Tahmoor Coal Pty Ltd

QUARTERLY PROGRESS REPORT

Myrtle Creek CMAP & Redbank Creek CMAP

June 2020

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Document Control

PUBLICATION DATE: 30/06/2020

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VERSION NUMBER: **Ver1**

COMMENTS:

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Contents

1 Introduction

Tahmoor Coal Mine (**Tahmoor Mine**) is an underground coal mine located approximately 80 kilometres (**km**) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (**NSW**).

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (**Tahmoor Coal**) since the mine commenced in 1979 using bord and pillar mining methods, 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**).

Remediation works on Redbank and Myrtle Creeks commenced in late 2019. This Report provides progress for Quarter 2, 2020.

1.1 Reporting

Tahmoor Coal has committed to providing the following reports for the Myrtle Creek CMAP and Redbank Creek CMAP:

- Quarterly Progress Report (31 March, 30 June, 30 September, and 31 December);
- Remediation Stage Completion Reports; and
- Final Completion Report.

The reports are submitted to the following stakeholders:

- NSW Resources Regulator;
- DPE – DRG;
- Wollondilly Shire Council;
- Tahmoor Coal Community Consultative Committee (**TCCCC**); and
- Other stakeholders as directed by NSW Resources Regulator.

1.2 Scope

This Quarterly Progress Report **(Report)** outlines the following information:

- Works completed in previous period;
- Works proposed in next period;
- Review against program;
- Monitoring results;
- Assessment against completion criteria;
- Community and stakeholder consultation; and
- Complaints and incident management.

2 Myrtle Creek

2.1 Project Background

Tahmoor Coal prepared a Myrtle Creek Corrective Management Action Plan (**Myrtle Creek CMAP**) in response to a Section 240(1)(d) Notice issued on 5 December 2016, under the *Mining Act 1992,* requiring the submission of a CMAP for Myrtle Creek. The Myrtle Creek CMAP was prepared to comply with the requirements of the Notice and was approved by the NSW Resources Regulator on 4 May 2018.

2.2 Works Completed

The Quarterly Progress Report (March 2020) listed works completed within that reporting period, including:

- Approvals (Fisheries Permit, Erosion and Sediment Control Plan);
- Risk Assessment;
- Pool Mapping and Photogrammetry;
- Land Access; and
- 12 Characterisation Holes;
- Site 23 Trial;
- Pool Remediation Trials (including completion of Pool 18 colloidal silica trial) and
- Site 23 additional works.

Activities completed during this reporting period are listed below.

2.2.1 Myrtle Creek CMAP Stage 2

Myrtle Creek CMAP Stage 2 (**Stage 2**) was prepared and submitted to the Resources Regulator on 8 May 2020. Stage 2 contains proposed works at Myrtle Creek following learnings made from the implementation of Myrtle Creek CMAP. These include vital information regarding the fracture network at Myrtle Creek, groundwater interactions, and advancements in remediation methods. Stage 2 aims to remediate rock bars downstream of Pools 10, 11, 12a, 14, 18 and 20.

Additional water level monitoring gauges were installed at Pools 10, 12a, 14 and 18 in May 2020 to monitor pool level pre and post remediation during Stage 2.

2.3 Water Monitoring Results

Flow and level monitoring are conducted at various locations along Myrtle Creek (refer to **Figure 1**).

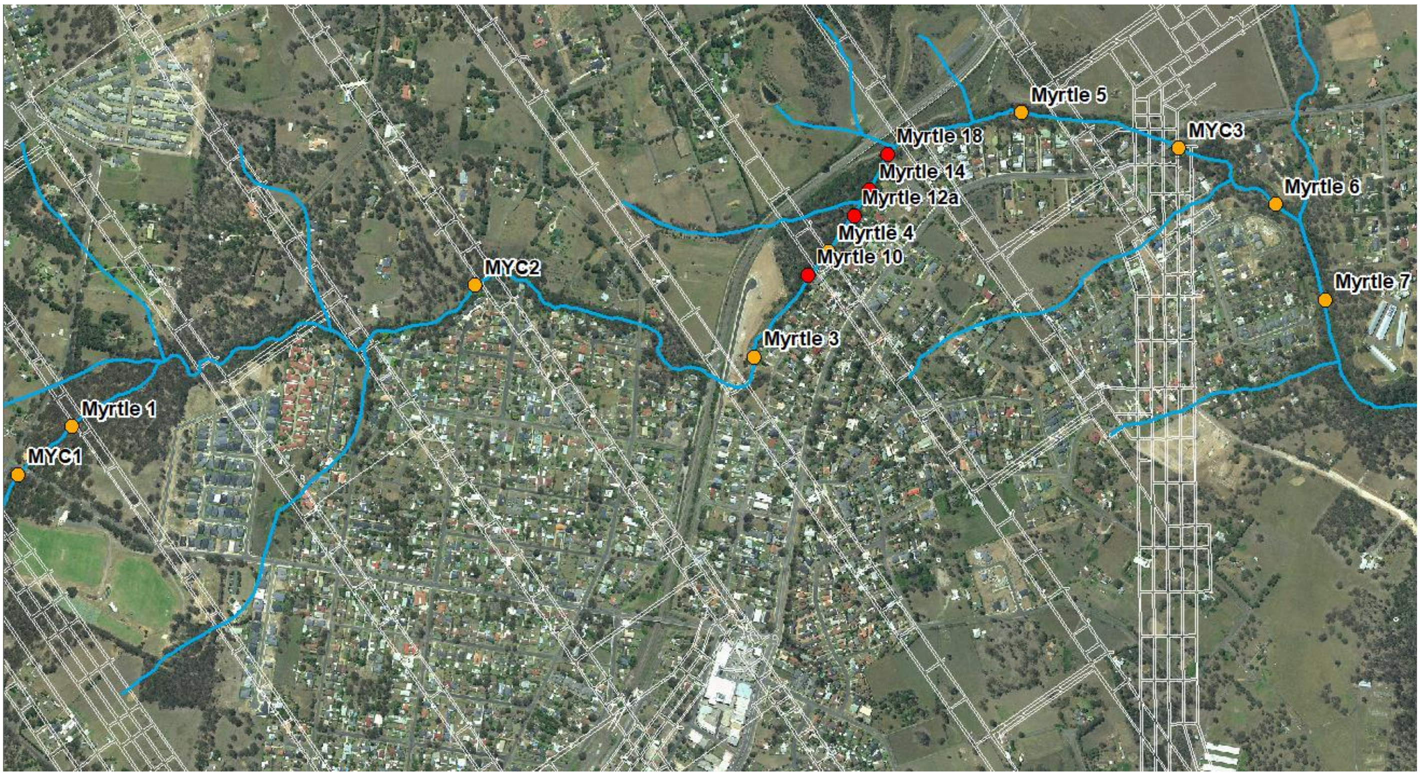


Figure 1: Myrtle Creek Surface Water Monitoring Locations
Orange – Water Monitoring Locations **Red – Stage 2 Water Monitoring Locations**

2.3.1 Water Level Monitoring

Level monitoring is conducted at 10 sites, including:

- Myrtle 1
- Myrtle 3
- Myrtle 4
- Myrtle 5
- Myrtle 6
- Myrtle 7;
- MYC1
- MYC2
- MYC3
- Myrtle 10
- Myrtle 12a
- Myrtle 14
- Myrtle 18
- Myrtle 20

MYC1, MYC2 and MYC3 were historical sites that were removed in 2010 and reinstated in 2019. Myrtle 10, 12a, 14, and 18 were installed in May 2020 to monitor water level behaviour pre and post remediation.

Level monitoring is conducted at *Myrtle 5* which is located within Pool 23. **Figure 2** illustrates pool height level at Pool 23 with rainfall. Rainfall data is collected from the weather station located at Pool 23 from 11 October 2019 onwards and Tahmoor Coal mine site from 2010. Pool height is measured as zero if the monitoring equipment is not submerged in water. Prior to remediation works, rain events in 2019 had no noticeable impact to Pool 23 height due to subsidence impacts and its inability to competently hold water, hence no pool level was recorded. It can be observed, that following remediation works, Pool 23 has effectively filled to its full level which has since been sustained.

Continued monitoring at *Myrtle 5* will be used to compare long-term trends, including recession rate in a variety of climatic conditions.

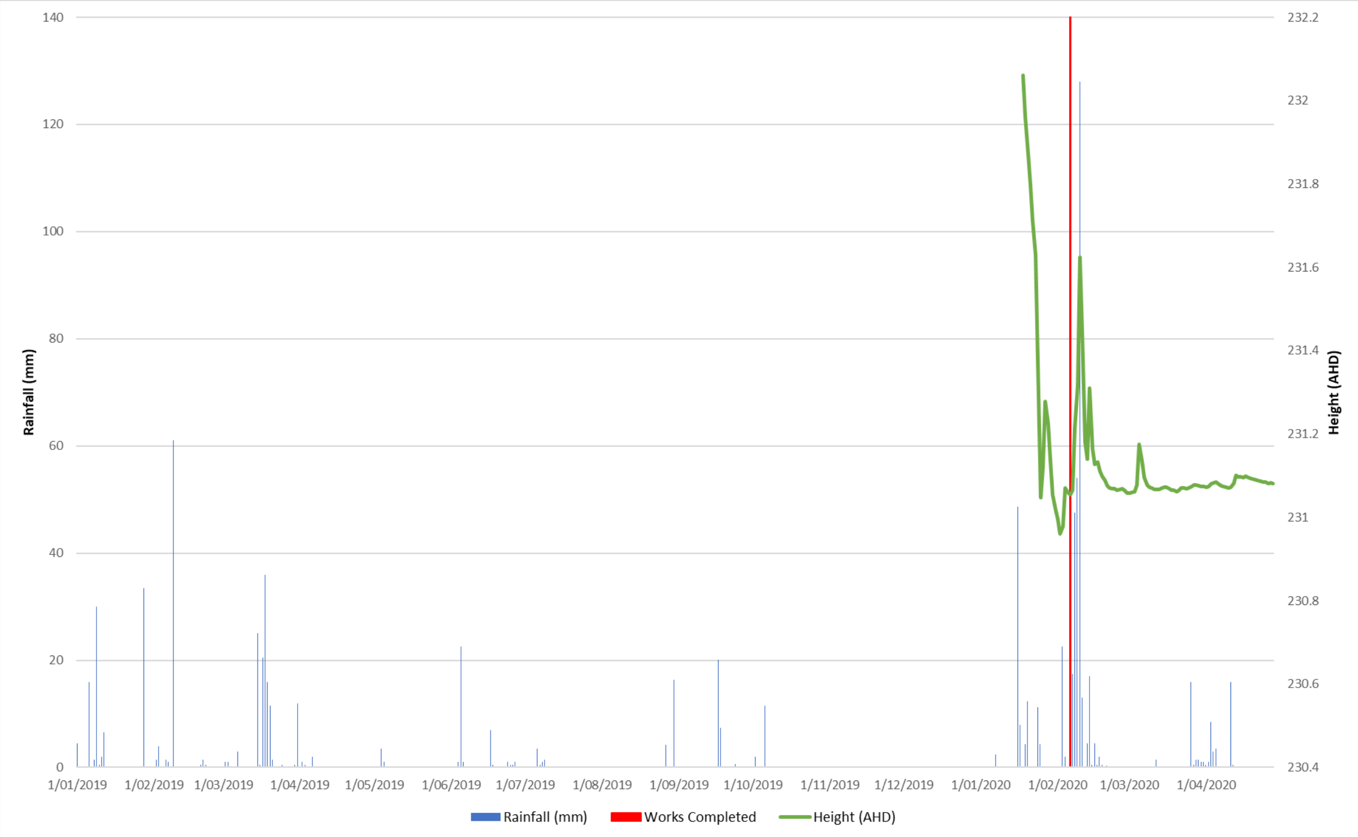


Figure 2: Myrtle Creek M5 – Pool 23 Level Monitoring

2.3.2 Flow Monitoring

Flow monitoring is conducted at 8 sites at Myrtle Creek, including:

- Myrtle 1
- Myrtle 3
- Myrtle 4
- Myrtle 6;
- Myrtle 7
- MYC1
- MYC2
- MYC3

The pools that contain *Myrtle 20* and *Myrtle 5* are planned to be surveyed so flow monitoring can then be conducted. *MYC1, MYC2* and *MYC3* were historical sites that were removed in 2010 and were reinstated in 2019.

2.3.3 Groundwater Monitoring

Figure 3 illustrates locations of groundwater monitoring bores along the banks of Myrtle Creek that were installed following characterisation drilling. The bores monitor standing water levels within the groundwater system. Additional groundwater monitoring bores (MB-01 to MB-04) were installed as part of the Pool 23 Trial Project.

Figure 3: Myrtle Creek Characterisation Holes Groundwater Monitoring

Figure 4 and 5 shows the standing groundwater level at locations near Pool 20. It can be observed that the water level sits at approximately 1 m below the creek level at P21, suggesting a losing system at this location, while it sits more than 2m above the creek level at P22, suggesting a gaining system at this location. The controlling rock bar at Pool 20, which is proposed to be remediated as part of Stage 2 sits between these two monitoring points. As the groundwater is at or above the creek level, it is anticipated that a grout curtain wall will have a positive effect on returning pool holding capacity at Pool 20.

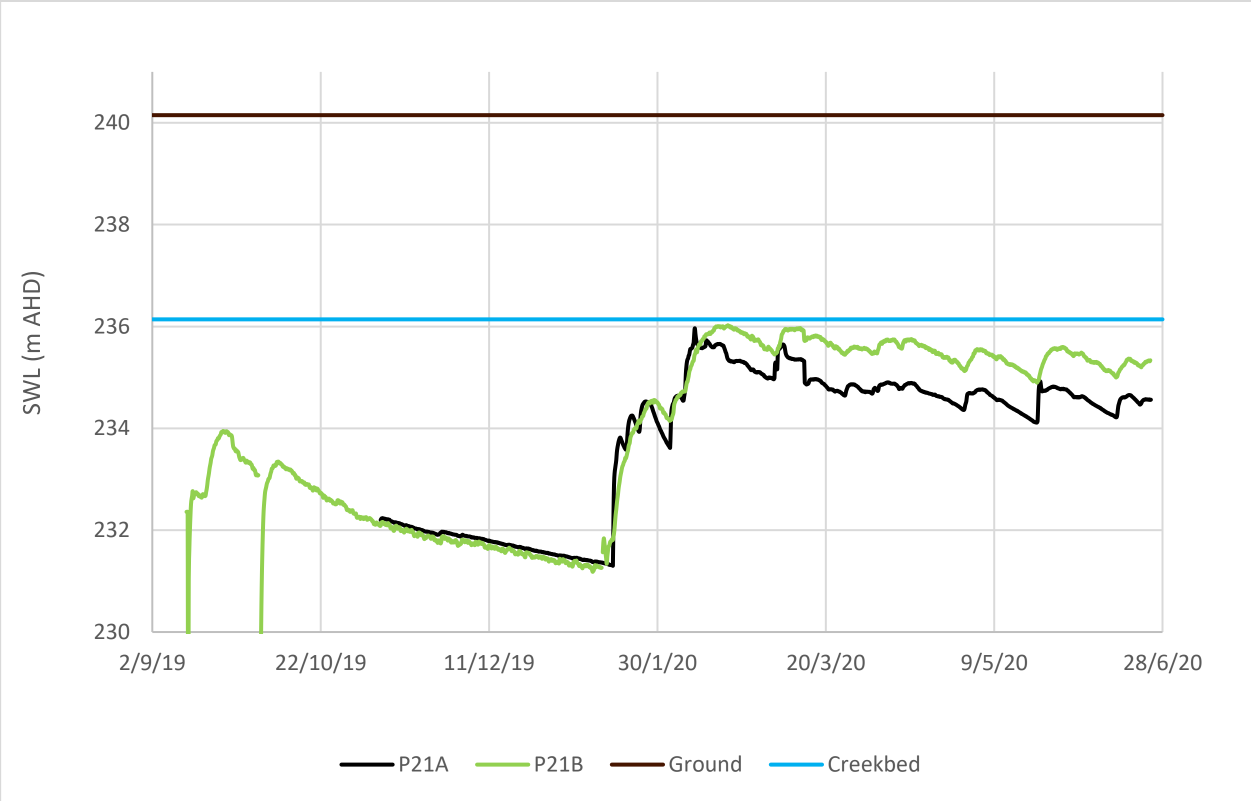


Figure 4: Standing Water Level at P21

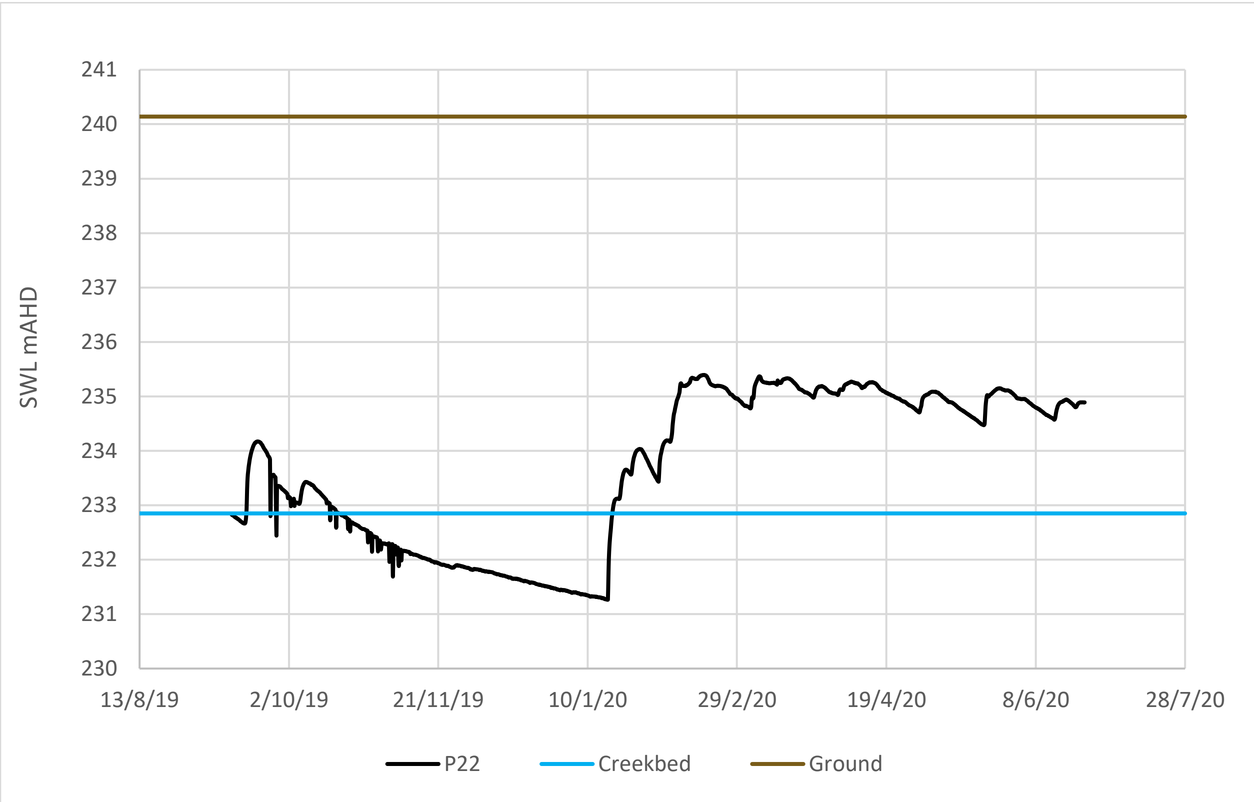


Figure 5: Standing Water level at P22

2.4 Schedule Review

All works have been completed as set out in Myrtle Creek CMAP Schedule. Stage 2 was submitted Resources Regulator on 8 May 2020. A final schedule for Stage 2 will be submitted following approval of Stage 2.

