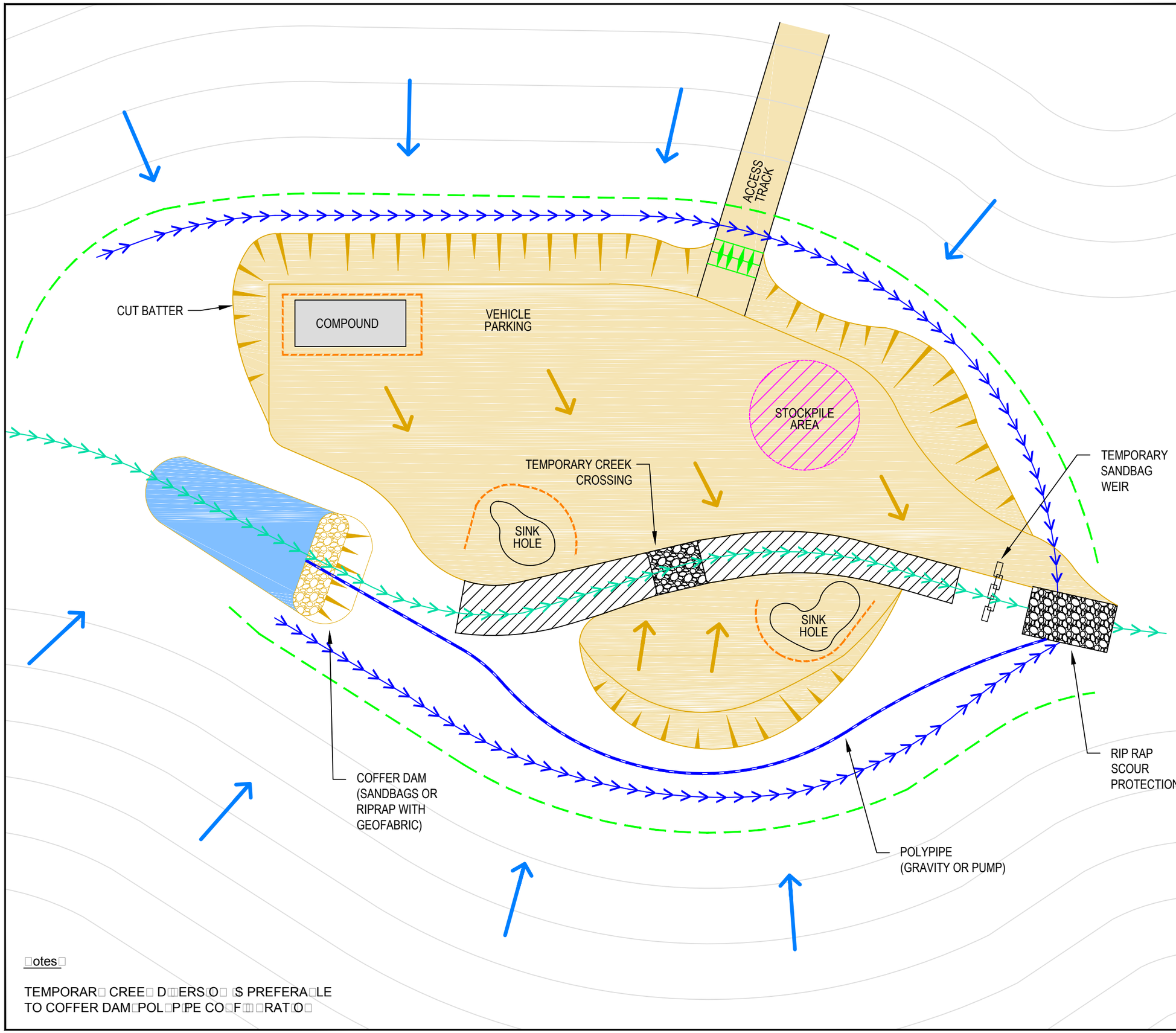
Control of erosion is important during the sinkhole rehabilitation works. The major objective is to minimise erosion until an adequate cover of vegetation is achieved. Erosion and sediment control (ESC) is required with any land disturbance but is not limited to the sinkhole area itself but also to any new tracks, the use of existing tracks and upstream erosion impacts.

The following ESC measures shall be used and constructed in accordance with the ‘Blue Book’ (Managing Urban Stormwater: Soils and Construction Vol. 1, 4th edition and Vol. 2E Mines and Quarries (Landcom, 2004 and DECCW, 2008)).

4.4.1 Minimising Disturbance

Land disturbance will be minimised during the sinkhole rehabilitation works through adherence with the following:

- Maximise the use of existing access tracks and all new access tracks will be constructed with appropriate drainage controls;
- Minimise exposure and disturbance of ground surface;
- Wherever possible native/pasture grasses and soil shall not be disturbed;
- Earthworks shall be minimised and ground cover retention should be maximised; and
- Where topsoil is removed, it is to be separated from any subsoil material and used in the rehabilitation works.



LEGEND

- Clean water diversion drain
- Polypipe (gravity or pump)
- Creek line
- Fence
- Barrier tape
- Cross bank
- Clean water general flow path
- Dirty water general flow path
- No go zone

For diagrammatic purposes only - not to scale

FIGURE 6

Typical Sinkhole Rehabilitation Site Plan with Co□er Dam □ Polypipe Di□ersion

Project:	Awaba Sinkhole Rehabilitation Plan
Client:	Centennial Coal Company Pty Ltd
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4.4.2 ESC Controls

Erosion and sedimentation during the sinkhole rehabilitation works will be controlled by implementing the following controls:

