SIMEC

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Tahmoor Coal Pty Ltd

ANNUAL REVIEW /ANNUAL ENVIRONMENTAL MANAGEMENT REPORT 2018

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1 Title Block

Name of operation	Tahmoor Coking Coal Operations – SIMEC Mining
Name of operator	Tahmoor Coal Pty Ltd
Development consent / project approval #	DA 1975, DA 1979, DC57/93, DC67/98, DA190/85, DA 162/76
Name of holder of development consent / project approval	Tahmoor Coal Pty Ltd
Mining lease #	Tahmoor Colliery Holdings - ML1376, ML1308, ML1539, ML1642 & CCL716 Bargo Colliery Holdings - CCL747
Name of holder of mining lease	Tahmoor Coal Pty Ltd Bargo Collieries Pty Ltd
Water licence #	WAL36442
Name of holder of water licence	Tahmoor Coal Pty Ltd
MOP/RMP start date	01/08/2012
MOP/RMP end date	01/08/2019
Annual Review start date	01/01/2018
Annual Review end date	31/12/2018
I, Ron Bush, certify that this audit report is a true and accurate record of the compliance status of Tahmoor Coking Coal Operations for the period 1 January 2018 and 31 December 2018 and that I am authorised to make this statement on behalf of Tahmoor Coal Pty Ltd. *Note.* *a) The Annual Review is an 'environmental audit' for the purposes of section 122B(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	**Ron Bush**
Title of authorised reporting officer	**Environment and Community Manager**
Signature of authorised reporting officer	
Date	*31/03/19*

2 Statement of Compliance

Table 1 outlines the statement of compliance with the relevant conditions for the reporting period.

Were all the conditions of the relevant approvals complied with?	Compliance
ML1376	No (minor non-compliance from 2017 Independent Environmental Audit)
ML1308	Yes
ML1539	No (minor non-compliance from 2017 Independent Environmental Audit)
ML1642	No (minor non-compliance from 2017 Independent Environmental Audit)
CCL716	No (minor non-compliance from 2017 Independent Environmental Audit)
CCL747	Yes
Auth206	Yes
Auth410	Yes
EPL 1389	No (minor non-compliance from draft 2017 Independent Environmental Audit) PRP22 close out date not complied with due to issues with commissioning of Waste Water Treatment Plant PRP26 delayed due to non completion of PRP22
WAL36442	Yes
DA 1975	Yes
DA 1979	Yes
DA 190/85	Yes
DA 57/93	No (minor non-compliance from 2017 Independent Environmental Audit)
DA 67/98	No (minor non-compliance from 2017 Independent Environmental Audit)

Table 1: Statement of Compliance

The 2017 Independent Environmental Audit identified 19 non-compliances, which ranged from administration to medium impact.

Non-compliances are outlined within **Table 1** and **Table 3** outlines the compliance status key.

The delivery date for commissioning of the Waste Water Treatment Plan (**WWTP**) required under PRP22 of EPL1389 was not achieved due to ongoing commissioning issues with the WWTP to meet the requirements set under PRP22. A Detailed Plan has been lodged with the EPA and work is currently ongoing to develop a strategy to enable the WWTP to meet the requirements set under PRP 22.

As a result of the failure to meet the delivery date for the PRP22 WWTP outcomes, PRP26 works requiring acquatic macroinvertebrate moinitoring has also been delayed.

Relevant Approval	Condition #	Condition Description	Compliance Status at end 2017	Compliance Status at end 2018	Comment	Where addressed in Annual Review
1999 Consent	44	The Applicant shall ensure that the management plans required under conditions of consent for the Tahmoor Mine are prepared in accordance with any relevant guidelines, and include: (a) detailed baseline data; (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the Tahmoor Mine or any management measures; (c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria; (d) a program to monitor and report on the: • impacts and environmental performance of the Tahmoor Mine; • effectiveness of any management measures (see c above); (e) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible; (f) a program to investigate and implement ways to improve the environmental performance of the Tahmoor Mine over time; (g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan. Note: The Director-General may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.	Administrative Non-Compliance	Compliant	Updated Noise Management Plan and Air Quality and Greenhouse Gas Management Plan	Noise Management Plan and Air Quality and Greenhouse Gas Management Plan have been updated
	45	By 31 March of each year, the Applicant shall prepare an Annual Review of the environmental performance of the Tahmoor Mine to the satisfaction of the Director-General. This review must: (a) describe the development (including any rehabilitation) that was carried out in the past calendar year, and the development that is proposed to be carried out over the next year; (b) include a comprehensive review of the monitoring results and complaints records of the Tahmoor Mine over the past calendar year, which includes a comparison of these results against: • the relevant statutory requirements, limits or performance measures/criteria; • the monitoring results of previous years; and • the relevant predictions in the EA; (c) identify any non-compliance over the past year, and describe what actions were (or are being) taken to ensure compliance; (d) identify any trends in the monitoring data over the life of the Tahmoor Mine; (e) identify any discrepancies between the predicted and actual impacts of the Tahmoor Mine, and analyse the potential cause of any significant discrepancies; (f) describe what measures will be implemented over the next year to improve the environmental performance of the Tahmoor Mine; and (g) assess the performance of the mine against the conditions of the consents and other licences and approvals relating to the mine. Note: the first Annual Review shall be prepared by 31 March 2013.	Administrative Non-Compliance	Complete	Changes made to current AEMR/Annual review to comply	Water Results and analysis included in Section 13 of this report
	46	Within 3 months of: (a) the submission of an Annual Review under Condition 47; (b) the submission of an incident report under Condition 49; (c) the submission of an audit under Condition 52; and (d) any modification to the conditions of this consent (unless the conditions require otherwise), the Applicant shall review, and if necessary revise, the strategies, plans, and programs required under this	Administrative Non-Compliance	Complete	Review of Management Plans to occur within 3 months of the submission of the Independent Environmental Audit.	Review of Management Plans to occurred within 3 months of the submission of the audit

		consent to the satisfaction of the Director- General. Note: This is to ensure the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the Tahmoor Mine.				
	50	By 30 September 2011 and every 3 years following, the Applicants shall commission and pay the full cost of an Independent Environmental Audit of the Tahmoor Mine. This audit must: (a) be conducted by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Director- General; (b) include consultation with the relevant agencies; (c) assess the environmental performance of the Tahmoor Mine and assess whether it is complying with the requirements in all relevant development consents and any relevant EPL or Mining Lease (including any assessment, plan or program required under these approvals); (d) review the adequacy of strategies, plans or programs required under the abovementioned approvals; and (e) recommend appropriate measures or actions to improve the environmental performance of the Tahmoor Mine, and/or any assessment, plan or program required under the abovementioned approvals. Note: This audit team must be led by a suitably qualified auditor and include experts in any fields specified by the Director-General.	Administrative Non-Compliance	Not triggered	TCCO will ensure that the next Independent Environmental Audit is conducted in line with this condition.	Next audit scheduled in 2020
1994 Consent	41	Submission of an integrated site management plan for the refuse emplacement within 4 months of the date of consent detailing: * Design criteria such as storm intensity, time of concentration, co-efficient of runoff calculated peak discharges, the catchment area and .a nominated storm return period. * Dimensions such as batter grades, outlet and pipe sizes, wall heights, wall thickness, freeboard and slope grades for all sediment traps, settling ponds, fill trenches and diversion banks . * Information in relation to the outletting of both clean and dirty water into Teatree Hollow Creek, including information on outlet size and placement and pipe· sizes and placement . Provision shall be made for treatment of dirty water to be outlet into Teatree Hollow Creek. * The upgrading of the haul road from the nune site, including information on drainage upgrading and no tree destruction in the area of Teatree Hollow Creek . (This area is Protected Land and the Department of conservation and Land Management must be consulted before any tree destruction occurs). * The length of time that the topsoil is to be stockpiled, and what cover crops will be used to decrease erosion of these stockpiles. * Maintenance of erosion control structures and drainage systems.	Non-Compliant (Low Risk)	Non compliance actions currently underway	REA Management Plan reviewed once MOP is approved by Resources Regulator	Rehabilitation at REA and REA performance addressed in Section 14
	46	Within 4 months of the date of this consent, a detailed refuse emplacement site rehabilitation and revegetation plan of management is to be submitted to council for approval. This is to include all existing works and embankments and proposed extensions and details are to include : (a) Topsoil depths and material to be placed upon the refuse and method of retention. (b) List of proposed species and planting densities. (c) Identification of each stage and species area. (d) A report describing the method of preparation of planting beds including planting methods, fertilising, mulching, staking etc and an outline of the provision to be made to maintenance. The rehabilitation plan is to give regard to species types indigenous to the native area. (e) Details of final finished levels relative to depth of refuse and the stated EIS objective of an average of 12 m depth of emplaced refuse.	Non-Compliant (Low Risk)	Non compliance actions currently underway	REA Management Plan reviewed once MOP is approved by Resources Regulator	Rehabilitation at REA and REA performance addressed in Section 14
EPL 1389	L2	Water Monitoring Criteria	Non-Compliant (Low Risk)	Compliant	Minor non-compliance in 2016	Water Results and analysis included in Section 13 of this report. No non-compliances in 2018 for water quality
	U1 PRP22	Stage 2 - Recommissioning of Water Treatment Plant The licensee must submit a report confirming the re-commissioning of the water treatment plant by the due date. The report must contain a summary of water quality achieved by the treatment plant and demonstrate that ANZECC 2000 trigger values for arsenic, nickel and zinc are being achieved in the Bargo River as	N/A	Non-Compliant (Medium Risk)	Non compliance actions currently underway	A Detailed Plan has been lodged with the EPA and work is currently ongoing to develop a strategy to enable the WWTP to meet the requirements set under PRP 22

		specified in Stage 1. Due Date: 30 November 2018				
	U2 PRP26	PRP 26 - Aquatic Health Monitoring Program U2.1 The Licensee must conduct an Aquatic Health Monitoring Program in Tea Tree Hollow and the Bargo River. The objective of the Aquatic Health Monitoring Program is to determine the effects of the discharge of mine water through Licensed Discharge Point 1 (LDP1) on Tea Tree Hollow and the Bargo River. The Aquatic Health Monitoring Program must be conducted following re-commissioning of the water treatment plant required by PRP 22. The licensee must submit a copy of the Aquatic Health Monitoring Program investigation report to the EPA by the due date. Due Date: 9 months following completion of PRP 22	N/A	Non-Compliant (Medium Risk)	Non compliance actions currently underway	PRP26 works requiring acquatic macroinvertebrate moinitoring delayed until completion of PRP22
SMPL27-30	2	The Leaseholder must carry out the activity generally in accordance with the SMP; subject to the conditions of this Approval. In the event of any inconsistency between the conditions of this Approval and the SMP, the conditions of this Approval prevail to the extent of any inconsistency.	Non-Compliant (Medium Risk)	Non compliance actions currently underway	Myrtle Creek CMAP Submitted and approved by Resource Regulator. Redbank CMAP submitted to Resources Regulator for approval.	CMAP Discussed in Section 11
	6	The Leaseholder must implement the SMP (as amended by the conditions of this Approval) and carry out any additional practicable measures necessary to prevent any harm to the environment that may result from the construction, operation, or rehabilitation of the activity. Where prevention can not be achieved the leaseholder is to demonstrate minimisation of harm to the environment that may result from the construction, operation, or rehabilitation of the activity	Non-Compliant (Medium Risk)	Non compliance actions currently underway	Myrtle Creek CMAP Submitted and approved by Resource Regulator. Redbank CMAP submitted to Resources Regulator for approval.	CMAP Discussed in Section 11
	9	The Leaseholder must implement any plan, programme or strategy required and approved pursuant to this Approval. Note: The Leaseholder may, at any time, submit an amended plan, programme or strategy for approval. Once approved, the amended plan, programme or strategy must be implemented, however, up until the date of approval, the Leaseholder must continue to implement the previously approved plan, programme or strategy.	Non-Compliant (Medium Risk)	Non compliance actions currently underway	Myrtle Creek CMAP Submitted and approved by Resource Regulator. Redbank CMAP submitted to Resources Regulator for approval.	CMAP Discussed in Section 11
	13	The Leaseholder must submit to the Director Environmental Sustainability & Land Use for approval an Environmental Management Plan (EMP) for the panels which are the subject of this Approval. This plan must address subsidence impacts on: a) surface and groundwater (quality and quantity) , including Myrtle and Redbank Creeks; b) flora and fauna; c) heritage sites including Aboriginal heritage sites; d) geomorphology, including rock bars and cliff lines; and e) surface and groundwater (quality and quantity); including groundwater bores on privately owned land within a 3 kilometre radius of the limit of mining. The leaseholder must not operate other than in accordance with an Environmental Management Plan (EMP) approved by the Director Environmental Sustainability & Land Use. This plan must address subsidence impacts above and must include: a) a detailed monitoring programme; b) trigger levels for subsidence impacts that require actions and responses; c) the procedures that would be followed in the event that the monitoring indicates an exceedance of trigger levels; d) measures to mitigate, remediate andlor compensate any identified impacts; e) a protocol for the notification of identified	Non-Compliant (Medium Risk)	Non compliance actions currently underway	Myrtle Creek CMAP Submitted and approved by Resource Regulator. Redbank CMAP submitted to Resources Regulator for approval.	CMAP Discussed in Section 11

		exceedances of the trigger levels; and f) a contingency plan. The leaseholder shall ensure that underground mining does not cause the performance outcomes in Table 1 to be exceeded.				
ML 1376	47	Prior to the commencement of "second working" extraction lease holder shall give three (3) months written notice of intention to carry out such mining to the owners of overlying land on which there are substantial improvements.	Administrative Non-Compliance	Complete	Letter sent out for notification of LW32 on 15 June 2018	Communitcations addressed in Section 12
ML 1539	57	Prior to the commencement of "second working" extraction the lease holder shall give three (3) months written notice of the intention to carry out such mining to the owners of all overlying land on which there are substantial improvements.	Administrative Non-Compliance	Complete	Letter sent out for notification of LW32 on 15 June 2018	Communitcations addressed in Section 12
CCL716	30	The lease holder shall conduct operations in such a manner as not to cause or aggravate soil erosion and the lease holder shall observe and perform any instructions given or which may be given by the Minister with a view to minimising or preventing soil erosion.	Non-Compliant (Low Risk)	Complete	REA topsoil stockpiles have been reduced to 3m in height.	Rehabilitation at REA and REA performance addressed in Section 14
ML 1642	10	(a) If an Environmental Officer of the Department believes that the lease holder is not complying with any provision of the Act or any condition of this lease relating to the working of the lease, he may direct the lease holder to:- (I) cease working the lease; or (ii) cease that part of the operation not complying with the Act or conditions; until in the opinion of the Environmental Officer the situation is rectified. (b) The lease holder must comply with any direction given. The Director-General may confirm, vary or revoke any such direction. (c) A direction referred to in this condition may be served on the Mine Manager.	Non-Compliant (Low Risk)	Complete	Drains at the REA have been amended and rock drains put in place.	Closed out in 2017 Annual Review
	2	The leaseholder shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation or rehabilitation of the development.	Non-Compliant (Low Risk)	Complete	Drains at the REA have been amended and rock drains put in place	Closed out in 2017 Annual Review
	5	The EMR must: a) report against compliance with the MOP; b) report on progress in respect of rehabilitation completion criteria; c) report on the extent of compliance with regulatory requirements; and d) have regard to any relevant guidelines adopted by the Director-General	Administrative Non-Compliance	Complete	Works on REA Drains complete	Rehabilitation at REA and REA performance addressed in Section 14
	18	Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution (including sedimentation) or soil contamination or erosion, unless otherwise authorised by a relevant approval, and in accordance with an accepted Mining Operations Plan. For the purpose of this condition, water shall be taken to include any watercourse, waterbody or groundwaters. The lease holder must observe and perform any instructions given by the Director-General in this regard.	Non-Compliant (Low Risk)	Complete	Additional monitoring at M4 dam to prevent exceedances at LDP1. Extensive monitoring has been occurring to maximise impact of flocculant	Water Results and analysis included in Section 13 of this report

Table 2: Non - Compliances

Risk Level	Colour Code	Description
High	Non-compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Moderate	Non-compliant	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-compliant	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 Non-Compliance	Non-compliant	Only to be applied where the non-compliance does not results in any risk of environmental harm

Table 3: Compliance Status Key

3 Introduction

Tahmoor Coking Coal Operations (**TCCO**) is located between the townships of Tahmoor and Bargo, approximately 80 km south west of Sydney. Surface facilities are situated to the south of the Bargo River and adjacent to Remembrance Driveway (Old Hume Highway). The Reject Emplacement Area (**REA**) is located to the east of the main southern railway. Tahmoor North underground workings extend north under the township of Tahmoor, and towards Thirlmere and Picton.

The Tahmoor Coal Mine (**Tahmoor Mine**) has been operated by Tahmoor Coal Pty Ltd (**Tahmoor Coal**) since the mine commenced in 1979 and via longwall mining methods since 1987.

Tahmoor Coal, trading as Tahmoor Coking Coal Operations (**TCCO**) is a subsidiary within the SIMEC Mining Division (**SIMEC**) of the GFG Alliance (**GFG**).

The Department of Planning and Environment (DPE) and the Resources Regulator approved that the Annual Review prepared under Condition 45 of Development Consent DA67-98 can also fulfil the requirement of the Annual Environmental Management Report (**AEMR**). This was to reduce duplication of reported information to both Government authorities.

This Annual Review is for the reporting period of 1 January 2018 to 31 December 2018.

A plan of TCCO showing the regional context, development consent boundary and mining lease boundaries is shown in **Figure 1**, and the current operational disturbance footprint and property boundaries are outlined within **Appendix 1**.

Contact information for TCCO senior management and environmentand community staff are outlined within **Table 4**.

Name	Position held	Contact details
Tahmoor Coking Coal Operations Management		
Peter Vale	General Manager	(02) 4640 0100
Environmental Management Team		
Ron Bush	Environment & Community Manager	(02) 4640 0100
Fiona Robinson	Environmental Coordinator	(02) 4640 0048
Samantha Beresford	Community Coordinator	(02) 4640 0079
April Hudson	Approvals Coordinator	(02) 4640 0022
Andrew Stuart	Environmental Projects Coordinator	(02) 4640 0033

Table 4: TCCO Senior Management and Environment & Community Team

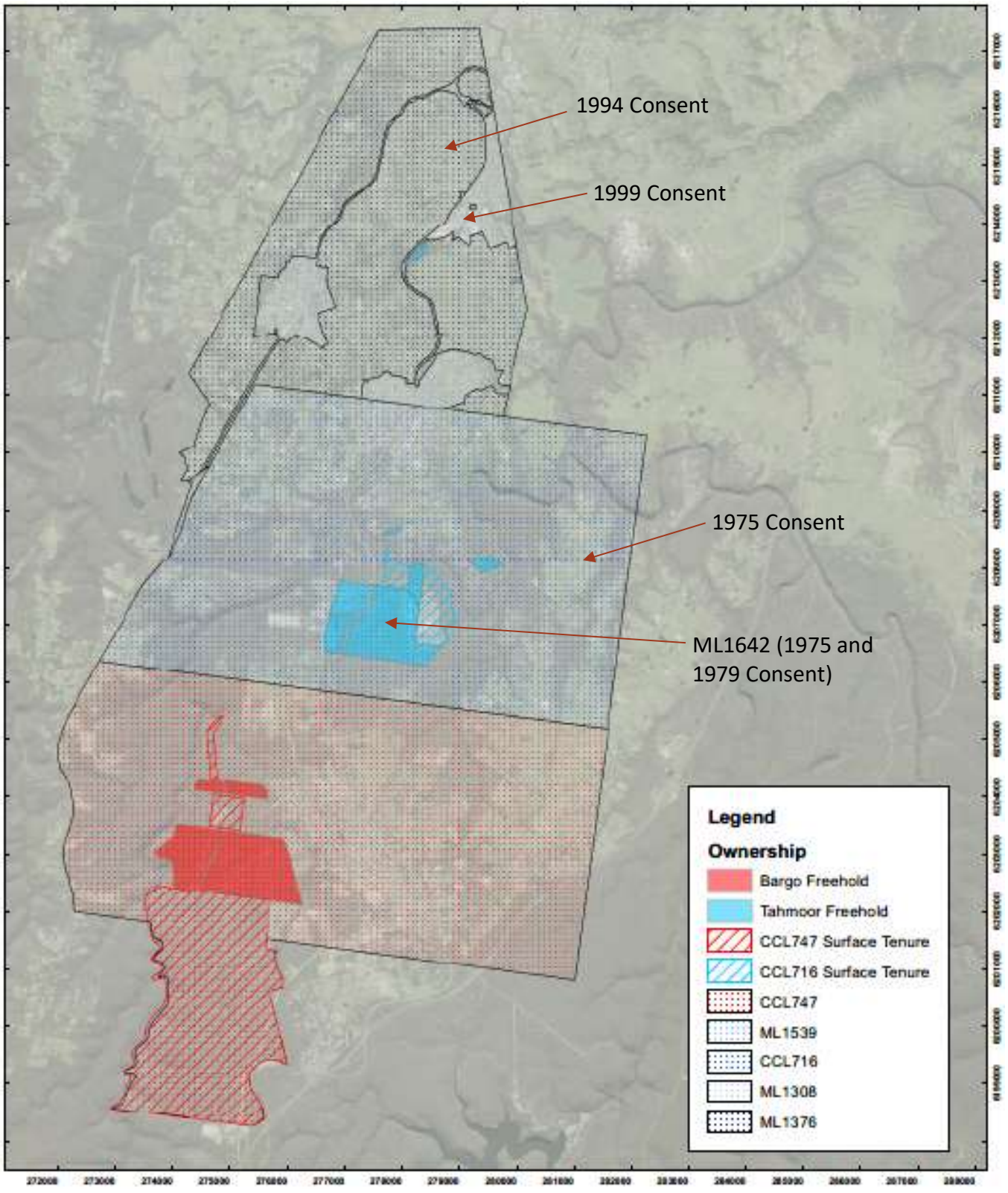

Figure 1: TCCO Mining Tenure

4 Approvals

The Tahmoor Mine development consents, mining tenure and environmental licences are outlined on **Table 5**.

Consent Number	Consent Description	Date Granted	Expiry Date
Development Consents			
DA 1975	Underground Mine	26/03/1975	No expiry
DA 162/76	Bargo Consent	21/04/1976	No expiry
DA 1979	Coal Preparation Plant Stockpiles and Refuse Emplacement Area	23/08/1979	No expiry
DA 1979 (Mod 1)	Modification for road haulage of trial coal shipments	16/09/1985	No expiry
DA 190/85	Surface Works for Gas Extraction	16/12/1985	No expiry
DA 1979 (Mod 2)	Modification for Upgrades for Longwall Mining	05/11/1986	No expiry
DA 1979 (Mod 3)	Modification for Road haulage in Wollondilly Shire and when rail unavailable	1988	No expiry
DA 57/93	Tahmoor North Project	07/09/1994	No expiry
DA 1979 (Mod 4)	Modification for Road haulage to Corrimal and Coal Cliff Coke Works	13/12/1994	No expiry
DA 67/98	Tahmoor North Extension Project	25/02/1999	16/06/2024
DA 67/98 (Mod 1)	Modification for additional areas to be subsided	26/11/2006	16/06/2024
DA 57/93 (Mod 1)	Modification for heritage approval condition	07/06/2007	No expiry
DA 67/98 (Mod 2)	Modification for Redbank Tunnel Subsidence Management	08/04/2012	16/06/2024
DA 67/98 (Mod 3)	Modification for Redbank Tunnel Rail Deviation – Subdivision of Land	25/11/2012	16/06/2024
DA 67/98 (Mod 4)	Modification for subsidence are update	15/10/2018	16/06/2024
Mining Tenure – Mining Leases & Exploration Authorisations			
Consolidated Coal Lease 716	Tahmoor Mining Lease	15/06/1990	13/03/2021
Mining Lease 1376	Tahmoor North Mining Lease	28/08/1995	28/08/2016 (approval pending)
Mining Lease 1308	Mining Lease to west of CCL716	02/03/2014	02/03/2035
Mining Lease 1539	Tahmoor North Extension Mining Lease	16/06/2003	16/06/2024
Mining Lease 1642	Pit Top and REA surface Mining Lease	27/08/2010	27/08/2031
Authorisation 206	Authorisation 206 - coincides with CCL 716	21/01/1981	Application for renewal has been withdrawn
Authorisation 410	Authorisation 410 - coincides with ML 1376 and ML 1539	26/04/1989	Application for renewal has been withdrawn
Consolidated Coal Lease 747	Bargo Mining Leases	23/05/1990	06/11/2025
Environmental Licences			
EPL 1389	Environmental Protection Licence	17/10/2000	No expiry
WAL36442	Water Access Licence	06/12/2013	No expiry

Table 3: Development Consents, Mining Tenure and Environmental Licences

5 Operations Summary

5.1 Mining Operations

Mining activities during the reporting period have been conducted in accordance with the approved Mining Operation Plan (**MOP**) and Subsidence Management Plan (**SMP**) approvals.

Extraction of Longwall 31 was completed on 17 August 2018.

Longwall 32 extraction commenced on the 30 October 2018.

No seismic or exploration activity has occurred during the reporting period.

Table 6 outlines a summary of operational performance at the Tahmoor Mine.

Material	Approved Limit (Specify Source)	Previous Reporting Period (Actual) Tonnes	This Reporting Period (Actual) Tonnes	Next Reporting Period (Forecast) Tonnes
Waste Rock /Overburden	-	-	-	-
ROM Coal/Ore	-	2,107,326	2,110,328	2,308,688
Coarse Reject	-	500,553	497,380	270,301
Fine Reject (Tailings)	-	0	0	0
Saleable Product	3,500,000 (EPL 1389)	2,208,695	1,599,017	1,915,848

Table 6: Tahmoor Mine Operational Performance

5.2 Next Reporting Period

Table 7 outlines the proposed longwall sequencing for the completion of mining within Tahmoor North Mining Domain. Longwall 32 has commenced mining and four (4) further longwalls are proposed within the Western Domain of the Tahmoor North Mining Domain.

Appendix 13 outlines the planned longwall layout and planned longwall progress plot for Longwall 32 and the Western Domain longwalls.

Longwall Block	Proposed Start	Proposed Completion
Longwall 32	30/10/2018	3/9/2019
Western Domain - Longwall West 1	8/11/2019	20/8/2020
Western Domain - Longwall West 2	19/05/2020	28/4/2021
Western Domain - Longwall West 3	10/6/2021	21/12/2021
Western Domain - Longwall West 4	31/1/2022	9/6/2022

Table 4: Tahmoor North Mining Domain - Longwall Sequencing

6 Actions Required from Previous Annual Review

No actions were required to be completed in response to the 2017 Annual Review / AEMR by the Department of Planning and Environment or Resources Regulator.

The Resources Regulator approved an application to align the date for the AEMR with the same date (31 March 2019) for the Annual Review.

7 Environmental Performance

Table 8 outlines the environmental performance at the Tahmoor Mine during the reporting period and identifies the implemented and/or proposed management activities.

Aspect	Approval Criteria/EIS Prediction	Performance During the Reporting Period	Trend/key management implications	Implemented / proposed management actions
Noise	Maximum L10 reading of 45dBA within 3m of a residence Maximum L10 reading of 37dBA at the Refuse Emplacement Area (REA)	Monitoring results returned levels all within compliance	Noise levels compliant	Continue implemented, regular monitoring of noise levels
Blasting	TCCO does not conduct surface blasting activities			
Air quality	Maximum deposited dust annual average of 4 g/m^2/month (DA67-98 MOD3)	Monitoring results returned levels all within compliance	Air quality levels compliant	Continue implemented, regular monitoring of air quality levels
	Maximum total suspended particulate (TSP) matter annual average of 90 $\mu g/m^3$ (DA67-98 MOD3)			
	Maximum particulate matter (PM10) annual average of 30 $\mu g/m^3$ (DA67-98 MOD3)			
	Maximum particulate matter (PM10) 24-hour average of 50 $\mu g/m^3$ (DA67-98 MOD3)			
	Maximum increase in deposited dust level over an annual period of 2 g/m^2/month (DA67-98 MOD3)			
Biodiversity	-	Nothing to report	Biodiversity compliant	Continue current management and monitoring activities
Heritage	Aboriginal cultural heritage site at Redbank Creek (AHIP received, see Section 11)	Nothing to report	Heritage compliant	Continue current management and monitoring activities

Table 5: Environmentasl Performance

8 Operational Noise

8.1 Environmental Management

Tahmoor Mine is approved to operate 365 days a year, 24 hours a day.

Tahmoor Mine and its associated facilities operate in accordance with noise criteria provided by the 1975 and 1994 Development Consents.

DA 57-93 Tahmoor North development consent noise conditions which are set out in Conditions 73 and 74 as follows:

> *Condition 73: The noise level emanating from Tahmoor Mine and any associated facilities, including the Washery, stock pile area and rail loading facility, shall not exceed an L10 level of 45dBA when measured within 3 m of any residence.*
>
> *Condition 74: The noise emanating from operations at the refuse emplacement site shall not exceed an L10 of 37dBA or background +5dBA whichever is the greater when measured within 3m of any residence.*

The DA 57-93 consent conditions are referenced at a distance of three (3) metres from any residence (constructed or approved prior to 1994).

TCCO operates a real-time noise monitoring system which includes a Trigger Action Response Plan (**TARP**) and alarm system, linked back to the mine's 24 hour control room.

Attended due diligence monitoring is conducted quarterly during the reporting period as part of ongoing noise compliance work aimed at identifying and implementing targeted reasonable and feasible noise reduction.

8.2 Environmental Performance

TCCO's real-time noise monitoring data and due diligence assessments continued to demonstrate compliance with the site's development consent noise criteria, with all monitoring results satisfying the noise assessment goals for the mine pit top, No.2 ventilation shaft and Reject Emplacement Area (**REA**) operational areas.

Appendix 2 outlines the locations of the noise monitoring locations and Appendix 3 contains a summary of noise monitoring completed from 2014 to 2018.

TCCO received one (1) noise complaint during the reporting period. This complaints related to perceived noise nuisance at a nearby residence sensitive receptors. Whilst this complaint is not related to an exceedance of the Tahmoor Mine noise criteria, it was reportable to the EPA as part of the site's EPL Annual Return, and are therefore summarised in **Section 20.4** and detailed in **Appendix 13**.

8.3 Further Improvements

TCCO will continue to operate and monitor the sites real-time noise monitoring network and alarm system, which includes a monitor at the mines Pit Top facility and at residences along Olive Lane, as this system has proved effective in managing compliance with development consent noise criteria.

9 Air Quality

9.1 Environmental Management

TCCO manages air quality in accordance with the air quality management plan approved by the DPE on 10 December 2012 (T*AH SD PLN 003 – Air Quality & Greenhouse Gas Management Plan).*

A comprehensive system of controls are detailed for managing particulate matter on-site, including dust suppression sprays on the coal stockpiles (automatically triggered by predefined meteorological conditions), and visual triggers for operators and site personnel. Water carts are used at the REA and Pit Top hardstand to reduce wheel generated dust from mobile equipment. Unsealed access ways are required to control dust utilising a water cart.

The site also utilises a chemical dust suppressant 'PetroTac' on highly trafficked areas to prevent wheel generated dust from mobile equipment. This suppressant is applied monthly to hardstand areas.

9.2 Environmental Performance

The annual average depositional dust monitoring results for the reporting period, expressed as insoluble solids g/m^2/month, are compared against those from previous reporting periods and reviewed on a monthly basi. Monitoring results indicate that all recorded dust levels are within limits set by EPL1389, with results below the annual average of 4 g/m^2/month.

Table 9 and **Figure 2** outlines the depositional dust results during the reporting period.

Air quality monitoring site locations are shown in **Appendix 9**.

Month/Site	1	2	3	4	7	8	9	10	11	12
09-Jan-18	0.5	0.4	1.5	1	0.9	1	0.5	0.4	0.6	0.6
08-Feb-18	0.2	0.3	1.1	1	0.7	0.9	0.5	1.2	1	1.4
08-Mar-18	0.6	0.6	3.9	0.5	0.7	1.3	0.9	1.1	2.1	3.1
09-Apr-18	0.3	0.4	2	0.3	0.4	0.4	0.3	0.3	0.8	1.4
09-May-18	0.3	0.4	1.2	0.6	0.5	1	0.3	0.3	#	0.9
08-Jun-18	0.7	0.4	1.5	0.3	0.2	1.2	0.6	0.4	0.8	1.7
10-Jul-18	0.3	0.3	0.3	0.2	0.2	0.4	0.3	0.7	0.2	0.8
10-Aug-18	0.3	0.2	0.2	0.3	0.2	0.4	0.8	0.6	1.3	3.1
11-Sep-18	0.7	1.3	1.5	0.4	0.6	1.4	1.6	0.8	1.8	1.6
12-Oct-18	0.6	0.2	1.1	0.4	0.3	0.4	0.3	0.4	1.7	0.8
13-Nov-18	0.7	0.6	3.2	0.8	0.7	1.3	0.6	0.5	1.1	0.7
12-Dec-18	1.2	0.6	1.6	1	1.2	1.4	1.2	1.6	1.4	1.3
Average	0.5	0.5	1.6	0.6	0.6	0.9	0.7	0.7	1.2	1.5

Note: # Funnel smashed during sampling period

Table 6: Depositional Dust Gauge Data

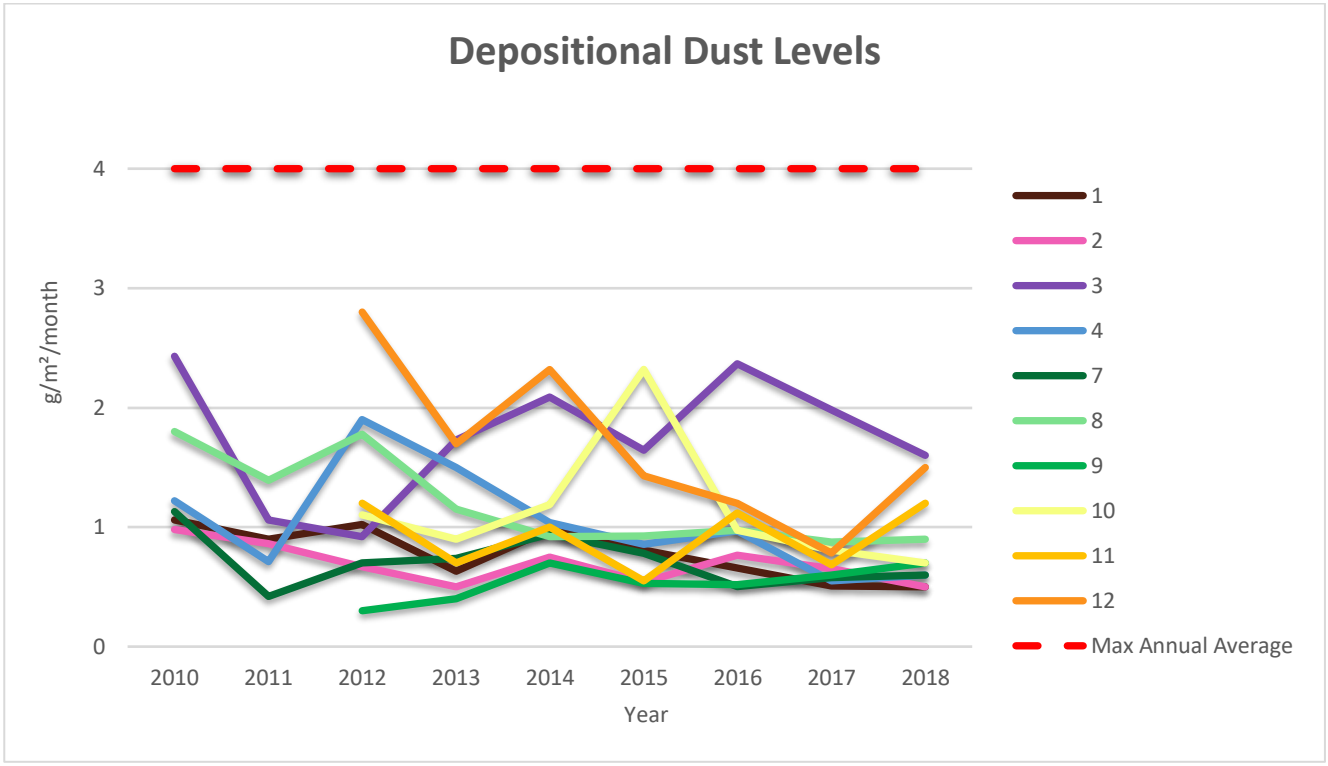

Figure 2: Depositional Dust Monitoring Results

Figure 2 indicates that there are no trends of concern occurring within depositional dust sites 1-12. In general, levels continue to fluctuate between an average of 0.5 – 2.0 g/m^2/month. Due to no significant changes to the scale and location of the mining operation, it is predicted in 2018 levels will continue within this range.

Figure 3 and **Figure 4** outline the performance of the particulate matter monitoring. These sites have been established since August 2013.

In 2018, concentrations continue to fluctuate between averages of 4.4 to 17.4 µg/m^3/24hrs for Olive Lane and Hodgson Grove sites. The performance criteria for PM_{10} is 50µg/m^3 over a 24 hour period and 30µg/m^3 annually.

All exceedances of the 50µg/m^3 over a 24 hour period were due to local hazard reduction burning events and maintenance activities around the monitoring equipment. Although there was a slight increase in the annual levels they are still well below the performance criteria. Due to power issues there was an outage for a period in March 2018 at the TEOM. The Hi-Vol ran during this period while repairs were made to the TEOM.

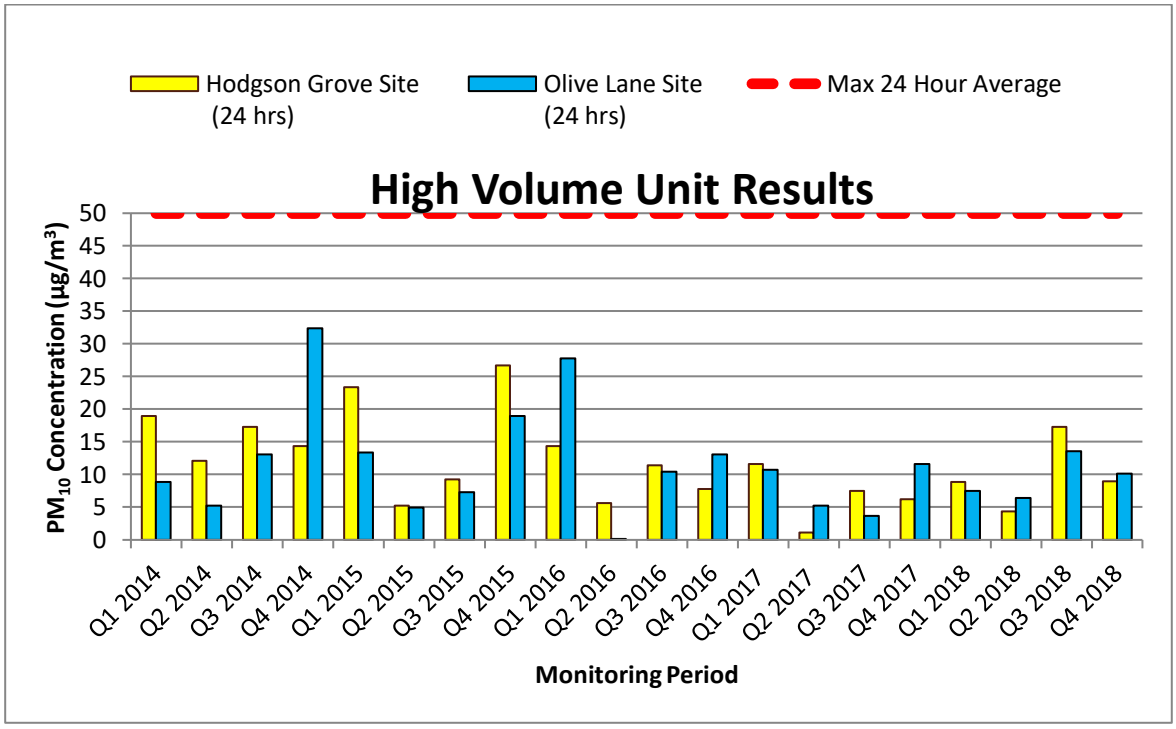

Figure 3: Hi Volume Air Quality Monitoring Results

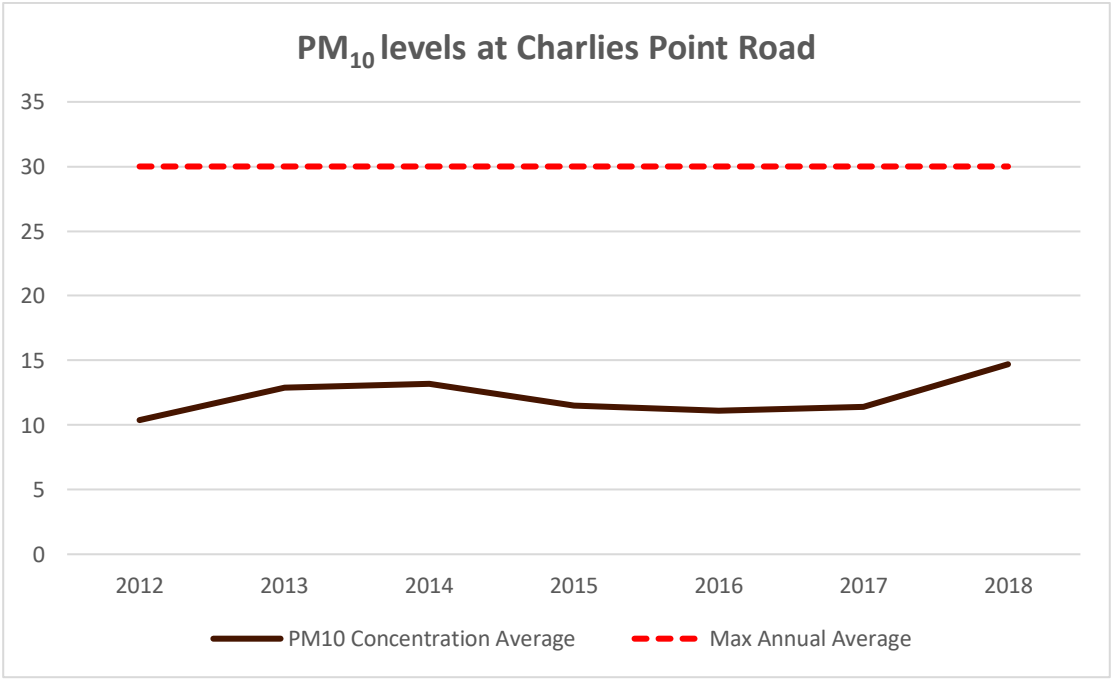

Figure 4: TEOM Monitoring Results

9.3 Further Improvements

No complaints have been received to date regarding dust or air quality in 2018, however one complaint was received regarding odour.

TCCO has entered into discussions with the landowner who made the odour regarding possible solutions.

10 Biodiversity

10.1 Environmental Management

TCCO undertakes flora and fauna assessments before undertaking activities likely to require vegetation clearing. Several threatened plant species have previously been identified on the surface mining lease areas, including *Grevillea parviflora* and *Persoonia bargoensis,* which have been identified at the REA and near the No.2 Shaft area.

Grevillea parviflora is listed as vulnerable on both the *Biodiversity Conservation Act 2016* (**BC Act**) and the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**). *Persoonia bargoensis* is listed as endangered under the BC Act and vulnerable under the EPBC Act.

Terrestrial flora and fauna and aquatic ecology studies have also been conducted along the Myrtle Creek and Redbank Creek to monitoring impacts from subsidence.

Baseline terrestrial flora and fauna and aquatic ecology studies have also been conducted within future potentially impacted subsidence within the Western Domain, such as, along Stonequarry Creek, Matthews Creek and Cedar Creeks.

10.2 Environmental Performance

Throughout the reporting period various due diligence flora and fauna surveys were completed at the REA and other operational areas associated where ground disturbance was planned to occur. This process of due diligence assessment is managed on-site through the implementation of TCCO 's Ground Disturbance Permit.

In 2018 ecological studies were undertaken for the new expansion area of the REA. Results of this ecology survey are outlined within **Appendix 4**.

There were no reportable incidents related to flora or fauna impacts during the reporting period.

10.3 Further Improvements

Flora and fauna surveys will continue to be undertaken as required to manage compliance and impact assessment.

11 Aboriginal Cultural and Historical Heritage

11.1 Environmental Management

An Aboriginal Heritage Impact Permit (**AHIP**) search is completed prior to the extraction of each longwall to confirm if new Aboriginal cultural or historical heritage sites have been identified.

A sandstone rock shelter that contains Aboriginal Art was identified in Redbank Creek as an Aboriginal object. The rock shelter is referred to as Redbank Creek 1. The rock shelter is located within the active subsidence zone of Longwalls 28, 29 and 30.

Longwall 31 End of Panel Report inspections found no new impacts have occurred to Redbank Creek 1 as a result of the extraction process. The site at Redbank Creek 1 will continue to be monitored during the extraction of Longwall 32.

During the reporting period no new Aboriginal cultural or historical heritage items were identified in the active subsidence zone.

11.2 Environmental Performance

All Aboriginal and historical heritage items were managed in accordance with the relevant approvals during the reporting period.

There were no reportable incidents related to Aboriginal or historical heritage items during the reporting period.

11.3 Further Improvements

Aboriginal cultural and historical heritage due diligence assessments will continue to be undertaken by qualified Aboriginal cultural and historic heritage consultants.

Aboriginal cultural and historical heritage assessment process will identify items of significance and propose mitigation measures to ensure compliance with statutory requirements. Additionally, TCCO will maintain a valued working relationships with local Registered Aboriginal Parties (**RAPS**).

12 Erosion & Sediment Control

12.1 Environmental Management

TCCO has a Soil & Water Management Plan and project specific Erosion & Sediment Control Plans, prepared generally in accordance with the requirements of *Managing Urban Stormwater* (OEH, 2008), including *Volume 2E Mines and Quarries* (2008) (also known as 'the Blue Book').

Various drive-in sump arrangements and settling dams are utilised to capture sediments prior to discharge to LDP1.

The unsealed equipment storage area between dams M1, M2, M3 and M4 is regularly treated with a dust suppressant to seal the area. The sealing agent is also useful in reducing sediment mobilisation in stormwater runoff.

The completed storm water consolidation project has allowed for better operational control of the site, and has allowed for flocculent to be dosed into surface water runoff prior to discharge.

12.2 Environmental Performance

Water sampling is carried out monthly as required by EPL 1389 at LDP1.

12.3 Further Improvements

TCCO will continue to implement control strategies identified in TCCO 's Soil & Water Management Plan.

13 Contaminated Land

13.1 Environmental Management

A Stage 1 Preliminary Contamination Investigation was completed by GHD in 2017 and actions from that audit have been closed out, including removal of former underground storage tanks (**USTs**) and remediation works around the waste oil tanks and diesel above ground storage tanks (**ASTs**).

Groundwater monitoring around the UST area is ongoing.

13.2 Environmental Performance

During the reporting period a Hazardous Building Material audit and inspection was undertaken by GHD during the reporting period.

This audit focused on:

- Asbestos containing materials (**ACM**);
- Lead based paint systems (Lead paints);
- Lead Dust;
- Synthetic Mineral Fibre (**SMF**);
- Polychlorinated Biphenyls (**PCBs**) in light fittings; and
- Ozone depleting substances (**ODS**).

The Hazardous Materials Audit identified a number of actions that are planned for completion during 2019 and these are outlined within **Table 10**.

Action	Proposed Completion Date
Remove vinyl floor tiles from 5 offices and replace with new tiles	2/12/2018
Labelling of all asbestos	5/01/2019
Seal or encapsulate the eaves of BU001 which were found to contain asbestos	30/03/2019
Remove dust on upper surface of ceiling panels in muster area	15/01/2019
Remove dust in Washery HV switchroom SR 105 and SR106- low level lead contamination	15/01/2019
Remove dust from No3 Switchroom SR103 - high lead on top of st169	15/01/2019

Table 10: Hazardous Building Material Audit Actions

There were no reportable incidents related to contaminated land during the reporting period.

13.3 Further Improvements

TCCO will continue to monitor potential areas of contaminated lands across the site in 2019 as well as complete actions from the 2018 Hazardous Building Materials Audit.

14 Bushfire Management

14.1 Environmental Management

During 2018, TCCO is continued to implement the Bushfire Management Plan (**BMP**) in consultation with the Wollondilly Rural Fire Service (**RFS**). The BMP provided significant detail on the location of all Tahmoor Coal land holdings with detailed maps showing Asset Protection Zones (**APZ**), Land Management Zones (**LMZ**) and Strategic Fire Zones (**SFZ**), gate/track/road access for all locations, and a detailed schedule of hazard reduction activities required for each location.

14.2 Environmental Performance

In 2018, no hazard reduction burns were completed, due to the scheduling constraints of the RFS.

Hazard reduction burns are planned for mid 2019, at an area next to the REA being selected in accordance with the BMP.

There were no reportable incidents related to fire management during the reporting period.

14.3 Further Improvements

Implementation of TCCO 's BMP wil continue in consultation with the RFS and the Wollondilly Bushfire Management Committee (**BFMC**).

15 Mine Subsidence

15.1 Environmental Management

During the reporting period, TCCO completed extraction of Longwall 31 in August 2018, and commenced extraction of Longwall 32 on 30 October 2018.

All subsidence related impacts are managed in accordance with the Longwall 31 and Longwall 32 SMP Approvals.

15.2 Environmental Performance

A detailed review of subsidence monitoring data and impacts is provided within the TCCO Longwall 31 End of Panel Report. A copy of the Longwall 31 End of Panel Report is contained within **Appendix 15**.

15.3 Surface Waters

During the reporting period, subsidence impacts resulted in stream bed cracking. Subsidence impacts were observed within Redbank Creek including a reduction in stream flow and pool levels as well as increased salinity and zinc, nickel and copper due to the extraction of Longwall 31 downstream to Site RR29 over Longwall 32.

Longwall 32 had not mined beneath Redbank Creek during the reporting period.

Connected stream "through-flow" has been interrupted or discontinued (outside of storm events) upstream of RW13 over the centre of Longwall 30, with flow recommencing downstream of Site RR29.

15.4 Groundwater

During the reporting period three (3) open standpipe shallow groundwater bores were installed in the future impact zone of Redbank Creek above Longwall 32 to 50m below initial water strike depth.

No adverse effects on private bore yield or water quality have been reported as a result of Longwall 31 extraction.

During the reporting period water level reduction in response to Longwall 31 was observed in the P9 open standpipe and vibrating wire piezometers along with general depressurisation due to the extended lack of rainfall recharge in the other regional piezometers.

15.5 Subsidence Event Notifications

There were 10 Incident and Ongoing Management Reporting notifications for Longwall 31 during the reporting period and 1 notifications for Longwall 32 in 2018.

The Subsidence Event Notifications are required as per condition 14 of Longwall 31 and Longwall 32 SMP Approvals and are summarised within **Table 11**.

Date	Location	Longwall	Subsidence Incident Reported
25/01/2018	Silton Lane, Tahmoor	31	Compression strain developed and shown in weekly ground survey of the area
15/02/2018	Survey peg ST23, Stilton Lane, Picton	31	Minor increase in subsidence profile shown in weekly ground survey of Stilton Lane at ST23
20/03/2018	Pools RB22, RR19. RR16, RB21 and RB14, Redbank Creek, Thirlmere	31	Draining of pools due to subsidence impacts from Longwall 31
28/03/2018	Pools RR29 Redbank Creek, Thirlmere	31	Delamination of sandstone rockbar at RR29 and the pool level has started to decline due to subsidence impacts from Longwall 31
12/04/2018	Piezometer P9, Redbank Creek, Thirlmere	31	The piezometer showed signs of the water level decreasing and in the early stage of a significant water level reduction
23/04/2018	Stilton Lane, Picton	31	Subsidence impacts of house
01/06/2018	Remembrance Driveway Tahmoor	31	Category 3 and 4 damage
02/07/2018	Thirlmere Carrier Pipe line and Bridge Street Thirlmere	31	Compressive ground strain increasing between Pegs BG105 and BG106, which cross a small tributary to Redbank Creek. Total ground strain has reached 2mm/m, related to valley closure movements.
03/07/2018	Coachwood Crescent, Picton	31	Subsidence impacts of house
26/07/2018	46m west of Pit No. 3186019 in the Thirlmere Carrier pipe, at Bridge Street	31	Longitudinal compression, resulting in the joint closing and the end of the pipe has been pushed into the adjacent pipe
19/12/2018	Between pegs RD2 and RD27 at Remebrance Driveway, Tahmoor	32	Cracking and compression on road and a noticeable bump formed in pavement. Increasing ground strain reported as 1.3mm/m

Table 11: Subsidence Event Notifications

15.6 Subsidence Monitoring

Condition 12 of Development Consent 67/98 requires TCCO to undertake detailed and ongoing monitoring of subsidence resulting from mining with the interpreted results included within the Annual Review.

Table 12 outlines TCCO subsidence monitoring for the 2018 reporting period.

During the reporting period Longwall 31 was completed and Longwall 32 was being extracted. On completion of a Longwall, the active subsidence zone is resurveyed and comparative analysis of predicted and actual subsidence forecasts are reported in an End of Panel Report. Longwall 31 End of Panel Report demonstrates that there is a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area and is contained within **Appendix 15**.

15.7 Further Improvements

A number of shallow groundwater piezometers are proposed to be installed adjacent to Matthews Creek, Cear Creek and Stonequarry Creek near Longwalls West 1 to West 4 down to 50m below initial water strike.

Condition	Monitoring Occurring	Interpretation of the Results
i) impacts on dams that may be affected by subsidence occurring in the DA area	All Monitoring occurred as detailed in the approved *Tahmoor Colliery Longwall 31 Management Plan for Potential Impacts to Built Structures (Revision A)* and *Tahmoor Colliery Longwall 32 Management Plan for Potential Impacts to Built Structures (Revision B).* Five dams (previously six) are located directly above Longwalls 30 and 17 dams are located directly above Longwall 31. All dams are inspected prior to and post mining.	All inspections completed to date with no major issues identified. The large dam over the main gate of Longwall 30 (Stilton Lane) has been removed and the land is being remediated in consultation with the landowner.
(ii) a survey of the stream channel system	All Monitoring occurred as detailed in the approved *Tahmoor Colliery Longwall 31 Environmental Management Plan (Revision B)* and *Tahmoor Colliery Longwall 32 Environmental Management Plan.* It is a requirement of the above mentioned Management Plan that detailed visual surveys are conducted along Redbank Creek on a weekly basis within the active subsidence area during the mining of Longwalls 30 and 31. There are also requirements as detailed in the *Tahmoor Colliery Longwall 31 Subsidence Monitoring Programme and Tahmoor Colliery Longwall 32 Subsidence Monitoring Programme* that survey lines are to be established to monitor valley closure.	As per Section 15 in the 2018 Annual Review, during the reporting period stream bed cracking, which is predominantly associated with a reduction in stream flow and pool levels has been observed in Redbank Creek due to the extraction of Longwall 31. Longwall 32 has not mined beneath Redbank Creek during the reporting period. All *subsidence event notifications* in response to monitoring are reported in Table 11 in the 2018 Annual Review. Cracking was observed in Redbank Creeks and pools were observed to drain at times of low flow, with subsurface flow diversion observed to re-emerge downstream of Longwall 32. Some adverse changes in water quality were observed at times of low flow. The observed impacts are within predictions. Valley closure surveys of cross-sections of Myrtle and Redbank Creek (surveys from the southern bank to the northern bank) demonstrate upsidence (negative subsidence) in the base of the creeks and valley closure across both stream profiles. The upsidence and closure was broadly within expectations.

(iii) monitoring of groundwater levels and quality	All Monitoring occurred as detailed in the approved *Tahmoor Colliery Longwall 31 Environmental Management Plan (Revision B)* and *Tahmoor Colliery Longwall 32 Environmental Management Plan (Revision ?)*. Monitoring of piezometric water levels and water quality is tested in groundwater bores and piezometric bores during mining.	As per *TCCO Environmental Management Plan* vibrating wire piezometers and open standpipes are monitored by GeoTerra bi-monthly during active subsidence for water quality testing and download of continuous 12 hourly readings. Two (2) shallow groundwater bores installed in impact zone of Redbank Creek directly above LW31. At the completion of LW31 active subsidence two (2) shallow groundwater bores were installed in the impact zone of Redbank Creek directly above LW32. Depressurization observed in boreholes above LW31 during the mining of LW31.
(iv) monitoring of remedial measures	Ongoing bi-monthly monitoring of Myrtle and Redbank Creeks as outlined in the Trigger Action Response Plan of *Tahmoor Colliery Longwall 31 Environmental Management Plan (Revision B)* and *Tahmoor Colliery Longwall 32 Environmental Management Plan*	A Corrective Management Action Plan (**CMAP**) for Myrtle creek was submitted to Department of Industry on 16 June 2017. This plan focused on the initial characterisation of Myrtle Creek and a remediation Trial Project Stage 1 in Myrtle Creek On completion of these works the effectiveness will be assessed for the appropriate approach and implementation at future sites within Myrtle and Redbank Creeks. This plan was accepted on 4 May 2018 Redbank Creek CMAP was submitted on 29 December 2018.
(v) a comparison of predicted impacts with actual impacts, including mapping of subsidence profiles in residential areas and of anomalous events	Predicted subsidence impacts are outlined in the *Tahmoor Colliery Longwalls 31 to 37 Subsidence Management Plan Application*, actual impacts are recording during active mining as outlined in the approved *Tahmoor Colliery Longwall 31 Subsidence Monitoring Programme* and *Tahmoor Colliery Longwall 32 Subsidence Monitoring Programme*, and the comparison of predicted and actual impacts is summarised in the *Tahmoor Colliery Longwall 31 End of Panel Report.*	As outlined in the *Tahmoor Colliery Longwall 31 End of Panel Report*, there is a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as the Main Southern Railway, sewer mains, water mains, gas mains and electrical and telecommunications infrastructure.
(vi) strains and impacts in the vicinity of the Nepean Fault Zone	Nepean Fault zone lies outside the zone of influence of current mining operations (35 degree angle of draw). Far field monitoring has been installed and monitored during the second half of mining Longwall 31 and during Longwall 32. Monitoring includes survey marks across the Nepean Fault at the Sydney Water Picton Water Recycling Plant, at the Picton Viaduct and Stonequarry Bridge, and in various locations across the fault zone.	Monitoring has detected very little differential movement across the Nepean Fault Zone, with no impacts observed to pipelines or access roads in the vicinity of the Nepean Fault Zone.

(vii) the angle of draw	Monitoring occurred as detailed in the approved management plans: *Tahmoor Colliery Longwall 31 Subsidence Monitoring Programme* and *Tahmoor Colliery Longwall 32 Subsidence Monitoring Programme*. The subsidence monitoring programme is reviewed and updated each longwall to include management and monitoring measures for surface infrastructure that is monitored during active mining within the active subsidence zone.	During 2018, survey monitoring was undertaken within the active subsidence zone. At the end of each longwall panel, a complete end of panel survey is undertaken to determine the degree of subsidence and the extent of movement. The angle of draw to the notional limit of subsidence line varies significantly depending on which side or end of the longwall block the measurement is made. For Longwall 31 we measured up to 26 degrees angle of draw over the unmined coal forming the next Longwall 32. While these angles of draw varied depending on the locations around the longwall block the subsidence parameters measures were generally within expectations and there were no unexpected significant impacts to natural or built features.

Table 12:7 Subsidence Monitoring Information required by DA67/98

16 Natural Heritage

16.1 Environmental Management

No natural heritage sites have been identified.

The Bargo River and the associated gorge are considered to hold recreational and aesthetic values in the local area. The Bargo River gorge is well outside the Longwall 31 and Longwall 32 subsidence zone, and is not impacted by future longwall extraction in Tahmoor North.

16.2 Environmental Performance

As the gorge is not impacted by future longwall extraction in Tahmoor North there is no monitoring data for the current reporting period.

There were no reportable incidents related to natural heritage during the reporting period.

16.3 Further Improvements

Natural heritage surveys will continue to be undertaken as per operational needs and approval requirements to manage compliance and impacts.

17 Water Management

17.1 Groundwater

17.2 Environmental Management

Longwalls are extracted within Tahmoor North at a depth of approximately 450m in the Bulli Seam. Water from sedimentary layers above the mine workings seep into the mine at a rate of approximately 2.5 ML/day. This water is pumped to the surface and directed to the mine's pit top treatment dams. Water quality is monitored under the conditions of the site's EPL as described above.