2.5 Upcoming Works

Stage 2 remediation works will commence following approval from the Resources Regulator.

3 Redbank Creek

3.1 Project Background

Tahmoor Coal prepared a Redbank Creek Corrective Management Action Plan (Redbank Creek CMAP) in response to a Section 240(1)(d) Notice (*DI 0680 2018 ACES Ref: 0353-2016 Out17/48999*) dated 4 May 2018, under the *Mining Act 1992* requiring the submission of a CMAP for Redbank Creek. The Redbank Creek CMAP was prepared to comply with the requirements of the Notice and was approved by the NSW Resources Regulator in June 2019.

3.2 Works Completed

The Quarterly Progress Report (December 2019) listed works completed within that reporting period, including:

- Risk Assessment;
- Pool Mapping and Photogrammetry;
- Land Access;
- 12 Characterisation Holes;
- Fisheries Permit approval;
- Erosion and Sediment Control Plan approval; and
- Commencement of remediation of 5 pools (RR7, RR8, RR9, RR10 and RR11).

Activities completed during this reporting period are detailed below.

3.2.1 Pool Remediation

Remediation of 5 pools at Redbank Creek (RR7, RR8, RR9, RR10 and RR11) commenced in February 2020 and were completed in early May 2020. All pools were located within an exposed sandstone shelf that had been impacted by subsidence (see **Figure 6**). Remediation efforts were aimed at increasing pool holding capacity at individual pools and to return surface flow after future rock bar grout curtain works upstream. The works carried out at each pool included:

- RR7 – Grout Curtain, 2 m deep, 8 m wide;
- RR8 – grout Curtain, 2 m deep, 16 m wide;

- RR9 – Grout Grid Pattern, 1 m deep, 12 m x 12 m;
- RR10 – Grout Grid pattern, 1 m deep, 12 m x 14 m; and
- RR11 – Grout Curtain, 2 m deep, 16 m wide.

Appendix A provides Completion Reports for Pools RR7 to RR11. They detail the works carried out at each pool, materials used, review and recommendations for improvements in future pool remediation.

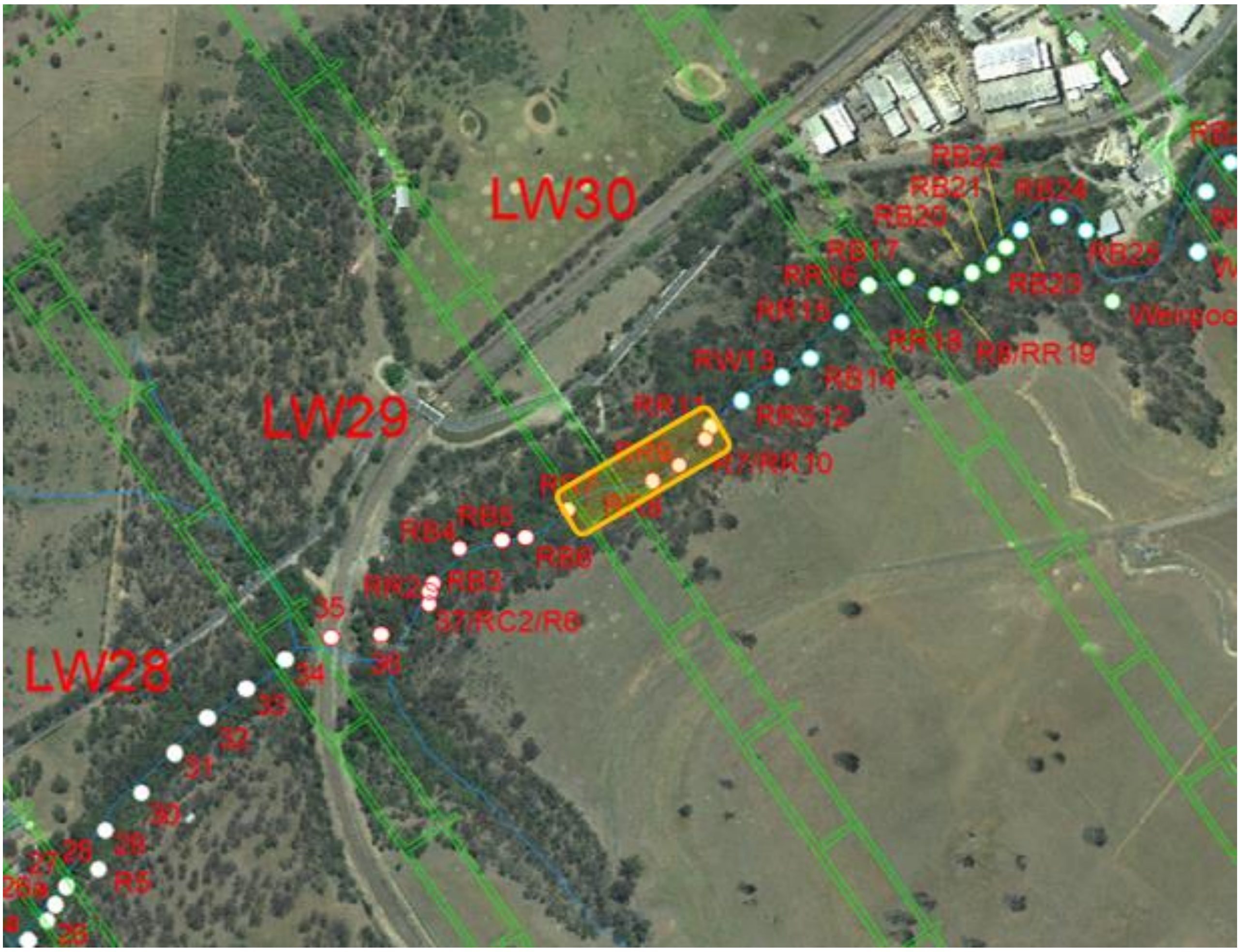


Figure 6: Redbank Creek Remediation Sites

Two remediation styles were used, shallow grout curtain and grid pattern grouting. The shallow grout curtain technique involves drilling a series of holes in a line intercepting a controlling feature at the creek, i.e. a rock bar. The holes are typically drilled to 1-2m deep and injected with PUR. Grid pattern grouting involves drilling a series of holes to 1m depth in a grid network in the base of a pool and PUR injected.

Pool holding capacity was tested using Pool Recession Rate (PRR) testing, which involves filling a pool with a pre-determined volume of water, typically 13,000L and measuring the rate at which it takes for the pool to drain. PRR is conducted prior to and following remediation. An increase in PRR was measured following remediation for all pools, however grid pattern grouting was significantly more effective than shallow curtain grouting.

Key learnings and improvements proposed include the following:

1. Grid pattern grouting was significantly more effective at improving pool holding capacity than shallow curtain grouting.
2. Stage grid pattern grouting from the centreline outwards. A clear correlation was realised between grout take and distance from the centre of the creek, i.e. grout takes were substantially increased at the centre of the creek. Future works will begin works at the centre of the creek and progress outwards.
3. Increase grouting intensity to more adequately in-fill fracture network. In general, holes were spaced at 2 m during works. Future works will aim to reduce this to 1 m or closer, depending on fracture characteristics.
4. Use PRR to determine key fractures prior to remediation and target those regions.

3.3 Water Monitoring Results

Flow and level monitoring are conducted at various locations along Redbank Creek (refer to **Figure 7**).

3.3.1 Water Level and Flow Monitoring

Level and flow monitoring are conducted at 14 sites at Redbank Creek, which are listed below:

- Redbank 1
- Redbank 2
- Redbank 3
- Redbank 4
- Redbank 5
- Redbank 7
- Redbank 8
- Redbank 9
- Redbank 10
- Redbank 11
- RC1
- RC2
- RC5
- RC6

RC1, RC2, RC5 and RC6 were historical sites that were removed in 2010 and reinstated in 2019.

Figure 7: Redbank Creek Surface Water Monitoring Locations

3.3.2 Flow Monitoring

Flow monitoring is conducted at 14 sites at Redbank Creek, including:

Redbank 1	Redbank 9
Redbank 2	Redbank 10
Redbank 3	Redbank 11
Redbank 4	RC1
Redbank 5	RC2
Redbank 7	RC5
Redbank 8	RC6

RC1, RC2, RC5 and RC6 were historical sites that were removed in 2010. They were reinstated in 2019.

3.3.3 Groundwater Monitoring

Figure 8 illustrates locations of groundwater monitoring bores along the banks of Redbank Creek. The bores monitor standing water levels within the groundwater system which assist in determining future remediation sites.

Figure 8: Redbank Creek Characterisation and Groundwater Monitoring Holes

Figure 9 illustrates the standing groundwater level at P30 relative to the creek bed. P30 is located within close proximity to Weir Pool / 26 and shows that the groundwater level is approximately 4 m below the creek bed. **Figure 10** illustrates the standing groundwater level at P33 relative to the creek bed. P33 is located within close proximity to Weir Pool / 26 and shows that the groundwater level varies approximately 2 m above and below the creek bed. The groundwater level determines the effectiveness of a grout curtain at varying depths.

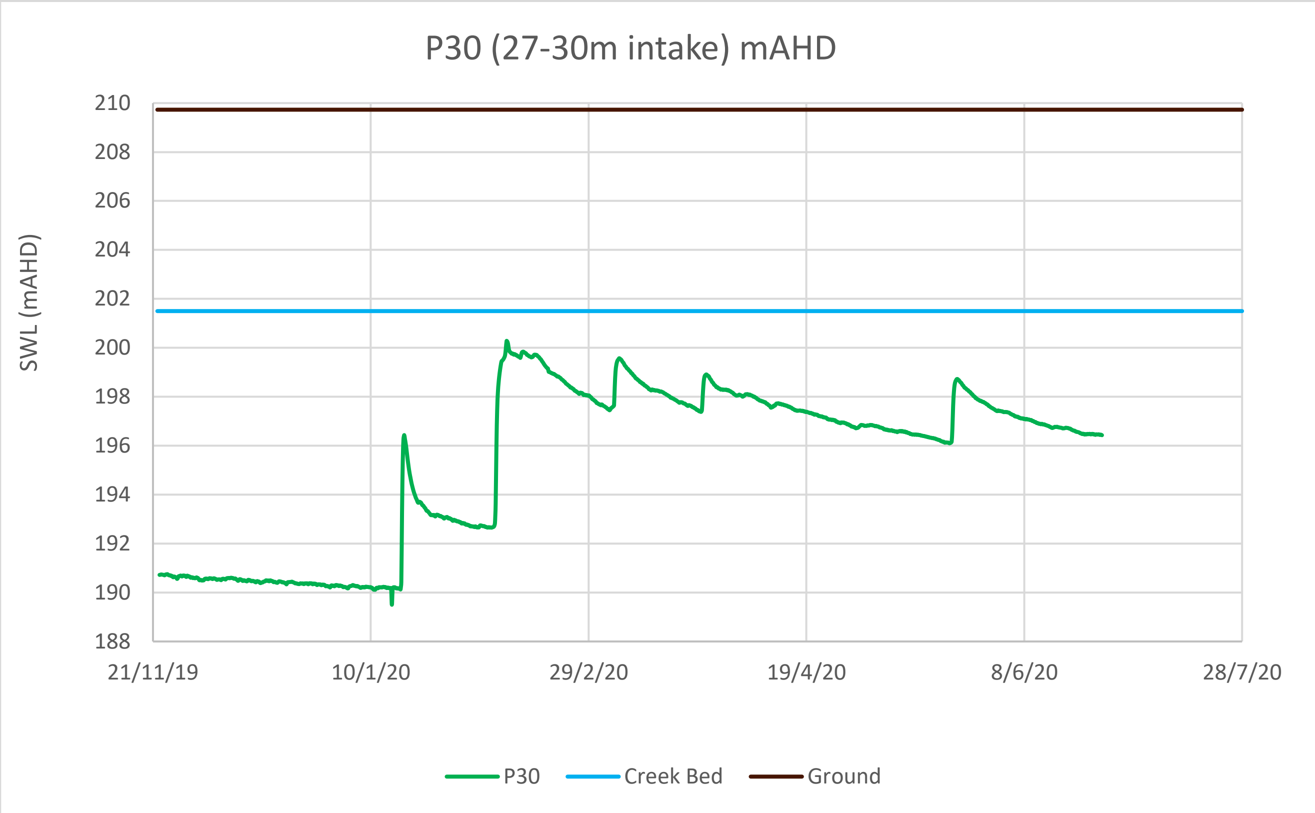


Figure 9: Standing Groundwater Level at P30 (Redbank Creek)

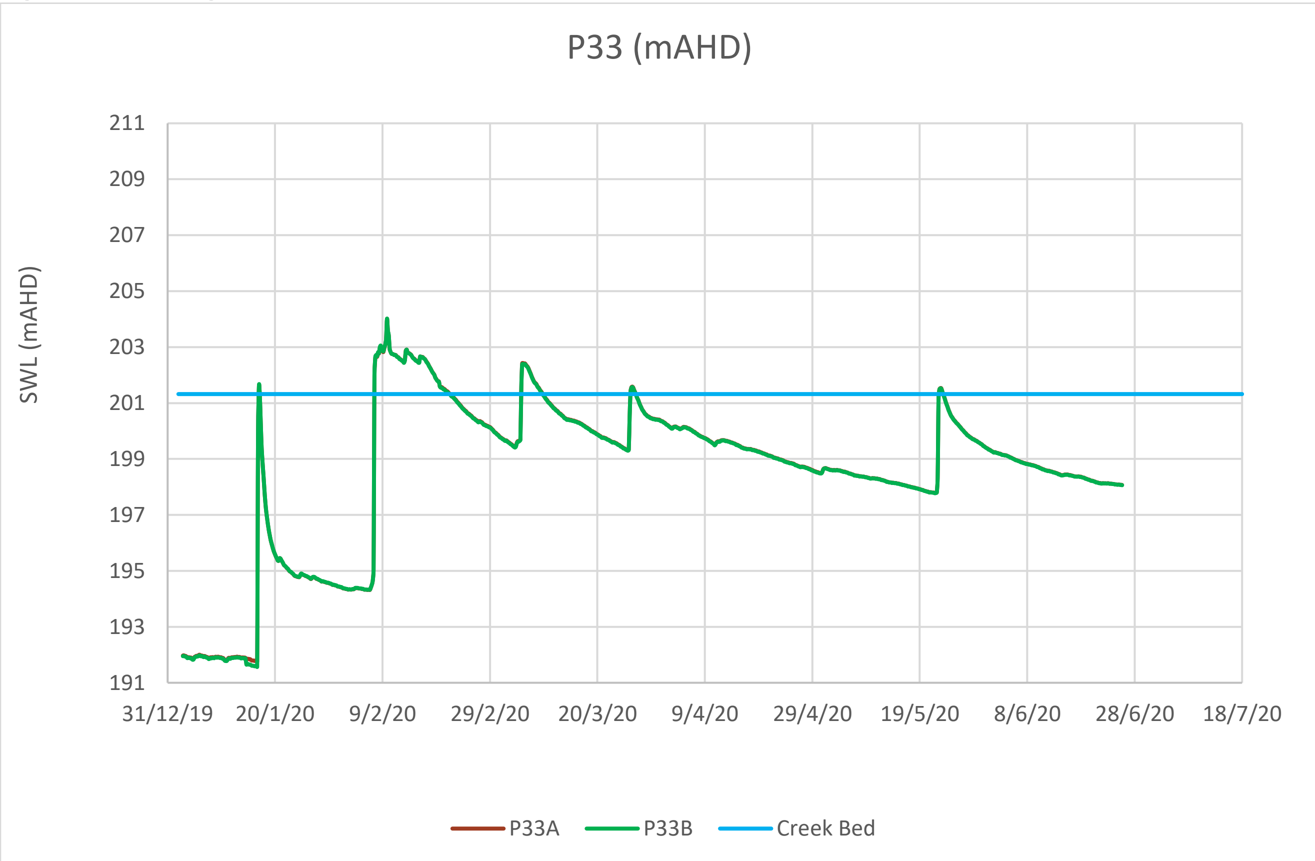


Figure 10: Standing Groundwater Level at P33 (Redbank Creek)

3.4 Schedule Review

The Redbank Creek CMAP Schedule is given in **Appendix C**. Completion of five pool remediation sites was completed ahead of schedule, in May 2020. A rock bar grout curtain at Weir Pool / 26, as well as shallow pattern grouting as part of pool remediation works at Pools 27 to 29 will commence on 6 July 2020, as per the schedule.