- Sediment run-off will be controlled by implementing sediment control procedures, such as sediment fencing down slope of the site disturbance and the fill material stockpiles (not within creek lines);
- Sediment fences are to be installed on the contour, trenched 100mm into the soil, trench backfilled and compacted with post's spaced 2.5m using star pickets. Where installation on the contour is not possible, single sand-bags shall be placed at 10m intervals along entire toe of the sediment fence to reduce flow velocity (refer to **Appendix A** for a Blue Book standard drawing of sediment fences);
- Sediment trapped in sediment fences, sediment traps and runoff diversion drains is to be removed once their capacity is reduced by 30% and deposited at stockpile sites;
- All proposed ESC measures will be implemented in advance of, or in conjunction with site establishment and sinkhole rehabilitation operations;
- Upstream diversion drains will be installed wherever upslope clean water run-on is expected to have significant adverse effects on the sinkhole rehabilitation sites;
- Ideally, any temporary runoff diversion drains should be designed in accordance with upstream catchment conditions with a minimum grade of 0.5-1% with all loose soil removed and compacted (rolled with rubber tyre or bucket) to resist erosion. If steeper grades (up to 7%) are required, runoff diversion drains should be stabilised by lining with jute mesh, seeding, and spraying with bitumen emulsion;
- Sediment laden runoff from the disturbed areas of the rehabilitation site will require some form of sedimentation control prior to discharging into the natural creek system. If water is being retained by an upstream coffer dam and then diverted around the site, the disturbed runoff can be allowed to enter the controlled creek system (upstream of where diverted runoff re-enters the creek) and then treated by a temporary sandbag weir (or equivalent) before discharging downstream (refer to **Figure 6**). Care should be taken when designing the location and height of the sandbag weir to prevent water ponding upstream to where the rehabilitation works are being undertaken. Alternatively, sediment fences could be used to treat disturbed runoff prior to entering the creek;
- All vehicles and machinery will be kept in good working order to prevent any spills of oil or fuel; and
- ESC devices will remain in place until the project area is fully rehabilitated.

4.4.3 Revegetation

Revegetation works are to commence as soon as practicable following the completion of sinkhole rehabilitation works (as described in **Section 4.7**).

4.4.4 Upstream Erosion Impacts

The following will be undertaken at Awaba Colliery to assess and remedy any erosion features (such as headcuts) in creek lines:

- Creek lines will be inspected before the commencement of rehabilitation works to identify any erosion features (such as headcuts) in the creek lines;
- Rehabilitation actions will be designed to stabilise any erosion features (such as headcuts) if:
    - They are likely to cause any instability to the sinkhole rehabilitation area;
    - They are likely to be de-stabilised as a result of the sinkhole rehabilitation;
- Appropriate remediation actions will be determined by a suitably qualified ESC specialist, based on the site specific observations. For erosion features such as headcuts, remediation actions to be considered would include bed control e.g. cut off trench, log sill, rock ramp etc. with adequately designed scour and outflanking protection; and
- For any erosion features to be remediated this will be undertaken in conjunction with the sinkhole rehabilitation, including creating temporary diversion structures around the erosion features.

Monitoring of works will be undertaken during quarterly inspections or after significant rainfall events for approximately one year following works. Monitoring will be completed to assess the need for maintenance (see **Section 6.3**), the condition of structures and to identify any further stabilisation works considered necessary.

4.5 Land Preparation

Land disturbance will be minimised by clearing the smallest practical area of land required to adequately rehabilitate the sinkholes. General vegetation clearing and stockpiling will occur first and then the soil will be stripped to a nominal depth before being stockpiled. All trees to be cleared should be retained so they can be spread back over the site once the rehabilitation works have been completed. All trees containing hollows should be avoided and not cleared where possible. Topsoil will only be stripped from areas that are to be disturbed. Where possible topsoil can be retained and worked over, particularly where the duration of the works are expected to be less than 1 week. If the topsoil is to be stripped, careful planning and supervision of topsoil stripping activities is critical in ensuring all suitable material is recovered, while avoiding unsuitable, subsoil materials. Topsoil can be potentially destroyed in the stripping process, therefore particular attention is given to the following matters:

- Vehicular traffic is kept to a minimum on those soils which are to be stripped to reduce soil compaction and structural decline;
- Soil should be stripped, where possible, when it is in a slightly moist condition. Material should not be stripped in either a dry or wet condition because of the possibility of soil structural decline;
- Equipment operators involved in topsoil stripping are instructed on topsoil identification to maximise recovery and to avoid contamination of the target soil with subsurface material; and
- Topsoil should be stockpiled to a maximum depth of 3m.

4.6 Backfilling Sinkholes - Inverted Filter Fill

The sinkholes are to be rehabilitated by essentially plugging them with fill material of varying grain sizes to prevent the ingress of surface water. If required, prior to filling a long reach excavator should be used to “pullback” any overhangs or under cutting that may have occurred to ensure that the site is stable and it is safe to move across with machinery (refer to **Figure 7**). A Risk Assessment will be completed prior to this work given the inherent risks. An engineer will inspect the site once the pullback works have been completed to ensure that the site is safe.

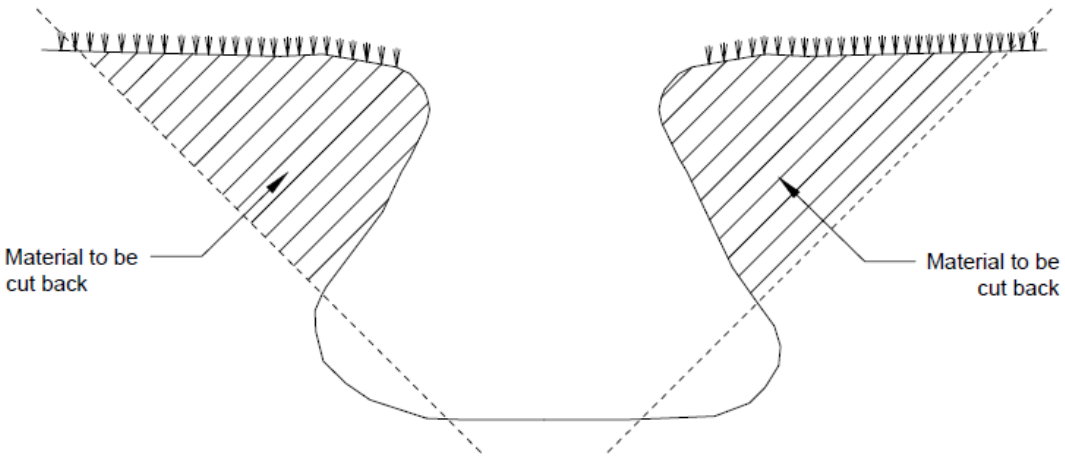

Figure 7 – Conceptual Sinkhole Areas to be Cut Back Prior to Backfilling

Once the site has been assessed as safe, all fill layers should be compacted using small mechanical compactors. Steps to fill the sinkholes include the following:

1. Fill the sinkhole with concrete grouted large diameter boulders to choke the throat of the sinkhole. This layer must be filled high enough to minimise 'rat-holing' and to prevent erosion of the sand layers above (if 'rat-holing' does eventuate);
2. Allow the concrete grouted boulders to set;
3. Remove all unstable material from the sidewalls of the sinkholes (using backhoe, longreach excavator etc.);
4. Add a layer of coarse gravel and sand above the concrete grouted boulders (greater than 150mm deep);
5. Add a layer of course sand above the course gravel and sand mixture (at least 150mm deep);
6. Add a layer of fine sand above the course sand layer (greater than 150mm deep);
7. Excavate soil around the sinkhole surface to a radius of 3 – 5 metres and replace the soil with compacted soil (98% compaction as per AS 3798) and backfill (ensure that the channel/area is reinstated with a continuous grade in the direction of the natural flow path); and
8. If the sinkhole is in or immediately adjacent to a creek, cover the soil with a geosynthetic/polysynthetic clay liner to prevent water ingress (that can reactivate the erosion processes within the sinkholes), ensuring to trench in the liner a minimum of 300mm at the edges. Many products are available to line the rehabilitated sinkhole. An example product brochure is provided in **Appendix B**.

Figure 8 shows the general arrangement of the process described above.

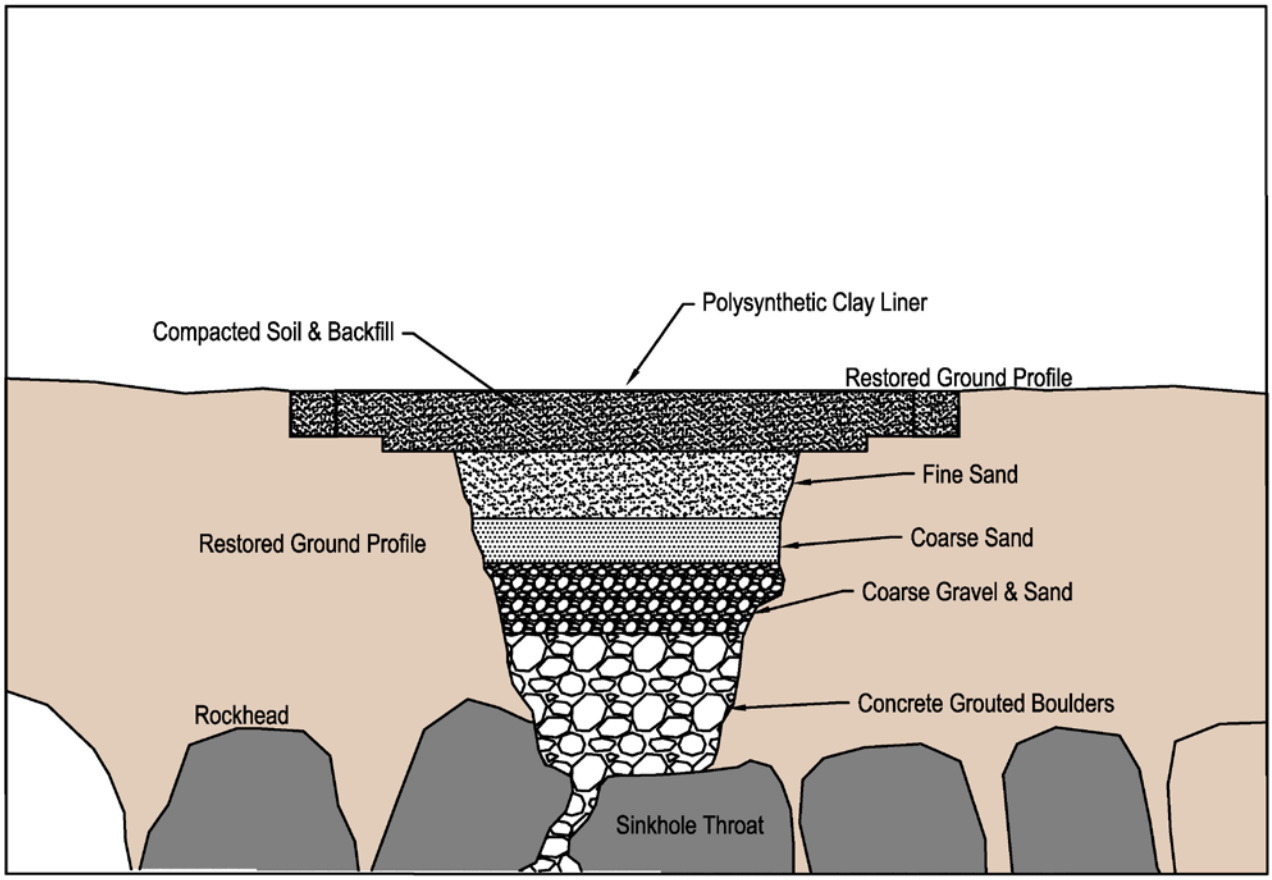

Figure 8 – General Sinkhole Rehabilitation Strategy

This method allows for continuation of natural drainage patterns within the area which it is believed may be responsible for the reactivation of sinkholes observed at Awaba Colliery.

Prior to undertaking backfilling of sinkholes as shown in **Figure 8**, it is important to have the site surveyed to determine the amount of fill required. Additional fill volume may be required (from Newstan or Awaba) if material is required to be cut away from the sinkholes for safety reasons during the backfilling works (as

shown in **Figure 7**). Additionally, it should also be noted that the sizes of sinkholes are also able to change significantly after rainfall events. This should be considered when calculating fill volumes.