Near surface ground water levels may be impacted by mine subsidence. Any property owner that has a registered borehole impacted by subsidence is provided with alternative supply by TCCO until the groundwater bore is repaired or replaced. For further information relating to groundwater impacts due to subsidence, refer to **Section 11**.

The Tahmoor Mine water management schematic and water quality infrastructure is outlined within **Appendix 10**.

17.3 Environmental Performance

Table 13 provides a summary of groundwater take.

A plan showing the location of all monitoring bores in the Tahmoor North mining area, as reported in the TCCO Longwall 31 End of Panel Report is outlined within the **Appendix 15**.

Historical records of the total groundwater withdrawn are outlined within **Appendix 11**.

There were no reportable incidents related to groundwater pollution during the reporting period.

17.4 Further Improvements

TCCO will continue to implement the Environment Management Plan, and ongoing monitoring and reporting will occur in-line with the conditions in the Water Licences.

Date	Water Licence #	Water Sharing plan/source and management zone (as applicable)	Entitlement (ML)	Passive take/inflow (ML)	Active Pumping (ML)	TOTAL (ML)	Total water to Underground
Jul 2015-Jun 2016	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1597.7	0	1597.7	252
Jan 2016-Dec 2016	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1536.6	0	1536.6	308
Jul 2016-Jun 2017	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1546.1	0	1546.1	440
Jan 2017-Dec 2017	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1552.8	0	1552.8	431
Jan 2018 – Dec 2018	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1402.8	0	1402.8	429.5

Table 13: Summary of Groundwater Take

17.5 Surface Water

17.6 Environmental Management

TCCO is licensed to discharge water from one (1) licenced discharge location and overflow from three (3) licenced overflow points during periods of wet weather. The location of the licensed discharge and overflow points is shown in **Table 14.**

Point	Location
LDP 1	Discharge from Dam M4.
LOP 3	Overflow from the REA Dam S9.
LOP 4	Overflow from REA Dam S4.
LOP 5	Overflow from REA Dam S8.

Table 14: Licensed Discharge and Overflow Points

17.7 Environmental Performance

Water discharging from the licensed discharge point is monitored monthly.

The current Environmental Protection Licence maximum limits for LDP 1 and results are provided in **Table 15** and the LDP1 water quality discharge trend is outlined on **Figure 5**.

	Total Suspended Solids (TSS)	Turbidity	Arsenic	Nickel	Zinc	pH	Electrical Conductivity	Oil & Grease
	mg/L	NTU	ug/L	ug/L	ug/L	pH Unit	µS/cm	mg/L
100th Percentile Concentration Limits	30	150	200	200	300	6.5-9	2,600	10
9/01/2018	30	3.0	65	69	61	8.4	2,040	<5
8/02/2018	7	1.1	88	68	52	8.5	2,230	<5
8/03/2018	<5	1.3	66	56	35	8.6	2,030	<5
9/04/2018	6	0.8	51	51	44	8.6	2,000	<5
9/05/2018	<5	2.2	50	51	68	8.6	1,930	<5
8/06/2018	7	6.3	39	47	104	8.7	1,780	<5
10/07/2018	<5	2.6	32	71	63	8.7	2,070	<5
10/08/2018	<5	3.8	23	76	239	8.6	1,990	5
11/09/2018	<5	0.6	14	82	54	8.5	2,300	<5
12/10/2018	8	12.8	50	72	121	8.1	2,070	<5
13/11/2018	<5	3.1	13	52	60	8.5	1,780	<5
12/12/2018	11	23.3	12	43	38	8.5	1,770	<5
23/01/2018	8	5.1	26	51	54	8.4	1,880	<5

Table 15: LDP1 Discharge Water Quality

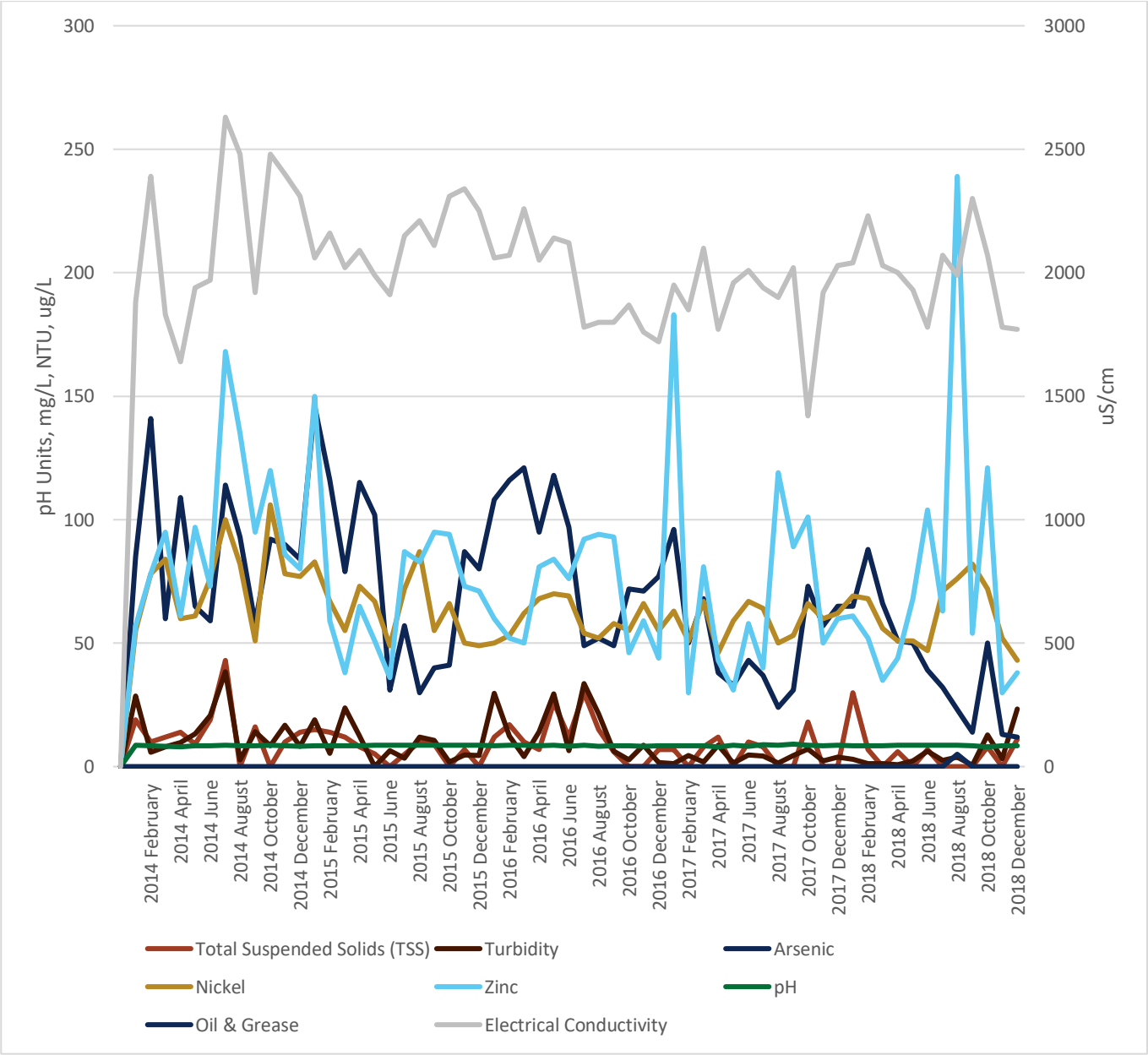

Figure 5: LDP1 Water Quality Data Trend

On average Tahmoor Mine discharged 3.9ML/day with a total of 1,458ML discharged during the reporting period, as shown on **Figure 6.**

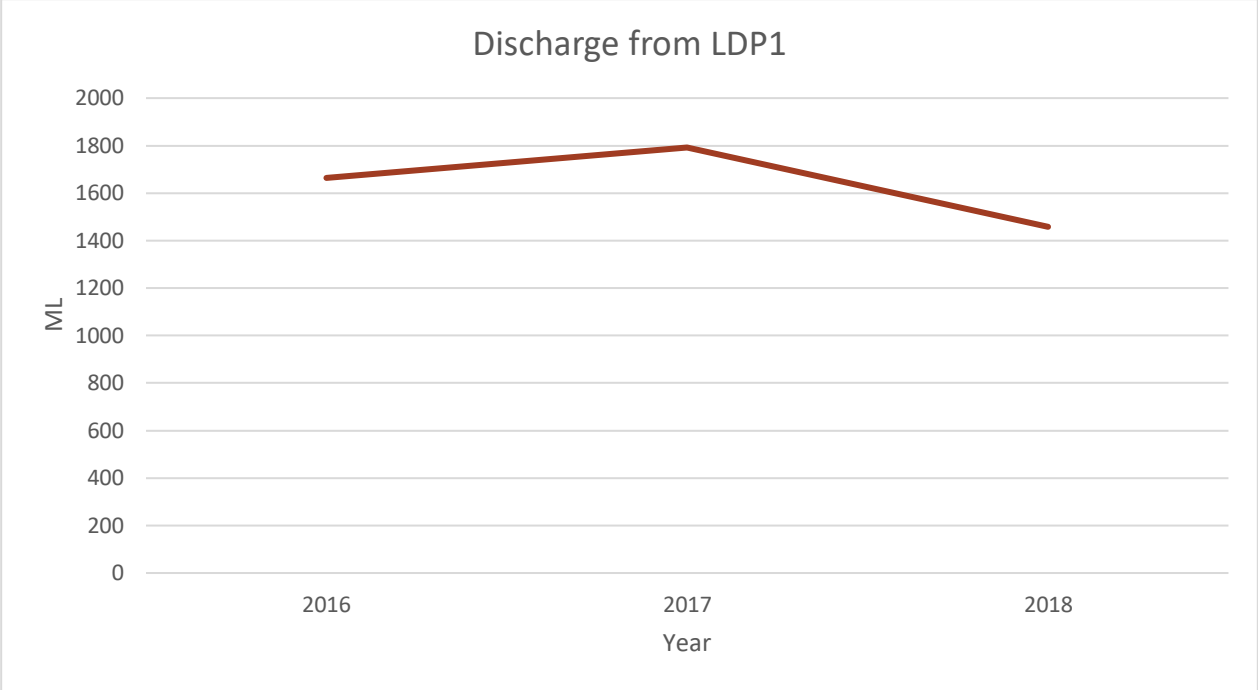

Figure 6: Volume of Discharge from LDP1

17.8 Further Improvements

TCCO has demonstrated a significant reduction in historical non-compliances with EPL water conditions, with the performance improvement attributed to the implementation of water management PRPs at TCCO from 2011 to present, including the successful completion of the Stormwater Consolidation Project at the REA.

17.9 Potable Water Supply

During the reporting period, surface and underground makeup potable water supply was from the Sydney Water main.

The average monthly potable water usage during the reporting period ranged from 7.02-36.44 ML/month, with average consumption of 21.33 ML/month.

17.10 Recycled Water Treatment Plant (RWTP)

TCCO continues to recycle mine water from the sealed longwall goafs to the south of the No.3 Shaft for reuse in the mine operation underground and various surface facilities. **Table 16** demonstrates that there was a significant increased in recycled water in 2018 compared with 2017.

Table 16 also outlines the water intensity since 2012, which shows that the potable water intensity continues to decrease during the report period. During 2014, the RWTP plant was out of order for a number of months which explains the increase in potable water intensity for that year.

In addition to the RWTP, the majority of water required at the Coal Handling and Preparation Plant (**CHPP**) and Stockpile Dust Suppression System uses recycled mine water.

Water Usage	2012	2013	2014	2015	2016	2017	2018
Potable Water Usage (kL)	569,370	509,650	549,250	437,440	402,840	259,668	133,389
Recycled Water Usage (kL)	0	175,490	128,750	261,870	308,290	200,755	388,449
ROM tonnes	2,516,088	2,765,678	2,424,576	2,632,695	2,721,284	2,107,326	2,110,328
Potable Water Intensity (L/ROM tonne)	226	184	227	166	156	123	63

Table 16: Recycled and Potable Water Use

17.11 Water Storage Volumes

Volume data for stored water is provided within **Appendix 9.**

TCCO does not participate in any salinity trading scheme, and therefore does not report controlled discharge water in this section.

Water used or contaminated by mining activities is discharged at the approved licence discharge or overflow point. Each discharge is sampled and tested monthly in accordance with the EPL conditions.

Mine water and storm water is discharged into Tea Tree Hollow which flows into the Bargo River. Water samples from the Bargo River are also taken monthly, upstream and downstream of the confluence of Tea Tree Hollow.

The layout of the site's water management system is outlined within **Appendix 10** and **Appendix 11**.

18 Rehabilitation

A summary of the Tahmoor Mine rehabilitation is provided within **Table 17**.

Mine Area Type	Previous Reporting Period (Actual)	This Reporting Period (Actual)	Next Reporting Period (Forecast)
	2017 (ha)	2018 (ha)	2019(ha)
A. Total mine footprint	130	142.5	142.5
B. Total active disturbance	62	74.5	74.5
C. Land being prepared for rehabilitation	0	0	5
D. Land under active rehabilitation	0	0	0
E. Completed Rehabilitation	0	0	0

Table 17: Rehabilitation Summary

Annual rehabilitation monitoring of long-term transects was conducted during the reporting period.

No significant changes in the vegetation quality, structure and diversity were observed during monitoring in 2018.

Generally, additional characteristics and changes that were noted included:

- Adequate growth in all canopy species including juveniles and seedlings;
- Senescent mature Acacias becoming less common with many already fallen creating habitat for both fauna and regenerating native species. However, senescence amongst the mid storey Acacia is more prevalent in 2018;
- Some death in all mid storey species including Hakea sp., possibly resulting from the drought conditions experienced in 2018;
- Weed cover was low overall, with current management practises proving effective;
- Growth rates overall are adequate in newly established revegetation;
- Number of target species recorded in all revegetation areas consistent with 2017 levels;
- Signs of a rabbit population observed;
- Minor gully erosion evident, however erosion control adequate with remediation on-going; and
- Herbivory of planted grasses in grass trials reducing reproductive potential of grass species.

Rehabilitation monitoring was undertaken in 2018 and the following recommendations were made:

- Infilling with native grass tubestock. Further protection of these plantings from herbivory is to be considered. Strategies to manage these grassy swards to increase soil organic matter would be beneficial;
- Care to avoid off-target damage during weed control works is to be considered. Control *Cenchrus setaceus* (Fountain Grass) by slashing prior to seed set in summer and spot spraying. Follow up is required for this species;
- Control the spread of *Leptospermum laevigatum* by controlling seedlings outside stages 1 and 2. Maintain monitoring for *Acacia saligna* and an appropriate weed control program;
- Repair areas of minor gully erosion with minor works; and

- Rabbit control programme desirable in conjunction with neighbouring properties. Consultation with Local Land Services advisable.

18.1 Environmental Performance

In 2018 the main works that occurred were in relation to the expansion of the REA. This included stripping and mulching vegetation, stripping the topsoil and the construction of new clean and dirty drains.

In addition, works occurred to the topsoil stockpiles with all heights reduced to three (3) metres and seeding.

Works also occurred to an area of salt scald in Stage 1 and 2, as outlined on **Figure 7**. This work involved three scalds being deeply ripped and have gypsum ripped into the profile. An organic mulch was then spread over the sites.

On the main scald a 45 x 2 metre rock lined cut-off drain was installed along the upslope edge. This drain lead to a small 3 x 3 metre sediment basin.

Figure 7: Salt Scold Repair Works - Before and After Rehabilitation

A Rehabilitation Improvement Plan in association with a TARP included a classification status of each assessed area forming the basis for the TARP for each stage showed in **Table 18**.

Annual Rehabilitation Status	Description	Action
VC	Generally exceeds the good practice standards and regulatory requirements by a significant margin.	No further action. Continue to maintenance activities as scheduled.
C	Generally good practise standards and regulatory requirements subject to normal variance.	No further action. Continue to maintenance activities as scheduled.
NC1	Not complying with some regulatory requirements and improvement needed to meet required good practice standards. Required works minor in nature and generally within budgeted site program.	Undertake minor works to improve rehabilitation to minimum standard prior to next annual inspection.
NC2	Not complying with significant risk to this inspection item, urgent corrective action needed. Requirements generally substantial in nature and beyond a budgeted site program.	Undertake major works required to improve rehabilitation to minimum standard prior to the next annual inspection.

Area	Status Rating	Comments/Opportunity for improvement
Stage 1-2	C	Some minor gully erosion to be improved, continued weed control.
Stage 3-5	C	Some crusting of soil surface, continued weed control. Opportunity for planting with understorey species in limited areas
Stage 7	NC1	Some evidence of surface crusting in limited areas, continued weed control. Opportunity for planting with understorey species
Stage 8	C	Continued weed control
Stage 6 & 9	NC1	Minor erosion, sediment fence to be replaced or removed. Opportunity for planting and brush mulching with understorey species
Stage 10	C	Continued weed control
Stage 12	C	Opportunity for brush mulching to increase species diversity in understorey species
Stages 14-16	C	Continued weed control for priority and environmental weeds

Table 18: TARP Rehbilitation Performance

18.2 Mine Closure

There are a number of post mining land use options that may be applicable for TCCO including residential, industrial or a return to native bushland.

The likely final land use option for most of the TCCO closure domains will be a return to native bushland. However the final land use options will be confirmed in the detailed closure planning process, which involves undertaking a final land use analysis.

The detailed closure plan will be prepared using the selected final land use at that time.

The REA key rehabilitation indicators include the following:

- Average depth of fill will be 12 metres;
- Maximum slope on final landform external batters will be 1:4 (generally will be 1:8);

- External batters should have gently sloping contour drains, reporting to water storage dams;
- Topsoil placement depth >300mm;
- All final landform slopes to be contour ploughed prior to seeding or planting;
- Target <10% weeds infestation within monitoring transects;
- Target evidence of second generation flora germination in monitoring transects; and
- Rehabilitation monitoring transects contain flora species and structural characteristics similar to the desired vegetation communities at the analogue sites.

The MOP outlines thta soils occurring at Tahmoor Mine have been identified as part of the Lucas Heights Soil Landscape and occurring adjacent to the Gymea Soil Landscape. Soil limitations of the landscape include stoniness, hard setting surfaces and low soil fertility. Erosion on the landscape is generally low. Where possible, deeper soil horizons are reserved for subsoil and capping material, while the top soil horizons with the highest organic content is reserved to rehabilitation and direct seeding/planting.

A combination of sterile cover crops and grass, shrub and tree seed mixes are used at the REA to achieve the rehabilitation objective of native bushland. A species list has been developed and refined based on TCCO 's development consents and the results of annual rehabilitation monitoring (identifying which species have proven more successful than others).

Hollow bearing trees and timber logs from clearing activities at the REA have been salvaged and stockpiled for use throughout rehabilitation areas. Logs and hollows are spread throughout rehabilitation areas where access permits, to provide structure and encourage colonisation by fauna.

All mine closure domains (including active domains still in operational use) specific in TCCO 's Conceptual Mine Closure Plan and MOP were assessed, to establish an annual record of the status of each domain, including photographic monitoring to show progress and changes year to year.

19 Weeds

19.1 Environmental Management

TCCO's Rehabilitation Monitoring, Annual Walkover of REA report identified a number of different weed species across the REA area. These weeds will be targeted going forward for removal or spraying.

A formal Weed Management Plan has been developed as part of the site Environmental Management System. The purpose of this plan is to outline management strategies and controls for noxious and environmental weeds, so that weed infestations are controlled and kept at an acceptable level on all lands owned or managed by the mine. A summary of weed species targeted during the reporting period, and control methods used, is provided in **Table 19.**

Target Weed Species	Date of Control	Treatment Method
African Lovegrass (*Eragrostis curvula*)	All seasons	Herbicide (Glysophate)
Hedge Mustard (*Sisymbrium orientale*)	All seasons	Herbicide (Glysophate Dicamba)
Whiskey Grass (*Andropogon virginicus*)	All seasons	Herbicide (Glysophate)
Serrated Tussock (*Nassella trichotoma*)	All seasons	Herbicide (Glysophate)
Fireweed (*Senecio riensis madagasca*)	Winter or as detected	Hand Weeding & Herbicide (Glysophate)
Swan Plant (*Gomphocarpus fruticosus*)	All seasons	Hand Weeding
Western Australian Golden Wattle *(Acacia saligna)*	All seasons	Cut stump removal and herbicide application

Table 19: Weed Species Targeted

19.2 Environmental Performance

Monthly weed management of all land owned or managed by TCCO has continued through the reporting period, with positive results noted through inspections.

Continuation of the current weed control program and additional attention to weed incursion in newly vegetated areas and control of *Andropogon virginicus, Eragrostis curvula, Sisymbrium officinale, Acacia saligna*, and seedling *Leptospermum laevigatum* has been recommended.

There were no reportable incidents related to weed management during the reporting period.

19.3 Further Improvements

Continue weed spraying activities on a monthly basis across TCCO leased and owned land, including throughout mine rehabilitation at the REA.

19.4 Actions for the Next Reporting Period

Tahmoor is planning to complete approximately 5 hectares of rehabilitation in 2019.

Tahmoor will update the MOP during 2019.

Rehabilitation targets are outlined in **Table 20** and **Appendix 1**.

Category	Targets for 2019 (ha)				
	Q1	Q2	Q3	Q4	Total (Target)
Disturbed	0	0	0	0	0
Levelled/Re-contoured	0	0	0	0	0
Seeded	0	0	0	5	5
Established	0	0	0	5	5

Table 20: Rehabilitation Targets

A summary of maintenance activities completed and proposed for all rehabilitated land is outlied within **Table 21**.

Nature of Treatment	Area (Ha) this reporting period	Area (Ha) next reporting period	Comments, Control Strategies, Treatment Detail
Additional erosion control (drains re-contouring, rock protection)	<1	<1	Routine improvements and maintenance to existing stormwater drainage system and erosion/sediment controls on disturbed areas.
Re-covering (detail – further topsoil, subsoil sealing, etc)	0	5	Rehabilitation Area - 300mm topsoil of the proposed area
Soil treatment (detail – fertiliser, lime, gypsum, etc)	<1	5	Rehabilitation Area – testion of soil to occur and then rates of fertiliser, gypsum and lime will be determined
Treatment management (detail – grazing, cropping, slashing, etc)	0	0	N/A
Re-seeding/planting (detail – species density, season, etc)	5	5	Rehabilitation Area – Spring rehabilitation, species and density as per the Rehabilitation and Toposil Management Procedure
Adversely affected by weeds (detail, type and treatment)	0	0	Note that the ongoing weed spraying program is conducted over approximately 80 ha of land at the REA. No areas are adversely affected by weed infestations.
Feral animal control (detail – additional fencing, trapping, baiting, etc)	0	80	Feral Cats and foxes to be trapped across site as required. Some shooting or baiting of rabbits next reporting period

Table 21: Rehabilitation Maintenance Activities for 2019

20 Community

20.1 Community Engagement Activities

Stakeholder engagement is an ongoing process which takes place throughout the life of the mining .

TCCO has previously established a good working relationship with its local community, and seeks to continue this as it establishes new projects, continues existing operations. In particular, the site focuses on providing timely and accurate information regarding its performance to its varied stakeholders.

The method of consultation used may vary depending on the scale of project, or the stakeholder type and preferred method of communication.

The following consultation methods are commonly used to identify and engage with stakeholders:

- Distribution of Residents Newsletter – email, paper mail and printed posters displayed in various locations;
- Resident Information Packs- Distributed to residents in current mining areas;
- Face to face consultation meetings – local landholders and community groups;
- 24 hour complaints line – phone number displayed on newsletter, TCCC website and distributed at face to face consultation meetings;
- Tahmoor Coal Community Consultative Meetings (TCCCC) – four (4) quarterly meetings held in 2018 (1 March, 7 June, 13 September and 6 December);
- Community Information Sessions – biannually or as required at the various locations (open to all members of the public);
- End of Panel Report – distributed to TCCCC and available on TCCC website; and
- 2017 Annual Environment Management Report – distributed to TCCCC and available on TCCC website (www.tahmoorcoal.com.au).

20.2 Community Contributions

As a significant contributor to the local community, TCCO promotes community sustainability where possible.

This is through consideration of support to charities and other non-for-profit organisations in the TCCO Community Investment Program.

20.3 Community Investment Program

In 2018 some of the major donations included:

- The Dementia Café, a safe and informal way for carers and people living with dementia to access support within the Wollondilly area. A place where they can socialise with others in a similar situation, and share their wisdom, tears and frustrations over a cup of tea or coffee.
- Picton High School- Australian Business Week (ABW) -ABW offers the opportunity for students to acquire the skills necessary to run their own company. The one week intensive program students have the opportunity to experience what it is like to run a multi-million dollar company and make decisions which have real outcomes. The program has a considerable cost for students that wish to participate therefore TCCC sponsored students for the high School to participate in the event.
- Our Community Pantry - The Pantry provides food for over 200 Families in the local area. In order to extend their opening hours and provide to an extended reach of families the Pantry required fridges and freezers. TCCC provided the Pantry with the finaical support to purchase this much needed equipment.
- Beach Bus - The Beach Bus primarily targets the 8000 young people in the LGA. Wollondilly is significantly transport disadvantaged and has a lack of free or affordable entertainment options for young people. The service enables young people to meet with or develop new friendships while undertaking a recreational activity that promotes healthy lifestyle and fitness. Ultimately, it connects the community throughout summer, providing them with an opportunity to socialise, exercise and unwind. TCCC provides the financial support to allow this bus to run during January with over 200 people using the bus in 2018.

In accordance with TCCO Community Development and Investment Protocol, all Community Investment activities, whether financial or in-kind support, should target the following group-wide focus areas:

- Community development;
- Education;
- Health; and
- Environment

An overview of TCCO during the reporting period community contributions are outlined in **Table 22**.

Category	2018 Spend
Capacity Building	$31,108.00
Health	$23,660.00
Environment	$5,000.00
Other	$41,192.00
Total	$100,960.00

Table 822: Community Contributions 2018

20.4 Community Works during Shut Down Period

During the Month of September and October 2018, TCCO was closed to operations due to ongoing investigations and repairs associated with the breakdown of the Shaft 3 winder. During this period the community was the true beneficiary, with TCCO using the opportunity to provide assistance to local initiatives, organisations and individuals.

Some of the work preformed during the shut down period included the following:

- NSW National Parks & Wildlife Service - Thirlmere Lakes National Park and Lookout road repairs, fencing, picnic furniture painting, step construction, drain construction
- Wollondilly Shire Council
    - Bargo Sports Fields – paint post & rail fencing
    - Thirlmere Playground – maintenance of playground equipment soft fall
    - Remembrance Drive – rubbish removal
    - Bridgwater Park- Clean up and mulch
- WaterNSW
    - Rubbish collection from Water catchment access roads
- Dilly Drought Drive (Wollondilly Farmers Relief & Support – Wollondilly Lions Club & Wollondilly Shire Council) (up to 8 local farms)
    - Fencing, property maintenance, timber cutting, weed removal, general farming duties
- Thirlmere Rail Museum
    - General clean up, property maintenance duties and building of new racking system
- His House Church
    - Property maintenance, install playground equipment, gardening, installing security system
- Residents properties on Stilton Lane, Picton
    - Rubbish removal from Redbank Creek, fencing, blackberry removal, general clean up duties
- Our Community Pantry
    - Replacement and rebuild of back veranda
    - Building Cool Room
    - Fencing
    - Gardening
    - General Property Maintenance
- Bargo Community Garden

- Cleaning up area
- Laying concrete slab
- Building shed
- Building garden beds

- Wollondilly Pony Club
  - Cleaning gutters
  - Cleaning up garden
  - Removing rubbish and leaf litter
- Riding for the Disabled
  - Painting
  - Cleaning Gutters
- The Oaks Scout Hall
  - Property maintenance
  - Gardening
  - Painting

20.5 Community Complaints

During the reporting period a total of 4 community complaints were received,which was well within the annual target set of less than 20 community complaints. As outlined on **Figure 8 and Table 23**, TCCO has seen a significant reduction in community compliants since 2010.

Details of all community complaints made during the reporting period are shown in **Appendix 12**.

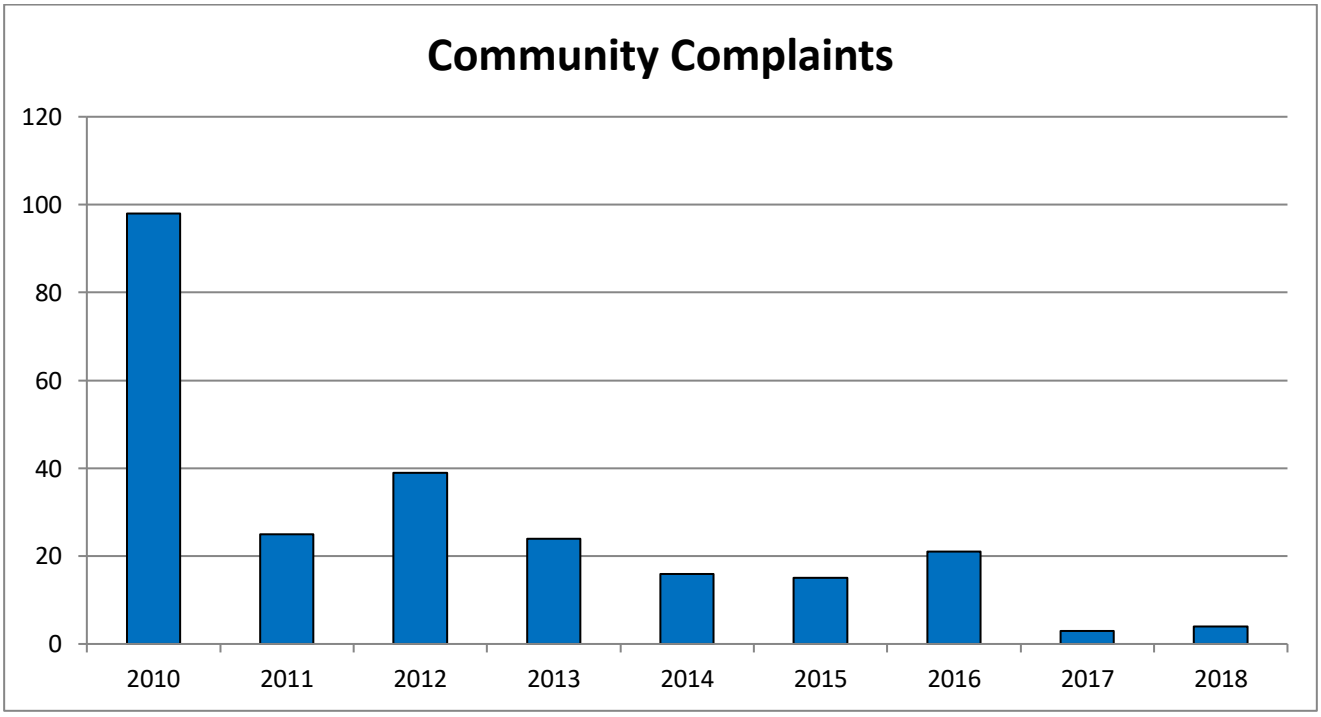

Figure 8: Community Complaint Statistics

Date	Type	Complaint Details
12 October 2018	Other	Complaint received from local developer.
26 October 2018	Air Quality	Complaint received by nearby neighbour regarding blue haze in the air. Complaint was investigated and no blue haze coming from Tahmoor Coal property.
5 November 2018	Noise	Noise complaint from Olive Lane, Bargo. Noise was regarding the ongoing low frequency humming and droning from the mine. Complaint was investigated and noise levels were within Development Consent Limits.
20 November 2018	Odour	Complaint received regarding odour from Number 2 Shaft. Ongoing discussion with the resident are occurring.

Table 23: Details of Community Compliants

21 Independent Audit

In 2017 an independent audits was conducted.

The final 2017 audit recommendations are outlined in **Table 24.**

The next independent audit is due to be conducted in 2020.

Ref	Description	Risk	Progress
DA 67/98			
	* Ensure that relevant Management plans are revised after an audit report is submitted. * Ensure relevant management plans are revised after receiving a directive (incident report) from DRG.	Low	Management Plans reviewed as required.
	a) Recommend including baseline data in the NMP and the AQGHGMP. b) Recommend including NMP statutory requirements in NMP, and including MP requirement in the NMP and the AQGHGMP. Also recommend including measures to monitor and report on the effectiveness of management measures in the NMP. e) Recommend TARP is attached the NMP & AGGHGMP, instead of being separate. g) Recommend including protocol for incidents, non-compliances and exceedances of criteria in the NMP. Also recommend on expanding on incidents, non-compliances and exceedances in the AQGHGMP. The entire Air Quality Monitoring Plan should be attached to the AQGHGMP.	Low	Plans have been combined
	* Include water quality results from previous years in future Annual Reviews. * Include comparisons against predictions of the EA for water quality in future Annual Reviews. * Provide trends for all data, not just dust, in future Annual Reviews. * Identify discrepancies between the predicted and actual impacts for water quality, in future Annual Reviews. * Progress in respect of rehabilitation completion criteria needs to be reported in future Annual Reviews. * Future Annual Reviews should report discharge volumes. in accordance with Section 7 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of the rehabilitation performance of the operation against the rehabilitation targets in the MOP in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of non-compliances in Section 11, in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include in Section 12 a timeline for implementation of measures, whether any management plans will need to be revised to reflect the measures to be implemented and any actions resulting from a condition of a relevant approval that will be triggered in the next reporting period in accordance with Section 8 of the Annual Review Guideline, dated October 2015.	Low	Included within Annual Review
DA 57/93			

Ref	Description	Risk	Progress
41, 46	* Continue to monitor grass planting trials where the survival and growth of planted grass species in areas where the existing vegetation (within revegetation areas) was sparse. * Undertake a grass seed mix trial, looking at increasing the diversity of grass seed mix in areas where groundcover is sparse. * The review of the Refuse Emplacement Area Management Plan should be completed and the Plan updated as required. The plan is now potentially out of date due tot he age. * Topsoil stockpiles resulting from future disturbance should be 3m high and be seeded with a temporary vegetation cover. * Ensure future contour drains and other water management structures at the REA are constructed in accordance with approved designs.	Low	Topsoil stockpiles have been reduced in height. REA Management Plan reviewed
EPL 1389			
	Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Additional monitoring occurring
SMP 27-30			
2,6	Ensure CMA Plan is implemented when required in the future. Implement agreed actions relating to rehabilitation of Myrtle Creek and Redbank Creek based on DRG feedback	Low	CMAP currently being implememented
9	Implement agreed actions relating to rehabilitation of Myrtle Creek and Redbank Creek based on DRG feedback	Low	CMAP currently being implememented
13	For end of panel reports and AEMR a table should be prepared comparing results observed against the performance outcomes in this table.	Low	Included within Annual Review
ML1376 and ML1539			
47, 57	*Tahmoor Underground must ensure that prior to the commencement of "second working" extraction they give three (3) months written notice to landowners.	Low	Complete
CCL716			
30	For any future topsoil stockpiles, they should be shaped to be less than 3m in height.	Low	Complete
ML1642			
2	Recommendation as per Condition L2.4 of the EPL. Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Complete

Ref	Description	Risk	Progress
5	As per overall recommendation for Annual Reviews - See Condition 45 of 1999 Development Consent. * Include water quality results from previous years in future Annual Reviews. * Include comparisons against predictions of the EA for water quality in future Annual Reviews. * Provide trends for all data, not just dust, in future Annual Reviews. Noise is also included and water pumping and usage trends * Identify discrepancies between the predicted and actual impacts for water quality, in future Annual Reviews. * Progress in respect of rehabilitation completion criteria needs to be reported in future Annual Reviews. Ecological report that is refenced throughout the report does this. This is in the appendic * Future Annual Reviews should report discharge volumes. in accordance with Section 7 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of the rehabilitation performance of the operation against the rehabilitation targets in the MOP in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of non-compliances in Section 11, in accordance with Section 8 of the Annual Review Guideline, dated October 2015. It is in section 10 * Future Annual Reviews should include in Section 12 a timeline for implementation of measures, whether any management plans will need to be revised to reflect the measures to be implemented and any actions resulting from a condition of a relevant approval that will be triggered in the next reporting period in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Additional subsidence reporting as per recommendations from DGS Report (Section 6)	Low	Included within Annual Review
18	Recommendation as per Condition L2.4 of the EPL. Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Monitoring occurred

Table 24: Actions from Independent Enviromental Audit

22 Incidents and Non-Compliances during the Reporting Period

TCCO had an Official Caution regarding a non-compliance. This related to the AEMR being submitted on the 30 March 2018 instead of the 1 March 2018. Since then the AEMR due date has been approved by the Resources Regulator to be changed to the 31 March each year to be in line with the Annual Review due date.

TCCO also received a Notice for further information with regards to the information held in the Annual Community Consultation Report for Authority 410. As a result of their investigation no non-compliance was found.

On the 22 May 2018 TCCO received the Enforceable Undertaking for the non-compliance from the 2017 inspection of the REA Drains. Works on the drains has since been completed and the Enforceable Undertaking is now in the process of being closed out.

A Notice (DI 0680 2018 ACES Ref: 0353-2016 Out17/48999) (Notice 2) was issued on 4 May 2018 with regards to rehabilitation of Redbank and Myrtle Creek. The Notice directed Tahmoor Coal to take steps to conserve the environment, protect it from harm as a result of activities under the mining leases to prevent, control or mitigate any such harm.

Specifically, Notice 2 required the following to the completed:

1 Review and update, by no later than 31 August 2018:

- The current Tahmoor Colliery Mining Operations Plan to incorporate the:
- Corrective Management Action Plan Final Revision B. Version 1, Dated 16 June 2017 Number TAHUG-2119843053-10 provided in response to 240(1)(b) Notice No. DI 0272-2016.

2 Amend and submit for approval of the Department an updated timeline providing dates the various stages for implementation of action by no later than 31 August 2018.

3 Take all reasonable steps to implement the works outlined in amended and approved timeline to remediate Myrtle Creek as per the Corrective Management Action Plan Final Revision B. Version 1, Dated 16 June 2017.

4 Plan, draft and submit for review a Corrective Management Action Plan for Redbank Creek by no later than 31 December 2018.

5 Review and update, by no later than 31 July 2019:

- The current Tahmoor Colliery Mining Operations Plan to incorporate a Corrective Management Action Plan for Redbank Creek.

Items 1 and 2 of Notice 2 were completed on 31 August 2018.

The Resources Regulator required further review and amendment to the submitted updated Myrtle Creek CMAP timeline on 5 October 2018 due to its concerns that the submitted timeline had excessive delays before any remediation works were commenced. A revised timeline was submitted on 10 October 2018 and approved by the Resources Regulator on 11 October 2018.

The Redbank Creek CMAP was prepared and submitted to the Resources Regulator on 31 December 2018 for approval.

Another non-compliance relates to the Waste Water Treatment Plant. As per PRP22 Stage 2 the Waste Water Treatment Plant was to have commissioning completed on 30 October 2018. Changes were made

by Minetek to reach this commitment, however during testing the plant failed once again. Minetek have since left the site and TCCO is reviewing strategies to complete PRP22.

A summary of all environmental incidents which occurred during the reporting period is outlined within **Table 25**.

In total there were 12 incidents, with 11 related to subsidence, , and one (1) related to malfunctioning monitoring equipment.

Date	Classification	Type	Location	Details	Action/s taken
25/01/2018	Cat 0	Subsidence event notification	Silton Lane, Tahmoor	Compression strain developed and shown in weekly ground survey of the area	Subsidence Advisory NSW notified; continued survey and inspections of area
14/02/2018	Cat 0	Monitoring equipment	Charlies Point Road, Tahmoor	Teom dust gauge was tripping power, potentially due to rain	Teom dust gauge reset. Electricians tested Teom dust gauge.
15/02/2018	Cat 0	Subsidence event notification	Survey peg ST23, Stilton Lane, Picton	Minor Increase in subsidence profile shown in weekly ground survey of Stilton Lane at ST23	Subsidence Advisory NSW notified; Continue OTDR testing and reporting on PCTN 3002 Section A (no impacts reported) by Telecommunications Engineer Colin Dove. Next inspection and testing Monday 19 February 2018. Focussed visual inspection of the dams (Figure 2) and culvert on Stilton Lane, no impacts on Telstra cables reported to date. Visual inspection completed 16 February 2018 and a visual inspection will be completed 19 February 2018.
20/03/2018	Cat 0	Subsidence event notification	Pools RB22, RR19. RR16, RB21 and RB14, Redbank Creek, Thirlmere	Draining of pools due to subsidence impacts from Longwall 31	Subsidence Advisory NSW notified; Continue photographic monitoring from same point during weekly inspection while in active subsidence zone. Ongoing consultation with DRG regarding CMAP.
28/03/2018	Cat 0	Subsidence event notification	Pools RR29 Redbank Creek, Thirlmere	Delamination of sandstone rockbar at RR29 and the pool level has started to decline due to subsidence impacts from Longwall 31	Subsidence Advisory NSW notified; Continue photographic monitoring from same point during weekly inspection while in active subsidence zone. Ongoing consultation with DRG regarding CMAP.
12/04/2018	Cat 0	Subsidence event notification	Piezometer P9, Redbank Creek, Thirlmere	The piezometer started to drop around 26/03/2018 and is in the early stage of a significant water level reduction	Subsidence Advisory NSW notified; Bimonthly logger download as outlined in Tahmoor Colliery LW31 Environmental Management Plan.
23/04/2018	Cat 0	Subsidence event notification	Stilton Lane, Picton	Subsidence impacts of house	Subsidence Advisory NSW notified; Building Inspections and reporting during active subsidence, structural assessment by Structural Engineer complete, mitigation works complete.
01/06/2018	Cat 0	Subsidence event notification	Remembrance Driveway Tahmoor	Category 3 and 4 damage	Subsidence Advisory NSW notified; Continued structural inspections by Subsidence Advisory NSW structural engineers.
02/07/2018	Cat 0	Subsidence event notification	Between pegs BG105 and BF108 of Thirlmere Carrier Pipe line and Bridge Street Thirlmere	Compressive ground strain increasing between Pegs BG105 and BG106, which cross a small tributary to Redbank Creek. Total ground strain has reached 2mm/m,	Subsidence Advisory NSW notified; ongoing surveys and inspections while in active subsidence zone. On completion of CCTV inspection of the Thirlmere Carrier pipe, further management actions will be determined by the SMG.

				related to valley closure movements.	
03/07/2018	Cat 0	Subsidence event notification	Coachwood Crescent, Picton	Subsidence impacts of house	Subsidence Advisory NSW notified; Ongoing surveys and inspections while in active subsidence zone. On completion of CCTV inspection of the Thirlmere Carrier pipe, further management actions will be determined by the SMG.
26/07/2018	Cat 0	Subsidence event notification	46m west of Pit No. 3186019 in the Thirlmere Carrier pipe, at Bridge Street	Longitudinal compression, resulting in the joint closing and the end of the pipe has been pushed into the adjacent pipe	Subsidence Advisory NSW notified; CCTV undertaken, continue weekly survey, continue twice weekly visual inspection, twice weekly manhole pit inspections.
19/12/2018	Cat 0	Subsidence event notification	Between pegs RD2 and RD27 at Remebrance Driveway, Tahmoor	Cracking and compression on road and a noticeable bump formed in pavement. Increasing ground strain reported as 1.3mm/m	Subsidence Advisory NSW notified; CCTV undertaken, increased visual inspections to twice weekly, road repaired following subsidence risk.

Table 25: Environmental Incidents

23 Activities to be Completed in the Next Reporting Period

During the next reporting period, the following activities are planned to be commenced:

- Commencement of Myrtle Creek CMAP Rehabilitation– Starting Q1 2019;
- Redesign and completion of changes to the Waste Water Treatment Plant -Q4 2019;
- Completion of the Extraction Plan for the Western Domain - April 2019;
- Mining beneath Picton Industrial Area – May 2019; and
- Mining Past Picton High School - April 2019.

No Management Plans will need to be updated to implement these measures.

Actions to be completed during the next reporting period include:

- Myrte Creek CMAP schedule and works program;
- Redbank Creek CMAP schedule and works program;
- Environmental Management Framework updated and revised;
- Notification of Extraction Plan to stakeholders and landowners in accordance with conditions of DA67/98;
- Recommissioning of WWTP in accordance with PRP22 of EPL1389; and
- Commencemnet of aquatic monitoring in accordance with PRP26 of EPL1389.

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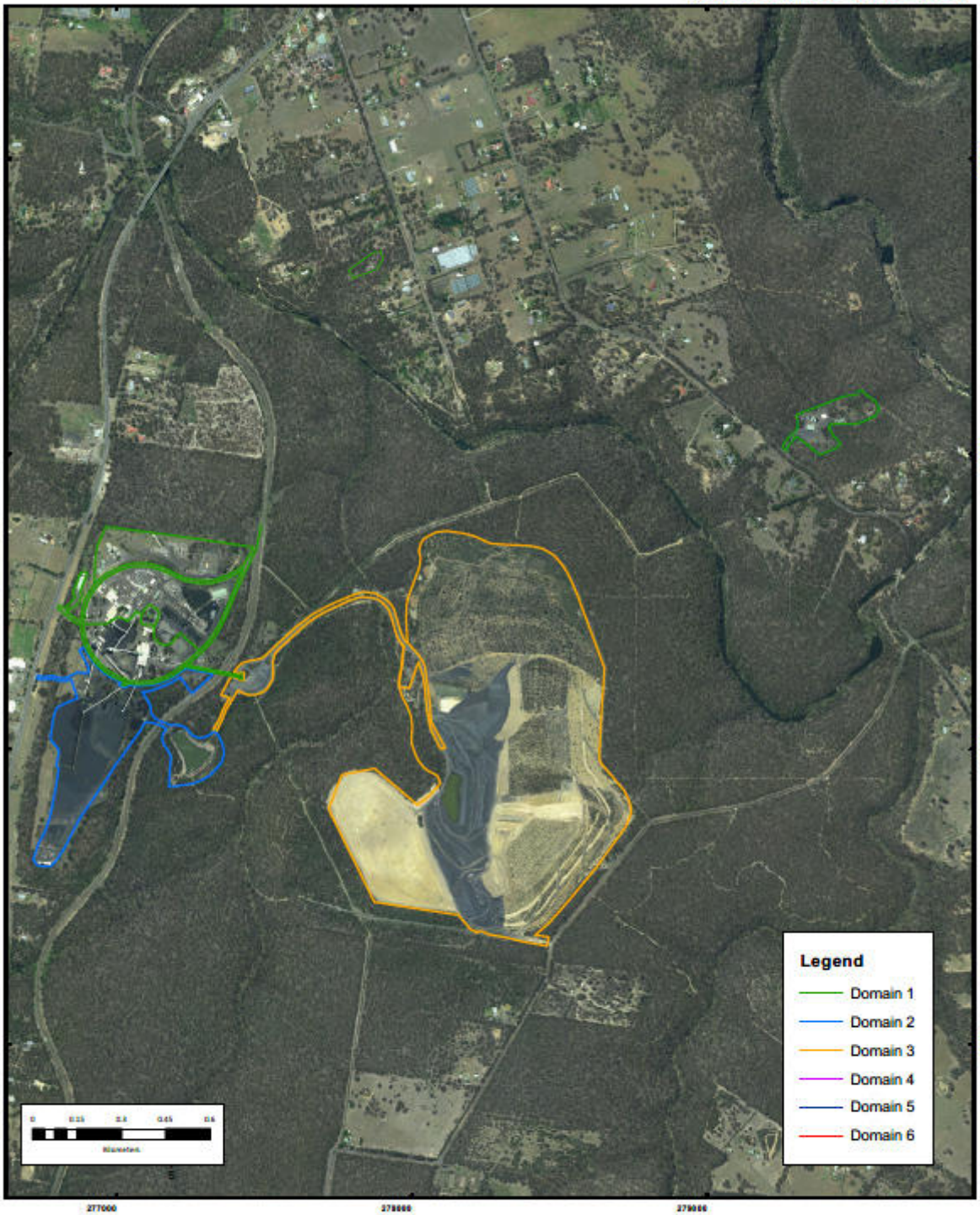
Tahmoor Coking Coal Operations
Disturbance Overview



Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994

DATA SOURCE
© Land and Property Information (2013)
© NSW DTRIS - Minerals & Petroleum (2013)
Date Created: 25/03/2019

Map Size: A4 Portrait

Ref: W:\Environment & Community\00 Arc GIS\Current\Environmental\AEMR2018\Disturbance Plan.mxd

Simec Mining

DISCLAIMER
Simec Mining makes every effort to ensure the quality of the information available on this map. Before relying on the information on this map, users should carefully evaluate its accuracy, currency, completeness and relevance for their purposes, and should obtain any appropriate professional advice relevant to their particular circumstances.
Simec Mining cannot guarantee and assumes no responsibility for the accuracy, currency or completeness of the information and by using this map you accept that Simec Mining has no liability for any loss or damage in any form whatsoever caused directly or indirectly from the use of this map.

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Noise M7
Noise M6
Noise M5
Noise M8
Noise M9
Noise M3
Noise M4
Noise M2
Noise M1
Noise M10
0
280
560
840
1,120
Meters
6209000
6208000
6207000
6206000
276000
277000
278000
279000
280000

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Year	Site	Assessment Goal L10	Estimated Contribution Q1 (L10)	Estimated Contribution Q2 (L10)	Estimated Contribution Q3 (L10)	Estimated Contribution Q4 (L10)	Description	Residential Property?
2014	**M1**	-	<45/6	<48	<48	<48	Remembrance Drive (Service Station)	No
2015			<52	<50	<46	54/5		No
2016			<50	<50	<55	<45		No
2017			53/4	50/1	54/5	53/4		No
2018			48/9	50/1	<45	<45		No
2014	**M2**	-	46/7	47	<60	47	Remembrance Drive (School entrance road)	No
2015			<53	<54	<47	55/6		No
2016			<50	<50	<50	<46		No
2017			53/4	55/7	56/7	52/3		No
2018			48/9	50/1	<45	<46		No
2014	**M3**	45	<44	<47	<45	<42	Olive Lane (End of cul-de-sac)	Yes
2015			<48**	<47	<42	44/5		Yes
2016			44/5	<40	<45	<45*		Yes
2017			<45**	<47**	<47	<45*		Yes
2018			<47***	<47**	<44	<47***		Yes
2014	**M4**	-	<45	<49	<47	<45	Olive Lane/Remembrance Drive Intersection	No
2015			<48	<53	<47	47/8		No
2016			<45	<40	<45	<46		No
2017			<48	<50	<50	<50		No
2018			<45	<50	<50	<48		No
2014	**M5**	45	<40	<40	<47	<40	Remembrance Drive (Service Station)	Yes
2015			<40	<46	<42	<42		Yes
2016			<40	<40	<45	<45*		Yes
2017			<45**	<45**	<45	<40		Yes
2018			<35	<35	<45	<40		Yes

2014	**M6**	45 (37)	<35 (<35)	<43 (<35)	<38 (<35)	<30	Stratford Road	Yes
2015			<30	40/1 (-)	40/1 (-)	39/40 (-)		Yes
2016			<35 (<35)	<35 (<35)	<35 (<35)	<40* (<35)		Yes
2017			<40** (<35)	<40** (<35)	<40 (<35)	<40 (<35)		Yes
2018			<35	<37	<40	<40**		Yes
2014	**M7**	45 (37)	<35	<35	<35	<30	Hodgson Grove (End of cul-de-sac)	Yes
2015			<30	35/6 (-)	<35	<30 (-)		Yes
2016			<30 (-)	<30 (-)	<30 (-)	<35* (-)		Yes
2017			<35** (<35)	<35** (<35)	<35 (<35)	<35 (<35)		Yes
2018			<35	<35	<35	<35		Yes
2014	**M8**	45 (37)	<35	<35	<35	<32	Rockford Road	Yes
2015			<33	32/3 (-)	<34	<35 (-)		Yes
2016			<33 (-)	<30 (-)	<30 (-)	<40* (<35)		Yes
2017			<35** (<35)	<35** (<35)	<37** (<35)	<37* (<35)		Yes
2018			<35	<35	<35	<40		Yes
2014	**M9**	45 (37)	<35	<35	<35	<30	Kammer Place (End of cul-de-sac)	Yes
2015			<30	<30 (-)	<30 (-)	<30 (-)		Yes
2016			<30 (-)	<30 (-)	<30 (-)	<35* (<35)		Yes
2017			<35** (<35)	<35** (<35)	<35** (<35)	<35 (<35)		Yes
2018			<35	<35	<35	<35		Yes
2014	**M10**	-	<35 (<35)	<36 (<35)	<32 (<35)	<30	Charlies Point Road	No
2015			<30	<30	<6	<35		No
2016			<30	<35	<35	<35		No
2017			<45	<45	<35	<35		No
2018			<35	<35	<35	<35		No

NOTES: *Includes +2dB correction for low frequency / ***Includes +5dB correction for low frequency / ( ) Noise Assessment Goal for refuse placement

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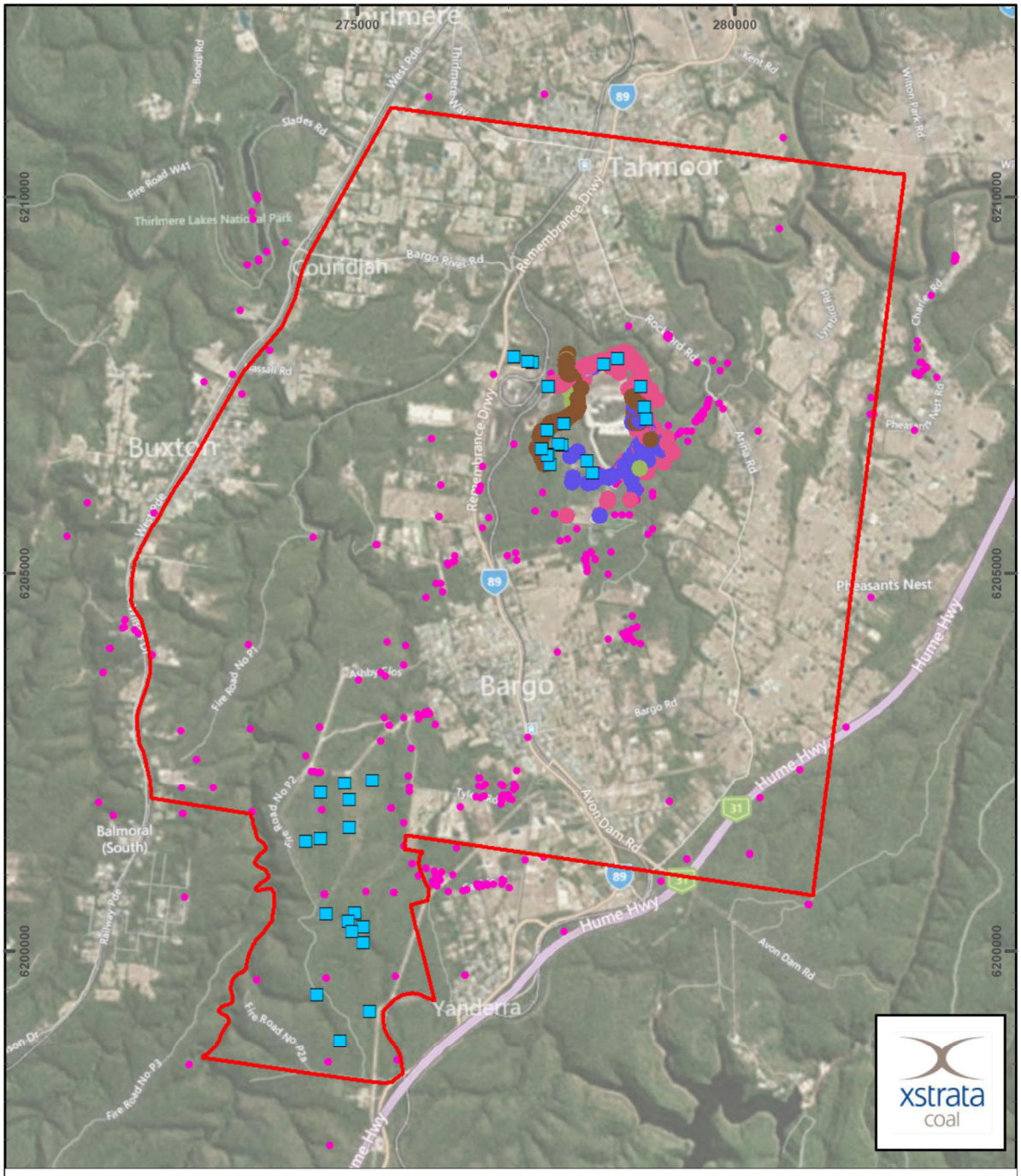


CCL747 - CCL716 Lease Area

BioBanking Plots

Threatened flora located during field survey

Epacris purpurascens var. purpurascens

Grevillea parviflora ssp. parviflora

Persoonia bargoensis

Persoonia glaucescens

Pomaderris brunnea

Previously recorded threatened fauna (8 March 2013)

Tahmoor Coal Survey - Threatened Flora

Drawn by: RJ

Project Mgr: NW

Date: 8/03/2013

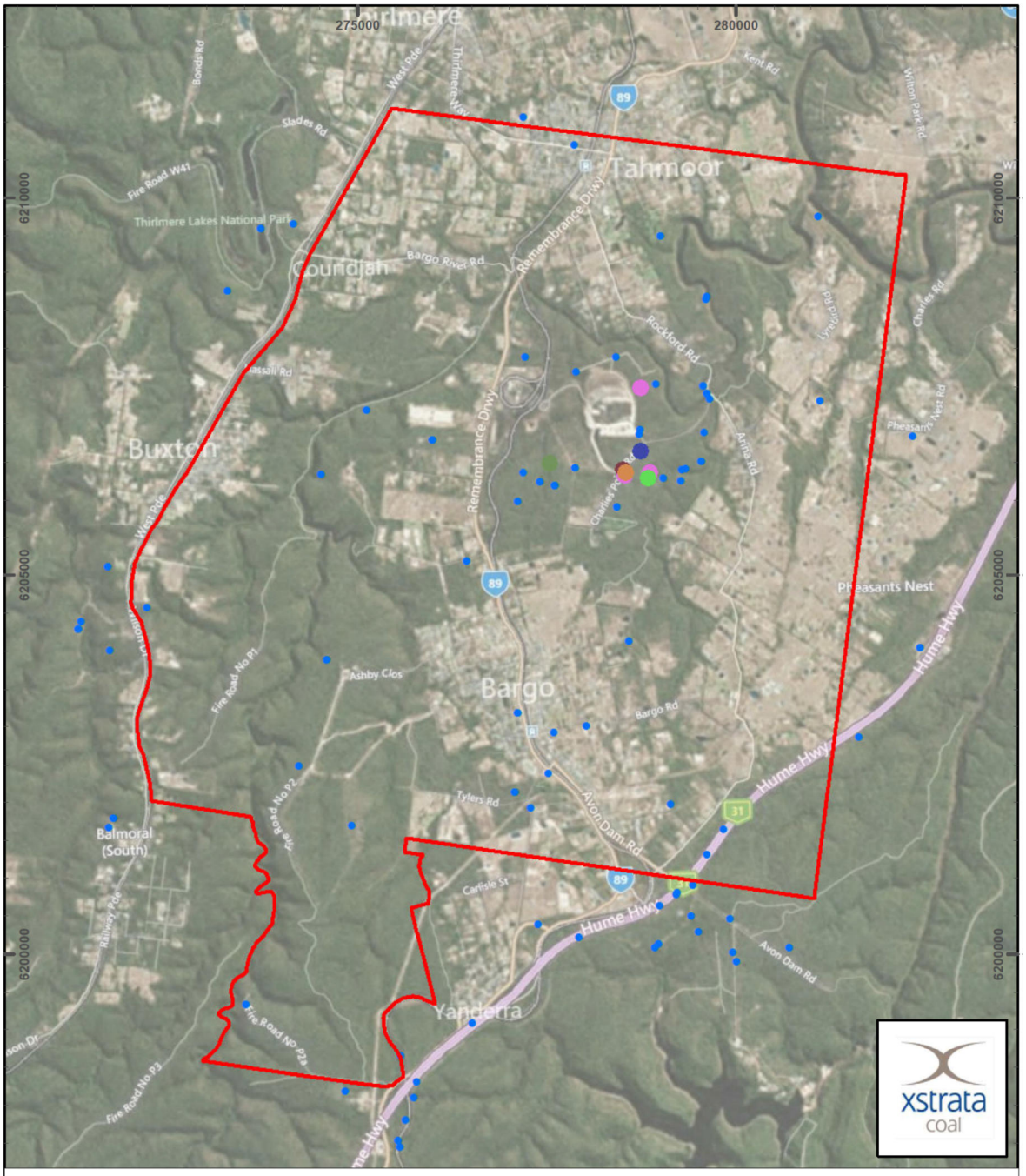
N W E S

km 0 1 2

Imagery: (c) 2010 Microsoft and its data suppliers

Horizontal Datum: GDA 1994 MGA Zone 56

niche Environment and Heritage



CCL747 - CCL716 Lease Area

Threatened fauna located during field survey

- East Coast Freetail Bat
- Eastern Bent-wing Bat
- Eastern Cave Bat
- Eastern False Pipistrelle
- Large-footed Myotis
- Little Eagle
- Powerful Owl