3.5 Upcoming Works

3.5.1 Weir Pool / 26 and Pools 27 to 29

A rock bar grout curtain at Weir Pool / 26, as well as shallow pattern grouting as part of pool remediation works at Pools 27 to 29 will commence on 6 July 2020. The rock bar grout curtain is proposed to consist of three stages to a total depth of 12 m. Progressive testing will be conducted at the completion of each stage to determine if further stages are required. Proposed works include the following:

- Stage 1 – Drill 16 m wide curtain to a depth of 2 m, with 0.5 m spacing and inject Spetec H100;
- Stage 2 – Drill 40 m wide curtain to a depth of 6 m with 2 m spacing and inject Spetec H100;
- Stage 3 – Drill 40 m wide curtain an additional 6 m depth with 2m spacing and inject Spetec H100.

Figure 11 illustrates the proposed grout stages at Weir Pool / 26. R9 is a level monitoring device in Weir Pool / 26. It will be used to measure PRR prior to and post remediation. It will also provide background data of pool behaviour prior to subsidence imapcts.

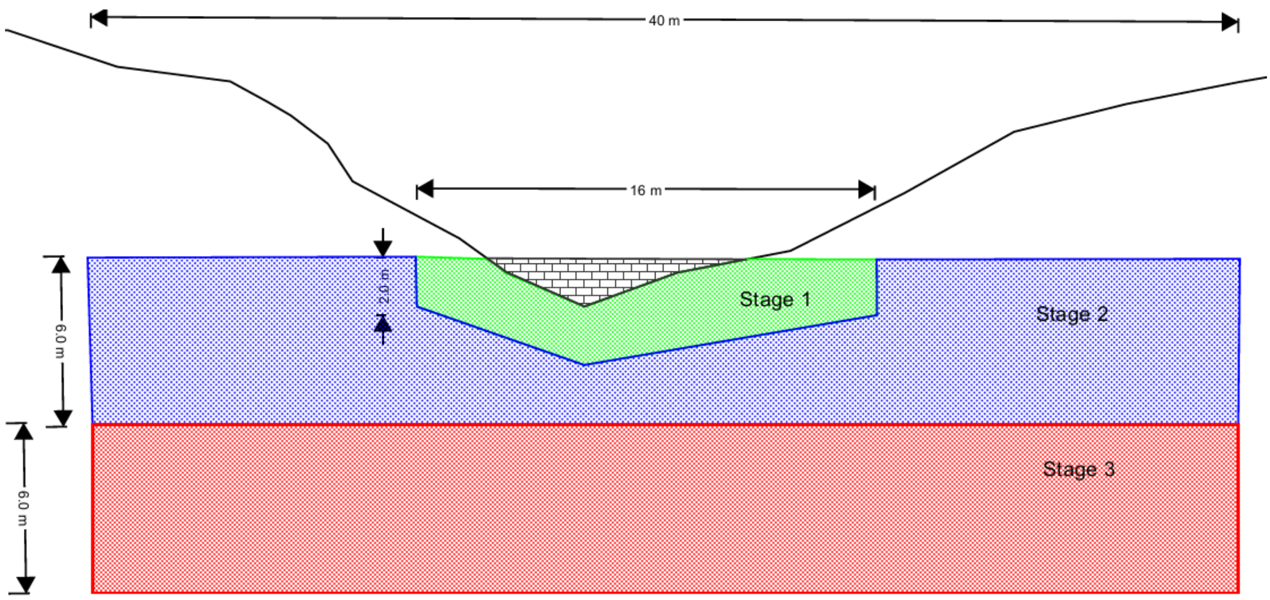


Figure 11: Proposed grouting stages at Weir Pool / 26

Shallow pattern grouting works will target the base of Pools 27, 28 and 29 to increase pool holding capacity. The pools immediately upstream (RB23, RB24 and RB25) and pools immediately downstream of Pool 29 do not appear to have been affected by subsidence. It is anticipated that these works will provide connective flow from RB23 to Pool 30, and into the reach of Redbank Creek that has not been undermined. **Figure 12** illustrates the proposed return to flow and pool holding capacity at Weir Pool / 26 and pools 27 to 29. Works will be conducted in parallel with each other and commence on 6 July 2020 and be completed in October 2020.

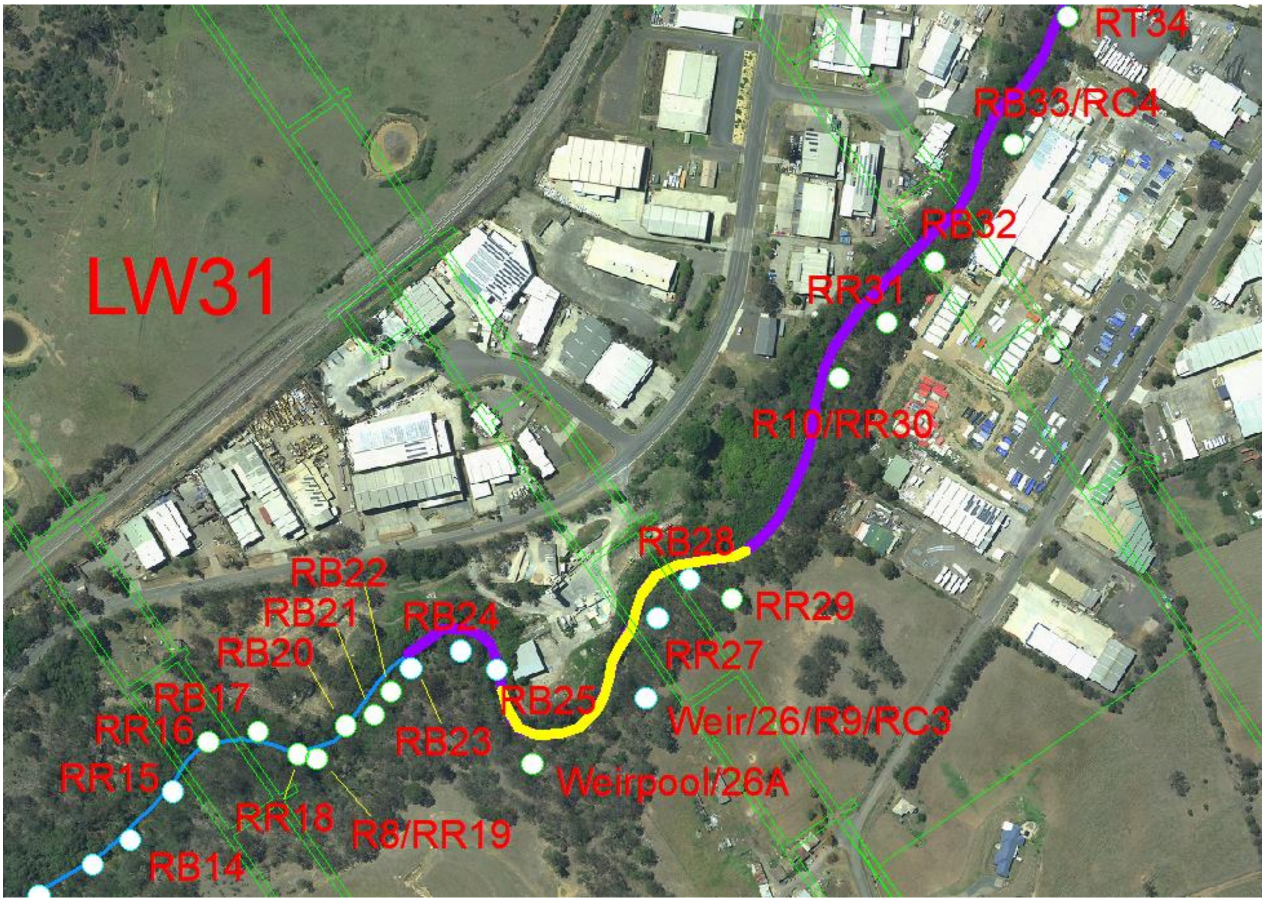


Figure 12: Anticipated remediated pool holding areas (yellow) and current pool holding areas (purple)

4 Community

An important aspect to the success of the Myrtle Creek CMAP and Redbank Creek CMAP is meaningful community consultation. This allows for transparent and two-way communication between Tahmoor Coal and relevant stakeholders with an ongoing interest in the successful implementation of the Myrtle Creek CMAP and Redbank Creek CMAP.

4.1 Newsletters

4.1.1 Myrtle Creek

Newsletters have been developed as part of the Myrtle Creek CMAP, allowing information to be distributed to community members that may have an interest in the remediation works. Newsletters have been issued regularly from April 2019. Newsletters have been distributed via hand delivery to letterbox, emailed to council and posted on the Tahmoor Coal website (http://www.simec.com/mining/tahmoor-coking-coal-operations/publications/creek-rehabilitation-newsletters/). One newsletter was distributed during Quarter 2 for 2020.

4.1.2 Redbank Creek

Newsletters are issued on an as-required basis from November 2019 for Redbank Creek CMAP and distributed via email to relevant stakeholders and posted on the Tahmoor Coal website (http://www.simec.com/mining/tahmoor-coking-coal-operations/publications/creek-rehabilitation-newsletters/). **Table 2** details a summary of CMAP newsletters. One newsletter was distributed during Quarter 2 for 2020.

Table 2: CMAP Newsletter Distribution

Period	Myrtle Creek	Redbank Creek
2019	8	1
Quarter 1 2020	2	2
Quarter 2 2020	1	1
Total	11	4

4.2 Tahmoor Coal Community Consultative Committee

The Tahmoor Coal Community Consultative Committee **(TCCCC)** meets quarterly and enables two-way communication between Tahmoor Coal and interested community members to discuss topics involving mining operations, including Myrtle and Redbank Creek CMAPs. Progress on the Myrtle Creek CMAP and Redbank Creek CMAP was discussed at the most recent TCCCC meeting, which was held on 4 June 2020 via Skype (due to COVID-19 restrictions). An invitation to inspect Pool 23 at Myrtle Creek was extended to all members however this visit will be delayed due to COVID-19 restrictions.

4.3 Wollondilly Shire Council

Staff and a councillor of Wollondilly Shire Council attended the TCCCC meeting held on 4 June 2020.

4.4 Complaints and Incident Management

Community complaints for Myrtle Creek CMAP and Redbank Creek CMAP are shown in **Table 3**. No complaints were recorded for Quarter 2, 2020.

Table 2: CMAP Community Complaints

Period	Myrtle Creek	Redbank Creek
2019	1	0
Quarter 1 2020	0	0
Quarter 2 2020	0	0
Total	1	1

Incidents for Myrtle Creek CMAP and Redbank Creek CMAP are shown in **Table 4**. No incidents were recorded at Myrtle Creek or Redbank Creek during CMAP works.

Table 4: CMAP Incidents

Period	Myrtle Creek	Redbank Creek
2019	1	0
Quarter 1 2020	0	1
Quarter 2 2020	0	0
Total	1	1

Appendix A.1 – RR7 (Pointe Engineering Pty Ltd)

COMPLETION REPORT

REDBANK CREEK CMAP RR7

June 29th, 2020
Document: PE-REP-2001-1
POINTE ENGINEERING PTY LTD

DOCUMENT CONTROL FORM

Project Name: Redbank Creek CMAP RR7

Project Number: P2001

Document Number: PE-REP-2001-1

REVISION HISTORY

REVISION	DATE	SUBMITTED BY	DISTRIBUTED TO
A (DRAFT)	26 June 2020	G.Price	A.Stuart
0	29 June 2020	G.Price	A.Stuart

1 INTRODUCTION

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7, Redbank Creek, Tahmoor, NSW.

Redbank Creek is a tributary of the Nepean River. Redbank Creek is overlying TCCO Longwalls 25 to 32. These longwalls are understood to have caused surface subsidence along the creek. TCCO has developed a Corrective Management Action Plan (CMAP) to remediate mine subsidence impacts. The subsidence impacts to Redbank Creek include cracking of the channel bedrock and rock bars resulting in a reduction in surface flow.

Pointe was contracted for their expertise and past experiences grouting foundations, tunnels and specifically for subsidence remediation grouting.

The works were carried out between the 27th of March to the 27th of April 2020 and this report details the following:

- Pre works (investigation),
- Works,
- Post works (success verification),
- Materials used,
- Success and recommendations for improvement in future pool remediation.

The works on this pool was completed together as a group of adjacent pools RR7 to RR11. This report only refers to the works completed in RR7 however a discussion on the collective works is given in Attachment A.

2 OBJECTIVE

The objective of the works was to increase the pool holding capacity. This is defined by the period of time that the pool retains water after rainfall runoff has entered it.

3 SCOPE

The scope included construction of an in-situ low permeability curtain across the creek. This method was used to target the open, shallow dipping, bedding planes at the pool's controlling rock bar.

The work included:

- A site investigation,
- Drilling a 2 m deep, 8 m wide curtain,
- Polyurethane injection of the curtain.

4 POOL DESCRIPTION

RR7 is a small (approximately 10 000L) pool. It contains alluvium base and alluvium deposit on both banks. The pool has a controlling rock bar that sits approximately 0.6 m above the pool base. The pool and surrounding rock mass contain many open bedding planes, at medium

spacing, dipping east at between 5° and 15°. There was limited evidence of open fractures in the pool base.

5 ACTIVITIES COMPLETED

5.1 Pre-Works

Investigation of the existing bedrock conditions were carried out ahead of the works. The investigation was undertaken between the October 2019 and January 2020 and included:

- A monitoring borehole; and
- A pool recession test.

5.1.1 Monitoring Borehole

TCCO undertook an investigation with assistance from Highland Drilling and Strata Control Technology (SCT). Two boreholes were drilled, logged, hydraulically tested and calliper tested in December 2019. The boreholes were labelled P19a and P19b and can be found in SCT report TAH5004b. The borehole was 170 m from the pool above the crest of the embankment. Results showed a high permeability (between 3.8×10^{-8} to $<1.9 \times 10^{-5}$ m/s) throughout the length of the borehole. Groundwater was measured at approximately 8 m below the creek surface.

5.1.2 Pool Recession Test

A baseline Pool Recession Test (PRT) was completed on the 30th of March 2020 prior to grout injection. The pool was filled with approximately 13000 L of water and then monitored to understand its existing retention. The 13 000L permeated through the rock bar immediately without any pooling.

Image 1: Pumping begins

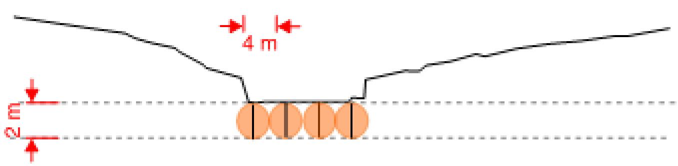
Image 2: At the end of pumping

5.2 Works

The works were focused on improving the upper portion of the pool's controlling rock bar. Results from mapping showed that the rock bar contained many open fractures and few open fractures on the pool base.

An 8 m wide curtain was constructed across the rock bar perpendicular to the flow. 18 boreholes, 38 mm in diameter, were drilled with a pneumatic hammer to 2 m below ground level. The holes were drilled with primary boreholes spaced at 4 m. The following boreholes split spaced between primaries and were drilled and injected such that a final spacing of boreholes was 0.5 m. Each hole was grouted in a single stage as shown in Figure 1.

Figure 1: Cross Section of Primary Boreholes



The boreholes were injected with a hydrophobic polyurethane (Spetec H100). A total of 734 L of Spetec H100 was injected during the works. With a laboratory expansion volume of between 5 and 12 times, Pointe has filled between 3600 and 8800 L of voids. Details of each bore shown in Table 1 and an as built drawing is shown in Plan 1.

Results show large grout takes up to the tertiary holes with noticeable decrease in grout take on the quaternaries. The grout takes remained high on the right hand side of the creek but were less than 1 litre per meter on the left hand side.

Table 1: Holes Drilled and Grouted

ID	Depth (mbgl)	Borehole Dia. (m)	No. Grouted Sections	Avg Volume Grouted per meter (L)
BH-PRI-1	2.0	0.038	1	40.0
BH-PRI-2	2.0	0.038	1	40.0
BH-PRI-3	2.0	0.038	1	40.0
BH-SEC-1	2.0	0.038	1	40.0
BH-SEC-2	2.0	0.038	1	40.0
BH-TER-1	2.0	0.038	1	30.0
BH-TER-2	2.0	0.038	1	40.0
BH-TER-3	2.0	0.038	1	37.5
BH-TER-4	2.0	0.038	1	2.5
BH-QUT-1	2.0	0.038	1	27.0
BH-QUT-2	2.0	0.038	1	27.0
BH-QUT-3	2.0	0.038	1	0.5
BH-QUT-4	2.0	0.038	1	0.5
BH-QUT-5	2.0	0.038	1	0.5
BH-QUT-6	2.0	0.038	1	0.5
BH-QUT-7	2.0	0.038	1	1.0

5.3 Post-Works

After completion the success of the remediation works was assessed. Criteria for success was based on a comparison between pool recession test results.

5.3.1 Pool Recession Test

Monitoring of pool recession, following a storm event, was undertaken and compared to observations from pre works. The time was measured from the point the pool stopped flowing over the rock bar, to the point the pool had no standing water remaining. A single event was able to be captured post grouting.

After a 28 mm rainfall event over 9 hrs the pool receded 600 mm in 2.5 hrs (time lapse cameras set to 1/2 hr intervals).

Prior to remediation the pool had no observable holding capacity. The works produced a holding time of 2.5 hrs as shown in Images 3 and 4.