4.7 Reshaping and Revegetation

Successful revegetation is required to achieve long term stability of the land surface after the sinkholes have been filled. The revegetation process involves establishing tree, shrub and grass species selected from the Awaba area. Revegetation will be undertaken in accordance with the Awaba Colliery Rehabilitation and Environmental Management Plan. The works site will be reshaped and regraded to be consistent with the surrounding landform. Reshaping works should endeavour where possible to convey surface water run-off away from the sinkhole location. To facilitate this water diversion drains employed during the rehabilitation works may be retained. This will be assessed at each of the sites once the sinkholes have been filled.

The preferred method of establishment is by direct hand seeding or hydroseeding, with supplement tube stock if required. Cover crops of annual and perennial grasses may also be selectively used where rapid stabilisation of the soil surface is required.

A significant proportion of the site is existing native vegetation. In the areas where revegetation is required (including above the rehabilitated sinkholes), the approach to be adopted is based on the objective to create a landform consistent with other naturally occurring landforms and vegetation compositions in the local area.

The following revegetation management provisions shall be used:

- After the sinkhole filling works have been completed all equipment and rubbish will be removed and the site will be left clean and ready for rehabilitation;
- Rehabilitation of disturbed areas should be carried out immediately following completion of the sinkhole filling works;
- Any imported material used, such as gravel or crushed rock, will be removed from the site;
- The stockpiled topsoil will be spread back across the site at the same depth of the surrounding area;
- All access tracks constructed, will be retained for access to the site; however once the rehabilitation has been successfully completed they will be ripped and reinstated to be consistent with the natural landform. Revegetation should occur immediately after re-spreading of topsoil. Seed and fertiliser shall be applied to all disturbed areas using grass and tree species consistent with those listed in **Table 2**. Species used will typically include fast growing, short-lived species and perennial grasses and legumes;
- The cleared trees will be dragged back across the site, with care taken to allow access to the site for inspections and any future maintenance (as may be required);
- Where possible, the timing of the topsoiling and sinkhole works will be scheduled to enable a preferred seasonal sowing of pasture and tree seed in autumn or spring;
- ESC devices will remain in place until the sinkhole site and temporary access tracks are fully rehabilitated;
- Disturbed areas will be regularly inspected until the area has been fully rehabilitated (refer to **Section 6.1**); and
- Following the establishment of revegetated areas, maintenance of the area will be undertaken in accordance with **Section 6.2**.

The revegetation strategy proposed includes species mixes for areas assigned for bushland use. If sinkholes are located within natural creek lines then appropriate riparian species for that creek should be used to revegetate the sinkhole work area. Areas will be direct seeded with the tree species described in **Table 1**.

Only sterile cover crop grasses will be used with the native tree species listed in **Table 1**.

Table 1 – Recommended Tree Species at Awaba Colliery

Species Name	Common Name
Acacia suaveolens	*Sweet wattle*
Acacia longifolia	*Golden wattle, sallow wattle*
Lomandra longifolia	*Spiny-headed mat-rush*
Banksia spinulosa	*Banksia*
Allocasuarina torulosa	*Forest oak*
Melaleuca nodosa	*Prickly leaf paperbark*
Eucalyptus saligna	*Sydney blue gum*
E. crebra	*Ironbark*
E. microyorys	*Tallowwood*
Acacia falcate	*Sickle wattle*
E.maculata	*Spotted emu bush*
Angophora costata	*Smooth-barked apple, rusty gum*

5.0 ALTERNATIVE SINKHOLE REHABILITATION METHODS

5.1 Grouting of Voids

This approach is only to be used as a means to stabilise a local area. It has been used in order to support buildings, highways, schools and churches located over goaves (Singh & Dhar, 1997). There are two commonly used grouting techniques:

- Use of a sand-grout mixture which is injected into rubblised zones of the roof failure and small voids in order to support the roof and to eliminate the available space for continued downward movement of the overburden material; and
- Gravel-grouted columns are used in areas of large voids to provide direct support to the mine roof.

6.0 POST REHABILITATION MONITORING AND MAINTENANCE

6.1 Rehabilitation Monitoring

Areas of completed rehabilitation will be monitored regularly. It will include frequent inspections following rehabilitation and then quarterly monitoring to make an assessment of rehabilitation works over time. Photos should be taken during every sinkhole inspection to aid these assessments. Monitoring will be undertaken for the following key aspects:

- Evidence of further subsidence within sinkholes;
- Evidence of any erosion or sedimentation;
- Success of initial establishment of crop or grass cover and tree seeding/plantings;
- Natural regeneration of native species;
- Weed infestation (primarily noxious weeds, although where rehabilitation areas are dominated by other weeds;
- Integrity of graded banks, diversion drains, waterways and sediment control structures; and
- General stability of the progressive or final rehabilitation areas.

6.2 Rehabilitation Maintenance

Where rehabilitation success appears limited, maintenance works will be undertaken. This may include: re-seeding and where necessary, re-topsoiling and/or the application of specialised treatments such as composted mulch or biosolids to areas with poor vegetation establishment.

Where monitoring indicates the presence of excessive weeds or the potential for noxious weed infestation, a weed control program will be employed in accordance with DTIRIS – DRE and the Office of Environment and Heritage (OEH) requirements. Records will be maintained of weed infestations and control programs will be implemented according to best management practice for the weed species concerned.

Monitoring results, required maintenance activities and any refinements of rehabilitation techniques will be reported in the sites Annual Environmental Management Report (AEMR).

6.3 Erosion Maintenance Program

ESC maintenance is usually highest during the early period while soils are still consolidating and vegetation is becoming established. Soil ESC measures should be monitored as part of the quarterly inspections or after rainfall events exceeding 15mm of rainfall, and maintained throughout the duration of the sinkhole rehabilitation operations and until the site is considered successfully rehabilitated. As mentioned previously in **Section 4.4.4**, sediment trapped in ESC devices such as sediment fences, sediment traps and runoff diversion drains is to be removed once their capacity is reduced by 30% and deposited at stockpile sites.

7.0 IMPLEMENTATION OF SINKHOLE REHABILITATION PLAN

7.1 Responsibility and Accountability

The site Environmental Coordinator is responsible for overseeing the implementation of this Sinkhole Rehabilitation Plan. The Mine Manager (or delegate) is responsible for:

- Delegating tasks associated with this Sinkhole Rehabilitation Plan when the Environmental Coordinator is absent;
- Providing adequate resources to implement this Sinkhole Rehabilitation Plan;
- Providing adequate training to employees and contractors regarding their requirements under this Sinkhole Rehabilitation Plan;
- Reviewing and updating the plan;
- Coordinating all activities and investigations under the plan;
- Coordinating all consultation with relevant stakeholders; and
- Being the first point of contact at Awaba in relation to rehabilitation issues.

7.2 Safety

Prior to undertaking any works, a health and safety risk assessment will be undertaken to identify any risks associated with any aspect of the sinkhole rehabilitation works and identify the most appropriate management methods/controls so that the identified risks are minimised or eliminated.

In addition, an Environmental Risk Assessment will be undertaken to ensure the impact of remediation works on the environment are minimised.

As the sinkholes are located within Crown Land, all possible hazards need to be managed and monitored to ensure the safety of the public; this includes erecting site fences, warning signs, and eliminating trip and slip hazards.

7.3 Reporting

Awaba Colliery will prepare a summary report to the DTIRIS-DRE as soon as practicable following the completion of field inspections. This report will provide details of the following:

- The identification of newly formed sinkholes (if any);
- An assessment outlining the condition of newly formed/existing sinkholes including the following:
    - Locality (including coordinates);
    - Site characteristics;
    - Approximate dimensions;
- An assessment outlining the condition of rehabilitated sinkhole areas (as outlined in **Section 6.1**).
- Identify any erosion features (such as headcuts) within creek lines.

The site AEMR will also provide details of all sinkhole rehabilitation works undertaken during the reporting period including the findings of inspections, monitoring results, required maintenance activities, any refinements of rehabilitation techniques and planned works for the coming year.

7.4 Review

This Sinkhole Rehabilitation Plan should be reviewed and updated regularly to ensure consistency with changes in legislation, policies and guidelines relevant to the rehabilitation of the sinkholes. In addition, it should be reviewed when there is a major shift in the operation away from that which this preliminary plan has been based.

8.0 REFERENCES

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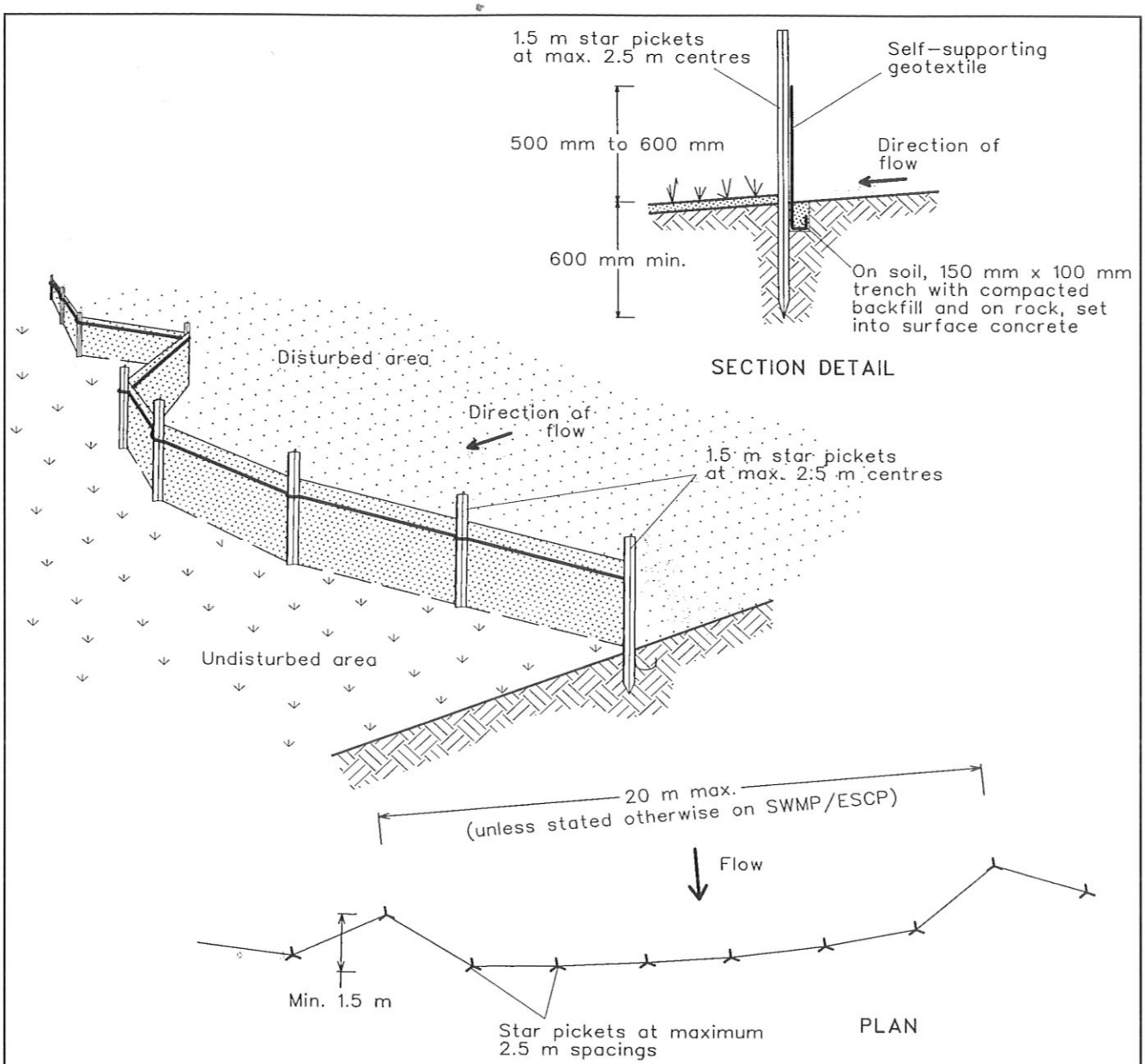
APPENDIX A

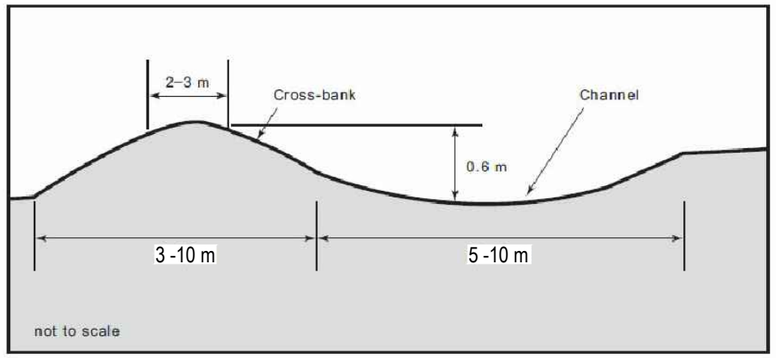


Construction Notes

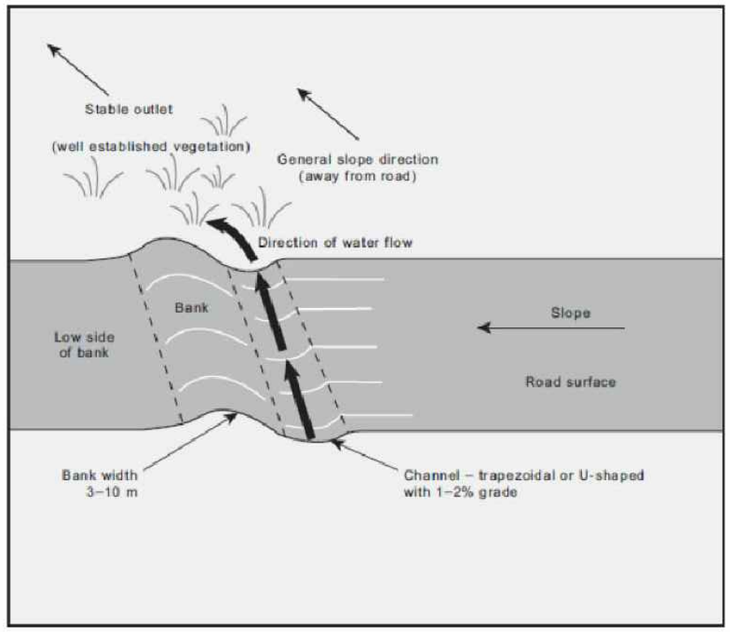
1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE — SD 6-8

Cross-Bank Typical Details

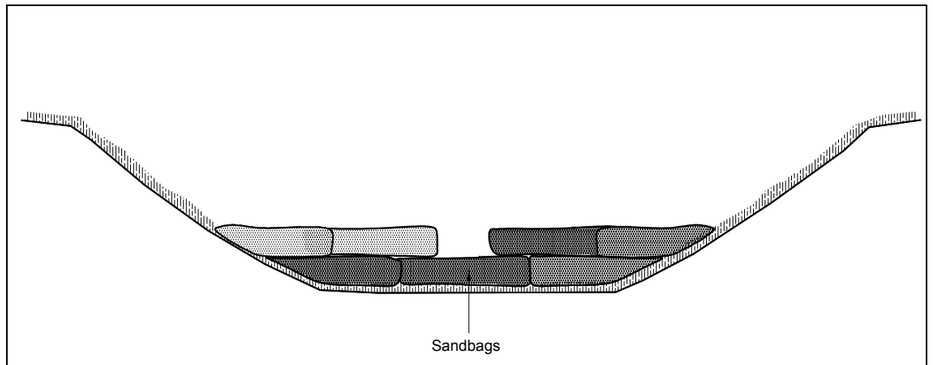


Cross-bank dimensions



Cross-bank profile

CROSS BANK TYPICAL DETAILS



SANDBAG WEIR CROSS SECTION

CONSTRUCTION NOTES:

- During cross-bank construction
  - the track or road should be ripped to a depth of 200-300 millimetres across the width of the road or track, back from the chosen outlet point. The loose earth should then be pushed into a bank, commencing at the uphill side of the track and working across the outlet side
  - the material used for bank construction should be free of sticks and logs which can contribute to bank failure as they decay
  - a long, shallow excavation for the bank is preferable to a short, deep excavation. This will allow runoff to collect and be diverted while allowing access vehicles to cross
  - the crest width dimensions should be long enough for comfortable vehicle access. The channel depth dimensions are important to prevent runoff from overtopping the bank
  - cross-banks are most effective if constructed with only a slight angle to the track obtaining a grade of approximately 1: 20 to allow the water to be diverted freely off the road and prevent ponding behind the bank (which can also cause the bank to breach)
  - the entire length of the bank should be track- or wheel-rolled to obtain maximum compaction and a smooth, even surface

Maintenance Notes:

- Remove sediment from cross banks, sediment fences, channels, and dams if capacity has reduced by 30%
- If any channels are eroding, maintenance will be required which may include the placement of rock/ gravel or lining the channel.

LEGEND

Not to scale: for diagrammatic purposes only

Sediment and Erosion Typical Details

Project□
Awaba Sinkhole Management Plan

Client□
Centennial Coal Company Pty Ltd

File□
CCC□3□□□□□SedimentandErosionDetail□□□□□□□

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GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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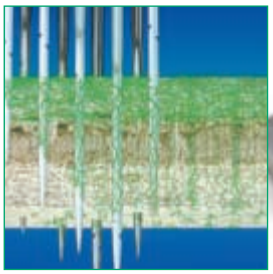
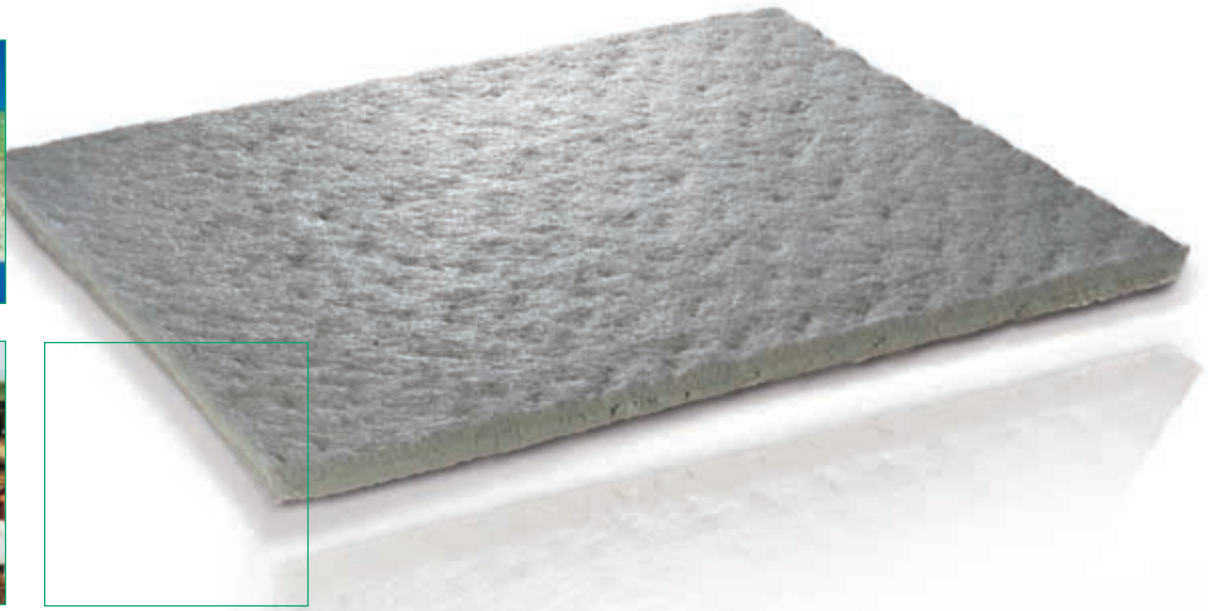
APPENDIX B

Advantages of needle-punched Bentofix®

Geosynthetic Clay Liners (GCLs)

- ☑ versatile sealing applications with different GCL types and sodium bentonite
- ☑ can reduce construction costs by replacing compacted clay
- ☑ robust geotextiles encapsulate and contain the bentonite
- ☑ withstands differential settlement
- ☑ uniform peel stength provides multi-directional shear strength
- ☑ Thermal Lock process increases internal shear strength and interface friction angles
- ☑ self-sealing overlaps available
- ☑ installation advantages with 4.85 m wide rolls
- ☑ quick and easy to install
- ☑ BBA certified waterproofing systems (Bentofix® BFG 5000)
- ☑ ISO 9001 certified
- ☑ CE marked

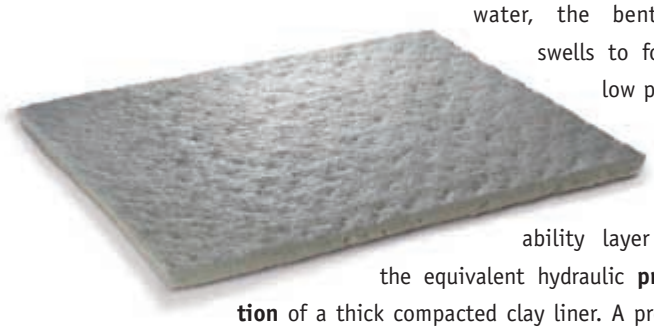




NAUE

General

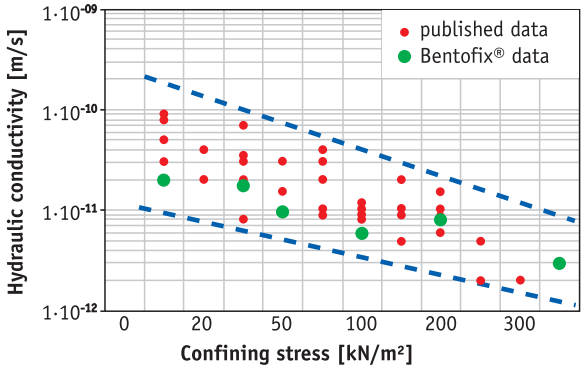
Bentofix® Thermal Lock geosynthetic clay liners (GCLs) are needle-punched reinforced composites which combine two durable geotextile outer layers and a uniform core of high swelling powder sodium bentonite clay to form a hydraulic barrier. When hydrated with fresh water, the bentonite swells to form a low permeability layer with the equivalent hydraulic **protection** of a thick compacted clay liner. A proprietary heat treating process – Thermal Lock – in addition permanently locks the needle-punched fibres, increases the pull-out resistance of the fibres and ensures long term shear resistance. Bentofix® GCLs are part of an important trend toward the combined use of geosynthetics and clay materials in barrier applications as a stand alone liner system or synergistically with geomembranes to maximise liner system efficiency. Bentofix® Thermal Lock GCLs are used but not limited to the following applications: landfill caps, closures, base seals; environmental protection under roads; railways, airports; dams and dykes; vertical barriers; pond applications; waterproofing and secondary containment.



Advantage: Water permeability

Bentofix® Thermal Lock GCLs are designed for applications to replace relatively thick, hard and expensive to install compacted clay layers (CCL) and bentonite enriched soils (BES) due to their numerous advantages when contrasted to a CCL or BES. Bentofix® Thermal Lock consists of an evenly distributed layer of high swelling sodium bentonite powder encapsulated between two geotextile components acting as the sealing element. The main advantage of the powder bentonite is its uniform distribution and its immediate sealing performance. When hydrated and permeated under confinement with fresh water the bentonite layer swells and forms a gel-like low permeable barrier. Over a range of normal loads Bentofix® Thermal Lock GCLs provide an excellent hydraulic performance and can be significantly lower than a typical CCL or BES, even under high gradient conditions. Another beneficial feature of Bentofix® is the bentonite impregnation of the longitudinal edges during the manufacturing process. These overlapped areas are immediately sealed without needing to add any additional bentonite on site.