Previously recorded threatened fauna (8 March 2013)

Tahmoor Coal Survey - Threatened Fauna

Drawn by: RJ

Project Mgr: NW

Date: 8/03/2013

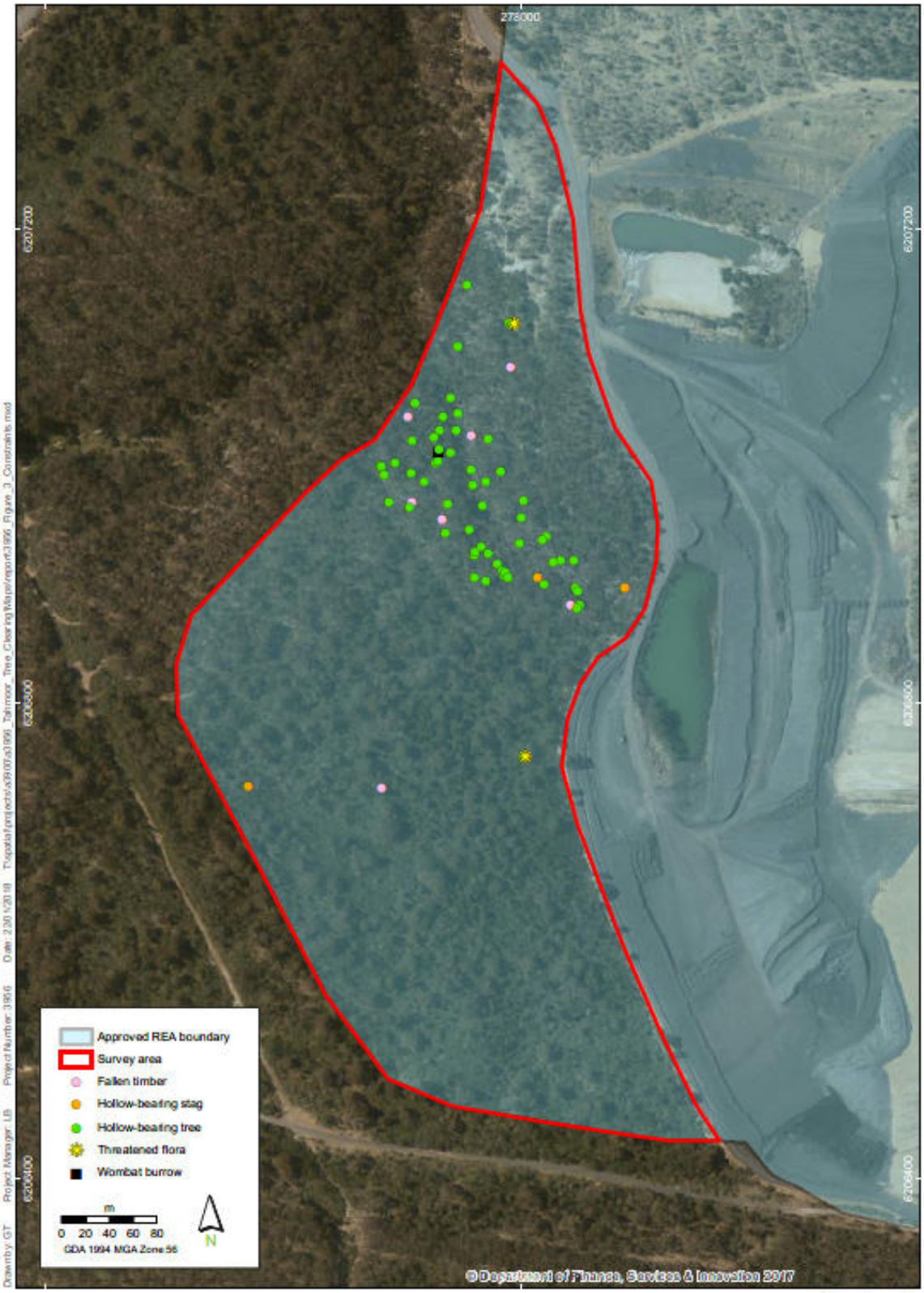
N W E S

km 0 1 2

Imagery: (c) 2010 Microsoft and its data suppliers

Horizontal Datum: GDA 1994 MGA Zone 56

niche Environment and Heritage



Constraints

Tahmoor Coal REA Approved Vegetation Clearing Inspection

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Water Storage Name	Estimated Water Volume		Capacity	Comments
	Beginning 2018	End 2018		
M5	1.0ML	1.0ML	3.0ML	First settling dam for No.2 Shaft site area. (stormwater)
M6	0.5ML	0.5ML	4.5ML	Second settling dam for No.2 Shaft site area. (stormwater)
S4	10.0ML	20.0ML	36.9ML	This dam is designed to act as a retention basin with a controlled outlet. Discharges via Overflow Point 4.
S8	0.15ML	0.3ML	0.45ML	Dam in reject area. Pumps to S9 dam. Discharges via Overflow Point 5.
S9	0.15ML	0.15ML	0.4ML	Silt trap only for sealed haul road. Wet well pumps to S4 dam. Discharges via Overflow Point 3.
Tank No.1	250kL	250kL	250kL	Underground potable water supply.
Tank No.2	250kL	250kL	250kL	Underground potable water supply.
M1	1.8ML	1.8ML	1.8 ML	M series dams act together to treat mine water pumped from underground and stormwater, discharge via LDP1
M2	0.5ML	0.5ML	0.5ML	
M3	9.0ML	9.0ML	9.0ML	
M4	8.0ML	8.0ML	8.0ML	
S1	0ML	0ML	14.5ML	The coking coal stockpile acts as a retention basin during major storms. Discharges to S2 dam. Stockpile dams are kept full and are used to supply water used for dust suppression. Discharges to S4 dam.
S2 / S3	7.9ML	8.3 ML	8.3 ML	
S5	0.01 ML	0.01 ML	0.5 ML	Silt trap only, discharges to dam S6.
S6	1.3ML	0.5ML	1.5 ML	This dam is designed to act as a retention basin with a controlled outlet.
S7a	12Ml	12ML	12.0ML	These dams are designed to act as retention basins with a controlled outlet to S7 Dam.
S7b	1ML	0.5ML	1.0ML	
S7	8ML	5ML	41.5ML	This is the main catchment for runoff from the REA. The dam is a retention basin during peak rainfall. All water is pumped to Dam S4.
Sewage Maturation Pond 1	590kL	590kL	590kL	Treated effluent overflows to M1 dam.
Sewage Maturation Pond 2	590kL	590kL	590kL	

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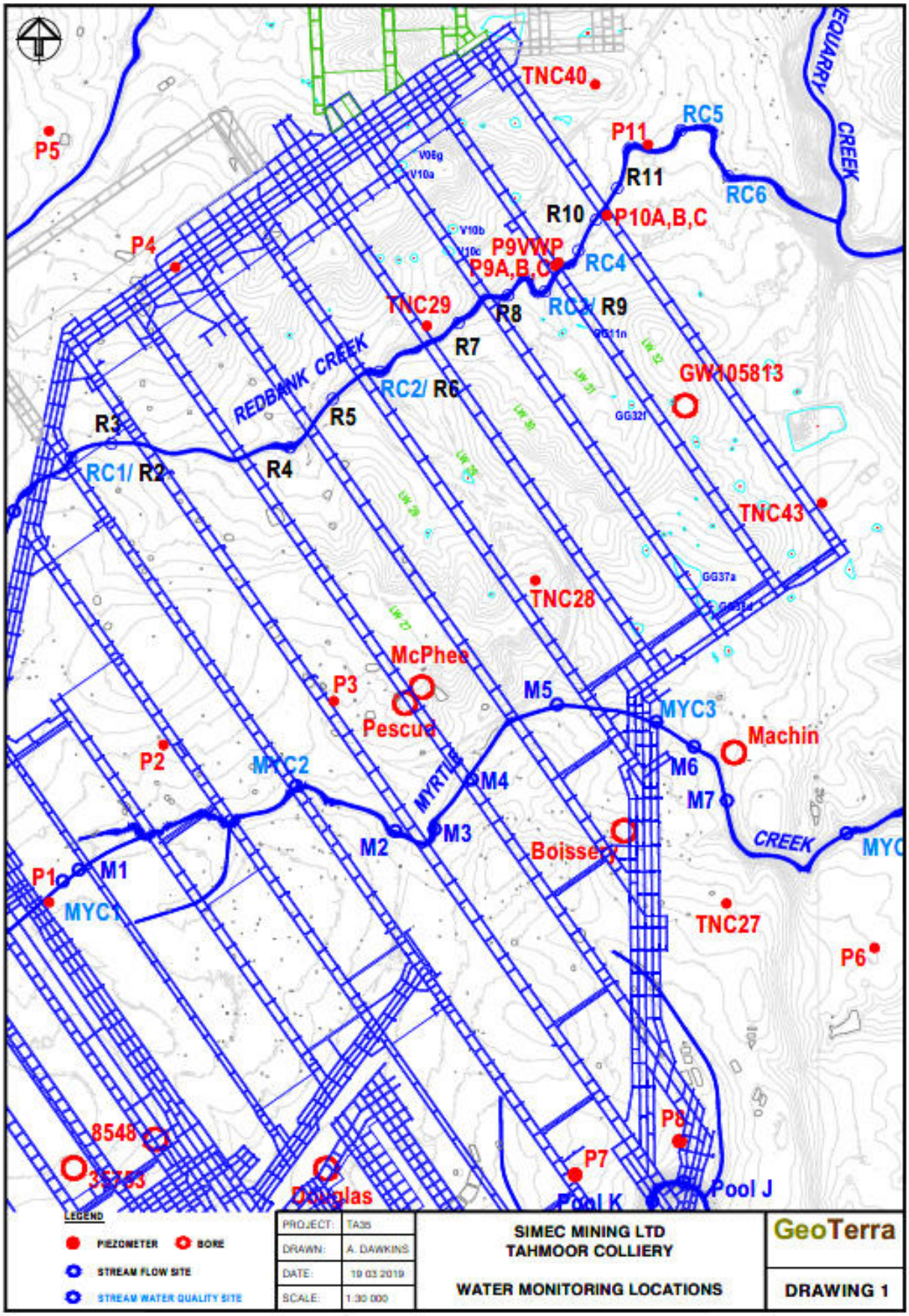
TNC40
P5
P11
RC5
R11
RC6
R10
P10A,B,C
P4
P9VWP
P9A,B,C
RC4
TNC29
R8
RC3/ R9
R7
REDBANK CREEK
RC2/ R6
GW105813
R3
R5
RC1/ R2
R4
TNC43
TNC28
McPhee
P3
M5
MYC3
Machin
Pescud
P2
MYC2
M6
M4
M7
M2
M3
Boissery
P1
M1
MYC1
TNC27
P6
P8
8548
P7
Douglas
Pool K
Pool J
LEGEND
PIEZOMETER
BORE
STREAM FLOW SITE
STREAM WATER QUALITY SITE
PROJECT: TA35
DRAWN: A. DAWKINS
DATE: 19 03 2019
SCALE: 1:30 000
SIMEC MINING LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS
GeoTerra
DRAWING 1

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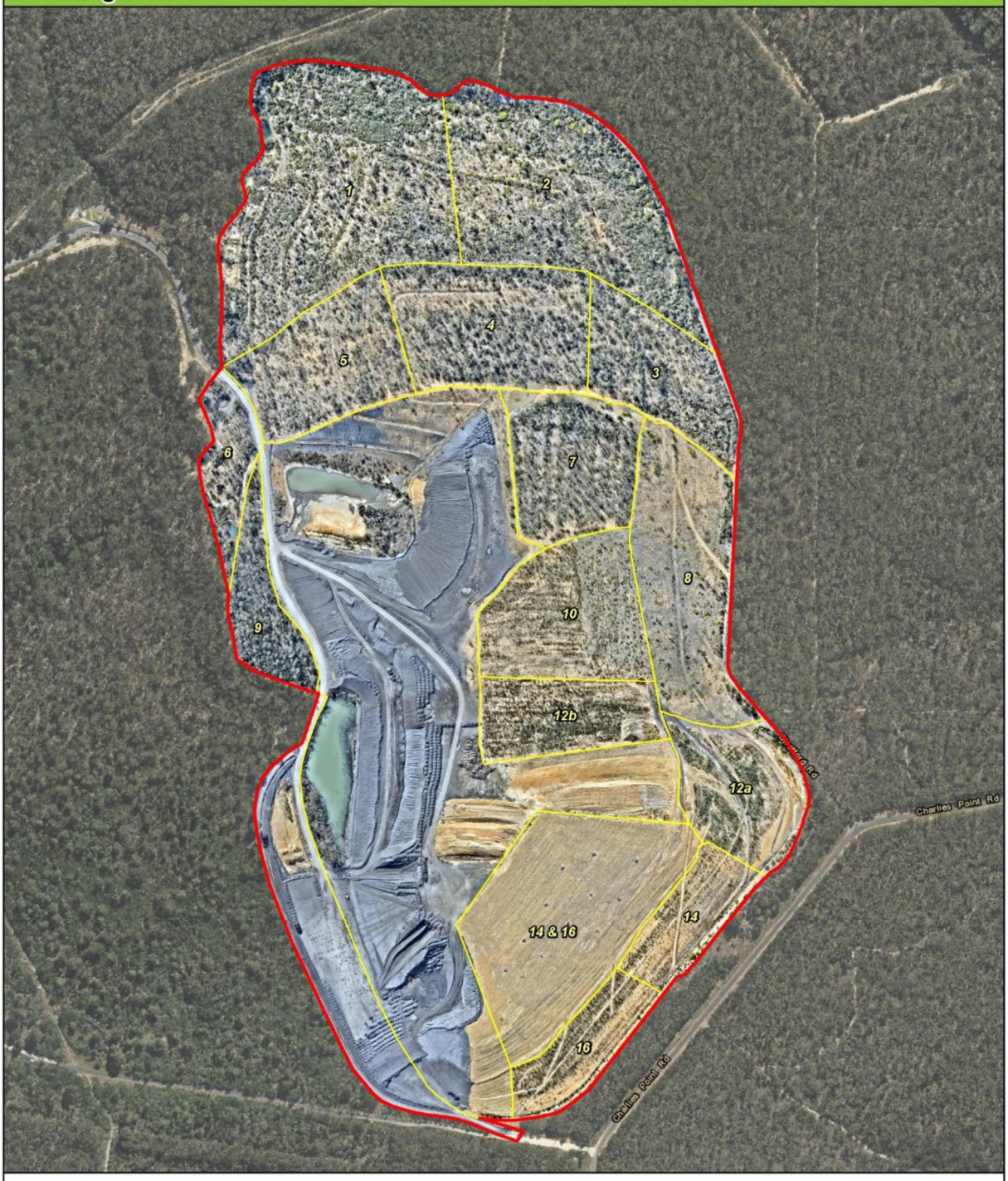
REA Stages



Legend

- Refuse Emplacement Area
- Stage Boundaries (2016)

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 56

N

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www.ecoaus.com.au

Prepared by: NK Date: 27/10/2016

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Date	Type	Complaint Details
12 October 2018	Other	Complaint received from local developer.
26 October 2018	Air Quality	Complaint received by nearby neighbour regarding blue haze in the air. Complaint was investigated and no blue haze coming from Tahmoor Coal property.
5 November 2018	Noise	Noise complaint from Olive Lane, Bargo. Noise was regarding the ongoing low frequency humming and droning from the mine. Complaint was investigated and noise levels were within Development Consent Limits.
20 November 2018	Odour	Complaint received regarding odour from Number 2 Shaft. Ongoing discussion with the resident are occurring.

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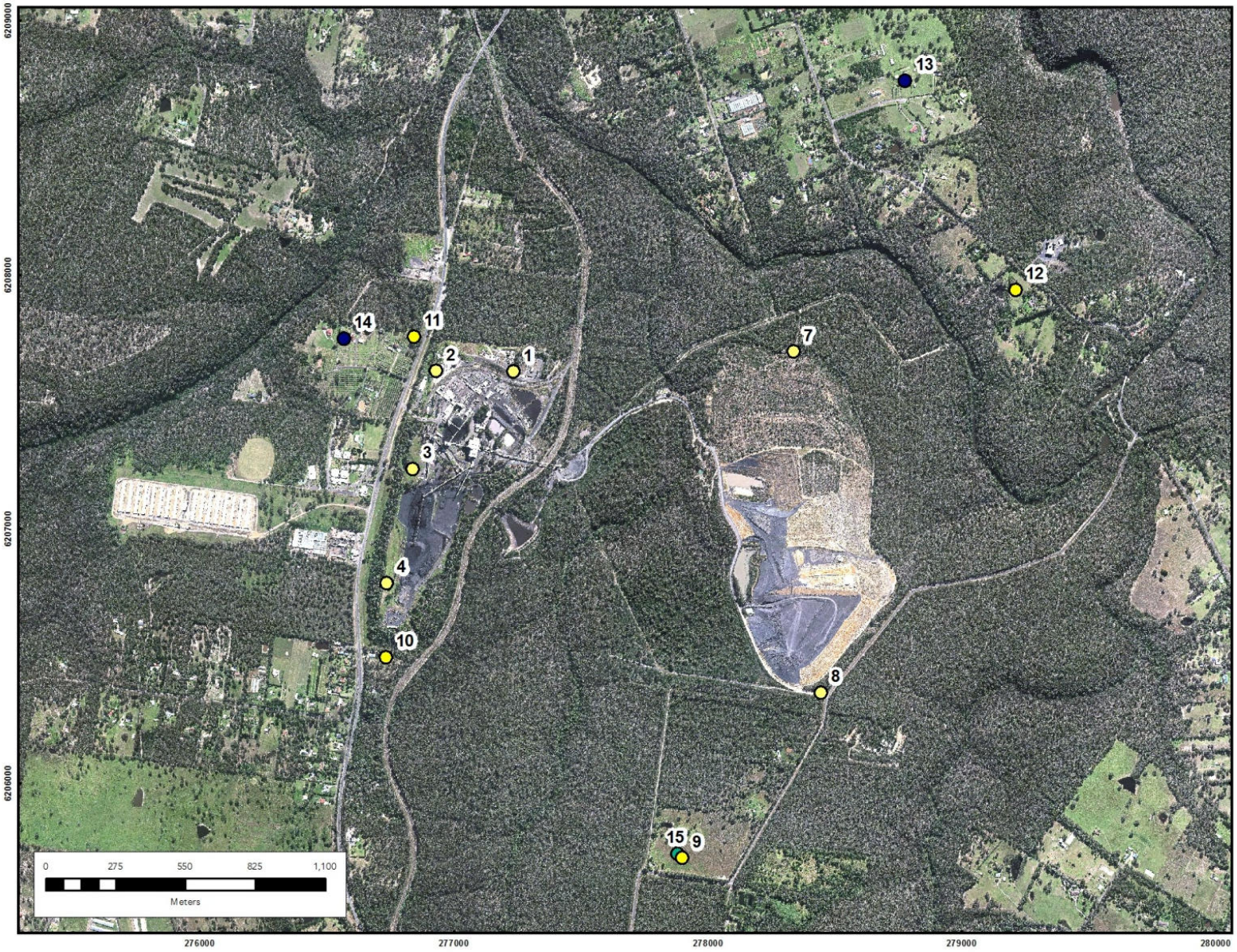
6209000
6208000
6207000
6206000
276000
277000
278000
279000
280000
13
12
14
11
2
1
7
3
4
10
8
15
9
0
275
550
825
1,100
Meters

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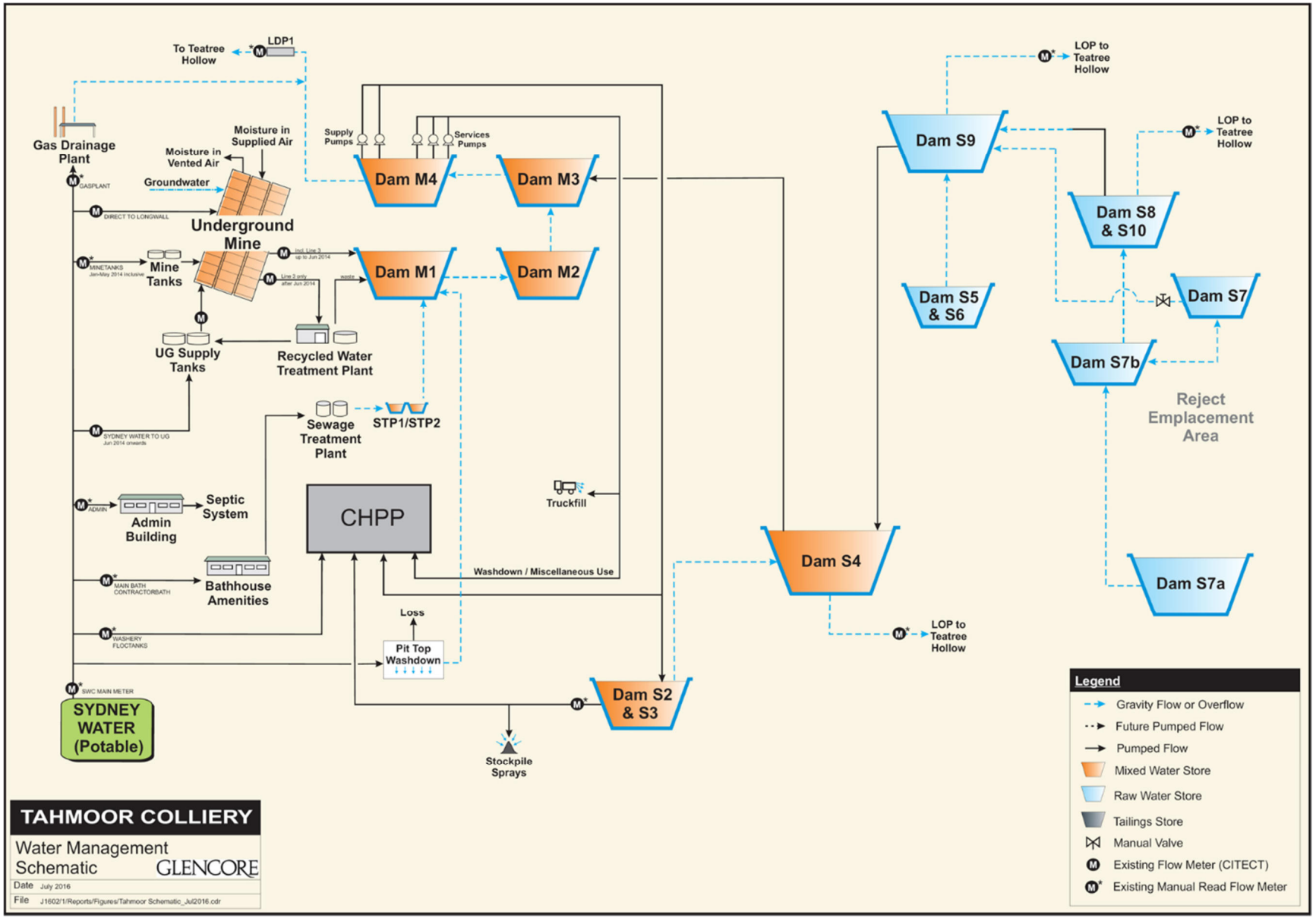
To Teatree Hollow
LDP1
Gas Drainage Plant
GASPLANT
Moisture in Vented Air
Moisture in Supplied Air
Groundwater
DIRECT TO LONGWALL
Underground Mine
MINETANKS Jan-May 2014 inclusive
Mine Tanks
Incl. Line 3 up to Jun 2014
Line 3 only after Jun 2014
waste
UG Supply Tanks
Recycled Water Treatment Plant
SYDNEY WATER TO UG Jun 2014 onwards
Sewage Treatment Plant
STP1/STP2
ADMIN
Admin Building
Septic System
MAIN BATH CONTRACTORBATH
Bathhouse Amenities
WASHERY FLOCTANKS
SWC MAIN METER
SYDNEY WATER (Potable)
Supply Pumps
Services Pumps
Dam M4
Dam M3
Dam M1
Dam M2
CHPP
Truckfill
Washdown / Miscellaneous Use
Loss
Pit Top Washdown
Stockpile Sprays
Dam S2 & S3
Dam S4
LOP to Teatree Hollow
Dam S9
LOP to Teatree Hollow
Dam S8 & S10
Dam S5 & S6
Dam S7
Dam S7b
Reject Emplacement Area
Dam S7a
Legend
Gravity Flow or Overflow
Future Pumped Flow
Pumped Flow
Mixed Water Store
Raw Water Store
Tailings Store
Manual Valve
Existing Flow Meter (CITECT)
Existing Manual Read Flow Meter
TAHMOOR COLLIERY
Water Management Schematic
GLENCORE
Date July 2016
File J1602/1/Reports/Figures/Tahmoor Schematic_Jul2016.cdr

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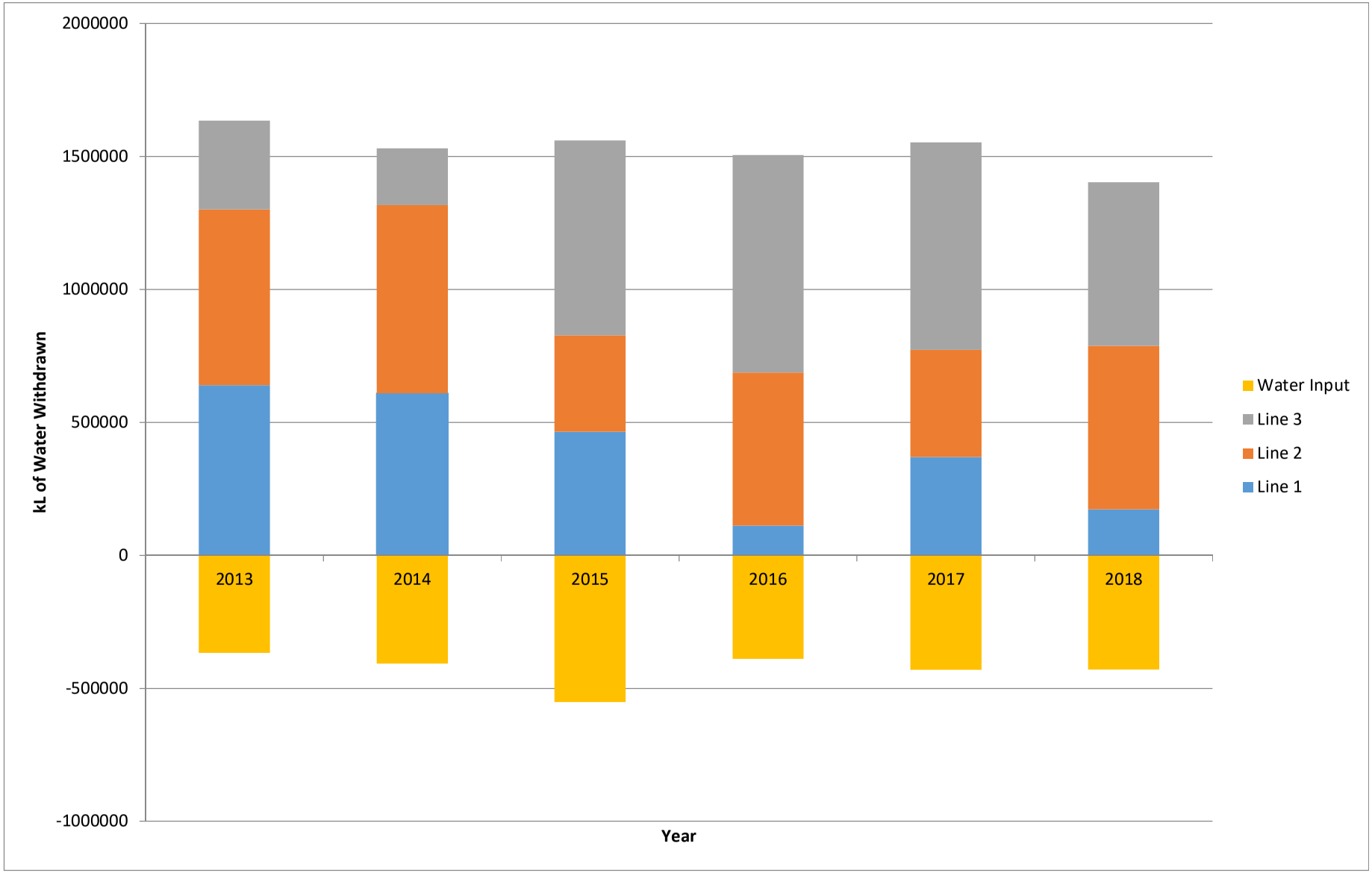
2000000
1500000
1000000
500000
0
-500000
-1000000
kL of Water Withdrawn
2013
2014
2015
2016
2017
2018
Year
Water Input
Line 3
Line 2
Line 1

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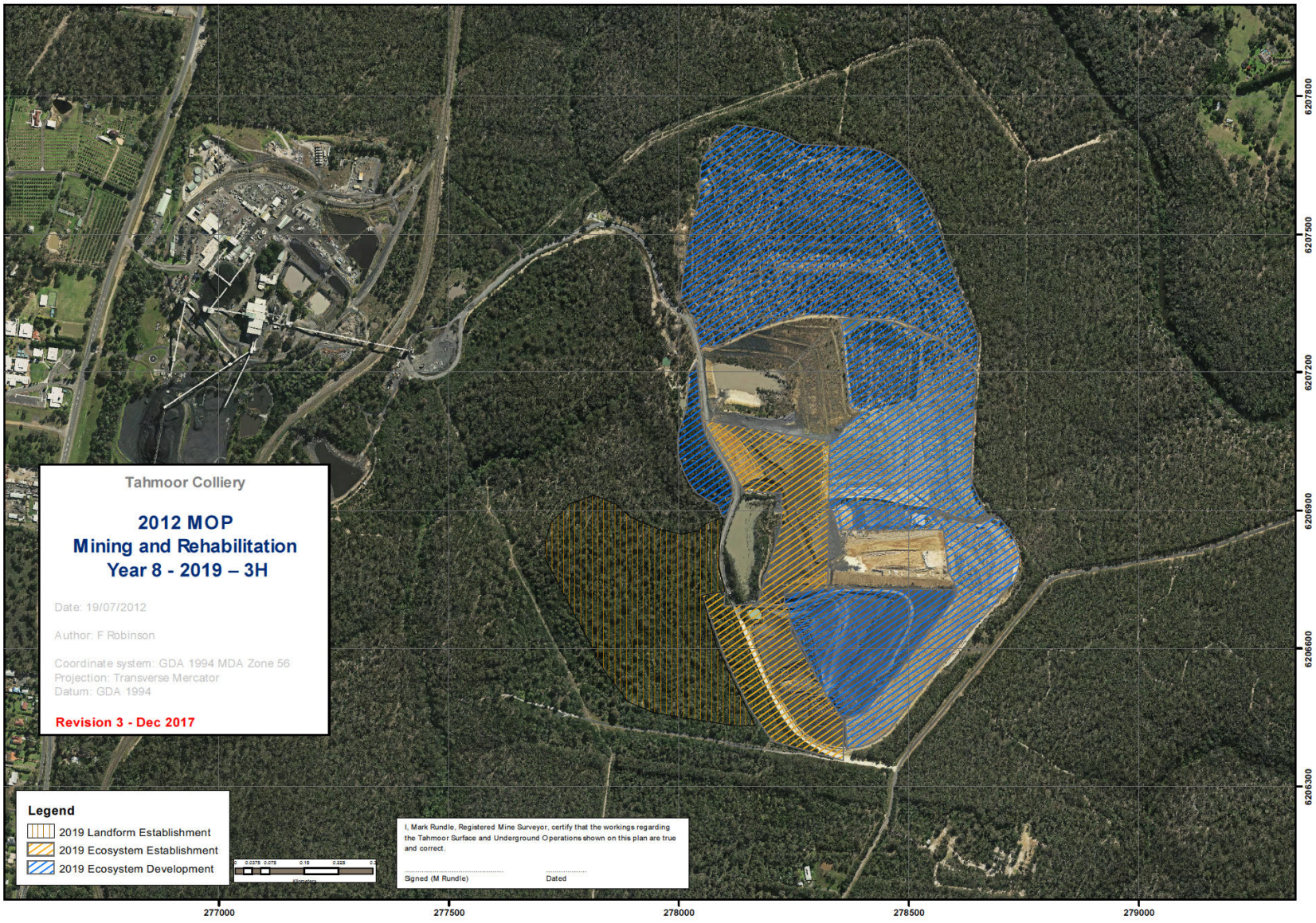
Tahmoor Colliery
2012 MOP
Mining and Rehabilitation
Year 8 - 2019 – 3H
Date: 19/07/2012
Author: F Robinson
Coordinate system: GDA 1994 MDA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Revision 3 - Dec 2017
Legend
2019 Landform Establishment
2019 Ecosystem Establishment
2019 Ecosystem Development
I, Mark Rundle, Registered Mine Surveyor, certify that the workings regarding the Tahmoor Surface and Underground Operations shown on this plan are true and correct.
Signed (M Rundle)
Dated
6207800
6207500
6207200
6206900
6206600
6206300
277000
277500
278000
278500
279000

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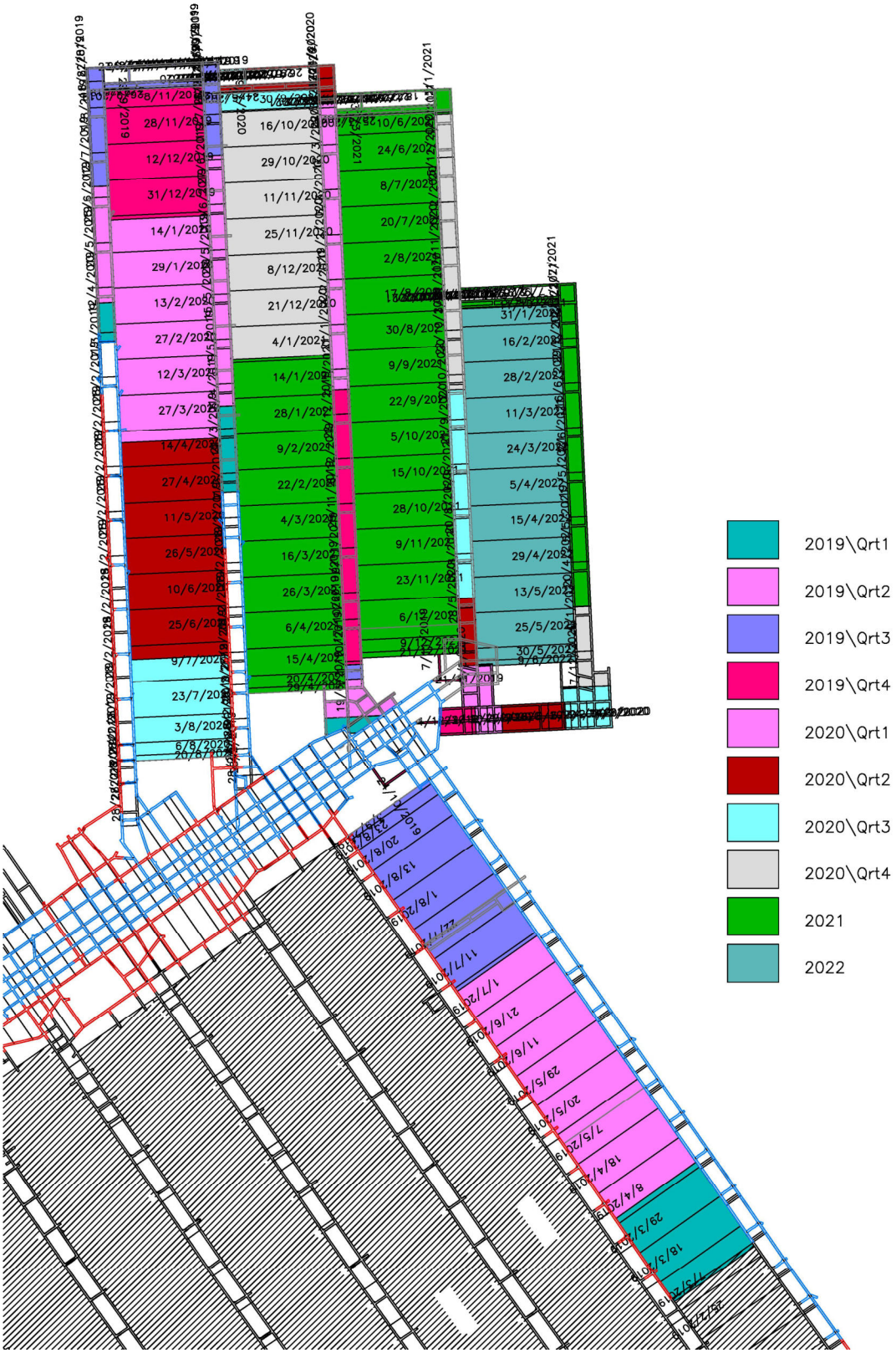
2019\Qrt1
2019\Qrt2
2019\Qrt3
2019\Qrt4
2020\Qrt1
2020\Qrt2
2020\Qrt3
2020\Qrt4
2021
2022

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Tahmoor Colliery Rehabilitation Monitoring 2018

Tahmoor Coal Pty Ltd

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A TETRA TECH COMPANY

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DOCUMENT TRACKING

Project Name	Tahmoor Colliery Rehabilitation Monitoring 2018
Project Number	18SYD 11467
Project Manager	Toni Frecker
Prepared by	Mike Lawrie and Toni Frecker
Reviewed by	Meredith Henderson
Approved by	Meredith Henderson
Status	**Final**
Version Number	**V2**
Last saved on	**28 March 2019**

This report should be cited as 'Eco Logical Australia 2018. *Tahmoor Colliery Rehabilitation Monitoring 2018*. Prepared for Tahmoor Coal Pty Ltd.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Fiona Robinson, Tahmoor Coking Coal

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Template 2.8.1

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2.2 Monitoring results in 2018 6

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Abbreviations

Abbreviation	Description
ELA	Eco Logical Australia Pty Ltd
GCAA	Glencore Coal Assets Australia
MOP	Tahmoor Colliery Mine Operations Plan 2012 - 2019 (XCN 2012)
OGM	Organic Growth Medium
REA	Refuse Emplacement Area

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1. Introduction

In 2018, rehabilitation monitoring was carried out by Eco Logical Australia in accordance with the Tahmoor EMS-MGP-002 Biodiversity and Land Management Plan and GCAA CAA HSEC PRO 0010 11.16 Completion Criteria and Rehabilitation Monitoring guidelines which require both:

- an annual walkover inspection of all areas within the Refuse Emplacement Area (REA) where rehabilitation activities have been completed including newly established revegetation
- monitoring of permanent monitoring sites within each mine closure Domain. Within the REA (closure Domain 3) permanent plots have been established within each development stage to assess revegetation progress.

These guidelines state:

"The objective of this monitoring is to evaluate progress of rehabilitation towards fulfilling long term land use objectives, such as the development towards a self-sustaining ecosystem."

Rehabilitation of vegetation within the REA has been carried out since 1993 as each stage of the refuse emplacement was constructed. The permanent monitoring sites program began in 2010 with the initial establishment of two permanent plots within each existing section of the REA and two analogue plots established within relatively undisturbed native vegetation nearby. In addition to these initial plots, further plots were established in areas greater than four hectares to address the recommendations for native vegetation monitoring provided in CAA HSEC PRO 0010 11.16 Completion Criteria and Rehabilitation Monitoring. In future, in accordance with monitoring guidelines, additional permanent plots will be installed as each area of revegetation within the REA reaches an age of 5 years from planting.

Monitoring of permanent sites in the rehabilitation areas provides information regarding changes in both vegetation growth, senescence, colonisation and species diversity. In addition, indication of the success of the rehabilitation is gained through comparison of both vegetation structure and species composition with the analogue sites monitored in nearby bushland. Methods for measuring these values include detailed species counts and cover within 2 m x 2 m plots and species diversity, canopy cover, growth rates, reproductive potential and progress within a 20 m x 10 m plot. Photographic monitoring of plots is also implemented.

The walkover inspection records details across each stage and includes information on the following factors

- evidence of soil profile development and visual assessment of surface materials
- evidence of erosion and stability and function of erosion and sediment control structures
- growth rates and evidence of plant mortality or dieback
- species diversity including identification of target species
- presence of over-storey, mid-storey and understorey species
- evidence of reproductive potential
- evidence of biological nutrient cycling
- occurrence of potholing or slumping and evidence of spontaneous combustion

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- evidence of contamination or other limitations to vegetative establishment.

Native grass species have been trialled in areas where the existing vegetation within established revegetation areas was sparse. These grass planting trials were monitored to review the survival and growth of planted species.

2. Results

2.1 Monitoring results prior to 2018

Revegetation across the REA was highly variable with some sections approximately 20 years old and others newly established with seeding carried out in the last 12 months. The native species included in the revegetation mix also varies, in both diversity and structural representation, between those areas revegetated prior to 2006 and those revegetated more recently.

Characteristics of sections revegetated prior to 2006 include:

- canopy species including *Eucalyptus* species, *Angophora* species and *Allocasuarina littoralis* providing cover ranging from good to limited, heights up to 10 m and exhibiting good growth. Second generation *Allocasuarina littoralis* were common near mature plants, with other canopy species second generation plants beginning to appear.
- smaller tree species including *Acacia decurrens and Acacia binervia* were also regenerating with second generation individuals present
- a midstorey that varied from dense stands of *Kunzea ambigua* (Tick Bush) or the non-local species *Leptospermum laevigatum* (Coast Teatree) to scattered *Acacia* species interspersed with other less abundant native species.
- highly effective weed control actions reduced weed cover where extensive stands of the weed *Andropogon virginicus* (Whiskey Grass) and smaller populations of *Eragrostis curvula* (African Lovegrass) were present and excluded all other species. Weed cover generally low with weed control providing good on-going results.
- increasing colonisation by native grasses with cover increasing annually in most areas, including where exotic grasses have been controlled.
- vegetation that was dominated by *Acacia* species, many of which are senescent or in some sections mixed native vegetation that is not representative of the local native plant communities. Senescent Accacias becoming less common.
- good species diversity including target species; however many species had a low abundance.
- all species exhibited signs of good reproduction potential including the threatened species, *Persoonia bargoensis* and *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea).

Characteristics of sections revegetated in 2007 (Stage 8)

- originally planted with pasture species as a stabiliser, and was still dominated by exotic grasses in 2016
- trial of reseeding using the soil amelioration product OMG proved not suitable for the REA
- very limited cover by native species, both target and non-target
- scattered patches of native grasses with good cover prior to 2017.

Characteristics of sections revegetated post 2010 are:

- generally good germination rates on level areas with species from all strata represented
- germination more variable on slopes but still adequate
- growth rates moderate to very good

- limited weed populations.

2.2 Monitoring results in 2018

Erosion control structures have been rock lined to further control erosion on the slopes of the REA. These structures have led to reduces levels of erosion, however minor gully erosion is present in limited areas. Only minor works are required to rectify this erosion.

An area in Stage 1 where seepage was affecting vegetation growth has been rehabilitated with the ripping of the soil surface and mulching.

The grass trials ground cover persists, although herbivory remains a limitation to the reproductive potential of the grasses. Sub-shrubs have colonised sections within the grass trial area in some instances.

Stage 8 has been revegetated by direct seeding, and germination rates are not assessable as yet.

Vegetation quality, structure and diversity were observed during monitoring with no significant change in the past 12 months. There has been a significant dry period since the last monitoring which has affected primarily the two lower strata. Generally, additional characteristics and changes that were noted include

- adequate growth in all canopy species including juveniles and seedlings
- senescent mature Acacias becoming less common with many already fallen creating habitat for both fauna and regenerating native species. However, senescence amongst the mid storey Acacia is more prevalent in 2018
- some death in all mid storey species including *Hakea* sp., possibly resulting from the drought conditions experienced in 2018
- weed cover was low overall, with current management practises proving effective
- growth rates overall are adequate in newly established revegetation
- number of target species recorded in all revegetation areas consistent with 2017 levels
- signs of a rabbit population observed
- minor gully erosion evident, however erosion control adequate with remediation on-going
- herbivory of planted grasses in grass trials reducing reproductive potential of grass species.

Table 1 provides further details of the monitoring results from 2018 in comparison with results from earlier years and recommendations.

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Table 1: Key monitoring results

Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 20017	Results from survey 2018	Recommendations
Soil profile development	Highly variable and developing in the older stages of rehabilitation around leaf and grass litter, fallen timber, native grass clumps, and newer revegetation in rip lines.	Development recorded in rip lines and areas with high leaf litter. Cover with grass litter low due to dry conditions.	Infill planting with native grass tubestock in areas of limited groundcover. Slash grasses following seeding to provide additional organic litter where cover is good and increase in rainfall.
Evidence of erosion	Isolated areas of minor gully erosion, rill and sheet wash have been recorded. Remediation works carried out at several locations. Additional drains installed to direct stormwater and addressing erosion in new rehabilitation area.	Stormwater drains in some sections have been rock lined to provide better erosion control. Limited minor gully erosion present.	Repair areas of minor gully erosion with minor works.
Native plant species diversity	Species diversity has increased since monitoring began, with an increase in groundcover species seen in areas of weed control within the early revegetation areas. Native herbs and forbs are more abundant in areas where native grasses are colonising. The midstorey is dominated by *Acacia* spp., but also includes *Dodonaea* spp*., Persoonia* spp*., Kunzea ambigua and Cassinia* sp*.* Groundcover species diversity is good with herbs, sedges, lilies and grasses all represented, however many species have low abundance.	Native species diversity remains consistent with 2016 levels overall allowing for a dry season and decrease in species diversity in undisturbed bushland. *Acacia* diversity reduced with senescence in some shrub species. The number of target species (i.e. those consistent with analogue sites and nearby native vegetation) within each monitoring plot remains adequate to good. Species diversity in canopy species adequate on average in most REA stages, however some sections have more limited diversity. Midstorey species diversity more limited.	Maintain weed control program with particular attention to avoiding off-target damage. Re-assess diversity following non-drought conditions.

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Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 20017	Results from survey 2018	Recommendations
Native plant cover (overstorey, midstorey, groundcover)	Native cover is highly variable within all strata across the REA and, with some small areas devoid of vegetation. Canopy cover varies from good to very low, with much of the revegetation too young to provide a meaningful measurement. Sub-shrub cover is more limited with a number of species failing to reach maturity. Groundcover varies within the established revegetation areas from 100% to 0%. Colonisation by grasses and groundcover species is patchy, but improving slowly.	Native plant cover remains variable across the REA, with groundcover varying greatly and some areas devoid of groundcover species. Otherwise, native plant cover is increasing at a slow rate. Colonisation by groundcover species including grasses and sedges delayed by dry conditions In more recent revegetation areas, native cover is consistent with high numbers of juvenile canopy species.	Infilling with native grass tubestock. Further protection of these plantings from herbivory is to be considered. Strategies to manage these grassy swards to increase soil organic matter would be beneficial. Maintain weed control program. Monitor rabbit population Planting of canopy tubestock or brush mulching with canopy species (other than *Acacia* species) in sections with no canopy species. Any additional tubestock planting will require irrigation for 6 months to ensure establishment.
Native plant growth rates and regeneration	Canopy species growth is adequate and is consistent with the growth rates determined in the undisturbed nearby native vegetation. Second generation canopy species are prevalent in the earlier revegetation areas. Many *Acacia parramattensis* are senescent or have died and fallen. Some species (particularly sub shrubs) failing to thrive to maturity, possibly due to selective herbivory by rabbits. Native grasses are regenerating and spreading in some sections strongly.	Growth rates are variable in newly established revegetation areas. Growth rates are generally better in those areas with low slope, indicating moisture availability is limiting growth on steeper sections. The growth rate in canopy species remains consistent. Senescent *Acacia* midstorey species are present across the REA. Growth rates, other than that of sub-shrubs, are adequate but variable. Second generation recruitment in this stratum is greatest in *Acacia* species, with recruitment in other species increasing slowly. Spread of grass species delayed by dry conditions.	Maintain monitoring annually to detect impact of other factors other than drought conditions

Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 20017	Results from survey 2018	Recommendations
Threatened Flora	Two threatened species have been observed within the rehabilitation areas, *Grevillea parviflora* subsp. *parviflora* and *Persoonia bargoensis*	The population of *Grevillea parviflora* subsp. *parviflora* is stable. The population of *Persoonia bargoensis* is increasing with numerous seedlings recorded within areas of early revegetation and along the No 2 shaft 11kV power line.	Continue to monitor. Weed control in the vicinity of these species to be carried out by hand.
Weed occurrences and cover	Weed densities were highly variable across the REA. Heavy infestations of *Andropogon virginicus* (Whiskey Grass) and smaller populations of *Eragrostis curvula* (African Lovegrass), *Sisymbrium officinale* (Hedge Mustard) and *Nassella trichotoma* (Serrated Tussock) were observed within the early rehabilitated areas in the north of the REA prior to 2010. Weed control programs were instigated with strong results. *Andropogon virginicus* and *Eragrostis curvula* continued to be present in isolated patches within the REA. *Cenchrus setaceus* (Fountain Grass) colonised the slopes of Stage 5 in 2017.	Overall weed cover is low, with most weed species only represented by scattered individual plants. One plant of *Nassella trichotoma* (Serrated Tussock) was observed. *Cenchrus setaceus* (Fountain Grass) continues to spread on the slopes of Stage 5, although control efforts are evident. The population of Hedge Mustard has increased over the last 12 months.	Maintain weed monitoring and weed control program overall. Care to avoid off-target damage during weed control works is to be considered. Control *Cenchrus setaceus* (Fountain Grass) by slashing prior to seed set in summer and spot spraying. Follow up is required for this species.

Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 20017	Results from survey 2018	Recommendations
Non-local native species	Non-local native species are common within those sections of the REA which were revegetated prior to 2000 and are uncommon elsewhere. *Leptospermum laevigatum* is the most abundant non-local native species and is colonising strongly outside the original area of planting. *Acacia saligna* (Western Australian golden wattle) was recorded as both mature trees and juveniles and had the potential to spread and inhibit colonisation by local native species. This species was controlled across the REA prior to November 2016. Most other species within this category are present in limited numbers and populations are not increasing.	*Leptospermum laevigatum* remains abundant within the oldest revegetation area with scattered individuals beyond stages 1 and 2. These species have not been included in more recent seedings for revegetation within the REA.	Control the spread of *Leptospermum laevigatum* by controlling seedlings outside stages 1 and 2. Maintain monitoring for *Acacia saligna* and an appropriate weed control program.
Feral fauna	Evidence of significant rabbit population. Herbivory by this species was considered to be impacting on the success of revegetation by the selective removal of some species. Rabbit population limited in 2017.	Rabbit numbers appear to have increased.	Rabbit control programme desirable in conjunction with neighbouring properties. Consultation with Local Land Services advisable.

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Eco Logical Australia 2017a. *Tahmoor Colliery Rehabilitation Monitoring 2017 – Mine Closure Domains 1 – 5. Permanent Sites*. Prepared for Tahmoor Coal Pty Ltd

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APPENDIX 15

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Tahmoor Coking Coal Operations - Longwall 31

End of Panel Subsidence Monitoring Report for Longwall 31

DOCUMENT REGISTER

Revision	Description	Author	Date
A	First issue	DJK	Mar-19

Report produced for:- Compliance with conditions attached to the SMP Approval set by DTIRIS.

Associated reports:-

MSEC (2014). Tahmoor Colliery Longwalls 31 to 37 - Subsidence Predictions and Impact Assessments for Natural and Built Features in support of the SMP Application. (Report MSEC647, Revision A, December 2014), prepared by Mine Subsidence Engineering Consultants.

MSEC909-R01 to MSEC909-R34 – Subsidence Monitoring Reports, issued during the extraction of Longwall 31 between August 2017 and October 2018.

MSEC910-R02 to MSEC910-R67 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 31 between July 2017 and October 2018.

GeoTerra (2019). Longwall 31 Surface Water, Dams & Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA31-R1, March 2019.

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Drawings

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

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MSEC1001-01	Monitoring Lines	A
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1.0 INTRODUCTION

This report has been prepared by Mine Subsidence Engineering Consultants (MSEC) for Tahmoor Coking Coal Operations to comply with conditions of the SMP Approval for Tahmoor Colliery Longwall 31 dated 3 May 2017.

This report includes:-

- A summary of the subsidence and environmental monitoring results for Longwall 31,
- An analysis of these results against the relevant impact assessment criteria, monitoring results from previous panels and predictions provided in the SMP application,
- The identification of any trends in the monitoring results, and
- A description of actions that were taken to ensure adequate management of any potential subsidence impacts.

The location of Longwall 31 is shown in Drawing No. MSEC1001-01, which together with all other drawings, is attached in Appendix B at the back of this report.

This report also includes many of the movements and impacts observed during the extraction of Longwalls 22 to 30. Note that Longwall 24B was extracted prior to Longwall 24A. The dates of extraction for all longwalls are provided in Table 1.1.

Table 1.1 Start and Finish Dates for Longwalls 22 to 31

Longwall	Start Date	Completion Date
Longwall 22	31 May 2004	27 July 2005
Longwall 23A	13 September 2005	21 February 2006
Longwall 23B	22 March 2006	26 August 2006
Longwall 24B	14 October 2006	2 October 2007
Longwall 24A	15 November 2007	19 July 2008
Longwall 25	22 August 2008	21 February 2011
Longwall 26	30 March 2011	15 October 2012
Longwall 27	8 November 2012	10 April 2014
Longwall 28	24 April 2014	1 May 2015
Longwall 29	29 May 2015	18 April 2016
Longwall 30	20 June 2016	15 June 2017
Longwall 31	28 June 2017	17 August 2018

The predicted movements and impacts resulting from the extraction of Longwall 31 were provided in Report No. MSEC647 (2014, Revision A). The comparisons provided here are based on the subsidence predictions provided in this report.

Longwall 31 was approximately 2,450 metres long and 283 metres wide, rib to rib. The pillar width was approximately 39 metres, rib to rib. The depth of cover over the panel varied from 450 metres to 500 metres. The seam thickness over the panel was approximately 2.1 metres.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 31. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 31.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 31.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 31 and compares these with the MSEC assessed impacts. The reported impacts on surface water are provided in other reports.

Appendices A and B include figures and drawings associated with this report.

2.1.1. Comparison between Observed and Predicted Maximum Subsidence Parameters

Maximum observed incremental and total subsidence parameters during or after the mining of Longwall 31 are shown in Table 2.1. The maximum values do not include parameters observed in creeks, which are discussed separately in this report.

Table 2.1 Summary of Maximum Incremental and Total Subsidence Parameters due to the mining of Longwall 31 (beyond creeks)

Monitoring Line	Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Comp. Strain (mm/m)
Incremental due to LW31 only	803	8.2	1.8	-3.3
Total after LW31	1070	8.2	4.6	-4.5

The maximum observed incremental subsidence was greater than predicted maximum incremental subsidence for Longwall 31, which was 725 mm. The difference is within 15% of the prediction, which is within the typical range of accuracy.

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 31 are summarised in Table 2.2. The maximum value for each parameter (not including creeks) is highlighted in yellow.

Table 2.2 Summary of Maximum Subsidence Parameters along Monitoring Lines

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
Remembrance Drive	LW31 Inc	52	0.8	0.4	-0.6
Bollard Place	LW31 Inc	8	0.2	0.1	-0.3
Thirlmere Way	LW31 Inc	26	0.3	0.4	-0.5
Thirlmere Carrier (East)	LW31 Inc	11	0.3	0.4	-0.8
Optical Fibre Line	LW31 Inc	473	1.9	0.9	-0.7
	Total	1070	4.8	1.7	-4.5
Stilton Lane	LW31 Inc	803	8.2	1.8	-2.3
	Total	838	8.2	1.9	-2.4
Main Southern Railway (2D) (incl. creek)	LW31 Inc	791	7.1	1.3	-2.5
	Total	1051	6.9	2.4	-9.5
Bridge St	LW31 Inc	742	5.6	0.9	-3.3
	Total	970	6.3	4.6	-1.2
Redbank Place	LW31 Inc	94	0.7	0.3	-0.2
	Total	93	0.5	0.5	-0.4
Thirlmere Carrier	LW31 Inc	117	0.5	0.4	-0.3
	Total	823	3.2	1.1	-1.1

2.1.2. Observed Subsidence during the extraction of Longwall 31

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 31.

In summary, there is generally a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area.

The extraction of longwalls at Tahmoor Coking Coal Operations has generally resulted in mine subsidence movements that were typical of those observed at other collieries in the Southern Coalfield of NSW at comparable depths of cover.

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27. Monitoring during the mining of Longwalls 28 to 31 has found that subsidence behaviour has returned to normal levels.

2.1.3. Analysis of Measured Strain

A distribution of the observed incremental tensile and compressive strains along monitoring lines from the extraction of Longwall 31, for survey bays located directly above goaf, is shown in Fig. 2.1. In the cases where the survey bays were measured a number of times during mining, the maximum tensile strain and the maximum compressive strain for each survey bay were used in these distributions.

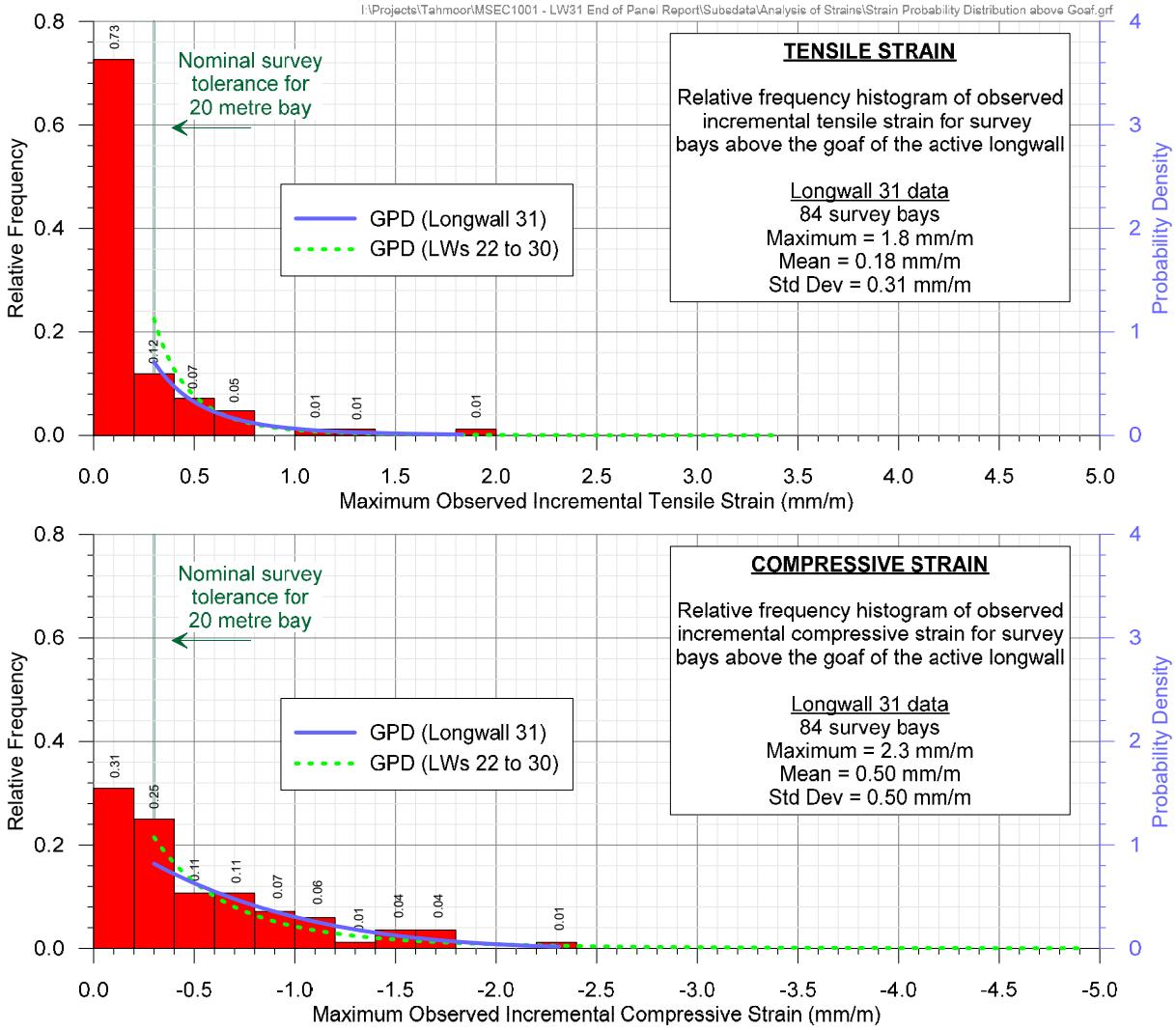


Fig. 2.1 Observed Incremental Strain for Survey Bays above Goaf resulting from the Extraction of Longwall 31

A *Generalised Pareto Distribution (GPD)* has been fitted to the raw strain data for Longwall 31, as shown in blue.