Image 3: Water stops flowing over rock bar

Image 4: Water has drained from pool

5.4 Material

SPETEC H100 grout was used for injection. The product was chosen by the client to complete the work based on success with the product during trials at Myrtle Creek. SPETEC H100 is a single part hydrophobic polyurethane grout suitable for potable water use. It comes in a liquid form and an accelerator (SPETEC H100 ACC) is added prior to injection. When the accelerated polyurethane is injected it comes into contact with groundwater, which is the catalyst for the grout to begin setting. SPETEC H100 then foams and expands, between 5 and 12 times its volume, filling voids and pushing itself further into the formation. For example, 50 L of grout has the potential to fill up to 600 L of voids.

SPETEC H100 is a versatile grout as it has no particles, a medium viscosity, expanding volume and has an adjustable gel time. This suits injection in a full range of rock fractures with or without flowing water.

5.5 Discussion

The works carried out contributed to the reduction of rock mass permeability, were completed safely and in an environmentally safe way.

As shown by the grout takes, the works have in-filled fractures at the rock bar, inferring a reduction in rock mass permeability. This can also be noted by the improvement from no pool holding capacity to 2.5 hours.

The shallow curtain demonstrated an improvement in pool holding capacity however not enough to reach pre-mining levels. An improvement might however be the addition of a grid pattern drilled and grouted in the upstream pool. The curtain was chosen as the strategy based on geotechnical mapping showing large fractures in the rock bar and few in the pool base. The post works recession monitoring suggested that water travelling through the rock bar was greatly reduced however water may be permeating through the pool base. The effectiveness of the grid was shown when a downstream pool was drilled and injected in a grid and achieved excellent results. Based on this Pointe believes that, for the purpose of pool retention, combining shallow curtains and grids would be an effective strategy moving forward.

The pool does not currently have connective flow. Future works propose the construction of a deep curtain wall upstream of the pool, which has potential to return surface flow. It is anticipated that constant flow into the pool will greatly increase pool holding capacity.

The drilling method was efficient, safe and effective for the difficult access location of the works. The injection material proved to be practical to use while being low risk to inject. The works were completed safely with no lost time incidents.

Spetec H100 polyurethane was injected efficiently. The large fracture apertures suited its viscosity, expansion, and available set times. The viscosity and fast set time was also well suited to the length of fractures, with many fractures daylighting only a meter from the injection point. The risk to the environment was low with the use of grout approved for potable water use. The grouts set time allowed for good control of the grout spread. This removed the risk of contaminating groundwater or pools downstream.

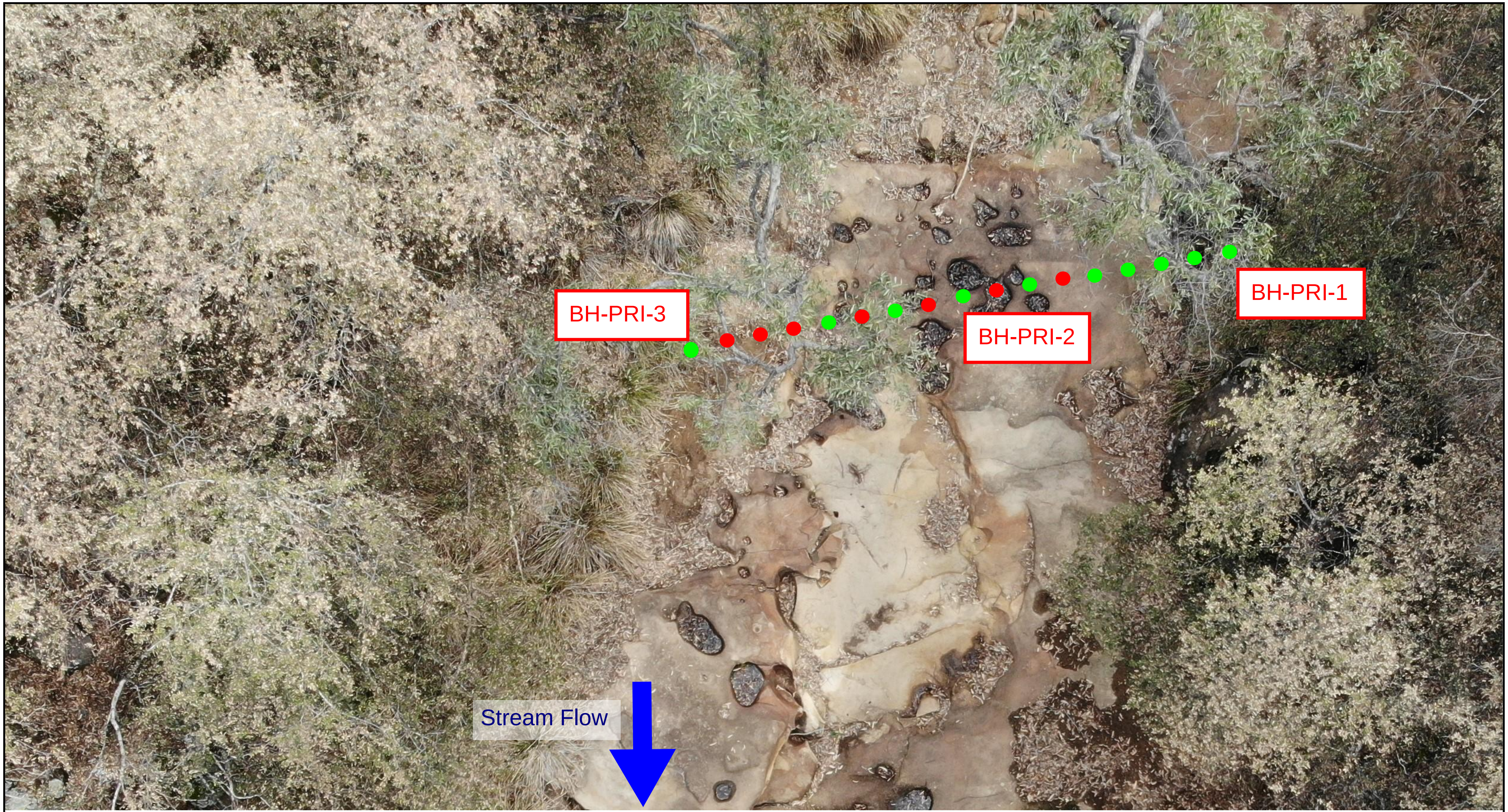
Pointe thanks you for entrusting us to carry works and look forward to working with you in the future.

Yours faithfully,

POINTE ENGINEERING PTY LTD

Glynn Price

Senior Geotechnical Engineer, BE Civil, CPEng



Legend

- >20L
- 5 - 20L
- <5L
- Not drilled

Redbank Ck CMAP RR7		POINTE
GENERAL ARRANGEMENT		
Plan 1 - Rev 0	G.Price	

ATTACHMENT A

REDBANK CREEK RR7 TO RR11 CMAP

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7 to RR11, Redbank Creek, Tahmoor, NSW.

The works on these pools was completed together as a group of adjacent pools in the first half of the year 2020. Separate completion reports were published for individual pools and therefore this Attachment is provided in each of these reports to show how these works relate and enable a discussion on the collective works.

1 DOCUMENTATION

Individual reports on each of the five pools is provided in:

- RR7 Pointe Report P2001-REP-1
- RR8 Pointe Report P2001-REP-2
- RR9 Pointe Report P2001-REP-3
- RR10 Pointe Report P2001-REP-4
- RR11 Pointe Report P2001-REP-5

2 LOCATION

The five sites are located in Redbank Creek in Tahmoor, NSW. The five sites are adjacent to one another along the creek with the most upstream pool being RR7 and most downstream RR11. A plan of the site is shown in Plan 2.

3 SCOPE

A summary of the scope of each of the sites is as follows:

- RR7 - Grout Curtain, 2 m deep, 8 m wide
- RR8 - Grout Curtain, 2 m deep, 16 m wide
- RR9 - Grout Grid Pattern, 1 m deep, 12 m x 12 m
- RR10 - Grout Grid Pattern, 1 m deep, 12 m x 14 m
- RR11 - Grout Curtain, 2 m deep, 16 m wide

Generally two systems of grouting were undertaken, shallow curtain and grid pattern. A decision on what system was based on the fracture characteristics observed. A curtain for multiple open fractures in the rock bar and a grid for multiple open fractures in the pool.

4 RESULTS

A summary of the results is provided in Table 1. These should be read in conjunction with the above report.

Table 1: Results Summary

Site	Initial PRT (hrs)	Final PRT (hrs)	Delta (hrs)	Factor
RR7	0.0	2.5	2.5	>250
RR8	0.0	1.25	1.25	>125
RR9	0.25	1.5	1.25	>5
RR10	0.25	49	48.75	>196
RR11	31.5	68	36.5	>2

5 MATERIAL

The same injection material was used across all sites. Details and discussion are provided in the individual reports.

6 DISCUSSION

All the works carried out contributed to the reduction of rock mass permeability. However, Pointe has identified a number of improvements that can be made for future works.

For the works Pointe assigned a system (curtain or grid pattern) based on the location of the highest density of connective fractures. From observing the works this should not be a choice but rather a combination of the two for all sites seeking to increase pool retention. The grid pattern proved to be more effective at retaining water. The curtain however demonstrated that at certain sites higher intensity grouting at the rock bar is needed, due to higher intensity of fracturing.

The grid pattern achieved good results however two improvements are proposed to further these results. These are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing in rows outwards. Drilling would cease when consecutive rows will not take grout. Works could then be focused on the areas that have the greatest intensity of voids.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity. This combined with the outward progression has the potential for greater intensity without extra work, increasing pool retention time.

It is therefore recommended that for future shallow works that we:

1. Plan for grid pattern, grouting across the base and rock bar of the pool (to 1 m deep)
2. Allow for higher intensity grouting across the rock bar (as part of this grid, to 1 m deep)
3. Begin works at a row in the creek centreline
4. Progress works outwards assessing grout takes to establish a boundary
5. Once a boundary is determined, return to the creek centre to intensify grouting

Appendix A.2 – RR8 (Pointe Engineering Pty Ltd)

POINTE | GEOTECHNICAL ENGINEERING

COMPLETION REPORT

REDBANK CREEK CMAP RR8

June 29th, 2020
Document: PE-REP-2001-2
POINTE ENGINEERING PTY LTD

DOCUMENT CONTROL FORM

Project Name:	Redbank Creek CMAP RR8
Project Number:	P2001
Document Number:	PE-REP-2001-2

REVISION HISTORY

REVISION	DATE	SUBMITTED BY	DISTRIBUTED TO
A (DRAFT)	26 June 2020	G.Price	A.Stuart
0	29 June 2020	G.Price	A.Stuart

1 INTRODUCTION

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR8, Redbank Creek, Tahmoor, NSW.

Redbank Creek is a tributary of the Nepean River. Redbank Creek is overlying TCCO Longwalls 25 to 32. These longwalls are understood to have caused surface subsidence along the creek. TCCO has developed a Corrective Management Action Plan (CMAP) to remediate mine subsidence impacts. The subsidence impacts to Redbank Creek include cracking of the channel bedrock and rock bars resulting in a reduction in surface flow.

Pointe was contracted for their expertise and past experiences grouting foundations, tunnels and specifically for subsidence remediation grouting.

The works were carried out between the 27th of March to the 28th of April 2020 and this report details the following:

- Pre works (investigation),
- Works,
- Post works (success verification),
- Materials used,
- Success and recommendations for improvement in future pool remediation.

The works on this pool was completed together as a group of adjacent pools RR7 to RR11. This report only refers to the works completed in RR8 however a discussion on the collective works is given in Attachment A.

2 OBJECTIVE

The objective of the works was to increase the pool holding capacity. This is defined by the period of time that the pool retains water after rainfall runoff has entered it.

3 SCOPE

The scope included construction of an in-situ low permeability curtain across the creek. This method was used to target the open, shallow dipping, bedding planes at the pool's controlling rock bar.

The work included:

- A site investigation,
- Drilling a 2 m deep, 16 m wide curtain,
- Polyurethane injection of the curtain.

4 POOL DESCRIPTION

RR8 is a small (approximately 10 000L) pool. It contains alluvium base and alluvium deposit on both banks. The pool has a controlling rock bar that sits approximately 0.3 m above the pool base. The pool and surrounding rock mass contain many open bedding planes, at medium

spacing, dipping east at between 5° and 15°. There was limited evidence of open fractures in the pool base.

5 ACTIVITIES COMPLETED

5.1 Pre-Works

Investigation of the existing bedrock conditions were carried out ahead of the works. The investigation was undertaken between the October 2019 and January 2020 and included:

- A monitoring borehole; and
- A pool recession test.

5.1.1 Monitoring Borehole

TCCO undertook an investigation with assistance from Highland Drilling and Strata Control Technology (SCT). Two boreholes were drilled, logged, hydraulically tested and calliper tested in December 2019. The boreholes were labelled P19a and P19b and can be found in SCT report TAH5004b. The borehole was 170 m from the pool above the crest of the embankment. Results showed a high permeability (between 3.8×10^{-8} to $<1.9 \times 10^{-5}$ m/s) throughout the length of the borehole. Groundwater was measured at approximately 8 m below the creek surface.

5.1.2 Pool Recession Test

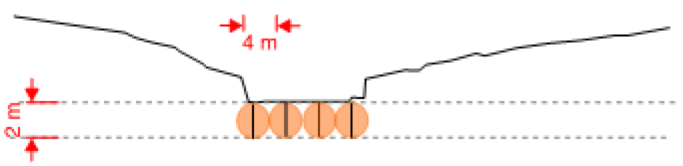
A baseline Pool Recession Test (PRT) was completed on the 30th of March 2020 prior to grout injection. The pool was filled with approximately 13000 L of water and then monitored to understand its existing retention. The 13 000L permeated through the rock bar immediately without any pooling.

5.2 Works

The works were focused on improving the upper portion of the pool's controlling rock bar. Results from mapping showed that the rock bar contained many open fractures and few open fractures on the pool base.

An 8 m wide curtain was constructed across the rock bar perpendicular to the flow. 18 boreholes, 38 mm in diameter, were drilled with a pneumatic hammer to 2 m below ground level. The holes were drilled with primary boreholes spaced at 4 m. The following boreholes split spaced between primaries and were drilled and injected such that a final spacing of boreholes was 0.5 m. Each hole was grouted in a single stage as shown in Figure 1.

Figure 1: Cross Section of Primary Boreholes



The boreholes were injected with a hydrophobic polyurethane (Spetec H100). A total of 812 L of Spetec H100 was injected during the works. With a laboratory expansion volume of between 5 and 12 times, Pointe has filled between 4000 and 9700 L of voids. Details of each bore shown in Table 1 and an as built drawing is shown in Plan 1.

Results show large grout takes up to the tertiary holes with noticeable decrease in grout take on the quaternaries. The grout takes were larger in the centre of the creek with less than 1 litre per meter on ends.

Table 1: Holes Drilled and Grouted

ID	Depth (mbgl)	Borehole Dia. (m)	No. Grouted Sections	Avg Volume Grouted per meter (L)
BH-PRI-1	2.0	0.038	1	0.5
BH-PRI-2	2.0	0.038	1	40.0
BH-PRI-3	2.0	0.038	1	33.8
BH-PRI-4	2.0	0.038	1	40.0
BH-PRI-5	2.0	0.038	1	39.0
BH-SEC-1	2.0	0.038	1	0.5
BH-SEC-2	2.0	0.038	1	40.0
BH-SEC-3	2.0	0.038	1	40.0
BH-SEC-4	2.0	0.038	1	0.5
BH-TER-1	2.0	0.038	1	0.5
BH-TER-2	2.0	0.038	1	0.5
BH-TER-3	2.0	0.038	1	12.5
BH-TER-4	2.0	0.038	1	40.0
BH-TER-5	2.0	0.038	1	15.0
BH-TER-6	2.0	0.038	1	40.0
BH-TER-7	2.0	0.038	1	40.0
BH-TER-8	2.0	0.038	1	0.5
BH-QUT-4	2.0	0.038	1	0.5
BH-QUT-5	2.0	0.038	1	0.5
BH-QUT-6	2.0	0.038	1	0.5
BH-QUT-7	2.0	0.038	1	6.3
BH-QUT-8	2.0	0.038	1	0.8
BH-QUT-9	2.0	0.038	1	0.5
BH-QUT-10	2.0	0.038	1	1.3
BH-QUT-11	2.0	0.038	1	1.3
BH-QUT-12	2.0	0.038	1	1.3
BH-QUT-13	2.0	0.038	1	8.8
BH-QUT-14	2.0	0.038	1	1.3

*BH-QUT-1 to 4 were not drilled.

5.3 Post-Works

After completion the success of the remediation works was assessed. Criteria for success was based on a comparison between pool recession test results.

5.3.1 Pool Recession Test

Pointe completed a Pool Recession Test (PRT) on the 6th May 2020 after completion of the works. The pool was filled with approximately 13000 L of water and time for it to recede was recorded. Prior to remediation the pool had no observable holding capacity. The test results show the pool receded 300 mm 75 minutes as shown in Images 1 and 2.

Image 1: Filled with 13000 L

Image 2: Water has drained from pool

5.4 Material

SPETEC H100 grout was used for injection. The product was chosen by the client to complete the work based on success with the product during trials at Myrtle Creek. SPETEC H100 is a single part hydrophobic polyurethane grout suitable for potable water use. It comes in a liquid form and an accelerator (SPETEC H100 ACC) is added prior to injection. When the accelerated polyurethane is injected it comes into contact with groundwater, which is the catalyst for the grout to begin setting. SPETEC H100 then foams and expands, between 5 and 12 times its volume, filling voids and pushing itself further into the formation. For example, 50 L of grout has the potential to fill up to 600 L of voids.

SPETEC H100 is a versatile grout as it has no particles, a medium viscosity, expanding volume and has an adjustable gel time. This suits injection in a full range of rock fractures with or without flowing water.