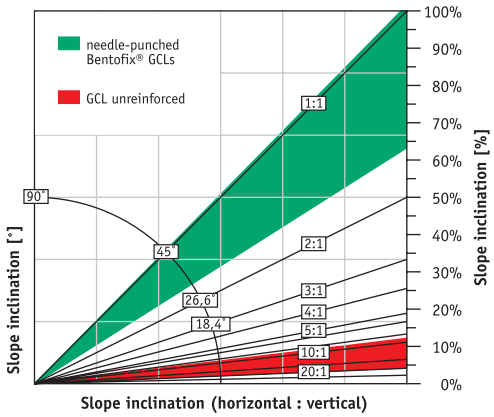
Hydraulic conductivity
for different GCLs with gradients up to i = 500



Advantage: Shear resistance

By needlepunching fibres from the cover nonwoven through the layer of sodium bentonite into the carrier geotextile, a completely uniform, reinforced GCL is produced with long-term high shear strength, excellent creep resistance, and stability advantages important to any application. The Thermal Lock process is then used to more permanently lock the needle-punched fibres into place. This process reduces the pull-out of fibres and increases the GCL shear stress and additionally increases the interface friction properties of the Thermal Lock side due to its rough surface. Bentofix® Thermal Lock replaces other GCLs as well as other soil barriers on steep side slopes and assures low permeability without sacrificing slope stability.

Internal shear angle of needle-punched Bentofix® GCLs
for a confining stress up to 100 kN/m².



Advantage: Bentofix® extra coated

Bentofix® "X" types are a needlepunched GCL comprising a uniform layer of powder sodium bentonite encapsulated between a slit-film woven and a staple fiber nonwoven geotextile. The woven fabric is coated with a low permeability and gas-tight polyolefin coating to achieve an immeadiate gas and radon barrier prior to hydration.

APPLICATION

BENTOFIX® SEALING AT TOULOUSE-BLAGNAC AIRPORT

One of the largest infrastructure projects in Europe in recent years has been in Toulouse-Blagnac in France on the premises of the airport and the Airbus factory where the new Airbus A 380 is built. During this construction project not only hangars were built but the whole infrastructure was aligned to accommodate the new dimensions of the Airbus A 380. Runway No. 2, which was originally built as a test track for the supersonic Concorde, serves now the Airbus A 380. The necessary construction work includes widening the almost 4 km long runway by two meters in order to accommodate the 700 ton „silver bird“ with its wing span of almost 80 meters.

The conceptual design and advisory services for the client were carried out in a cooperation between the airport operating company ADP Aeroport de Paris and the engineering company Scéauroute and the decision was taken to employ Bentofix® NSP 4900 to seal the runway. The whole system prevents any contaminated drainage water polluting the ground water. The earth-moving activities, installation of sewer pipes, service lines and pipelines, construction of roads and

Fig. 1 Runway widening with Bentofix® for environmental protection

approach runways had to be completed within two months, without any hindrance to air traffic. As Bentofix® can be installed easily and extremely quickly in comparison to other conventional sealing systems, general construction work went ahead smoothly; in fact the Bentofix® installation work was completed earlier than scheduled.

In total, 40,000 m² of Bentofix® and 24,000 m² of the separation nonwoven Secutex® 201 GRK 3 were installed within just two weeks by a pool of contractors - SCAM TP, SOGEA Hydraulique and AMEC Spie.

LANDFILL IN ESTONIA

The largest landfill in Estonia, Pääsküla Landfill, just outside the capital city of Tallinn, was capped in 2005 and 2006. Several parts of the landfill had been filled over the past years so that substantial settlements were expected. To verify this fact the owner has carried out several in-situ measurements even during the capping operation. The original design considered a soil-gas-drainage layer, covered by a GCL, a 300 mm thick rainwater drainage layer of coarse gravel and a 1 m thick cover soil layer. After analysing the settlement data the designer came to the conclusion that further differential settlement had to be expected so that the final capping system would have to be able to withstand such stresses. After comparing various GCL types Bentofix® B4000 was approved as the capping GCL. Bentofix® B4000 is a needle-punched GCL with a cover nonwoven and a scrim reinforced carrier nonwoven, which encapsulates the bentonite sealing core. Numerous studies have shown that this Bentofix® type can easily withstand differential settlement of at least 30 % without any reduction of its hydraulic performance and is therefore perfectly suited where differential settlement is expected. Additionally the two nonwoven surfaces allowed an excellent interface shear performance on steeper slopes as high as 28° – 32° and allowed a steeper slope design than the anticipated 18°. At the same time the nonwoven geotextiles on both sides are a protection against any installation stresses occurring on site, since a nonwoven is less vulnerable than the typical used slit-film wovens. During the construction the contractor had issues on maintaining a high quality for the gravel of the rainwater collection layer. It was decided to replace the gravel drainage layer with a geosynthetic drainage system - Secudrain® 151 WD 501. The German geosynthetic consultant BBG, Bauberatung Geokunststoffe GmbH & Co. KG, supported the local designer and proved that the Secudrain® solution was equivalent to the gravel rainwater collector.

Fig. 2 Bentofix® capping installation

The main contractor for this capping project was Skanska's Estonian company. The installation of each 260,000 m² of Bentofix® GCL and Secudrain® drainage system was carried out by NAUE's agent in Estonia, Via Con Eesti. The supervisors for this project were C + E from Chemnitz, Germany.

INSTALLATION

Bentofix® transportation

Storage on site

Subgrade preparation

Bentofix® installation

Bentofix® self-sealing overlap

Penetration detail

Geomembrane installation over GCL

Cover soil distribution

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