The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 30 are also shown in this figure, as dashed green lines. It can be seen from these comparisons, that the overall distribution of tensile and compressive strain resulting from the extraction of Longwall 31 was similar to that observed during the mining of Longwalls 22 to 30.

2.2. Identification of Non-Systematic Subsidence Movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.2. The locations were selected based on ground monitoring results or observed impacts that appear to have been caused by non-systematic movement. A total of approximately 55 locations (not including valleys) have been identified over the extracted Longwalls 22 to 31, of which 1 new location was observed during the mining of Longwall 31.

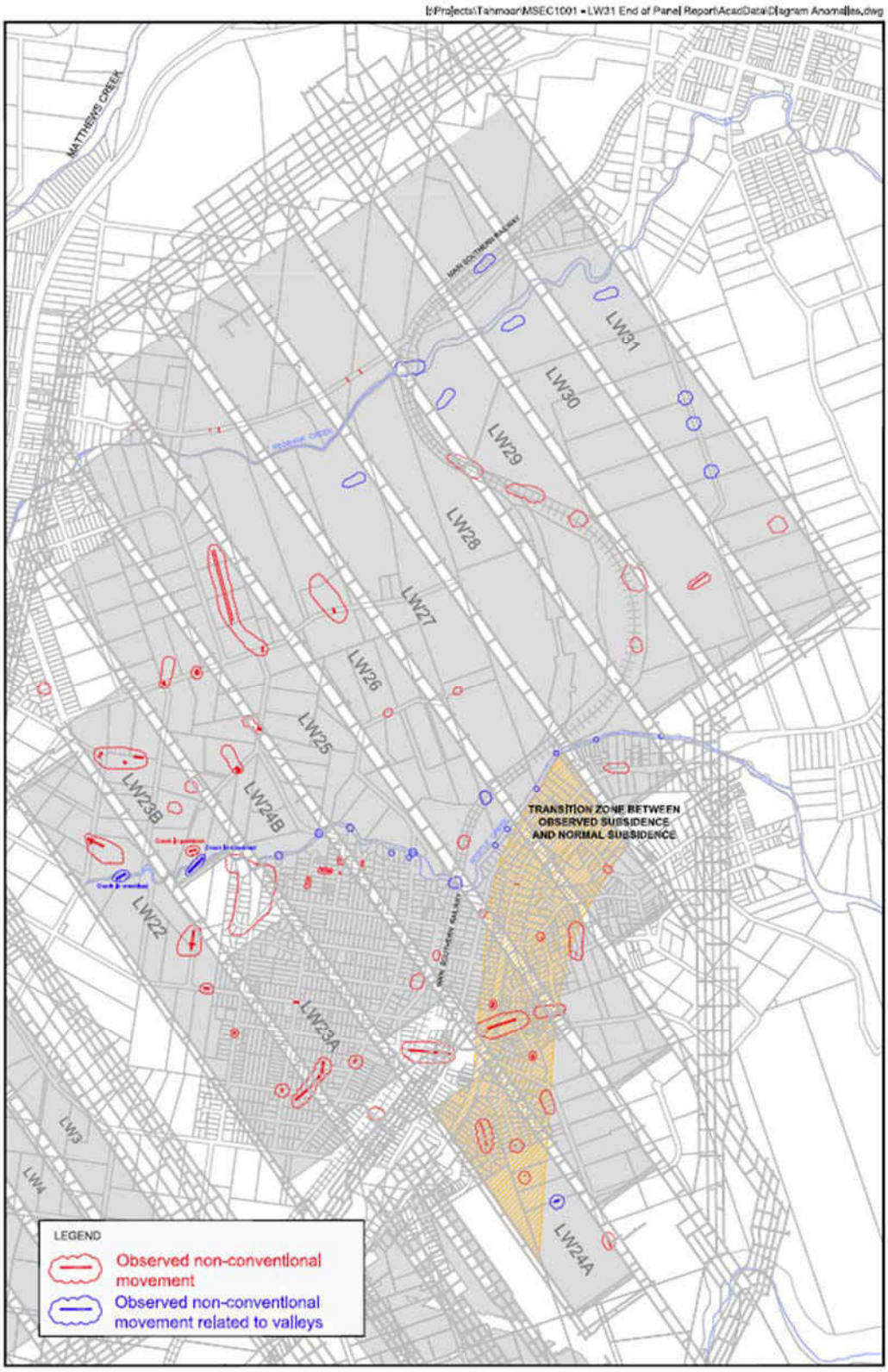


Fig. 2.2 Map of Locations of Potential Non-Systematic Movements

Monitoring lines were surveyed where non-systematic movement was identified. A summary of non-systematic movements at these locations is provided below in Table 2.3.

Table 2.3 Locations of New Identified Non-Systematic Movements during Longwall 31

Monitoring Line or Location	Maximum Change in Vertical Alignment during LW31 (mm)	Maximum Incremental Strain during LW31 (mm/m)	Type	Impacts on Surface Features
Main Southern Railway at 90.660 km to 90.680 km	13 mm over 40 m bay	-2.4	Valley closure	Increase in crack widths in brick arch culvert at outlet. The cracks were inspected by a structural engineer. Integrity of culvert was maintained.
Main Southern Railway at 90.680 km to 90.700 km	5 mm over 40 m bay	-2.5	Valley closure	
Stilton Lane No. 95 Stilton Lane	-	-	Non-conventional movement	Substantial impacts on northern part of house.
Stilton Lane Pegs ST8 to ST11	20 mm over 44 m bay	-1.7	Valley closure	No impacts
Stilton Lane Pegs ST18 to ST19	45 mm over 43 m bay	-1.7	Valley closure	No impacts
Stilton Lane Pegs ST23 to ST24	113 mm over 47 m bay	-2.3	Valley closure	Bump in road pavement near Peg ST25
Bridge Street Pegs BG105 to BG106	19 mm over 45 m bay	-3.3	Valley closure	Impacts observed to Sydney Water's Thirlmere Carrier Pipe and local road. Reversal of grade observed to Thirlmere Carrier Pipe over short, 23m bay length where upsidence observed. Joints observed closed with compressive cracks in pipework, with no leakage observed. Cracks and compressive humps observed along side of road pavement. Compressive hump across pavement at old joint line where sewer crosses the road, which was patched. Cracks in width and extent in the culvert pipes and joints and concrete headwall.

Valley closure movements were also observed across Redbank Creek and its tributaries, and the results of these surveys are discussed in following sections of this report.

Changes in vertical alignment have been calculated by measuring the difference in subsidence between each peg and average subsidence of the adjacent two pegs. The calculations quantify the small 'bumps' that are observed in the subsidence profiles.

2.3. Redbank Creek

Ground surveys were undertaken in relative 3D from Bridge Street to a monitoring line that is located in cleared pasture land along the top of the valley, as shown in Fig. 2.3. This has provided measurements of total valley closure. Some survey pegs have been installed along a fence line on the southern side to a point where surveyors can sight a survey peg on Bridge Street. Despite the best efforts of the survey team, the accuracy of the survey is challenged by the lack of cross lines across Redbank Creek. Baseline monitoring indicates that the valley closure measurements were accurate to approximately 20 to 30 mm.

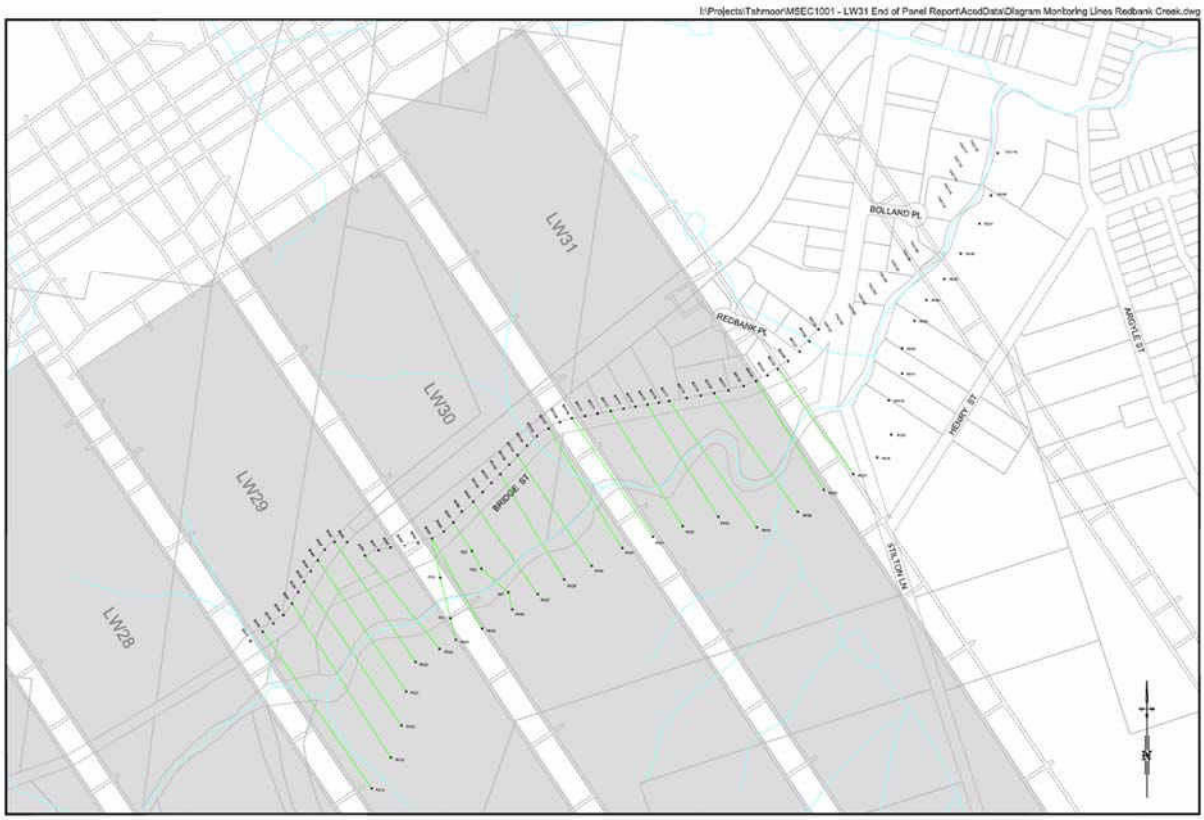


Fig. 2.3 Location of survey marks across Redbank Creek

Graphs showing observed subsidence, tilt and strain along each of the monitoring lines are provided in Figs. A.15 to A.20 and drawings showing incremental subsidence and relative horizontal movements are shown in Drawings Nos. MSEC1001-02 and MSEC1001-03.

The development of valley closure across Redbank Creek and its tributaries during the mining of Longwall 31 against time is shown in Fig. 2.4.

The closures are based on calculating changes in horizontal distance between pegs located across the valley in an orientation that is approximately parallel to the longwall panel. This orientation was chosen as Redbank Creek flows approximately at right angles across the panel.

Different results can be derived if the calculations were based on different pairs of pegs, though it is considered that if different pairs were chosen, such calculations would include an additional component of conventional and non-conventional ground shortening that occurs across the panel in both plateau areas or valleys. This is particularly the case if the pegs are located across the width of the longwall panel from each other. When comparing the results against predictions of valley closure, it was considered simpler to choose pegs that are approximately aligned with longwall direction so as not to make allowances for the additional effects of conventional lateral ground closure movements.

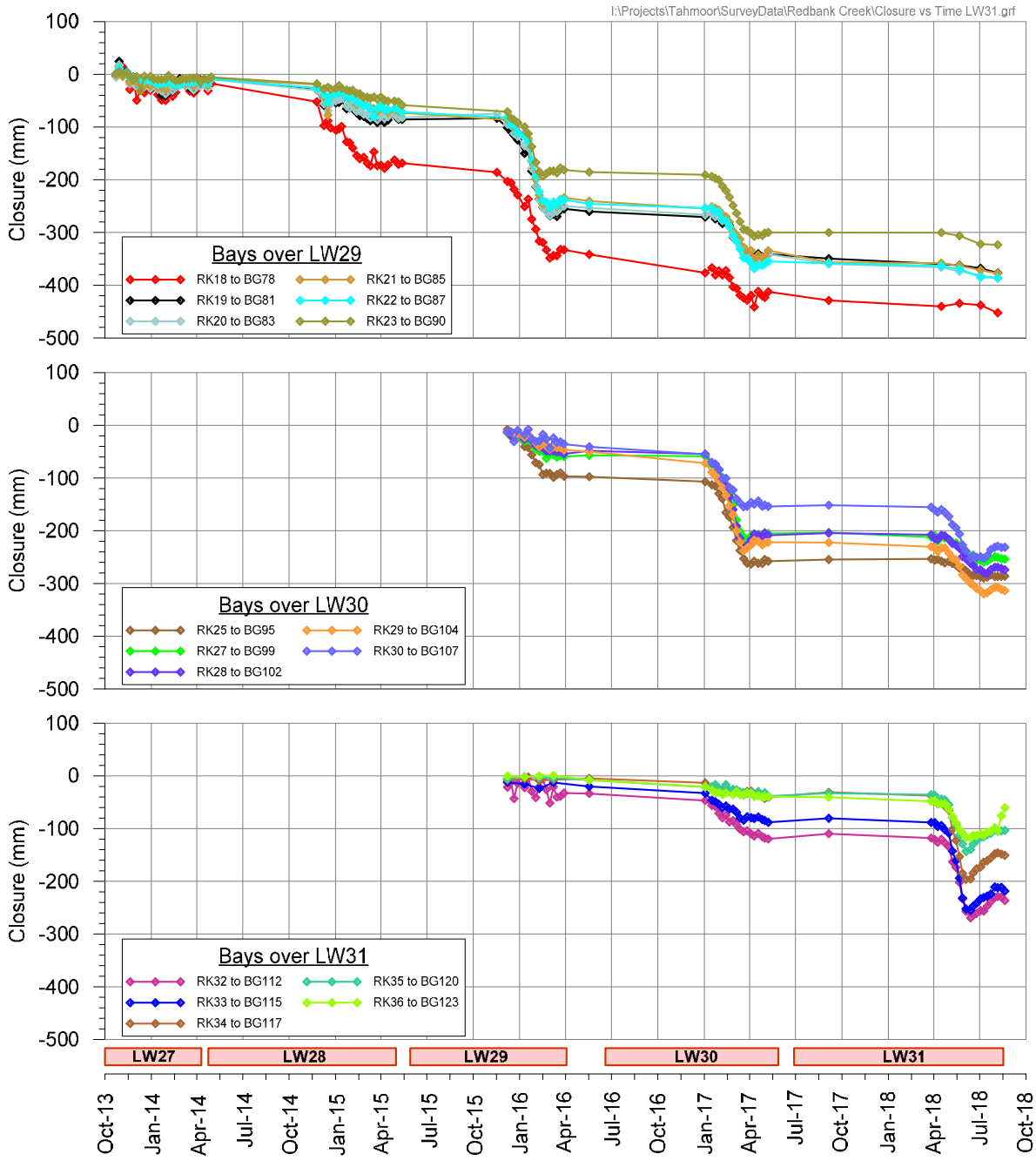


Fig. 2.4 Observed development of closure across Redbank Creek over time

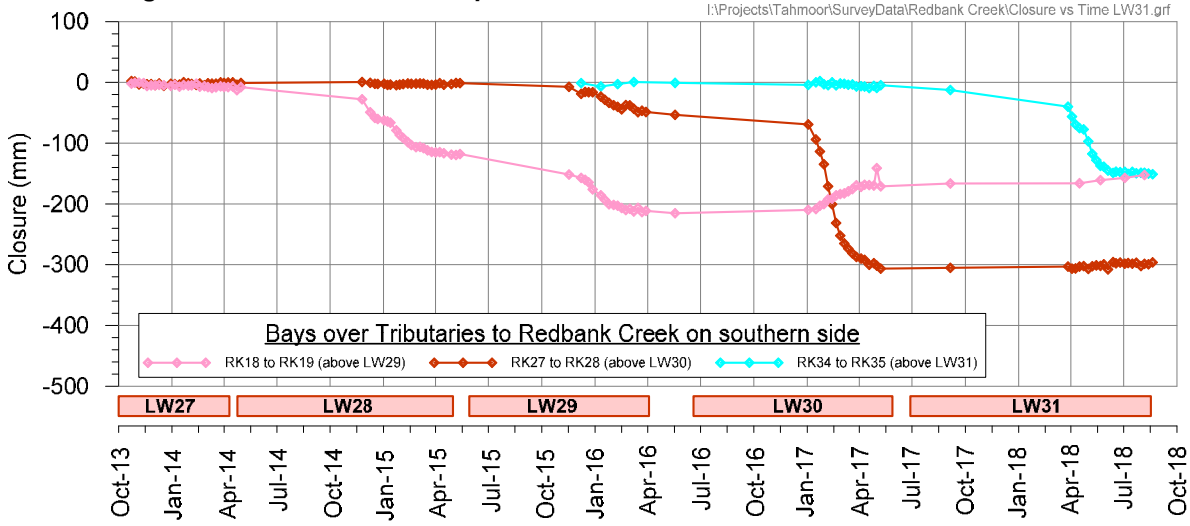


Fig. 2.5 Observed development of closure across tributaries to Redbank Creek over time

A number of observations are made from the monitoring data:

- It can be seen from Fig. 2.4 that valley closure was slightly greater for a temporary period of time, when the transient effects of the subsidence travelling wave passed through the valley.
- Maximum observed closure above Longwall 31 was similar to maximum observed closure above Longwall 30 and less than maximum observed closure above Longwall 29. This was predicted as the valley is deeper and more incised above Longwall 29.

A comparison between observed and predicted valley closure along Redbank Creek is shown in Fig. 2.6. A number of observations are made from the monitoring data:

- There has been a reasonable correlation between predicted and observed closure at the completion of Longwall 31.
- Observed total closure from the mining of Longwalls 26 to 31 is less than predicted.

Maximum predicted valley closure due to extraction of Longwall 31 was 152 mm. As shown in the bottom graph of Fig. 2.6, observed maximum incremental valley closure at the completion of Longwall 31 was 138 mm.

It can also be seen, from the top graph of Fig. 2.6 that observed total closure from the mining of Longwalls 26 to 31 is less than predicted along the length of Redbank Creek. Maximum observed total closure is 452 mm, which is less than the predicted total closure of 575 mm due to the mining of Longwalls 22 to 31, as reported in Report No. MSEC647.

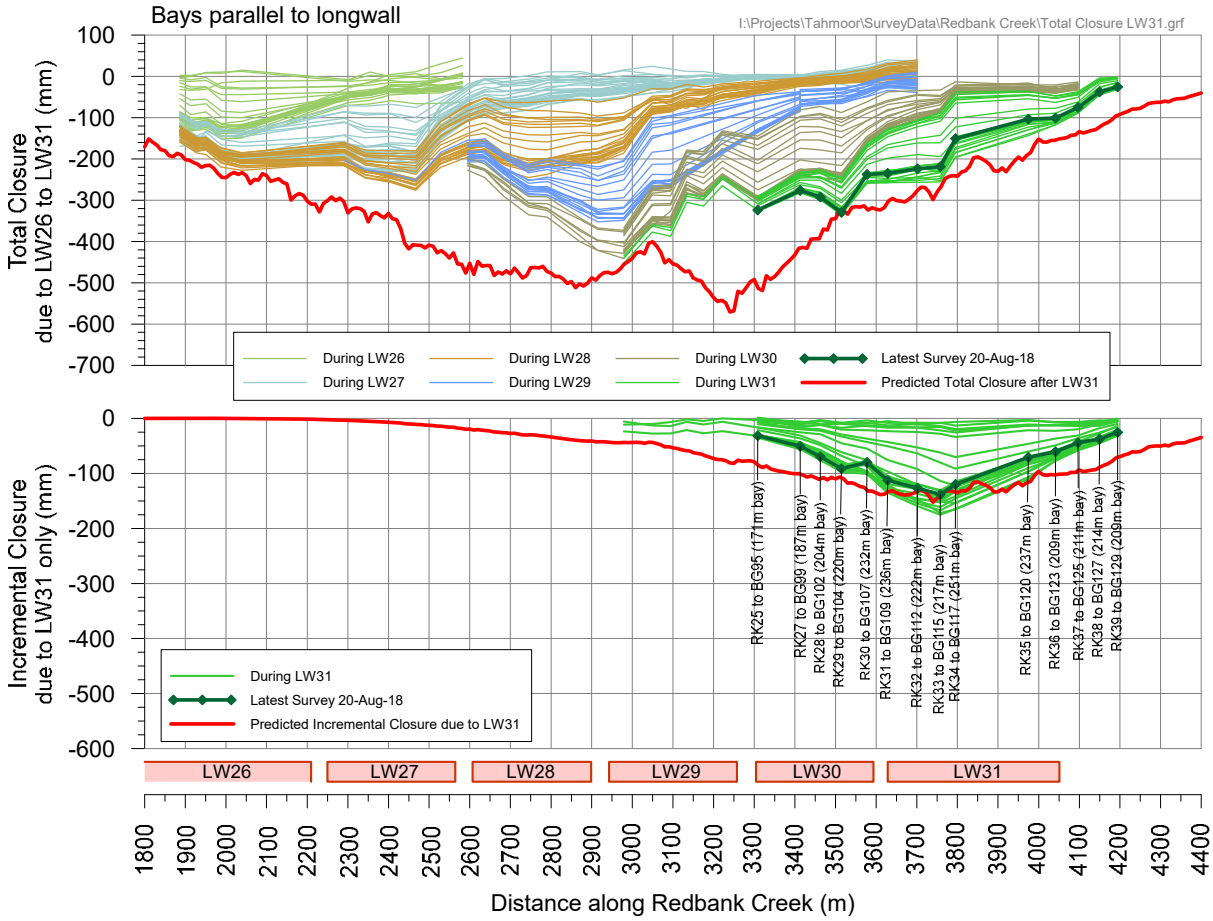


Fig. 2.6 Comparison between observed and predicted valley closure along Redbank Creek

2.4. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 63 times on a weekly basis during the extraction of Longwall 31. Details of the monitoring undertaken are provided in the monitoring reports prepared by MSEC on behalf of Tahmoor Coking Coal Operations and these reports have been provided to ARTC throughout the mining period.

The Main Southern Railway experienced maximum incremental subsidence of 791 mm during the mining of Longwall 31.

When comparing predicted and observed subsidence, the following comments are provided:

- Observed maximum subsidence is greater than predicted maximum subsidence.
- There is a reasonable correlation between the shapes of the predicted and observed subsidence profiles. There is, therefore, a reasonable correlation between predicted and observed maximum tilt though observed maximum tilt is greater than predicted maximum tilt.
- Increased ground strain was observed between 92.660 km and 92.700 km, where the railway crosses a small tributary to Redbank Creek. A substantial change in vertical and horizontal alignment was previously observed at 90.660 km during the mining of Longwall 30. While further changes were observed at this location during the mining of Longwall 31, the impacts on track geometry were less noticeable. Impacts were observed in the brick arch culvert at the outlet end, with increases in crack widths observed. The cracks were inspected by a structural engineer, who advised that the integrity of culvert was maintained.
- Observed ground strains along the railway corridor have generally been relatively small in magnitude.

2.4.1. Automated Track Monitoring

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 to 60 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 31. Rail stresses exceeded Blue trigger on one occasion during the mining of Longwall 31, due to high compressive stress at time of high rail temperature. The rail was unclipped and re-clipped to achieve a change in SFT.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 31. Mining-induced changes were observed, though larger temperature-induced changes were observed. Some low level (Blue) alarms were triggered as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

2.4.2. Redbank Creek Culvert and Embankment at 91.265 km

A total of 23 ground surveys, 24 extensometer surveys and 24 detailed visual inspections were undertaken for the Redbank Creek Culvert and Embankment on a weekly to monthly basis in accordance with the agreed management plans with ARTC.

The Culvert has subsided between approximately 340 mm and 610 mm in total during the mining of Longwalls 27 to 31.

Observed absolute horizontal movements along the Main Southern Railway are shown in Fig. 2.7. It can be seen that the rockmass on the southern of Country side of the Culvert has moved in a different direction to the northern or Sydney side of the Culvert.

Observed total subsidence and horizontal movement of survey marks in the immediate of the culvert and embankment are shown in Fig. 2.8. The results show that boundaries of the rockmass in the south-western quadrant intersect with the country side of the culvert. The corner of the rockmass is approximately aligned with midpoint of the culvert, which correlates well with observed detailed closure measurements inside the culvert itself.

The observed gradual development with time of differential horizontal movements between selected pegs at the culvert and embankment are shown in Fig. 2.9. Maximum observed closure was measured between the long bay survey pegs on the track at 91.220 km and 91.360 km, though a similar result was observed between Pegs RBCCU4 and RBCCU6, RBCU4 and RBCU6, and between RBCD2 and RBCD6, which are located in the base of the embankment across the upstream inlet. This suggests that closure across the valley of Redbank Creek and its tributary, were focussed at the culvert. This was confirmed at greater detail from additional detailed surveys in the culvert, which are discussed later.

Whilst the ends of the wingwall on the upstream end have closed by 274 mm, the culvert barrel at the inlet has opened by 20 mm. Measured closure at the ends of the wingwall on the downstream end is 59 mm, and the culvert barrel at the inlet has opened 21 mm.

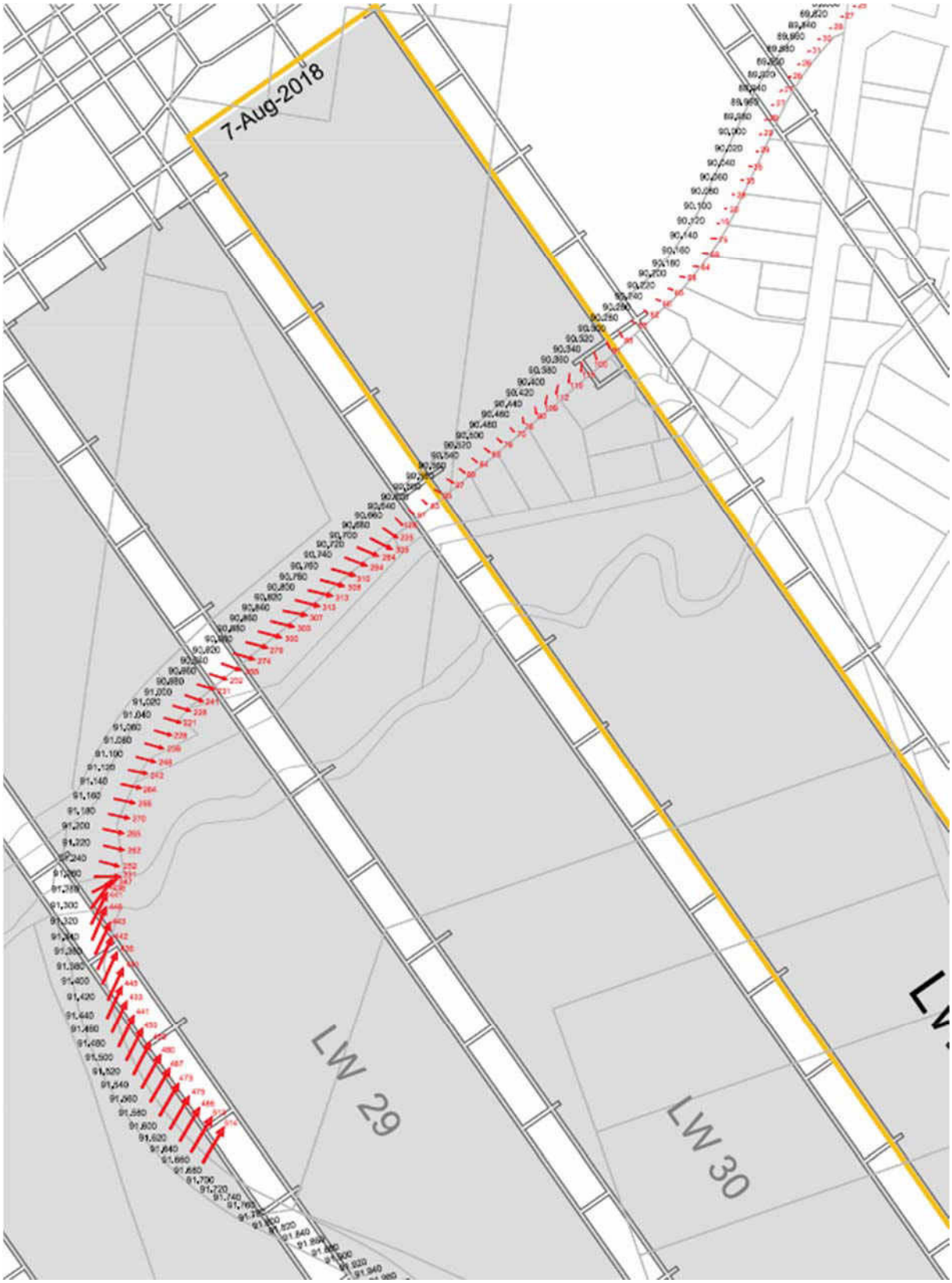


Fig. 2.7 Observed total horizontal movement along Main Southern Railway during the mining of Longwalls 27 to 31

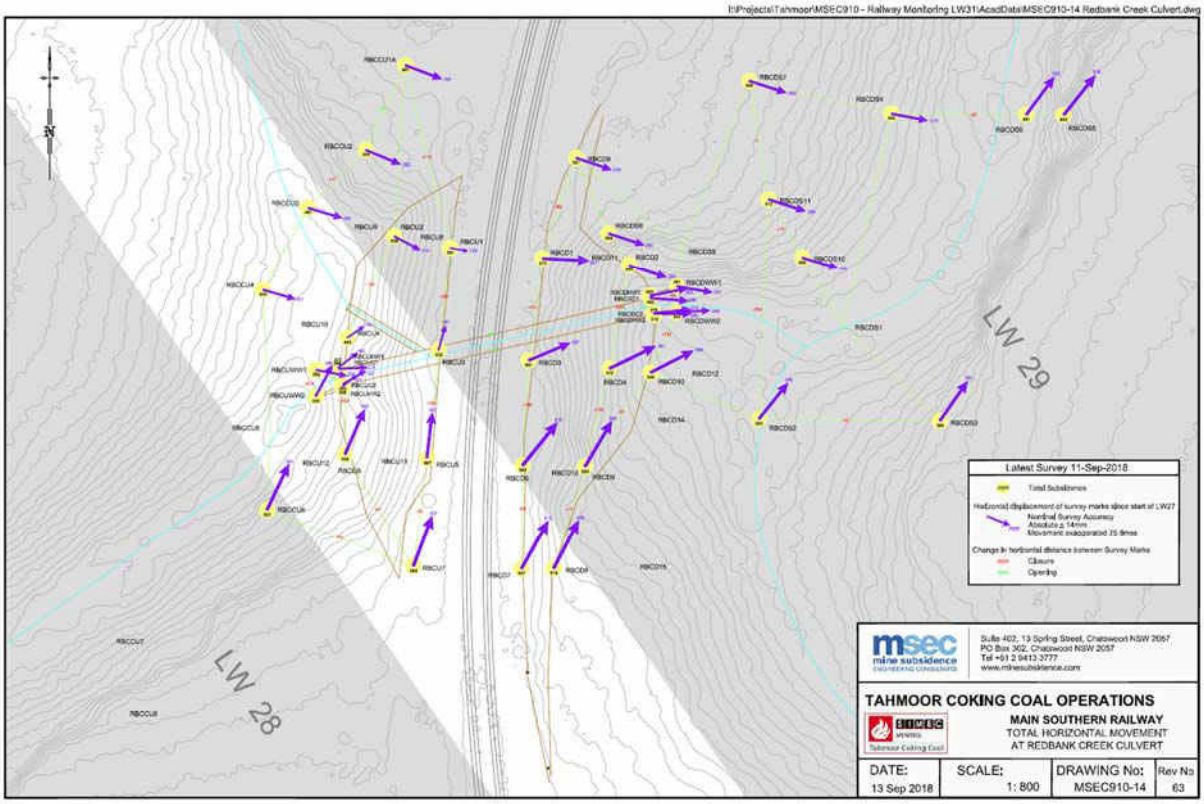


Fig. 2.8 Observed total horizontal movement at Redbank Creek Culvert and embankment during the mining of Longwalls 27 to31

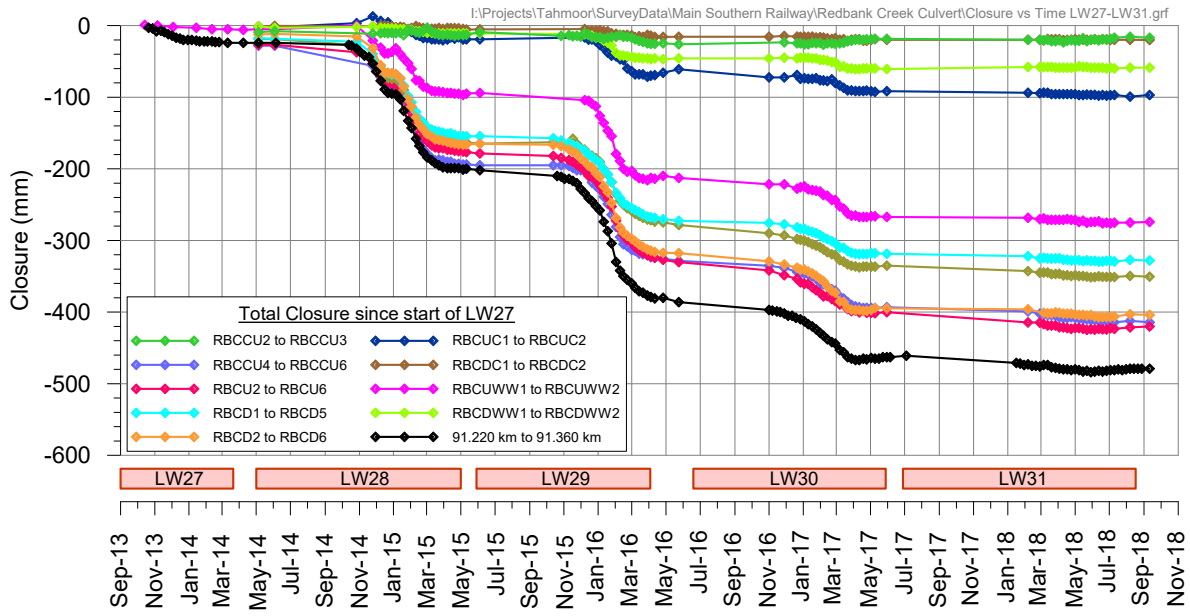


Fig. 2.9 Observed Total Valley Closure over time across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 31 (includes closure from Longwalls 27 to 30)

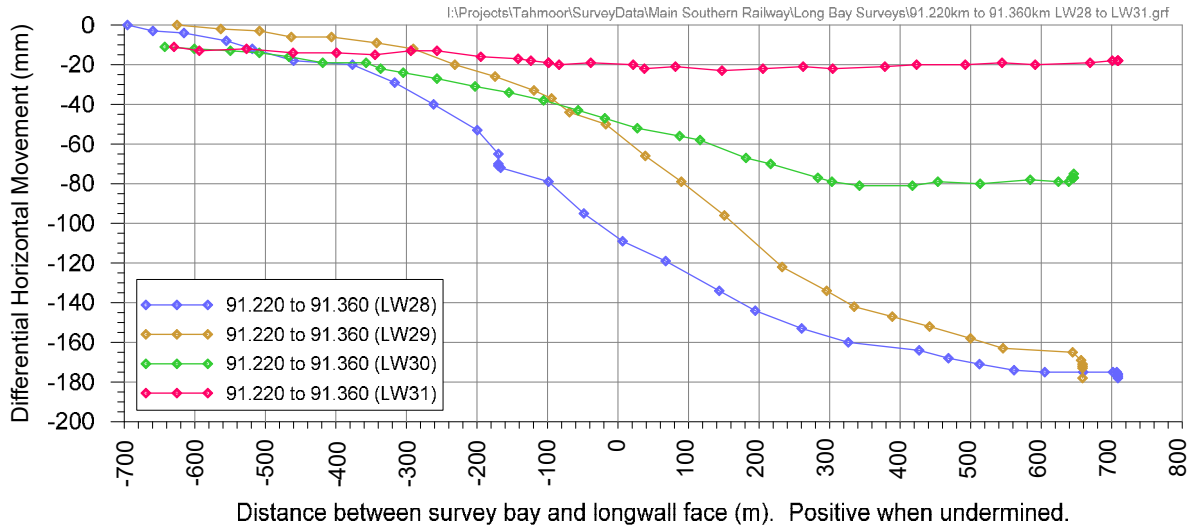


Fig. 2.10 Observed incremental valley closure as measured by long bay survey, relative to face distance, across Redbank Creek Culvert at Main Southern Railway during the mining of Longwalls 28 to 31

It can be seen from Fig. 2.10 that only minor valley closure movements occurred during Longwall 31. When compared to the development of valley closure during the mining of Longwalls 28 and 30, it can be seen that valley closure was substantially less than observed during previous longwalls. By the end, the increment of valley closure due to the extraction of Longwall 31 was a quarter of the increment observed due to the extraction of Longwall 30.

Observed subsidence along the base of the embankment on the upstream side is shown in Fig. 2.11. The results show valley closure focussing between Pegs RBCCU4 and RBCCU6, with upsidence observed at Peg RBCCU4. It can also be seen that very little change in ground strain was observed during the mining of Longwall 31.

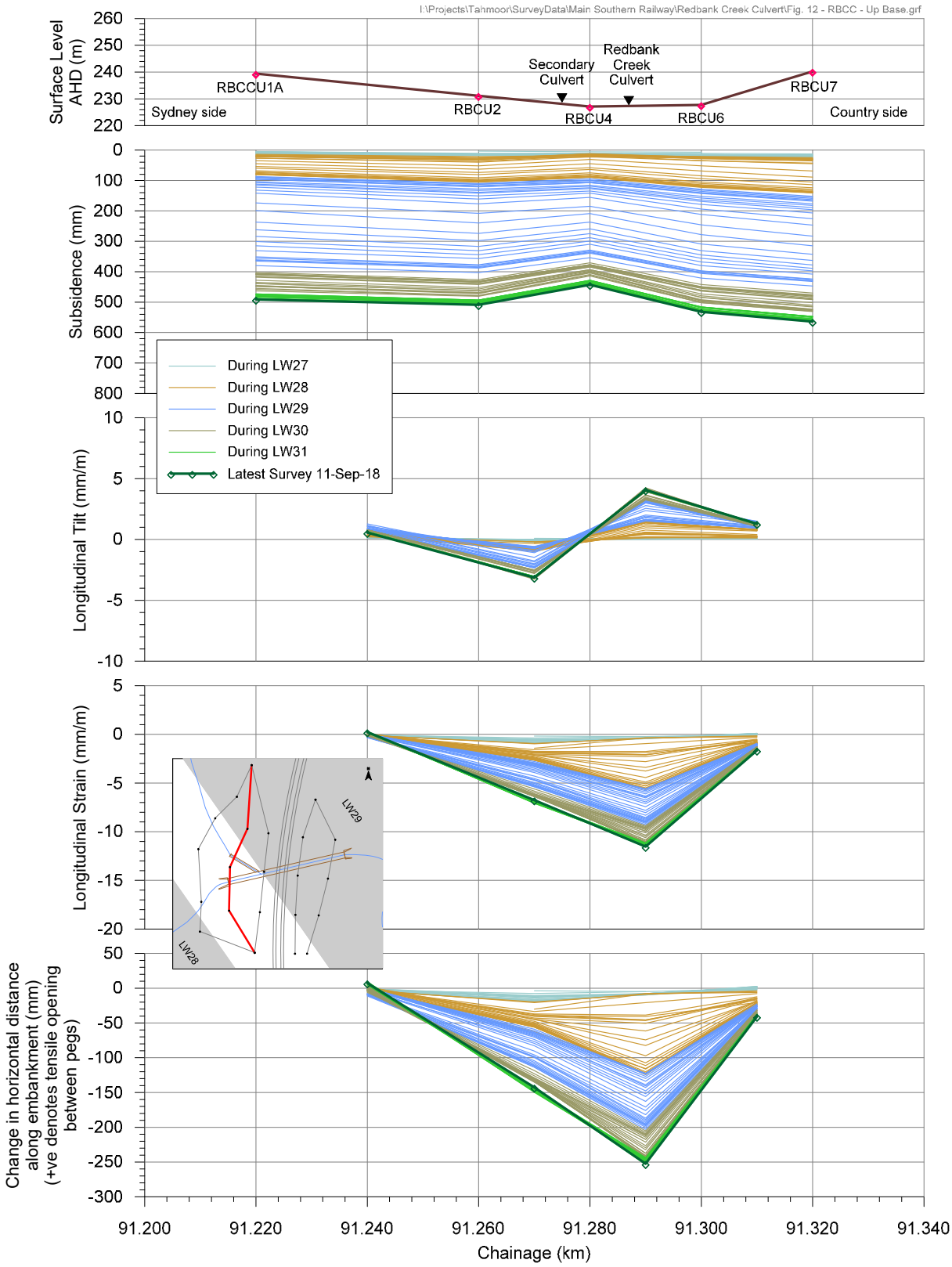


Fig. 2.11 Observed total subsidence, tilt and strain across the upstream base of Redbank Creek Culvert due to the mining of Longwalls 27 to 31

2.5. Sewer Infrastructure

2.5.1. Sewer grades

Subsidence monitoring was undertaken along the streets and along the Thirlmere Carrier pipe during the mining of Longwall 31.

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. A total of 24 surveys were undertaken along the Thirlmere Carrier during the mining of Longwall 31. Small improvements in sewer grade were observed above the eastern edge of previously extracted Longwall 30 between Pegs BG106 and BG108, as expected. An improvement in grade was not observed between Pegs BG105 and BG106. An invert level survey was completed on 6 September to improve understanding of current levels along the pipe. The survey confirmed a reversal of grade at the Pits Nos. 3186019 and 3186018, which are located opposite Pegs BH105 and BH106, respectively. While good flows continue to be observed, the replacement pipe will be laid to re-establish a positive grade.

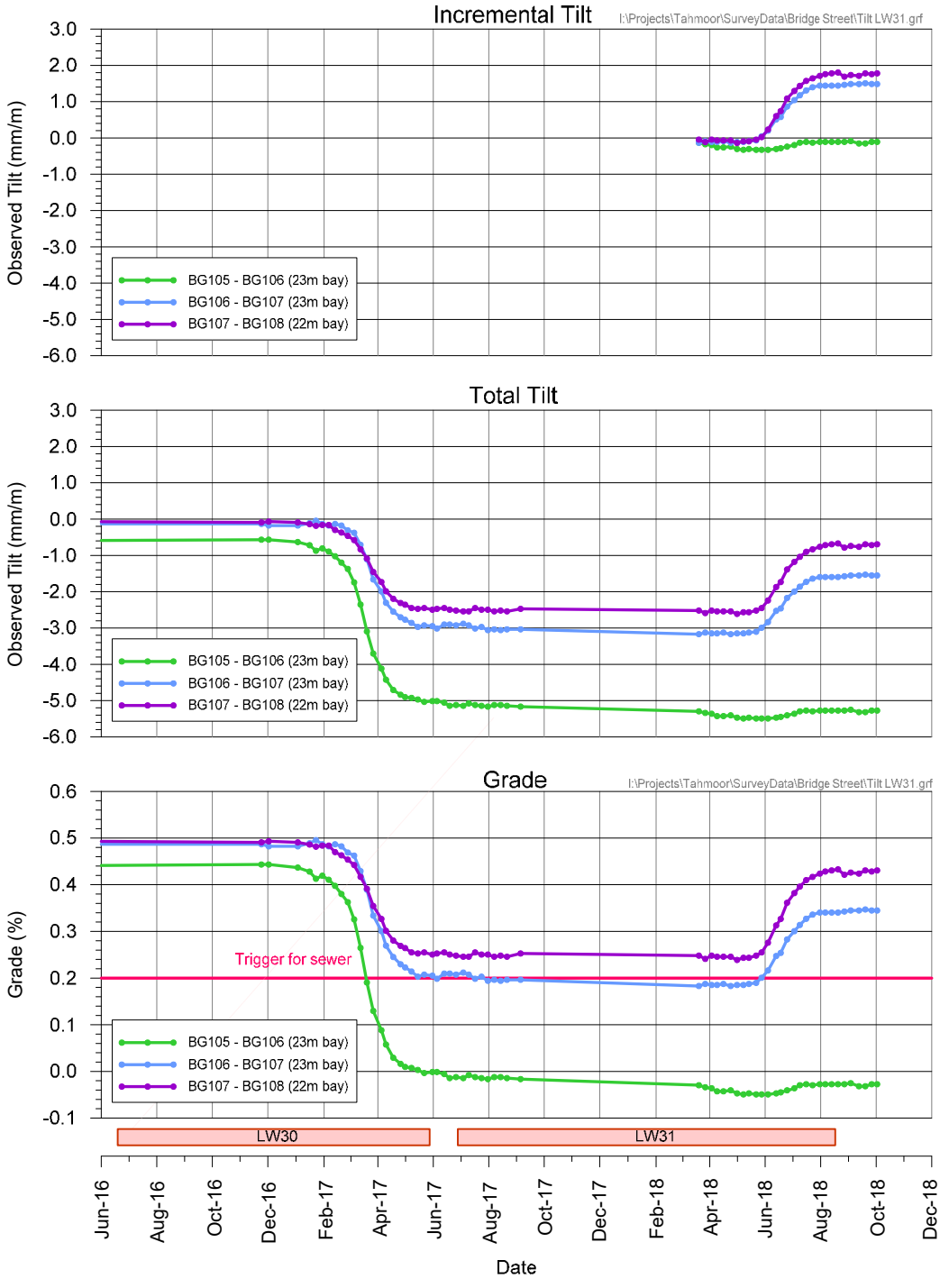


Fig. 2.12 Development of tilt on Bridge Street between pegs BG105 and BG108

2.6. Power Pole Surveys

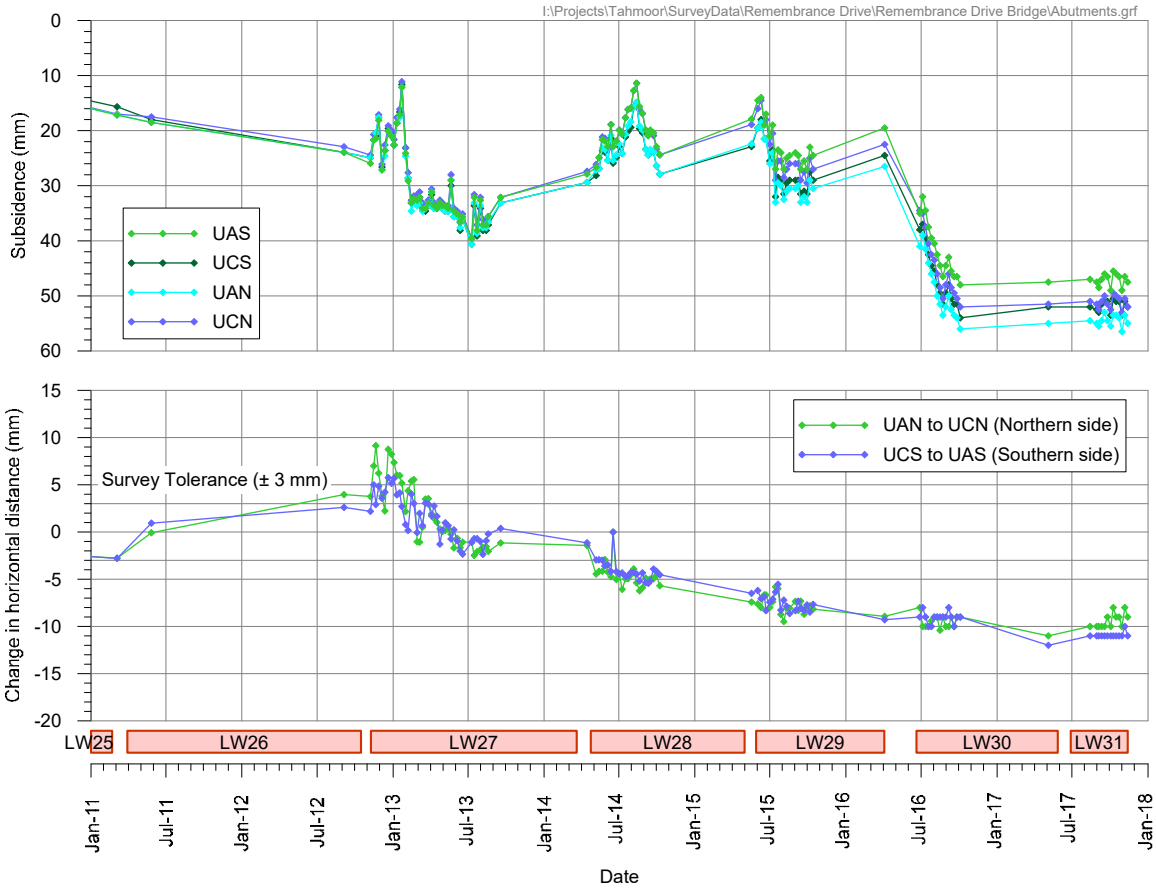
A total of 74 surveys of selected power poles were conducted in accordance with the agreed management plan with Endeavour Energy. No impacts were observed to any power pole or cables during the mining of Longwall 31, as expected.

Of the poles that were surveyed, maximum incremental subsidence of 618 mm was observed at Pole 623341 located on Bridge Street above Longwall 31.

2.7. Wollondilly Shire Council

2.7.1. Remembrance Drive Bridge

Survey marks were installed on the Remembrance Drive Road Bridge prior to the extraction of Longwall 24A. While the Bridge has experienced approximately 60 mm of subsidence, measured changes in horizontal distances between the abutments are small. Minor closure has been measured, as shown in Fig. 2.13. This includes the measured changes in horizontal distances across the gas pipe supports. Vertical subsidence is relatively consistent across all survey marks, indicating that no measurable upsidence has occurred to date.



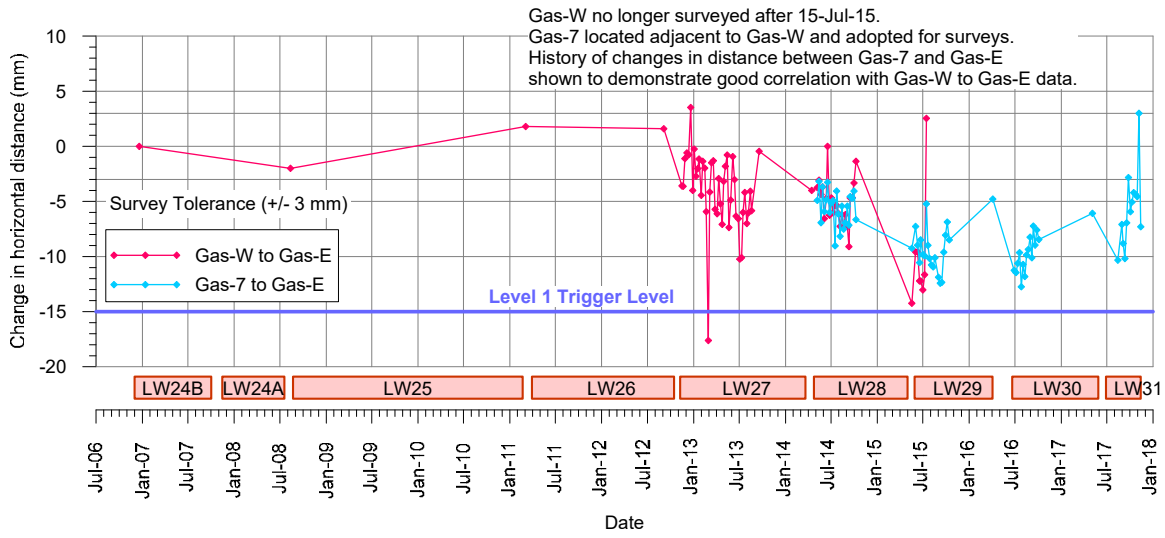


Fig. 2.13 Observed subsidence and changes in horizontal distances across the abutment and gas pipe supports at Remembrance Drive (Myrtle Creek) Road Bridge

3.0 SUMMARY OF SURVEYS AND INSPECTIONS

Many surveys and inspections were conducted to meet the requirements of the Surface, Safety and Serviceability Management Plans for Longwall 31. A timeline showing when each type of survey and inspection was conducted is shown in Fig. 3.1 below.

Fig. 3.1 Timeline of surveys and inspections during Longwall 31

A summary of surveys and inspections is provided in Table 3.1

Table 3.1 Surveys and inspections conducted during Longwall 31

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	SMEC	125
Sub-Total		**125**
Natural Features		
Redbank Creek Survey Lines	SMEC	22
Redbank Creek Visual inspections	GeoTerra	28
Sub-Total		**50**
Main Southern Railway		
Ground Surveys	Southern Rail Surveys	63
Rail Creep Surveys	Southern Rail Surveys	63
Long Bay Surveys	Southern Rail Surveys	63
Track Geometry Surveys	BloorRail	63
Track Inspections	BloorRail	63
Cutting Surveys	Southern Rail Surveys	29
Embankment Surveys	Southern Rail Surveys	51
Noise Wall Surveys	Southern Rail Surveys	6
Deviation Overbridge Surveys	Southern Rail Surveys	25
Bridge St Overbridge Surveys	Southern Rail Surveys	19
Redbank Creek Culvert Surveys	Southern Rail Surveys	23
Far-field Surveys	Southern Rail Surveys	10
Sub-Total		**434**
Jemena - Gas		
Remembrance Drive Bridge Surveys	SMEC	13
Sub-Total		**13**
Sydney Water - Sewer		
Thirlmere Carrier Pipe Surveys	SMEC	24
Sub-Total		**24**
Endeavour Energy - Electrical		
Power Pole Surveys	SMEC	74
Sub-Total		**74**
Telstra - Telecommunications		
Optical Fibre Line Surveys	SMEC	22
Sub-Total		**22**
Commercial / Industrial		
Picton Industrial Area	SMEC	25
Sub-Total		**25**
Heritage		
Queen Victoria Memorial Home	Veris	14
Koorana	SMEC	7
Mill Hill	SMEC	12
Sub-Total		**33**
Wollondilly Shire Council		
Remembrance Drive Footbridge Surveys	SMEC	13
Sub-Total		**13**
Total		**813**

4.1. Summary of Impacts to Surface Features

A comparison between assessed and observed impacts to surface features is summarised in Table 4.1 below. The assessed and observed impacts to surface features compare reasonably well.

Table 4.1 Summary of Predicted and Observed Impacts during Longwall 31

Surface Feature	Predicted Impacts	Observed Impacts
Natural Features		
Redbank Creek	Potential cracking in creek bed. Potential surface flow diversion. Potential reduction in water quality during times of low flow. Potential increase in ponding.	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over LW's 25 to 31 and future LW 32. Changes observed in salinity levels downstream of Redbank Creek subsidence zone, along with elevated Total Nitrogen, Total Phosphorous, copper, nickel, zinc, iron and manganese. These observations have been reported in ferruginous pools since LW29. Refer report by GeoTerra and Section 4.2.
Aquifers or known groundwater resources	Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops. Groundwater levels should recover with no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops Potential impacts to privately owned groundwater bores. Please refer report by GeoTerra.	Previously depressurised groundwater monitoring boreholes have gradually re-pressurised. No indication of any adverse interconnection between aquifers and aquitards within 20m of the surface. No impacts on privately owned bores in yield and serviceability. Please refer report by GeoTerra.
Steep slopes and cliffs	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during Longwall 31.
Natural vegetation	No impacts anticipated.	No impacts observed during Longwall 31.
Public Utilities		
Railway	Railway will remain safe and serviceable with management plans in place.	Railway maintained in safe and serviceable condition during mining. The railway infrastructure has experienced some impacts during mining. Refer to Section 4.3 for further details.
Roads and Bridges (all types)	Minor cracking and buckling may occur in isolated locations. Bridges will remain safe and serviceable with management plans in place.	Minor impacts to pavement and kerbs in isolated locations. Minor cracking and minor compression on Bridge Street. Refer Section 4.4 for further details.

Surface Feature	Predicted Impacts	Observed Impacts
Water pipelines	Minor impacts possible to pipelines, particularly older cast iron pipes with lead joints.	No impacts observed during Longwall 31. Refer Section 4.5 for further details.
Gas pipelines	Ground movements unlikely to adversely impact pipelines if systematic movement occurs.	No impacts observed during Longwall 31. Refer Section 4.6 for further details.
Sewer pipelines	Mining induced tilt unlikely to reduce grade less than that required for self-cleansing. Cracking to pipes and joints is unlikely if systematic movement occurs. Potential impacts where non-systematic movement occurs.	Short section of Thirlmere Carrier Pipe with slight reversal of grade. No impacts on flows observed. Cracks observed by CCTV inspection in Thirlmere Carrier Pipe approx. 50 m to the west of creek crossing, where increased compressive strains have been measured. Refer Section 4.7 for further details.
Electricity transmission lines or associated plants	Ground movements unlikely to adversely impact electrical infrastructure if systematic movement occurs.	No impacts observed during Longwall 31. Refer Section 4.8 for further details.
Telecommunication lines or associated plants	Ground movements unlikely to adversely impact telecommunications infrastructure if systematic movement occurs. Most vulnerable cables are older cables such as air pressurised lead sheathed cables. Strains may be higher where cables connect to support structures or where affected by tree roots.	No impacts observed during Longwall 31. Refer Section 4.9 for further details.
Public Amenities	No public amenities affected by Longwall 31.	No public amenities affected by Longwall 31
Queen Victoria Memorial Gardens	All structures expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining.	No impacts observed during Longwall 31.
Farmland and Facilities		
Farm buildings or sheds	Negligible to slight impacts predicted for all farm buildings and sheds if systematic movement occurs.	No impacts observed during Longwall 31.
Fences	Potential for impacts to fences and gates.	No impacts reported to fences on farm properties during Longwall 31.
Farm dams	Potential adverse effects on dam walls and storage capacity. Please refer report by GeoTerra.	No dam wall cracking and no adverse effects on dam wall integrity or dam water storage reduction have been observed from field investigations. Please refer report by GeoTerra.
Wells or bores	Potential impact on one NOW registered bore. Please refer report by GeoTerra.	No impacts observed during Longwall 31. Please refer report by GeoTerra
Industrial, Commercial or Business Establishments	All structures expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Potential impacts predicted to occur to structures, equipment and machinery.	Minor impacts on business and commercial establishments affected by Longwall 31. Establishments remained safe and serviceable during the mining of Longwall 31.
Areas of Archaeological Significance	Potential fracturing, rock falls or water seepage affecting artwork on rock shelter on Redbank Creek. Potential for fracturing and buckling of bedrock in the vicinity of the grinding groove site on Redbank Creek ,which is located above future Longwall 32. Low potential impacts on isolated artefact sites, which are located directly above Longwall 31.	No impacts on archaeological sites observed during Longwall 31.