5.5 Discussion

The works carried out contributed to the reduction of rock mass permeability, were completed safely and in an environmentally safe way.

As shown by the grout takes, the works have in-filled fractures at the rock bar, inferring a reduction in rock mass permeability. This can also be noted by the improvement from no pool holding capacity to 1.25 hours.

The shallow curtain demonstrated an improvement in pool holding capacity however not enough to reach pre-mining levels. An improvement might however be the addition of a grid pattern drilled and grouted in the upstream pool. The curtain was chosen as the strategy based on geotechnical mapping showing large fractures in the rock bar and few in the pool base. The post works recession monitoring suggested that water travelling through the rock bar was greatly reduced however water may be permeating through the pool base. The effectiveness of the grid was shown when a downstream pool was drilled and injected in a grid and achieved excellent results. Based on this Pointe believes that, for the purpose of pool retention, combining shallow curtains and grids would be an effective strategy moving forward.

The pool does not currently have connective flow. Future works propose the construction of a deep curtain wall upstream of the pool, which has potential to return surface flow. It is anticipated that constant flow into the pool will greatly increase pool holding capacity.

The drilling method was efficient, safe and effective for the difficult access location of the works. The injection material proved to be practical to use while being low risk to inject. The works were completed safely with no lost time incidents.

Spetec H100 polyurethane was injected efficiently. The large fracture apertures suited its viscosity, expansion, and available set times. The viscosity and fast set time was also well suited to the length of fractures, with many fractures daylighting only a meter from the injection point. The risk to the environment was low with the use of grout approved for potable water use. The grouts set time allowed for good control of the grout spread. This removed the risk of contaminating groundwater or pools downstream.

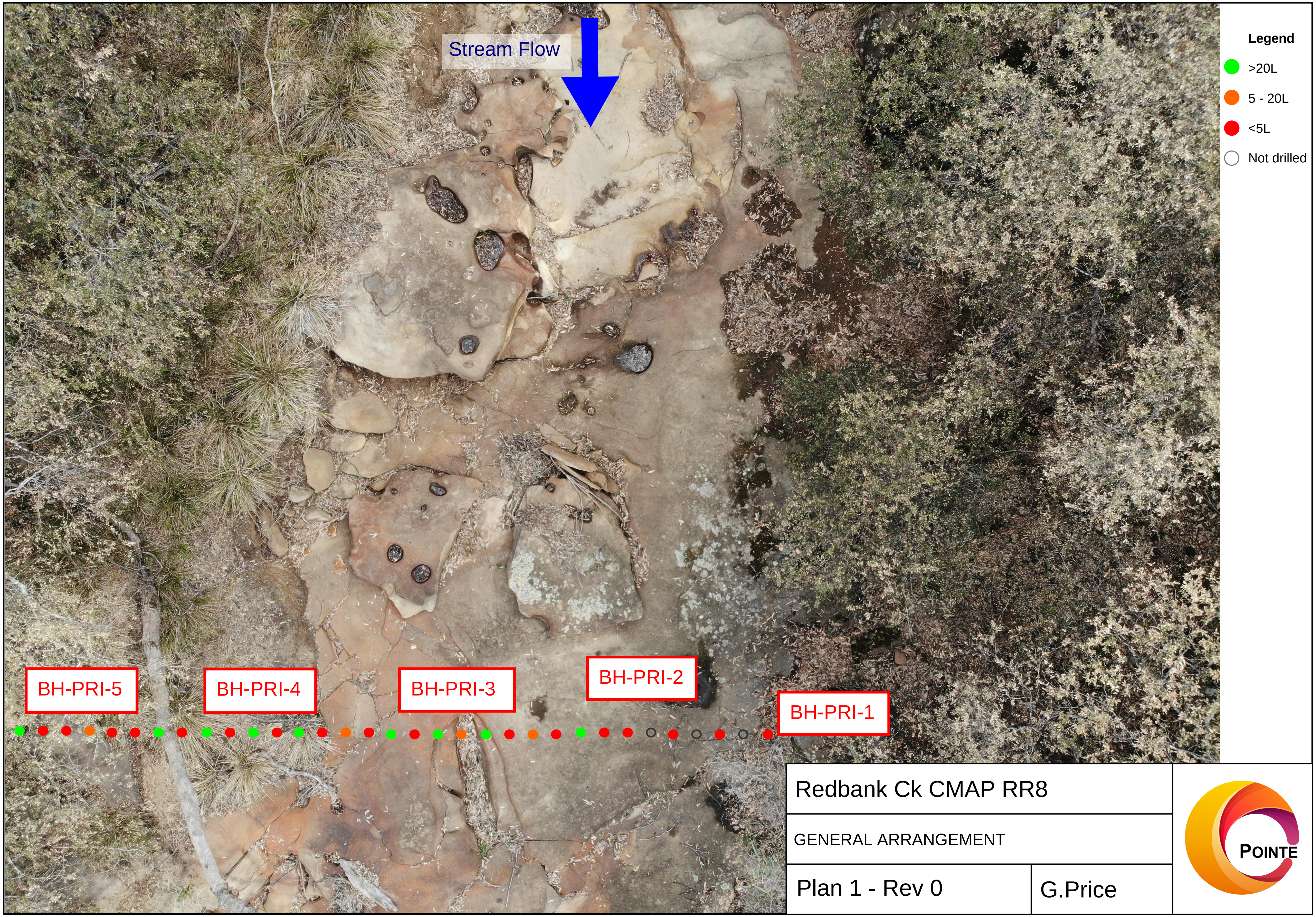
Pointe thanks you for entrusting us to carry works and look forward to working with you in the future.

Yours faithfully,

POINTE ENGINEERING PTY LTD

Glynn Price

Senior Geotechnical Engineer, BE Civil, CPEng



Redbank Ck CMAP RR8

GENERAL ARRANGEMENT

Plan 1 - Rev 0

G.Price

POINTE

ATTACHMENT A

REDBANK CREEK RR7 TO RR11 CMAP

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7 to RR11, Redbank Creek, Tahmoor, NSW.

The works on these pools was completed together as a group of adjacent pools in the first half of the year 2020. Separate completion reports were published for individual pools and therefore this Attachment is provided in each of these reports to show how these works relate and enable a discussion on the collective works.

1 DOCUMENTATION

Individual reports on each of the five pools is provided in:

- RR7 Pointe Report P2001-REP-1
- RR8 Pointe Report P2001-REP-2
- RR9 Pointe Report P2001-REP-3
- RR10 Pointe Report P2001-REP-4
- RR11 Pointe Report P2001-REP-5

2 LOCATION

The five sites are located in Redbank Creek in Tahmoor, NSW. The five sites are adjacent to one another along the creek with the most upstream pool being RR7 and most downstream RR11. A plan of the site is shown in Plan 2.

3 SCOPE

A summary of the scope of each of the sites is as follows:

- RR7 - Grout Curtain, 2 m deep, 8 m wide
- RR8 - Grout Curtain, 2 m deep, 16 m wide
- RR9 - Grout Grid Pattern, 1 m deep, 12 m x 12 m
- RR10 - Grout Grid Pattern, 1 m deep, 12 m x 14 m
- RR11 - Grout Curtain, 2 m deep, 16 m wide

Generally two systems of grouting were undertaken, shallow curtain and grid pattern. A decision on what system was based on the fracture characteristics observed. A curtain for multiple open fractures in the rock bar and a grid for multiple open fractures in the pool.

4 RESULTS

A summary of the results is provided in Table 1. These should be read in conjunction with the above report.

Table 1: Results Summary

Site	Initial PRT (hrs)	Final PRT (hrs)	Delta (hrs)	Factor
RR7	0.0	2.5	2.5	>250
RR8	0.0	1.25	1.25	>125
RR9	0.25	1.5	1.25	>5
RR10	0.25	49	48.75	>196
RR11	31.5	68	36.5	>2

5 MATERIAL

The same injection material was used across all sites. Details and discussion are provided in the individual reports.

6 DISCUSSION

All the works carried out contributed to the reduction of rock mass permeability. However, Pointe has identified a number of improvements that can be made for future works.

For the works Pointe assigned a system (curtain or grid pattern) based on the location of the highest density of connective fractures. From observing the works this should not be a choice but rather a combination of the two for all sites seeking to increase pool retention. The grid pattern proved to be more effective at retaining water. The curtain however demonstrated that at certain sites higher intensity grouting at the rock bar is needed, due to higher intensity of fracturing.

The grid pattern achieved good results however two improvements are proposed to further these results. These are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing in rows outwards. Drilling would cease when consecutive rows will not take grout. Works could then be focused on the areas that have the greatest intensity of voids.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity. This combined with the outward progression has the potential for greater intensity without extra work, increasing pool retention time.

It is therefore recommended that for future shallow works that we:

1. Plan for grid pattern, grouting across the base and rock bar of the pool (to 1 m deep)
2. Allow for higher intensity grouting across the rock bar (as part of this grid, to 1 m deep)
3. Begin works at a row in the creek centreline
4. Progress works outwards assessing grout takes to establish a boundary
5. Once a boundary is determined, return to the creek centre to intensify grouting

Appendix A.3 – RR9 (Pointe Engineering Pty Ltd)

POINTE | GEOTECHNICAL ENGINEERING

COMPLETION REPORT

REDBANK CREEK CMAP RR9

June 29th, 2020
Document: PE-REP-2001-3
POINTE ENGINEERING PTY LTD

DOCUMENT CONTROL FORM

Project Name: Redbank Creek CMAP RR9

Project Number: PE-P2001

Document Number: PE-REP-2001-3

REVISION HISTORY

REVISION	DATE	SUBMITTED BY	DISTRIBUTED TO
A (DRAFT)	28 June 2020	G.Price	A.Stuart
0	29 June 2020	G.Price	A.Stuart

1 INTRODUCTION

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR9, Redbank Creek, Tahmoor, NSW.

Redbank Creek is a tributary of the Nepean River. Redbank Creek is overlying TCCO Longwalls 25 to 32. These longwalls are understood to have caused surface subsidence along the creek. TCCO has developed a Corrective Management Action Plan (CMAP) to remediate mine subsidence impacts. The subsidence impacts to Redbank Creek include cracking of the channel bedrock and rock bars resulting in a reduction in surface flow.

Pointe was contracted for their expertise and past experiences grouting foundations, tunnels and specifically for subsidence remediation grouting.

The works were carried out between the 7th of April to the 4th of May 2020 and this report details the following:

- Pre works (investigation),
- Works,
- Post works (success verification),
- Materials used,
- Success and recommendations for improvement in future pool remediation.

The works on this pool was completed together as a group of adjacent pools RR7 to RR11. This report only refers to the works completed in RR9 however a discussion on the collective works is given in Attachment A.

2 OBJECTIVE

The objective of the works was to increase the pool holding capacity. This is defined by the period of time that the pool retains water after rainfall runoff has entered it.

3 SCOPE

The scope included drilling and injection in a grid pattern across the pool base. This method was used to target the open, shallow dipping, bedding planes in the pool's base and controlling rock bar.

The work included:

- A site investigation,
- Drilling a 1 m deep, 12 m by 12 m wide grid pattern,
- Polyurethane injection of the curtain.

4 POOL DESCRIPTION

RR9 is a small (approximately 20 000L) pool. It contains a sandstone base and alluvium deposit on the south bank and sandstone on the north. The pool has a controlling rock bar that sits approximately 0.2 m above the pool base. The pool and surrounding rock mass contain many open bedding planes, at medium spacing, dipping east at between 5° and 15°. There was a number of open fractures in the pool base.

5 ACTIVITIES COMPLETED

5.1 Pre-Works

Investigation of the existing bedrock conditions were carried out ahead of the works. The investigation was undertaken between the October 2019 and January 2020 and included:

- A monitoring borehole; and
- A pool recession test.

5.1.1 Monitoring Borehole

TCCO undertook an investigation with assistance from Highland Drilling and Strata Control Technology (SCT). Two boreholes were drilled, logged, hydraulically tested and calliper tested in December 2019. The boreholes were labelled P19a and P19b and can be found in SCT report TAH5004b. The borehole was 170 m from the pool above the crest of the embankment. Results showed a high permeability (between 3.8×10^{-8} to $<1.9 \times 10^{-5}$ m/s) throughout the length of the borehole. Groundwater was measured at approximately 8 m below the creek surface.

5.1.2 Pool Recession Test

A baseline Pool Recession Test (PRT) was completed on the 16th of April 2020 prior to grout injection. The pool was filled with approximately 13000 L of water and then monitored to understand its existing retention. The 13 000L dissipated within 16 minutes, a 200 mm drop.

Image 1: Water at the end of 13000L

Image 2: Water has drained from pool

5.2 Works

A 12 m wide by 12 m long grid was established encompassing the pool. 45 boreholes, 38 mm in diameter, were drilled with a pneumatic hammer to 1 m below ground level. The holes were drilled on a 2 m initial grid spacing. The following boreholes split spaced between primaries and were drilled and injected to fill areas that remained permeable

The boreholes were injected with a hydrophobic polyurethane (Spetec H100). A total of 880 L of Spetec H100 was injected during the works. With a laboratory expansion volume of between 5 and 12 times, Pointe has filled between 4400 and 10600 L of voids. Details of each bore shown in Table 1 and an as built drawing is shown in Plan 1.

Results show large grout takes in the center and north embankment. The south embankment was much tighter with little grout take. This was consistent the length of pool.

Table 1: Holes Drilled and Grouted

ID	Depth (mbgl)	Borehole Dia. (m)	No. Grouted Sections	Avg Volume Grouted per meter (L)
A9	1	0.038	1	40.0
A10	1	0.038	1	1.0
A11	1	0.038	1	40.0
B9	1	0.038	1	40.0
B12	1	0.038	1	26.0
B13	1	0.038	1	29.0
B14	1	0.038	1	26.0
B15	1	0.038	1	29.0
C9	1	0.038	1	17.5
C10	1	0.038	1	40.0
C11	1	0.038	1	40.0
C12	1	0.038	1	26.0
C13	1	0.038	1	29.0
C14	1	0.038	1	26.0
C15	1	0.038	1	29.0
CC12	1	0.038	1	25.0
D9	1	0.038	1	2.5
D10	1	0.038	1	40.0
D11	1	0.038	1	40.0
D12	1	0.038	1	26.0
D13	1	0.038	1	29.0
D14	1	0.038	1	26.0
D15	1	0.038	1	29.0
DD12	1	0.038	1	40.0
E9	1	0.038	1	1.0
E10	1	0.038	1	40.0
E11	1	0.038	1	40.0
E12	1	0.038	1	0.0
E13	1	0.038	1	1.0
E14	1	0.038	1	1.0
E15	1	0.038	1	29.0
F9	1	0.038	1	1.0
F10	1	0.038	1	1.0
F11	1	0.038	1	1.0
F12	1	0.038	1	0.0
F13	1	0.038	1	1.0
F14	1	0.038	1	26.0
F15	1	0.038	1	5.0
G9	1	0.038	1	2.5
G10	1	0.038	1	1.0
G11	1	0.038	1	1.0
G12	1	0.038	1	0.0
G13	1	0.038	1	1.0
G14	1	0.038	1	2.0
G15	1	0.038	1	29.0

5.3 Post-Works

After completion the success of the remediation works was assessed. Criteria for success was based on a comparison between pool recession test results.

5.3.1 Pool Recession Test

Pointe completed a Pool Recession Test (PRT) on the 6th May 2020 after completion of the works. The pool was filled with approximately 13000 L of water and time for it to recede was recorded. The pool retained water for 1.5 hours. The test results show an increase in holding time of 1.25 hours or greater than 5 times that of the pre works test, as shown in Images 3 and 4

Image 3: Filled with 13000 L

Image 4: Water has drained from pool

5.4 Material

SPETEC H100 grout was used for injection. The product was chosen by the client to complete the work based on success with the product during trials at Myrtle Creek. SPETEC H100 is a single part hydrophobic polyurethane grout suitable for potable water use. It comes in a liquid form and an accelerator (SPETEC H100 ACC) is added prior to injection. When the accelerated polyurethane is injected it comes into contact with groundwater, which is the catalyst for the grout to begin setting. SPETEC H100 then foams and expands, between 5 and 12 times its volume, filling voids and pushing itself further into the formation. For example, 50 L of grout has the potential to fill up to 600 L of voids.

SPETEC H100 is a versatile grout as it has no particles, a medium viscosity, expanding volume and has an adjustable gel time. This suits injection in a full range of rock fractures with or without flowing water.

5.5 Discussion

The works carried out contributed to the reduction of rock mass permeability, were completed safely and in an environmentally safe way.

The works carried out improved pool retention. The works progressed towards the key criteria of increasing pool holding capacity. The works also showed extensive fracture in-filling in the pool, inferring a reduction in rock mass permeability. This can also be noted by the improvement in pool holding capacity by greater than 5 times.

The grid was an effective remediation strategy. Two improvements proposed are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing outwards. Drilling would cease when consecutive rows will not take grout.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity.

The pool does not currently have connective flow. Future works propose the construction of a deep curtain wall upstream of the pool, which has potential to return surface flow. It is anticipated that constant flow into the pool will greatly increase pool holding capacity.

The drilling method was efficient, safe and effective for the difficult access location of the works. The injection material proved to be practical to use while being low risk to inject. The works were completed safely with no lost time incidents.

Spetec H100 polyurethane was injected efficiently. The large fracture apertures suited its viscosity, expansion, and available set times. The viscosity and fast set time was also well suited to the length of fractures, with many fractures daylighting only a meter from the injection point. The risk to the environment was low with the use of grout approved for potable water use. The grouts set time allowed for good control of the grout spread. This removed the risk of contaminating groundwater or pools downstream.

