SOUTH32 Illawarra Metallurgical Coal




GEORGES RIVER REHABILITATION PLAN

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DOCUMENT REVISION LOG

Persons authorising this plan

NAME	TITLE	DATE
Gary Brassington	Manager Approvals	7/08/2023

Document Revisions

REVISION	DESCRIPTION OF CHANGES	DATE
A (formerly rev 1)	Update following completion of Longwall 38	9/06/2016
B (formerly rev 2)	Update following feedback from OEH & DRE	14/09/2016
C (formerly rev 3)	Update following feedback from DPIE & OEH (dated 2/11/2017)	17/01/2018
D (formerly rev 4)	Update following feedback from DPIE & OEH and including WSP Water Balance Model	3/10/2019
E (formerly rev 5)	Update following feedback from EES and EPA	24/3/2020
1.0	Issue document number (APNMP0134) and revision number, incorporation of REF recommendations, legislation changes relating to Mining Leases and Rehabilitation, and format update	7/08/2023

Persons involved in the review of this Plan

NAME	TITLE	COMPANY	EXP (YRS)	DATE
Nicola Curtis	Approvals Principal	IMC	9	7/08/2023
Gary Brassington	Approvals Manager	IMC	30	7/08/2023
Chris Schultz	Superintendent Environment	IMC	27	7/08/2023

1. INTRODUCTION

1.1 Background

Mining of West Cliff Longwalls 31 to 38 was undertaken in accordance with the approved West Cliff Area 5 Subsidence Management Plans (SMP), Extraction Plan (EP) and Georges River Management Plan (GRMP). Impacts associated with Longwalls 32 to 38 have been identified in the Georges River, some requiring rehabilitation as outlined in the SMP, EP and GRMP.

Reporting of impacts has been carried out as required under the SMPs, EP and GRMP. Inspections have identified gas releases, iron staining and rock fracturing to pools and rockbars along the Georges River, adjacent to West Cliff Area 5. A decline in water level below baseline in some pools has also been recorded. Some impacts require Corrective Management Actions (CMAs). Impacts associated with Longwalls 32 to 36 have previously been addressed in the West Cliff Colliery Longwall 33 Georges River Impacts Rehabilitation Options, October 2010 and the Georges River Remediation Plan, 2014. This Plan updates the proposed rehabilitation of the Georges River, following the completion of extraction of West Cliff Area 5.

A review of water monitoring data from the Georges River and an assessment of options available for rehabilitation of the river in the area of Marhnyes Hole was undertaken by GHD-Longmac (December, 2002).

The broad conclusions reached from a review of the monitoring of groundwater levels were that:

- Prior to mining, the Georges River consisted of a leaky, perched, unconfined aquifer with a groundwater table below river level. The “leaky” perched aquifer situation involved harbouring the river water within a natural aquiclude. The aquiclude did not fully contain the river water, as leakage occurred down to a deeper confined aquifer within the rockmass.
- Subsequently, the rockmass was affected by underground mining. In regard to the river system, the important feature is loosening and shearing that occurs in the uppermost 20 m to 25 m of the rockmass.
- The hydrogeological situation produced by the loosening of the rockmass increases the permeability (transmissivity) of the aquiclude, and thereby increasing the rate of leakage to the lower aquifer. As a result, pool water levels reduce when the flow in the river is less than the rate of leakage. The loosening of the rockmass due to the mining subsidence moves the quazi-static equilibrium of the system from that where the leakage from the river does not exceed flow to a situation where leakage does exceed flow.

The challenge is to re-instate the river condition, defined as a leaky perched unconfined aquifer. In general terms, this means re-instating the permeability of the aquiclude to its previous lower level, at least sufficiently to reinstate water flow in the river for the pools to be re-established. Within the understanding of the hydrogeological model, this does not involve elevation of the entire groundwater table. Such would be a variation from the conditions prior to mining.

The options available to reduce the permeability of the loosened rockmass broadly relate to grouting of one form or another, and various methods of application.

It is believed that the perched river water results from a natural process of binding the base of the river with fines and detritus. The natural permeability of the rockmass results from the permeability of the rock fabric and the permeability of joints and natural defects throughout the rockmass. Incomplete isolation of the river water occurs as a result of mining, resulting in a leaky, perched, unconfined aquifer.

Rehabilitation activities are therefore directed towards a reduction of the permeability defects within the rockmass. These include:

- Natural joints and bedding plane partings in their previous condition;
- Similar natural defects that have been opened as a result of mining subsidence; and
- New mining induced fracturing (shear cracking and dilatancy of existing defects).

The aim of the grouting is to introduce an additive into the rockmass that reduces the transmissibility of both large and fine defects in the rockmass.

1.2 Scope

The approved SMPs for West Cliff Longwalls 31 to 36 and EP for Longwalls 37 and 38 require rehabilitation for major cracking and/or water loss and in the event that pools become dry due to mining subsidence impacts. In addition, the Plans state that should minor cracking or water diversion not lead to pools draining, further studies may be warranted.

1.3 Land Ownership

The majority of land to the east of the impacted sections of the Georges River is Government owned land with a land claim by the Tharawal Local Aboriginal Land Council (subject to agreement). The majority of the land to the west of the Georges River is owned by the Department of Planning and Environment (DPE), National Parks and Wildlife Service (NPWS) as well as private landholders. Not all land ownership is displayed in Figure 1-1.

Figure 1-1 Stream features and land ownership associated with the Georges River adjacent to West Cliff Area 5, Longwalls 32 to 38.

1.4 Statutory Requirements

On 22 December 2011 the Planning and Assessment Commission (PAC), under delegation of the Minister for Planning, approved Illawarra Metallurgical Coal's (IMC) application (MP 08_0150) under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) to continue mining operations associated with the Bulli Seam until the year 2041. The Bulli Seam Operations Project (BSOP) includes activities associated with West Cliff Mine (now incorporated in the Appin Mine complex). A number of Conditions within the Project Approval are relevant to this Georges River Rehabilitation Plan, including:

- *Condition 5, Schedule 3* requires preparation of an EP to manage the potential subsidence effects, impacts and/or environmental consequences associated with the extraction of coal from the approved areas. Previously approved SMPs were deemed to be approved EPs.

  Condition 1, Schedule 3 contains the performance measures for natural and heritage features. This condition states the Proponent shall ensure that the project does not cause any exceedances of the performance measures in Table 1, to the satisfaction of the Secretary. The Condition outlines negligible environmental consequences including:

  - Negligible diversion of flows or changes in the natural drainage of pools;
  - Negligible gas releases and iron staining; and
  - Negligible increase in water cloudiness over at least 80% of the stream length subject to vertical subsidence >20 mm; and
  - No subsidence impact or environmental consequence greater than minor.

- *Condition 31, Schedule 4* outlines rehabilitation objectives. For the Georges River, the objectives are:

  - restore pre-mining surface flow and pool holding capacity as soon as reasonably practicable; and
  - hydraulically and geomorphologically stable, with riparian vegetation that is the same or better than prior to mining.

- *Condition 33, Schedule 4*[1] required the preparation of a Rehabilitation Management Plan to be to the satisfaction of the Executive Director Mineral Resources. This plan must:

  - be prepared in consultation with the Department, Office of Environment and Heritage (OEH), Department of Primary Industries (DPI) Water Division, Council and the Community Consultative Committee (CCC);

[1] Superseded in MOD 3, approved in April 2022.

- be prepared in accordance with any relevant Division of Resources and Energy (DRE) (DT&I) guideline and be consistent with the rehabilitation objectives in the BSOP Environmental Assessment and in Table 11 of the Consent; and
- build, to the maximum extent practicable, on the other management plans required under this approval.

This GRRP provides further detail on the programs referred to in the existing approved plans and addresses the requirements of these Conditions.

Sections 75U (1) and (2) of the EP&A Act outline the authorisations that are not required for a Project approved under Part 3A that would otherwise ordinarily be required. These include:

- Approval under Sections 201, 205 and 219 of the *Fisheries Management Act, 1994*. These sections relate to dredging or reclamation work in rivers, harming of marine vegetation and blocking of fish passage.
- Approval under Part 3A of *the Rivers and Foreshores Improvement Act, 1948*. This is related to excavation in protected lands, and activities that alter the flow of protected waters. Note that the RFIA was repealed in 2008 and the appropriate approval currently required is a controlled activity approval (CAA) under the Water Management Act 2000. A CAA confers a right on its holder to carry out a specified controlled activity at a specified location in, on or under waterfront land.

Licensing from the Environment Protection Authority is not required; however, any rehabilitation works would be undertaken in accordance with Section 120 of the *Protection of the Environment Operations Act*, which refers to not polluting waters.

1.5 Rehabilitation Management Plan

The GRRP was approved by the Resources Regulator following consultation with the relevant agencies noted above on 24 April 2020 as part of the Mining Operations Plan. DPE approved the remedial actions as described in the Georges River Remediation Plan on 25 June 2020.

The instruments of variation to mining leases issued in 2022 removed all conditions relating to closure and rehabilitation. Conditions relating to progressive rehabilitation were included in Schedule 8A of the *Mining Regulation 2016.* The Regulation includes standard mining lease conditions which require the preparation and implementation of a Rehabilitation Management Plan (RMP) for the life of the mine.

The rehabilitation requirements for Appin Mine are outlined in Conditions 31 to 33 of Schedule 4 of the Project Approval, which includes the preparation of a RMP (Condition 33). This Plan now forms part of the RMP. As noted in Section 6 of the RMP, the rehabilitation will be undertaken in accordance with this Plan. IMC will continue to work with the Resources Regulator to progress this project in accordance with the stages as outlined in this Plan.

1.6 Aims of the Rehabilitation Project

The approved SMP requires rehabilitation of the river bed and rockbars to restore flows to the surface of the river and ensure pool levels respond in a similar way to pre-mining levels during periods of low and no flow. The rehabilitation is aimed at improving the water flows in the river to enable the natural system to support the ecology of the area following mining.

Objectives of rehabilitation are outlined in the Project Approval Schedule 4, Condition 31. This condition states the Proponent shall rehabilitate the site in accordance with the conditions imposed on the mining lease(s) associated with the project under the *Mining Act*. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the EA and Preferred Project Report (PPR) and comply with the objectives in Table 10 of the Project Approval. The relevant objective for these works is to restore pre-mining surface flow and pool holding capacity as soon as reasonably practicable, hydraulically and geomorphologically stable, with riparian vegetation that is the same or better than prior to mining.

In addition, the rehabilitation also aims to:

- Maintain flows in the Georges River so that pools affected by subsidence impacts retain water during low flow conditions;
- Carry out rehabilitation works in a manner that protects to the greatest practicable extent the ecological values of the area;
- Repair the aesthetic values of the area where necessary;
- Reduce the interaction of surface and groundwater flow where it has been enhanced through mining;
- Restore hydraulic gradients across impacted rockbars;
- Have rivers, creeks and pools functioning in a similar manner to the pre-impact state;
- Not obstruct fish passage;
- Have surface flows and pool water quality continue to provide suitable aquatic habitat;
- Re-establish the ecological values of the area to a similar state to that existing before mining;
- Have creeks and catchments yielding similar water quantity and quality following mining;
- Monitor and report effectiveness of the program; and
- Generate environmental benefits that are permanent and ongoing, avoiding the need for ongoing work in the area, which improves the sustainability of the project.

1.7 Consultation

The following updates were made to the GRRP following consultation with OEH (now the Environment and Heritage Group (EHG)) and DPE on 22 October 2018.

1.7.1 Pool Water Retention

The term 'pool water retention' is defined as: The time taken for a pool to drain once it has reached equilibrium, following cease-to-flow conditions, in the absence of additional catchment inputs, which includes rainfall events and upstream discharges. Pool water level will be measured by a pressure transducer with logger.

1.7.2 Consideration of Stochastic Rainfall Events and Brennan's Creek Dam Discharge

The GRRP accounts for any catchment inputs into the Georges River study area. As such, assessment of rehabilitation success will account for any rainfall contributions or discharge from Brennan's Creek Dam (BCD) to the study area. Where necessary, flows will be diverted around targeted pools and rockbars to ensure flow and pool water level measurements are not confounded by additional catchment inputs.

1.7.3 Explicit Performance Measures and Success Criteria

The 'Performance Measures' and 'Success Criteria' have been updated to reflect recommendations made by EHG. These updates are detailed in Table 4 1.

1.7.4 Continuous Monitoring of Downstream Reference Site

Georges River Pool 64 and Rockbar 64 will be monitored as a downstream reference site; the site is outside the zone of influence from mining. A pressure transducer and continuous logger will be installed at the site to monitor water levels.

1.7.5 Additional Upstream Monitoring Site

A flow and water level monitoring site will be installed at Georges River Pool 28, which is located upstream of the proposed rehabilitation sites, and downstream of past rehabilitation sites.

1.7.6 Progress Reporting

A progress report will be prepared at 6 monthly intervals for the duration of the rehabilitation program, providing a summary of works completed, available monitoring results and a review of the rehabilitation and monitoring methods. The progress report will also provide a mechanism for feedback from DPE and Resources Regulator.

1.7.7 Hydrologic Analysis of Flow Recession and Pool Drawdown

A Georges River Catchment Model has been developed by WSP (Section 4.3) in response to feedback on this Plan from DPE, EHG and the Natural Resources Access Regulator (NRAR). The remediation scenarios included in the model are:

- Current scenario (no sealing);
- Partially sealed rockbar (at 20%, 50% and 80% sealed); and
- Fully sealed rockbar.

The fourth scenario recommended by NRAR 'pool level loss between 0 to 20% standing pool water level, based on constructed hydrographs modelling pre-mining pool drawdown levels' was reviewed by WSP who recommended duration curves be prepared to show the pool water level outcomes for the full range of release / sealing scenarios modelled. These have been included in the modelling report.

1.8 Rehabilitation Approach

IMCs aim is to reduce and manage subsidence impacts by implementing the following hierarchical processes wherever possible:

- Avoidance of impacts;
- Minimising impacts;
- Mitigation of impacts; and
- Rehabilitation as required.

This report outlines the options available for the rehabilitation activities. Once preferred options are identified and approved, a detailed implementation plan will be developed in consultation with key stakeholders.

1.9 Intended Schedule of Rehabilitation Works

The intended schedule of rehabilitation works for the Georges River is as follows:

1. Initial review of GRRP by DPE and EES (October 2019);
2. Implement recommendations from DPE and EES review (March 2020);
3. Receive approval of the GRRP from DPE (June 2020);
4. Receive approval from the landholders to undertake the work (Tharawal Local Aboriginal Land Council (complete 2020), National Parks and Wildlife Service (pending) DPE (complete 2022), private landholders (pending) (+3 months);
5. Tendering and procurement of the project team, equipment and any additional assessments March 2023);
6. Site-specific assessments, work schedule, Review of Environmental Factors (REF) (Surface Works Assessment Form) (July 2023);
7. Establishment of access to the rehabilitation sites (+2 weeks);
8. Rehabilitation timing per site (2 weeks – approx. 6 months' total);
9. Post rehabilitation monitoring, analysis and reporting (minimum of6 months); and
10. Peer review of final report (1 month).

Delays in rehabilitation may occur due to environmental issues such as site access, bushfire, wet weather and flooding. The timelines of post rehabilitation monitoring is dependant on sufficient rainfall/flows occurring in the river to measure success. Works are being undertaken in stages, with each stage focusing on a group of target pools. Pools 54, 56 and 57 are the initial target pools, anticipated to commence Q1 FY24. Steps 5-10 above will be repeated as each section of the Georges River is remediated.

2. IMPACTS OBSERVED ALONG THE GEORGES RIVER

2.1 Overview of Surface Impacts Associated with Longwalls 32 to 38

Fracturing, iron staining and gas releases have been observed during routine monitoring of the Georges River (Table 1). The impacts have been identified as Level 1 and 2 when assessed against the GRMP for Longwalls 34-36 and the EP for Longwalls 37 and 38. Trigger Action Response Plans (TARPs) from both the GRMP and EP are included as Appendix 2 of this document. Figure 2-1 to Figure 2-11 show the location of impacts in relation to each pool, and also depicts features targeted for rehabilitation.