Surface Feature	Predicted Impacts	Observed Impacts
Areas of Heritage Significance	Potential low level impacts at Queen Victoria Memorial Home, Mill Hill Homestead and Koorana Homestead, which are located adjacent to but not directly above Longwall 31.	No items of heritage significance affected by Longwall 31, including Queen Victoria Memorial Home, Mill Hill Homestead and Koorana Homestead.
Permanent Survey Control Marks	Ground movement predicted at identified survey marks.	Ground movement occurred.
Residential Establishments		
Houses, flats or units	All houses expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some houses. Refer Section 4.11 for details.	While impacts occurred, houses were safe, serviceable and repairable during Longwall 31. Refer Section 4.11 for details.
Swimming pools	While predicted tilts are not expected to cause a loss in capacity, tilts are more readily noticeable in pools as the height of the freeboard will vary along the length of the pool. While predicted strain impacts are low, many of the pools are inground, which are more susceptible.	Impact to 36 pools during the mining of Longwalls 22 to 31, with impact to no additional pools reported damaged during the mining of Longwall 31. Impact observed to one pool fence during the mining of Longwall 31.
Associated structures such as workshops, garages, on-site wastewater systems, water or gas tanks or tennis courts	Potential impact to pipes connected to inground septic tanks. Negligible impacts predicted for non-residential domestic structures, including sheds and tanks.	Impact to 1 pergola and associated garden walls was reported during Longwall 31.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to external pavements were reported by 1 property during Longwall 31.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	No impacts to fences reported during Longwall 31.

4.2. Creeks

4.2.1. Redbank Creek

GeoTerra undertook an investigation into the effects of Longwall 31 on surface and ground waters in the area (GeoTerra, 2019).

During the mining of Longwall 31, new subsidence effects were observed at Sites RR29 (rock bar delamination and uplift and reduction in pool water levels), and Sites RR30, RR31, RB32 and RC4 (reduction in pool water levels with no obvious cracking). The new impact sites were observed above future Longwall 32. No new impact sites were observed directly above Longwall 31, though additional cracking was observed in pools that previously experienced impacts during the mining of Longwall 30.

Pools located directly above Longwall 31 and future Longwall 32 have experienced a reduction in pool water levels and low water flows compared to baseline monitoring. Approximately half of the pools have been observed dry during the mining of Longwall 31.

Re-emergence of the connected stream “through-flow” has been observed downstream of future Longwall 32, at site RR29 (refer to report by GeoTerra for locations of sites).

Increased salinity was observed directly above and downstream of the subsidence zone, particularly during periods of low flow. Elevated levels of Total Nitrogen, Total Phosphorous, copper, iron, manganese, zinc and nickel were observed during the mining of Longwall 31 and are observed in ferruginous pools.

A number of seeps were identified in Redbank Creek prior to mining. No new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 31, though increased ferruginous and salinity levels have been observed in the stream over Longwalls 29 to Longwall 31 and future Longwall 32.

4.2.2. Comparison against Triggers in Natural Features Management Plan

The observed impacts have been compared against the triggers stated in Section 3.1.1 of the *Environmental Management Plan for Longwall 31*, (Rev. 0, May 2017).

Table 4.2 Comparison against Triggers for Myrtle and Redbank Creeks during Longwall 31

Trigger	Redbank Creek
Redirection of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability	Trigger exceeded during mining of LW31 at 16 sites: Sites RW13, RB14 and RR15 above LW30, Site RR16 above the chain pillar between LW30 and LW31, Sites RB17, RR18, RR19, RB20 to RB27 incl Weir 26 above LW31, Site RR27 above the chain pillar between LW31 and LW32 Sites RR28 and RR29 east of LW31.

4.3. Main Southern Railway

4.3.1. Railway Track

While changes were observed, the Main Southern Railway remained serviceable at all times during the mining of Longwall 31. The track condition deteriorated slightly in isolated locations as a result of mining and the track was resurfaced.

During the mining of Longwall 31 some of the triggers associated with the *Tahmoor Colliery Longwall 31 Management Plan for Longwall Mining beneath the Main Southern Railway (Rev A, April 2017)* were exceeded.

Some low level (Blue) rail stress triggers and switch displacement triggers were exceeded during the mining of Longwall 31 as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

4.3.2. Redbank Creek Culvert and Embankment

Tahmoor Coking Coal Operations has successfully managed Redbank Creek Culvert during the extraction of Longwall 31. Substantial ground shortening of approximately 480 mm was observed along the length of the embankment, and ground extension of approximately 260 mm was observed in the transverse direction across the base of the embankment.

A detailed Subsidence Management Plan was developed to manage potential impacts on the Redbank Creek Culvert and Embankment during the mining of Longwall 31.

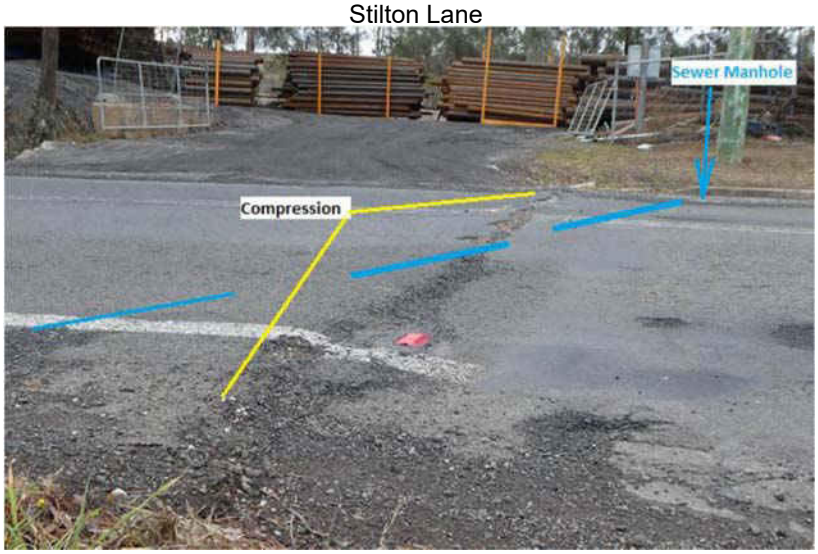
The Redbank Creek Culvert and Embankment has remained safe and serviceable during the mining of Longwall 31.

4.4. Roads and Bridges

4.4.1. Roads

Approximately 28 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 54 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 520 metres of pavement. The impacts were minor and did not present a public safety risk. A collection of photographs of impacts is provided in Fig. 4.1.

Stilton Lane



Bridge Street

Photographs courtesy of Colin Dove

Fig. 4.1 Photographs of Impacts to Road Pavements during Longwall 31

4.5. Potable Water Infrastructure

Longwalls 22 to 31 have directly mined beneath approximately 5.4 kilometres of ductile iron concrete lined (DICL) pipe and 19 kilometres of cast iron concrete lined (CICL) pipe, with only minor impacts recorded. No impacts were observed during the mining of Longwall 31.

4.6. Gas Infrastructure

Longwalls 22 to 31 have directly mined beneath approximately 18 kilometres of gas pipes and no impacts have been recorded so far. The local nylon and 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced at Tahmoor to date.

4.7. Sewer Infrastructure

Longwalls 22 to 31 have directly mined beneath approximately 29.4 kilometres of sewer pipes. The observed impacts to date have been within expectations. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages have been observed. This includes observations at locations above Longwalls 24A to 30 where specific ground surveys were undertaken to confirm that mining-induced tilts did not exceed pre-mining grades.
  For the first time during the mining of Longwalls 22 to 31, a sewer pipe has experienced a permanent reversal of grade. An improvement in grade was not observed between Pegs BG105 and BG106 after it was observed to reduce during the mining of Longwall 30. An invert level survey was completed on 6 September to improve understanding of current levels along the pipe. The survey confirmed a reversal of grade at the Pits Nos. 3186019 and 3186018, which are located opposite Pegs BH105 and BH106, respectively. While good flows continue to be observed, the replacement pipe will be laid to re-establish a positive grade

- *Physical damage to pipes*
  There were no observations of damage during the mining of Longwalls 22 to 24 and Longwalls 27 to 30. Physical damage was observed at three locations during the mining of Longwall 25. In each case the pipes remained serviceable, though repairs were required at each location.

    - Crushing and vertical bending of 150 mm diameter pipe at Abelia Street. The impacts coincide with a large measured ground strain of 4.6 mm/m (over a 22 metre bay length) between Pegs A12 and A13, a measured vertical bump in the subsidence profile and an observed hump in the road pavement. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
    - Crushing and vertical bending of 150 mm diameter pipe at Remembrance Drive. The impacts coincide with a large measured ground strain of 2.8 mm/m (over a 37 metre bay length) between Pegs R1 and RE1, a measured vertical bump in the subsidence profile and an observed hump in the road pavement and roundabout. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
    - Crushing and vertical bending of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek. There is no monitoring line above this bore.

  Physical damage was observed at two locations during the mining of Longwall 26. In each case the pipes remained serviceable, though repairs were required at each location.

    - Deformation and cracking of 100 mm diameter pipe at Tahmoor Road. The pipe was repaired.
    - Deformation of 150 mm diameter pipe between Abelia Street and Oxley Grove where non-systematic subsidence movements were observed (this may have occurred during the mining of Longwall 25). The pipe was repaired.
    - Continued deformation of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek from Castlereagh Street to Brundah Road.

  Physical damage was observed at one location during the mining of Longwall 31.

    - Longitudinal (axial) compression and cracking of the Thirlmere Carrier Pipe approximately 50 metres of the creek crossing. Further details are provided below.

Compressive strain was observed to increase between Pegs BG105 and BG106. CCTV inspections were undertaken on multiple locations and Sydney Water conducted pit lid inspections during mining to check for any signs of backing up of wastewater.

Whilst no impacts were observed between Pegs BG105 and BG106, cracks were found approximately 50 metres to the west between Pegs BG102 and BG103. The locations of the impact sites are shown in Fig. 4.2.

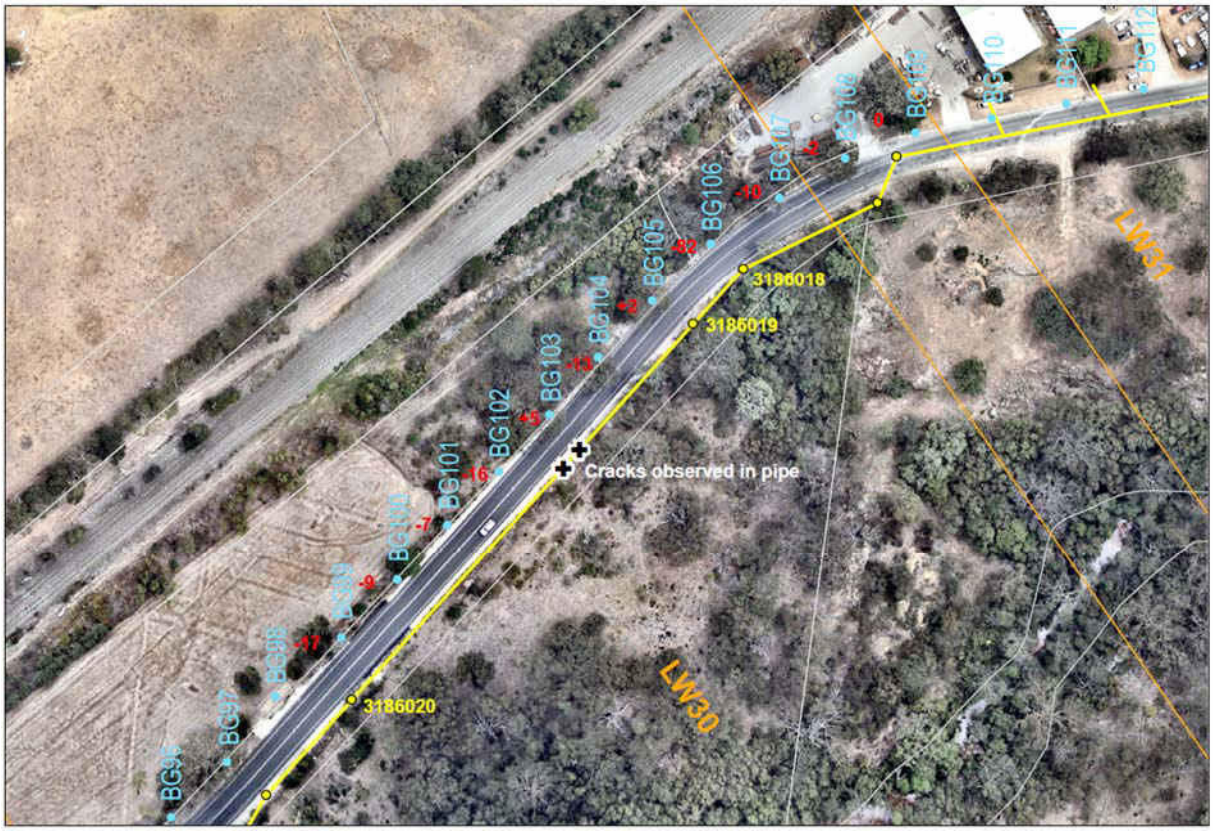


Fig. 4.2 Locations of cracks observed by CCTV inspection in Thirlmere Carrier Pipe on 25 July 2018

The damage is consistent with a mechanism of longitudinal (axial) compression, where the joint has closed and the end of the pipe has been pushed into the adjacent pipe. The location is approximately 50 to 55 metres to the west of the concrete encased creek crossing, where compressive strains have been observed between Pegs BG105 and BG106. Actual ground strains at the damage location are relatively small, in the order of -0.6mm/m compressive, and 0.2mm/m tensile. The small red values in Fig. 4.2 are measured changes in horizontal distance between the pegs, where negative values represent closure and positive values represent ground extension. It is considered that the pipes have been pushed in response to compression and the pipe joints have progressively closed up in a concertina fashion. Sydney Water has viewed the attached photographs and advise that there are no immediate concerns, but the damage will have to be repaired.

4.8. Electrical Infrastructure

Longwalls 22 to 31 have directly mined beneath approximately 41 kilometres of electrical cables and 1050 power poles and no significant impacts have been recorded so far. However, minor changes in tension of some aerial cables has been observed.

4.9. Telecommunications Infrastructure

Longwalls 22 to 31 have directly mined beneath approximately 43.1 kilometres of buried copper cable and 3.2 kilometres of buried optical fibre cable and 6.5 kilometres of aerial cable and no impacts have been recorded to telecommunications services so far.

Adjustments to tension of aerial telecommunications cables were required during the mining of Longwall 26 on Tahmoor Road and Krista Place. Damage was also observed to a conduit on the north-western abutment of the Castlereagh St Bridge. No issues were detected during the mining of Longwalls 27 to31.

4.10. Picton Industrial Area

Tahmoor Coking Coal Operations undertook intensive surveys and visual inspections of structures, equipment and machinery of commercial, industrial and business establishments within the Picton Industrial Area during the mining of Longwall 31.

All structures within the Picton Industrial Area remained safe and serviceable during the mining of Longwall 31. Minor impacts were observed to structures, equipment and machinery.

4.11. Residential Establishments

All structures remained safe and serviceable during the mining of Longwall 31.

Information on impacts is based on claims received from the Subsidence Advisory NSW (formerly Mine Subsidence Board). Information on the nature of the impacts was provided by the Subsidence Advisory NSW (Mine Subsidence Board.

A summary of reported impacts following the completion of Longwall 31 is provided in Table 4.3. The count of residential structures and public amenities includes only those structures that were predicted to experience more than 20 mm of subsidence due to the extraction of Longwalls 22 to 31.

Table 4.3 Summary of Observed Impacts to Structures

	Total after LWs 22 to 30	Increment during Longwall 31
Number of structures within zone of influence (predicted subsidence > 20 mm)	1961	22
Number of properties with reported impacts (not including refused claims)	555	8
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	494	5
Number of properties with reported impacts that only relate to associated structures	61	3

4.11.1. Discussion of Results

Prior to the mining of Longwall 27, the probabilities of impacts for each house within the SMP Area for Longwalls 27 to 30 were assessed using the method developed as part of ACARP Research Project C12015, based on observations of impacts during the mining of Longwalls 22 to 24A. Additional statistical information was collected in 2016 after the mining of Longwall 29. The timing of the data is such that it accounts for much of the time lag effect that occurs between the time of impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW.

A summary of the observed distribution of impacts for all houses within a 35° angle of draw of previously extracted Longwalls 22 to 29 as at 2016 is provided in Table 4.4.

Table 4.4 Observed Frequency of Impacts for Building Structures Resulting from the Extraction of Tahmoor Longwalls 22 to 29

Group	Repair Category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses within 35 degree angle of draw of LWs 22 to 29 (total of 1890)	1430 (76 %)	329 (17 %)	111 (6 %)	20 (1%)

It is noted that a comparison cannot easily be made based on the total number of affected houses. It is very difficult to separate effects on houses due to the mining of Longwall 31 only due to the time lag effect discussed previously. All properties that reported impacts during the mining of Longwall 31 were associated with the mining of previous Longwalls 22 to 29.

It is recommended, therefore, that comparisons be made based on total percentages of claims, where a reasonable correlation can be seen.

The primary risk associated with mining beneath houses is public safety. Residents have not been exposed to immediate and sudden safety hazards during the mining of Longwall 31. One house experienced substantial damage and measured were undertaken during mining to maintain safety and serviceability.

4.11.2. Swimming Pools

No pools were reported damaged during the mining of Longwall 31, though one pool gate was damaged.

4.11.3. Associated Structures

One pergola and associated garden walls was reported damaged during Longwall 31.

4.11.4. Fences

The potential for impacts to fences was raised in the SMP Report, however, no properties have claimed impacts to gates and fences during the mining of Longwall 31, with the exception of one pool gate.

5.0 SUMMARY OF RESULTS

In summary, there is generally a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area.

As anticipated prior to mining, little to no increased subsidence was observed during the first stages of mining Longwall 31. The maximum observed incremental subsidence due to the mining of Longwall 31 was 803 mm, which is slightly more than the maximum predicted incremental subsidence for Longwall 31, with the difference being within the accuracy of the subsidence prediction methods.

There is a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as the Main Southern Railway, sewer mains, water mains, gas mains, and electrical and telecommunications infrastructure.

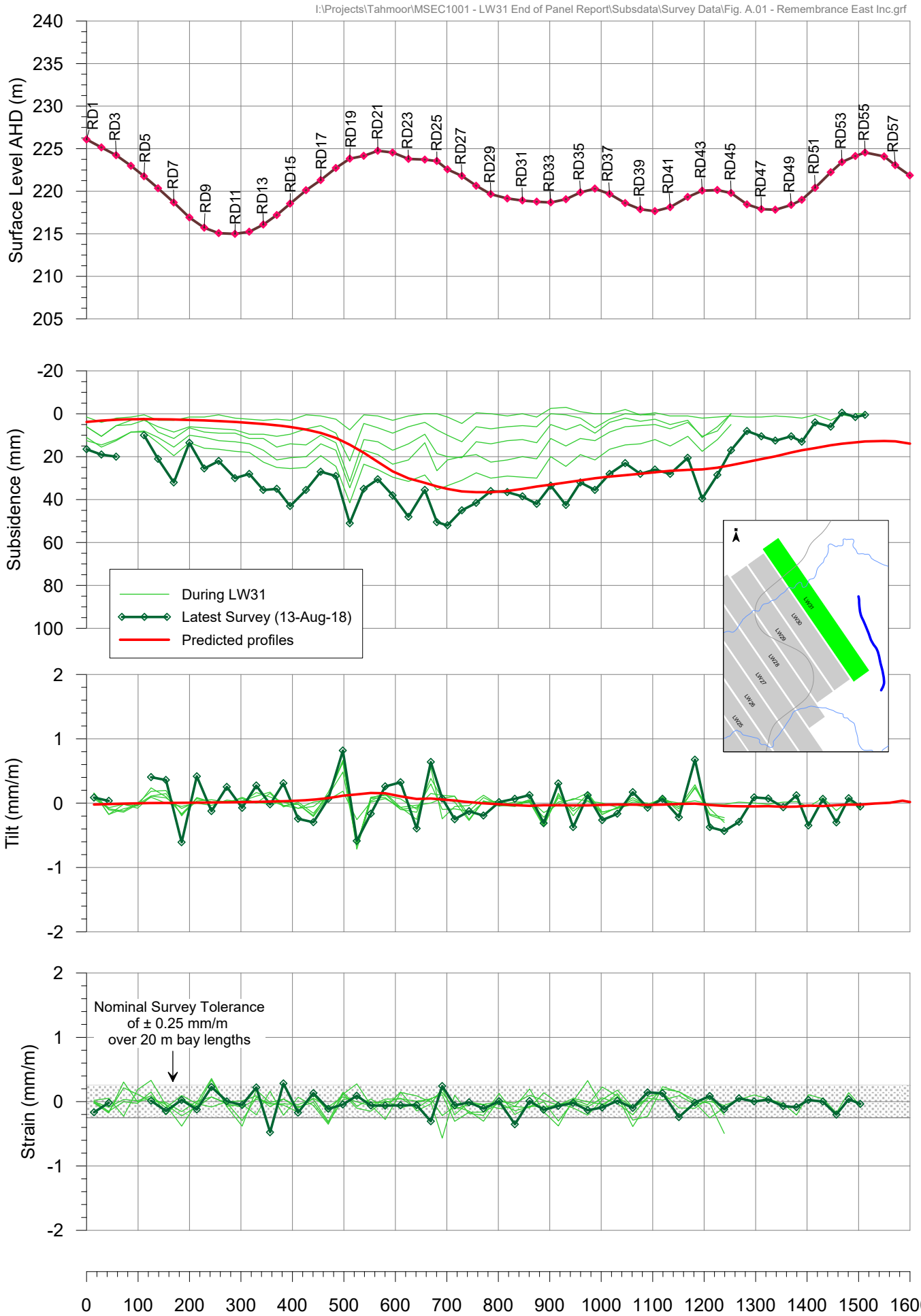
All structures remained safe and serviceable during the mining of Longwall 31.

In relation to Redbank Creek, there was a reasonable correlation between predicted and observed incremental valley closure movements due to the mining of Longwall 31.

Cracking was observed in Redbank Creek and pools were observed to drain at times of low flow, with sub-surface flow diversion observed to re-emerge downstream of Longwall 32. Some adverse changes in water quality were observed at times of low flow. The observed impacts are within predictions.

APPENDIX A. FIGURES

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Remembrance Drive



msec

Fig. A.01

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Bollard Place

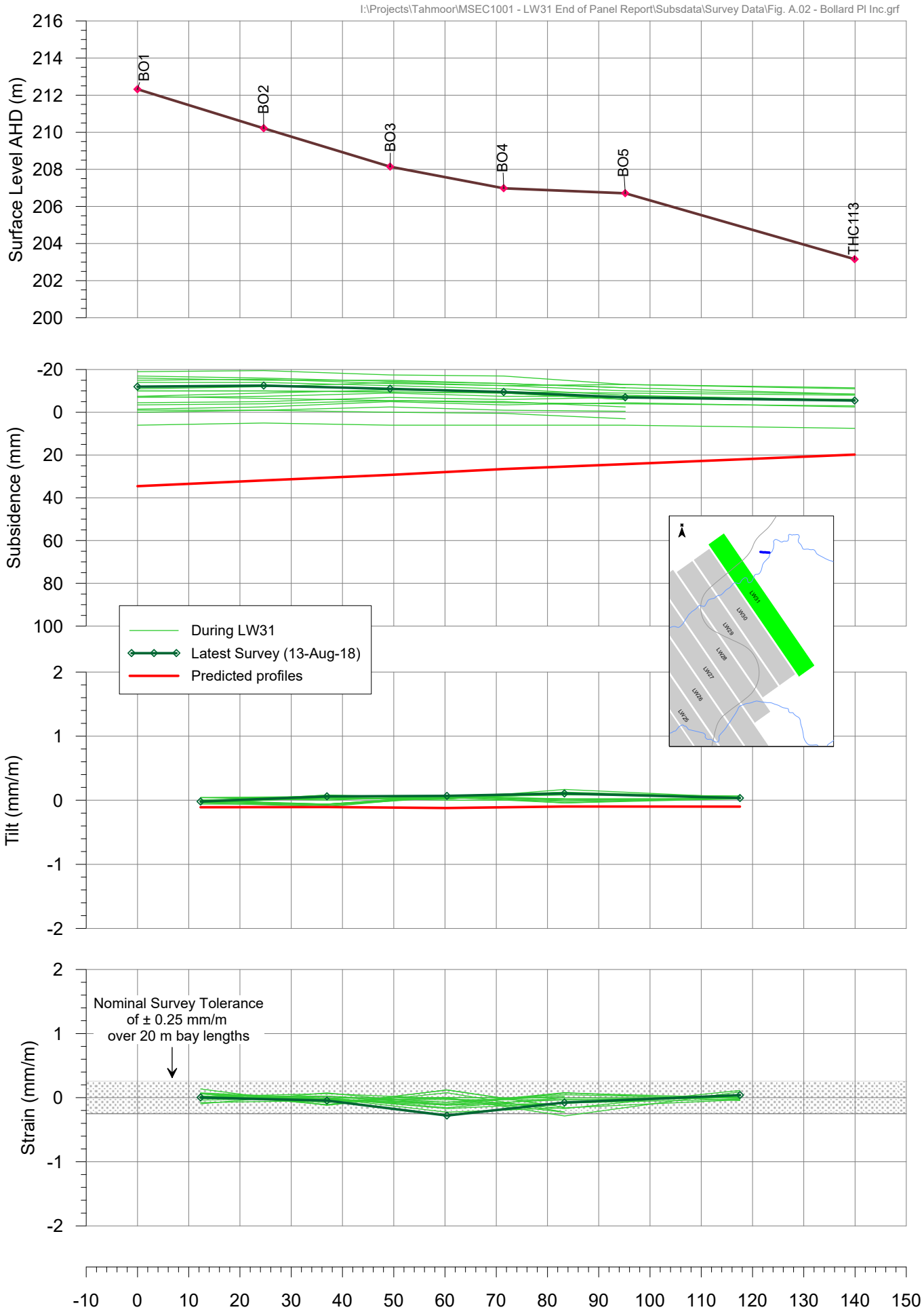


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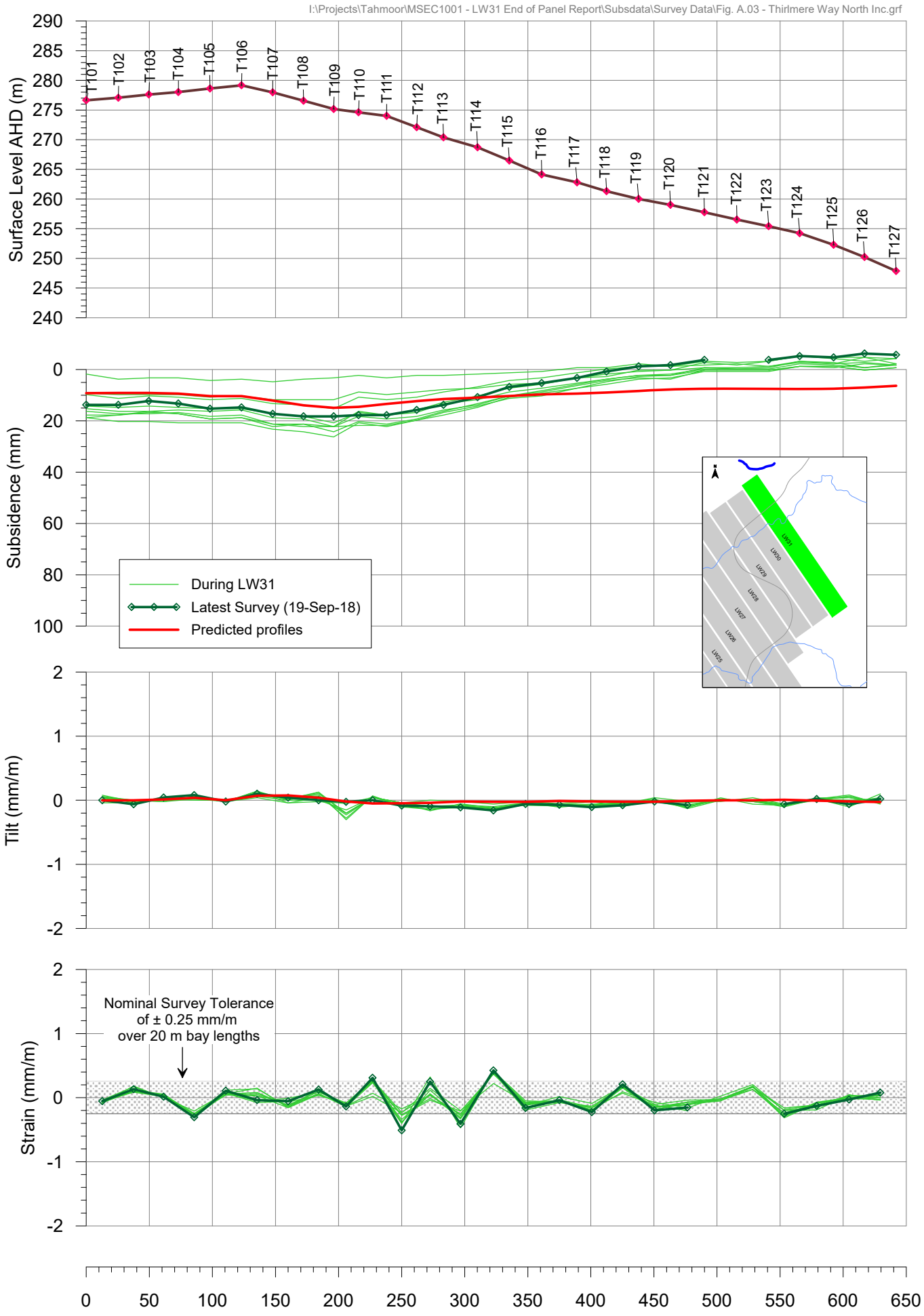
Fig. A.02

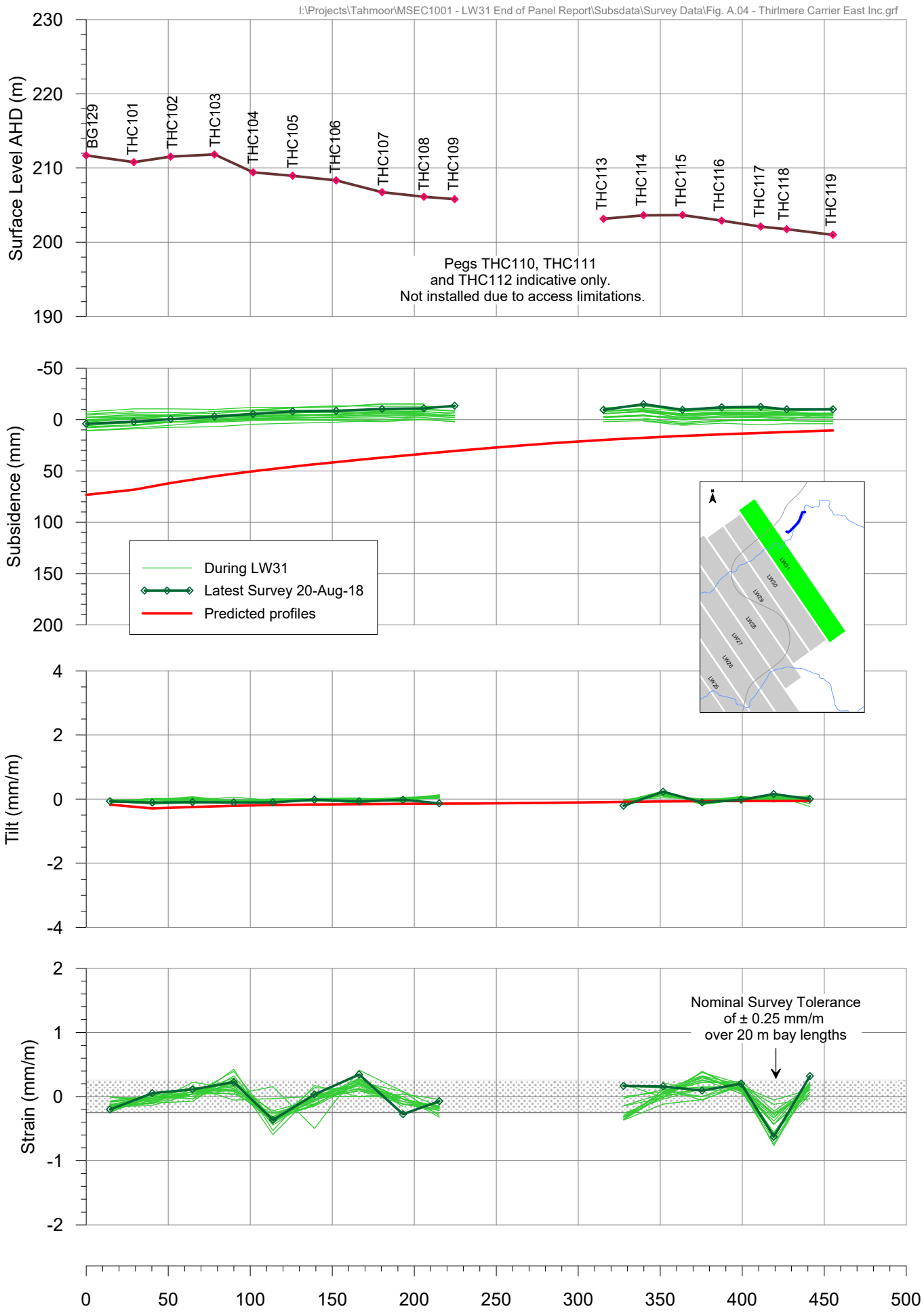
Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Thirlmere Way



msec

Fig. A.03

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Thirlmere Carrier (east)



msec

Fig. A.04

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along the Optical Fibre Line

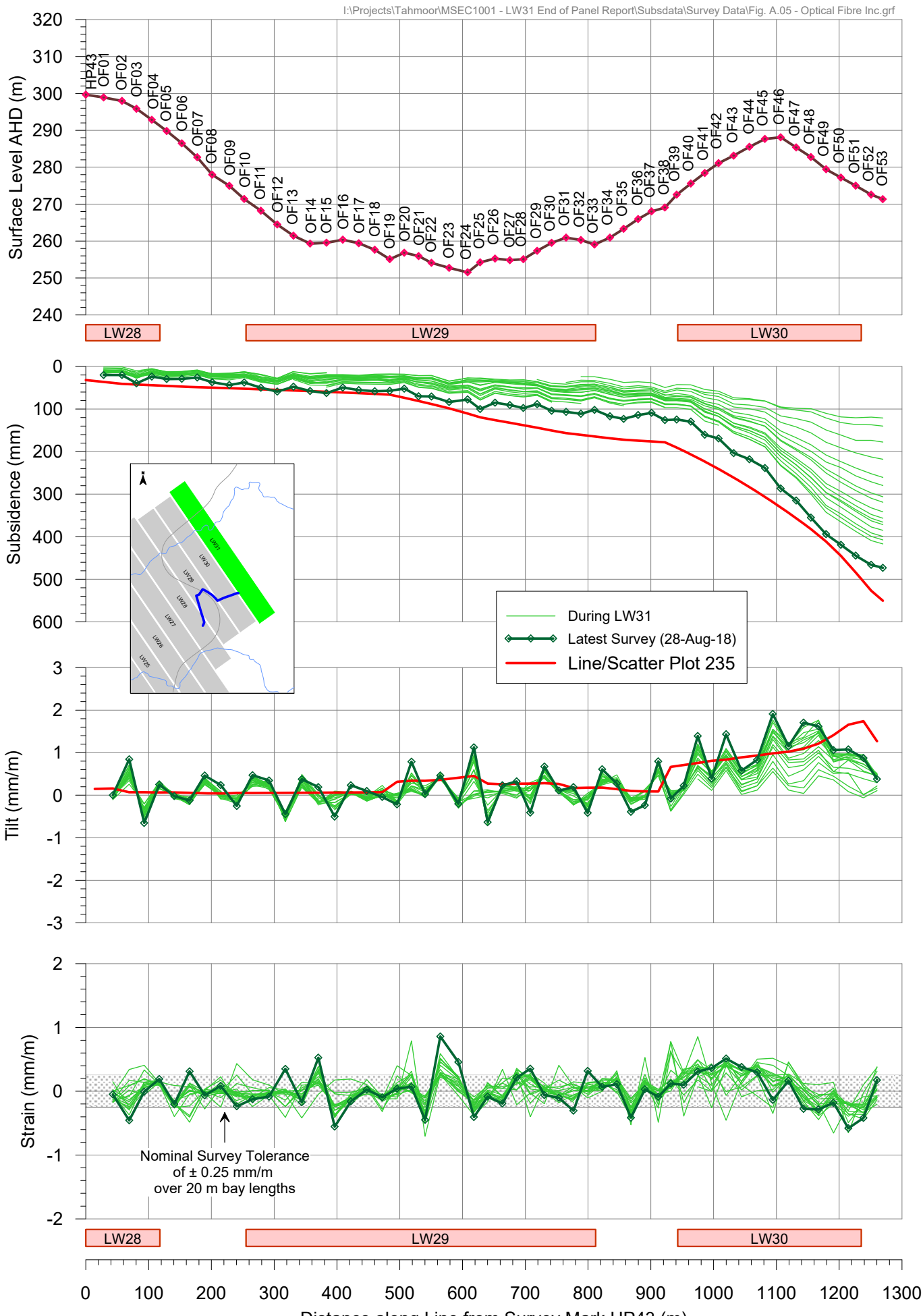


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Fig. A.05

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along the Optical Fibre Line

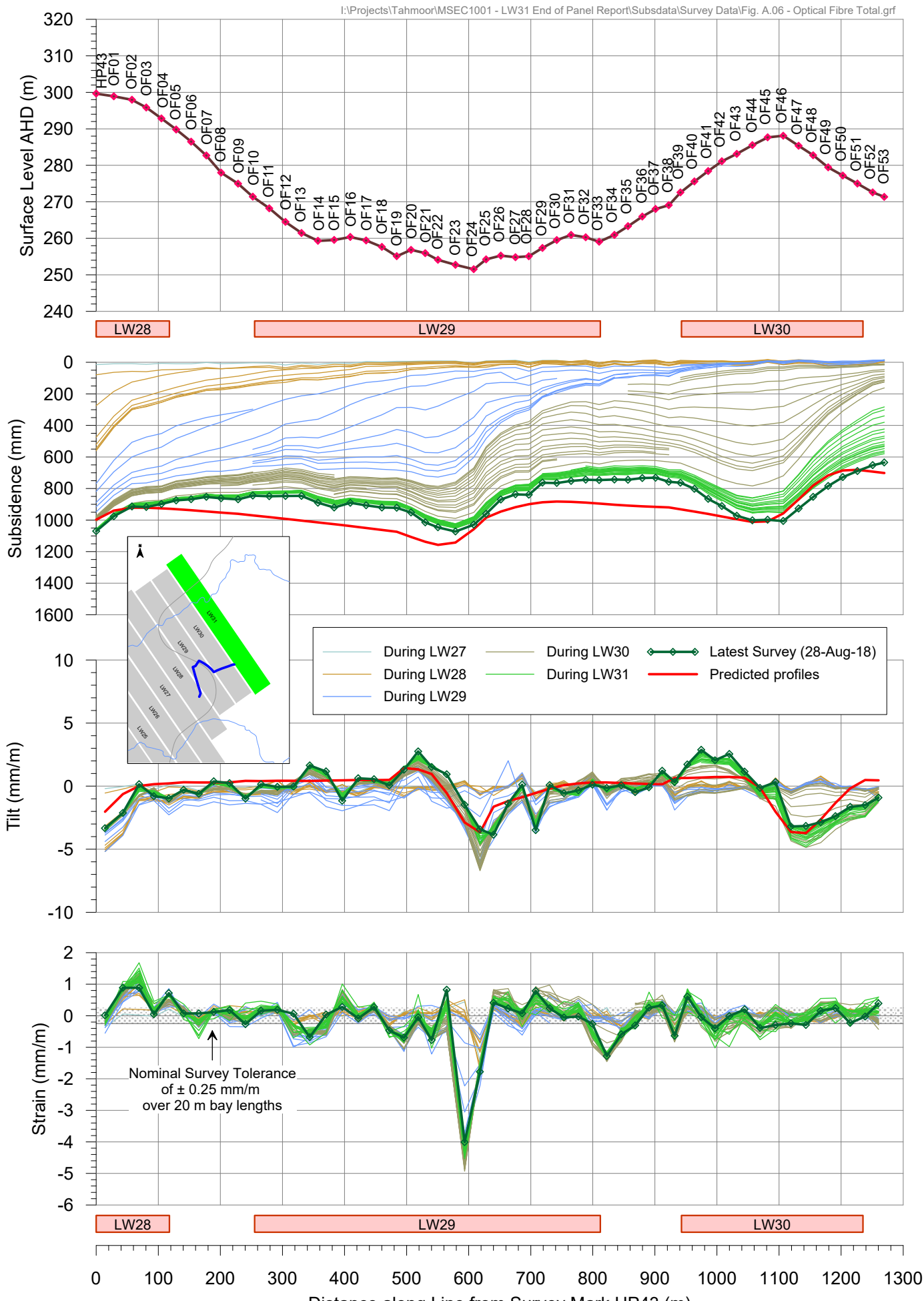
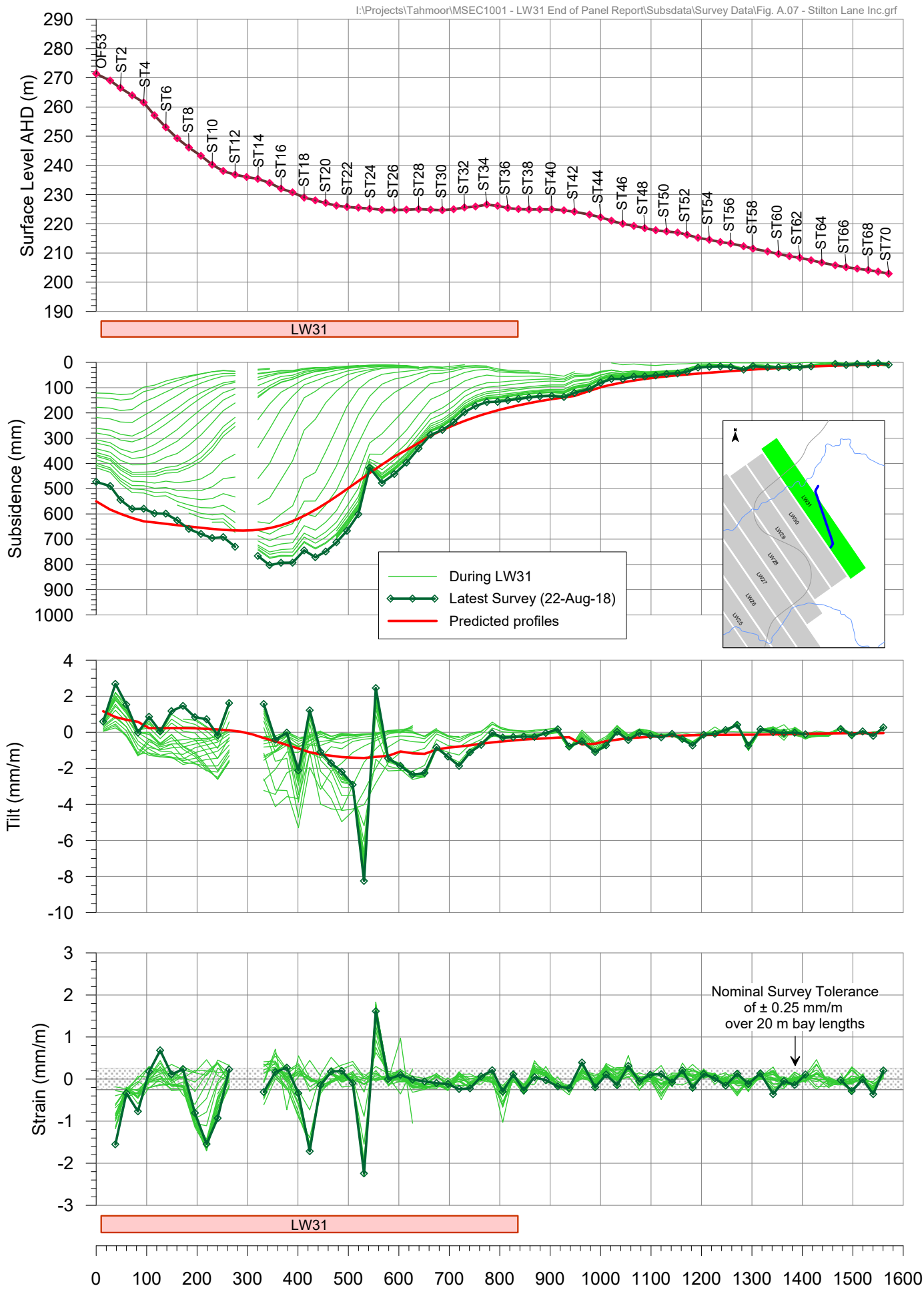


Fig. A.06

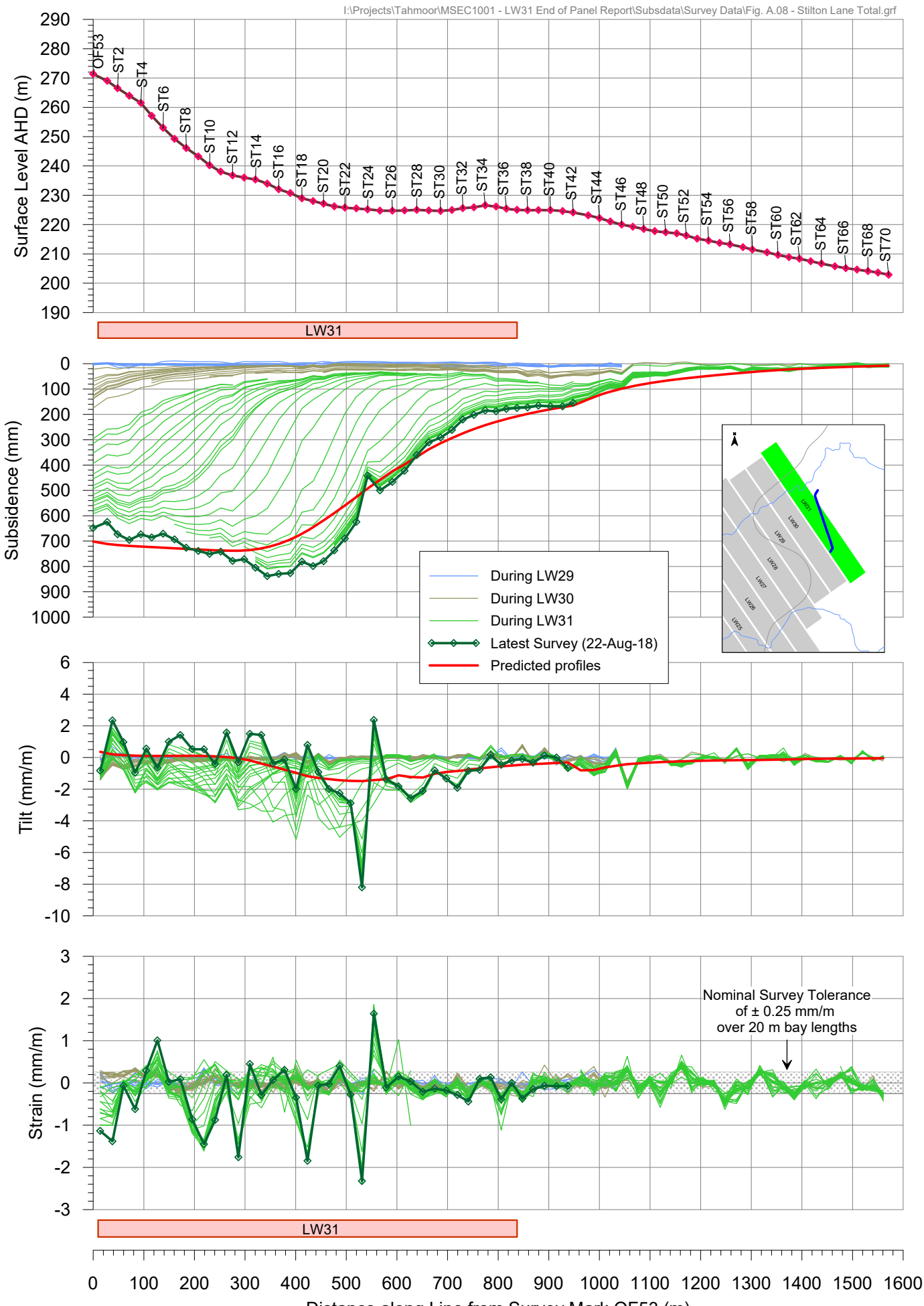
Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Stilton Lane



msec

Fig. A.07

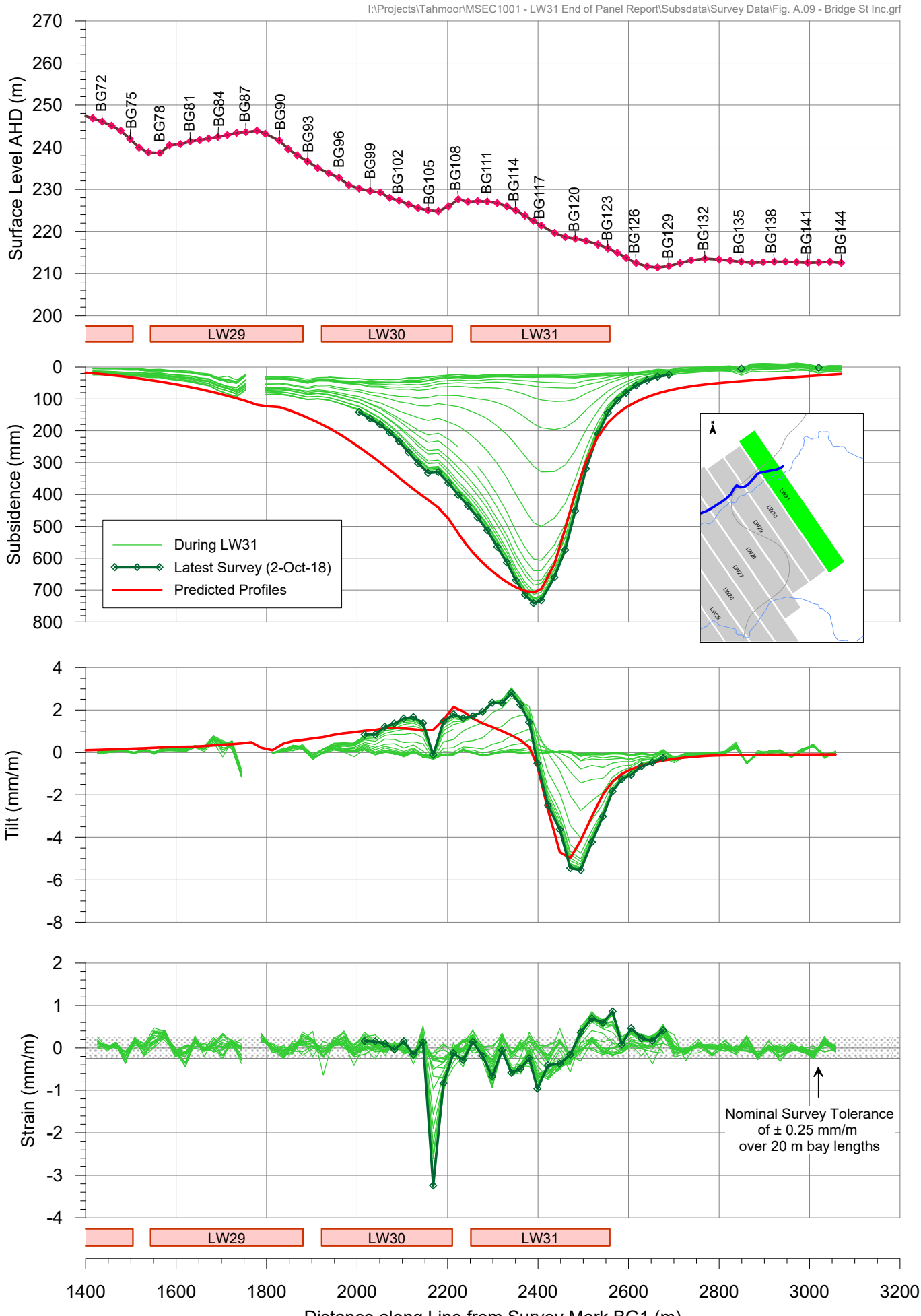
Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along Stilton Lane



msec

Fig. A.08

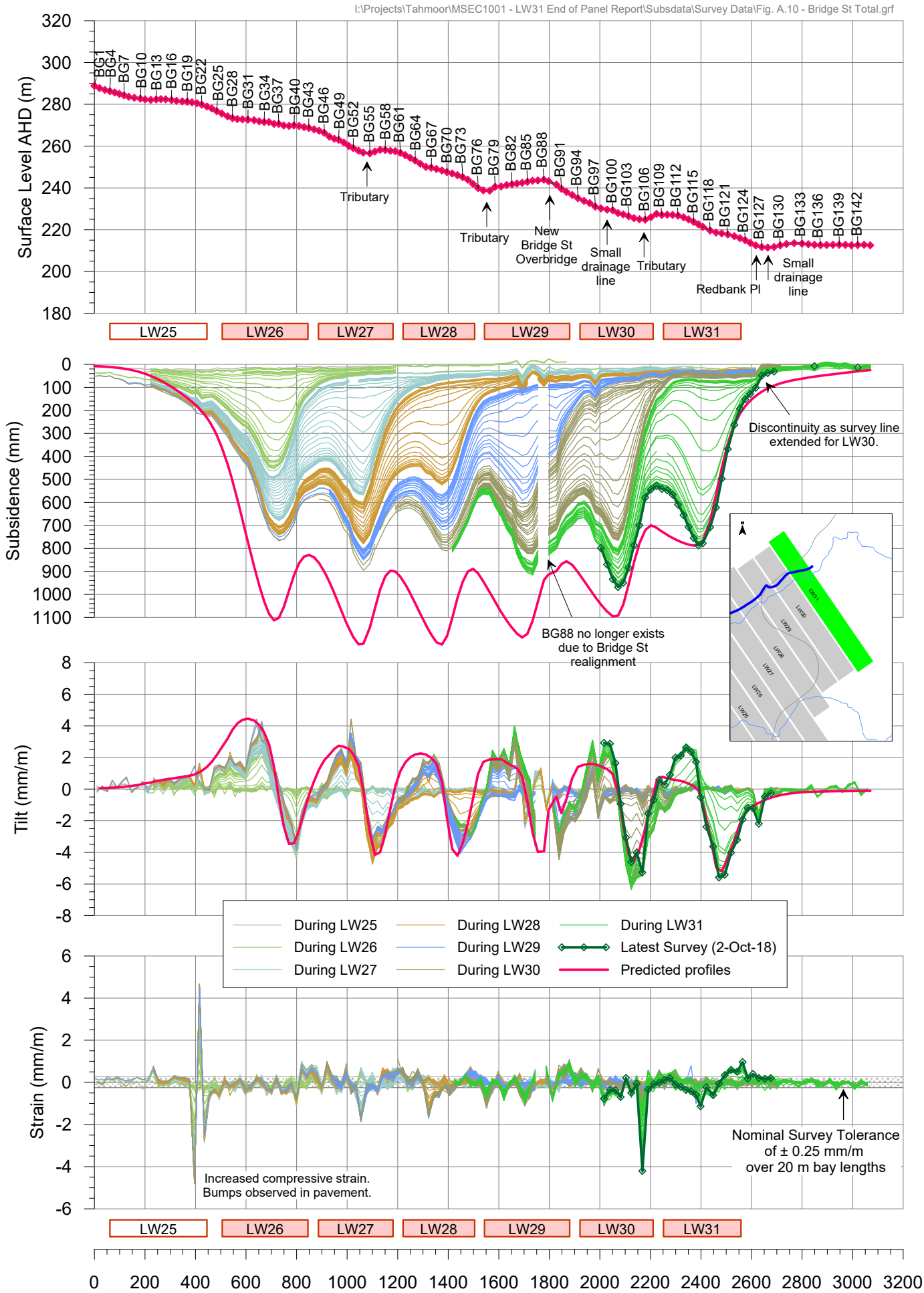
Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Bridge Street



msec

Fig. A.09

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along Bridge Street



msec

Fig. A.10

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Redbank Place

I:\Projects\Tahmoor\MSEC1001 - LW31 End of Panel Report\Subsdata\Survey Data\Fig. A.11 - Redbank Pl Inc.grf

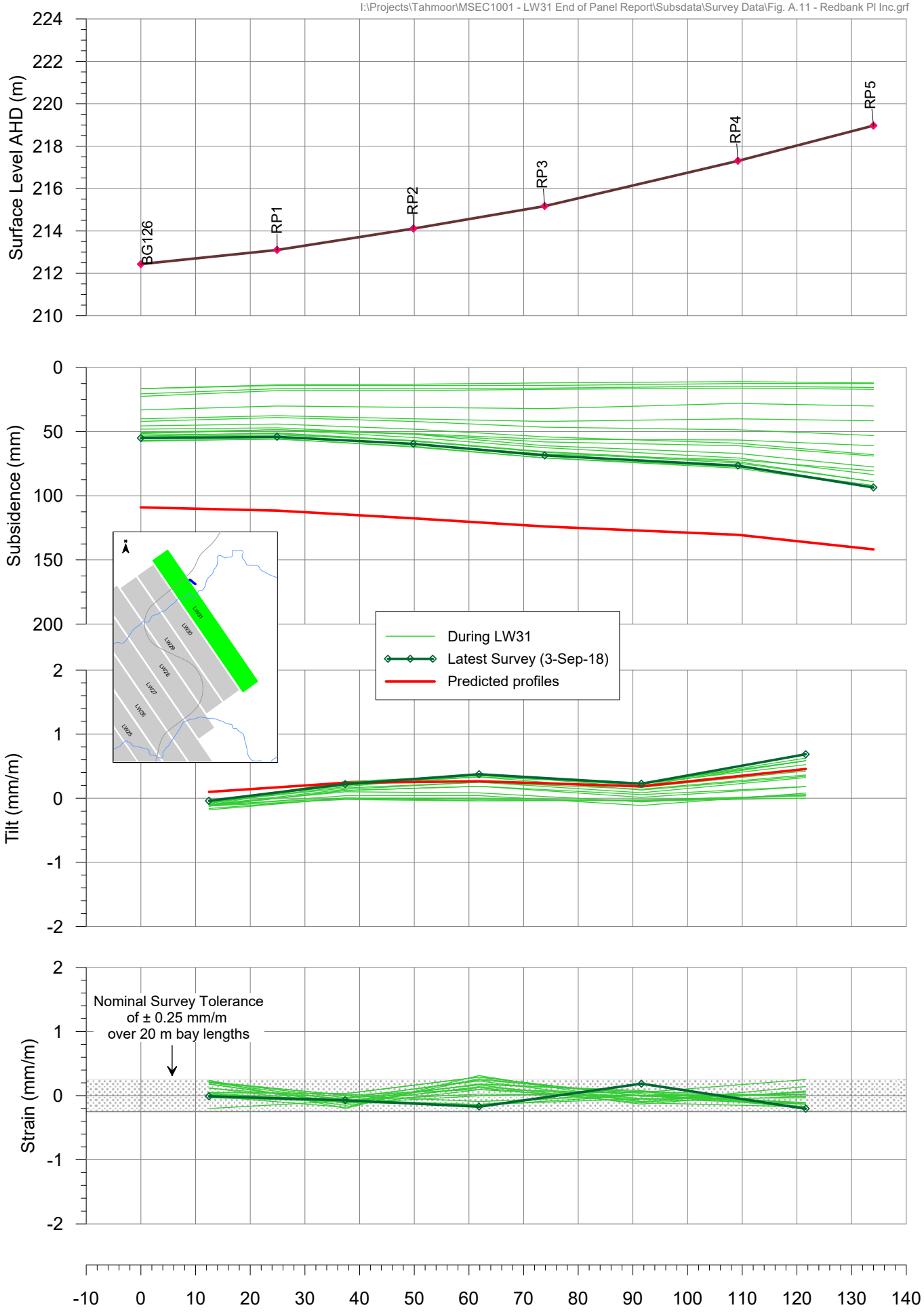


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Fig. A.11

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along Redbank Place

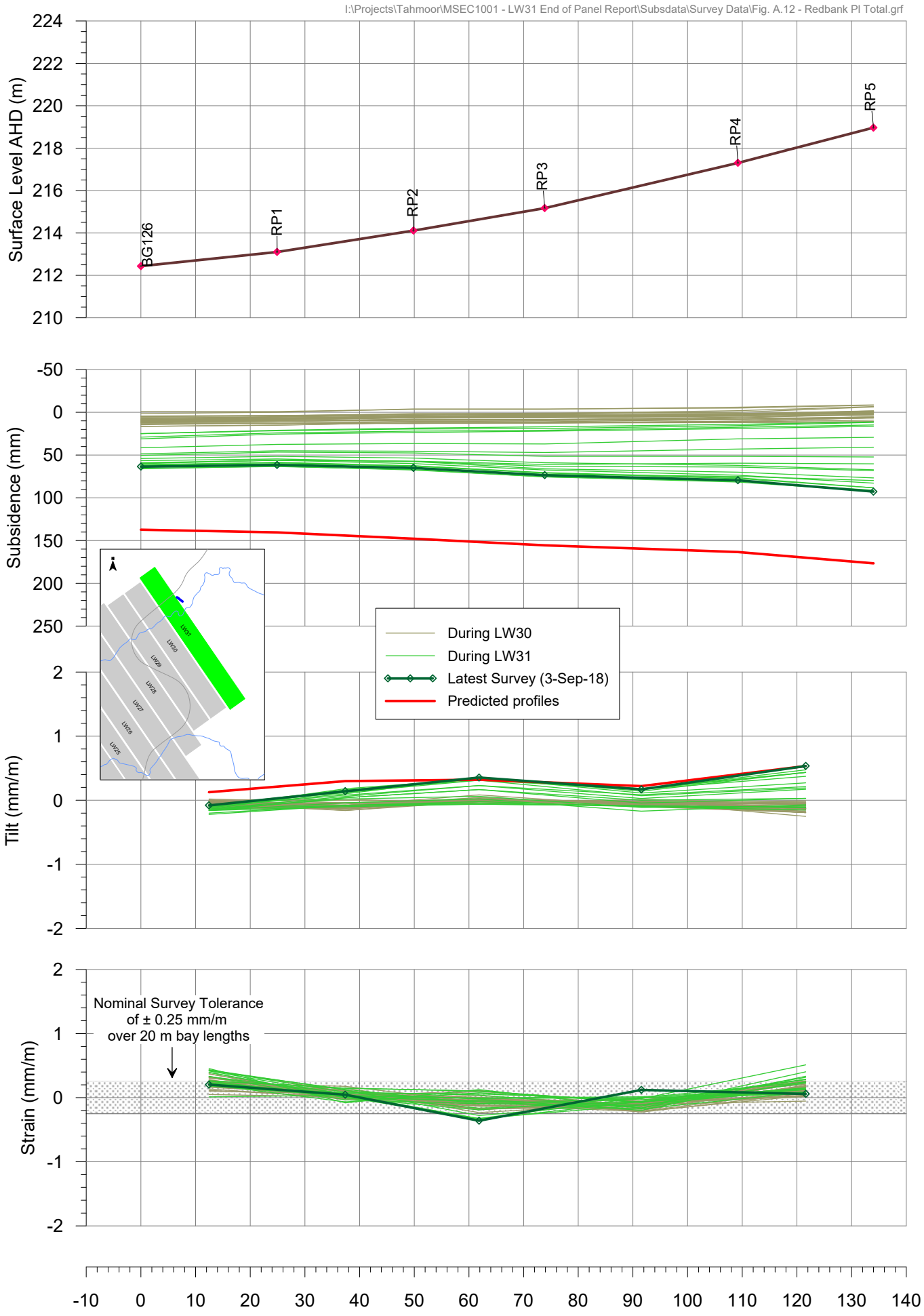

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Fig. A.12

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Thirlmere Carrier Pipe

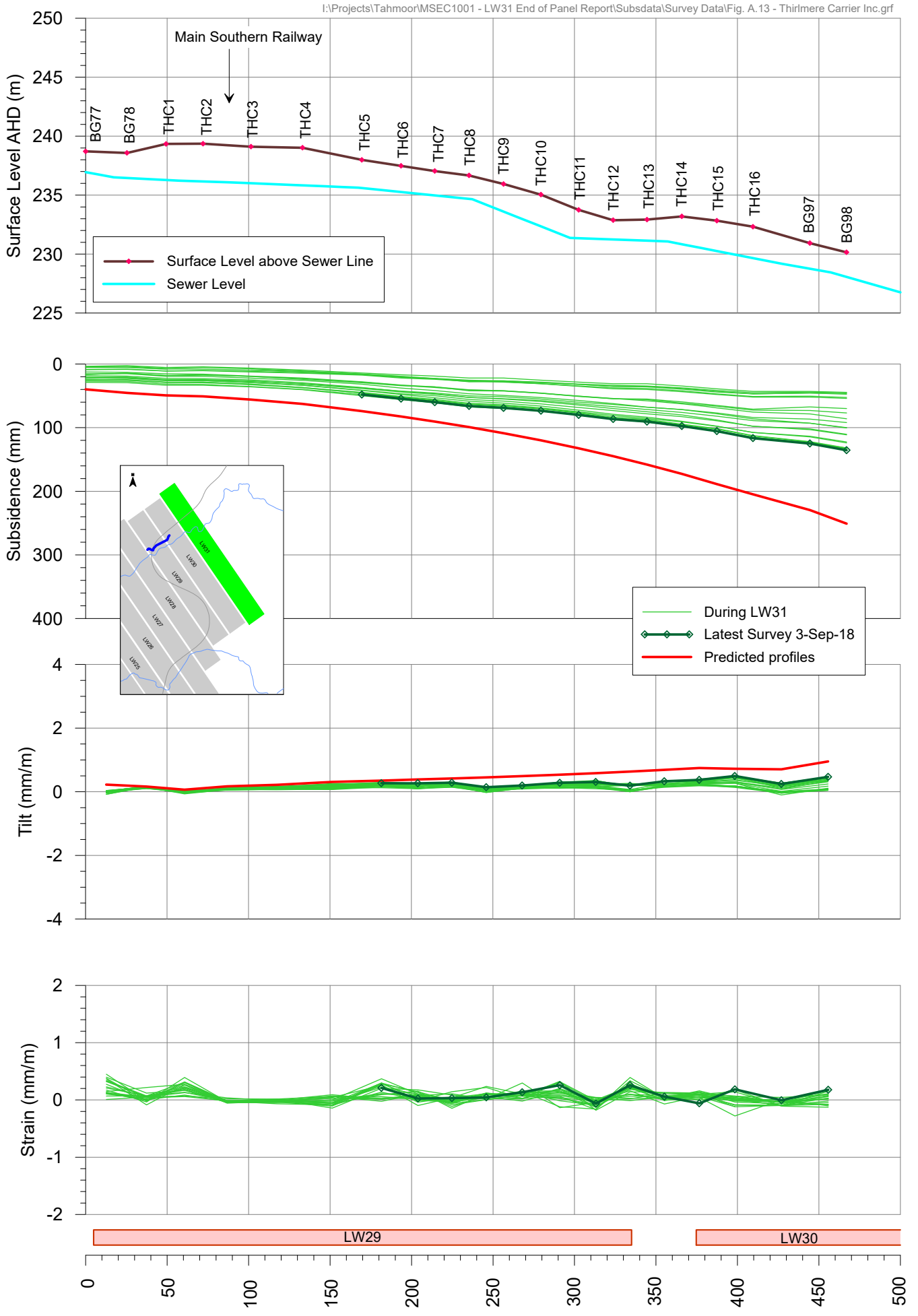
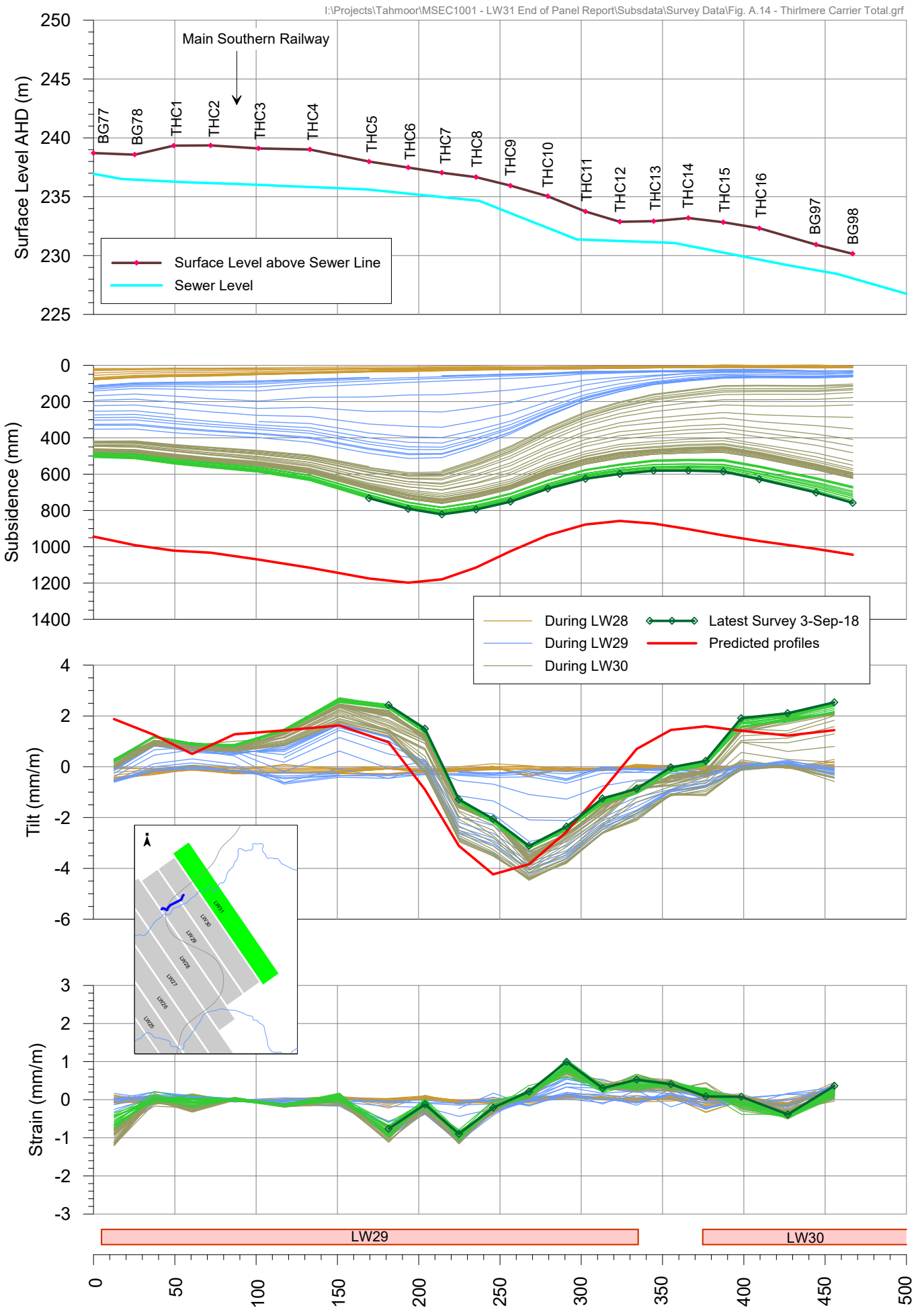


Fig. A.13

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles along Thirlmere Carrier Pipe



msec

Fig. A.14

Tahmoor Coking Coal Operations - Longwall 31
Relative 3D surveys along Redbank Creek RK Line (incremental)

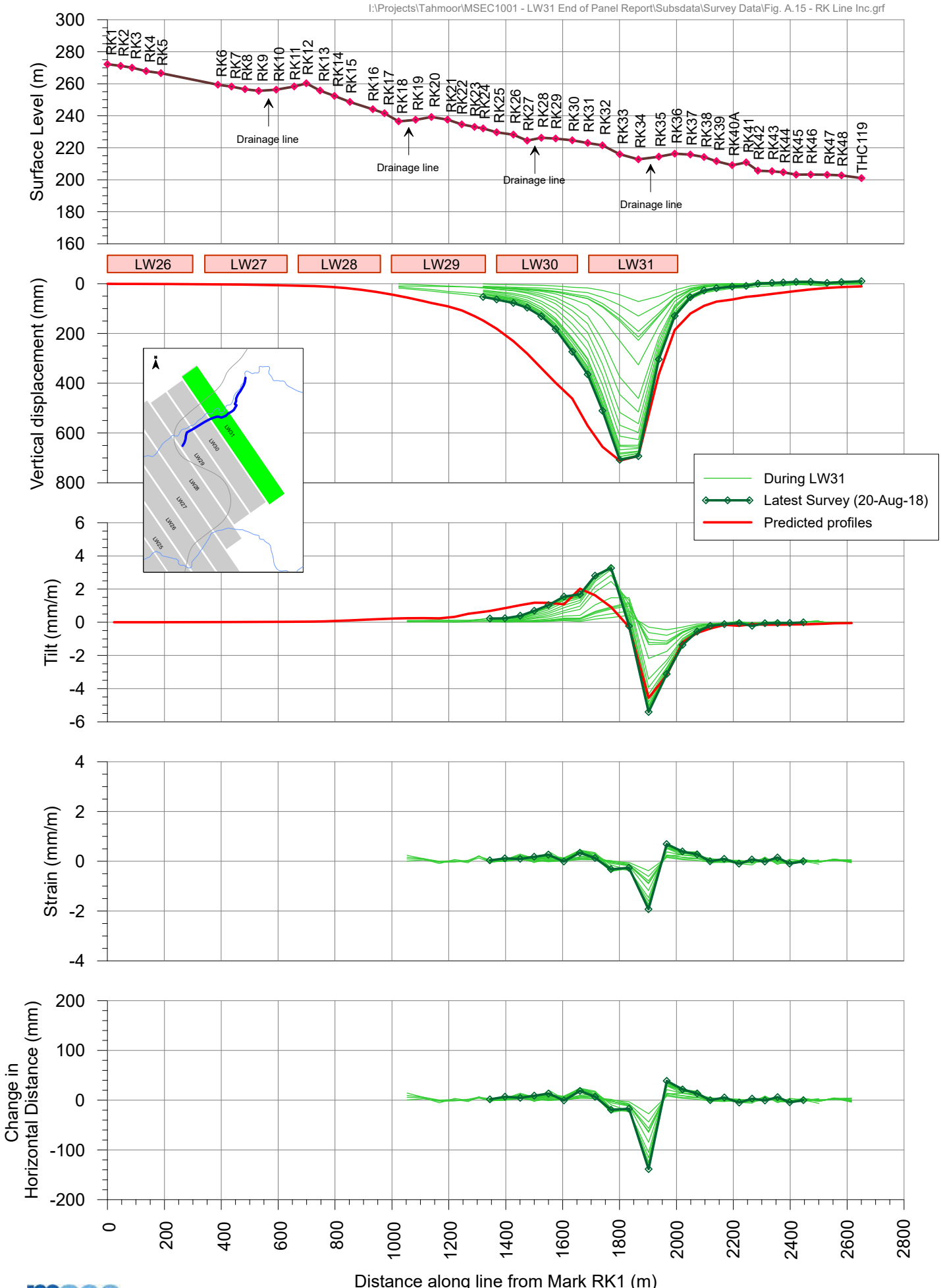


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Fig. A.15

Tahmoor Coking Coal Operations - Longwall 31
Relative 3D surveys along Redbank Creek RK Line (total)

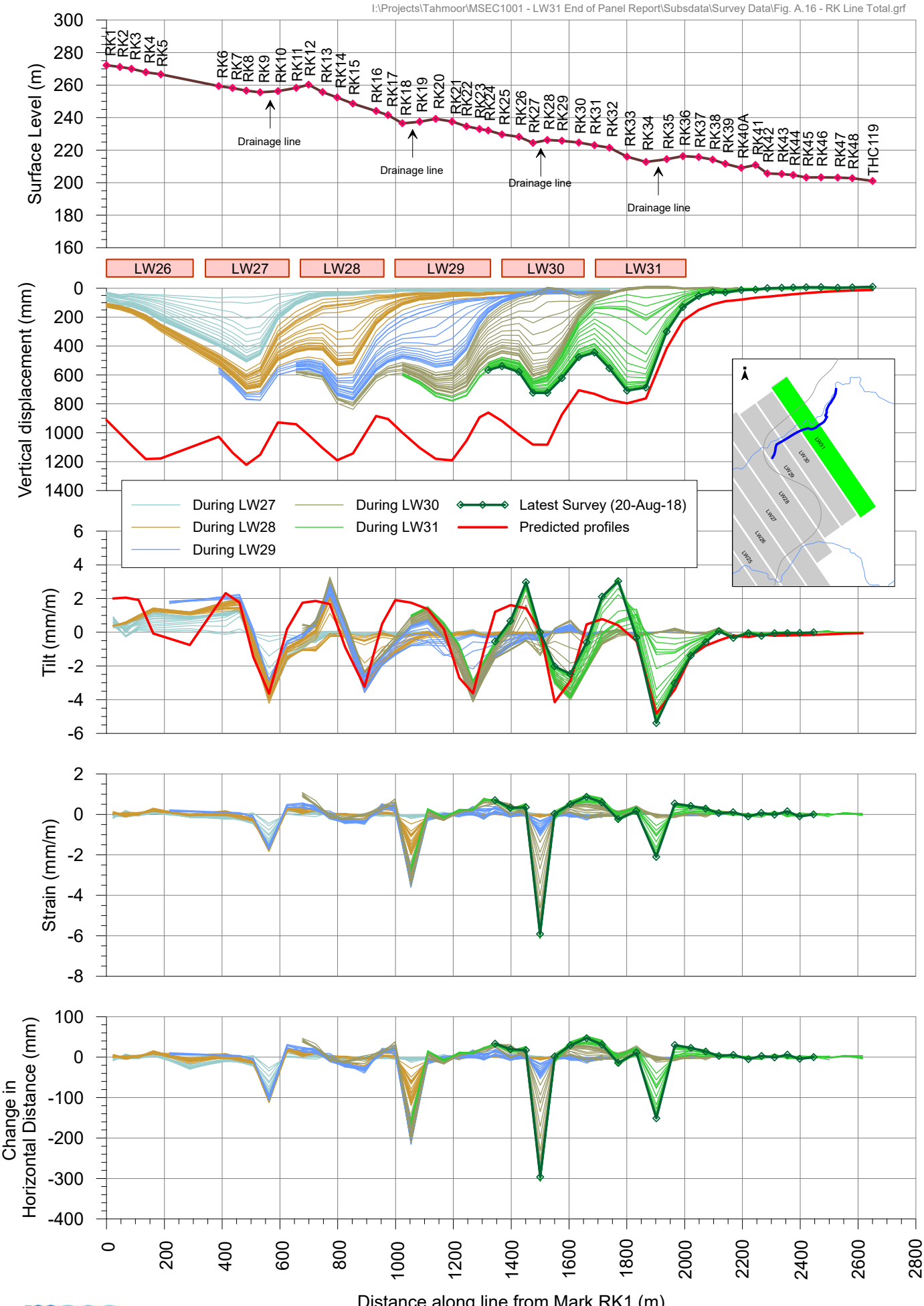

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Fig. A.16

Tahmoor Coking Coal Operations - Longwall 31
Relative 3D Surveys along Redbank Creek RY Line (incremental)

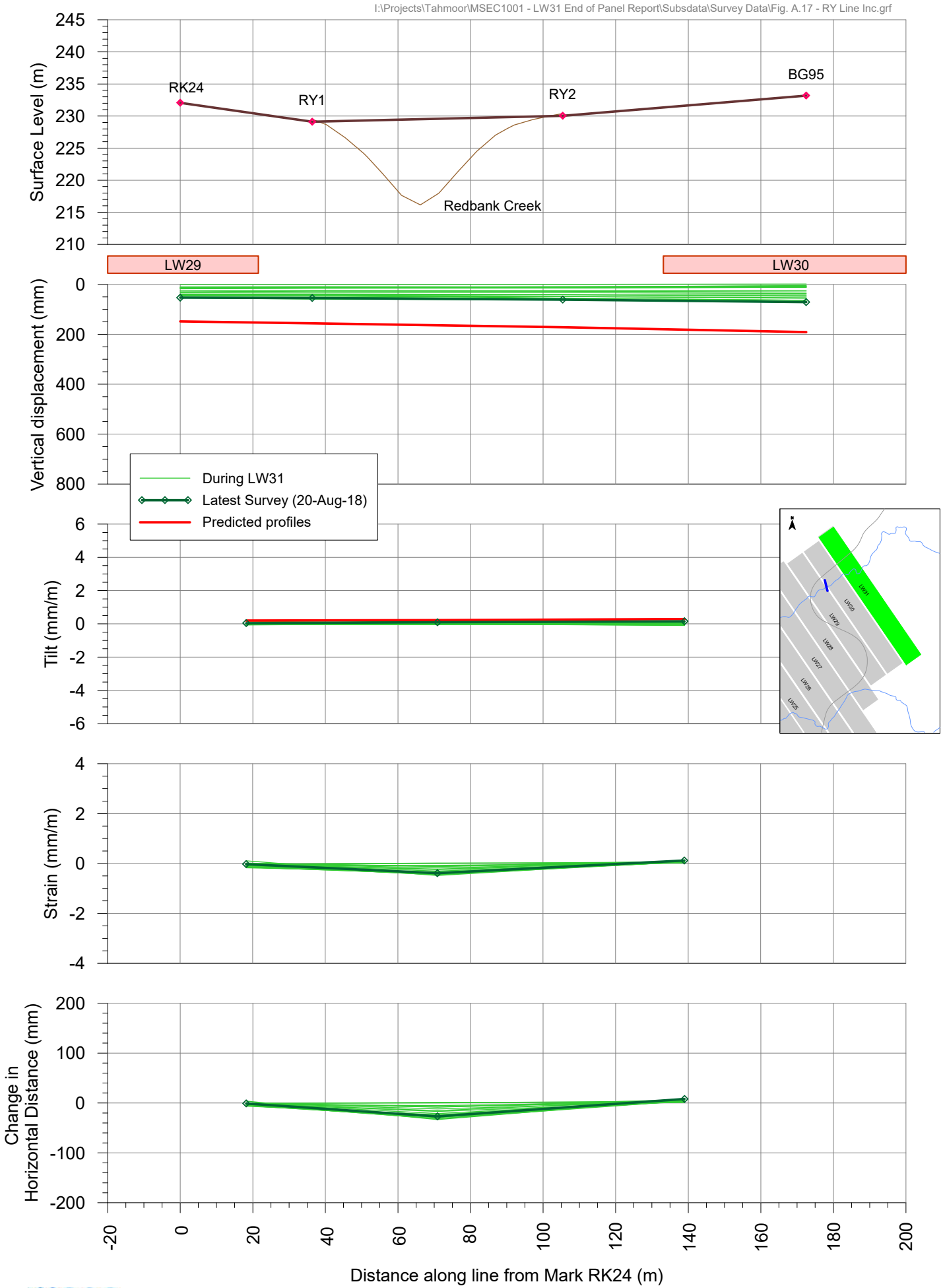

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Fig. A.17

Tahmoor Coking Coal Operations - Longwall 31
Relative 3D Surveys along Redbank Creek RY Line (total)

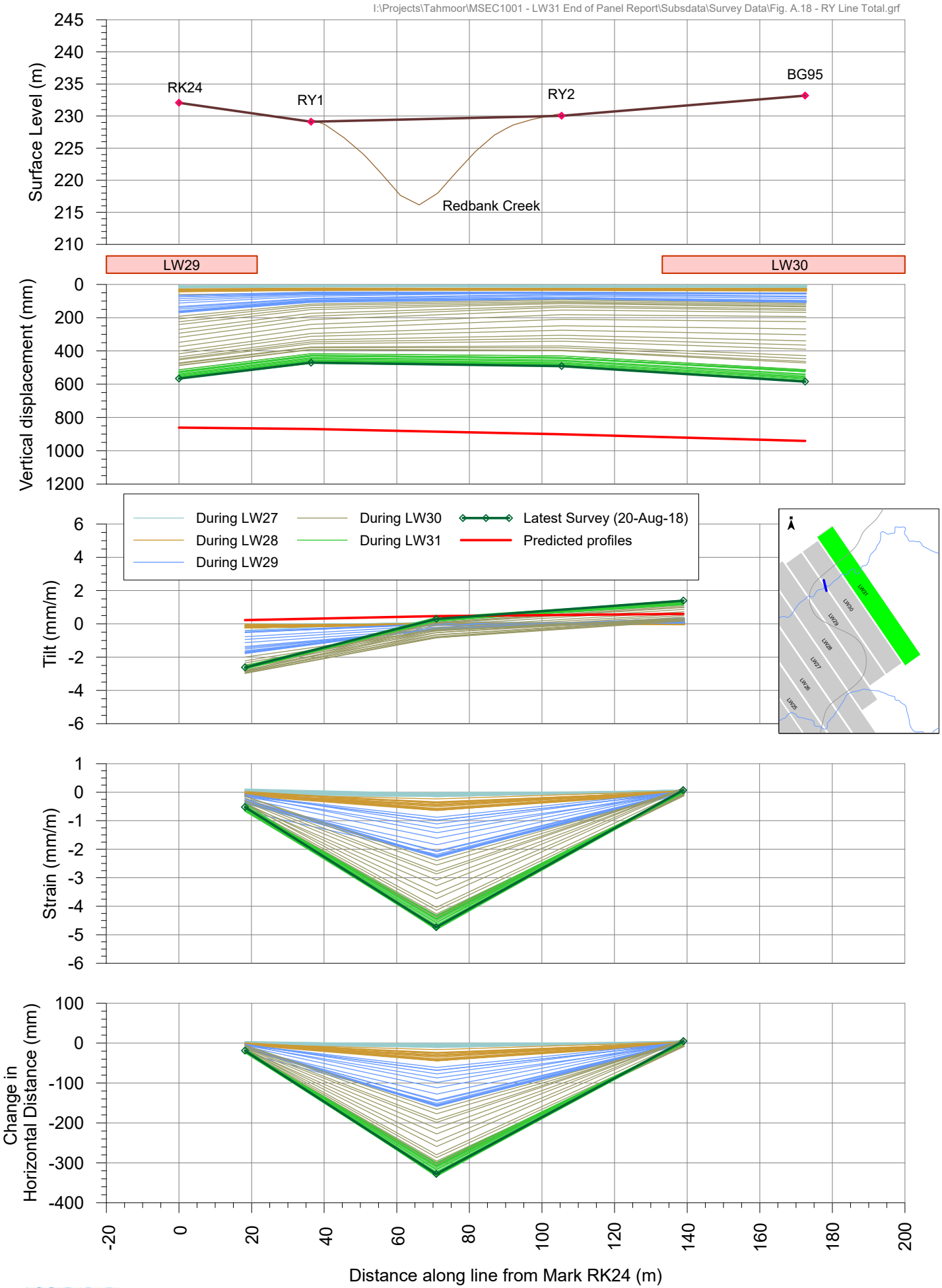

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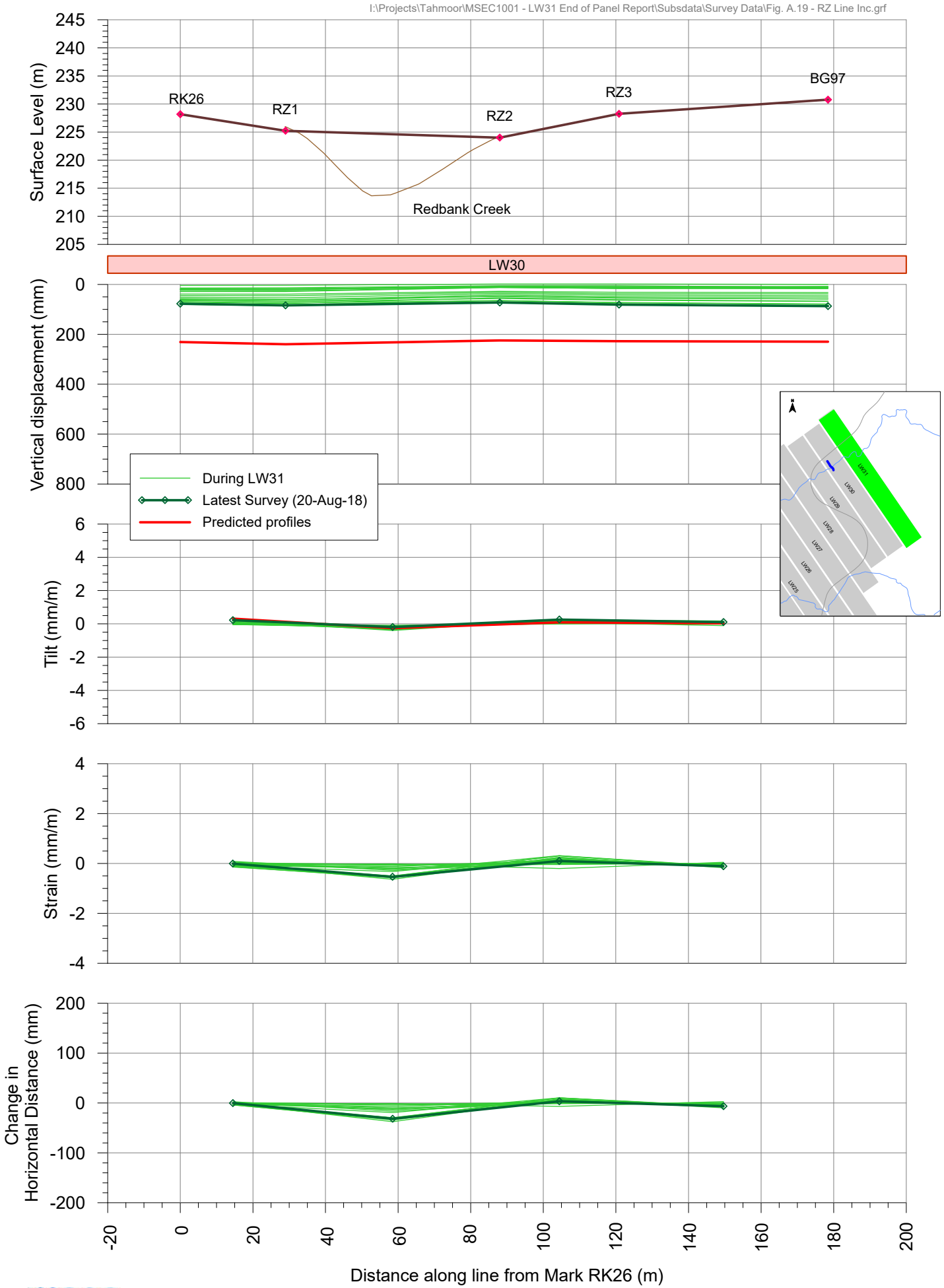
Fig. A.18

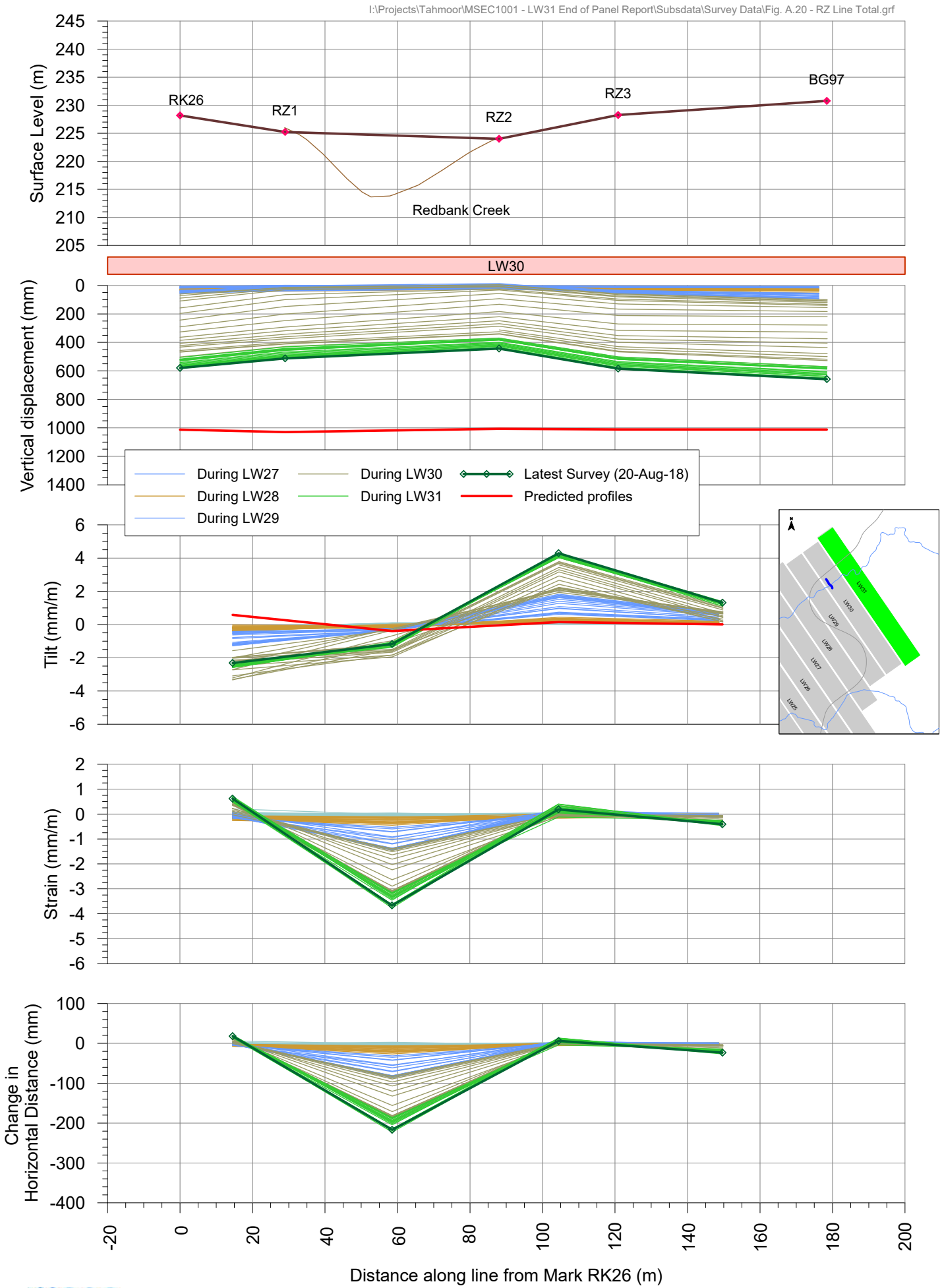
Tahmoor Coking Coal Operations - Longwall 31
Relative 3D Surveys along Redbank Creek RZ Line (incremental)



msec

Fig. A.19

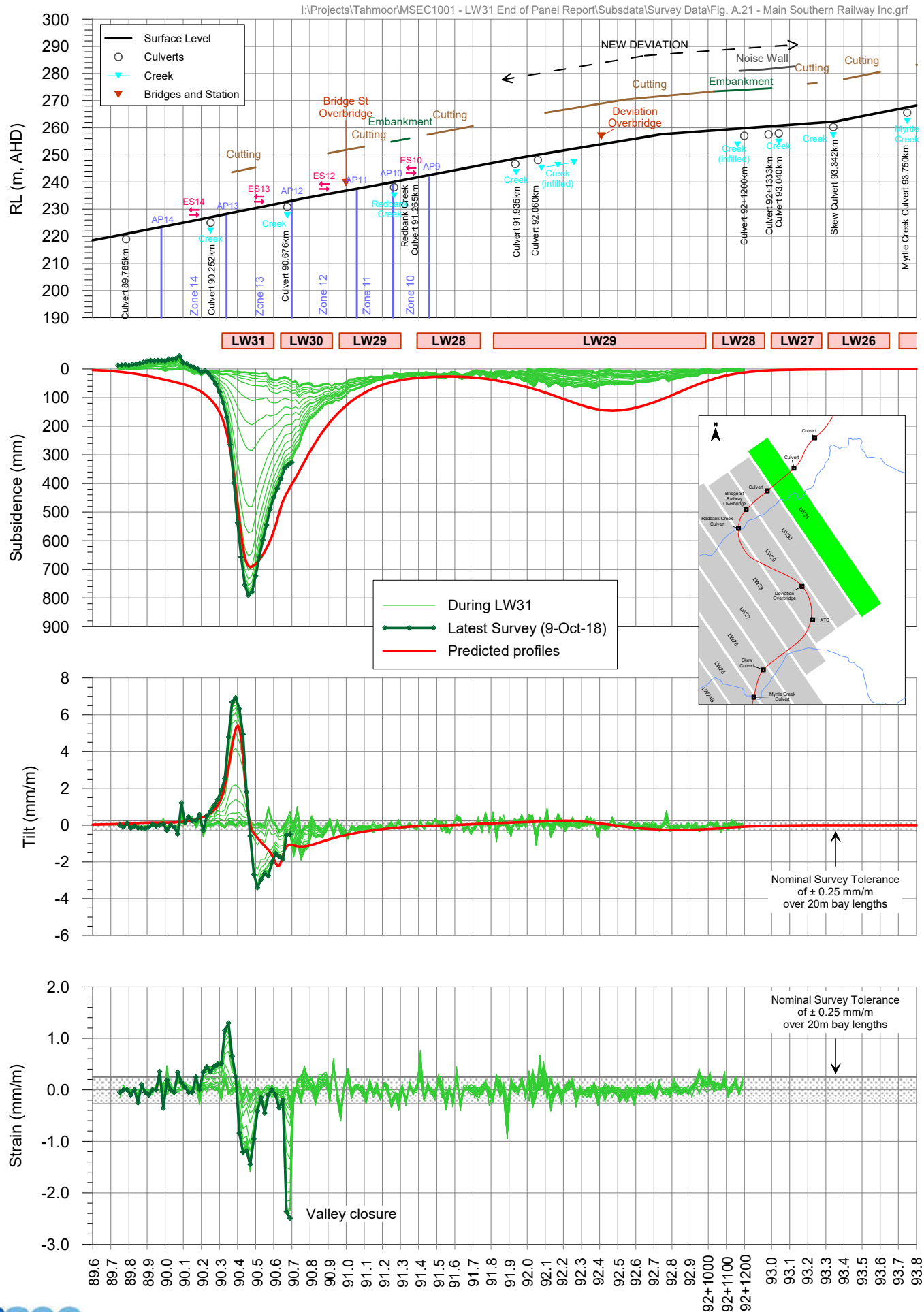
Tahmoor Coking Coal Operations - Longwall 31
Relative 3D Surveys along Redbank Creek RZ Line (total)



msec

Fig. A.20

Tahmoor Coking Coal Operations - Longwall 31
Incremental Subsidence Profiles along Main Southern Railway



msec

Fig. A.21

Tahmoor Coking Coal Operations - Longwall 31
Total Subsidence Profiles Main Southern Railway

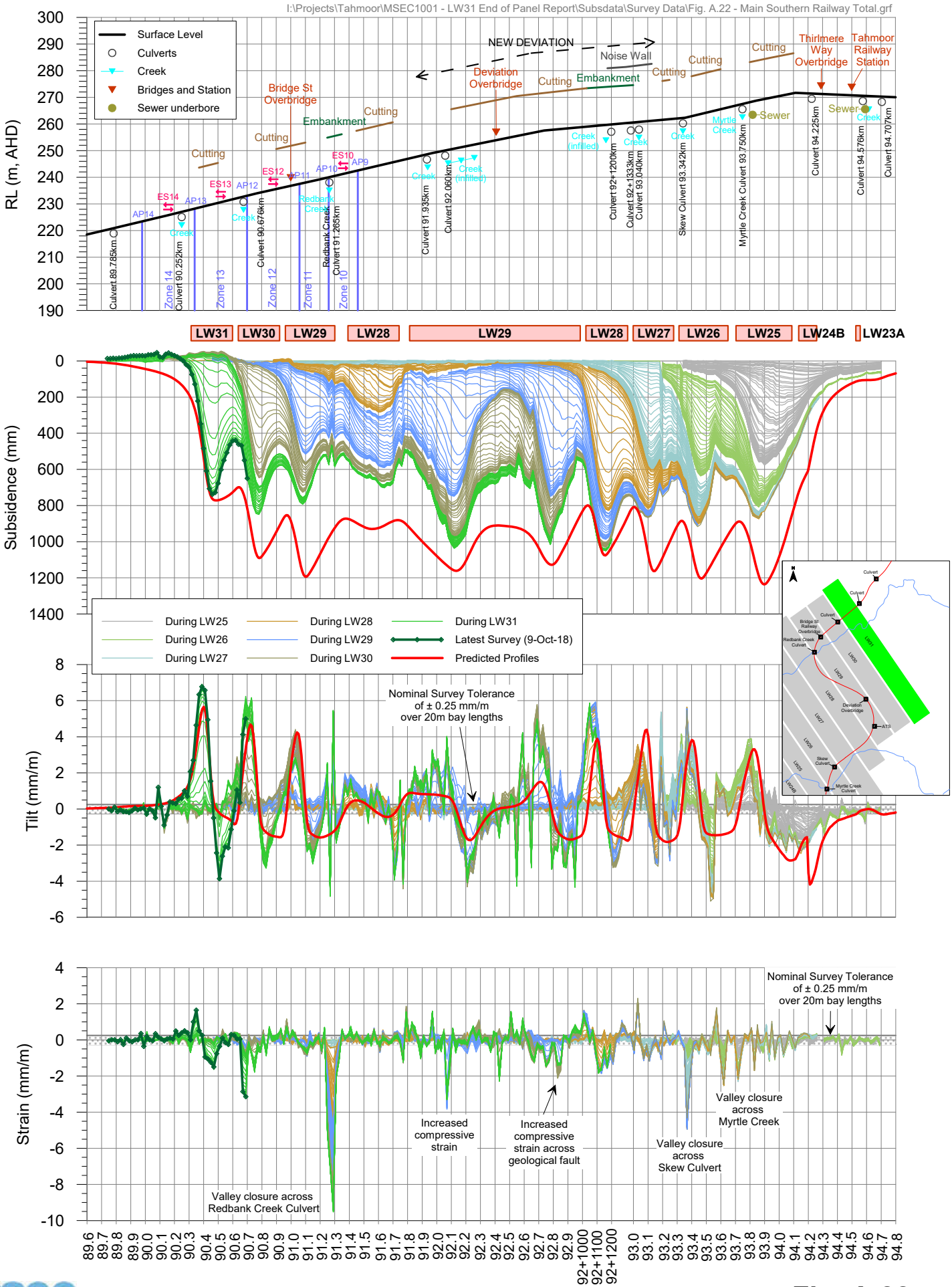


Fig. A.22

APPENDIX B. DRAWINGS

I:\Projects\Tahmoor\MSEC1001 - LW31 End of Panel Report\AcadData\MSEC1001-01 Monitoring LW31.dwg

msec mine subsidence ENGINEERING CONSULTANTS
Suite 402, 13 Spring Street, Chatswood NSW 2067
PO Box 302, Chatswood NSW 2057
Tel +61 2 9413 3777
www.minesubsidence.com

TAHMOOR COKING COAL OPERATIONS

SIMEC MINING Tahmoor Coking Coal

TAHMOOR NORTH - LW31
MONITORING OVER LW31

DATE:	SCALE:	DRAWING No:	Rev No
26 Mar 2019	1:15000	MSEC1001-01	A

277 500 278 000 278 500 279 000

Grid to MGA co-ordinates

6 214 500 6 214 000 6 213 500 6 213 000 6 212 500 6 212 000 6 211 500 6 211 000

THIRLMERE WAY
RUMKER ST
ARGYLE ST
BRIDGE ST
BOLLARD PL
REDBANK PL
REDBANK CREEK
HENRY ST
STILTON LN
REMEMBRANCE DRIVEWAY
MAIN SOUTHERN RAILWAY
MYRTLE CREEK

LW 31
LW 30
LW 29
LW 28
LW 27
LW 26

PREDICTED 20mm SUBSIDENCE CONTOUR DUE TO LW31
35° ANGLE OF DRAW LW31

623338 623348 623344 623346 628465 628632 628573 805777 805778 628027 628623 628482 628485

Refer Railway diagram for details (MSEC863-03)

Dam removed 2016

Myrtle Creek Bridge

LEGEND
- Existing Monitoring Lines
- Future Monitoring Lines
- Surveys During LW31
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

I:\Projects\Tahmoor\MSEC1001 - LW31 End of Panel Report\AcadData\MSEC1001-02 Redbank Creek Subsidence.dwg

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TAHMOOR COKING COAL OPERATIONS

SIMEC MINING Tahmoor Coking Coal

REDBANK CREEK LINES
OBSERVED INCREMENTAL SUBSIDENCE
AND CHANGES IN HORIZONTAL DISTANCE
DURING LONGWALL 31

DATE:	SCALE:	DRAWING No:	Rev No
11 Mar 2019	Not to Scale	MSEC1001-02	A

Subsidence
72 mm (colour scale as shown)
Change in horizontal distance between survey marks
mm Closure
mm Opening

0 20 50 100 200 300 400 500 600 700 800 900 1000 1200 1400

LW31
LW30
LW29
LW28
BOLLARD PL
REDBANK PL
BRIDGE ST
HENRY ST
STILTON LN
N

I:\Projects\Tahmoor\MSEC1001 - LW31 End of Panel Report\AcadData\MSEC1001-03 Redbank Creek Horizontal Movement.dwg

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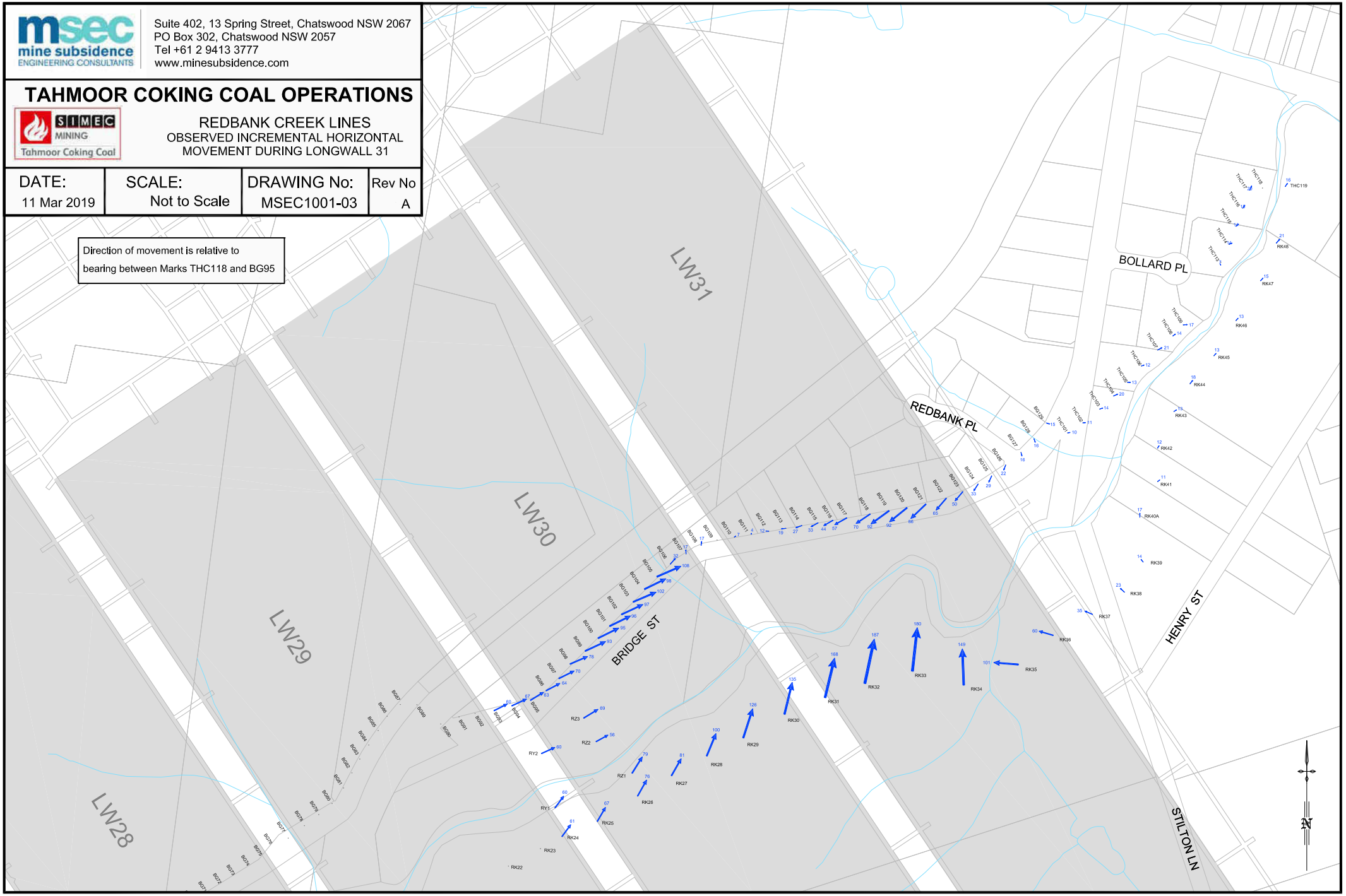
TAHMOOR COKING COAL OPERATIONS

SIMEC MINING Tahmoor Coking Coal

REDBANK CREEK LINES
OBSERVED INCREMENTAL HORIZONTAL MOVEMENT DURING LONGWALL 31

DATE:	SCALE:	DRAWING No:	Rev No
11 Mar 2019	Not to Scale	MSEC1001-03	A

Direction of movement is relative to bearing between Marks THC118 and BG95



GeoTerra

Tahmoor Colliery

Longwall 31
Surface Water, Dams and Groundwater
End of Panel Monitoring Report

TA31-R1A

21 March, 2019

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Tahmoor Coal Pty Ltd
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PO Box 100
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Attention: Ron Bush

Ron,

RE: Tahmoor Coking Coal Operations End of Longwall 31 Surface Water, Dams and Groundwater Monitoring Report

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)
Principal Hydrogeologist / Geochemist

Distribution:	Original	GeoTerra Pty Ltd
	1 electronic copy	Tahmoor Colliery
	1 electronic copy	MSEC Pty Ltd

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Name	Andrew Dawkins
Signature	
Position	Principal Hydrogeologist / Geochemist

Date	Rev	Comments
20/03/2019		Initial draft
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Executive Summary

The following table summarises the potential and observed effects on Redbank Creek as well as the Tahmoor North dams and groundwater systems within the Longwall 31, 20mm subsidence zone, and the observed effects due to subsidence related to extraction of the subject longwall and previous longwalls.

Potential Impacts	Observed Impacts Due to Extraction of Longwall 31
Surface Water	
Bedrock cracking and loss of plateau stream flow not anticipated in Redbank Creek or smaller gullies over Longwalls 22 to 30 due to mitigating effects of stream sediment cover	Stream bed cracking and loss of pool holding capacity has been observed in pools and stream reaches in Redbank Creek over LW's 25 to 32
No adverse ecological changes to plateau streams due to subsidence	No adverse effect on plateau stream ecology has been reported
Possible localised ponding may occur in plateau streams	No localised stream ponding due to subsidence has been observed
No adverse effects on plateau stream water quality anticipated	Increased salinity OVER AND downstream of the Redbank Creek subsidence zone, particularly at Sites RC3 and RC4, along with elevated iron, Total Nitrogen, Total Phosphorous, copper, zinc, nickel and manganese.
Plateau stream bed incision may occur	No plateau stream bed incision has been observed
Dams	
Subsidence, strain or tilting may cause adverse effects on dam walls or may affect dam storage capability	No dam wall cracking and no adverse effects on dam wall integrity or dam water storage reduction has been reported.
Groundwater	
Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	No adverse interconnection between aquifers and aquitards observed within 20m of the surface
Potential increased rate of recharge into the plateau	No increased rate of recharge into the plateau
Temporary lowering of regional phreatic water levels by up to 10m which may stay at that level until maximum subsidence develops	No lowering of shallow or phreatic open standpipe piezometer water levels greater than 10m due to Longwall 31
Groundwater levels should recover over a few months and no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	Previously depressurised open standpipe piezometers have gradually re-pressurised to similar, albeit lower pre-mining levels
The yield and serviceability in 1 NOW registered bore (P4) may be affected by subsidence	No private bores have been reportedly adversely affected by subsidence associated with Longwall 31
Horizontal displacement may make the private bore inaccessible	No private bores were reported to have been horizontally displaced in the Longwall 22 to 31 subsidence zone

Potential Impacts	Observed Impacts Due to Extraction of Longwall 31
Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels and increase the potential private bore yields	No private bores were reported to have been adversely affected by subsidence impacts associated with extraction of Longwall 31
Private bore groundwater may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	No private bores were reported to have been adversely affected by Fe / Mn precipitates associated with extraction of Longwall 31
Interface drainage, ferruginous, brackish seeps may be generated in streams on the plateau	Increased ferruginous and salinity levels have been observed over Longwall 29 - 32 in Redbank Creek
Increased groundwater seepage inflow into the Bulli Seam workings should not occur	No increase in groundwater inflow to the mine
Strata gas discharge into private bores may occur	No strata gas discharge into private bores has occurred

1. INTRODUCTION

Tahmoor Coking Coal Operations (TCCO) has extracted the Bulli Seam in Longwalls 22, 23A, 23B, 24A, 24B and 25 to 31 by retreat mining within the Tahmoor North Lease Area since June 2004.

The previous and current longwall (Longwall 32) are located underneath Tahmoor and Thirlmere villages, as well as surrounding urban and semi-rural areas as shown in **Drawing 1,** which are approximately 4 kilometres (km) south of Picton in the Southern Coalfield of NSW.

This report provides a compilation of physical and geochemical groundwater, as well as Redbank Creek and catchment dam monitoring that has been conducted, and observation of any subsidence related changes that have occurred since August 2004, up to and including the extraction of Longwall 31.

Surface water and groundwater features within the Longwall 31, 20mm subsidence zone include:

- the main channel and tributaries of Redbank Creek, which flows ENE into Stonequarry Creek and subsequently, the Nepean River;
- the northern headwater tributaries of Matthews Creek, which flows to the northeast and joins with Cedar Creek and Stonequarry Creek, then into Racecourse Creek and subsequently the Nepean River;
- 15 generally small and 2 large earthen wall dams that directly overly Longwall 31, and;
- Four vibrating wire piezometer arrays (VWP) in bores TNC28 and TNC29 (now decommissioned) as well as TNC43 and P9(VWP), one open standpipe piezometer (P9) and one licensed private bores (GW105813 - Koorana).

Redbank Creek is a Category 2 stream with a 3rd order or higher channel, whilst its tributaries are Category 1 streams, being 1st or 2nd order channels.

Monitoring has been conducted since June 2004 by assessing the;

- ephemeral or perennial nature and flow in streams over the panels;
- creek bed and bank erosion and channel bedload;
- stream and dam water quality;
- stream bed and bank vegetation;
- nature of alluvial land along stream banks;
- presence, size and integrity of dams and their water levels,
- presence and use of groundwater bores, and;
- assessment of standing water levels and water quality.

2. PREVIOUS STUDIES

An assessment of potential subsidence levels and impacts for Longwalls 27 to 30 was studied by MSEC (2009).

Assessment of the baseline characteristics and prediction of possible subsidence related effects on the surface water and groundwater system were assessed for Longwalls 27 to 30 by GeoTerra (2009).

Surface water and groundwater monitoring End of Panel reports have been prepared for Longwalls 22, 23A, 23B, 24A, 24B and 25 to 30 by GeoTerra Pty Ltd.

Ongoing monitoring of water levels, flows and water quality in the plateau streams and groundwater bores is being conducted throughout extraction of Panel 32 by colliery staff, GeoTerra Pty Ltd and Hydrometric Consulting Systems Pty Ltd (HCS) in accordance with procedures outlined in GeoTerra (2013).

3. GENERAL DESCRIPTION

3.1 Mine Layout and Progression

Tahmoor Colliery has extracted coal by longwall mining Panels 1 to 31 to the south, southwest and northwest of the current panel (Longwall 32).

Longwall 31 commenced on 28 June 2017 and was completed on 17th August, 2018 as outlined in **Table 1**, with Longwall 32 extraction continuing updip in the Bulli Seam from south to north.

Table 1 Panel Extraction Details

Panel	Start	Finish	Length (m)	Depth of Cover (mbgl)
22	02/06/04	11/07/05	1877	420 – 432
23A	07/09/05	20/02/06	776	430 – 450
23B	15/03/06	21/08/06	771	430 – 440
24B	15/10/06	26/08/07	2072	430 – 440
24A	15/11/07	190/7/08	983	420 - 448
25	22/08/08	27/02/11	3730	440 - 460
26	30/03/11	11/10/12	3480	440 - 470
27	10/11/12	22/03/14	3030	420 - 495
28	20/04/14	01/05/15	2629	420 - 500
29	29/05/15	03/04/16	2322	425 - 490
30	20/6/16	15/05/17	2322	425 - 490
31	28/06/17	17/08/2018	2450	450 - 500
32	1/11/18	currently mining	2500	450 - 500

Extraction of Panel 31 occurred from 450 - 500m below surface with a seam thickness of approximately 2.1m.

Longwall 31 was 283m wide rib to rib, with a 39m wide chain pillar and approximately 2450m long as shown in **Drawing 1**.

3.2 Topography and Drainage

The plateau is generally flat to undulating and incised by the Bargo River gorge which is up to 104m deep in the Longwalls 22 to 28 (20mm subsidence area) with steep to vertical sandstone cliff faces and vegetated scree slopes, whilst the gorge and river bed comprise a series of exposed sandstone shelves interspersed with sandstone boulder fields and pools.

The Longwall 22 to 31, 20mm subsidence area also contains the main channel and tributaries of Myrtle and Redbank Creeks, which flow both to the Nepean River, with the Bargo River being approximately 2,490m to the south, whilst the Nepean River is approximately 1,340m south east of Longwall 31.

Both Myrtle and Redbank Creeks drain the residential areas of Tahmoor and Thirlmere, as well as semi-rural fallow, orchard and grazing areas outside of the villages.

3.2.1 Bargo River

The Bargo River is present in the south-eastern part of the Longwall 22 to 28 monitoring area, which covers approximately 1,130m of the river bed, with the closest panel (24A) being at least 289m from the edge of the gorge and 354m from the centre of the river.

The Bargo River over Longwalls 12 and 13 has previously sustained up to 550mm of subsidence, 2mm/m of tensile and 3mm/m of compressive strain in the “potholes” area and Rockford Road Bridge (GeoTerra, 2006) where the gorge was directly undermined.

The Bargo River and its associated gorge is outside the Longwall 31, 20mm subsidence zone, and is not discussed further in this report.

3.2.2 Myrtle Creek

Myrtle Creek is approximately 550m south of Longwall 31.

Its headwaters are located upstream of Longwall 22 and generally consist of small grass covered channels that become larger and more incised downstream of Longwalls 23 to 30.

Myrtle Creek has been undermined by Longwalls 4, 22, 23B, 24B and 25 to 28, whilst Longwalls 29 to 31 did not undermine the creek.

The riparian flanks have been significantly altered by residential development in Tahmoor, whilst the channel has not been significantly affected except where general rubbish or solid waste has been dumped in the creek or it is overgrown by invasive weeds. Some isolated weeding and stream bank regeneration works have been conducted, however many of the areas are re-infested with weeds.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

No Water NSW registered water extraction is listed within the creek, however an unlicensed pump was present over the middle of Longwall 25, off Castlereagh Street.

Myrtle Creek is outside the Longwall 31, 20mm subsidence zone, and is not discussed further in this report.

3.2.3 Redbank Creek

Redbank Creek drains into Stonequarry Creek, which subsequently flows to the Nepean River approximately 1.2km downstream of the monitoring area.

Redbank Creek has been undermined by Longwalls 25 to 31.

Within the monitoring area the creek has a reasonably incised, narrow (<10m wide) channel with a wetland upstream of Longwall 23.

The creek overlies the western end of Longwall 25 as a small channel with an incised bed 1m to 2m deep which evolves into a channel up to 3m deep and 10m wide downstream of Longwall 26.

The Redbank Creek channel becomes sequentially deeper and wider over Longwall 27, and subsequently is additionally wider and deeper over Longwalls 28 to 31.

The headwaters of Redbank Creek, outside of the monitoring area, lie within the residential development area of Thirlmere, with housing and road development

significantly affecting the banks of the creek.

In the vicinity of Longwalls 25 to 31, the creek flows out of the Thirlmere residential area, into the downstream urban fringe and through the Thirlmere Industrial Estate.

The creek does not exhibit significant bed and bank erosion and is not significantly eroded due to the high vegetative and weed cover as well as exposed sandstone rock bars and shelves along the creek.