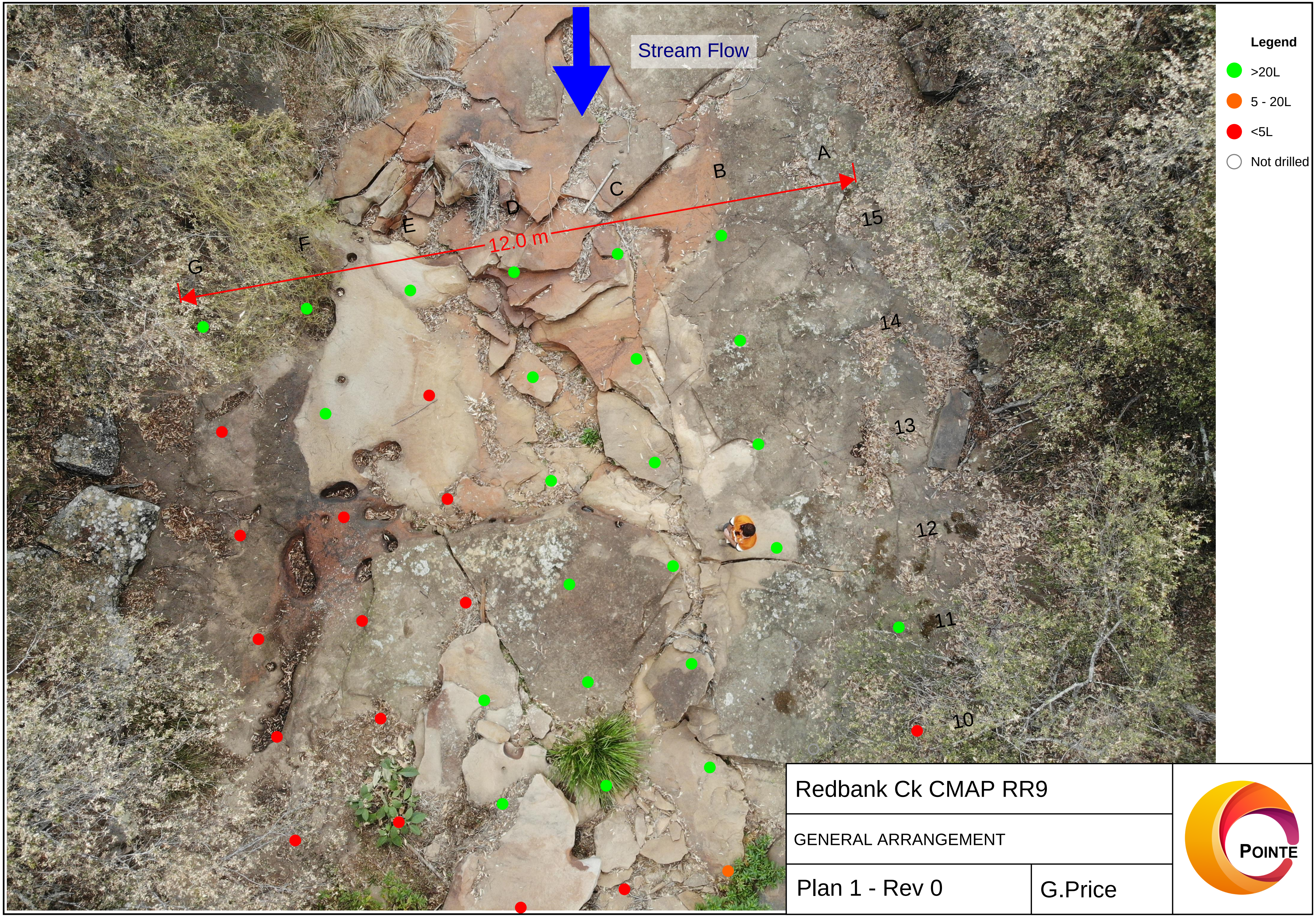
Pointe thanks you for entrusting us to carry works and look forward to working with you in the future.

Yours faithfully,

POINTE ENGINEERING PTY LTD

Glynn Price

Senior Geotechnical Engineer, BE Civil, CPEng



Redbank Ck CMAP RR9

GENERAL ARRANGEMENT

Plan 1 - Rev 0	G.Price

ATTACHMENT A

REDBANK CREEK RR7 TO RR11 CMAP

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7 to RR11, Redbank Creek, Tahmoor, NSW.

The works on these pools was completed together as a group of adjacent pools in the first half of the year 2020. Separate completion reports were published for individual pools and therefore this Attachment is provided in each of these reports to show how these works relate and enable a discussion on the collective works.

1 DOCUMENTATION

Individual reports on each of the five pools is provided in:

- RR7 Pointe Report P2001-REP-1
- RR8 Pointe Report P2001-REP-2
- RR9 Pointe Report P2001-REP-3
- RR10 Pointe Report P2001-REP-4
- RR11 Pointe Report P2001-REP-5

2 LOCATION

The five sites are located in Redbank Creek in Tahmoor, NSW. The five sites are adjacent to one another along the creek with the most upstream pool being RR7 and most downstream RR11. A plan of the site is shown in Plan 2.

3 SCOPE

A summary of the scope of each of the sites is as follows:

- RR7 - Grout Curtain, 2 m deep, 8 m wide
- RR8 - Grout Curtain, 2 m deep, 16 m wide
- RR9 - Grout Grid Pattern, 1 m deep, 12 m x 12 m
- RR10 - Grout Grid Pattern, 1 m deep, 12 m x 14 m
- RR11 - Grout Curtain, 2 m deep, 16 m wide

Generally two systems of grouting were undertaken, shallow curtain and grid pattern. A decision on what system was based on the fracture characteristics observed. A curtain for multiple open fractures in the rock bar and a grid for multiple open fractures in the pool.

4 RESULTS

A summary of the results is provided in Table 1. These should be read in conjunction with the above report.

Table 1: Results Summary

Site	Initial PRT (hrs)	Final PRT (hrs)	Delta (hrs)	Factor
RR7	0.0	2.5	2.5	>250
RR8	0.0	1.25	1.25	>125
RR9	0.25	1.5	1.25	>5
RR10	0.25	49	48.75	>196
RR11	31.5	68	36.5	>2

5 MATERIAL

The same injection material was used across all sites. Details and discussion are provided in the individual reports.

6 DISCUSSION

All the works carried out contributed to the reduction of rock mass permeability. However, Pointe has identified a number of improvements that can be made for future works.

For the works Pointe assigned a system (curtain or grid pattern) based on the location of the highest density of connective fractures. From observing the works this should not be a choice but rather a combination of the two for all sites seeking to increase pool retention. The grid pattern proved to be more effective at retaining water. The curtain however demonstrated that at certain sites higher intensity grouting at the rock bar is needed, due to higher intensity of fracturing.

The grid pattern achieved good results however two improvements are proposed to further these results. These are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing in rows outwards. Drilling would cease when consecutive rows will not take grout. Works could then be focused on the areas that have the greatest intensity of voids.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity. This combined with the outward progression has the potential for greater intensity without extra work, increasing pool retention time.

It is therefore recommended that for future shallow works that we:

1. Plan for grid pattern, grouting across the base and rock bar of the pool (to 1 m deep)
2. Allow for higher intensity grouting across the rock bar (as part of this grid, to 1 m deep)
3. Begin works at a row in the creek centreline
4. Progress works outwards assessing grout takes to establish a boundary
5. Once a boundary is determined, return to the creek centre to intensify grouting

Appendix A.4 – RR10 (Pointe Engineering Pty Ltd)

POINTE | GEOTECHNICAL ENGINEERING

COMPLETION REPORT

REDBANK CREEK CMAP RR10

June 29th, 2020
Document: PE-REP-2001-4
POINTE ENGINEERING PTY LTD

DOCUMENT CONTROL FORM

Project Name:	Redbank Creek CMAP RR10
Project Number:	PE-P2001
Document Number:	PE-REP-2001-4

REVISION HISTORY

REVISION	DATE	SUBMITTED BY	DISTRIBUTED TO
A (DRAFT)	26 June 2020	G.Price	A.Stuart
0	29 June 2020	G.Price	A.Stuart

1 INTRODUCTION

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR10, Redbank Creek, Tahmoor, NSW.

Redbank Creek is a tributary of the Nepean River. Redbank Creek is overlying TCCO Longwalls 25 to 32. These longwalls are understood to have caused surface subsidence along the creek. TCCO has developed a Corrective Management Action Plan (CMAP) to remediate mine subsidence impacts. The subsidence impacts to Redbank Creek include cracking of the channel bedrock and rock bars resulting in a reduction in surface flow.

Pointe was contracted for their expertise and past experiences grouting foundations, tunnels and specifically for subsidence remediation grouting.

The works were carried out between the 4th of March to the 30th of April 2020 and this report details the following:

- Pre works (investigation),
- Works,
- Post works (success verification),
- Materials used,
- Success and recommendations for improvement in future pool remediation.

The works on this pool was completed together as a group of adjacent pools RR7 to RR11. This report only refers to the works completed in RR10 however a discussion on the collective works is given in Attachment A.

2 OBJECTIVE

The objective of the works was to increase the pool holding capacity. This is defined by the period of time that the pool retains water after rainfall runoff has entered it.

3 SCOPE

The scope included drilling and injection in a grid pattern across the pool base. This method was used to target the open, shallow dipping, bedding planes in the pool's base and controlling rock bar.

The work included:

- A site investigation,
- Drilling a 1 m deep, 12 m by 14 m wide grid pattern,
- Polyurethane injection of the curtain.

4 POOL DESCRIPTION

RR10 is a small (approximately 20 000L) pool. It contains a sandstone base and alluvium deposit on the south bank and sandstone on the north. The pool has a controlling rock bar that sits approximately 0.3 m above the pool base. The pool and surrounding rock mass contain many open bedding planes, at medium spacing, dipping east at between 5° and 15°. There was a number of open fractures in the pool base.

5 ACTIVITIES COMPLETED

5.1 Pre-Works

Investigation of the existing bedrock conditions were carried out ahead of the works. The investigation was undertaken between the October 2019 and January 2020 and included:

- A monitoring borehole; and
- A pool recession test.

5.1.1 Monitoring Borehole

TCCO undertook an investigation with assistance from Highland Drilling and Strata Control Technology (SCT). Two boreholes were drilled, logged, hydraulically tested and calliper tested in December 2019. The boreholes were labelled P19a and P19b and can be found in SCT report TAH5004b. The borehole was 170 m from the pool above the crest of the embankment. Results showed a high permeability (between 3.8 x 10^{-8} to <1.9 x 10^{-5} m/s) throughout the length of the borehole. Groundwater was measured at approximately 8 m below the creek surface.

5.1.2 Pool Recession Test

A baseline Pool Recession Test (PRT) was completed on the 17^{th} of March 2020 prior to grout injection. The pool was filled with approximately 13000 L of water and then monitored to understand its existing retention. The 13 000L dissipated within 17 minutes, a 300 mm drop.

Image 1: Water at the end of 13000L

Image 2: Water has drained from pool

5.2 Works

A 12 m wide by 14 m long grid was established encompassing the pool. 64 boreholes, 38 mm in diameter, were drilled with a pneumatic hammer to 1 m below ground level. The holes were drilled on a 2 m initial grid spacing. The following boreholes split spaced between primaries and were drilled and injected to fill areas that remained permeable

The boreholes were injected with a hydrophobic polyurethane (Spetec H100). A total of 1520 L of Spetec H100 was injected during the works. With a laboratory expansion volume of between 5 and 12 times, Pointe has filled between 7600 and 18200 L of voids. Details of each bore shown in Table 1 and an as built drawing is shown in Plan 1.

Results show large grout takes in the center and north embankment. The south embankment was much tighter with little grout take. This was consistent the length of pool.

Table 1: Holes Drilled and Grouted

ID	Depth (mbgl)	Borehole Dia. (m)	No. Grouted Sections	Avg Volume Grouted per meter (L)
A1	1	0.038	1	40.0
A2	1	0.038	1	35.0
A3	1	0.038	1	7.5
A4	1	0.038	1	2.0
A5	1	0.038	1	40.0
A6	1	0.038	1	40.0
B1	1	0.038	1	40.0
B2	1	0.038	1	23.5
B3	1	0.038	1	7.5
B4	1	0.038	1	40.0
B5	1	0.038	1	40.0
B6	1	0.038	1	40.0
B7	1	0.038	1	40.0
B8	1	0.038	1	40.0
C1	1	0.038	1	40.0
C2	1	0.038	1	40.0
C3	1	0.038	1	40.0
C4	1	0.038	1	40.0
C5	1	0.038	1	40.0
C6	1	0.038	1	40.0
C7	1	0.038	1	40.0
C8	1	0.038	1	40.0
CC3	1	0.038	1	40.0
CC4	1	0.038	1	40.0
CC5	1	0.038	1	40.0
D1	1	0.038	1	40.0
D2	1	0.038	1	40.0
D3	1	0.038	1	40.0
D4	1	0.038	1	2.5
D5	1	0.038	1	40.0
D6	1	0.038	1	30.0
D7	1	0.038	1	40.0
D8	1	0.038	1	2.5
DD3	1	0.038	1	40.0
DD4	1	0.038	1	20.0
DD5	1	0.038	1	35.0
DD6	1	0.038	1	35.0
DD7	1	0.038	1	40.0
E1	1	0.038	1	16.5
E2	1	0.038	1	2.0
E3	1	0.038	1	2.5
E4	1	0.038	1	40.0
E5	1	0.038	1	40.0
E6	1	0.038	1	1.0
E7	1	0.038	1	40.0
E8	1	0.038	1	1.0
EE3	1	0.038	1	1.0

EE4	1	0.038	1	0.0
EE5	1	0.038	1	0.0
EE6	1	0.038	1	25.0
EE7	1	0.038	1	0.0
F1	1	0.038	1	23.5
F2	1	0.038	1	2.0
F3	1	0.038	1	1.0
F4	1	0.038	1	1.0
F5	1	0.038	1	2.5
F6	1	0.038	1	2.5
G2	1	0.038	1	2.0
G3	1	0.038	1	23.5
G4	1	0.038	1	1.0
G5	1	0.038	1	5.0
G6	1	0.038	1	1.0
G7	1	0.038	1	1.0
G8	1	0.038	1	1.0

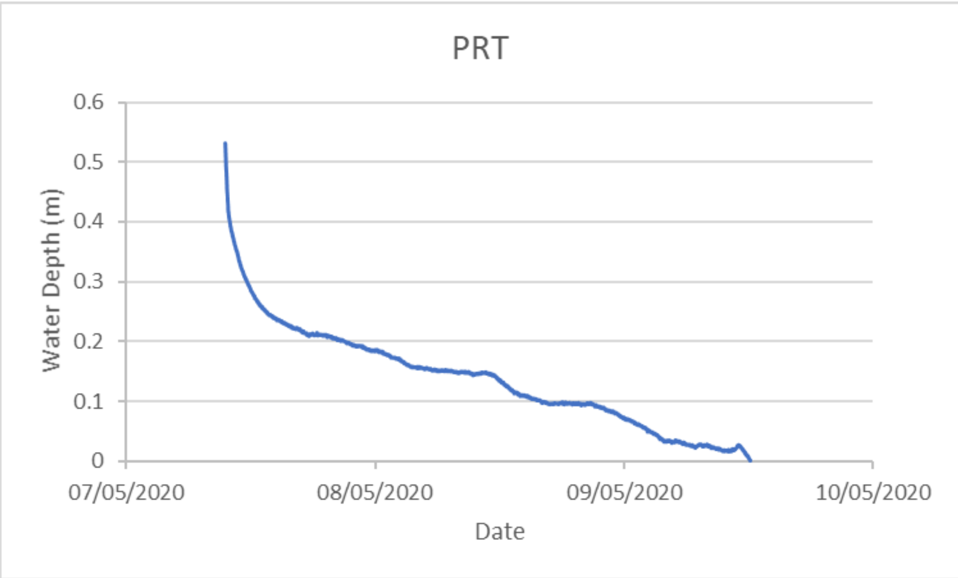
5.3 Post-Works

After completion the success of the remediation works was assessed. Criteria for success was based on a comparison between pool recession test results.

5.3.1 Pool Recession Test

Pointe completed a Pool Recession Test (PRT) on the 7th May 2020 after completion of the works. The pool was filled with approximately 13000 L of water and time for it to recede was recorded. The pool retained water for 49 hours. The test results show an increase in holding time of 48.5 hours or greater than 200 times that of the pre works test as shown in Chart 1.

Chart 1: Pool Recession Test Depth Over Time



5.4 Material

SPETEC H100 grout was used for injection. The product was chosen by the client to complete the work based on success with the product during trials at Myrtle Creek. SPETEC H100 is a single part hydrophobic polyurethane grout suitable for potable water use. It comes in a liquid form and an accelerator (SPETEC H100 ACC) is added prior to injection. When the accelerated polyurethane is injected it comes into contact with groundwater, which is the catalyst for the grout to begin setting. SPETEC H100 then foams and expands, between 5 and 12 times its volume, filling voids and pushing itself further into the formation. For example, 50 L of grout has the potential to fill up to 600 L of voids.

SPETEC H100 is a versatile grout as it has no particles, a medium viscosity, expanding volume and has an adjustable gel time. This suits injection in a full range of rock fractures with or without flowing water.

5.5 Discussion

The works carried out contributed to the reduction of rock mass permeability, were completed safely and in an environmentally safe way.

The works carried out improved pool retention. The works progressed towards the key criteria of increasing pool holding capacity. The works also showed extensive fracture in-filling in the pool, inferring a reduction in rock mass permeability. This can also be noted by the improvement in pool holding capacity by greater than 200 times.

The grid was an effective remediation strategy. Two improvements proposed are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing outwards. Drilling would cease when consecutive rows will not take grout.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity.

The pool does not currently have connective flow. Future works propose the construction of a deep curtain wall upstream of the pool, which has potential to return surface flow. It is anticipated that constant flow into the pool will greatly increase pool holding capacity.

The drilling method was efficient, safe and effective for the difficult access location of the works. The injection material proved to be practical to use while being low risk to inject. The works were completed safely with no lost time incidents.