Table 1 Georges River impacts associated with West Cliff Area 5 Longwalls 32 to 38.

Pool 26		
WCA5_Iron_Pool 26	Iron staining observed in Pool 26 prior to completion of LW32.	Level 1
Pool 35 and Rockbar 36		
WCA5_Gas_001	Gas zone observed in Pool 35 prior to completion of LW32.	Level 1
WCA5_Gas_002	Gas zone observed on Rockbar 36 prior to completion of LW32.	Level 1
WCA5_Gas_003	Gas zone observed on Rockbar 36 prior to completion of LW32.	Level 1
WCA5_Fracture_001	Fracturing observed on Rockbar 36 prior to completion of LW32. No flow diversion observed.	Level 1
WCA5_Fracture_002	Fracturing observed on Rockbar 36 prior to completion of LW32. No flow diversion observed.	Level 1
WCA5_Gas_004 (LW33)	Gas zone observed on Rockbar 36 prior to completion of LW33.	Level 1
WCA5_Gas_007	Gas zone observed in Pool 35 prior to completion of LW32.	Level 1
WCA5_Gas_008	Gas zone observed in Pool 35 prior to completion of LW32.	Level 1
WCA5_Fracture_001(LW33)	Fracturing observed on Rockbar 36 prior to completion of LW32. Flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_002(LW33)	Fracturing observed on Rockbar 36 prior to completion of LW32. No flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_003	Fracturing observed on Rockbar 36 prior to completion of LW33. No flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_004	Fracturing observed on Rockbar 36 prior to completion of LW33. No flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_011	Fracturing observed on Rockbar 36 following completion of LW33. Some flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_012	Fracturing observed on Rockbar 36 following completion of LW33. No flow diversion was observed through fracturing.	Level 1
WCA5_Fracture_013	Fracturing observed on Rockbar 36 following completion of LW33. No flow diversion was observed through fracturing.	Level 1

Pool 36		
WCA5_Gas_009	Gas zone observed in Pool 36 prior to completion of LW32.	Level 1
Pool 37 to Pool 38		
WCA5_Iron_001	Iron staining observed in Pool 38 prior to the completion of LW32.	Level 1
WCA5_Gas_004	Gas release observed in Pool 38 prior to completion of LW32.	Level 1
WCA5_Gas_006	Gas zone observed in minor pool upstream from Pool 38 prior to completion of LW32.	Level 1
WCA5_Gas_001(LW33)	A series of small gas releases upstream from Pool 38, identified prior to completion of LW33.	Level 1
WCA5_Gas_002(LW33)	Multiple gas releases originating from joints upstream from Pool 38. Observed prior to completion of LW33.	Level 1
WCA5_Gas_003(LW33)	A series of small gas releases observed in Pool 38 prior to completion of LW33.	Level 1
WCA5_Gas_005(LW33)	Multiple gas releases originating from joints and potholes minor pools between Pool 37 and Pool 38. Observed prior to completion of LW33.	Level 1
WCA5_Gas_006(LW33)	A series of small gas releases originating from joints of minor pools between Pool 37 and Pool 38. Observed prior to completion of LW33.	Level 1
WCA5_Fracture_005	Fracturing to the base of Pool 38 prior to completion of LW33. Proceeding flow diversions and below baseline pool water recorded at site. Maintenance of Pool 38 water level temporarily unattainable with additional BCD release.	Level 2
Rockbar 39 to Pool 40		
WCA5_Iron_002	Iron observed in small pothole on base of Pool 40, prior to completion of LW32.	Level 1
WCA5_Gas_005	Gas zone observed in Pool 40 towards end of LW32.	Level 1
WCA5_Fracture_006	Fracturing to Rockbar 39 identified prior to completion of LW33. Flow diversion observed through fracture following initial identification.	Level 1
WCA5_Fracture_007	Fracturing and uplift to Rockbar 39 identified prior to completion of LW33. Flow diversion observed through fracture following initial identification.	Level 1
WCA5_Fracture_007a	Fracturing to the base of Pool 39 observed prior to completion of LW33. Outflow of upstream flow diversion observed through fracture.	Level 1

WCA5_Fracture_008	Fracturing to rock outcrop of small tributary of Georges River (GR114).	Level 1
Impact WCA5_Fracture_009	Fracturing to downstream end of Rockbar 40, directly downstream from Pool 41. No observed flow diversion.	Level 1
Impact WCA5_Fracture_010	Fracturing observed on Rockbar 39 following completion of LW33. No observed flow diversion.	Level 1
WCA5_Gas_007(LW33)	Gas zone observed in Pool 39 following completion of LW33.	Level 1
Pool 41		
Impact WCA5LW34_Fracture Zone_002	Fracturing observed on Rockbar 41, directly downstream from Pool 41. No observed flow diversion.	Level 1
Impact WCA5LW34_Iron_003	Iron observed originating from minor pool on Rockbar 41.	Level 1
Pool 42		
Impact WCA5_LW35_016	Fracturing to side of Pool 42. No observable flow diversion.	Level 1
Impact WCA5_LW35_017	Fracturing to Rockbar 43, directly downstream from Pool 42. Flow diversion observed through fracturing.	Level 1
Impact WCA5_LW35_021	Iron staining observed originating from side of Pool 42.	Level 1
Pool 43		
Impact WCA5LW34_Fracture Zone_004	Fracturing to Rockbar 45, directly downstream from Pool 43. Existing diversion of surface flow through dilated joint during baseline period. No change following mining.	Level 1
Impact WCA5_LW35_014	Fracturing to rock shelf directly adjacent to Pool 43. No flow diversion observed.	Level 1
Pool 44		
Impact WCA5_LW35_013	Extensive fracturing and uplift to Rockbar 45. Flow diversion observed through fracturing.	Level 1
Impact WCA5_LW35_025	‘Dry Below Benchmark’ measurement recorded at various times during low flow conditions following completion of LW35. Maintenance of Pool 44 water level temporarily unattainable due restriction on BCD release (EPL 2504).	Level 2
Pool 45		
	No surface impacts identified to Pool 45.	n/a

	Installed benchmark was buried by river sediments during extended periods of monitoring, preventing measurement of water level. Dry Below Benchmark observation recorded multiple times following completion of LW34.	
Pool 47		
Impact WCA5_LW38_008	No surface impacts identified to Pool 47. No decline in water level below baseline levels. Rock fracturing and flow diversion at downstream Rockbar 49. Observed following passing of LW38.	Level 2
Pool 49		
Impact WCA5_LW38_009	Decline in water level past measurable point. This semi-quantitative observation was experienced once during the baseline period. This observation was experienced multiple times following completion of LW35. Iron staining downstream from Pool 49. Observed following passing of LW38.	Level 1
Pool 50		
	No surface impacts identified at Pool 50. No decline in pool water level below baseline levels.	n/a
Pool 51		
Impact WCA5_LW35_025	Decline in pool water level, below the lowest baseline level, experienced following the completion of LW35. No surface impacts have been identified at Pool 51.	Level 1
Pool 52		
	No surface impacts identified at Pool 52. No decline in pool water level below baseline levels.	n/a
Pool 53		
Impact WCA5_LW35_027	Decline in pool water level, below the lowest baseline level, experienced following the completion of LW35. Maintenance of Pool 53 water level temporarily unattainable due restriction on BCD release (EPL 2504). No surface impacts have been identified at Pool 53.	Level 2
Pool 54		
Impact WCA5_LW35_007	Fracturing to base of pool observed prior to completion of LW35, shortly followed by decline in pool water level below baseline levels. Active flow diversion later observed at site. Maintenance of Pool 54 water level temporarily unattainable due restriction on BCD release (EPL 2504).	Level 2
Impact WCA5_LW35_018	Fracturing to edge of pool identified following completion of LW35. No flow diversion observed.	Level 1

Pool 56		
Impact WCA5_LW35_012	Fracturing to pool base and rockbar as LW35 passed section of river Pool 56 recorded pool water level below baseline following completion of LW35 Below baseline pool water level observations recorded since during low flow conditions Maintenance of Pool 56 water level temporarily unattainable due to restriction on BCD release (EPL 2504).	Level 2
Pool 57		
Impact WCA5_LW35_019	Fracturing to base of Pool 57 observed towards end of LW35 extraction Pool 57 recorded pool water level below baseline following completion of LW35 Below baseline pool water level recorded since during low flow conditions Maintenance of Pool 57 water level temporarily unattainable due restriction on BCD release (EPL 2504).	Level 2
Pool 58		
Impact WCA5_LW35_010	Gas zone observed in pool as LW35 passed section of river. Gas has since ceased.	Level 1
Impact WCA5_LW35_011	Additional gas zone observed in pool Fracturing also observed during this inspection.	Level 1
Impact WCA5_LW35_022	Pool 58 recorded pool water level below baseline following completion of LW35 Below baseline pool water level recorded since during low flow conditions Maintenance of Pool 58 water level temporarily unattainable due restriction on BCD release (EPL 2504).	Level 2
Pool 59		
Impact WCA5_LW35_009	Gas releases initially observed in Pool 59 Releases have since ceased and are no longer evident	Level 1
Impact WCA5_LW35_020	Iron staining observed originating from Pool 58 Iron staining reappeared at various times- usually associated with low flow conditions.	Level 1
Pool 60		
Impact WCA5_LW35_008	Gas releases initially observed in Pool 60 Releases have since ceased and are no longer evident.	Level 1
Impact WCA5_LW35_023	Pool 60 recorded pool water level below baseline following completion of LW35	Level 2

	Below baseline pool water level recorded since during low flow conditions Maintenance of Pool 60 water level temporarily unattainable due restriction on BCD release (EPL 2504).	
Pool 61		
Impact WCA5_LW35_028	Pool 61 recorded pool water level below baseline following completion of LW36. Likely to be result of LW35 impacts upstream combined with low flow conditions. Maintenance of Pool 61 water level temporarily unattainable due restriction on BCD release (EPL 2504).	Level 2

Figure 2-1 Location of Subsidence impacts from Pool 35 to Rockbar 37

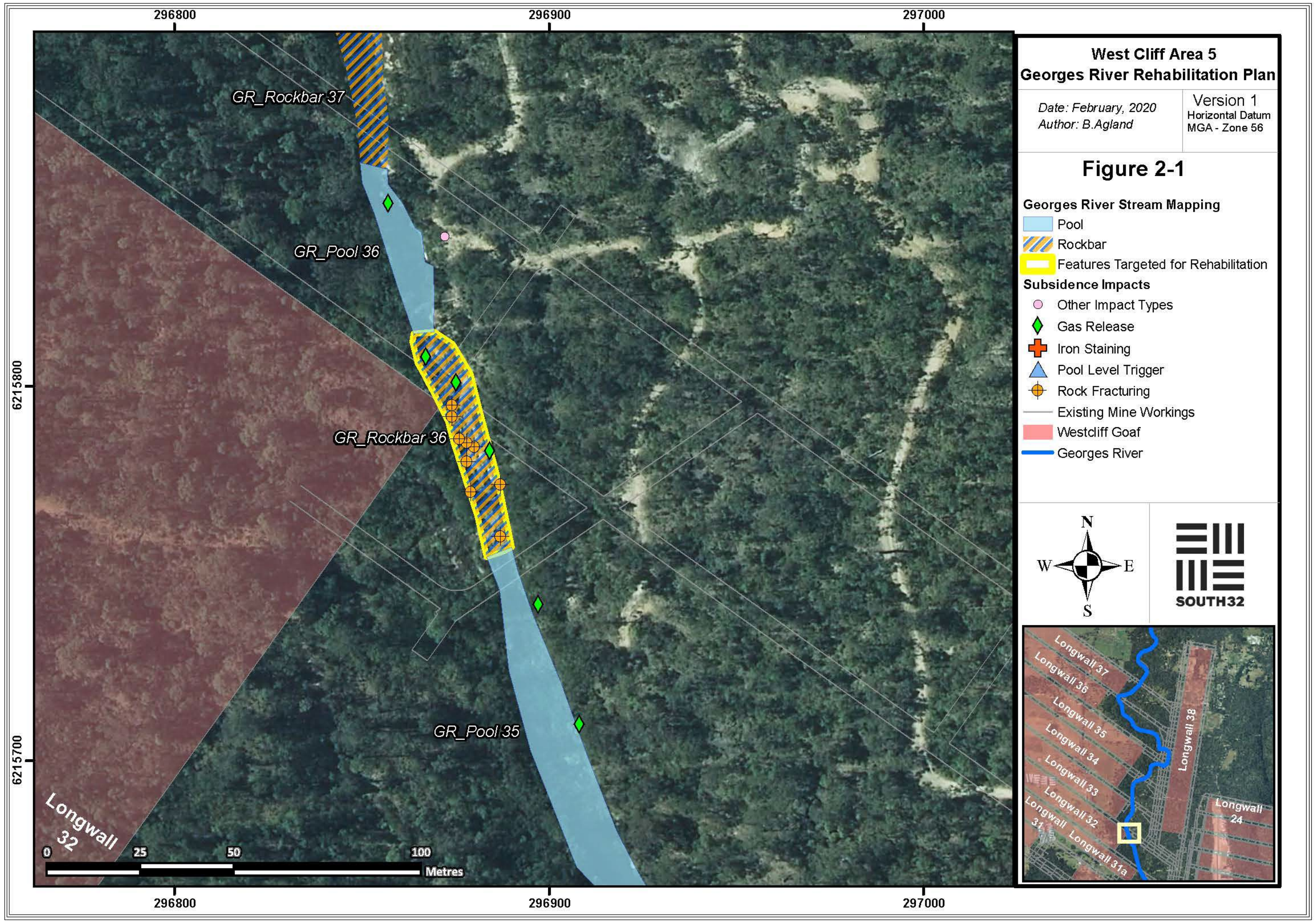

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Figure 2-2 Location of impacts from Pool 37 to Rockbar 37b

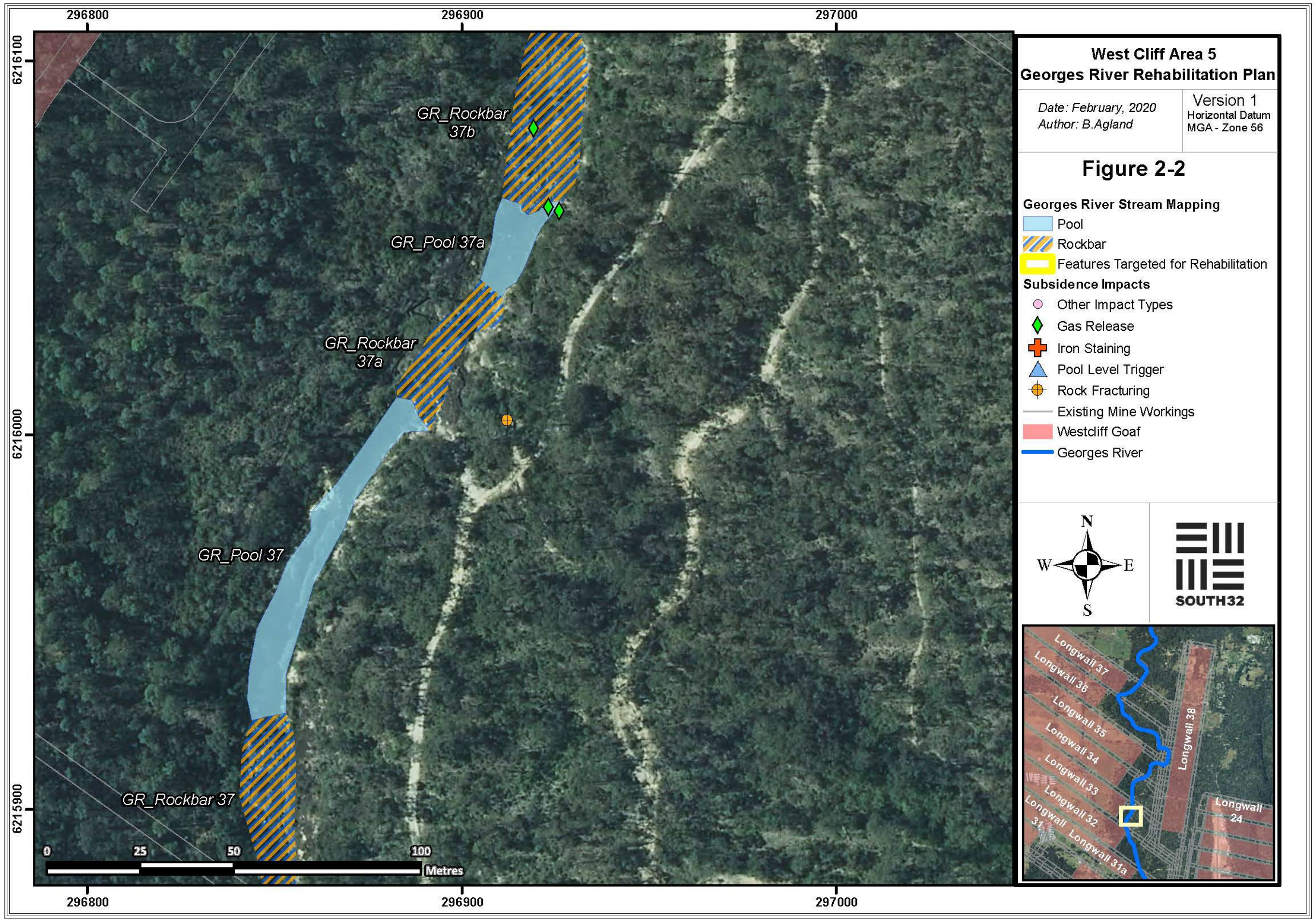


Figure 2-3 Location of impacts from Pool 37b to Pool 40

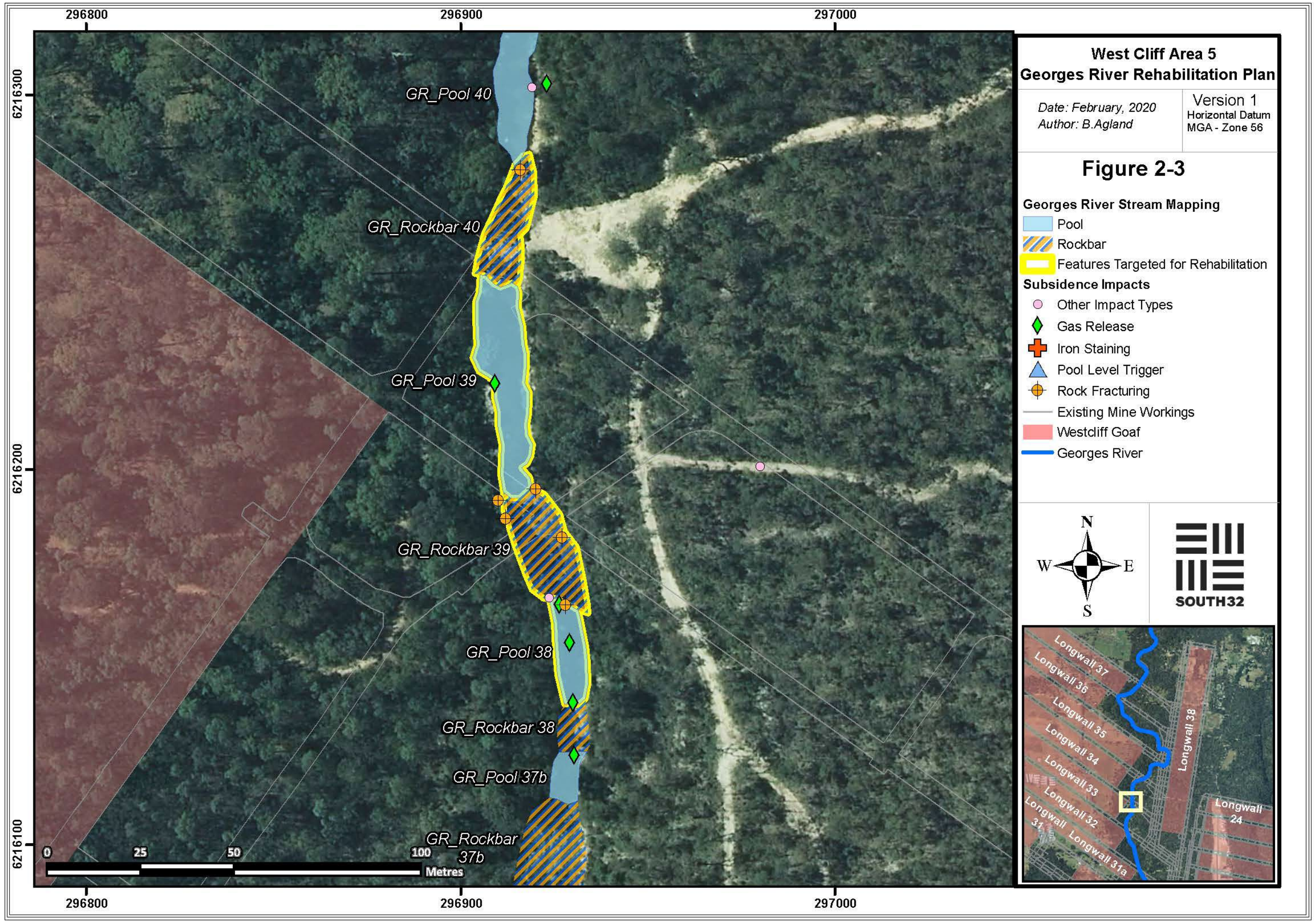


Figure 2-4 Location of impacts from Pool 40a to Pool 43

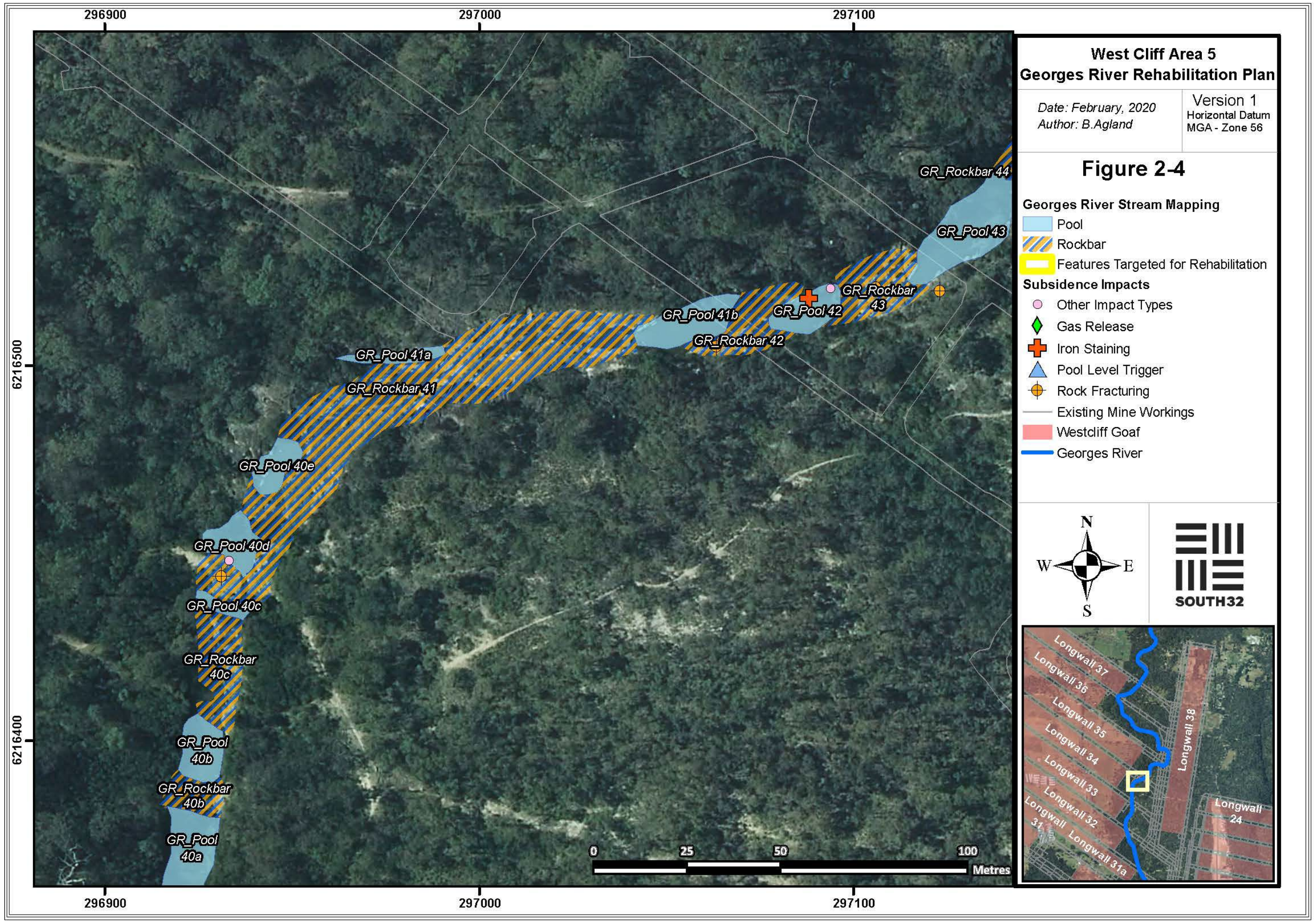


Figure 2-5 Location of impacts from Rockbar 44 to Pool 46

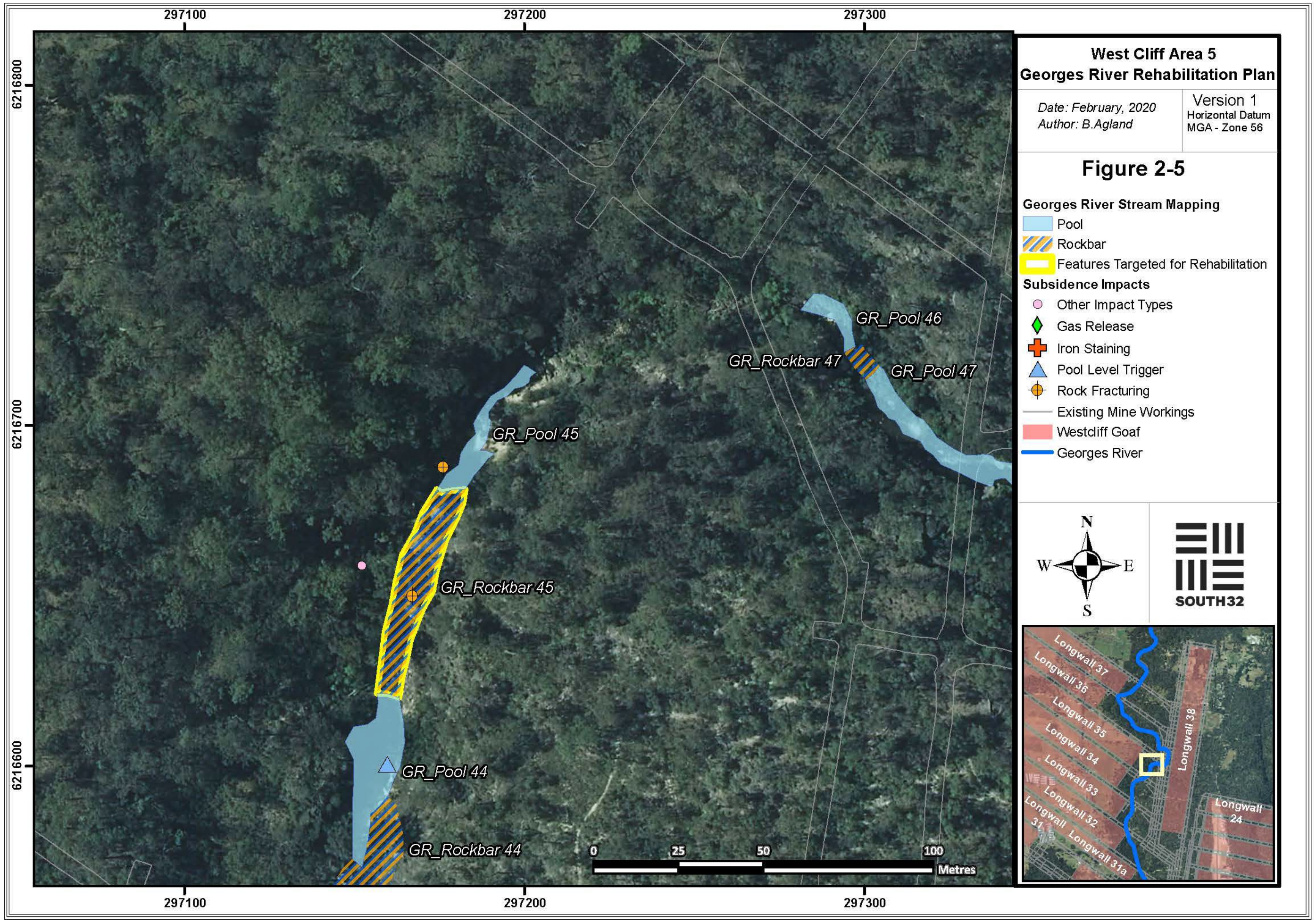


Figure 2-6 Location of impacts from Pool 47 to Pool 51

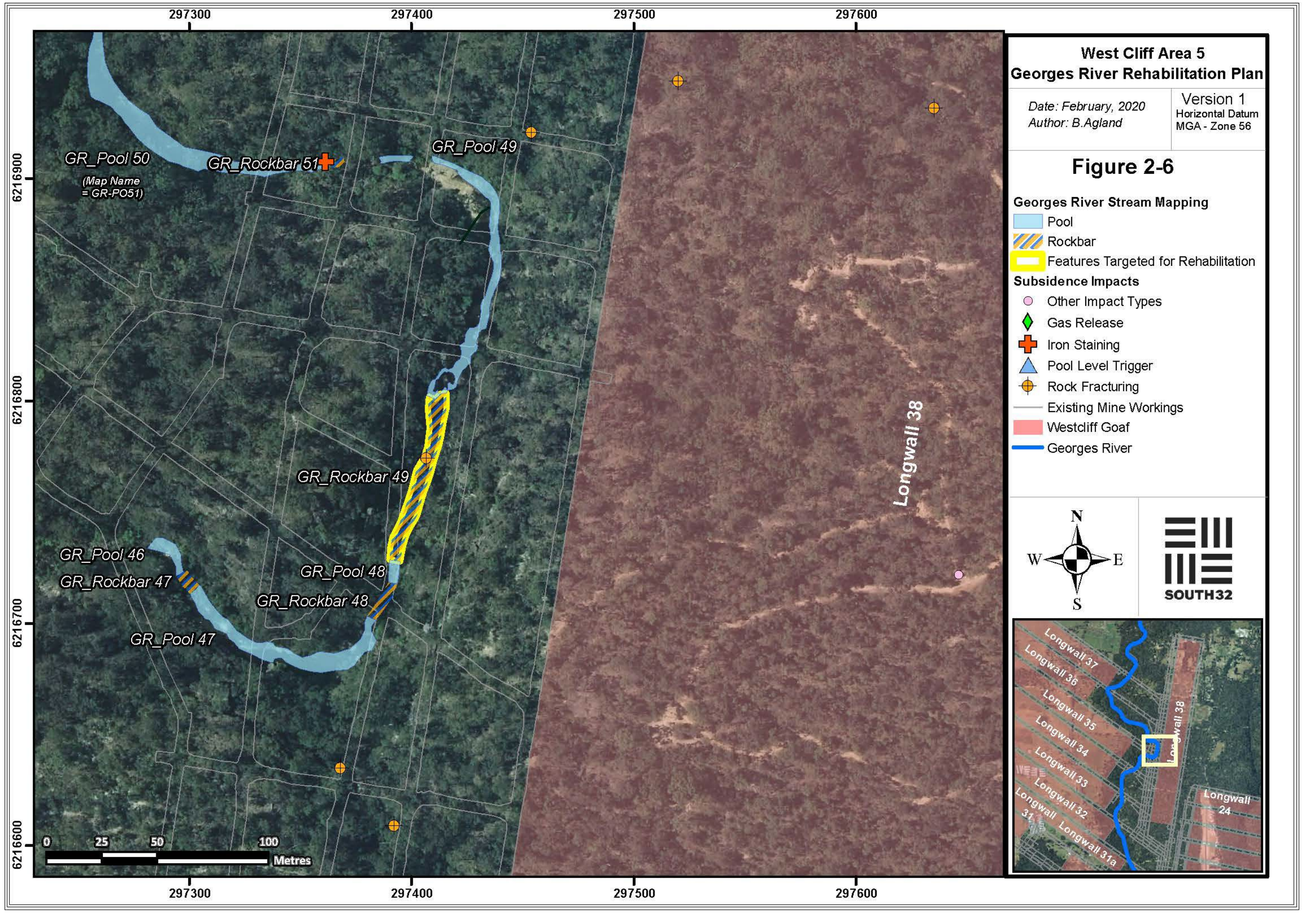


Figure 2-7 Location of impacts from Pool 51 to Pool 54

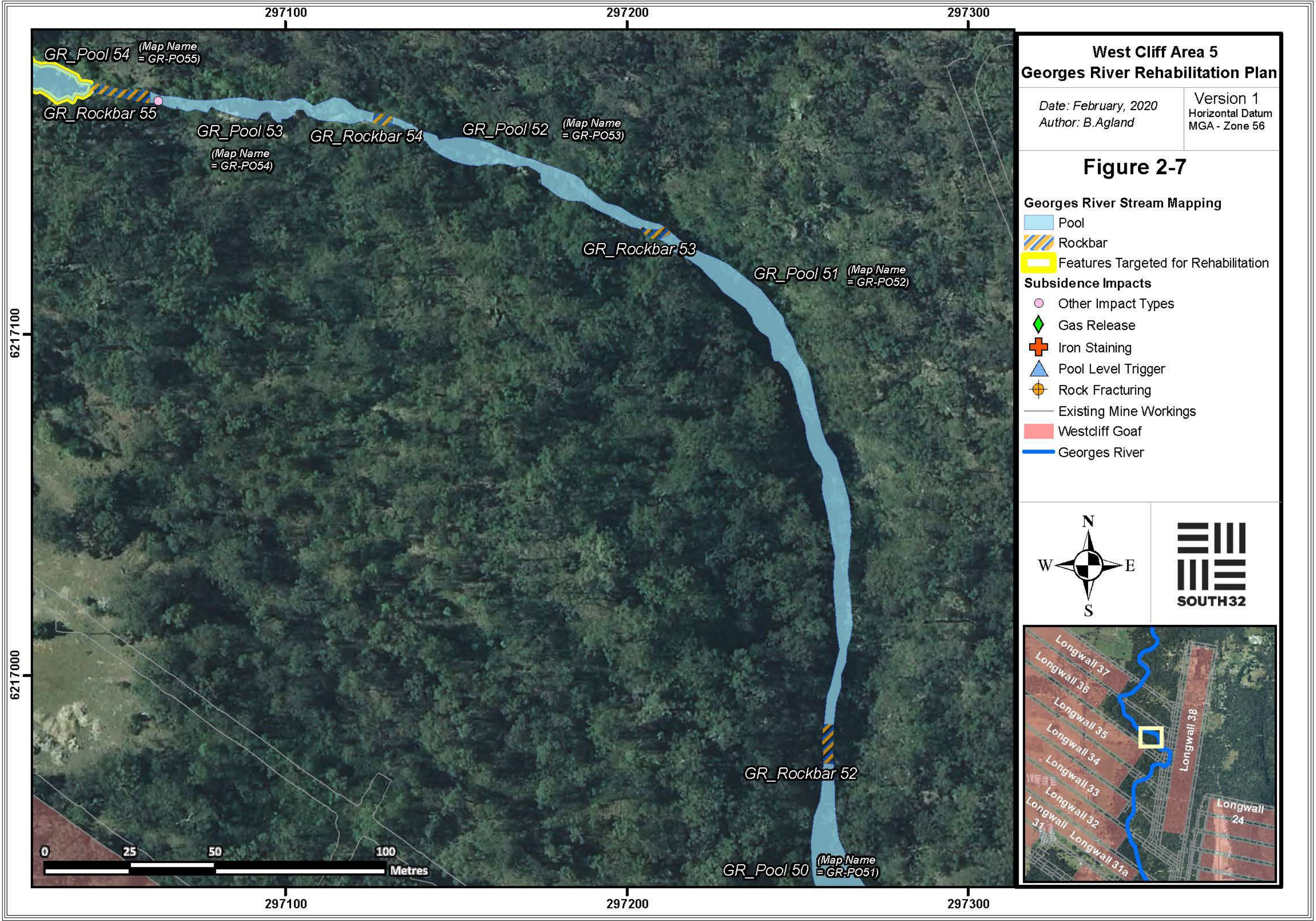


Figure 2-8 Location of impacts from Pool 54 to Pool 57

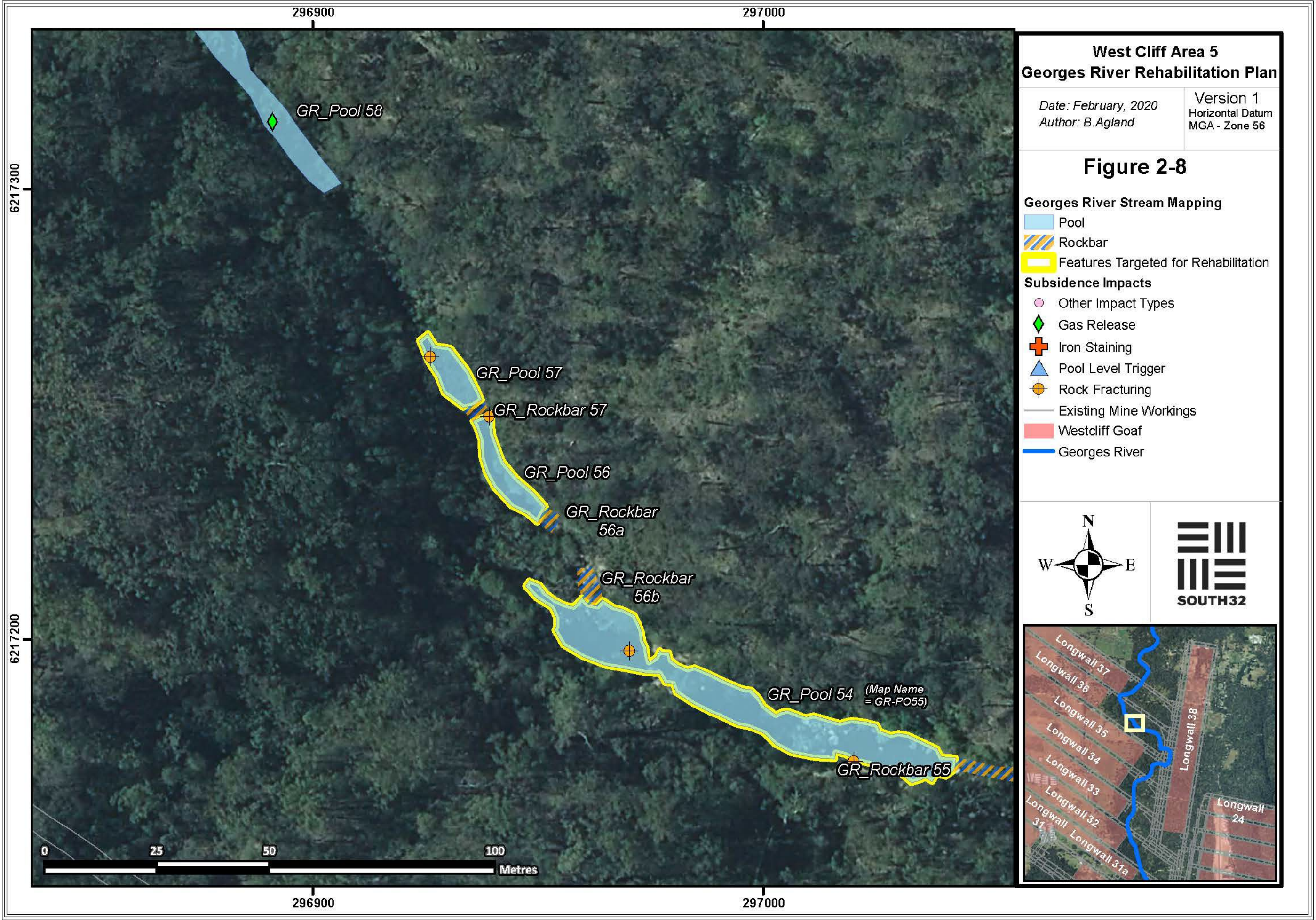


Figure 2-9 Location of impacts from Pool 58 to Pool 60

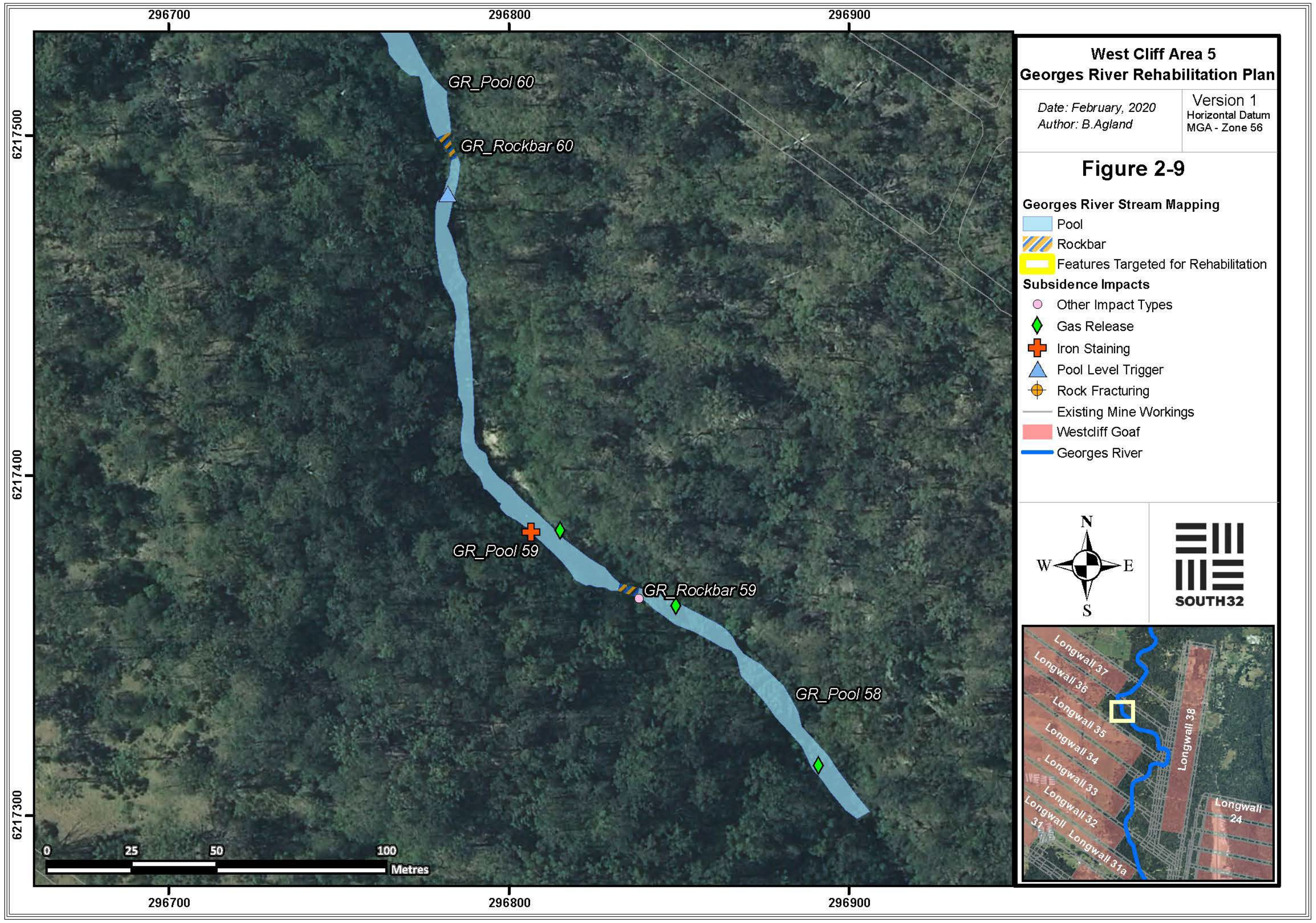


Figure 2-10 Location of impacts from Pool 59 to Pool 60

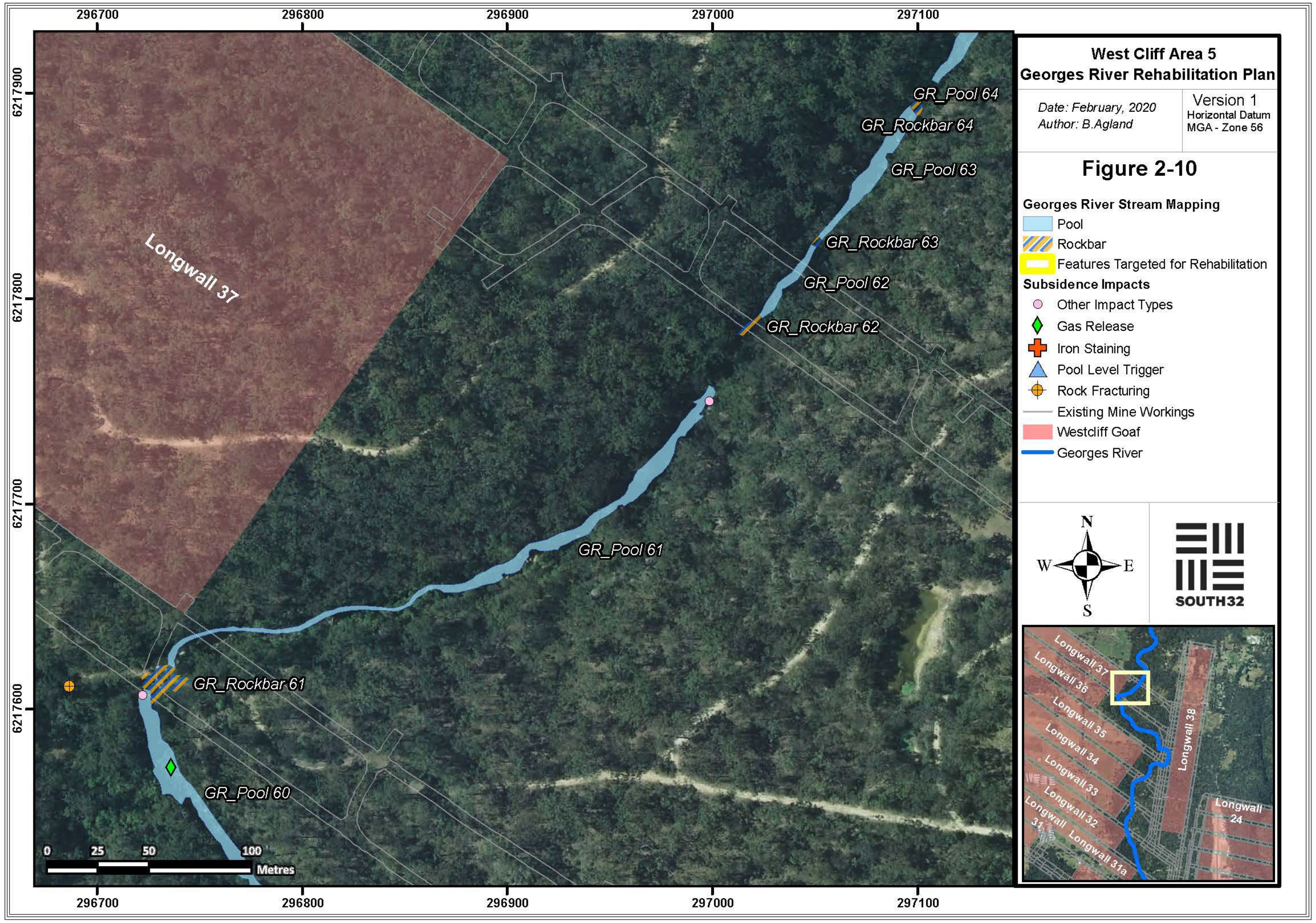
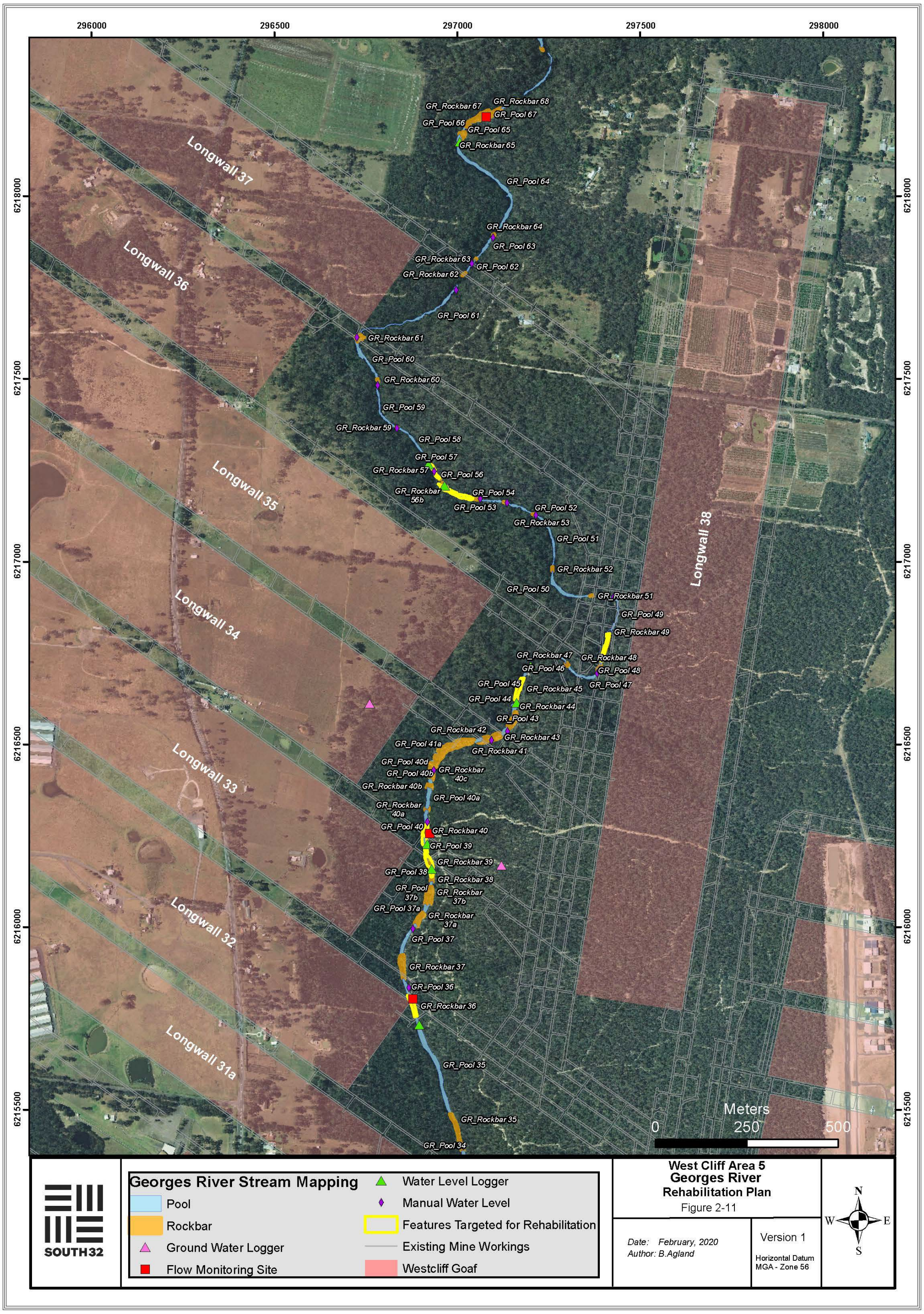


Figure 2-11 Georges River Rehabilitation Overview Plan



3. REHABILITATION OPTIONS

3.1 Previous Rehabilitation Activities

3.1.1 Previous Studies

Rehabilitation programs for the Georges River and the Cataract River have been investigated previously and options and results of the rehabilitation works have been presented in the following reports:

- International Environmental Consultants, December 2002. Marhnyes Hole Rehabilitation Options, Addendum to Environmental review of Mining Effects. Prepared for BHP Billiton.
- BHP Billiton Illawarra Coal, March 2004. West Cliff Mine Environmental Management System: Georges River Report Baseline Assessment in Support of Remediation of Georges River, Longwalls 5A1-4.
- International Environmental Consultants, May 2004. Pattern Grouting Remediation Activities, Review of Environmental Factors Georges River Pools 5 -22. Prepared for BHP Billiton.
- The Ecology Lab, September 2004. Effects of Remediation of Georges River at Marhnyes Hole on Aquatic Ecology. Report to BHP Billiton, Illawarra Coal.
- BHP Billiton Illawarra Coal, November 2006. West Cliff Mine Environmental Management System: Georges River Report Assessment of Georges River Remediation, Longwalls 5A1-4.
- BHP Billiton Illawarra Coal, December 2006. Appin Colliery, Review of the Feasibility of the Proposed Remediation Methods, Area 3 Longwalls 301A to 302.

3.1.2 Successful Techniques Used Previously

The remediation works carried out to date in the Georges River at Pools 8, 9, 14, 15 and 16, Marhneys Hole and Jutts Crossing demonstrate that rehabilitation of mining-induced subsidence impacts can be achieved within acceptable environmental limits.

The following grouting techniques have previously been implemented without significant impact to the river:

- Hand mortaring;
- Pattern grouting;
- Curtain Grouting; and
- Deep-angled hole grouting.

The works have proven successful, with flows and water levels during low flow conditions being restored in areas where remediation works have been completed. An example of the results of the work is shown in Photo 1 and Photo 2, which provides images of Georges River Pool 14 before and after remediation works.

Photo 1: Pool 14 on 22/11/02 following mining.

Photo 2: Pool 14 on 6/7/05 following remediation works.

Remediation to Georges River features discussed in this report will be implemented using techniques that have proved successful in the Cataract River, Georges Rivers and Waratah Rivulet. Proposed methods for the Georges River sites are considered feasible and practical with a high likelihood of success. The outcomes of previous remediation activities in the Georges River are discussed in detail in the reports listed in Section 3.1.1.

3.2 Remediation Options

Based on previous experience and the nature of the current impacts, a range of options have been identified to treat the riverbed of the Georges River. The methods have been grouped and are discussed below.

3.2.1 Natural Rehabilitation

Natural rehabilitation would leave the river in its current condition and rely on natural processes to re-establish river flows.

IMC is required to remediate the area for environmental reasons and mining approval was granted based on rehabilitation of the area as a contingent measure should impacts warrant such works. Consequently, this option is not proposed.

3.2.2 Active Sealing of Mining Induced Fractures

Where there is limited ability for cracks and fractures to seal naturally, it is necessary to carry out remedial measures. To repair bedrock fractures that will not seal naturally, sealing by injecting a cement grout into them and into the voids beneath the creek or riverbed was proposed as part of the SMP for the Georges River. Rehabilitation can be achieved by using a variety of methods listed below and described in more detail in Section 3.2.3:

- Hand grouting – involving applying a variety of sealing products using small hand-held equipment in localised situations.
- Curtain grouting – drilling a line of closely spaced grout injection drill holes, through which cement grout is injected into the rockmass. Multiple passes are usually required.

- Lining – providing coverage of the wetted area of the river with an applied membrane.
- Pattern grouting – drilling holes on a grid pattern and injecting a grout medium into the holes.
- Permeation grouting – isolating a section of river bed by temporary bunding which permits the impoundment of grouting media of various viscosities that then permeate the rock due to gravity.
- Deep angled hole grouting - directionally drilling holes into the river from some distance away to allow grout to be delivered from a remote location.

The following section provides a description of these rehabilitation methods; options under each of these methods; and examples of application of the methods; providing advantages and disadvantages for each application. The likelihood of success and an assessment of potential adverse consequences during implementation of the methods are also included.

3.2.3 Active Sealing Options

3.2.3.1 Hand Mortaring

Where water transfer is observed through well-defined large, joints or fractures, the joints and fractures can be sealed using a variety of products, some of which can be applied in wet conditions and under water. These materials are normally applied using small hand-held equipment and in localised situations. The technique involves identifying and treating wide, visible cracks in the rock mass with hand held tools and specialised cement based or synthetic mortars.

This option involves low technology, skilled labour and small volumes of materials and can be carried out relatively quickly. This technique was used in the Georges River Pool 14 successfully, prior to pattern grouting.

As this treatment option only allows cracks to be treated at the surface, it is a partial solution, being largely cosmetic. Consequently, hand mortaring will be used in conjunction with other preferred methods.

The technique uses sandstone-coloured cement, river sands and coloured oxides to create a raw material that looks similar to the natural sandstone.

All equipment is hand held so there is minimum impact to the rockbar and the environment. Tools and material are transported onto the rockbar by hand. Typical equipment includes cement mixer, trowels, packers, buckets, knives, bars, injectors and small saws.

3.2.3.2 Pattern Grouting

Large surfaces of the river bed may be sealed using pattern grouting. Pattern grouting involves drilling injection holes in the base of the river in a grid pattern (commencing at a nominal grid spacing of 1 m x 1 m to 3 m x 2 m) and injecting a grouting medium into the voids of the fractured strata. The intention of this grouting is to achieve a low permeability ‘layer’ approximately 1-2 meters thick below the riverbed over the length of the impacted area.

The most efficient way to drill the holes taking into account potential environmental impact is by using small hand-held drills which do not result in significant impact to the environment. The drills are powered by compressed air which is distributed to the work area from a compressor.

This technique is undertaken in a number of stages addressing small areas at a time. The technique requires the site to be sufficiently dry to accommodate the drilling activities. The grid pattern would be drilled by air driven jackhammers throughout the section of the river channel being treated.

The turnaround between drilling of each hole is approximately five minutes. Rockbars are readily treated while pools may require the installation of temporary coffer dams and arrangements to by-pass flow to provide a suitable grouting site. This is anticipated to occur over 1-2 days at each site.

Mechanical packers are installed just below the surface and grout injected at a low pressure. The grout will be pumped into the holes from a small mixing plant. The grout will be mixed and pumped according to the preferred grout design. A grout of high viscosity will be used if vertical fracturing is believed to be present since it has a faster setting time. A low viscosity grout will be used if cross-linking is noted during grouting. Once the grout has been installed the packers will be removed and cleaned.

After sufficient time for the product to harden the area may be in-filled with additional grouting holes that target areas of significant grout take from the previous pass. The entire grouting exercise can be completed with hand held drilling equipment and no large equipment will be necessary in the riverbed itself. Grout will be pumped to the riverbed via a hose from a small tanker on a trailer located adjacent to the river.

Grouting volumes and locations are recorded and high-volume areas identified. Once the grout take in the area is reduced and the material has cured, the grouted section of the pool will be filled with water and monitored. These results will be compared with pre and post mining monitoring to determine the level of success of the grouting exercise.

The grouting process is iterative; relying on detailed monitoring of grout injection quantities, grout backpressure analysis and water holding capacity measurements. An area is targeted for the grouting and this area is completed to the agreed success criteria prior to moving to other sites.

A number of passes of grouting are generally required to seal the subsurface layers. Images of the pattern grouting equipment and activities are outlined in the Georges River Report - Assessment of Georges River Remediation (BHPBIC, 2006).

The advantages of this option are that the drillhole injection system minimises site disturbance, multiple passes can be accommodated, surface disturbance is minimised and good control of injection pressures and penetration into the rock can be obtained.

Various grouts may be used, some of which are considered more appropriate than others due to potential environmental impacts and/or costs. The choice of grout is dependent upon the permeability of the rock from site to site. The selection of a particular grout includes an analysis of any aquatic ecosystem toxicity. Providing appropriate grout is chosen, the risks associated with this treatment option are considered to be low and the expectation of success high.

This form of grouting has been successfully used to reduce impacts along a 2.7 km section of the George River previously mined beneath by the West Cliff mining operations.

3.2.3.3 Curtain Grouting

Installation of a grout curtain involves drilling a line of closely spaced grout injection drill holes into the rock, and pumping grout into the holes. Multiple passes, with several grout stages are usually required. Curtain grouting generally occurs to the full depth of fracturing of about 20-25 m. Curtains may be installed sequentially down the river.

The advantages of this treatment option include working in a closely defined area, known technology, ready containment of spills and the ability to test the grouting by borehole testing. Disadvantages include the possibility of not restoring water levels but producing intermittent ‘level ponds’, and the potential for uncontrolled release of grout. While the risks are considered low to moderate, the expectation of success of this form of treatment is limited to returning groundwater flow to the surface.

3.2.3.4 Permeation Grouting

Permeation grouting involves isolating a section of riverbed by temporary bunding, to allow the impoundment of grouting media of various viscosities that then permeate the rock due to gravity. The grout mixture would vary for the treatment of wide through to finer cracks. Impoundment and treatment would be repeated cyclically along the identified length of river.

Advantages of this method include the very high likelihood of success, the ability to change the mix as the programme advances and the reuse of ponding grout. Disadvantages include the risk of release of grout to the river should unexpected high rainfall cause a breach in the bund, the potential for material to leave the site and the short-term impacts on the environment.

While this option may be suitable in the future, the current level of confidence in this method is insufficient and it is therefore not the preferred option.

3.2.3.5 Deep-angled Hole Grouting

Where access constraints make pattern grouting inappropriate (for example where a pool has not totally drained), directionally drilled holes may be installed some distance away from the river to allow grouting to be delivered remotely. This technique was used to access and grout fracture horizons under Marhnyes Hole.

Pumping continues until the grout material is returned to the top of the delivery holes. Regular inspections are undertaken throughout and following the operation to ensure there are no significant releases of grout into the river.

The use of this method would be as required, determined by pool access conditions during remediation. Other treatments outlined as preferred would be used preferentially.

3.2.3.6 Impermeable Lining

This option involves lining the ground surface of pools with an applied membrane / coating of some impermeable material. This requires the removal of all material from the riverbed prior to construction of the liner and therefore has short and long-term impacts on the environment. Impermeable materials that could be used include shotcrete and geosynthetic clay liners.

The main advantage of this treatment option is its known effectiveness as a widely used technology. Disadvantages are considerable and include environmental impacts during construction, uncertainty of durability, potential for water quality issues, the potential need for repeat applications and ongoing maintenance. The disadvantages are seen to outweigh the advantages and therefore this option is not recommended.

3.2.4 Grout Material Options

The choice of grouts available for the work includes:

- General purpose cement;
- Bentonite alone;
- Bentonite and cement;
- Polyurethane foaming or non-foaming; and
- Hydrogel (e.g. Duraseal) and cement.

3.2.4.1 Preferred Grout Material

In previous rehabilitation activities IMC has chosen the grout material known to have the least impact on the environment and proven results. The recommended grouting product proposed is a cement mix (see Appendix 4 for the Safety Data Sheet) that may be mixed with small amounts of bentonite for added flowability and flexibility.

This material has been selected because:

- It swells and seals in contact with water;
- The mix reduces washout compared to individual material alone;
- It has increased durability;
- It reduces water-bleed and shrinkage; and
- It is economically viable.

This material has been used successfully in the rehabilitation works in upstream areas or the Georges River and in other applications such as sealing leaking rock masses in dams and tunnels. The material is relatively flexible and was not observed to leak out of the rock mass during grouting in the Georges River (e.g. at Pools 14 and 15). The grouting will be permanent and will assist with long-term natural sealing of fractures.

A polyurethane (PUR) grout similar to that used for rehabilitation projects within the Waratah Rivulet within the Woronora Special Area is the alternate proposed grout product, should the proposed cement mix be unsuitable in for the conditions. The Safety Data Sheet for the proposed PUR products are included in Appendix 4.

4. PROPOSED REHABILITATION METHOD

The rehabilitation work is proposed to be carried out in a number of stages, as grouting works will need to be conducted iteratively. These stages are as depicted in Section 4.6. Pools with more significant impacts will generally be targeted as a priority, as this may then indirectly improve the condition of pools with lesser impacts.

The staged nature of the rehabilitation project has been designed to enable improvements and efficiencies to be incorporated in later activities. As such the activities listed may be adjusted during implementation.

4.1 Site Access

The proposed remediation activities require light vehicle access to sections of the riparian zone and plateaus of the Georges River. The proposed access to the area is from the east through Government land (Tharawal Local Aboriginal Land Council land), and the west through a large, relatively open property owned by NSW DPE. Some vegetation clearing will be required from existing trails to gain closer access to the proposed river sites.

The equipment to be used in the remediation works is small, generally fitting on the trailer of a light vehicle. Drilling and ancillary equipment will be carried to the river from existing trails as well as new trails and staging areas, cleared as part of the rehabilitation plan. Each staging area will allow access to multiple rehabilitation sites. Where required, any erosion on existing access tracks will be repaired using standard road work techniques. Erosion controls along the access roads will be provided in the form of retention basins and sediment fences, as required.

4.2 Timing Of Work

The rehabilitation works are proposed to commence shortly after all approvals have been received, as subsidence movements at the site have ceased since the completion of Longwall 38.

Prior to the commencement of rehabilitation in each section of the river it will need to be sufficiently dry to allow for the safe execution of works. In most cases this will be achieved by scheduling the works during a dry period with low or no flows in the river and/or controlling discharges from Brennans Creek Dam. Where this cannot be achieved, a cofferdam will be constructed of sandbags and plastic liners immediately upstream of the work site. Water flow will be diverted from upstream of the coffer dam via a pipe system that will discharge the river water below the work site.

Works will be carried out progressively along the river; however, will generally target pools with the most significant impacts as a priority (Table 4 1). This may result in improvements to downstream pools with less significant impacts without undertaking direct intervention.

The length of river undergoing rehabilitation activities at any one point in time will be limited in order to reduce impacts to the environment and to make it easier to monitor success of remediation works. Works will be finalised in each section before moving on to the next. This will reduce the total length of impact time to any particular area which should reduce the remediation time required for disturbed areas.

The duration of remediation works at each location will be site specific and depend on the success of each grouting pass as pattern grouting is not necessarily fully successful with a single pass. The initial works at any particular site are anticipated to take approximately two weeks. This will involve installing a coffer dam (if required) around the area of work, drilling the area on a pattern grid, pumping grout material into the holes and cleaning up the work site prior to removal of the coffer dam. Following this the effectiveness of the work will be evaluated and further stages in the remediation designed as appropriate.

Pollution Reduction Plans (PRPs) were previously in place for the Georges River catchment. In 2013, the EPA issued a notice of variation of EPL 2504, which included a requirement to carry out a program of works to reduce the level of contaminants being released to the Georges River via discharge Point 10 (PRP19). PRP20 was also added to the Licence with the aim of assessing the aquatic health of Brennans Creek and the Upper Georges River as projects required under PRP19 are commissioned.

An Environmental Improvement Program (EIP) was also developed, which superseded the PRPs.

In April 2019, the EPA issued IMC with a Notification of Intention (NoI) to make licence changes to provide greater certainty in the achievement of water quality outcomes, address the ongoing delays in environmental improvements and to provide for greater public involvement in the regulatory decision-making process. The EPA issued a Notice of Variation to EPL 2504 in March 2020. The EPA revoked EIP2 and attached Special Condition E1.1 to the EPL requiring the installation and operation of a Water Treatment Plant (WTP) at Appin North by 31 March 2021 to meet revised water quality concentration limits (detailed in Condition E1.1).

The Georges River Aquatic Health Monitoring Program (GRAHMP) was a requirement of EPL 2504[2], Special Condition E3 which stated:

E3.1 The licensee must prepare an aquatic health monitoring program to verify improvements to the aquatic health of the Georges River following commissioning of the reverse osmosis water treatment plant required by condition E1.1. The monitoring must include:

- *quantitative sampling of macroinvertebrates;*
- *ecological assessment processed using DNA extracted from sediment (as appropriate);*
- *in-stream water quality; and*
- *laboratory water testing.*

The mandate for the Appin North WTP is to improve discharge water quality into Brennans Creek, and reduce its toxicity. The aim of the GRAHMP is to verify these changes by:

a) comparing water quality in the Georges River before and after commencement of the Appin North WTP;

[2] Special Condition E3.1 was removed from EPL 2504 in the November 2021 variation.

b) assessing the ecotoxicity of discharge waters from the Appin North WTP;

c) comparing the in-stream and sediment biota of pools downstream of the discharge with reference sites (located upstream of the Brennans Creek confluence);

d) calculating changes over time in the composition of in-stream and sediment biota, particularly downstream of the discharge; and

e) assessing the downstream gradient changes in composition of the in-stream and sediment biota.

There is likely to be interaction with the GRAHMP that will need to be considered during the implementation of the rehabilitation activities outlined in this document. However, the end result of rehabilitation works should benefit from any improved water quality or flow regimes.

4.3 Georges River Catchment Modelling

A Georges River Catchment Model has been developed by consultants WSP (Attachment A). The Model is required to measure success against the criteria of the proposed rehabilitation project (Section 4.5).

The initial stage (Stage 1) of the Georges River Catchment Model includes developing a water balance model of the Upper Georges River pool and rockbar system and assessing the performance of proposed measures to remediate mine subsidence impacts to the system. This stage is required to determine:

- the hydrological characteristics of the river system, including the catchment runoff response to rainfall and the effects of licensed releases from West Cliff and Appin East pit top surface operations on pool water levels;
- the existing water level regime within key pools affected by mine subsidence impacts; and
- the response of the water level regime within key pools to the proposed rehabilitation measures.

Key pools of interest for the study (Pools 35, 38, 39, 40, 44, 45, 53, 54, 56, 57 and 58) have been based on field observations of subsidence impacts and analysis of water level data. The proposed rehabilitation project and catchment model is therefore focused on these pools. Pool 28 has also been identified as a key pool of interest for the catchment model, as it is located upstream of the identified impacts and is representative of the baseline pool seepage loss and water level regime. Pool 64 (including Rockbar 64) has been selected as the downstream extent of the model and is used as a calibration site as the site is located outside the zone of influence of subsidence.

Pools 25 to 64 were represented in the model. The key pools were surveyed and are defined within the model as ‘reservoir’ elements, using the surveyed invert and overflow elevations and stage-volume-area relationships. The other pools between Pools 25 and 64 were represented in the model in a simplified form based on assumed storage characteristics.

The pool water balance model was used to calculate the volume of water in pools at the end of each day by considering daily releases to the Georges River from BCD, rainfall-runoff inflow, direct rainfall inflow, evaporation losses, seepage losses, seepage return and pool overflows. The model calculates the pool volume and water level for water levels up to the overflow level (i.e. downstream controlling rockbar level) only. As the model is a water balance model rather than a hydraulic model, it is not capable of predicting water levels under high flow situations when water levels are above the pool overflow level.

The volume of surface water runoff for the Upper Georges River catchment has been estimated using the Australian Water Balance Model (AWBM). The AWBM rainfall-runoff model incorporated into the water balance model was calibrated to the local streamflow gauge and is capable of reliable predictions of the catchment rainfall-runoff response. The pool water balance model was calibrated to continuous logged pool water level records and manual flow records for the ~2.5-month period 28 December 2018 to 14 March 2019 and is capable of predicting the general pattern of pool water level rise and fall in response to rainfall-runoff events and the effects of releases from BCD. The model is capable of assessing the relative performance of remediation measures by simulating the change in response of the pools to reductions in seepage losses at each pool as a result of sealing.

The pool water balance model was simulated using historical daily rainfall and evaporation data sourced from Scientific Information for Land Owners (SILO) Data Drill for the 130-year period from 1 January 1889 and 14 March 2019. Distribution plots for pool water depths and overflows were developed using the daily results.

The model has been simulated for various operational scenarios by varying the assumed pool seepage losses corresponding to the following remediation scenarios:

- current scenario (no sealing)
- partially sealed rockbar (at 20%, 50% and 80% sealed)
- fully sealed rockbar.

A separate model of the pre-mining natural catchment has also been developed to provide an understanding of the hydrological behaviour of the Upper Georges River pool system under pre-mining conditions.

The Stage 1 model excludes detailed modelling of West Cliff or Appin East surface operations. Instead, licensed releases have been modelled as a set constant release from BCD (the main site dam at West Cliff). Various release scenarios ranging from a constant release of 0 to 3.5 ML/day have been simulated in the model in combination with the remediation scenarios. The report focuses on results for operational scenarios with no release from BCD, as at the completion of mining operations in the BCD catchment (and following acceptable rehabilitation) it is not anticipated that there will be an ongoing release from the BCD catchment apart from rainfall-runoff from rehabilitated and remnant natural catchment areas. BCD constant releases ranging from 0.5 ML/day to 3.5 ML/day are provided in Appendix D.

The model results indicate the percentage of time that pools were predicted to be full for the operational scenarios increased as the degree of rockbar sealing increased (Refer to Attachment A). As expected, as the degree of rockbar sealing increases, the release from BCD required to maintain pools at full decreases. The fully sealed rockbar scenario with no release from BCD achieves pool water depth and overflow durations and frequencies that are close to the base case. However, the predicted pool water depths and overflows are still slightly lower for the fully sealed scenario compared to the base case because of the reduction in catchment area contributing to the Georges River for the operational scenarios associated with BCD (BCD catchment area ~ 485 ha).

As per the recommendations of the WSP report, Stage 2 of the model will extend the pool water balance model to include West Cliff surface operations, including BCD and upstream water management infrastructure. Stage 2 will be produced as a separate report, following the approval of the GRRP.

4.4 Environmental Monitoring & Reporting

4.4.1 Rehabilitation Monitoring

The following monitoring strategies will be employed to inform the progress of the rehabilitation works:

- Implement an iterative grouting approach. Once grouting is complete in one section of the river, a small section will be tested to confirm its effectiveness, before moving off-site. Each section of river will be filled with water to measure treatment effectiveness. In this way a planning – operations feedback loop would be established;
- monitoring will be undertaken to ensure water quality is maintained;
- the injection pressure and volumes will be measured at the hole so that the potential for hydraulic fracturing (and therefore wastage of grout product) can be assessed; and
- once remediation activities are completed, all equipment and materials used in the works will be removed. Routine monitoring will continue as described in the Approved Extraction Plan, or otherwise required.

All monitoring associated with the proposed rehabilitation activities (including pre, during and post remediation) is outlined below and in Table 2.

4.4.2 Water Level and Quality

Groundwater and surface water flow and quality will continue to be monitored via the boreholes and surface sites currently established. Localised flow measurements can also be used to measure the success of grouting activities as sections of remediation works are completed.

Flow releases from Licence Discharge Points will be controlled, including cessation of discharge where appropriate, to assess the success of grouting activities in improving surface flows and pool holding capacity.

Water quality and aquatic health monitoring related to Environment Protection Licence 2504 will be undertaken as prescribed. Remediation works will consider the interaction with the GRAHMP and any other relevant approvals.

4.4.3 Rehabilitation Success

The effectiveness of the rehabilitation grouting works will be assessed through regular monitoring of pool water levels, river flows and quality (outlined in Table 2). This monitoring work will continue in consultation with government and community until no longer deemed necessary.

The effectiveness will ultimately be assessed against the requirements of the Project Approval and relevant management plans.

Rehabilitation success will be measured against the TARP performance measures from the Georges River Management Plan and Extraction Plans (Appendix 2).

4.4.4 Reporting and Review

A progress report will be prepared at 6 monthly intervals for the duration of the rehabilitation program, providing a summary of works completed, available monitoring results and a review of the rehabilitation and monitoring methods. The progress report will also provide a mechanism for feedback from DPE and Resources Regulator.

A final report will be prepared, following the completion of the rehabilitation works including a period of post rehabilitation monitoring, to inform key stakeholders of the outcomes of the project. The final report will outline the following;

- Definition and description of remediation works;
- Materials and methods used and an outline of procedures used/developed;
- Results of work completed;
- Monitoring Results;
- Assessment against Success Criteria; and
- Recommendations and conclusions.

The final report will be peer reviewed by an independent expert, prior to submission to DPE and Resources Regulator. Information will also be made available to the members of the community via established community groups.

Monitoring results from the rehabilitation project will be provided via regular reporting processes including the Annual Review and Annual Rehabilitation Report.

4.5 Success Criteria and Rehabilitation Overview

Table 2 Georges River rehabilitation performance measures, proposed rehabilitation techniques, monitoring methods and success criteria

Target Features for Rehabilitation	Performance Measure	Proposed Rehabilitation Techniques	Monitoring Methods	Success Criteria
Rockbar 36 (1) ***Pool 38*** (3) ***Rockbar 39*** (2) ***Pool 39*** (3) ***Rockbar 40*** (1) ***Rockbar 45*** (2) ***Rockbar 49*** (4) ***Pool 54*** (3) ***Pool 56*** (3) ***Pool 57*** (3) **Each target feature name refers to a rockbar and pool complex.** **Targeted sites were chosen based on field observations of subsidence impacts and analysis of water level data.** **Additional features, adjacent to the targeted features, will be considered for rehabilitation based on the rehabilitation success at each site.**	**Project Approval - Schedule 4, Condition 31** The Proponent shall rehabilitate the site in accordance with the conditions imposed on the mining lease(s) associated with the project under the Mining Act 1992.. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the EA and the PPR, and comply with the objectives in Table 10, which states: *(a) Watercourses of 3rd order or above subject to subsidence impacts: Restore pre-mining surface flow and pool holding capacity as soon as reasonably practicable.* *(b) Hydraulically and geomorphologically stable, with riparian vegetation that is the same or better than prior to mining.*	The following methods will be employed, where applicable, at each site. More details on specific techniques are presented in Section 3.2.3 **Stage 1** Hand mortaring: Large surface cracks with observable flow diversion. **Stage 2** Pattern Grouting: commencing with a nominal grid spacing, determined per site. Angled holes under bank where the work zone is concurrent with the bank edge. Drill holes away from front lip so as not to damage the rockbar; angled holes upstream to grout under front lip. **Stage 3** Monitoring success of works and repeat as necessary with informed and amended techniques (refer '*predicted values of success' column and Remediation TARP*). **Stage 4** Pattern Grouting: if initial pattern grouting is insufficient, recommence the process with a smaller grid spacing within nominated zones. If pattern grouting is insufficient, a grout curtain in nominated sections of rockbar will be considered; nominally two rows (1 m offset) with 1 m spacing. Deep-angle grouting: Where access constraints make pattern grouting inappropriate (for example where a pool has not totally drained), directionally drilled holes may be installed from some distance away from the river to allow grouting to be delivered from a remote location. Testing/monitoring success of works (refer '*Success Criteria' column and Remediation TARP*).	**Iterative Grouting Approach** Monitoring of grout injection quantities, grout backpressure and water holding capacity measurements will be used to determine the progress of works at each site. Once completed, the site will be filled with water and monitoring (see below techniques) will confirm the effectiveness of the grouting, before moving off-site. **Surface Water Level** Water level monitoring (pressure transducer with logger) will be employed in all phases of the project (pre, during and post rehabilitation) as a critical component in the assessment of pool water retention (see 'Success Criteria'). Each targeted feature complex (pool and rockbar) will be instrumented. **Surface Water Flow** Surface flow monitoring by quantitative flow gauging (where suitable gauging sites are present) will be used to assess the flow over the rockbar (see 'Success Criteria'). Where a suitable gauging site is not available, qualitative methods (time-lapse camera and field observations) will be employed in conjunction with relevant pool water level measurements. **Groundwater Level** Two deep groundwater level sites, adjacent to the Georges River rehabilitation project area, will be monitored with a pressure transducer and logger. These sites will be used to infer potential groundwater inputs into the Georges River during the rehabilitation project. As such, groundwater inputs will be considered when assessing the success of rehabilitation at each site. **Water Quality** In-field water quality parameters (pH, EC, DO and ORP) will be monitored downstream of the grouting works. **Aquatic Health** Water quality and aquatic health monitoring related to EPL 2504 will be undertaken as prescribed.	**Rockbar** *No observable flow diversion through fractures during test period.* Where surface fractures are hand-mortared, no surface flow is visually observed diverting through the fractures. This is used as an initial indicator of success and is complimentary to other monitoring and criteria. *Flow over rockbar when there is upstream flow.* Flow at the rockbar is commensurate with flow at the reference flow sites. This is determined when pools within the study area have risen above the cease-to-flow point. At sites where flow gauging is practical, flow at the target rockbar is also compared to discharge from BCD. At sites where flow gauging is not practical, a qualitative approach will be employed, using time-lapse cameras to observe flow conditions on the rockbar. Interpretations of the qualitative data will incorporate quantitative data from the surrounding sites. **Pool** *Pool water retention during post-rehabilitation test period greater than pre-rehabilitation test period.* Pool water retention is defined as: the time taken for a pool to drain once it has reached equilibrium, following cease-to-flow conditions, in the absence of additional catchment inputs, which includes rainfall events and upstream discharges. Pool water levels comparable to baseline conditions under similar pre-mining flows. Pool water retention and level will be tested via pressure transducer and logger. Monitoring will be conducted during periods of no catchment inflow and no discharge from BCD.

1) Site will be monitored by flow gauging at the rockbar and water level logging in the corresponding upstream pool.
2) Site will be monitored by visual observations of surface flow at the rockbar and water level logging of corresponding upstream pool.
3) Site will be monitored by water level logging of the pool and visual observation of surface flow at the corresponding downstream rockbar.
4) Site is not suitable for flow gauging and will be monitored by visual observation of surface flow at the rockbar.

4.6 Georges River Rehabilitation Plan – Decision Making Chart

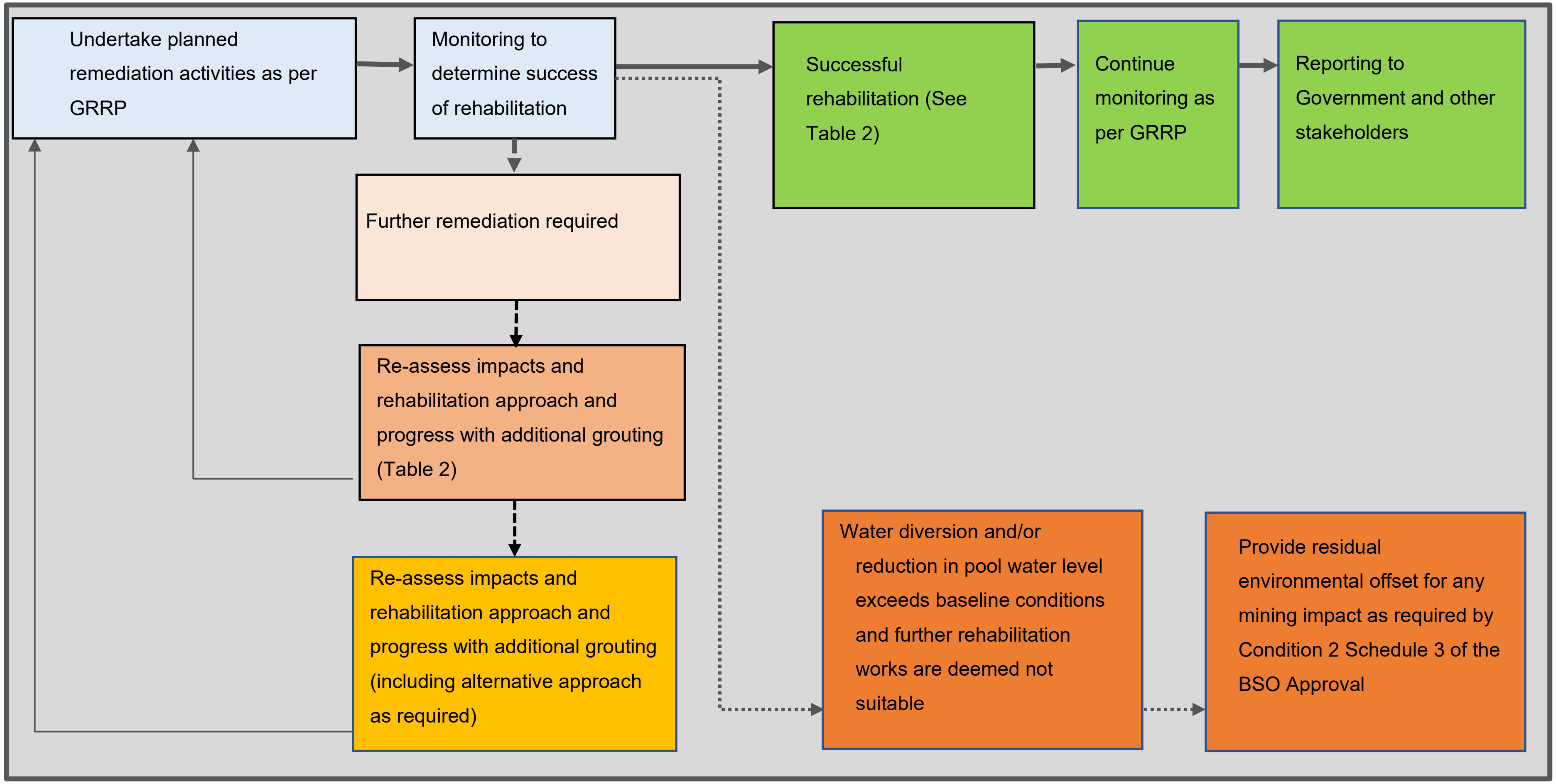


Figure 4-1 Decision making chart depicting the iterative approach that will be employed during the rehabilitation project

5. ENVIRONMENTAL AND COMMUNITY CONSIDERATIONS

5.1 Safety

The safety of the rehabilitation team, the community and personnel involved in using the area are paramount in the rehabilitation project. Appropriate controls and safety measures will be detailed in the site specific Safety Management Plan prepared by the contractor.

5.2 Erosion, Sediment and Stability

A key consideration of the rehabilitation project is to ensure that the work areas are left stable without risk of active erosion in the future. As such, disturbance during rehabilitation will be minimised, and where disturbance is unavoidable, the surface of the work area will be stabilised following the completion of the works.

Throughout any rehabilitation works, temporary sediment controls (e.g. sand bags, filter fabric) will be installed where appropriate to intercept sediment movement that may occur during the works and for a period after completion. Erosion and sediment control works will be designed and installed in accordance with applicable erosion and sediment control principles and guidelines (e.g. the requirements of the NSW Blue Book "Managing Urban Stormwater – Soil and Construction").

These controls will be maintained as required by removing any excessive build-up of sediment and repairing any failure of the structures e.g. due to storm activity. Sediment fencing and/or sandbags and coir logs would be proposed for the sediment controls.

5.3 Community Impacts

Potential impacts to the community during the proposed rehabilitation works include:

- Limited access to the area adjacent to the Georges River during the rehabilitation works to ensure the safety of the community while there is equipment on site; and
- Access through private and public property.

Safety of the public, IMC personnel and contractors is a priority for the proposed rehabilitation project. A safety protocol will be used to ensure an effective and consistent approach is taken at the site. This protocol will be followed during the rehabilitation works and while there is any risk to the community due to the work.

5.4 Surface Waters

Potential impacts on water quality, as a result of the rehabilitation works, include sedimentation and the possibility of release of potential contaminants brought to site. Safeguards will be put in place to control the impacts from potential contaminants, which could include fuel, lubricants, grout, human waste and domestic waste.

There are not expected to be any significant long-term impacts from the undertaking of remediation activities. As reported in the End of Panel Reports for West Cliff Longwalls 37 and 38, the water quality monitoring programs during longwall extraction maintained a similar variability to pre-mining data. The completion of remediation works, combined with any water quality and/or flow regime improvements implemented, would be likely to have a beneficial influence on surface water quality within the project area.

5.5 Aesthetics

The aesthetics of the area in which the fractures have been identified are a consideration in the rehabilitation activities. The intended results of the rehabilitation activities are to leave the area as natural as possible, and limit activities that will have permanent unnatural visual impacts in the landscape.

Potential aesthetic impacts associated with remediation activities include:

- Short term visual impacts associated with disturbance of vegetation and rehabilitation areas; and
- Damage to rock platforms due to equipment on site.

Visual impacts will be temporary in nature and not significant. Damage to the sites will be minimised by predominately using hand-held equipment.

5.6 Flora and Fauna Habitat

During rehabilitation activities, impacts on native flora and fauna will be avoided or minimised wherever feasible. The amount of vegetation disturbance required by the rehabilitation activities will be of a size that revegetation of the disturbed area would occur naturally from adjacent native vegetation. Monitoring of the areas will occur and should it be necessary, actions will be taken to ensure that before the area is no longer monitored, the flora and fauna habitat will be safe stable and non-polluting.

Terrestrial flora and fauna habitats in the area have been studied by ecologists. Some primary and secondary clearing will be required to establish staging areas and access to the sites. The work will be implemented such that significant flora and fauna, or their habitats is minimised where practical. Vegetation clearing will be undertaken in accordance with the process and management measures in Section 6 of the Appin Mine Biodiversity Management Plan (BMP).

The area was investigated on the 29 and 30 May 2023, and 19 June 2023 by Niche Environment and Heritage (Niche). The purpose of these site inspections was to verify existing vegetation mapping, including the presence of Threatened Ecological Communities (TECs) and to determine flora and fauna habitat of the study area. As this was primarily a habitat-based assessment, targeted threatened species surveys were not undertaken, apart from a targeted search for Small-flower Grevillea (*Grevillea parviflora subsp. parviflora*) (SFG).

The study area contains several plant community types (PCTs) including # 3615 Sydney Hinterland Apple-Blackbutt Gully Forest and # 4086 Sydney Coastal Sandstone Riparian Scrub. Both of these PCTs are not listed as a TEC under the *Biodiversity Conservation Act* (*BC Act*) or *Environmental Protection and Biodiversity Conservation Act* (*EPBC Act*). The threatened flora species recorded within the study area is SFG. This species is considered vulnerable under both the *BC Act* and *EPBC Act*. 63 plants were identified from 23 locations across the study area. There is a known broader Appin and Wedderburn population for this species and there are 1049 local records within 10 km recorded on BioNet.

The threatened flora species SFG was detected at 23 locations within the study area, including on existing pedestrian tracks that were intended to be cleared and extended to driving tracks. The SFG will be avoided by realigning the access road where practical, and in consultation with the landowner and an ecologist.

5.7 Dust

The rehabilitation techniques proposed will not generate dust. Increased vehicular movements have the potential to generate dust. The following safeguards will be employed to protect air quality:

- Minimise soil disturbance.
- All vehicles, plant and equipment are modern, well maintained and fit for purpose. Emissions from these items will be regulated by their standard exhaust systems.
- All vehicles and other equipment will be switched off when not in use.

5.8 Noise

The rehabilitation area is remote from sensitive receivers and noise is not expected to be an issue. Operations will only be conducted during daylight hours.

5.9 Fuels and Lubricant Management

Any fuels or lubricants required will be kept in self-contained vessels or appropriately bunded away from the river. Volumes of material on site will be limited to that to be used for day to day operations.

Emergency spill response equipment will be located at the work sites where spills could occur.

5.10 Waste Management

Consumables and rubbish generated from any rehabilitation works will be removed from work sites daily. Fully maintained chemical toilets will be made available for the work crews for the duration of the rehabilitation activities.

5.11 Site Management of Work Area

IMC. The Contractor will be responsible for managing the site and will develop site specific Safety and Environmental management plans for review by IMC prior to commencement of work.

5.12 Review of Environmental Factors

A Review of Environmental Factors (REF) will be prepared by a specialist consultant and submitted to the DPE prior to the commencement of rehabilitation works. The REF will address, in detail, the criteria noted in Section 5.

As noted in the letter from DPE approving the remedial actions as described in the GRRP on 25 June 2020, the REF is not required for approval of the rehabilitation. The REF, including an Aboriginal Cultural Heritage Due Diligence Assessment, was prepared in July 2023 and the findings incorporated into this document and the rehabilitation contractor's management plans.

The outcomes and recommendations of the Aboriginal Cultural Heritage Due Diligence Assessment is summarised in Section 5.13, in accordance with the recommendations of the REF.

5.13 Aboriginal Cultural Heritage Due Diligence Assessment

Niche was commissioned by IMC to undertake an Aboriginal Objects Due Diligence (DD) Assessment in for remediation works along the Georges River.

An extensive Aboriginal Heritage Information Management System (AHIMS) search was completed on 2 May 2023 (Service ID # 777716) covering the Activity Area and a minimum buffer of 3 km. The AHIMS search identified 115 Aboriginal cultural heritage sites and no Aboriginal Places. Several sites occur within 100 m of the Activity Areas. Two sites identified in the AHIMS search area were recorded as having restricted status (AHIMS ID# 52-2-2101 and 52-2-4747). Heritage NSW confirmed by email on 4 May 2023 that neither site will be impacted by the proposed works, on the basis of information provided.

A site inspection was conducted by Niche heritage consultant on 29 May 2023 – 30 May 2023. The inspection surveyed proposed rehabilitation work locations, laydown locations and access tracks. One new Aboriginal cultural heritage site Georges River Tree-1 (AHIMS ID#TBC) was identified along the southern bank of the proposed area of works. The site contains a Blackbutt tree (*Eucalyptus pilularis*) with a single south facing elongated scar with regrowth. No other new sites were identified during the site survey.

Aboriginal cultural heritage sites Georges River No 1 (AHIMS ID#52-2-2234) and Georges River Tree-1 (AHIMS ID#TBC) were identified within the Activity Area, in proposed Working Area 11 and 7 respectively. Aboriginal cultural heritage site Georges River No 3 (AHIMS ID# 52-2-2244) was located approximately 20 m south of proposed Working Area 9 and 20 m west of proposed Working Area 8.

Table 3 Summary of AHIMS sites in close proximity to the Activity Areas

AHIMS ID #	Site name	Site details	Site status on AHIMS	Proximity to Activity Area
52-2-2234	GEORGES RIVER NO.1	Shelter with Art	Valid	Directly adjacent to Working Area 11 to the west
52-2-2244	GEORGES RIVER NO.3	Shelter with Art	Valid	20 m west of Working Area 8 and 20 m south of Working Area 9
AHIMS ID#TBC	Georges River Tree-1	Scar tree	N/A	Adjacent to Working Area 7

The assessment concluded that the proposed works are unlikely to directly impact the three identified Aboriginal cultural heritage sites. The following safeguards will be implemented during the works, in addition to the safeguards within the Appin Mine Heritage Management Plan (HMP):

- Consideration of avoidance or minimisation of harm strategies as per Section 7.5 of the HMP to ensure no indirect impacts as a result of the proposed works.
- Demarcate (flag) the identified Aboriginal cultural heritage sites adjacent to work areas, or of the approved disturbance footprint for the work area.
- Should earthworks be required to be undertaken outside the footprint assessed in the DD assessment, a further assessment should be undertaken prior to work in those areas.
- All workers should be inducted into the work area, so they are made aware of their obligations under the *National Parks and Wildlife Act 1974* prior to, during and following the proposed works.
- Work vehicles must be confined to designated access tracks and work areas.
- The Aboriginal cultural heritage sites will be managed in accordance with the unanticipated finds protocol outlined in Section 9.3 of the Appin Mine HMP (2021).
- In the event that impacts are identified at Aboriginal cultural heritage sites during proposed works, Section 9.1 of the HMP will be followed. If unanticipated human remains are discovered, the procedure outlined in Section 9.4 of the HMP is to be followed.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis of monitoring data, Georges River catchment modelling and an assessment of rehabilitation options available, the proposed rehabilitation of Georges River features will involve sealing of the fractured riverbed using a combination of hand mortaring, pattern grouting and grout curtains. Such techniques were used to successfully restore water levels and flows to the Georges River where West Cliff previously mined directly beneath it.

The criteria for success for the remediation activities have been derived through consultation with key agencies and subsequent revision of this Plan. The proposed rehabilitation works and the key success criteria for the project are outlined in Table 2.

7. APPENDIX 1 – GEORGES RIVER SUBSIDENCE IMPACTS

8. APPENDIX 2 – GEORGES RIVER MANAGEMENT PLAN TARP

GEORGES RIVER	CHARACTERISTICS OF LEVEL	ACTIONS	ACTION BY	NOTIFICATION
Normal	• No observable mining induced fractures in rockbars or base of Georges River • No reduction in water level of mapped pools under similar flows comparing pre-mining and post-mining – pools generally full • Where no discharge from BCD occurs, Georges River becomes ephemeral - some pools drain naturally at pre-mining rate • Survey Cross Lines: <100 mm closure measured	• No remedial action necessary • Monthly review meeting • Continue monitoring program	Manager Approvals	None necessary Notify agencies for information only if BCD discharges reduce/cease and pool water levels drop due to natural causes
Level 1 (Within Predicted Impact Criteria)	• Fracturing in rockbar or bed of the Georges River which does not cause reduction of water level in mapped pools, when comparing pre-mining baseline and post mining • Iron staining greater than pre-mining levels • Gas releases • Water chemistry parameters do not exceed first trigger point when comparing against upstream/downstream and/or pre-mining and post-mining results • Survey Cross Lines: >100 mm closure measured as a result of LW35 - 36	• No remedial action necessary • Monthly review meeting • Continue monitoring program • Increase Survey Monitoring Programme to weekly for all Georges River Cross Lines	Manager Approvals Manager Survey	Notify agencies of Level 1 impacts in monthly subsidence report
Level 2 (Within Predicted Impact Criteria)	• More than negligible diversion of flows or changes in the natural drainage behaviour of pools for less than 20% of the stream length subject to vertical subsidence >20 mm e.g. fracturing in rockbar or bed of the Georges River which causes reduction of water level in mapped pools, which are unable to be maintained with intervention • More than negligible iron staining or gas releases for less than 20% of the stream length subject to vertical subsidence >20 mm e.g. iron staining or gas releases resulting in a measurable ecological impact • More than negligible increase in water cloudiness for less than 20% of the stream length subject to vertical subsidence >20 mm e.g. water cloudiness resulting in a measurable ecological impact • Survey Cross Lines: >200 mm closure measured as a result of LW35 - 36	• Increase monitoring/inspection frequency of key sites to twice weekly • Increase discharge from BCD to maintain pool water levels for ecosystem protection • Develop and following appropriate approvals implement remedial action such as manual crack filling with local materials e.g. sand and debris to reduce rockbar bypass flow • Review management options, including implementation of; measures to reduce the level of observed impacts and mine plan changes to ensure Level 3 impacts are not induced by future longwall(s) • Within three months of the completion of the longwall, assess the magnitude of pool water level reduction. If ongoing mining induced pool water level reduction is occurring, develop remedial works to restore pool water level. Implement remedial works as soon as subsidence movements within Area 5 that may affect the rehabilitation works are complete and appropriate approvals are in place • Develop and implement monitoring program to ensure effectiveness of remedial works if they are required	Manager Approvals	Notify agencies of Level 2 impacts within 24 hours of confirmation Notify agencies of gas release, iron staining and/or minor water quality changes in monthly report Confirm implementation of action(s) with agencies Notify relevant technical specialists Update progress in monthly subsidence report
Level 3 (Exceeding Predicted Impact Criteria)	• Exceed Subsidence Impact Performance Measures as specified in the Bulli Seam Operations Project Approval (see Section 2 above), including: • More than negligible diversion of flows or changes in the natural drainage behaviour of pools for more than 20% of the stream length subject to vertical subsidence >20 mm e.g. fracturing in rockbar or bed of the Georges River which causes reduction of water levels in mapped pools, which are unable to be maintained with intervention • More than negligible iron staining or gas releases for more than 20% of the stream length subject to vertical subsidence >20 mm e.g. iron staining or gas releases resulting in a measurable ecological impact • More than negligible increase in water cloudiness for more than 20% of the stream length subject to vertical subsidence >20 mm e.g. water cloudiness resulting in a measurable ecological impact	• Increase monitoring/inspection frequency of key sites to twice weekly • Increase discharge from BCD or Appin East Main Dam to provide a minimum refuge water level in pools for minimum ecosystem protection • Implement remedial action such as manual crack filling with sand or hand mortaring to reduce rockbar bypass flow • Review management options, including implementation of additional mitigation and contingencies measures to reduce the level of observed impacts (e.g. maintenance watering of aquatic plants and relocation of aquatic fauna) and mine plan changes to ensure further Level 3 impacts in other parts of the Georges River are not induced by future longwall (s) • Within three months of the completion of the longwall, assess the magnitude of pool water level reduction. If ongoing mining induced pool water level reduction is occurring, develop remedial works to restore pool water level. Implement remedial works as soon as subsidence movements within Area 5 that may affect the rehabilitation works are complete and appropriate approvals are in place • Develop and implement monitoring program to ensure effectiveness of remedial works	Manager – Approvals	Notify agencies of Level 3 impacts within 24 hours of confirmation Confirm implementation of action(s) with agencies Notify relevant technical specialists Update progress in monthly subsidence report Provide completion report that demonstrates successful rehabilitation outcomes

9. APPENDIX 3 - GEORGES RIVER - LONGWALL 33 REMEDIATION OPTIONS

Option	Brief Description	Essence of Method	Examples of application	Advantages	Expectation of success	Disadvantages	Likelihood of adverse impact	Conse-quence	Risk
	"Do nothing"								
1	"Do nothing"	Leave the river in its current condition and rely upon natural processes to re-establish the perched river as existed prior to mining.	Natural processes	This method does not introduce materials into the river system and relies upon natural sealing of openings in the rock mass though river detritus and sediments.	High (in the long term)	It may take many decades for the natural processes to re-establish the perched river environment.	Almost Certain (in the short term)	Medium	High (in the short term)
	Local crack treatment								
2	Hand grouting	Identify and treat, with hand-held tools and injection using mortar, wide cracks within the rockmass that have been identified as points of water diversion.	Surface fracture	Low technology; semi-skilled labour; small volumes, hence potential spill minimal; may need several attempts	Moderate	Limited ability to treat other than surface, hence partial solution; prone to damage (wilful or otherwise); difficulty in identification of point of leakage; may be cosmetic only	Rare	Insignificant	Very Low
	Curtain grouting								
3	Cement curtain grouting	Drill a line of closely spaced grout injection drill holes, through which cement grout is injected into the rockmass. Multiple passes, with several grout stages is anticipated. Grouting down to 20m to 25m is required. Curtains may be repeated sequentially down the river.	Dam construction	Closely defined area of work, hence aerial impact is minimised; known technology; spills can be readily contained; grouting success can be determined by borehole testing	Low	Single "line of defence"; creation of sub-surface weirs which may not fully restore water levels but produce intermittent "level ponds";	Possible	Minor	Low to Moderate
	Lining								
4	Eg: shotcrete, geosynthetic clay liner (GCL)	Provide a coverage of the wetted area of the river with an applied membrane that varies from: pneumatically applied shotcrete; sprayed bituminous layer; artificial liners (FML & GCL) as used for landfill liners; to a conventionally placed (in a civil engineering context) low permeability clay liner. All these options involve removal of all material from the river bed prior to construction of the liner, and hence have a short term impact upon the ecosystem in the river bed.	Civil engineering tunnels and mining works underground, rock stabilisation on F3 and similar roadways	Effective surface barrier; known civil and mining engineering technology; performance outcome; sculptured and coloured to match existing rockmass; small area application possible; readily mobilised; latex modifiers may assist (but not yet proven).	High	Brittle layer susceptibility to cracking in the event of rockmass shakedown (from, for example, further bedding down of subsidence or earthquake), hard surface; short term water quality and environmental impact during construction	Possible	Minor	Low to Moderate
	Pattern grouting								
5	Cement (+/- bentonite) pattern grouting	Drill injection holes on a pattern (commencing at a grid spacing of between 2m x 2m to 1m x 1m), therein injecting a grouting medium. The intention of this grouting would be to achieve a low permeability "layer" a couple of metres thick beneath the river bed over its length. Use of small air-powered drill.	Georges River remediation work	Drillhole injection system minimises site disturbance; multiple passes can be accommodated;	Very High	Poor control on grout take and travel	Possible	Minor	Low to Moderate
6	Polyurethane injection		Waratah Rivulet	Minimises surface disturbance; good control of injection pressures and penetration into rockmass	Very High	Potential use of solvents for clean-up; handling requires specific OH&S techniques;	Possible	Minor	Low to Moderate
	Permeation grouting								
7	Bentonite / sand / cement	Isolate a section of river bed by temporary bunding which will permit the impoundment of grouting media of various viscosities, that permit introduction of the grout by flowing under the influence of gravity. The mixture will vary for treatment of open (wide) cracks and fine cracking. The impoundment and treatment would be repeated cyclically along the identified length of the river.	Natural infiltration; variation of in-situ stabilisation work at KCT stockyard (2 km long)	Mimics natural process to introduce grout into rockmass; continue within isolated paddock until sealing of rockmass is achieved; can take advantage of existing river sediment. "sucker" trucks or pumps enable re-use of ponded grout; ability to change mixture as programme advances in a paddock	High	Breach of coffer dam (say flood induced erosion) will release grout into river; short term impact upon riverine environment; likely to need viscous grout to achieve grouting of open cracks	Possible	Minor	Low to Moderate
	Deep angled hole grouting								
8	Cement / bentonite delivered remotely	Directionally drilling holes into the river from some distance away to allow grout to be delivered from a remote location	Pools that are not completely drained	Allows grouting where access difficulties make pattern grouting inappropriate (for example where a pool has not totally drained)	High	Need for directional drilling and grout of particular viscosity to inject.	Possible	Minor	Low to Moderate
	Combination of methods.								
9	Combination of methods.	Selective treatment using the best of various methods - such as local crack treatment with a broad area method suited to treatment of fine cracks.		Employ the best elements of several methods to address rockmass defects of different size, opening and extent	Very High	The preferred combination is pattern grouting and hand mortaring.	Possible	Minor	Low to Moderate

10. APPENDIX 4 – SDS

11. APPENDIX 5 - WEST CLIFF AREA 5 LWS 37 & 38 EXTRACTION PLAN TARP

Attachment A – Table 2 West Cliff Area 5 Longwall 37 and 38 Water TARP

Monitoring	Trigger	Action
WATER QUALITY		
Adjacent and downstream sites for Longwalls 37 and 38. • Georges River: - Pool 54 - Pool 64 - GR100	***Level 1 **** • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing the baseline period to mining period for that site i.e. : – pH drop between 0.5 and 1.0 units from the minimum baseline value	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing the baseline period to mining period for that site i.e.: – pH drop between 1.0 and 1.5 units from the minimum baseline value	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3 * • Reduction in water quality (observed for more than 2 consecutive months) when comparing the baseline period to mining period for that site i.e.: – pH drop of 1.5 units from the minimum baseline value	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Emplacement of sandstone rocks in constricted stream flow areas to increase the aeration capacity where it is appropriate to do so - Grouting of fractures which result in flow diversion • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

Monitoring	Trigger	Action
GROUNDWATER		
BHPBIC Piezometers: • GR27 • GR28 • GR29 • GR70 • WC54 • WC95 **Private bores:** • GW32310 • GW72454 • GW105921 • GW108322 Mine water budget	***Level 1 **** • Increase in water flow from the goaf between 2.7-3 ML/day (20 day average) • 5.0 – 7.5 m reduction in the Hawkesbury Sandstone greater than predicted standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Rise in water flow from the goaf between 3-3.4ML (20 day average) • 7.5 – 10 m reduction in the Hawkesbury Sandstone greater than predicted standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved
	Level 3 * • Abnormal rise in water flow from the goaf >3.4ML (20 day average) • >10m reduction in the Hawkesbury Sandstone standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period • Total loss of groundwater level within a private bore	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Any actions agreed to in the Property Subsidence Management Plan - Provision of alternate water supply where this has been impacted by mining • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful
APPEARANCE AND POOL WATER LEVEL		
Georges River: • All mapped pools in the mining area	***Level 1 **** • Fracturing with no observable surface water diversion • Pool water level lower than baseline in any mapped pool located in the mining area (within 400m of the longwall) • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR

Monitoring	Trigger	Action
	Level 2 * • Pool water level lower than baseline in the majority of mapped pools located in the mining area (within 400m of the longwall) • Fracturing with observable surface water diversion	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts. Prevailing rainfall and catchment conditions will be taken into account when assessing pool water level response and the need for CMAs*
	Level 3 * • Pool water level lower than baseline in all mapped pools in the mining area (within 400m of the longwall) • Fracturing with observable water diversion results in any mapped pool becoming dry during a mitigation flow in the River	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Grouting of fractures which result in flow diversion • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders *<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts. Prevailing rainfall and catchment conditions will be taken into account when assessing pool water level response and the need for CMAs*
	Exceeding Performance Measures • More than negligible diversion of flows or changes in the natural drainage behaviour of pools over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in water cloudiness over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in iron staining over more than 20% of the stream length subject to vertical subsidence >20mm • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

LANDSCAPE FEATURES		
Cliffs: • GR-CL01 and • GR-CL02 **Steep slopes** **Georges River – including pools and rockbars:** • GR-RB42 • GR-RB43 • GR-RB44 • GR-RB45 • GR-RB47 • GR-RB48 • GR-RB49 • GR-RB51 • GR-RB52 • GR-RB53 • GR-RB54 • GR-RB55 • GR-RB56a • GR-RB56b • GR-RB57 • GR-RB59 • GR-RB60 • GR-RB61 • GR-RB62 • GR-RB63 • GR-RB64 • GR-RB65 • GR-RB66 • GR-RB67	***Level 1 **** • Rock fall from a cliff where the cliff is left mostly intact (<10% length of the cliff) • Surface movement or rock displacement where any exposed soil surface is stable • Crack at the surface which does not result in ongoing erosion or ground movement • Erosion which stabilises within the period of monitoring without CMA • Crack or fracture up to 100mm width • Crack or fracture up to 10m length	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Rock fall from cliff where the characteristics of the cliff change (>10% length of the cliff) • Ground disturbance that is unlikely to stabilise within the period of monitoring without CMA • Mass movement of a slope causing areas of exposed soil • Crack or fracture between 100 and 300mm width • Crack or fracture between 10 and 50m length	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Provide safety signage and barricades as appropriate • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3 * • Cliff collapse (100% length of cliff) • Ground disturbance that does not stabilise within the period of monitoring • Mass movement of a slope causing areas of exposed soil that does not stabilise within the period of monitoring • Crack or fracture over 300mm width • Crack or fracture over 50m length	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Erosion prevention works - Establishment of vegetation • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*

	Exceeding Performance Measures • For cliffs of 'special significance' - more than negligible environmental consequences (i.e. more than occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impact more than 0.5% of the total face area of such cliffs within any longwall mining domain) • Other cliffs - more than minor environmental consequences (that is occasional rockfalls, displacement or dislodgment of boulders or slabs or fracturing, that in total impact more than 3% of the total face area of such cliffs within any longwall mining domain)	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

* These may be revised in consultation with DP&I and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data. These TARPs relate to West Cliff Area 5 Longwalls 37 and 38.

Office of Environment and Heritage (OEH)
Department of Planning and Infrastructure (DP&I)
Department of Primary Industries: including Division of Resources and Energy, Office of Water, Fisheries (DPI)

12. APPENDIX 6 – GEORGES RIVER CATCHMENT MODELLING STAGE ONE (WSP)

13. APPENDIX 7 – RISK ASSESSMENT