Areas of iron hydroxide precipitation that pre-existed mining related subsidence in Redbank Creek were observed in the reach between Redbank Creek Sites 24 and 25, as well as sites 30 to 37 (a.k.a. RC2 and R6) and downstream to RR29 over Longwall 32.

3.2.4 Dams

Surface runoff into the local streams and subsequently, the Bargo or Nepean Rivers is regulated by 17 dams that directly overly Longwall 31 or its chain pillars as shown in **Drawing 1**.

The dams are constructed of earthen walls that collect and store surface runoff that would otherwise drain directly into Redbank or Myrtle Creeks.

3.2.5 Geology

The Bargo River gorge is underlain by the fine to medium to coarse grained Hawkesbury Sandstone, with Wianamatta Shale outcrop present in the headwaters and mid-stream of Myrtle Creek and Redbank Creek, which transgresses to Hawkesbury Sandstone further downstream as shown in **Figure 1**.

Further details on the area's geology structure and stratigraphy are outlined in (GeoTerra, 2006).

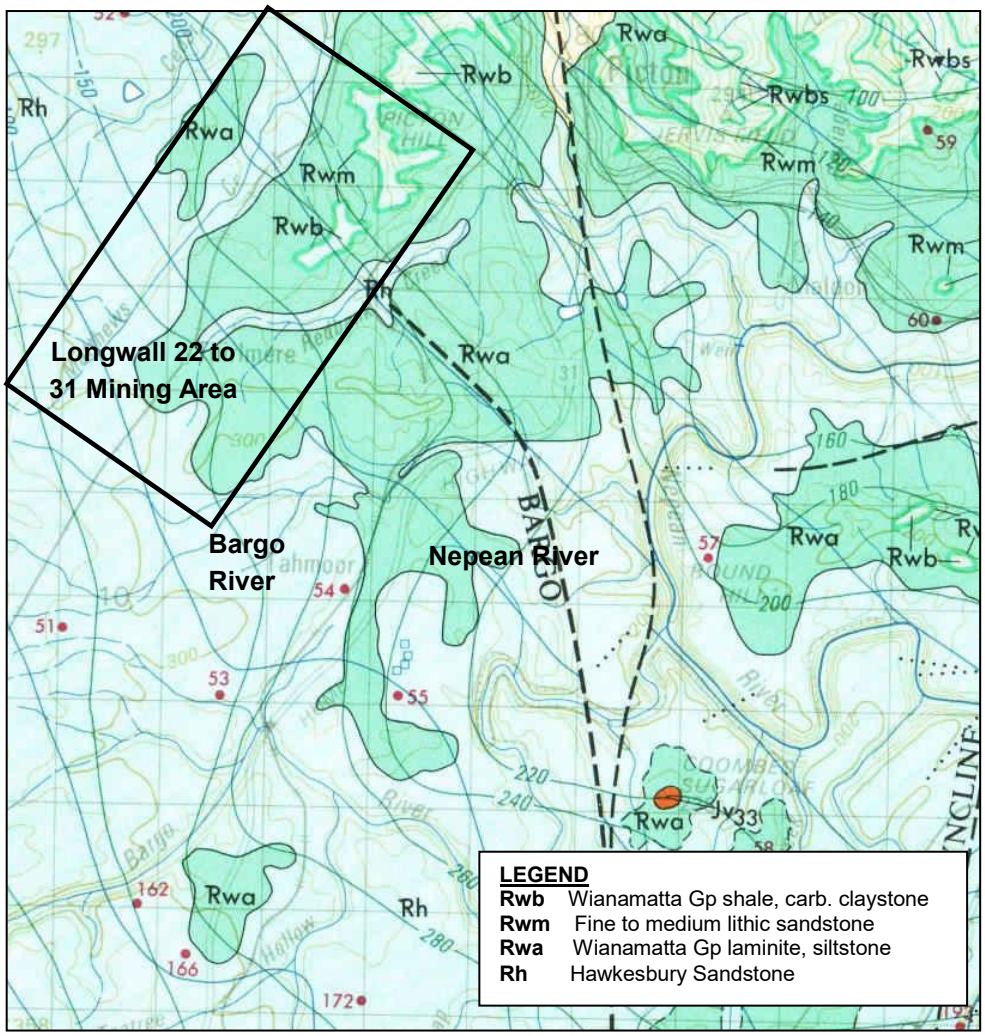


Figure 1 Surficial Geology

3.3 Hydrogeology

The Bargo River is a 'gaining' system, where groundwater flows from the plateau under a regional hydraulic gradient to the river, with groundwater flow being dominantly horizontal within confined flow along discrete layers that are underlain by fine grained or relatively impermeable strata.

The Hawkesbury Sandstone sequence exposed in the gorge is characteristic of sedimentary deposition and erosion in a braided stream with individual facies representing local sedimentary processes that generally do not persist across the area.

The Hawkesbury Sandstone within the Sydney Basin generally provides low yielding aquifers with low hydraulic conductivities.

Eight Water NSW registered private bores, two uncased coal exploration bores and fifteen registered piezometers are located within the Longwall 22 to 31 monitoring area as shown in **Drawing 1** and **Table 2**.

Open standpipe piezometers P9A, P9B and P9C are installed adjacent to Redbank Creek and overly Longwall 31 and the Longwall 31 / 32 chain pillar, whilst P10A, B and P10C are also located adjacent to Redbank Creek, immediately to the north of Longwall 32.

P9B and P9C were installed in November 2018 to replace the VWP intakes that failed at the same depths when the P9 VWP array was undermined by Longwall 31.

Piezometer P11 was installed in November 2018 adjacent to Redbank Creek approximately 330m downstream of the Longwall 32 tailgate edge.

Table 2 Monitoring Bores and Open Standpipe Piezometers

GW	Drilled	Depth (m)	SWL (m)	Aquifer (mbgl)	YIELD (L/s)	Purpose
SMP Area						
P1 (GW106281)	2004	48	Fig 7	18 - 20	0.75	monitoring
P2	-	150	Fig 7	-	n/a	coal exploration
P3	-	100	Fig 7	-	n/a	coal exploration
P4 (GW67570)	1988	85	Fig 7	-	0.22	domestic
P5 (GW63525)	1954 / 1990	76 / 91	Fig 7	60-66 & 70-91	1.0	stock domestic irrigation
P6 (GW42788)	1976	148	Fig 7	105 - 135	1.52	agriculture
P7 (GW110435)	2008	100	Fig 7	95 - 100	0.76	monitoring
P8 (GW110436)	2008	105	Fig 7	90 - 105	V low	monitoring
P9A (GW no. pending)	2017	23	Fig 7	18 - 23	+20L/sec	monitoring
P9B	2018	28	Fig 7	18 - 28	n/a	monitoring
P9C	2018	40	Fig 7	18 - 40	n/a	monitoring
P10A	2018	29	Fig 7	24 - 74	n/a	monitoring
P10B	2018	44	Fig 7	24 - 74	n/a	monitoring
P10C	2018	74	Fig 7	24 - 74	n/a	monitoring
P11	2018	29	Fig 7	22 - 29	n/a	monitoring
McPhee (GW105254)	2002	163	80.0	113 - 156	0.67	domestic
Koorana (GW105813)	2003	168	28	114 – 115 146 - 147 160 - 161	6.6	stock / domestic
Pescud (GW109010)	2008	169	89	n.a.	0.8	stock domestic
Boissery (GW109224)	2008	132	60	n.a.	1.0	domestic
Machin (GW107918)	2007	60	42.49	40 - 48	2.2	domestic

Note: All bore water supply is from Hawkesbury Sandstone.
redrill depth for bore replaced by Tahmoor Colliery
- no data available

Groundwater has been obtained from sandstone aquifers with yields ranging from 0.2L/sec to 5.0L/sec between 18m and 138m below surface.

Water NSW bore data indicates it is likely that significant aquifers are intersected below depths of approximately 18m to 60m, depending on whether the bore is spudded on top of a hill or in a valley. Shallower, low yielding groundwater may be present above that depth range as perched ephemeral aquifers.

Alluvial sediments within the plateau gullies and river bed are too shallow to be used as aquifers for groundwater supply.

3.3.1 Vibrating Wire Piezometer Arrays

One cement / bentonite sealed exploration bore (TNC29) was installed with vibrating wire piezometer (VWP) arrays over Longwall 30, whilst TNC28 was installed over Longwall 29.

Both of these arrays have now been decommissioned as they have been undermined and cracked and due to VWP arrays being a potential electrical hazard to the underground workings

Three VWP arrays (TNC36, 40 and 43) are located to the east and north of Longwall 31 as shown in **Drawing 1** and **Table 3**.

Readings from the VWP intakes at P9B (28mbgl) and P9C (38mbgl) were discontinued on 19th May 2018 due to shearing of the bore following undermining by Longwall 31, whilst P9D (68mbgl) monitoring has continued.

Table 3 Tahmoor North Vibrating Wire Piezometer Installation

Piezometer	Intake Depth (mbgl)	Formation	Piezometer	Intake Depth (mbgl)	Formation
TNC36	65	Hawkesbury Sandstone	TNC40	27	Wianamatta Shale
	97	Hawkesbury Sandstone		65	Hawkesbury Sandstone
	169	Colo Vale Sandstone		131	Hawkesbury Sandstone
	214	Colo Vale Sandstone		225	Hawkesbury Sandstone
	298.5	Colo Vale Sandstone		352	Bulgo Sandstone
	412.5	Colo Vale Sandstone		452	Bulgo Sandstone
	463.5	Bulli Seam		501.9	Bulli Seam
TNC43	65	Hawkesbury Sandstone	P9 (VWP)	(B) 28	Hawkesbury Sandstone
	111.5	Hawkesbury Sandstone		(C) 38	Hawkesbury Sandstone
	213	Hawkesbury Sandstone		(D) 68	Hawkesbury Sandstone
	240	Bulgo Sandstone			
	332.6	Bulgo Sandstone			
	425.2	Bulgo Sandstone			
	476.3	Bulli Seam			

3.4 Subsidence

The maximum monitored subsidence, tilt and strain following the completion of extraction of Longwall 31 is shown in **Table 4**.

Table 4 Maximum Subsidence at the Completion of Longwall 31

Component	Observed Total Movement
Vertical subsidence	1070 mm
Tilt	8.2 mm/m
Tensile / Compressive Strain	4.6 / -4.5 mm/m

3.4.1 Redbank Creek

The ability to survey valley closure across the creek has been constrained due to refusal by landowners to provide access, with no available access on the northern bank and limited access on the southern bank (MSEC, 2019), with the available survey data (accurate to approximately 20 – 30mm) shown in **Table 5**.

Valley closure was slightly greater for a temporary period of time when the transient effects of the subsidence travelling wave passed through the valley, with the maximum incremental valley closure due to Longwall 31 equalling 152mm.

Table 5 Maximum Redbank Creek Valley Closure up to Completion of LW31 (mm)

	After LW26	After LW27	After LW28	After LW29	After LW30	After LW31
Valley Closure (mm)	151	233	276	350	420	450

Source (MSEC, 2019)

3.5 Redbank Creek Monitoring

3.5.1 Water Level and Chemistry Monitoring Site Descriptions

Stream water level, and subsequently stream flow monitoring, as well as field chemistry and laboratory analysis of water samples has been conducted in Redbank Creek since April 2005 at the sites summarised in **Table 6** and shown in **Drawing 1**.

Table 6 Redbank Creek Water Level and / or Chemistry Monitoring Locations

Site	Description	Monitored Parameters
RC1	Off the end of Windeyer Street	field and laboratory chem, bedrock cracking / pool depth
RC2	Downstream of Railway bridge	field and laboratory chem, bedrock cracking / pool depth
RC3	Cement works weir	field and laboratory chem, bedrock cracking / pool depth
RC4	End of Bollard Place	field and laboratory chem, bedrock cracking / pool depth
RC5	Remembrance Drive culvert	field and laboratory chem, bedrock cracking / pool depth
RC6	Downstream of Council swimming pool	field and laboratory chem, bedrock cracking / pool depth
R1	Downstream of Turner Street bridge	Weir plate
R2	End of Windeya Street	Rock bar pool depth and flow
R3	350m downstream of R2	Rock bar pool depth and flow
R4	Upstream of railway culvert	Rock bar pool depth and flow
R5	Downstream of railway culvert	Rock bar pool depth and flow
R6	Downstream of R5 near RC2	Rock / gravel pool depth and flow
R7	Adjacent to Bridge Street	Rock bar pool depth and flow
R8	Downstream of R6	Rock bar pool depth and flow
R9	Access from old Highway thru Picton	Weir plate
R10	Between Nepean Conveyors and Site 9	Rock bar pool depth and flow
R11	Behind Nepean Conveyors	Rock bar pool depth and flow

Weekly monitoring of Redbank Creek over Longwalls 30, 31 and 32 commenced on 14th March 2018 and continued until 29th August 2018 at the observation sites shown in **Tables 7** and **8**.

Bi-monthly monitoring of the creek was conducted before and after this period.

Redbank Creek was first undermined by Longwall 31 on approximately the 3rd April, 2018.

Table 7 LW31 Redbank Creek Weekly Monitoring Sites

Site	Description	Additional Sites
RR7	long sandstone race with ferruginous rock shelf pools	R7
RR8	shallow sandstone race with ferruginous rock shelf pools	
RR9	shallow sandstone race with ferruginous rock shelf pools	
RR10	shallow sandstone race with ferruginous rock shelf pools	
RR11	shallow sandstone race with ferruginous rock shelf pools	
RRS12	extended sandstone rock shelf with ferruginous overflow	
RW13	<0.5m high sandstone rock step / waterfall constrained pool	
RB14	boulder constrained shallow ferruginous rock pool	
RR15	shallow sandstone race with ferruginous rock shelf pools	
RR16	shallow sandstone race with ferruginous rock shelf pools	
RB17	boulder constrained shallow ferruginous rock pool	
RR18	shallow sandstone race with ferruginous rock shelf pools	
RR19	shallow sandstone race with ferruginous rock shelf pools	R8
RR20	shallow sandstone race with ferruginous rock shelf pools	
RR21	shallow sandstone race with ferruginous rock shelf pools	
RR22	shallow sandstone race with ferruginous rock shelf pools	
RR23	shallow sandstone race with ferruginous rock shelf pools	
RR24	shallow sandstone race with ferruginous rock shelf pools	
RR25	rock bar constrained ferruginous pool	
Weir26	Long ferruginous pool regulated by a 1.5m high concrete weir	RC3 / R9
RR27	rock bar constrained ferruginous pool	
RB28	rock bar constrained ferruginous pool	
RR29	rock bar constrained ferruginous pool	
RR30	rock bar constrained ferruginous pool	R10
RR31	rock bar constrained ferruginous pool	
RB32	rock bar constrained ferruginous pool	

RB33	Boulder / rock bar constrained ferruginous pool	RC4

NOTE: RR= Redbank Ck rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

3.5.2 Pre Longwall 31 Creek Subsidence Observations

Subsidence effects observed due to extraction of Longwall 31 (i.e. prior to early April 2018, when Longwall 31 first undermined Redbank Creek) at the following sites included;

Over Longwall 25

- 4 to 9 – pool desiccation in a clay incised section of the creek with cobbles and limited exposed sandstone rockbars.

Over Longwall 26

- 12 to 13 – sandstone stream bed cracking, with no obvious effect on pool holding capacity;
- 14 to 14a - pool desiccation in a cobble / sandstone based section;
- 15 to 17 - pool desiccation in sandstone based pools; and
- 17a to 19 - pool desiccation in cobble / sandstone based pools.

Over Longwall 27

- 21 to 21a - pool desiccation in sandstone based pools;
- 22 - pool desiccation in a cobble / sandstone based section;
- 22a to 23 – significant cracking and pool desiccation in sandstone based pools;
- 24 to 25 – pool desiccation with significant iron hydroxide in cobble / sandstone based pools;
- 25a to 26 - significant cracking and pool desiccation in sandstone based pools;

Over Longwall 28

- 26a to 28 - pool desiccation in sandstone based pools, and
- 29 – reduced flow over sandstone rock shelf.
- 30 to 34 – drying up of previously ferruginous pools in boulder and rock bar pools.

Over Longwall 29

- 35 to 37 and RB3 to RB5 – reduced pool level or drying up of previously ferruginous pools in boulder and rock bar pools.

Over Longwall 30

- Sites RB6 to RR11 – with additional cracking of rock shelves and total drying up of the pools outside of storm flow periods;
- partial drying up (without obvious cracking) at RRS12;
- partial drying up of the RW13 pool;

Over Longwall 31

- new cracking, without flow impacts at RR23, RR24;
- new cracking and reduced flow impacts at RB25;
- new cracking downstream of the Weir 26 concrete weir, without flow impacts, and;
- new cracking, without flow impacts at RR27 and RB28 over the Longwall 31 / 32 chain pillar

3.5.3 Post Longwall 31 Creek Subsidence Observations

After undermining by Longwall 31 in April 2018, Redbank Creek was observed to have undergone subsidence effects as summarised in **Table 8**.

In addition to the sites over Longwall 31 that had previously been affected by Longwall 30, subsidence (or additional subsidence) effects were observed:

Over Longwall 31

- no new sites

Over Longwall 32

- rock bar delamination and uplift at RR29, with pool level reduction, and;
- pool level reduction, without obvious cracking at RR30, RR31, RB32 and RC4.

Table 8 Redbank Creek Subsidence Effects During and After LW31 Extraction

Site	Relative Location	Effect	Date Initially Observed	TARP First Triggered
Over Longwall 30				
RR8	tailgate	cracking and drying up of long shallow sandstone race with ferrug. rock shelf pools without cracks	cracks 30/12/15 pool dry 28/1/16	31/5/16
RR9	tailgate	cracking / delamination and drying up of rock shelf / race with ferruginous pools	cracks 17/12/15 pool dry 13/1/16	18/2/16
R7 / RR10	tailgate / centre	cracking and drying up of rock shelf / race with ferruginous pools	cracks 7/1/16 pool dry 28/1/16	31/5/16 (R10) 27/3/17 (R7,8,9)
RR11	centre	drying up (without obvious cracking) of rock shelf / race with ferruginous pools	cracks 7/1/16 pool dry 28/1/16	27/3/17
RRS12	centre	partial drying (without obvious cracking) of extended rock shelf with overland ferruginous flow	pool dry 1/2/17	27/3/17
RW13	centre	reduction of pool level downstream of <0.5m high rock face / waterfall	pool reduced 1/2/17	15/6/18
RB14	centre - maingate	cracking and partial drying up of ferruginous pool	pool reduced 1/2/17	24/5/18
RR15	maingate	cracking and partial drying up of extended rock based ferruginous pool	cracks / pool reduced, 9/3/17	28/6/18
RR16	chain pillar	rock bar dry, pool very low, no obvious cracks	rock bar dry, pool very low, no obvious cracks 18/4/18	21/6/18
Over Longwall 31				
RB17	tailgate	pool very low to dry, cracked	pool very low to dry, no obvious cracks 18/4/18	5/7/18
RR18	tailgate	pool dry, cracked	pool dry, no obvious cracks 18/4/18	28/6/18
RR19	tailgate	pool dry, cracked	pool dry, no obvious cracks 18/4/18	28/6/18
RR20	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18

Site	Relative Location	Effect	Date Initially Observed	TARP First Triggered
RR21	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18
RR22	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18
RR23	centre	cracking and partial drying up of extended rock based ferruginous pool	cracks / pool reduced 9/3/17	15/6/18
RR24	centre	cracking and partial drying up of extended rock based ferruginous pool	cracks / pool reduced 9/3/17	21/6/18
RR25	centre	cracking and partial drying up of rock bar constrained ferruginous pool	cracks / pool reduced 9/3/17	21/6/18
Weir26 / RC3	centre - maingate	Partial level reduction of ferruginous weir constrained pool	cracks / pool reduced 9/3/17	24/5/18
RR27	maingate	cracking without flow impacts in ferruginous pool	cracks 9/3/17	15/6/18
Over Longwall 32				
RR28	LW31 / 32 chain pillar	cracking without flow impacts in ferruginous pool	cracks 02/03/17	28/6/18
RR29	Tailgate LW32	Pool low, cracking, significant strata delamination	Pool v low, strata delam, 18/4/18	7/6/18
RR30	centre	Reduced pool level , no cracking	Pool medium depth, no cracks 18/4/18	_
RR31	Centre / maingate	Reduced pool level , no cracking	pool dry, no obvious cracks 27/4/18	_
RB32	Chain pillar	Reduced pool level , no cracking	pool dry, no obvious cracks 18/4/18	_
RB33 / RC4	Dwnstm of chain pillar	Reduced pool level , no cracking	pool dry, no obvious cracks 18/4/18	_

NOTE: RR= rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

Photos of selected pools and stream reaches after the extraction of Longwall 31 are shown in **Appendix A**.

As shown in **Table 8**, the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered on the following dates;

- 24/5/18 RB14 (LW30), RR20, 21, 22, Weir 26/RC3 (LW31)
- 07/6/18 RR29 (LW32)
- 15/6/18 RW13 (LW30), RR23 and RR27(LW31)
- 21/6/18 RR16 (LW30), RR24, 25 (LW31)
- 28/6/18 RR15 (LW30), RR18, 19 (LW31), RR28 (LW32), and
- 05/7/18 RB17 (LW31)

3.5.4 Redbank Creek Pool Depth and Creek Flow Monitoring

GeoTerra commenced monitoring water levels in Redbank Creek in April 2005 (GeoTerra, 2011). HCS took over stream flow monitoring and decommissioned the original RC1-3 sites in January 2010.

Pool levels and creek flow at monitoring locations R1 – R3, as monitored by Hydrometric Consulting Services (HCS), are shown in **Figure 3**.

HCS are converting selected site stream depths to flow as sufficient manual stream flow data is collected, however insufficient readings are available for the conversion at all sites.

Reversal of flow in the creek has not occurred due to subsidence as the creek gradient exceeds the subsidence tilt in the stream bed.

Site R1 is situated upstream of Longwall 24, whilst R2 is located at north eastern upstream corner of Longwall 25, and upstream of Longwall 26.

Pool R3 is located at the northern western end of Longwall 25 and upstream of Longwall 26 and R4 is located over Longwall 27 as shown in **Drawing 1**.

Pool R5 is located downstream of Longwall 27, whilst R6 is situated over the middle of Longwall 29 and contains the permanently ferruginous pool RC2.

Pool R7 is located over mid Longwall 30, R8 is over the tailgate side whilst R9 is located over the maingate side of Longwall 31.

Pool R10 is situated over mid Longwall 32 and R11 is located over mid Longwall 32A as shown in **Drawing 1**.

The majority of pools over and downstream of Longwalls 25 to 32 show evidence of subsidence related pool holding capacity effects, whilst R11 does not, as shown in **Figure 2**.

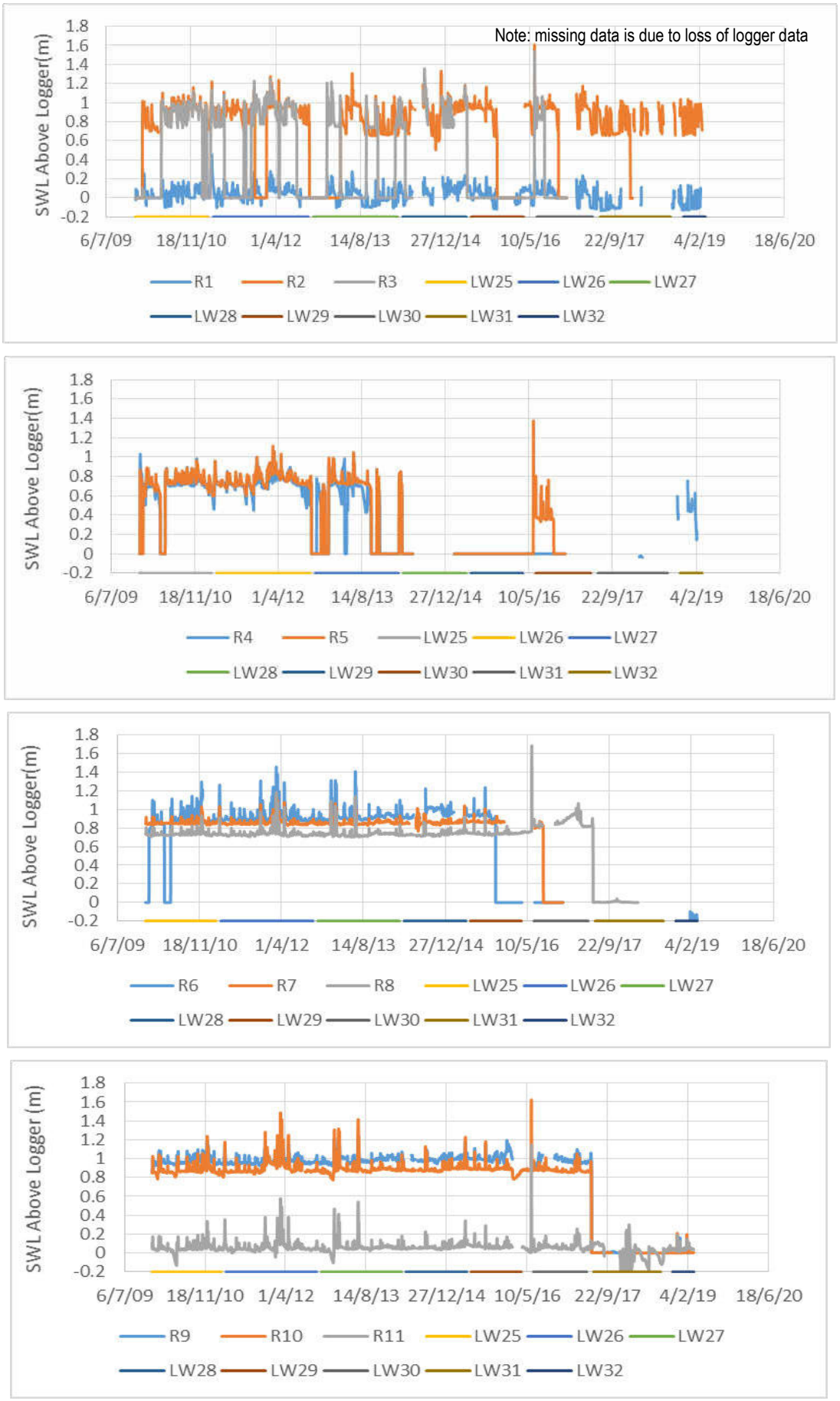


Figure 2 Redbank Creek Pool Depth

3.5.5 Redbank Creek Water Quality

Redbank Creek has had an EC range from 22 – 3,290uS/cm and pH between 3.10 and 7.50, with the creek generally being more acidic and saline at RC2 as shown in **Figure 3**.

During extraction of Longwall 31, pH in Redbank Creek distinctly acidified at all monitored sites, whilst salinity did not show a specific trend, except for higher salinity during low flow periods.

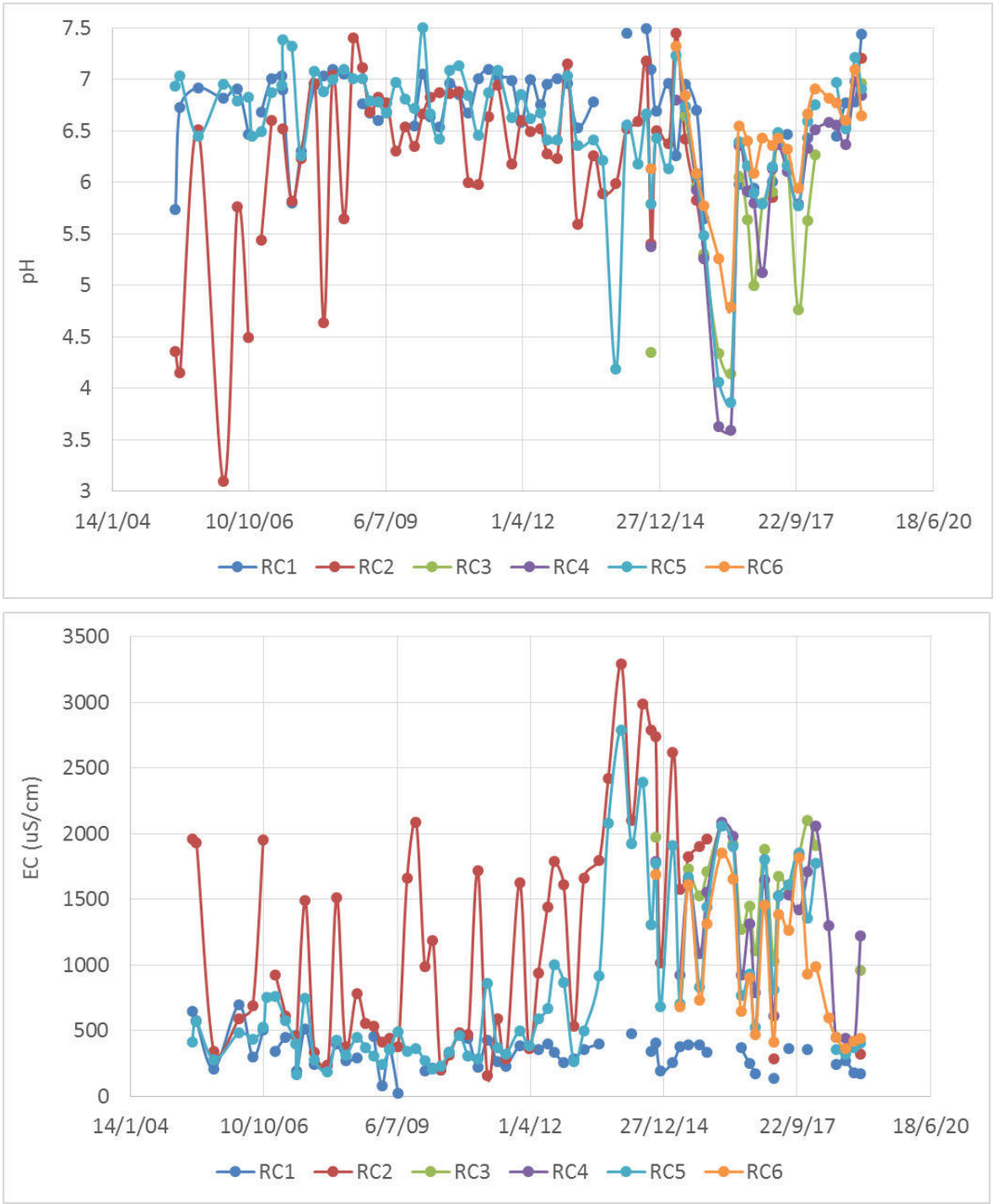


Figure 3 Redbank Creek Field Water Quality

Enhanced salinity and lower pH is predominantly associated with the more ferruginous seeps in the stream.

Redbank Creek generally contains elevated iron and, occasionally, above ANZECC 2000 Protection of 95% of Freshwater Aquatic Species trigger level manganese at RC2 in association with the upstream tributary seepage as shown in **Figure 4**.

The stream reach at RC2 (a.k.a. Site 37) has had a definitive ferruginous hydroxide precipitate in the standing pool since monitoring was started in early 2005 which is present due to upwelling and re-oxygenation of chemically reduced waters in the creek between sites 30 to 35.

Ferruginous seeps are also present at a tributary entering Redbank Creek downstream of the railway tunnel at Site 36, as well as sites RC37, RR2, RB3-6, RR7-11, RRS12, RW13, RB14 and RR15 - 29.

The iron and manganese levels vary with rainfall in the catchment, with lower concentrations after wetter periods, however a definitive rise in iron has been observed at RC2 and for manganese at RC2 and RC5 since Longwalls 27 to 30 undermined Redbank Creek.

Manganese also rose during extraction of Longwall 30 at Sites RC3 to RC6 (at which time RC1 and RC2 were dry).

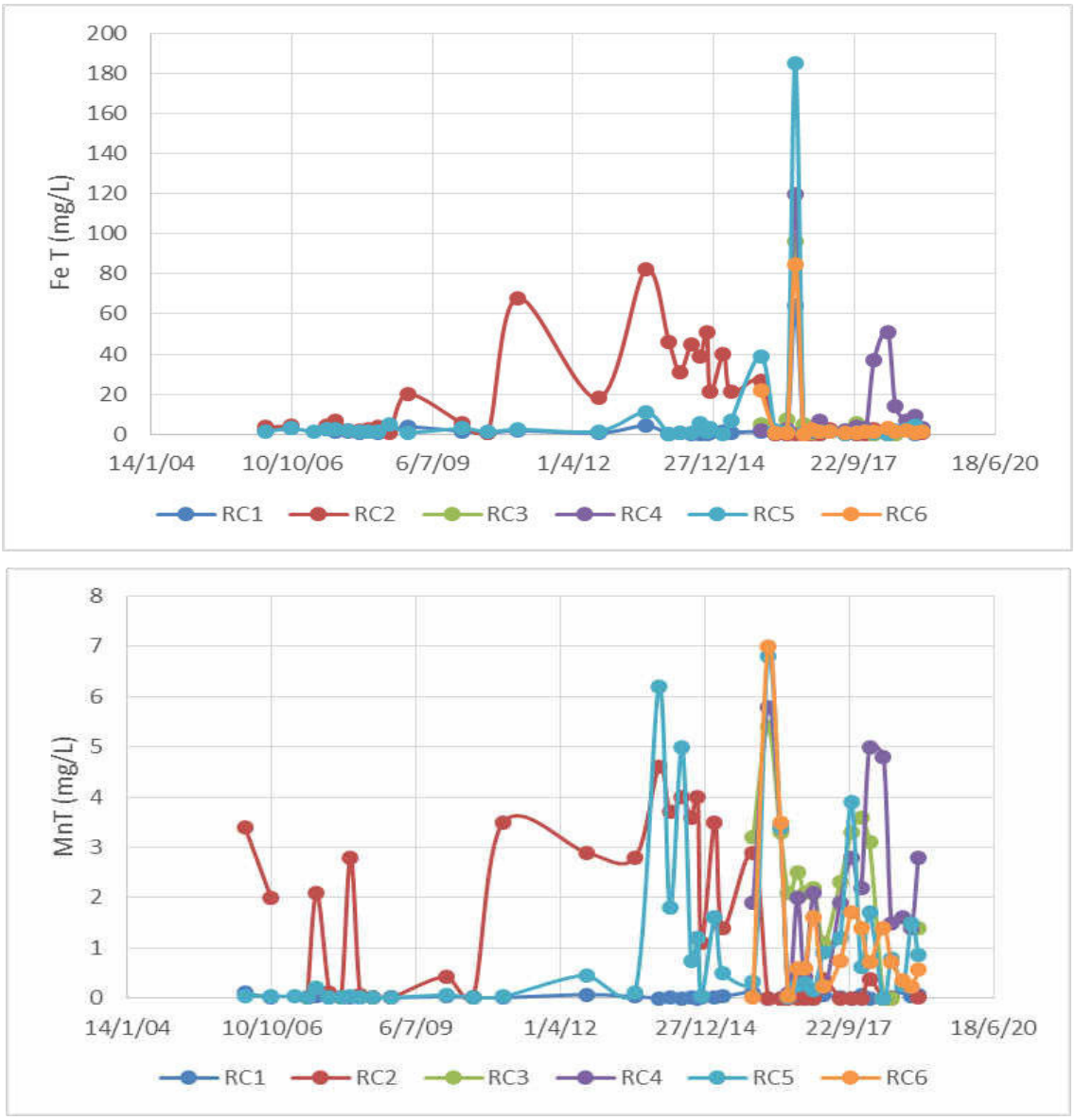


Figure 4 Redbank Creek Iron and Manganese

The creek can have total nitrogen (TN) up to 15mg/L and total phosphorous (TP) up to 0.47mg/L, which can be above the ANZECC 2000 SE Australian Upland Stream criteria at all monitored sites as shown in **Figure 5**.

The above criteria nutrients are present in the creek due to urban, rural / residential and industrial runoff in the catchment, and are not related to mining influences.

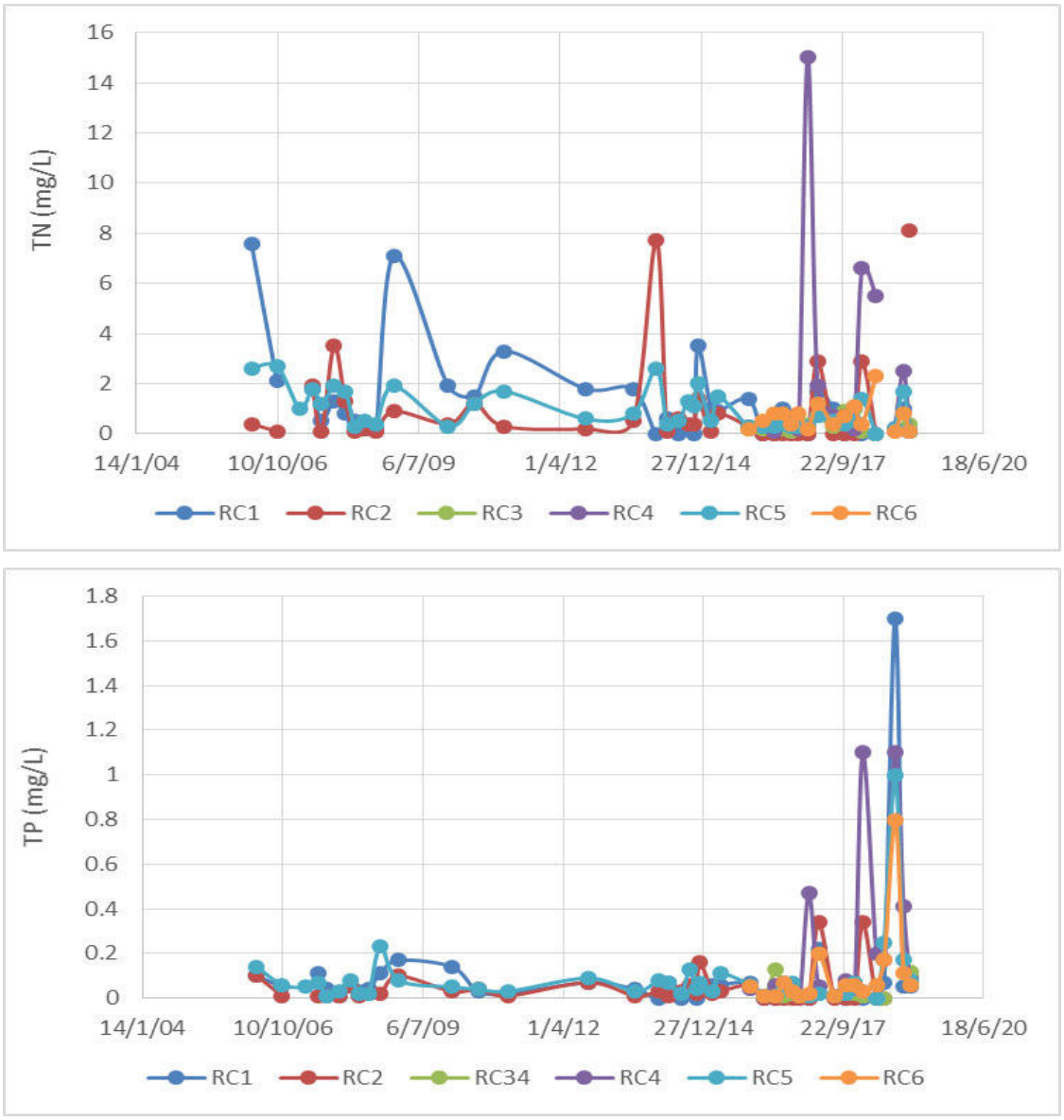


Figure 5 Redbank Creek Nutrients

Redbank Creek can also exceed the ANZECC 2000 trigger levels for filterable aluminium (<0.26mg/L), although the peak levels occurred during late 2007 and early 2008, with no observable increase above background levels during the Longwall 26 to 30 mining period.

Copper can reach up to 0.013mg/L, however no sustained increase as a result of Longwalls 28 to 30 is observed as shown in **Figure 6**.

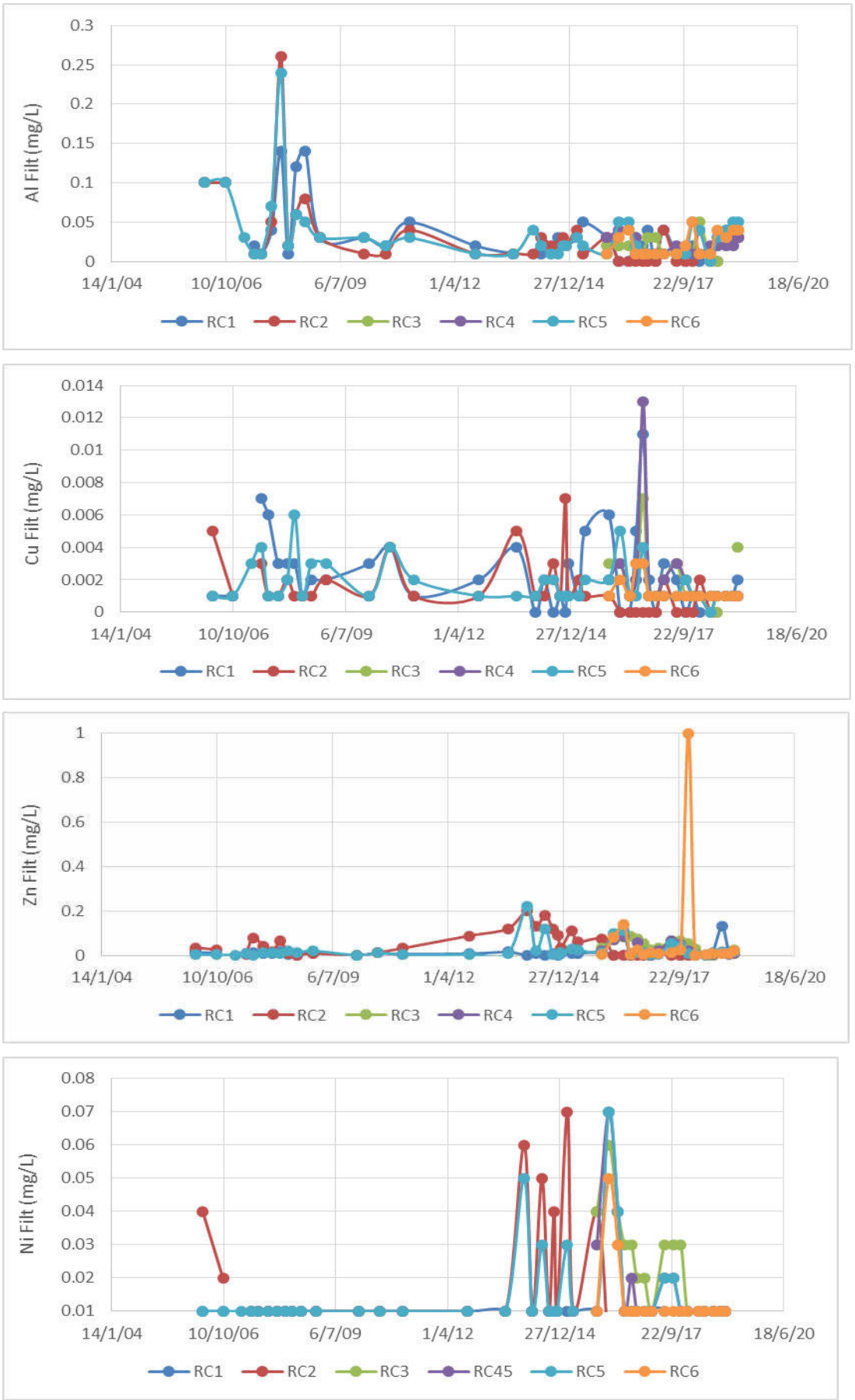


Figure 6 Redbank Creek Metals

Zinc can reach up to 1.0mg/L as shown in **Figure 6**, with its concentration being observed to rise at RC2 since late 2010, and since August 2013 at RC3 with an erratic, although generalised reduction since February 2014 and subsequent rise after extraction of Longwall 29 and after Longwall 31.

Nickel has also significantly increased at all sites since August 2013, reaching up to 0.07mg/L.

Both the zinc and nickel concentration increases indicate a response in the Redbank Creek water quality due to undermining of Redbank Creek by Longwalls 27 to 31 and the associated enhanced through flow of waters through freshly cracked sandstone.

3.6 Dams

Seventeen generally small dams directly overlie Longwall 31 as shown in **Drawing 1**.

All of the dams are located within rural residential properties apart from the two large dams at the southern end of LW31 which are associated with a plant nursery.

All dams have had variable water levels in response to rainfall recharge and / or water extraction rates.

No direct evidence of dam wall or floor cracking was reported by landowners, and the associated adverse water level, water storage or water quality effects due to subsidence associated with Longwall 31.

3.7 Groundwater

3.7.1 Open Standpipe Piezometers and Private Bores

Regular manual and data logger based standing water level monitoring was initiated in June 2004, with the piezometers being installed on various times at locations as summarised below;

- P1 - 450m south west of Longwall 22;
- P2 - within a remnant coal exploration bores over Longwall 23B;
- P3 - within a remnant coal exploration bore over the chain pillar between Longwall 25 and 26;
- P4 - within an undeveloped, unsecured block of land, 300m northeast of Longwall 26;
- P5 - 950m north-west of Longwall 26 that was used for general domestic / irrigation water. Monitoring ceased in P5 in August 2010 due to a request from the property tenant;
- P6 - 1.1km east of Longwall 26 in the old Jay-R Stud; and
- P7 and P8 - within the Inghams Turkey property, between the eastern end of Longwall 25 and 26 and the Bargo Gorge.
- P9A – adjacent to Redbank Creek within the Hanson cement works over the Longwall 31 / 32 chain pillar
- P9B,C – replaced the discontinued P9B and P9C VWP loggers within the Hanson cement works over the Longwall 31 / 32 chain pillar
- P10A,B,C – adjacent to Redbank Creek within the Narellan Pools factory
- P11 – adjacent to Redbank Creek upstream of the Thirlmere Way culvert

The actively used private bores GW105254 (McPhee), GW107918 (Machin), GW109010 (Pescud) and GW109224 (Boissery) and GW105813 (Koorana) are fully sealed with pump equipment and their water levels are not able to be monitored.

The Pescud and McPhee private bores are located over Longwall 26. The Boissery and Machin bores are located to the south east of Longwalls 28 and 29 respectively, whilst the Koorana bore is located over Longwall 32.

All piezometers and bores are located as shown in **Drawing 1** whilst the monitored groundwater levels are shown in **Figure 7**.

No significant open standpipe piezometer water level reduction occurred during the Longwall 31 extraction period (except for the P9 series as discussed further in Section 3.7.5), and no complaints of adverse effects on private bore water levels or yield were received by the Colliery during extraction of Longwall 31.

The last impacted bore was at the Pescud property (GW109010), which was reported to the colliery in December 2015.

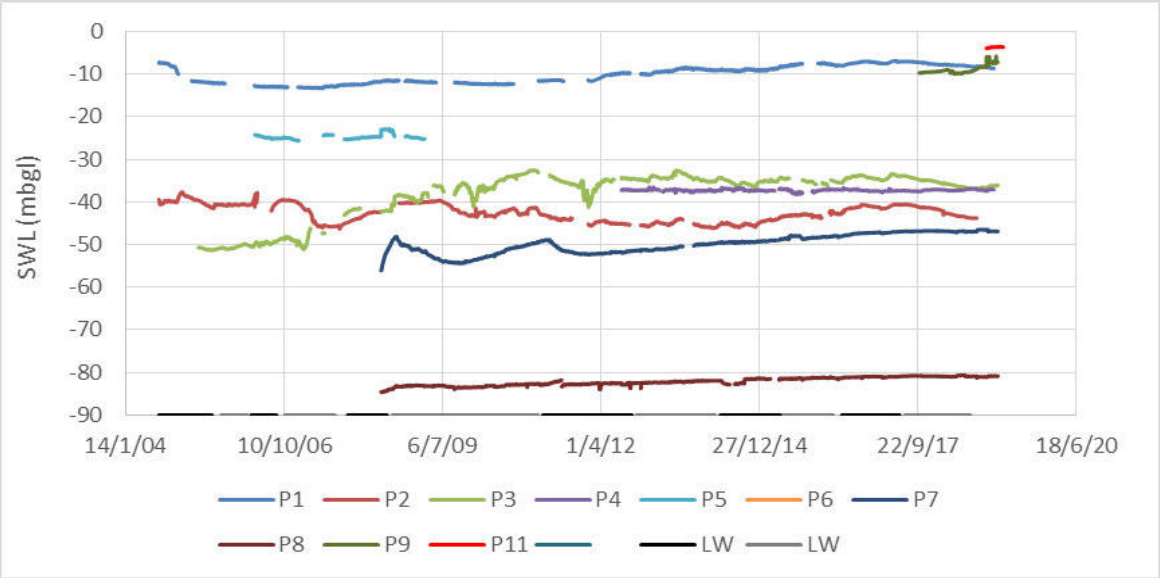


Figure 7 Standing Water Levels and Panel Extraction

3.7.2 Vibrating Wire Piezometers

Vibrating wire piezometers (VWP) TNC28 and 29 were discontinued prior to the start of Longwall 30 as they had been undermined and severed due to ground movements and are shown in the previous End of Panel report (GeoTerra, 2016).

The Bulli Seam has been dewatered in TNC28 and 29, whilst the Bulgo Sandstone has undergone partial depressurisation in TNC28 and TNC29, along with the Scarborough Sandstone in TNC29. TNC28 overlies Longwall 29, whilst TNC29 overlies the chain pillar between Longwalls 29 and 30. TNC29 was decommissioned prior to it being undermined by the longwall.

The TNC28 and 29 VWP data has not changed since the Longwall 29 End of Panel report (GeoTerra, 2016) and is not discussed further.

Ongoing monitoring at VWPs TNC36, 40 and 43 are shown in **Figure 8**.

TNC36 is located approximately 1600m north of Longwall 29, whilst TNC40 is located approximately 1300m north east and TNC43 is approximately 1050m north east of Longwall 29.

Partial depressurisation is observed in the Hawkesbury Sandstone at 97mbgl as well as in the Bulgo Sandstone (at 169 / 214 / 299mbgl) and the Bulli Seam in TNC36.

The Hawkesbury Sandstone (225mbgl) in TNC40 is undergoing partial depressurisation, along with the Bulgo Sandstone (at 252 & 352mbgl), whilst the Bulli Seam started significant depressurisation in April 2016.

Gradual depressurisation is observed in the Hawkesbury Sandstone (213mbgl) as well as in the Bulgo Sandstone (at 240 / 333 / 425mbgl) and Bulli Seam in TNC43.

None of the above depressurisation observations exceeded the TARP trigger level *(10m water level reduction for greater than 2 months)* as they do not exceed predictions outlined in the groundwater model prepared for the Environmental Application (EA) for the deeper strata and the Bulli Coal Seam, where depressurisation greater than 10m was predicted.

No shallow strata exceeded the Longwall 31 TARP Trigger during the Longwall 31 extraction period.

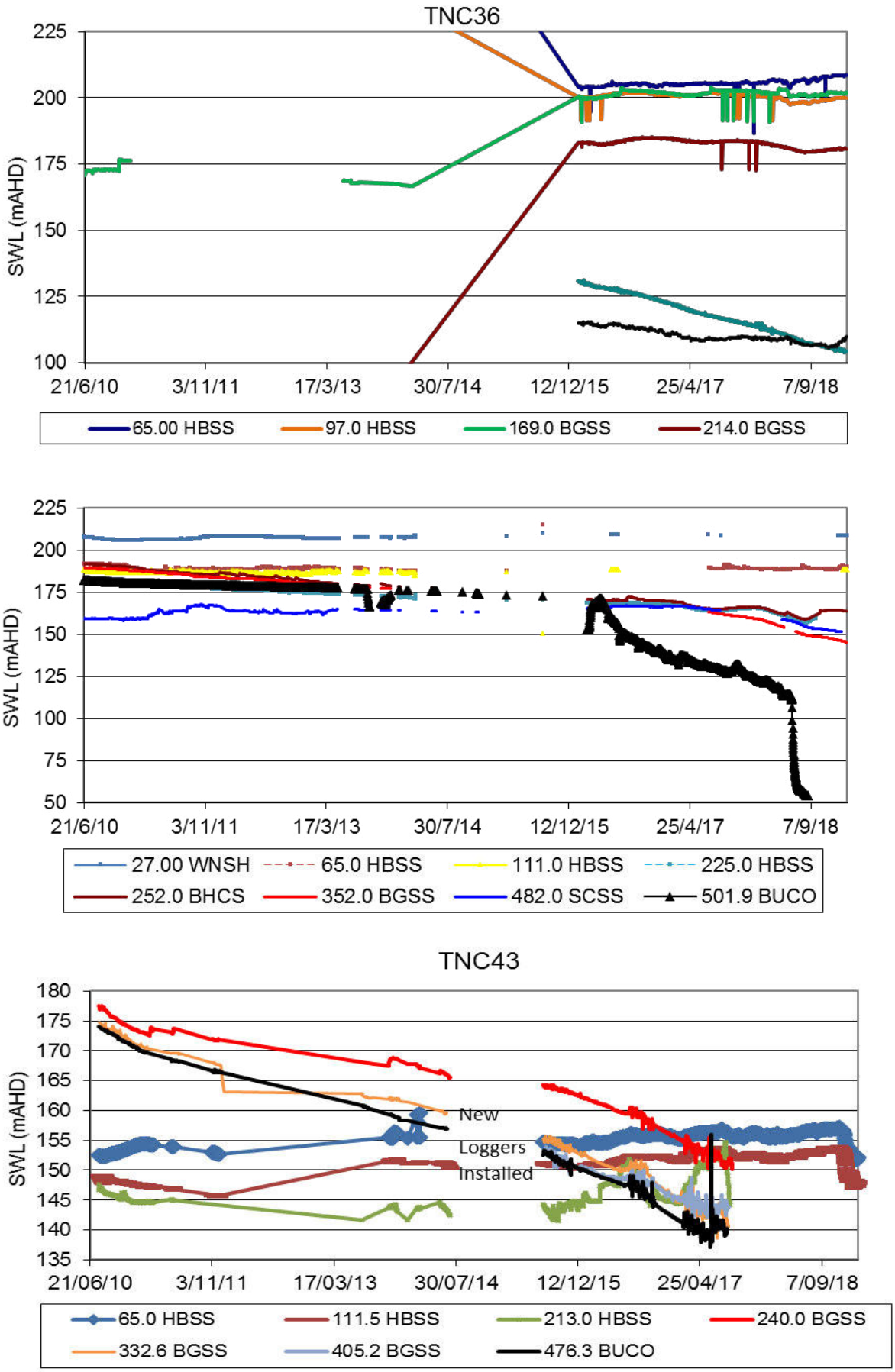


Figure 8 Vibrating Wire Piezometer TNC36, 40 and 43 Groundwater Levels

VWP array intakes were installed at 10, 20 and 50m below the initial water table strike depth (18m) at Site P9 in the Hanson cement works over the chain pillar between Longwall 31 and 32.

The P9 series monitoring results are discussed further in Section 3.7.5.

3.7.3 Aquifer / Aquitard Interconnection

The available data from the open standpipe piezometers, coal exploration and private bores, as well as the piezometric head monitoring in TNC28 and TNC29 have not indicated any adverse breaching or interconnection between the Hawkesbury Sandstone and Bulgo Sandstone, or through the Bald Hill Claystone.

Hydraulic connection has been instigated between the Bald Hill Claystone and Bulgo Sandstone in TNC28 as well as between the base of the Scarborough Sandstone and the Wombarra Shale in TNC29 during extraction of Longwalls 22 to 30.

Significant step changes in depressurisation also occurred in TNC40 in the Bulli Seam during mid-June 2018, whilst TNC43 had a definitive step change in the 65 and 111.5mbgl intakes in the Hawkesbury Sandstone during late October 2018, after all other loggers in the bore discontinued readings in late August 2017.

No significant depressurisation step changes have yet been observed in TNC36.

3.7.4 Groundwater Seepage To The Underground Workings

To date, no loss of stream flow from Redbank Creek into the Tahmoor mine workings has occurred.

3.7.5 Interconnection of Redbank Creek and the Adjacent Shallow Groundwater

A definitive reduction in pool depth and downstream overland connective flow occurred within Redbank Creek in the concrete weir based pool (R9 / RC3) on and after 10/3/18 as shown in **Figure 9,** when Longwall 31 was approximately 140m south of the creek bed.

The R9 / RC3 weir pool is located approximately 125m upstream of the P9 open standpipe and VWP array.

Connective stream flow and ponding re-appeared in the creek at and downstream of Redbank Creek site RB28, which is approximately 90m downstream of the R9 weir and approximately 25m downstream of the P9 piezometer location.

The creek has basically been dry for the majority of time after it was impacted by subsidence, and only holds water for short periods after significant rainfall / runoff in the catchment.

The P9 piezometers also showed a gradual reduction in water level in the deepest (P9D at 68mbgl) intake since installation (10/10/2017), whilst the shallowest piezometer (P9A at 5m below the first intersected water level of 18mbgl), did not show a definitive depressurisation.

The two middle piezometers (38 and 48mbgl) showed a minor ongoing, gradual depressurisation since installation.

A definitive step change in depressurisation, particularly in the deepest intake, occurred in all piezometers around the 21st to 23rd of April 2018, when Longwall 31 had progressed 40m north of the creek bed, and had just undermined the piezometers.

The depressurisation maximised at 6.55m below its starting depth in the deepest piezometer around 10th May 2018, after which its level (erratically) recovered to slightly

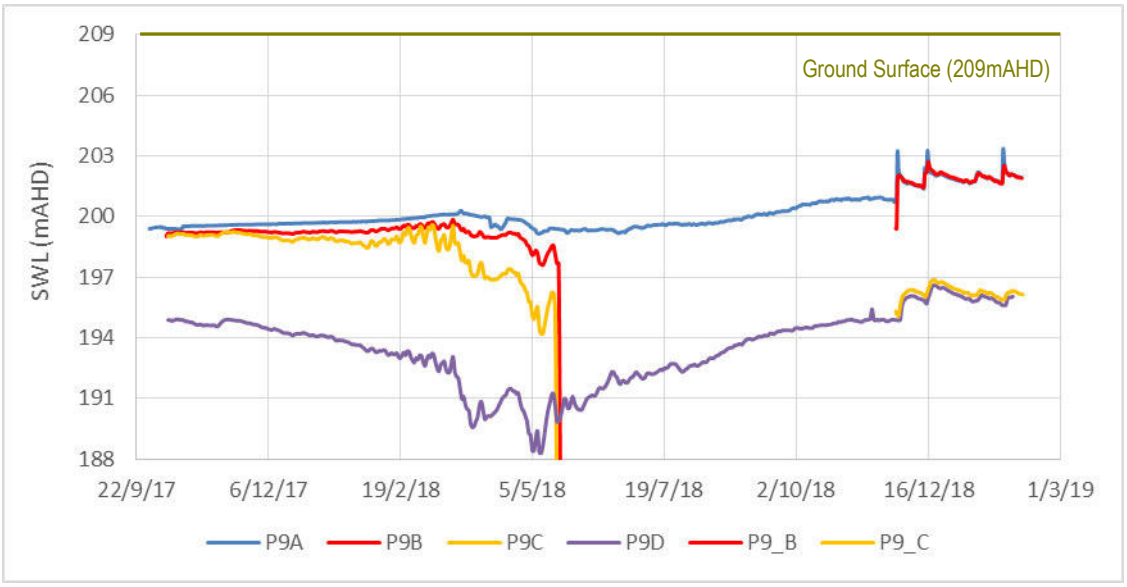
above its initial level. The higher rates of recovery correlate to rain periods.

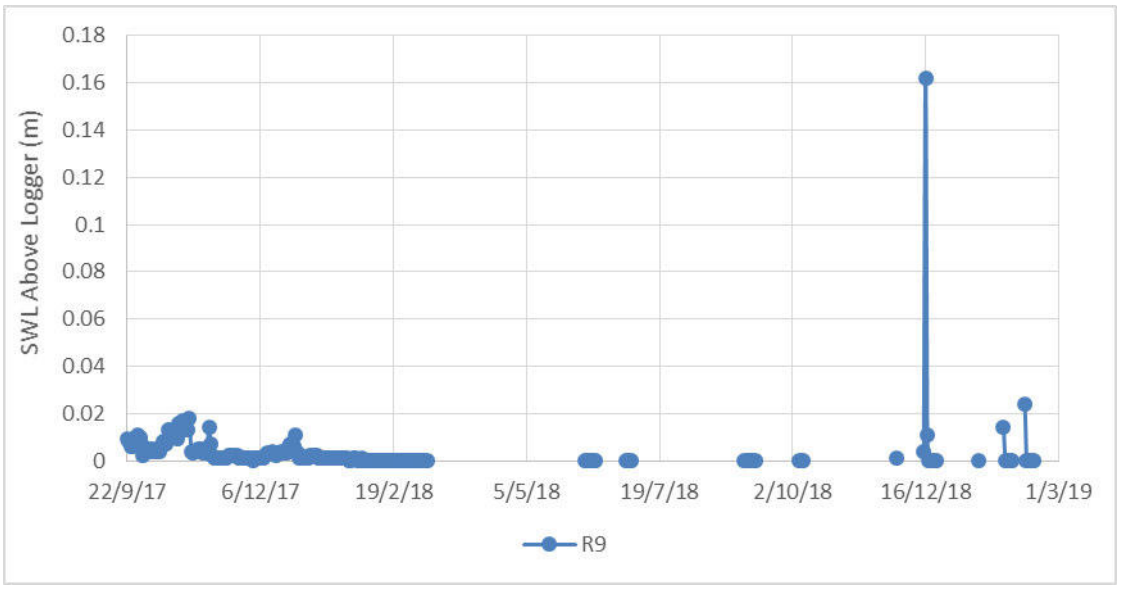
Both VWP intakes at 38mbgl and 48mbgl (P9B and PC) failed to record any further readings after 19th May 2018, when they sheared off.

P9B and P9C were replaced with open standpipe piezometers on 28/11/2018. After that time they have both shown a heightened response to rainfall in the catchment and recharge of pools in Redbank Creek, compared to before they were undermined.

Observation of the P9 piezometers, pool levels in Redbank Creek and rainfall indicates undermining of the creek and P9 piezometers by Longwall 31 has increased the fracture connection with the creek and enables a heightened recharge / discharge response after rain events within the shallow strata.

It has also been observed that the pre-undermining separation of the four individual hydrographs has modified so that the upper two intakes are at an equivalent elevation, whilst the two deeper intakes are also at an equivalent, deeper elevation. The separation between the two post undermining systems occurs at around 10.5m below surface.





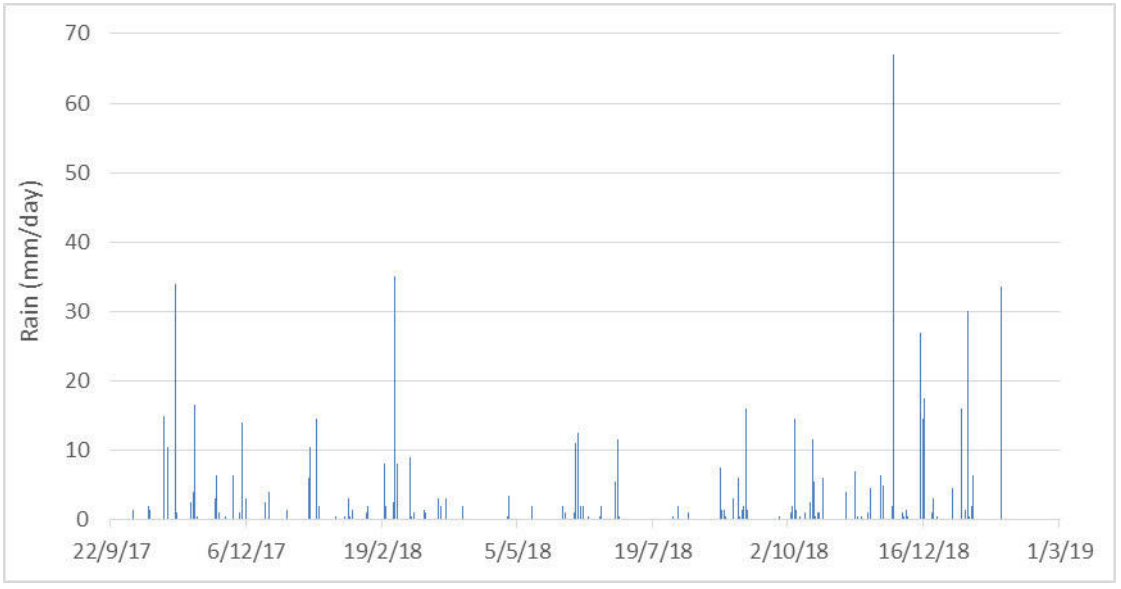


Figure 9 P9 Series Groundwater Levels, Pool R9 Water Level and Rainfall

3.7.6 Groundwater Quality

Groundwater in the study area has generally brackish salinity (459µS/cm to 12,250µS/cm) with acid to circum-neutral pH (3.06 to 7.6) as shown in **Figure 10** and **Figure 11**.

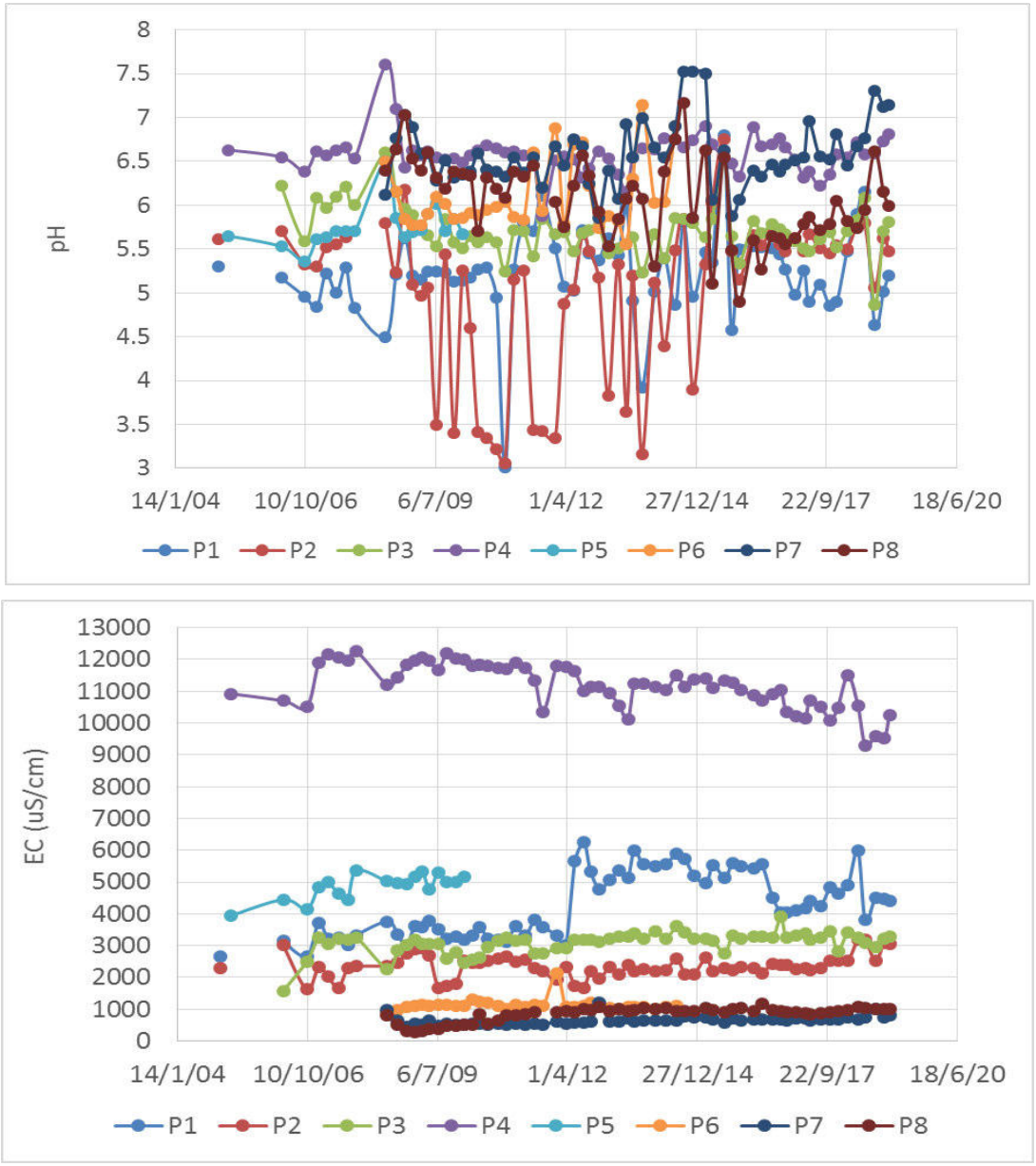


Figure 10 Field Groundwater Quality

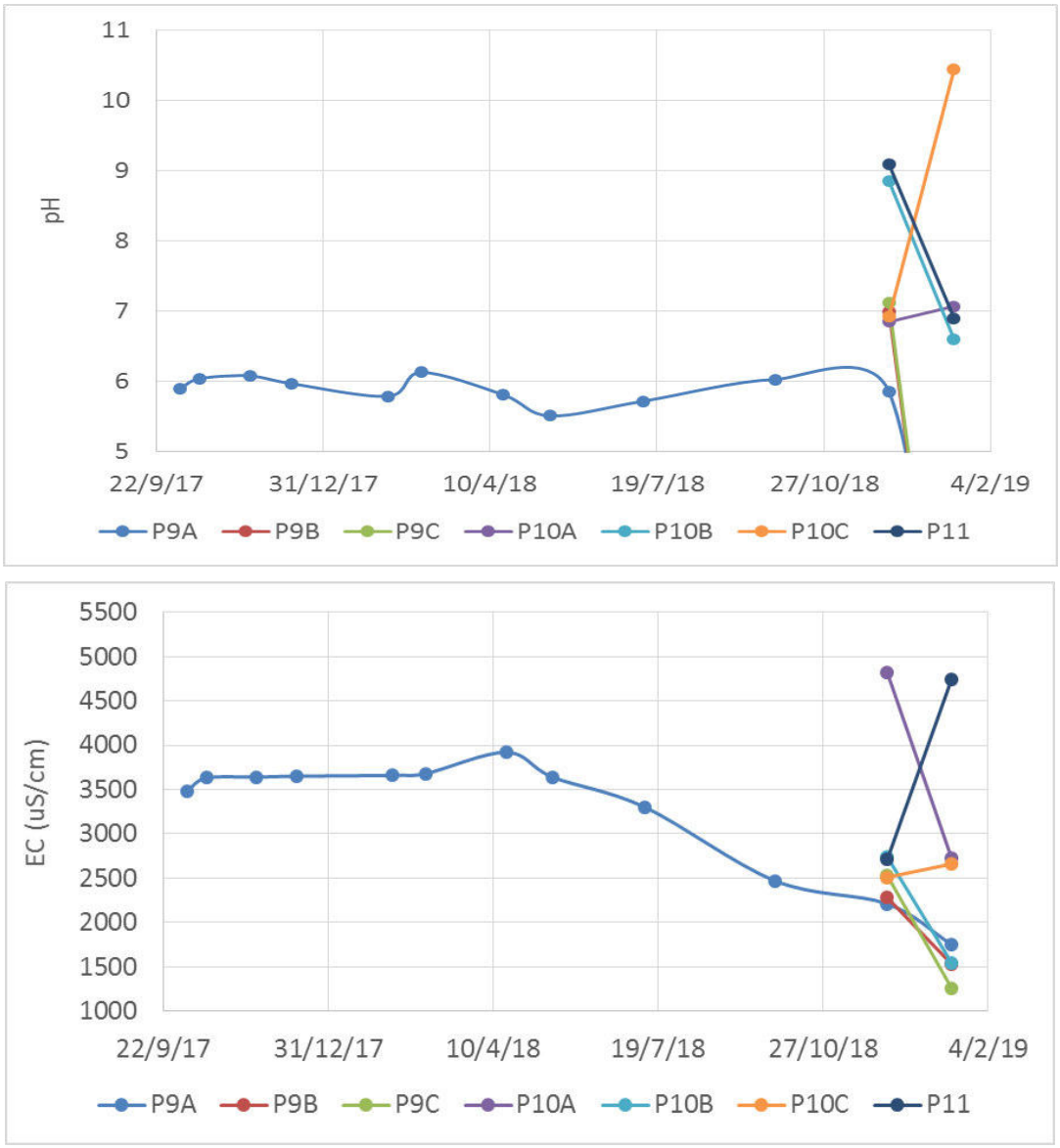


Figure 11 Field Groundwater Quality

Laboratory analyses obtained to date indicate that the bore water generally is outside ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust upland rivers / 95% protection of freshwater species / livestock / irrigation) for:

- pH;
- Electrolytical conductivity;
- Sodium;
- Hardness;
- Total nitrogen, total phosphorous, as well as; and
- Filterable manganese, copper, zinc, nickel, aluminium and, to a small degree, lead.

The exceedance varies depending on the applicable guideline applied for the end use of the water.

Groundwater in the Longwall 22 to 31 subsidence area is suitable for selected livestock and limited irrigation use, but not for potable water.

No complaints regarding groundwater quality changes have been reported in the study area during the monitoring period.

No adverse change to groundwater quality in the subsided bores has been observed, along with no distinctive increase in salinity, iron or manganese.

4. SUBSIDENCE IMPACT MANAGEMENT

During and after extraction of Longwall 31, the LW31 TARP criteria triggers that occurred involved the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* on the following dates;

- 24/5/18 RB14 (LW30), RR20, 21, 22, Weir 26/RC3 (LW31)
- 07/6/18 RR29 (LW32)
- 15/6/18 RW13 (LW30), RR23 and RR27(LW31)
- 21/6/18 RR16 (LW30), RR24, 25 (LW31)
- 28/6/18 RR15 (LW30), RR18, 19 (LW31), RR28 (LW32), and
- 05/7/18 RB17 (LW31)

Accordingly, the colliery prepared and submitted a Corrective Management Action Plan (SIMEC, 2018) on 31/12/2018 to address the ongoing monitoring, management and subsequent remediation of Redbank Creek.

5. CONCLUSIONS

Based on monitoring of streams, dams and groundwater conducted prior to, during and after extraction of Longwall 31, the following conclusions can be made:

- Stream bed cracking, associated with a reduction in stream flow and mostly complete drying up of pools has been observed in Redbank Creek due to extraction of Longwall 31 (and preceding longwalls) to Site RR32, downstream of Longwall 32;
- Connected stream "through-flow" has been interrupted or discontinued (outside of storm events) over Longwalls 26 to 32, with connected flow (albeit with reduced pool levels) recommencing at RR29;
- The "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered at 16 sites between RW13 and RR29 between 24/5/18 and 5/7/18
- Significant depressurisation of the Bulli Seam has been observed in the vibrating wire piezometer bore at TNC40 and TNC43 along with partial depressurisation in the upper and middle Hawkesbury Sandstone in TNC43
- Up to 6.55m of depressurisation was observed in the 68mbgl VWP intake at P9, adjacent to Redbank Creek and over the Longwall 31/21 chain pillar, which subsequently recovered to just above its initial water level, and;
- No adverse effects on private bore yield or water quality have been reported during or after Longwall 31 extraction.

6. REFERENCES

ANZECC 2000 Australian and New Zealand Guidelines For Fresh and Marine Water Quality

GeoTerra, 2009 Longwall Panels 27 to 30 Surface Water & Groundwater Assessment

GeoTerra, 2013 Tahmoor Colliery Groundwater Management Plan

GeoTerra, 2017 End of Longwall 30 Surface Water, Dams and Groundwater Monitoring Report

Mine Subsidence Engineering Consultants Pty Ltd 2009 Longwalls 27 to 30 Subsidence Predictions and Impact Assessment for Natural Features and Items of Surface Infrastructure

Mine Subsidence Engineering Consultants Pty Ltd 2019 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 31

SIMEC, 2018 Redbank Creek Corrective Management Action Plan

Tahmoor Underground, 2017 Tahmoor Colliery Longwall 31 Environmental Management Plan

LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between GeoTerra Pty Ltd (GeoTerra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the clients requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, GeoTerra has relied upon information and documentation provided by the client and / or third parties. GeoTerra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. GeoTerra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. GeoTerra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to GeoTerra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of GeoTerra.

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Ecology End of Panel Report
Tahmoor Longwall 31

Prepared for Tahmoor Colliery | 31 March 2019

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Document control

Project number	Client	Project manager	LGA
4838	Tahmoor Colliery	Luke Baker	Wollondilly Shire

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D1	Lucy Porter/ Sarah Hart	Luke Baker	Draft	27 March 2019

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1. Introduction

1.1 Background

Tahmoor Coal Pty Ltd (Tahmoor Colliery) has completed extraction of Longwall 31. Tahmoor Colliery is required to develop an End of Panel (EoP) Report for Longwall 31, to comply with Subsidence Management Plan Approval.

Niche Environment and Heritage (Niche) was commissioned by Tahmoor Colliery to conduct an EoP assessment of the terrestrial and aquatic ecological values within the limit of subsidence of Longwall 31 (Study Area).

This report takes into consideration the predicted and observed impacts on terrestrial and aquatic ecological values within the Study Area in order to assess the impacts against the relevant Trigger Action Response (TARPs) associated with the Tahmoor Colliery (2015) Longwall 31 Environmental Management Plan. In particular, this assessment has utilised monitoring data collected as part of the following monitoring campaigns and specialist studies:

- Niche (2018a) Tahmoor North Longwall 31, Stream Health Assessment, Prepared for Tahmoor Coal.
- Niche (2018b) Tahmoor North, Aquatic Baseline Monitoring, Prepared for Tahmoor Coal.
- Niche (2018c) Tahmoor North, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Niche (2014) Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment, Prepared for Tahmoor Coal December 2014.
- Mine Subsidence Engineering Consultants (MSEC) (2019) Tahmoor Coking Coal Operations - Longwall 31 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 31.
- Geoterra (2019). Longwall 31 Surface Water, Dams and Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA31-R1.

2. Subsidence Monitoring Results

2.1 Subsidence Monitoring Results Summary (MSEC)

The EoP Subsidence Report for Longwall 31 prepared by MSEC (2019 – MSEC1001) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 31.

Subsidence has the potential to impact terrestrial ecological values. Table 1 outlines the observed subsidence impacts and the potential consequences for terrestrial ecological values relevant to Longwall 31. As indicated in Table 1, overall the recorded subsidence on natural landscape features resulting from the extraction of Longwall 31 was similar to those predicted.

Table 1. Observed impacts from Longwall 31 due to subsidence and their correlation to potential terrestrial ecology impacts

Natural feature	Summary of predicted impacts (MSEC 2019)	Subsidence monitoring results (MSEC 2019)	Correlation to Terrestrial Ecological Values
Redbank Creek	Potential cracking in creek bed. Potential surface flow diversion. Potential reduction in water quality during times of low flow. Potential increase in ponding.	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over Longwalls 25 to 31 and future Longwall 32. Changes in salinity has been observed downstream of Redbank Creek subsidence zone, along with elevated nickel, zinc, iron and manganese. Increased ferruginous and salinity levels have been observed in Redbank Creek over Longwalls 29 and 30 and future Longwall 31. The location of the sites are detailed in GeoTerra (2019).	Change in water levels due to ponding, flooding and inundation or desiccation has the potential to alter the distribution of water plant habitat for amphibians, drown riparian vegetation or remove foraging habitat for any fauna dependant on pools.
Steep slopes and Cliffs	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during the mining of Longwall 31.	Soil slippage may result in erosion causing vegetation loss, direct impacts to threatened fauna and disruption of habitat.
Natural vegetation	No anticipated impacts	No impacts observed during Longwall 31	Subsidence has the potential to change hydrology, thus resulting in changes to flora reliant upon such a hydrological regime.

3. Environmental Monitoring

3.1 Biodiversity Monitoring

Biodiversity monitoring has been undertaken as part of the Tahmoor North monitoring campaign, which includes the areas of Redbank Creek which occurs within the Study Area. The monitoring undertaken by Niche applicable to this assessment includes:

- Niche (2018a) Tahmoor North Longwall 31, Stream Health Assessment, Prepared for Tahmoor Coal.
- Niche (2018b) Tahmoor North, Aquatic Baseline Monitoring, Prepared for Tahmoor Coal.
- Niche (2018c) Tahmoor North, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Mine Subsidence Engineering Consultants (MSEC) (2019) Tahmoor Coking Coal Operations - Longwall 31 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 31.
- Geoterra (2019). Longwall 31 Surface Water, Dams and Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA31-R1.

3.1.1 Amphibian and riparian monitoring

The Longwall 31 Study Area includes monitoring sites associated with the biodiversity (amphibian and riparian) monitoring program (Niche 2018c). This monitoring program collected riparian vegetation monitoring along Redbank Creek, which entailed traverses of the creek, and collection of flora plots/transect; and amphibian transects at set monitoring locations along Redbank Creek. Further monitoring sites are located along Stonequarry Creek, Cedar Creek, Newlands Gully, Matthews Creek, which a detailed methodology provided in Niche (2014).

To date, the biodiversity (amphibian and riparian) monitoring has been undertaken on the following dates:

Riparian vegetation monitoring:

- Summer monitoring 2017: 7th, 13th and 14th of December 2017
- Autumn monitoring 2017: 13th, 19th and 20th of April 2018.
- Summer monitoring 2018: 26th, 29th, 30th of December 2018 and 6th December 2018.

Amphibian monitoring:

- Summer monitoring 2017: 4th, 5th and 7th of December 2017
- Autumn monitoring 2017: 3rd, 8th 17th of May 2018.
- Summer monitoring 2018: 4th, 5th and 6th of December 2018.
- Autumn monitoring 2019: 19th, 20th and 21st March 2019 (not included in Niche 2018c).

3.1.2 Aquatic ecology monitoring

The Longwall 31 Study Area includes monitoring sites associated with the Biodiversity (Aquatic Ecology) Monitoring Program (Niche 2014), and Longwall 31 Stream Health Monitoring (Niche 2018a).

Aquatic ecological monitoring of the Longwall started in spring 2017 before the Redbank Creek was undermined by Longwall 31. Three sites were monitored at and downstream of Longwall 31. These location were surveyed again in Autumn 2018 post-undermining of Redbank Creek. The monitoring included:

- Physiochemical in situ surface water sampling
- Habitat assessment
- AUSRIVAS macroinvertebrate monitoring

- Quantitative macroinvertebrate monitoring.

3.1.3 Surface water, dam and groundwater monitoring

Surface water, dams and groundwater monitoring program for Longwall 31 has been conducted by GeoTerra since June 2004. The monitoring by GeoTerra has assessed the following features which relate to terrestrial ecology:

- Ephemeral or perennial nature and flow in streams over the panels
- Creek bed and bank erosion and channel bedload
- Stream and dam water quality
- Stream bed and bank vegetation
- Nature of alluvial land along stream banks
- Presence, size and integrity of dams and their water level
- Presence and use of groundwater bores
- Assessment of standing water levels and water quality.

The results of GeoTerra (2019) has been incorporated throughout this assessment where applicable.

4. Monitoring Results

4.1.1 Riparian monitoring results

During the Niche (2018c) monitoring, and Niche (2014) biodiversity impact assessment, it was confirmed that the native vegetation along Redbank Creek was in a degraded condition prior to mining due to historic clearing and high weed presence. For the most part, the vegetation along the banks of Redbank Creek consisted of the Threatened Ecological Community (TEC) Shale Sandstone Transition Forest within a degraded condition, which integrated with areas of Grey Myrtle Dry Rainforest community closer to the creek.

No areas of any vegetation die back have been recorded during the monitoring campaigns, or significant changes to vegetation were recorded across the monitoring to date.

4.1.2 Aquatic monitoring results

During the Niche (2014) biodiversity impact assessment, it was confirmed that Redbank Creek is unlikely to support habitat for any threatened amphibian species. To date, the Niche (2018c) monitoring has not recorded any threatened amphibian species, nor recorded any population of amphibians of a significant scale. This is largely attributed to the absence of water and pools within Redbank Creek within the Longwall 31 Study Area.

4.1.3 Aquatic ecology monitoring

Details of the monitoring are provided in Niche (2018a; 2018b) however in summary the monitoring presented similar results to surveys conducted in 2014 found Redbank Creek showed obvious signs of deterioration in stream condition with stream bed cracking, loss of pool holding capacity and loss of aquatic habitat.

The monitoring detected that most sites monitored were recorded low dissolved oxygen below ANZECC Default Tigger Values (DTVS), however pH was generally within DTVs. Stream health as indicated by AUSRIVAS and SIGNAL showed impairment of macroinvertebrate communities (that is, some sites were missing families expected to occur at the site naturally) which generally consisted of pollution tolerant macroinvertebrate families. Overall, it was considered that natural environmental stressors (predominantly

low flow) are likely to be driving these observations with local anthropogenic influences exacerbating these conditions. Monitoring suggested that high salinity/electrical conductivity recorded in Redbank Creek in autumn 2018 could be harmful to aquatic organisms.

The details of the Steam Health Assessment associated with Longwall 31 are provided in Niche (2018b). In general, the 2017 monitoring showed similar results to surveys conducted in 2013 and 2015 which found the riparian and channel condition in a disturbed condition, with rubbish and exotic species present. The water quality had consistently high salinity, and low dissolved oxygen, however pH was generally with ANZECC guidelines in 2017. Stream health as indicated by AUSRIVAS and SIGNAL showed impairment of macroinvertebrates (that is, sites that are missing families that expected to occur at the site naturally) and generally consisted of pollution tolerant macroinvertebrate families. Overall this indicated that Redbank Creek is in poor stream health which is likely due to a number of factors including natural environmental stresses, local pollution from the urban catchment and undermining of the Redbank Creek from previous longwall mining upstream of Longwall 31.

Redbank Creek is likely to have been impacted from longwall mining, particularly recent cracking as a result of longwall 31. This has resulted in loss of water holding capacity at monitoring Site 1, Site 2 and Site 3 and availability of aquatic habitat. Mine subsidence has also possibly led to the measured condition changes between spring 2017 and autumn 2018 i.e. increase in electrical conductivity/salinity concentrations (from approx. 1000- 3000 µS/cm) and changed macroinvertebrate community at Sites 1, 2 and 3. The Diptera family Chaoboridae was found to be dominant in autumn 2018 sampling at Sites 1,2 and 3. This family is pollution tolerant (SIGNAL 2) and are associated slow-flowing creeks, seepages, or swampy ground (MDFRC 2018). Therefore, while Redbank Creek was already in a very poor condition (2014 and spring 2017), its health appears to have declined between the monitoring seasons. This could be attributed to longwall mining and associated mine subsidence, however could also be attributed to the urban landscape context.

4.1.4 Surface water, dam and groundwater monitoring

The GeoTerra (2019) report details the results and reported impacts from the on-going monitoring of environmental values within the limit of subsidence of Longwall 31.

Impacts from mining of Longwall 31 identified by GeoTerra (2019) include the following:

- Stream bed cracking and loss of pool holding capacity has been observed in pools and stream reaches in Redbank Creek over Longwalls 25 to Longwall 32.
- Increased salinity over and downstream of the Redbank Creek subsidence zone, particularly at Sites RC3 and RC4, along with elevated iron, Total Nitrogen, Total Phosphorous, copper, zinc, nickel and manganese.
- Increased ferruginous and salinity levels have been observed over Longwall 29 - 32 in Redbank Creek.
- No adverse effect on plateau stream ecology has been reported.
- No localised stream ponding due to subsidence has been observed.

5. Impacts on threatened biodiversity

5.1 Field survey

A one day field inspection was undertaken by Sarah Hart (Ecologist – Niche) on the 22nd March 2019 along Redbank Creek within the predicted subsidence zone, to observe any areas of vegetation die back that may have been attributed to subsidence.

During field survey, no signs of vegetation die back were observed along the riparian zones within the limits of subsidence for Longwall 31. Furthermore, no threatened flora or fauna were recorded whilst traversing the area during the field survey.

5.2 Threatened ecological communities

Niche (2014) and Biosis Research (2009) recorded three Threatened Ecological Communities (TECs) within the vicinity of Longwall 31: Cumberland Plain Woodland, Shale Sandstone Transition Forest, and Moist Shale Woodland. These communities are listed as TECs under the NSW *Biodiversity Conservation Act 2016* (BCT) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Both Niche (2014) and Biosis Research (2009) concluded mining within the vicinity of Longwall 31 is unlikely to have a significant impact on any of these TEC's.

Subsidence associated with the extraction of Longwall 31 is consistent with the subsidence impact assumptions in the Niche (2014) and Biosis (2009) report and no changes in any of these vegetation communities has been reported (GeoTerra 2019) or observed during the Niche survey inspection and monitoring. It should be noted that whilst Niche and GeoTerra were not able to inspect all areas of the TECs given the location of TEC patches within private properties, it is highly unlikely that subsidence would impact upon the TECs given they are not solely groundwater dependant, and any cracking of soil within the vegetation community is unlikely to result any significant floristic and structural changes.

5.3 Threatened flora

No threatened terrestrial or aquatic flora species were recorded in the study area during the Niche (2014) the monitoring undertaken by Niche, or survey conducted by Biosis Research (2009). However, within the vicinity of Longwall 31, potential habitat was determined for four threatened flora species that may potentially be impacted by subsidence: *Epacris purpurascens var. purpurascens* and *Pomaderris brunnea* Niche (2014) concluded that mining of longwall 31-37 is unlikely to have a significant impact on any of threatened flora. A similar conclusion was reached in Biosis Research (2009) in relation to Longwalls 27-30.

Subsidence associated with the extraction of Longwall 31 is consistent with the subsidence impact assumptions in Niche (2014) due to the following:

- No threatened flora were recorded during the Niche field survey.
- *Epacris purpurascens* var. *purpurascens*, and *Pomaderris brunnea* are relatively conspicuous and unlikely to remain undetected during the field survey.
- No threatened flora were recorded during the monitoring and Biosis (2009).

As such it is not likely that the extraction of coal from Longwall 31 has led to any impacts on these four threatened plant species.

5.4 Threatened fauna

Thirty-four threatened and/or migratory fauna were considered to have limited potential habitat within the study area (Niche 2014). These species include:

- Amphibians: Red-crowned Toadlet.
- Birds: Regent Honeyeater, Fork-tailed Swift, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Square-tailed Kite, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl.
- Invertebrates: Cumberland Plain Land Snail.
- Mammals: Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Koala, Grey-headed Flying-fox, Greater Broad-nosed Bat.

The impact assessments completed as part of Niche (2014) and similar assessment completed by Biosis (2009) (which covered most of the Study Area), concluded that mining of Longwall 31 was unlikely to have a significant impact on a local population of any of these threatened fauna species as potential roosting/sheltering habitat for these species is outside the subsidence footprint of Longwall 31.

Subsidence associated with the extraction of Longwall 31 is consistent with the subsidence impact assumptions in the Niche (2014) report and the Biosis (2009) report, and the extraction of coal from the Longwall is not likely to have had a significant impact on any threatened fauna species.

No aquatic threatened species listed under the Fisheries Management Act 1991 (FM Act) occur within Redbank Creek. As such there in no impact to threatened aquatic fauna.

6. Assessment of predicted and observed impacts

The predicted and observed impacts on TEC's and threatened species (and their habitats) resulting from the Longwall 31 is provided in Table 2. The table focuses on the three main ecological values which were the subject of the assessment undertaken by Niche (2014) for the development of Longwalls 31 to 37.

Table 2: Summary of the predicted and observed impacts on general habitat and threatened flora and fauna Associated with Longwall 31

Ecological Values	Predicted Impact	Observed Impact based on Niche survey, GeoTerra (2019) and MSEC (2019)	Within Prediction (yes/no)
Endangered Ecological Communities (and other vegetation)	Potential gas emissions may result in small, isolated areas of vegetation dieback. Potential surface fracturing and gas emissions considered unlikely to result in alteration of species composition or distribution. Unlikely to have a significant impact on any plant communities.	No vegetation impacts have been observed or reported. No significant impacts to TECs or vegetation are likely to have occurred.	Yes
Threatened flora	Volume of water available for plant use is unlikely to be significantly impacted. It is considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. No significant impact to threatened flora.	No vegetation impacts have been observed or reported. No significant impacts to flora and flora habitat. The Niche (2014) report assumed flow diversion and pool level changes would occur as a result of mining Longwalls 31 to 37. Furthermore, the Biosis (2009) assessment which includes portions of Longwall 31 has similar assumptions. Given, such predictions were considered in the impact assessment, and no threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 31, observations are within the predicted impacts for flora, fauna and TECs.	Yes
Threatened fauna and fauna habitat	Changed surface water conditions, such as effects to pools and streams. Impacts to steep slopes and cliffs. Impacts of gas emissions on water quality and riparian vegetation. No significant impacts to any threatened fauna.	No vegetation impacts have been observed or reported. No significant impacts to fauna and fauna habitat. The Niche (2014) report assumed flow diversion and pool level changes would occur as a result of mining Longwalls 31 to 37. Given, such predictions were considered in the impact assessment, and no threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 31, observations are within the predicted impacts for flora, fauna and TECs.	Yes

7. Trigger Action Response Plan

An address of each of TARPS related to terrestrial and aquatic ecology are provided in Appendix A.

In summary, based on the field observations and monitoring completed by Niche to date, and the GeoTerra (2019) assessment, no TARPS associated with terrestrial flora and fauna (amphibians and riparian) have been triggered which have led to any significant terrestrial ecology impacts to date. This is due to the following:

- Impacts do not exceed that predicted in Niche (2014) Biodiversity impact assessment.
- No threatened amphibians recorded during monitoring by Niche (2018c).
- No threatened amphibians recorded during monitoring by Niche (2018c).
- No significant decline in amphibian populations likely given the low abundance currently along Redbank Creek.
- No vegetation die back has been observed during the monitoring or field survey.
- The riparian monitoring has not detected any significant changes in flora within the Redbank Creek monitoring sites during the monitoring year.

Similarly, in relation to the aquatic ecology (macroinvertebrates) TARPs, these are unlikely to have been exceeded due to the following:

- Redbank Creek is in a relatively poor condition prior to Longwall 31 mining.
- AUSRIVAS and SIGNAL completed as part of Niche (2018a) indicated that the poor health of Redbank Creek within the Longwall 31 Study Area is likely due to a number of factors including natural environmental stresses, local pollution from the urban catchment and undermining of the Redbank Creek from previous longwall mining upstream of Longwall 31.
- Whilst the monitoring to date along Redbank Creek detailed in Niche (2018a) indicated by AUSRIVAS and SIGNAL showed impairment of macroinvertebrates following mining, Redbank Creek was in a poor steam health state prior to mining of Longwall 31.
- Continuation of macroinvertebrate and steam health monitoring along Redbank Creek is recommended to provide further data for analysis in regards to the potential impacts of longwall mining impacts.

8. Conclusion

This report compares the observed impacts of subsidence associated with the extraction of Longwall 31 at Tahmoor Colliery against the impacts predicted prior to extraction of coal from the Longwall in relation to biodiversity values. This assessment is based on a review of monitoring observations and measurements undertaken by Niche (2014; 2018a, 2018b; 2018c), MSEC (2019), and GeoTerra (2019).

The impacts which have occurred within the limit of subsidence for Longwall 31 are within the parameters of the predicted impacts outlined in the terrestrial ecological assessment for Longwalls 31 to 37 (Niche 2014).

No TARPs associated with terrestrial and aquatic ecology have been exceeded based on the specialist studies, field survey and monitoring results to date.

It is recommended that the current monitoring program continue along Redbank Creek in order to assist in the early detection of TARP exceedances associated with the future longwall activities.

References

Biosis Research (2009) Tahmoor Colliery Longwalls 27-30 Impacts of Subsidence on Terrestrial Flora and Fauna Final Report.

GeoTerra (2019). End of Longwall 31 Streams, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA19-R1. Mine Subsidence Engineering Consultants

MSEC (2019) Glencore: Tahmoor Colliery - Longwall 31 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 30.

Niche (2018a) Aquatic baseline monitoring –Tahmoor North. Prepared for Tahmoor North

Niche (2018b) Aquatic streamhealth assessment for longwall 31. Prepared for Tahmoor Colliery.

Niche (2018c) Biodiversity Monitoring (Riparian and Amphibian Monitoring) Tahmoor North. Prepared for Tahmoor Colliery.

Niche (2014) Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment, Prepared for Tahmoor Coal December 2014

Appendix A: TARP Trigger Observations and Impacts associated with Longwall 31

Natural feature	Impact	Trigger	Monitoring	Timing and frequency	By whom	TARPs triggered?
Flora and fauna	Macroinvertebrates	None	Stream Health Assessment	Prior to undermining Redbank Creek End of Panel Reporting	Niche	Stream Health Monitoring has been completed by Niche. Details provided in Niche 2018a.
	Macroinvertebrates	Impacts occurring to the significance of stream health	ERG to consider any additional management and monitoring actions	Within 1 week	ERG	Redbank Creek is in a relatively poor condition prior to Longwall 31 mining. AUSRIVAS and SIGNAL completed as part of Niche (2018a) indicated that the poor health of Redbank Creek within the Longwall 31 Study Area is likely due to a number of factors including natural environmental stresses, local pollution from the urban catchment and undermining of the Redbank Creek from previous longwall mining upstream of Longwall 31. Whilst the monitoring to date along Redbank Creek detailed in Niche (2018a) indicated by AUSRIVAS and SIGNAL showed impairment of macroinvertebrates following mining, Redbank Creek was in a poor steam health state prior to mining of Longwall 31. Monitoring is recommended to continue to assist in interpreting this TARP.
			Prepare remediation plan in consultation with OEH and Fisheries	After active subsidence is complete	Tahmoor Colliery	
Flora and fauna	Amphibian	None	Record and monitoring prior to undermining Redbank Creek	Prior to undermining Redbank Creek	Niche	No threatened amphibians recorded during monitoring by Niche (2018c).
Flora and fauna	Amphibian	Impacts occurring to the significance of an amphibian population	ERG to consider any additional management and monitoring actions	Within 1 week	Niche	No threatened amphibians recorded during monitoring by Niche (2018c). No significant decline in amphibian populations detected during monitoring to date.
			Prepare remediation plan in consultation with OEH	After active subsidence is complete	Tahmoor Colliery	
Flora and fauna	Riparian	None	Record and monitoring	Prior to undermining Redbank	Niche	Riparian monitoring has not detected any

Natural feature	Impact	Trigger	Monitoring	Timing and frequency	By whom	TARPs triggered?
			prior to undermining Redbank Creek	Creek		significant changes in flora within the monitoring sites (Niche 2018c).
				End of Panel Reporting	Niche	
Flora and fauna	Riparian	Impacts occurring to the significance of ecology in riparian zone	ERG to consider any additional management and monitoring actions	Within 1 week	Niche	No vegetation die back has been observed during the monitoring or field survey. The riparian monitoring has not detected any significant changes in flora within the monitoring sites (Niche 2018c).
			Prepare remediation plan in consultation with OEH	After active subsidence is complete	Tahmoor	

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27 March 2019

Ms Fiona Robinson
Environment Coordinator
Tahmoor Colliery
Remembrance Drive
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Via email: Fiona.Robinson@simecgfg.com

Dear Fiona,

Re: Tahmoor Colliery Longwall 31 End of Panel Reporting: Heritage review and reporting

As outlined in the Management Plan and Aboriginal Heritage Impact Permit (AHIP #3781) for the Aboriginal archaeological site Redbank Creek-1 (AHIMS ID #52-2-3254), Niche Environment and Heritage (Niche) has undertaken a further site inspection of Redbank Creek-1 to assess any observable impacts may have occurred to the site during the extraction of Longwall 31 with representatives from the following Registered Aboriginal Parties (RAPs):

- Cubbitch Barta Native Title Claimants
- Tharawal Local Aboriginal Land Council

Peter Falk, of Peter Falk consultancy has now retired and will not need any further consultation in regards to this project.

The inspection found that no new impacts have occurred at Redbank Creek-1 (AHIMS ID #52-2-3254) from the extraction process.

The following Historical Heritage Sites were assessed as part of this End of Panel assessment:

- Mill Hill; and
- Korana Homestead

The following recommendations have been made:

- Tahmoor Colliery should continue their consultation with the Aboriginal community in regards to Redbank Creek-1 (AHIMS ID #52-2-3254) as required by AHIP #3781; and
- Redbank Creek-1 (AHIMS ID #52-2-3254), Mill Hill and the Korana Homestead should continue to be monitored during the extraction of Longwalls 32

Please do not hesitate to contact me should you require any further information.

Yours sincerely

Renée Regal- Aboriginal Heritage Team Leader

Statement of management objective

The management objective of Redbank Creek-1 (AHIMS ID #52-2-3254) is to ensure that any impacts to the site resulting from the extraction of Longwall 31 are reduced and minimised over the long term. The impacts to be minimised include; adverse effects to the art panels of the site, through further movements of the shelter, or through changes to water seepage patterns due to subsidence related cracking.

Background and introduction

Niche was commissioned by Tahmoor Colliery to conduct an End of Panel assessment of the Aboriginal cultural heritage and Historical heritage sites within the limit of subsidence of Longwall 31 at Tahmoor Colliery.

The site inspections for this End of Panel assessment were carried out by Renée Regal (Aboriginal Heritage Team Leader--Niche), Sarah Hart (Ecologist- Niche) on 22 March 2019, Glenda Chalker (RAP-Cubbitch Barta Native Title Claimants) and Jason Mitchell (RAP- Tharawal Local Aboriginal Land Council).

Strata Control Technologies (SCT) (2014) predicted that the extraction of Longwalls 31 would have less than 20% chance of harming Redbank Creek-1. Such a risk is considered relatively high in the context of the Southern Coalfields, therefore an Aboriginal Heritage Impact Permit (AHIP) for Redbank Creek-1 (AHIMS ID #52-2-3254) has been obtained.

During this assessment no observable impacts as a result of mining were identified at the Aboriginal archaeological site of Redbank Creek-1 (AHIMS ID #52-2-3254). However, changes from seepage due to mould growth at the lower levels of the shelter were observed. It is unclear at this stage whether these changes can be attributed to mining. Further damage was evident to the back of the shelter at site Redbank Creek-1 and its deposit from wild goats rubbing against the sandstone and living in the shelter.

Niche (2014) identified three European heritage sites that could be impacted by subsidence from Longwall 31. Based on the predictions by MSEC (2014), Koorana Homestead is located directly above Longwall 32 and could experience minor impacts. Mill Hill is located at the end of Longwall 31 and could experience minor impacts. The Rural Landscape located on Thirlmere Way is unlikely to experience impacts from subsidence.

Koorana Homestead is listed as an item of local heritage significance on the Wollondilly Local Environmental Plan (LEP) 2011 ('Koorana Homestead, outbuildings and trees' – item ID:1207). Niche heritage consultants (2017) have prepared a Statement of Heritage Impact (SoHI) with the input from MSEC (subsidence engineers) and John Matheson & Associates (structural engineer). The SoHI for Koorana Homestead was prepared in consultation with the property owner and has been approved by Wollondilly Shire Council.

The site was inspected by MSEC during their works for this End of Panel assessment and there were no observed impacts as a result of mining.

Subsidence results summary (MSEC)

The End of Panel Subsidence Report for Longwall 31 prepared by MSEC (MSEC1001_Revision A) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 31.

In relation to matters that may affect Aboriginal cultural heritage values, MSEC notes the following (MSEC1001_Revision A: Table 4.1):

- In relation to Redbank Creek, stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over Longwall 31.
- No impacts were observed during the extraction of Longwall 31 to the steep slopes and cliffs.
- There were no impacts observed to Redbank Creek-1
- There were no impacts observed at Mill Hill or Korana Homestead.

Aboriginal community consultation

Aboriginal community consultation has continued as outlined in the recommendations made by Biosis Research (2009) and Niche (2014).

The following Aboriginal groups were contacted via email and telephone in March 2019 to organise a site inspection and sent a copy of the Longwall 31 End of Panel report:

- Cubbitch Barta Native Title Claimants
- Tharawal Local Aboriginal Land Council

The following RAPs registered their interest to attend:

- Mrs Glenda Chalker, Cubbitch Barta Native Title Claimants
- Rebecca Ede, Tharawal Local Aboriginal Land Council

A draft copy of this report was sent to the RAPs on 28 March 2019. Comments will be incorporated once they have been received.

Previous site assessment summaries

Historical Heritage

Niche (2014) identified three European heritage sites that could be impacted by subsidence from Longwall 31. Based on the predictions by MSEC (2014), Koorana Homestead is located directly above Longwall 32 and could experience minor impacts, Mill Hill is located at the end of Longwall 31 and could experience minor impacts and the Rural Landscape located on Thirlmere Way is unlikely to experience impacts from subsidence.

Koorana Homestead is listed as an item of local heritage significance on the Wollondilly Local Environmental Plan (LEP) 2011 ('Koorana Homestead, outbuildings and trees' – item ID: 1207). Niche heritage consultants (2017) have prepared a Statement of Heritage Impact (SoHI) with the input from MSEC (subsidence engineers) and John Matheson & Associates (structural engineer). The SoHI for Koorana

Homestead was prepared in consultation with the property owner and has been approved by Wollondilly Shire Council.

Niche were engaged by Tahmoor Colliery to prepare a SoHI for Mill Hill with input from MSEC (subsidence engineers) and John Matheson & Associates (structural engineer). The SoHI for Koorana Homestead will be prepared in consultation with the property owner was approved Wollondilly Shire Council on 4 October 2017.

The Rural Landscape adjacent to Thirlmere Way is partly located above Longwall 31. The vertical subsidence transitions from the maximum values directly above the proposed longwalls to slightly reduced values above the chain pillars. These variations in the vertical subsidence of around 200 mm to 300 mm occur over distances of 320 metres and, therefore, are not visually perceptible. It is unlikely, therefore, that the vertical subsidence would reduce the visual aesthetics or the heritage value of the land (MSEC 2014).

Aboriginal Heritage

Redbank Creek-1 (AHIMS ID #52-2-3254) was recorded with AHIMS in the 1990s prior to any detailed assessments of the site which occurred as a result of environmental assessments of potential subsidence effects associated with longwall mining. The Aboriginal archaeological site was inspected and assessed by Biosis in 2009 and re-recorded by Niche in 2014, as part of Tahmoor Colliery's AHIP application process. Summaries of both assessments are outlined below.

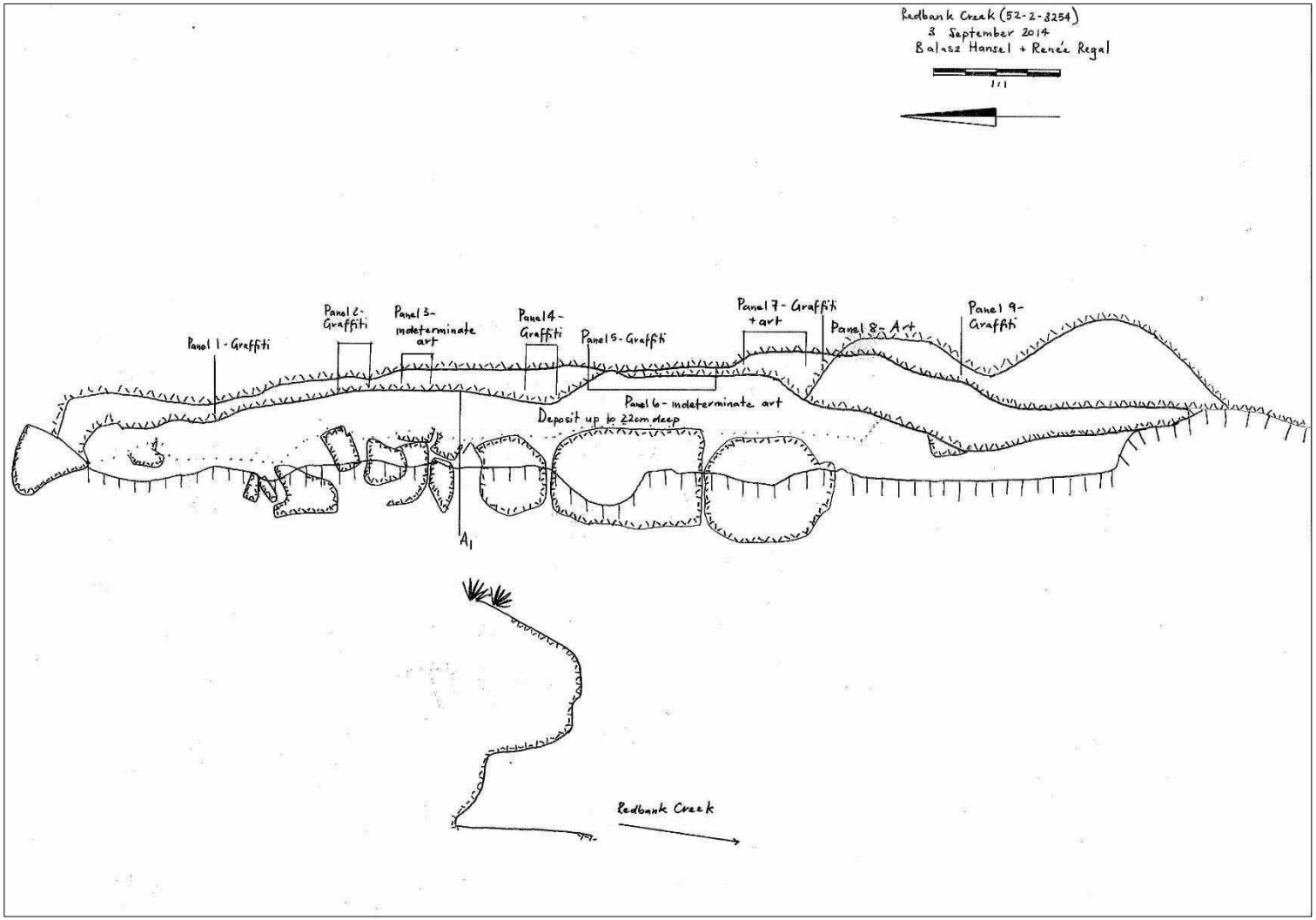
Redbank Creek-1 52-2-3254

This Aboriginal archaeological site is a shelter with art and deposit. The Aboriginal archaeological site was assessed in 2009 by Biosis, who recorded the following details:

The site has a large overhang that measures 24x4x3m with a living area approximately 10x5m; The shelter was formed by blockfall and cavernous weathering and faces north west; Grey loamy sand to an approximate depth of 35cm covers the floor of the shelter and 18 artefacts were identified; The art consists of one complete infill macropod and one infill indeterminates. Biosis also identified a number of new indeterminates under graffiti (Biosis 2009:72).

Biosis assessed that the condition of the shelter remained the same as its original recording, with the exception of faded and damaged artwork due to graffiti. The shelter was relatively dry with little microflora damage. The deposit had been disturbed by goats (Biosis 2009:72).

Niche (2014) conducted a detailed condition assessment of the site to be used as a baseline for any future assessments of the site's condition prior to any subsidence induced movements. The recording of the site included completing a revised site plan and section drawing (Drawing 1), additional photographs of the entire site, and noting features that would act as monitoring points. Attempts were made to find the previously identified stone artefacts within the drip-line, but they could not be located. It was considered that the artefacts had been disturbed through the extensive disturbance to the Aboriginal site by goats. The art was concluded to be in similar condition to its original recording in 1994.



Drawing 1. Revised site plan and section drawing of Redbank Creek-1 (Source: Niche 2014)

Subsidence summary

Strata Control Technologies (SCT) (2014) undertook a subsidence assessment for Redbank Creek-1. The assessment found that:

Site 52-2-3254 is associated with a sandstone cliff formation that is approximately 40m long, 6m high, and has an overhang of up to 4m. The probability of a rock fall at this site is assessed as being approximately 3 % based on experience of subsiding similar cliff formations elsewhere at Tahmoor Mine. The probability of perceptible impacts to the cliff formation such as cracking, shear movements, and possible dislocation of small pieces is assessed as being less than 20%. The bed of Redbank Creek adjacent to the site is considered likely to become fractured with surface flow diversion into the sub-surface fracture network (SCT 2014:i).

The assessment also found that intense rainfall in early 2013 had resulted in high levels of natural ground movement particularly in the vicinity of Dog Trap Creek, located near Redbank Creek. Natural rock falls, block movements, opening up of cracks in the ground, tree root invasion, and sediment rich water flowing out from the back of the overhanging rock formations caused discolouration of the back walls and the depositing of sediment. No mining had occurred in this area and the assessment demonstrated that such natural changes have the potential to degrade archaeological sites, irrespective of mining activity (SCT 2014:i).

MSEC (2014) prepared a management plan for potential impacts to Redbank Creek-1. The level of risk associated with impacts on the rock overhang, resulting in impacts on the artwork were assessed as moderate to very slight to low.

Monitoring measures of the site outlined in the plan are:

Ground Survey

Survey pegs are located along the valley sides of Redbank Creek to monitor subsidence and horizontal movements. They will be surveyed by Tahmoor Colliery on a minimum frequency of once per month when Redbank Creek is located with the active subsidence zone for each of Longwalls 29 to 31.

The survey results will inform the CHMP of the general nature of subsidenec movements in the vicinity of the site and when the rates of change in subsidenec have reduced to low levels.

Visual Inspections

Visual inspections of Redbank Creek will be undertaken by Tahmoor Colliery on a weekly basis during the period of active subsidence. The inspector will check the condition of Redbank Creek 1 from a remote distance as part of these inspections. For safety reasons, detailed inspections will not be undertaken during periods of active subsidence as if a rock fall occurs, there may be little warning beforehand.

*A detailed visual inspection will be undertaken by an archaeologist within 4 months of the completion of extraction of each of Longwalls 29, 30 and 31 and findings distributed to Office of Environment and Heritage and Aboriginal Stakeholders in the End of Panel Report (*MSEC 2014:11).

This End of Panel report has been written in accordance with the MSEC 2014 Management Plan for Redbank Creek-1.

Site inspection and results

A site inspection and assessment was carried out on 22 March 2019 by Renée Regal (Team Leader-Aboriginal Heritage) and Sarah Hart (Ecologist) and the following Registered Aboriginal Parties (RAPs):

- Mrs Glenda Chalker, Cubbitch Barta Native Title Claimants
- Mr Jason Mitchell, Tharawal Local Aboriginal Land Council

The purpose of the assessment was to observe and document the current conditions of Redbank Creek-1 so that any changes since the previous recordings could be documented. A summary of the findings are outlined in Table 1.

Table 1: Results

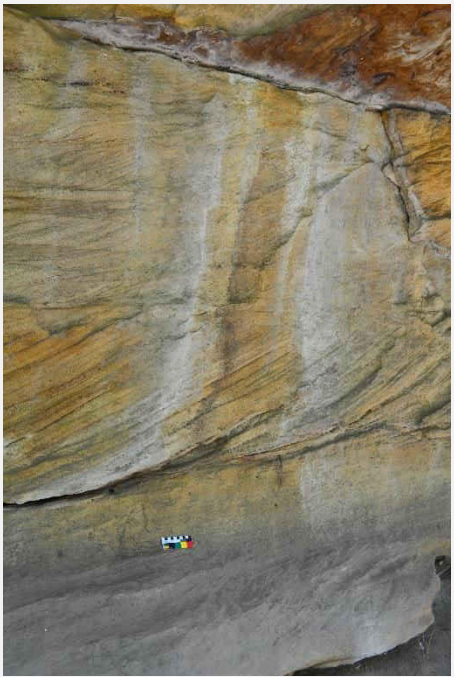
AHIMS Site #	Site Name	Results of Inspection	Photos
52-2-3254	Redbank Creek-1	The condition of the site has not changed due to mining related impacts since the Niche 2014 condition assessment of the site. The floor and back wall of the shelter however have suffered some damage as a result of wild goats living in the shelter. Seepage and mould growth are evident to the lower levels of the shelter	 Plate 1: View of Redbank Creek-1, photograph taken facing north  Plate 3: Naturally occurring mineral that was identified previously when monitored.

Plate 5: Overview of artefacts found within the shelter dripline.

Discussion and Conclusion

There were no observable changes as a result of the extraction of Longwall 31 to Redbank Creek-1.

The Trigger Action Response Plan (TARP) (Table 2) contains the Performance Measures along with the proposed Corrective Management Actions for Aboriginal heritage sites; as outlined in the Longwalls 27 to 30 SMP (Xstrata Coal Tahmoor 2013) and the Tahmoor Colliery Longwall 31 Environmental Management Plan (Tahmoor 2017).

The recommendations made below are designed to allow Tahmoor Colliery to discharge its obligations under the aforementioned management plan.

Recommendations

Based on community consultation with Aboriginal Stakeholders, baseline recordings, geotechnical assessments by Dr Ken Mills of SCT, Daryl Kay of MSEC, and Aboriginal Cultural Heritage Assessments by Niche (2014) and Biosis Research (2009), the following recommendations have been made for Redbank Creek-1 (AHIMS ID# 52-2-3254), Mill Hill, Korana Homestead and the Thirlmere Rural Landscape.

Recommendation 1:

Tahmoor Colliery should continue their consultation with the Aboriginal Community in regards to Redbank Creek-1 (AHIMS ID# 52-2-3254).

Recommendation 2:

Redbank Creek-1 (AHIMS ID# 52-2-3254), Mill Hill and Korana Homestead should continue to be monitored during the extraction of Longwalls 32.

Table 2: Trigger Action Response Plan

Feature	Monitoring			Management	
	Prior to Mining	**During Mining**	**Post Mining**	**Trigger**	**Action**
Aboriginal sandstone shelter sites: 52-2-3254	Baseline archival recording prior to Longwall mining Re-recording of the principal components identified by Sefton (Sefton 2000) Macro and micro recording using digital photography (Navin Officer 2003) Detailed elevation plans of shelter walls recording structural and surface features including but not limited to the art itself, graffiti, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, drip line and water seepage locations.	First impact assessment recording following initial subsidence movement of site Sandstone shelter and sites will be monitored during mining.	Further impact assessment recording twelve months after subsidence movement of the sites.	**Negligible** Change in shelter conditions not attributable to natural weathering or preservation that do not alter the heritage values of the place- e.g. mineral growth or micro-organism growth. Changes external to the shelter that effect cracking, boulder slumping, rock and/or tree falls. NO MAJOR TRIGGERS OBSERVED, CONTINUE WITH APPROVED ACTIONS **Major** Change in shelter condition not attributable to natural weathering or preservation- change in drip line or seepage, e.g. cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints. NO MAJOR TRIGGERS OBSERVED, NO ACTION REQUIRED. **Severe** Change in shelter conditions not attributable to natural weathering or preservation- e.g. cracking or exfoliation of art panel, movement of existing planes and joints in panel, block fall within the shelter or overhang, shelter or overhang collapse.	Continue with monitoring program if safe to do so. COMPLETED BY THIS REPORT Condition assessment and photographic record COMPLETED BY THIS REPORT Notify other relevant specialists COMPLETED BY THIS REPORT Notify key Stakeholders e.g. Aboriginal Groups, DRE and OEH COMPLETED BY THIS REPORT Report in End of Panel report and AEMR. COMPLETED BY THIS REPORT Continue with proposed monitoring program Condition assessment recorded Notify relevant technical specialists and seek advice on any Corrective Management Action (CMA) required. Notify key stakeholders e.g. Aboriginal Groups, DRE, OEH. Implement agreed CMAs as approved. Report in mitigation report, End of Panel Report and AEMR. Continue with proposed monitoring program Condition assessment recorded

		NO SEVERE TRIGGERS OBSERVED, NO ACTION REQUIRED.	Immediately notify relevant Aboriginal Groups, government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. Site visits with stakeholders if required. Develop site CMA in consultation with key stakeholders within 1 month. Completion of works following approvals Issue CMA report within 1 month of works completion Conduct initial follow up monitoring and reporting within 2 months of CMA completion if required. Report in mitigation report, End of Panel Report and AEMR.
Koorana Homestead	Baseline heritage and structural assessments. Surveys and visual inspections as outlined in Property Subsidence Management Plan (PSMP) Review monitoring data	None outlined.	Include in Subsidence Monitoring Report, End of Panel Report and Annual Review COMPLETED BY THIS REPORT
Mill Hill	Baseline heritage and structural assessments. Surveys and visual inspections as outlined in Property Subsidence Management Plan (PSMP) Review monitoring data	None outlined.	Include in Subsidence Monitoring Report, End of Panel Report and Annual Review COMPLETED BY THIS REPORT

References

Biosis Research 2009 *Longwalls 27-30 Subsidence Management Plan.* An unpublished report for Xstrata, Tahmoor Colliery

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Tahmoor Colliery (2017) *Tahmoor Colliery LW 31Environment Management Plan*. An unpublished report for Tahmoor Colliery

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