Spetec H100 polyurethane was injected efficiently. The large fracture apertures suited its viscosity, expansion, and available set times. The viscosity and fast set time was also well suited to the length of fractures, with many fractures daylighting only a meter from the injection point. The risk to the environment was low with the use of grout approved for potable water use. The grouts set time allowed for good control of the grout spread. This removed the risk of contaminating groundwater or pools downstream.

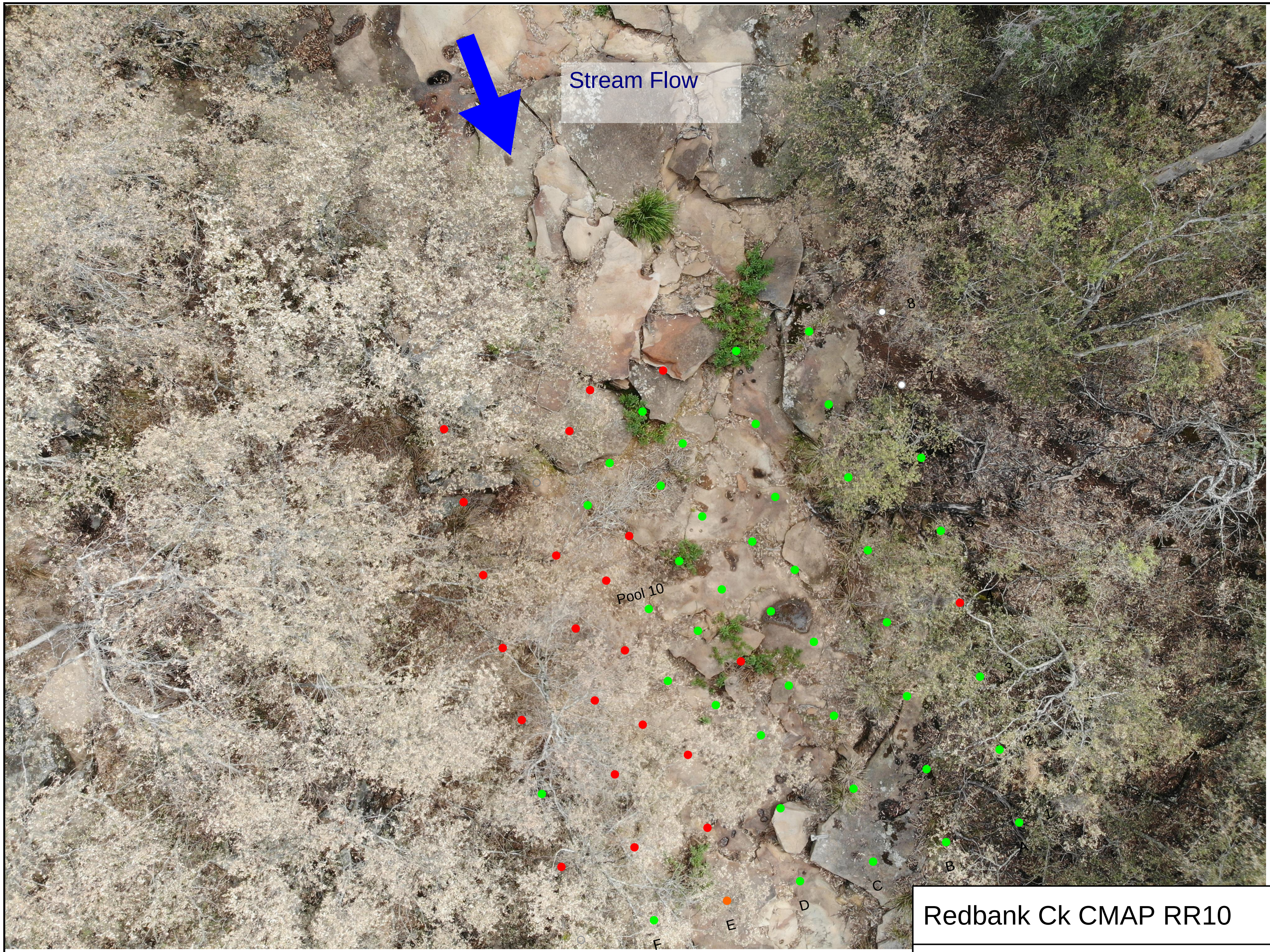
Pointe thanks you for entrusting us to carry works and look forward to working with you in the future.

Yours faithfully,

POINTE ENGINEERING PTY LTD

Glynn Price

Senior Geotechnical Engineer, BE Civil, CPEng



G

Legend

- >20L
- 5 - 20L
- <5L
- Not drilled

Redbank Ck CMAP RR10

GENERAL ARRANGEMENT

Plan 1 - Rev 0

G.Price

POINTE

ATTACHMENT A

REDBANK CREEK RR7 TO RR11 CMAP

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7 to RR11, Redbank Creek, Tahmoor, NSW.

The works on these pools was completed together as a group of adjacent pools in the first half of the year 2020. Separate completion reports were published for individual pools and therefore this Attachment is provided in each of these reports to show how these works relate and enable a discussion on the collective works.

1 DOCUMENTATION

Individual reports on each of the five pools is provided in:

- RR7 Pointe Report P2001-REP-1
- RR8 Pointe Report P2001-REP-2
- RR9 Pointe Report P2001-REP-3
- RR10 Pointe Report P2001-REP-4
- RR11 Pointe Report P2001-REP-5

2 LOCATION

The five sites are located in Redbank Creek in Tahmoor, NSW. The five sites are adjacent to one another along the creek with the most upstream pool being RR7 and most downstream RR11. A plan of the site is shown in Plan 2.

3 SCOPE

A summary of the scope of each of the sites is as follows:

- RR7 - Grout Curtain, 2 m deep, 8 m wide
- RR8 - Grout Curtain, 2 m deep, 16 m wide
- RR9 - Grout Grid Pattern, 1 m deep, 12 m x 12 m
- RR10 - Grout Grid Pattern, 1 m deep, 12 m x 14 m
- RR11 - Grout Curtain, 2 m deep, 16 m wide

Generally two systems of grouting were undertaken, shallow curtain and grid pattern. A decision on what system was based on the fracture characteristics observed. A curtain for multiple open fractures in the rock bar and a grid for multiple open fractures in the pool.

4 RESULTS

A summary of the results is provided in Table 1. These should be read in conjunction with the above report.

Table 1: Results Summary

Site	Initial PRT (hrs)	Final PRT (hrs)	Delta (hrs)	Factor
RR7	0.0	2.5	2.5	>250
RR8	0.0	1.25	1.25	>125
RR9	0.25	1.5	1.25	>5
RR10	0.25	49	48.75	>196
RR11	31.5	68	36.5	>2

5 MATERIAL

The same injection material was used across all sites. Details and discussion are provided in the individual reports.

6 DISCUSSION

All the works carried out contributed to the reduction of rock mass permeability. However, Pointe has identified a number of improvements that can be made for future works.

For the works Pointe assigned a system (curtain or grid pattern) based on the location of the highest density of connective fractures. From observing the works this should not be a choice but rather a combination of the two for all sites seeking to increase pool retention. The grid pattern proved to be more effective at retaining water. The curtain however demonstrated that at certain sites higher intensity grouting at the rock bar is needed, due to higher intensity of fracturing.

The grid pattern achieved good results however two improvements are proposed to further these results. These are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing in rows outwards. Drilling would cease when consecutive rows will not take grout. Works could then be focused on the areas that have the greatest intensity of voids.

Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity. This combined with the outward progression has the potential for greater intensity without extra work, increasing pool retention time.

It is therefore recommended that for future shallow works that we:

1. Plan for grid pattern, grouting across the base and rock bar of the pool (to 1 m deep)
2. Allow for higher intensity grouting across the rock bar (as part of this grid, to 1 m deep)
3. Begin works at a row in the creek centreline
4. Progress works outwards assessing grout takes to establish a boundary
5. Once a boundary is determined, return to the creek centre to intensify grouting

Appendix A.5 – RR11 (Pointe Engineering Pty Ltd)

COMPLETION REPORT

REDBANK CREEK CMAP RR11

June 29th, 2020
Document: PE-REP-2001-5
POINTE ENGINEERING PTY LTD

DOCUMENT CONTROL FORM

Project Name: Redbank Creek CMAP RR11

Project Number: PE-P2001

Document Number: PE-REP-2001-5

REVISION HISTORY

REVISION	DATE	SUBMITTED BY	DISTRIBUTED TO
A (DRAFT)	26 June 2020	G.Price	A.Stuart
0	29 June 2020	G.Price	A.Stuart

1 INTRODUCTION

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR11, Redbank Creek, Tahmoor, NSW.

Redbank Creek is a tributary of the Nepean River. Redbank Creek is overlying TCCO Longwalls 25 to 32. These longwalls are understood to have caused surface subsidence along the creek. TCCO has developed a Corrective Management Action Plan (CMAP) to remediate mine subsidence impacts. The subsidence impacts to Redbank Creek include cracking of the channel bedrock and rock bars resulting in a reduction in surface flow.

Pointe was contracted for their expertise and past experiences grouting foundations, tunnels and specifically for subsidence remediation grouting.

The works were carried out between the 25th of February to the 1st of April 2020 and this report details the following:

- Pre works (investigation),
- Works,
- Post works (success verification),
- Materials used,
- Success and recommendations for improvement in future pool remediation.

The works on this pool was completed together as a group of adjacent pools RR7 to RR11. This report only refers to the works completed in RR11 however a discussion on the collective works is given in Attachment A.

2 OBJECTIVE

The objective of the works was to increase the pool holding capacity. This is defined by the period of time that the pool retains water after rainfall runoff has entered it.

3 SCOPE

The scope included construction of an in-situ low permeability curtain across the creek. This method was used to target the open, shallow dipping, bedding planes at the pool's controlling rock bar.

The work included:

- A site investigation,
- Drilling a 2 m deep, 16 m wide curtain,
- Polyurethane injection of the curtain.

4 POOL DESCRIPTION

RR11 is a small (approximately 20 000L) pool. It contains a sandstone base and alluvium deposit on both banks. The pool has a controlling rock bar that sits approximately 0.3 m above the pool base. The pool and surrounding rock mass contain many open bedding planes, at medium

spacing, dipping east at between 5° and 15°. There was limited evidence of open fractures in the pool base.

5 ACTIVITIES COMPLETED

5.1 Pre-Works

Investigation of the existing bedrock conditions were carried out ahead of the works. The investigation was undertaken between the October 2019 and January 2020 and included:

- A monitoring borehole; and
- A pool recession test.

5.1.1 Monitoring Borehole

TCCO undertook an investigation with assistance from Highland Drilling and Strata Control Technology (SCT). Two boreholes were drilled, logged, hydraulically tested and calliper tested in December 2019. The boreholes were labelled P19a and P19b and can be found in SCT report TAH5004b. The borehole was 170 m from the pool above the crest of the embankment. Results showed a high permeability (between 3.8×10^{-8} to $<1.9 \times 10^{-5}$ m/s) throughout the length of the borehole. Groundwater was measured at approximately 8 m below the creek surface.

5.1.2 Pool Recession Test

A baseline Pool Recession Test (PRT) was planned for late February 2020 however due to heavy rain the pool continued to be fed by streamflow.

As the PRT method was not feasible, Pointe installed cameras to monitor recession rates after the rain event. The recession was measured using time lapse photography. The time was measured from the point the pool stopped flowing over the rock bar, to the point the pool had no standing water remaining. A single event was captured prior to grouting. The results are presented in Images 1 and 2. After heavy rainfall in February, including 260 mm on the 10th, 15 mm on the 13th and 15 mm again on the 17th, the creek continued to flow until the pool then receded approximately 300 mm in 31.5 hrs (the time lapse camera was set to 1/2 hr intervals).

Image 1: Water stops flowing over rock bar

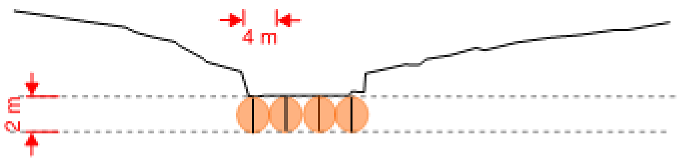
Image 2: Water has drained from pool

5.2 Works

The works were focused on improving the upper portion of the pool's controlling rock bar. Results from mapping showed that the rock bar contained many open fractures and few open fractures on the pool base.

A 16 m wide curtain was constructed across the rock bar perpendicular to the flow. 30 boreholes, 38 mm in diameter, were drilled with a pneumatic hammer to 2 m below ground level. The holes were drilled with primary boreholes spaced at 4 m. The following boreholes split spaced between primaries and were drilled and injected such that a final spacing of boreholes was 0.5 m. Each hole was grouted in a single stage as shown in Figure 1.

Figure 1: Cross Section of Primary Boreholes



The boreholes were injected with a hydrophobic polyurethane (Spetec H100). A total of 429 L of Spetec H100 was injected during the works. With a laboratory expansion volume of between 5 and 12 times, Pointe has filled between 2100 and 5100 L of voids. Details of each bore shown in Table 1 and an as built drawing is shown in Plan 1.

Results show large grout takes in the primary and secondary holes with noticeable decrease in grout take on the tertiaries. The grout takes on the final quaternary boreholes are less than 1 litre per meter. This indicates substantial fracture in-filling at rock bar occurred inferring a reduction in rock mass permeability.

Table 1: Holes Drilled and Grouted

ID	Depth (mbgl)	Borehole Dia. (m)	No. Grouted Sections	Avg Volume Grouted per meter (L)
BH-PRI-1	2.0	0.038	1	2.5
BH-PRI-2	2.0	0.038	1	2.5
BH-PRI-3	2.0	0.038	1	40.0
BH-PRI-4	2.0	0.038	1	10.0
BH-SEC-1	2.0	0.038	1	12.5
BH-SEC-2	2.0	0.038	1	16.0
BH-SEC-3	2.0	0.038	1	17.5
BH-SEC-4	2.0	0.038	1	5.0
BH-TER-1	2.0	0.038	1	40.0
BH-TER-2	2.0	0.038	1	0
BH-TER-3	2.0	0.038	1	8.8
BH-TER-4	2.0	0.038	1	2.0
BH-TER-5	2.0	0.038	1	5.5
BH-TER-6	2.0	0.038	1	40.0
BH-TER-7	2.0	0.038	1	2.5
BH-QUT-1	2.0	0.038	1	0.3
BH-QUT-2	2.0	0.038	1	0.3
BH-QUT-3	2.0	0.038	1	0.3
BH-QUT-4	2.0	0.038	1	0.5
BH-QUT-5	2.0	0.038	1	0.5
BH-QUT-6	2.0	0.038	1	1.0
BH-QUT-7	2.0	0.038	1	0.5
BH-QUT-8	2.0	0.038	1	0.5
BH-QUT-9	2.0	0.038	1	0.5
BH-QUT-10	2.0	0.038	1	1.0
BH-QUT-11	2.0	0.038	1	1.0
BH-QUT-12	2.0	0.038	1	1.3
BH-QUT-13	2.0	0.038	1	1.0
BH-QUT-14	2.0	0.038	1	1.0

5.3 Post-Works

After completion the success of the remediation works was assessed. Criteria for success was based on a comparison between pool recession test results.

5.3.1 Pool Recession Test

Monitoring of pool recession, following a storm event, was undertaken and compared to similar data from pre works. The time was measured from the point the pool stopped flowing over the rock bar, to the point the pool had no standing water remaining. A single event was able to be captured post grouting.

After a 28 mm rainfall event over 9 hrs the pool receded 300 mm in 68 hrs (time lapse cameras set to 1/2 hr intervals).

This was compared to the pre works monitoring that observed a much larger event. The monitoring showed an increase in holding time of 37 hrs or by a factor of greater than 2 (post-Works holding time/pre-Works holding time) as shown in Images 3 and 4.

Image 3: Water stops flowing over rock bar

Visual observation during the works noted that water that had been previously surfacing just downstream of the rock bar no longer occurred.

Image 4: Water has drained from pool

5.4 Material

SPETEC H100 grout was used for injection. The product was chosen by the client to complete the work based on success with the product during trials at Myrtle Creek. SPETEC H100 is a single part hydrophobic polyurethane grout suitable for potable water use. It comes in a liquid form and an accelerator (SPETEC H100 ACC) is added prior to injection. When the accelerated polyurethane is injected it comes into contact with groundwater, which is the catalyst for the grout to begin setting. SPETEC H100 then foams and expands, between 5 and 12 times its volume, filling voids and pushing itself further into the formation. For example, 50 L of grout has the potential to fill up to 600 L of voids.

SPETEC H100 is a versatile grout as it has no particles, a medium viscosity, expanding volume and has an adjustable gel time. This suits injection in a full range of rock fractures with or without flowing water.

5.5 Discussion

The works carried out contributed to the reduction of rock mass permeability, were completed safely and in an environmentally safe way.

As shown by the grout takes, the works have in-filled fractures at the rock bar, inferring a reduction in rock mass permeability. This can also be noted by the improvement from 32 hours to 68 hours.

The shallow curtain demonstrated an improvement in pool holding capacity however not enough to reach pre-mining levels. An improvement might however be the addition of a grid pattern drilled and grouted in the upstream pool. The curtain was chosen as the strategy based on geotechnical mapping showing large fractures in the rock bar and few in the pool base. The post works recession monitoring suggested that water travelling through the rock bar was greatly reduced however water may be permeating through the pool base. The effectiveness of the grid was shown when a downstream pool was drilled and injected in a grid and achieved excellent results. Based on this Pointe believes that, for the purpose of pool retention, combining shallow curtains and grids would be an effective strategy moving forward.

The pool does not currently have connective flow. Future works propose the construction of a deep curtain wall upstream of the pool, which has potential to return surface flow. It is anticipated that constant flow into the pool will greatly increase pool holding capacity.

The drilling method was efficient, safe and effective for the difficult access location of the works. The injection material proved to be practical to use while being low risk to inject. The works were completed safely with no lost time incidents.

Spetec H100 polyurethane was injected efficiently. The large fracture apertures suited its viscosity, expansion, and available set times. The viscosity and fast set time was also well suited to the length of fractures, with many fractures daylighting only a meter from the injection point. The risk to the environment was low with the use of grout approved for potable water use. The grouts set time allowed for good control of the grout spread. This removed the risk of contaminating groundwater or pools downstream.

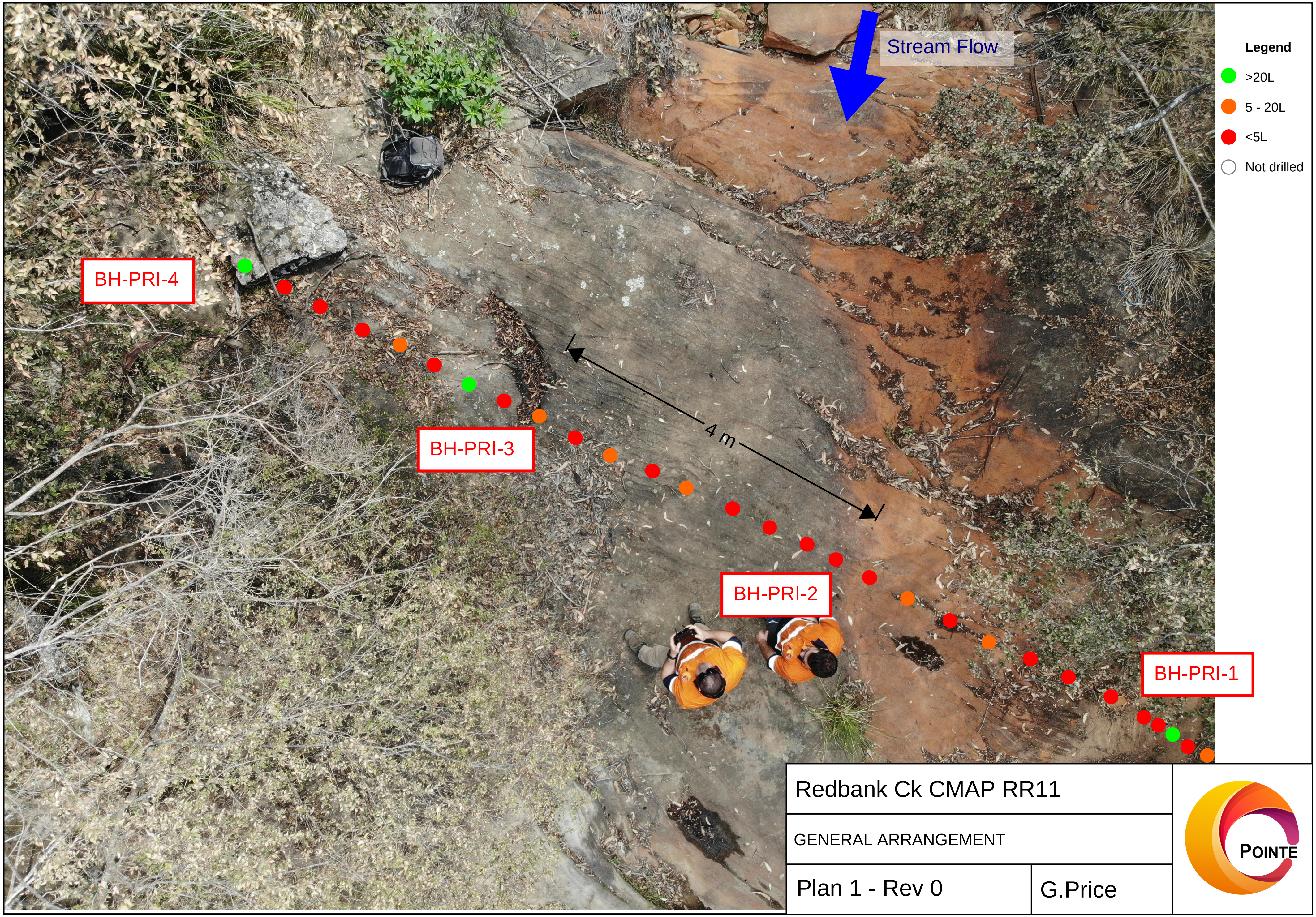
Pointe thanks you for entrusting us to carry works and look forward to working with you in the future.

Yours faithfully,

POINTE ENGINEERING PTY LTD

Glynn Price

Senior Geotechnical Engineer, BE Civil, CPEng



Redbank Ck CMAP RR11

GENERAL ARRANGEMENT

Plan 1 - Rev 0	G.Price

POINTE

ATTACHMENT A

REDBANK CREEK RR7 TO RR11 CMAP

Pointe Engineering Pty Ltd [Pointe] was engaged by Tahmoor Coking Coal Operations (TCCO) to undertake remediation grouting of RR7 to RR11, Redbank Creek, Tahmoor, NSW.

The works on these pools was completed together as a group of adjacent pools in the first half of the year 2020. Separate completion reports were published for individual pools and therefore this Attachment is provided in each of these reports to show how these works relate and enable a discussion on the collective works.

1 DOCUMENTATION

Individual reports on each of the five pools is provided in:

- RR7 Pointe Report P2001-REP-1
- RR8 Pointe Report P2001-REP-2
- RR9 Pointe Report P2001-REP-3
- RR10 Pointe Report P2001-REP-4
- RR11 Pointe Report P2001-REP-5

2 LOCATION

The five sites are located in Redbank Creek in Tahmoor, NSW. The five sites are adjacent to one another along the creek with the most upstream pool being RR7 and most downstream RR11. A plan of the site is shown in Plan 2.

3 SCOPE

A summary of the scope of each of the sites is as follows:

- RR7 - Grout Curtain, 2 m deep, 8 m wide
- RR8 - Grout Curtain, 2 m deep, 16 m wide
- RR9 - Grout Grid Pattern, 1 m deep, 12 m x 12 m
- RR10 - Grout Grid Pattern, 1 m deep, 12 m x 14 m
- RR11 - Grout Curtain, 2 m deep, 16 m wide

Generally two systems of grouting were undertaken, shallow curtain and grid pattern. A decision on what system was based on the fracture characteristics observed. A curtain for multiple open fractures in the rock bar and a grid for multiple open fractures in the pool.

4 RESULTS

A summary of the results is provided in Table 1. These should be read in conjunction with the above report.

Table 1: Results Summary

Site	Initial PRT (hrs)	Final PRT (hrs)	Delta (hrs)	Factor
RR7	0.0	2.5	2.5	>250
RR8	0.0	1.25	1.25	>125
RR9	0.25	1.5	1.25	>5
RR10	0.25	49	48.75	>196
RR11	31.5	68	36.5	>2

5 MATERIAL

The same injection material was used across all sites. Details and discussion are provided in the individual reports.

6 DISCUSSION

All the works carried out contributed to the reduction of rock mass permeability. However, Pointe has identified a number of improvements that can be made for future works.

For the works Pointe assigned a system (curtain or grid pattern) based on the location of the highest density of connective fractures. From observing the works this should not be a choice but rather a combination of the two for all sites seeking to increase pool retention. The grid pattern proved to be more effective at retaining water. The curtain however demonstrated that at certain sites higher intensity grouting at the rock bar is needed, due to higher intensity of fracturing.

The grid pattern achieved good results however two improvements are proposed to further these results. These are to stage the works from the creek centreline outwards and to increase the grouting intensity. Within all 5 pools, completed in the first half of 2020, a clear correlation was realised between grout take and distance from the creek centre. We propose beginning works at the creek centre and progressing in rows outwards. Drilling would cease when consecutive rows will not take grout. Works could then be focused on the areas that have the greatest intensity of voids.

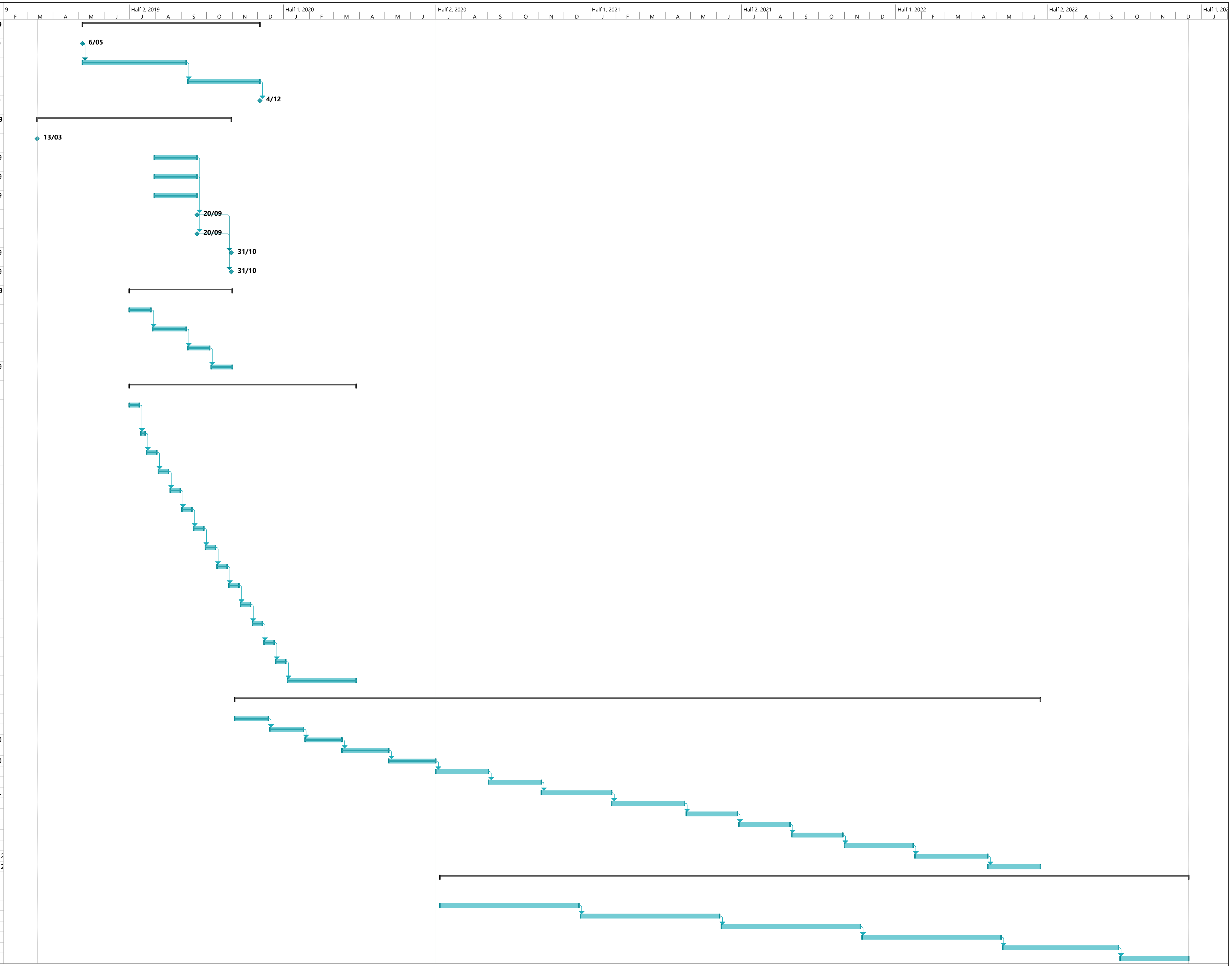
Increasing grouting intensity is also expected to have an improvement. In general holes were spaced at 2 m during the works. Planning works to reduce this to 1 m or closer, depending on fracture characteristics, will improve pool holding capacity. This combined with the outward progression has the potential for greater intensity without extra work, increasing pool retention time.

It is therefore recommended that for future shallow works that we:

1. Plan for grid pattern, grouting across the base and rock bar of the pool (to 1 m deep)
2. Allow for higher intensity grouting across the rock bar (as part of this grid, to 1 m deep)
3. Begin works at a row in the creek centreline
4. Progress works outwards assessing grout takes to establish a boundary
5. Once a boundary is determined, return to the creek centre to intensify grouting

Appendix B – Redbank Creek CMAP Schedule

ID	Task Name	Duration	Start	Finish
1	**Redbank Creek CMAP**	**152 days**	**Mon 6/05/19**	**Wed 4/12/19**
2	Submit Redbank Creek CMAP	0 days	Mon 6/05/19	Mon 6/05/19
3	Approval of Redbank Creek CMAP	90 days	Mon 6/05/19	Fri 6/09/19
4	Update MOP	62 days	Mon 9/09/19	Tue 3/12/19
5	Update MOP submitted	0 days	Wed 4/12/19	Wed 4/12/19
6	**Redbank Creek Approvals**	**166 days**	**Wed 13/03/19**	**Thu 31/10/19**
7	Redbank Creek CMAP Risk Assessment	0 days	Wed 13/03/19	Wed 13/03/19
8	Preparation of Erosion and Sediment Control Plan	37 days	Wed 31/07/19	Thu 19/09/19
9	Preparation of Part 7 Fisheries Permit	37 days	Wed 31/07/19	Thu 19/09/19
10	Preparation of Redbank Creek CMAP Safety Plan	37 days	Wed 31/07/19	Thu 19/09/19
11	Submit Erosion and Sediment Control Plan	0 days	Fri 20/09/19	Fri 20/09/19
12	Submit Part 7 Fisheries Permit	0 days	Fri 20/09/19	Fri 20/09/19
13	Approval of Erosion and Sediment Control Plan	0 days	Thu 31/10/19	Thu 31/10/19
14	Fisheries Permit Issued	0 days	Thu 31/10/19	Thu 31/10/19
15	**Redbank Creek Pool Mapping**	**89 days**	**Mon 1/07/19**	**Thu 31/10/19**
16	Creek Mapping Scoping & Preparation	20 days	Mon 1/07/19	Fri 26/07/19
17	Pool Mapping Photogrammetry	30 days	Mon 29/07/19	Fri 6/09/19
18	Data Analysis	20 days	Mon 9/09/19	Fri 4/10/19
19	Reporting	19 days	Mon 7/10/19	Thu 31/10/19
20	**Redbank Creek Characterisation**	**195 days**	**Mon 1/07/19**	**Fri 27/03/20**
21	Creek Characterisation Scoping & Preparation	10 days	Mon 1/07/19	Fri 12/07/19
22	Site Mobilisation	5 days	Mon 15/07/19	Fri 19/07/19
23	Charatersation - Site 1 Drilling & Testing	10 days	Mon 22/07/19	Fri 2/08/19
24	Charatersation - Site 2 Drilling & Testing	10 days	Mon 5/08/19	Fri 16/08/19
25	Charatersation - Site 3 Drilling & Testing	10 days	Mon 19/08/19	Fri 30/08/19
26	Charatersation - Site 4 Drilling & Testing	10 days	Mon 2/09/19	Fri 13/09/19
27	Charatersation - Site 5 Drilling & Testing	10 days	Mon 16/09/19	Fri 27/09/19
28	Charatersation - Site 6 Drilling & Testing	10 days	Mon 30/09/19	Fri 11/10/19
29	Charatersation - Site 7 Drilling & Testing	10 days	Mon 14/10/19	Fri 25/10/19
30	Charatersation - Site 8 Drilling & Testing	10 days	Mon 28/10/19	Fri 8/11/19
31	Charatersation - Site 9 Drilling & Testing	10 days	Mon 11/11/19	Fri 22/11/19
32	Charatersation - Site 10 Drilling & Testing	10 days	Mon 25/11/19	Fri 6/12/19
33	Charatersation - Site 11 Drilling & Testing	10 days	Mon 9/12/19	Fri 20/12/19
34	Charatersation - Site 12 Drilling & Testing	10 days	Mon 23/12/19	Fri 3/01/20
35	Characterisation Report	60 days	Mon 6/01/20	Fri 27/03/20
36	**Redbank Creek Pool Remediation Sites**	**688 days**	**Mon 4/11/19**	**Wed 22/06/22**
37	Pool No.1	30 days	Mon 4/11/19	Fri 13/12/19
38	Pool No.2	30 days	Mon 16/12/19	Fri 24/01/20
39	Pool No.3	32 days	Mon 27/01/20	Tue 10/03/20
40	Pool No.4	40 days	Wed 11/03/20	Tue 5/05/20
41	Pool No.5	40 days	Wed 6/05/20	Tue 30/06/20
42	Pool No.6	45 days	Wed 1/07/20	Tue 1/09/20
43	Pool No.7	45 days	Wed 2/09/20	Tue 3/11/20
44	Pool No.8	60 days	Wed 4/11/20	Tue 26/01/21
45	Pool No.9	63 days	Wed 27/01/21	Fri 23/04/21
46	Pool No.10	45 days	Mon 26/04/21	Fri 25/06/21
47	Pool No.11	45 days	Mon 28/06/21	Fri 27/08/21
48	Pool No.12	45 days	Mon 30/08/21	Fri 29/10/21
49	Pool No.13	60 days	Mon 1/11/21	Fri 21/01/22
50	Pool No.14	63 days	Mon 24/01/22	Wed 20/04/22
51	Pool No.15	45 days	Thu 21/04/22	Wed 22/06/22
52	**Redbank Creek Rock Bar Grout Curtain**	**640 days**	**Mon 6/07/20**	**Fri 16/12/22**
53	Rock Bar 1	120 days	Mon 6/07/20	Fri 18/12/20
54	Rock Bar 2	120 days	Mon 21/12/20	Fri 4/06/21
55	Rock Bar 3	120 days	Mon 7/06/21	Fri 19/11/21
56	Rock Bar 4	120 days	Mon 22/11/21	Fri 6/05/22
57	Rock Bar 5	100 days	Mon 9/05/22	Fri 23/09/22
58	Rock Bar 6	60 days	Mon 26/09/22	Fri 16/12/22



Project: Redbank Creek Schedu
Date: Tue 30/06/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress