NOTE (non-printing)

LIDDELL

GLENCORE

EPBC Approval 2013/6908

Annual Report 2021

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1. Introduction

1.1 Background

Liddell Coal Operations (LCO) is an established open-cut mine located at Ravensworth, approximately 25 kilometres north-west of Singleton in the Upper Hunter Valley of New South Wales. LCO is operated and managed by Liddell Coal Operations Pty Limited, a wholly owned subsidiary of Glencore Coal Pty Limited (Glencore), on behalf of a joint venture between Glencore (67.5%) and Mitsui Matsushima Australia (32.5%).

Mining operations at Liddell Coal have been continuous since the 1950s. Operations prior to the 1950s were intermittent, with underground operations commencing in 1923 and open cut operations in 1946. Current open cut operations access the coal reserves previously not mined by the underground operations. The current open cut mining operation has been in operation since 1990. Figure 1-1 shows LCO's referral areas under EPBC 2013/6908.

On 24th December 2014, LCO was granted EPBC Approval 2013/6908 for a controlled action under the Environment Protection and Biodiversity Conservation Act 1999 to expand the existing Liddell open cut coal mine operations in the Hunter Valley region in New South Wales, under the following Controlling Provisions:

- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 and 20A)
- Water resources/trigger (sections 24D and 24 E)

Mining activities commenced within the approval area on the 19 May 2015.

Figure 1-1 LCO EPBC 2013/6908 Referral Areas

1.2 Scope

Condition 19 of EPBC Approval 2013/6908 requires an annual compliance report to be published on the LCO website addressing:

- compliance with each of the conditions of the Approval; and
- details of implementation of the management plans required by the Approval.

This annual compliance report covers the period 19 May 2020 to 18 May 2021 for Condition 19 of EPBC Approval 2013/6908.

2. Statement of Compliance

Table 1 reproduces the "risk levels" from the ***Independent Audit Guideline. Post-approval requirements for State significant developments (Audit Guidelines)*** (DP&E, 2015) which were attributed to the non-compliances identified during the audit period.

Table 2 below outlines:

- The conditions of EPBC Approval 2013/6908
- A summary of actions completed during the reporting period with a respect to each condition
- The corresponding compliance status with reference to ***Table 1***.

Non-compliances identified in ***Table 2*** are ranked in accordance with the ***Audit Guidelines.***

Table 2-1 - Risk Levels for Non Compliances

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

Table 2-2 - EPBC 2013/6908 Compliance Status

Condition	Actions During Reporting Period	Status
1. The footprint of the action must be no more than 185 ha and must be kept within the areas marked as "Referral Areas" in Figure 1.2 (Annexure C). The approval holder must not clear more than 121 ha of native woodland.	Pre-strip clearing in the referral area was completed in January 2020. During the reporting period (19 May 2020 to 18 May 2021) LCO did not conduct any further clearing in the referral area. Since commencement of the action LCO has cleared 145.5ha of land within the referral area; of which 107.78ha consisted of native woodland including regenerating woodland.	Compliant
2. To protect threatened species, the approval holder must prepare and submit a Biodiversity Management Plan to the Minister for approval prior to commencement of the action. This Plan must contain detail of the following mitigation measures: a. Fencing and access control; b. Weed control; c. Feral animal control; d. Bushfire management; e. Habitat enhancement measures; f. Tree feeling procedure; g. Indirect impact mitigation measures; and h. Adaptive management.	The Biodiversity Management Plan (BMP) was submitted to the Department of Environment (DoE) on 26 March 2015. The BMP was deemed to meet the requirements of the condition and was approved on 14 May 2015. During the reporting period, a revised BMP was submitted on 4 June 2021 in accordance with Condition 22. LCO considers that implementation of the revised plan is not likely to cause new or increased impact. Operations have continued to be implemented as per the Biodiversity Management Plan detailed in **Section 3.1**.	Compliant

3. The approval holder must not commence the action until the Biodiversity Management required under Condition 2 has been approved by the Minister. The approved Plan must be implemented. Note: if more convenient for the approval holder, the requirements of this plan may be met through revision and submission for approval by the Minister of the existing Landscape Management Plan that provides: a. a copy of the management plan, marked up to show the revisions, in both hard copy and electronic copy; and b. A clear summary of all the revisions that have been made to the management plan, and the reasons for these revisions	The BMP was approved on 14 May 2015. The action was commenced on 19 May 2015. Implementation of the BMP commenced after approval and a summary of activities completed to date is provided in **Section 3.1**.	Compliant
4. The Biodiversity Management Plan required under condition 2, must include the following information, which must be specific, measurable, realistic and time-bound in relation to each measure listed in condition 2: a. environmental objectives; b. performance criteria; c. methodology; d. duration and frequency of actions to be implemented; e. monitoring and reporting of the effectiveness of the measures; f. corrective actions; g. criteria for triggering corrective actions, should performance criteria not be met; and h. responsibility for implementation.	The BMP submitted was deemed to meet the requirements of this condition and was approved on 14 May 2015. During the reporting period, a revised BMP was submitted on 4 June 2021 in accordance with Condition 22. LCO considers that implementation of the revised plan is not likely to cause new or increased impact.	Compliant
5. To protect threatened species and water resources, the approval holder must progressively rehabilitate the areas marked as "Referral Areas" in Figure 1.2 (Annexure C) to achieve a self-sustaining landform consisting of Central Hunter Grey Box-Ironbark Woodland and two mine voids. The Central Hunter Grey Box-Ironbark Woodland must be established progressively, in accordance with the Rehabilitation and	LCO undertook rehabilitation in accordance with the Rehabilitation Environmental Management Plan (RMP/MOP) as approved under the NSW Approval. A revised copy of the RMP/MOP was forwarded to the Department on 29th July 2021. Further detail is provided in **Section 3.1.3.**	Compliant

Environmental Management Plan required by Condition 39 of Schedule 3 of the NSW Approval, once the Plan is approved by the NSW Government. The approved Plan must be provided to the Department.		
6. In order to compensate for residual significant impacts on threatened species, the approval holder must protect the offset areas through a legal instrument under relevant conservation legislation prior to 30 June 2019 or another date agreed to in writing by the Minister. The legal instrument must: a. be registered on title of the Offset areas; b. provide for the protection and ongoing conservation management of the Offset areas in perpetuity; c. prevent any future development activities or clearing of native vegetation on the Offset areas; and d. require the approval of a State Planning or Environment Minister to be changed or revoked.	Offsets lands specified under this approval are owned by LCO and are managed in accordance with the Biodiversity Offset Management Plan (BOMP). On the 2nd July 2019 the Minister agreed in writing to extend the required date until 30th November 2019. There are four Conservation Agreements registered on title for the offset areas: • VC00505 Mitchell Hills South Conservation Area (08/08/2019) • VC0525 Mountain Block Conservation Area (01/10/2019) • VC00506 Bowmans Creek Riparian Corridor (01/10/2019) • VC00516 Bowmans Creek Riparian Corridor East (06/08/2019	Compliant
7. The approval holder must provide the Department with details of the offset areas, including offset attributes, shapefiles, textual descriptions and maps to clearly define the location and boundaries of the offset area, to be submitted to the Department prior to commencement of the action.	The required data was submitted on 4 May 2015. The action commenced on the 19 May 2015. An application to vary the boundary of the Bowmans Creek Riparian Corridor was submitted to the Department on 13 April 2017 along with a revised BOMP. This variation was approved along with the BOMP on 4 December 2017. Implementation of the Conservation Agreements to satisfy Condition 6 above required detailed survey of the offset	Compliant

	areas. Consequently LCO submitted revised attribute data to the Department on 24 December 2018.	
8. To ensure management of the offset areas, the approval holder must submit an Offset Management Plan to the Minister for approval prior to 31 May 2015 to provide for the conservation and management in perpetuity of the offset areas. The Plan must include: a. a detailed methodology, frequency, timing and duration of all Offset area management measures proposed. The management measures must include: i. weed and pest control; ii. fencing; iii. ecological monitoring; and iv. assisted regeneration. b. key milestones, performance indicators, corrective actions and timeframes for the completion of all actions outlined in the Plan; c. a detailed methodology, timing goals and corrective actions for revegetation of: i. the Bowmans Creek Riparian Corridor, in accordance with Figure 8.3 (Annexure D) ii. the Mountain Block Offset Site, in accordance with Figure 8.4 (Annexure E); and iii. exotic grassland and derived grassland areas of the Mitchells Hills South Offset Area, as depicted in Figure 3.1 of the letter from David Foster to the Department dated 29 October 2014 (Annexure F), with native woodland or forest communities that occur on the site.	The Biodiversity Offset Management Plan (BOMP) was submitted on 29 May 2015. The BOMP was deemed to meet the requirements of the condition and was approved on 5 January 2016. During the reporting period a revised BOMP submitted on 4 June 2021 in accordance with Condition 22. LCO considers that implementation of the revised plan is not likely to cause new or increased impact.	Compliant

9. The approved Offset Management Plan required under Condition 8 must be implemented.	Monitoring activities associated with the BOMP commenced in Spring/Summer 2015 while the plan was under assessment. Implementation of the BOMP has continued since this time, including the incorporation of changes made by a revision of this plan approved on 4 December 2017 and minor revisions submitted under condition 22 in: • November 2018 • September 2019; • February 2020; and • June 2021. LCO considers that implementation of the revised plan is not likely to cause new or increased impact. A summary of activities completed to date is provided in **Section 4.1**.	Compliant
10. To compensate for residual significant impacts on the Spotted-tailed Quoll, the approval holder must provide an Indirect Offset Plan to the Minister for approval, prior to 30 June 2015. This Plan must specify how it will allocate $243 000 over a period of not more than five years for recovery actions for the Spotted-tailed Quoll, as identified in either the Draft National Recovery Plan for the Spotted-tailed Quoll- Dasyurus maculatus (K. Long and J. Nelson 2008) or in the NSW Office of Environment and Heritage's Saving Our Species Project Species Action Statement. The Plan must include: a. a detailed description of the actions funding, including location and timing of activities; b. demonstration of how the funded activities are additional to any offset requirements of any existing approval conditions and additional to existing practise or other requirements; c. an explanation of how the activities described in the Plan will contribute to conservation of the Spotted-tailed Quoll;	The Indirect Offset Plan (IOP) was originally approved on 5 May 2016. A revised IOP was submitted to the Department on 30 March 2017. The revised IOP details amended projects Task 2 Surveying/Monitoring STQ Populations and Task 3 Assess Habitat Use by Female STQ. This IOP was deemed to meet the requirements of Condition 10 and approved 5 September 2017. Further revisions were submitted on 17 December 2020, and subsequently approved under Condition 10 on 26 May 2021.	Compliant

d. provisions to ensure appropriate management of funds and that auditable financial records are kept and maintained; e. provision for publication of findings: i. of a standard that would be acceptable for publication in an internationally recognised peer-reviewed scientific journal; and ii. together with methodologies and results, on the internet within twelve months of the collection of results and in a form that may be accessed by the public.		
11. The approved Indirect Offset Plan must be implemented.	Implementation of approved projects under the IOP is discussed in further detail in **Section 4.2**.	Compliant
12. To protect water resources and threatened species, the approval holder must submit a Water Management Plan (WMP) for approval by the Minister prior to commencement of the action which provides for the avoidance and mitigation of impacts to water resources and threatened species. The plan must include the following: a. Management action, mitigation measures and practices designed to limit impacts of the proposal on surface and ground water resources. Management actions, mitigation measures and practices prescribed by the plan must be clear, measurable, auditable and time bound; b. Surface and groundwater monitoring program, that must be implemented for the life of the action, to monitor the success of the management actions in the WMP, define measurable targets of management actions and performance indicators, and provide an adaptive management framework for the duration of the action's impact on water resources. This program must include: i. surface water quality, including pH, electrical conductivity, total suspended solids and total dissolved solids, in Bayswater Creek and Bowmans Creek each month, at each	The Water Management Plan (WMP) was submitted to the Department of Environment (DoE) on 26 March 2015. The WMP was deemed to meet the requirements of the condition and was approved on 14 May 2015. The action commenced on 19 May 2015. A revised WMP was approved on 26 July 2017, primarily amending the groundwater monitoring triggers and associated response plan. During the reporting period, the WMP was revised and submitted in accordance with Condition 22 on 12 July 2021. LCO considers that implementation of the revised plan is not likely to cause new or increased impact.	Compliant

of the sites specified in Figure 9.11 of the Preliminary Documentation; ii. groundwater quality at least every two months and groundwater pressures and levels at least monthly at each location depicted in figure 2-13 of the Groundwater Impact Assessment (Annexure A) and; iii. documentation of the reference value against which the 2 meter drawdown trigger for the Bowmans Creek alluvium will be assessed and a justification of this reference value. c. Clear objectives and performance indicators, timeframes for the completion of all actions outlined in the Plan as well as corrective actions for circumstances where a management action, mitigation measure or practice fails to meet its prescribed objective or performance indicator.		
13. The approved Water Management Plan must be implemented.	Implementation of the WMP commenced after approval and a summary of activities completed to date is provided in **Section 5**.	Compliant
14. The approval holder must only discharge water into the Hunter River or its tributaries in accordance with the Hunter River Salinity Trading Scheme.	During the reporting period, LCO discharged water into a Hunter River tributary in March and April 2021 under the provisions of the Hunter River Salinity Trading Scheme. Further information is provided in **Section 5.1.3**.	Compliant
15. If monitoring of surface water quality identifies an exceedance of the Trigger Values for surface water, the approval holder must: a. keep a written record of the exceedance; b. report the exceedance to the Department within 5 business days of the monitored exceedance if the exceedance has the potential to result in environmental harm; c. unless agreed otherwise by the Department in writing, complete an investigation into the potential for environmental harm for any	The surface water quality monitoring Investigation Trigger Action Response Plan (ITARP) was instigated during the reporting period. Further information is provided in **Section 5**.	Compliant

exceedance described in condition 15b. and provide a written report to the Department within 30 calendar days of receiving the result, including: i. a description of the investigations carried out; ii. a statement of the cause and extent of the exceedance; iii. an assessment of the potential for environmental harm; iv. actions taken to prevent environmental harm, if required; and v. actions taken to prevent exceedance from re-occurring in the future.		
16. If groundwater monitoring identifies groundwater drawdown in the alluvium of Bowmans Creek of more than 2 metres, the approval holder must: a. report this to the Department within 5 business days of the monitored exceedance; b. unless agreed otherwise by the Department in writing, complete an investigation into the potential for environmental harm and provide a written report to the Department within 30 calendar days of receiving the result, including: i. a description of the investigations carried out; ii. a statement of the cause and extent of the drawdown; iii. actions taken to prevent environmental harm; and iv. actions taken to prevent exceedance from re-occurring in the future.	The Bowmans Creek groundwater drawdown ITARP was not triggered during the reporting period. Further information is provided in **Section 5**.	Compliant
17. Within 21 calendar days after the commencement of the action, the approval holder must advise the Department in writing of the actual date of commencement.	The action was commenced on the 19th May 2015 and correspondence with communication regarding the notification of commencement was sent to the Department Post Approvals (reference LCO 15/039).	Compliant

18. The approval holder must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the Indirect Offset Plan (described in condition 10), Water Management Plan (described in condition 12) and Biodiversity Management Plan (described in condition 2) required by this approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	LCO maintains accurate records in accordance with Condition 18.	Compliant
19. Within three months of every 12 month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication must be provided to the Department at the same time as the compliance report is published.	The EPBC Approval 2013/6908 12-month anniversary of commencing the action is 19 May. The 2021 Annual report was published on the LCO public website on 17 August 2021. Notification was provided to the Department on 17 August 2021.	Compliant
20. Potential or actual contraventions of the conditions of the approval must be reported to the Department in writing within 2 business days of the approval holder becoming aware of the actual or potential contravention. All contraventions must be included in the compliance reports.	There were no contraventions of EPBC Approval 2013/6908 identified during the reporting period.	Compliant
21. Upon the direction of the Minister, the approval holder must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister. The independent auditor must be approved by the Minister prior to the commencement of the audit. Audit criteria must be agreed to by the	Not triggered during the reporting period.	Compliant

Minister and the audit report must address the criteria to the satisfaction of the Minister.		
22. The approval holder may choose to revise a management plan approved by the Minister under conditions 2, 8 and 12 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the approval holder makes this choice they must: i. notify the Department in writing that the approved plan has been revised and provide the Department with an electronic copy of the revised plan; ii. implement the revised plan from the date that plan is submitted to the Department; and iii. for the life of this approval, maintain a record of the reasons the approval holder considers that taking the action in accordance with the revised plan would not be likely to have a new or increased impact.	During the reporting period LCO made revisions to the following management plans and submitted the revised plans to the department in accordance with Condition 22: • Biodiversity Management Plan – submitted 4 June 2021; • Biodiversity Offset Management Plan – submitted 4 June 2021; and • Water Management Plan – submitted 12 July 2021.	Compliant
22A. The approval holder may revoke their choice under condition 22 at any time by notice to the Department. If the approval holder revokes the choice to implement a revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.	Not triggered during the reporting period.	Compliant
22B. If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then: i. Condition 22 does not apply, or ceases to apply, in relation to the revised plan; and ii. The approval holder must implement the plan approved by the Minister.	Not triggered during the reporting period.	Compliant

To avoid any doubt, this condition does not affect any operation of conditions 22 and 22A in the period before the day the notice is given. At the time of giving the notice the Minister may also notify that for a specified period of time that condition 22 does not apply for one or more specified plans required under this approval.		
22C. Conditions 22, 22A and 22B are not intended to limit the operation of section 143A of the EPBC Act which allows the approval holder to submit a revised plan to the Minister for approval.	During the reporting period a revised Indirect Offset Plan submitted for approval on 17 December 2020.	Compliant
23. Revoked.	Not applicable.	NA
24. If, at any time after seven years from the date of this approval, the approval holder has not substantially commenced the action, then the approval holder must not substantially commence the action without the written agreement of the Minister. Note: The date stated in condition 24 relates to the date of the approval decision (24 December 2014).	Not triggered. Action commenced on 19 May 2015.	Compliant
25. Unless otherwise agreed to in writing by the Minister, the approval holder must publish all management plans referred to in these conditions of approval on its website. Each management plan must be published on the website within 1 month of being approved and remain published for the life of the approval.	During the reporting period all management plans referred to in these conditions were published on the Liddell Coal Website within one month of being approved. Revised plan sent on this date & published on the website: • Indirect Offset Plan – 17 December 2020; • Biodiversity Management Plan – 4 June 2021; • Biodiversity Offset Management Plan – 4 June 2021; and • Water Management Plan – 12 July 2021	Compliant

3. Avoidance & Mitigation of Impacts

3.1 Biodiversity

The objectives of the Biodiversity Management Plan (BMP) are to provide direction for the short to long term management and enhancement of the biodiversity values of the BMP Area, as well as to provide a detailed description of the measures to be implemented to achieve this over the next three years. The BMP area is defined as all land within Mining Lease 1597 boundary excluding any biodiversity offset areas.

Since the BMP was initially approved in August 2015, LCO is reporting compliance with Year 6 performance criteria during this reporting period. **Table 3-1** summarises the performance criteria set for Year 5 of operation of the BMP; and actions completed to date.

Table 3-1 - Biodiversity Management Plan Implementation Summary

Action/Item	Performance Indicator	Compliance	Performance Comment
Year 6 2020			
Fencing, Signage and Access Control			
Minimum twice-yearly inspections of fences and signage to identify any works required. Fencing and signage of relevant parts of BMP area should be as per Section 4.1	Inspections undertaken nominally in March and September. Damaged critical fences to be repaired within 1 week (temporary if needed), final repairs and non-critical repairs to be completed in 1 month	Compliant	Signage installed and maintained as required
Access Track Maintenance			
Minimum twice a year BMP Area inspections to identify track conditions, any works required and any unnecessary tracks to be remediated	Inspections undertaken nominally in March and September. Action and repair track damage or remediation where applicable.	Compliant	
Topsoil Management			
Areas containing weeds that may pose a threat to rehabilitation are targeted using appropriate weed control methods prior to topsoil stripping. Methods may include, foliar spraying, basal bark spaying, cut and paint, slashing and other mechanical methods as deemed appropriate.	Pre-stripping weed control of topsoil is completed, as needed.	Compliant. Weed control is completed prior to topsoil stripping (where required) to minimise future potential impact to	Weeds are managed in line with Weed Action Plan. Preclearance survey identifies any weed infestations requiring further management.

Action/Item	Performance Indicator	Compliance	Performance Comment
		rehabilitation success.	
Pathogen Management			
If reasonable potential for pathogens is identified in the BMP Area, appropriate pathogen monitoring and management protocols are developed and implemented.	If reasonable potential is identified, pathogens are considered in design and implementation of monitoring works. If identified (or potential identified), management actions for specific pathogens are developed and implemented.	Compliant	No signs likely to be associated with Phytophthora, myrtle rust or chytrid fungus observed during 2020 BMP monitoring.
Seed Collection			
Where suitable remnant vegetation is available, implementation of seed collection and handling program for use in revegetation/rehabilitation works.	Pre-clearing surveys identify potential seed sources. Seeds are collected, stored and handled according to appropriate program. Collected seed resources are used in revegetation/rehabilitation works.	Compliant.	Seed resources being collected and substituted in seed mix for rehabilitation as key species are available.
Vegetation Clearing			
Detailed pre-clearing procedure is to be implemented when clearing of woody native vegetation (including shrub, groundcover and isolated trees in grasslands).	Pre-clearing process is to be implemented as part of Ground Disturbance Permit process. Outcomes of pre-clearing process are recorded and recommendations are implemented.	Compliant.	LCO implements pre-clearing as part of Ground Disturbance Permit process with outcomes recorded and recommendations implemented.

Action/Item	Performance Indicator	Compliance	Performance Comment
Detailed tree-felling process is to be implemented when clearing areas of woody native vegetation (including shrub, groundcover and isolated trees in grasslands).	Tree felling process is to be implemented as part of the Ground Disturbance Permit process. Outcomes of tree-felling process are recorded and recommendations are implemented.	Compliant.	LCO implements tree-felling as part of Ground Disturbance Permit process, with outcomes recorded and recommendations implemented.
Translocation Works			
Translocation of tiger orchids or other threatened flora species (if encountered during pre-clearing process) to biodiversity offset areas.	Tiger orchids identified during pre-clearing process are salvaged during the tree felling process and are translocated into biodiversity offset areas. Any translocated individuals are subject to regular monitoring and maintenance works, if required. Reporting of translocation works and monitoring works is maintained.	Compliant.	One tiger orchid was relocated to the Mountain Block BOA and has been subject to regular monitoring and maintenance. Translocation is thus far deemed successful.
Remnant Vegetation and Habitat Management			
Remnant vegetation is to be protected from accidental impact.	Areas to be disturbed will be clearly defined in the field to prevent accidental impact to remnant vegetation.	Compliant	Remnant monitoring sites are in areas of undisturbed vegetation which are fenced to prevent unauthorised access. No accidental damage or removal of remnant vegetation was evident during BMP inspections. Fence line inspections are undertaken biannually in accordance with commitments of the BMP.

Action/Item	Performance Indicator	Compliance	Performance Comment
Remnant vegetation is protected from disturbance.	Remnant vegetation will be fenced or sign-posted as necessary to protect from disturbance. Annual inspections are completed to assess condition of fences and signs, areas of erosion concern, weeds or feral animals requiring control. Management works will be conducted, as necessary.	Compliant	Remnant monitoring sites are in areas of undisturbed vegetation which are fenced to prevent unauthorised access. No accidental damage or removal of remnant vegetation was evident. Annual monitoring included assessment of areas of erosion concern and introduced species. Fence line inspections are undertaken biannually in accordance with commitments of the BMP.
Annual inspections undertaken by suitably qualified personnel to assess the extent of natural regeneration occurring.	Annual inspection undertaken by suitably qualified personnel to assess extent of natural regeneration occurring. Appropriate action is undertaken if regeneration is deemed as being inadequate.	Partially compliant	Annual monitoring included assessing degree of regeneration of native trees. Native regeneration was identified and considered adequate at W02 and WR02. R01 is almost entirely dominated by weeds (particularly with increase in rainfall) in the ground cover and regeneration by native trees is unlikely to occur. Partial compliance rating to reflect further management action required to occur at R01.
Weed Control			
Complete weed inspections of BMP area every two months to document diversity and abundance of noxious weed records. This will then inform ongoing control actions (as needed), including timing, frequency, target species and methods to be used.	Inspections completed every two months, followed by implementation of required control methods, as required.	Compliant	Inspections being completed as required with appropriate weed priorities actioned.

Action/Item	Performance Indicator	Compliance	Performance Comment
Weed inspections of remnant and rehabilitation areas	Annual inspections are undertaken of remnant vegetation to identify areas of weed infestation. Weed management actions of infestations are undertaken in accordance with current or other best practice approaches.	Compliant.	Inspections being completed as required with appropriate weed priorities actioned. Annual Weed Action Plan completed and implemented. Annual monitoring undertaken and management recommendations to be actioned. Previously identified weeds being targeted and noted as being effective during monitoring and inspections.
Feral Animal Control			
Complete feral animal inspections of BMP area every two months to document sighting and abundance records. This will then inform ongoing control actions (as needed), including timing, frequency, target species and methods to be used.	Inspections completed every two months, followed by implementation of required control methods.	Complete	Inspections for feral fauna are completed every two months.
Develop and implement an effective annual pest animal action plan.	Develop and implement pest animal action plan. Stable or downward trend in population size recorded.	Compliant	Annual Pest Action Plan developed and implemented for 2020. Pest numbers appeared to be stable and low.
Develop a vertebrate pest control register to document when and where each control method is implemented.	Update and maintain vertebrate pest control register.	Compliant	Vertebrate pest control register maintained and updated throughout 2020.
Blue-billed Duck Management			
Complete habitat enhancement, maintenance and monitoring works (as required) for the blue-billed duck	Ongoing enhancement and management works within Dam 3 and two Triangle Dams. Monitoring works as required.	Compliant	Habitat values for Dam 1 and Triangle dams assessed during 2020 monitoring. Both provide moderate habitat value and water levels were good. Habitat enhancement was recommended through planting of aquatic vegetation.

Action/Item	Performance Indicator	Compliance	Performance Comment
			Seeding of the dams with aquatic species was completed in April 2021.
Habitat Enhancement			
Salvage of habitat features (particularly for the spotted-tailed quoll) such as hollow-bearing trees, logs, stumps, large rocks and boulders.	Suitable habitat features identified during the pre-clearing process are salvaged. Salvaged features are either re-instated into areas with low levels of habitat features or stockpiled appropriately for later use. Timber or boulder piles will be constructed in riparian areas and areas of regeneration, revegetation and/or rehabilitation (as appropriate) to provide potential quoll denning habitat.	Compliant	Habitat material is identified during the pre-clearance process and salvaged where possible to reinstate into BMP areas.
Nest boxes are providing habitat value for native fauna.	Biodiversity offset areas, areas of remnant vegetation and suitably established rehabilitated vegetation (not in disturbance areas) will be supplemented with nest boxes as required.	Compliant	Remnant vegetation and suitably established rehabilitation areas have been supplemented with nest boxes. Annual monitoring in accordance with "Year B" conducted in 2020.
Salvaged–reinstated hollows	An indicative sample of salvaged and re-instated hollows are subject to annual monitoring in conjunction with nest boxes.	Compliant	Habitat features suitable for salvage are stockpiled or directly placed into rehabilitation and offset areas. Ongoing habitat augmentation works will continue as per recommendation from monitoring events.
Timing of nest box installation	Removed hollows will be replaced (with nest boxes) within six months of each discrete clearing event.	Compliant	Hollows and logs removed during clearing works have been placed in offset and rehabilitation areas.

Action/Item	Performance Indicator	Compliance	Performance Comment
			46 various bird and bat nest boxes were required after January 2020 clearing and were installed within the Bowmans Creek offset area.
Foraging specific plant resources	Rehabilitation and revegetation plantings undertaken include bulloak (Allocasuarina luehmannii), swamp oak (Casuarina glauca), broom bitter pea (Daviesia genistifolia), sickle wattle (Acacia falcata), hickory wattle (Acacia implexa) and cooba (Acacia salicina)	Compliant	Continue to undertake plantings that provide foraging resources.
Grazing Management			
Stock rotation	Cattle are grazed within improved pasture areas within mine rehabilitation >3years where practical Stocked will be managed to allow pasture recovery and maintain pasture availability and sufficient groundcover.	Compliant	LCO coordinate a cattle grazing trial and rotate stock between paddocks under supervision of district agronomist
Bushfire Management			
Bushfire Management Plan will be implemented	Implementation of requirements of updated Bushfire Management Plan.	Compliant	Bushfire Management Plan updated in 2020. Annual inspection undertaken prior to bushfire season. Vegetation control undertaken at assets identified as being at risk. Compliance check undertaken on private powerlines. No signs of bushfire impacts were noted during 2020 monitoring.
Ecological Monitoring			

Action/Item	Performance Indicator	Compliance	Performance Comment
Undertake floristic, fauna, LFA, waterbird, nest box, stygofauna and instream/riparian monitoring program throughout LCO	Monitoring program completed and reported.	Compliant	Monitoring completed in 2020. Results summarised in Section 3.1.1 below and report published ***Monitoring documents (glencore.com.au).*** Monitoring program to continue to track progress of all aspects.
Undertake annual inspections of LCO rehabilitation areas as per the MOP	Annual inspections completed	Compliant	Annual inspections of LCO rehabilitation areas completed and included in Section 3.1.2.
Native fauna presence in rehabilitation/regeneration areas	Fauna monitoring completed.	Compliant	Discussed further in Section 3.1.1 and 3.1.2 below. Maintain current pest control programs. Ongoing placement of habitat features such as log and rock piles as well as small retention dams and vegetated corridors in rehabilitation areas will also increase the niche availability for native fauna colonisation. Report available at ***Monitoring documents (glencore.com.au).***

3.1.1 Biodiversity Monitoring

During the reporting period, LCO undertook biodiversity monitoring in accordance with the BMP to assess progress/performance against the BMP criteria and Rehabilitation Management Plan (RMP/MOP) performance criteria. This section details the results from rehabilitation and biodiversity monitoring within the BMP area.

In general, remnant vegetation sites have maintained broadly consistent vegetation and fauna diversity and abundance since monitoring commenced in 2012 except for decreases in groundcover species and diversity as a result of drought. Rehabilitation site WR01 conversely has undergone significant growth of canopy vegetation. Both provide a range of habitat features that have remained intact and unaltered by mining and mining-related activities. Prolonged drought conditions are considered to have impacted the monitoring results of the BMP area.

The key findings of the 2020 biodiversity monitoring program were as follows:

- Substantial weed and pest management works have been undertaken by LCO throughout 2020, however the rainfall prior to monitoring has encouraged prolific weed growth.
- Remnant vegetation at W02 is generally in a good condition; however, some potentially problematic weed species are present in this area such as galenia (*Galenia pubescens*) and fireweed (*Senecio madagascariensis*).
- Riparian remnant site R01 is dominated by introduced species in the groundcover. This is unlikely to recover to former levels without substantial intervention.
- Rehabilitated vegetation at WR02 has undergone a slight increase in native diversity since baseline.
- There has not been a notable increase in the extent of feral species presence. This appears to be being suppressed by LCO management action.
- No signs consistent with myrtle rust, *Phytophthora cinnamomi* or Chytrid fungus were identified.
- Stygofauna diversity at all sites remains low.
- Rehabilitated vegetation at WR02 is in moderate condition (species diversity and plant health), however could be assisted in becoming more compatible with reference vegetation by:
    - reducing weed levels/ maintaining weed management efforts and focus and
    - increasing diversity of native flora species in the groundcover and canopy.

LCO will continue to implement the BMP commitments and recommendations detailed in the 2019 BMP monitoring report. Key recommendations to be implemented during 2021 by LCO will include:

- Continued supplementary plantings to assist in infilling vegetation where gaps in certain strata have been identified.
- Continued weed and feral fauna management.

As per the BMP, LCO will prepare an Annual Ecological Monitoring Report (AEMR), which will document the monitoring methods and results from the winter monitoring period through to the autumn monitoring period. The intent of this report will be to provide a comparison of the data collected with previous monitoring event and to provide (where necessary) ongoing management recommendations and ameliorative methods to ensure the biodiversity within the BMP area is subject

to a positive feedback loop. The full report summarising the method and results of the 2020 Annual Ecological Monitoring Program is available on the LCO website.

3.1.2 Rehabilitation Program

Rehabilitation activities during the reporting period were completed generally in accordance with the approved Mining Operations Plan (MOP). LCO achieved the 2020 rehabilitation targets as specified in the ***2018-2020 MOP Amendment B*** during the reporting period. LCO achieved 51.5ha of rehabilitation during 2020 compared to 50ha as described in the MOP.

The LCO ***2021-2023 MOP*** target for rehabilitation in 2021 is 17 ha.

LCO will continue to implement the MOP/RMP and BMP to progressively rehabilitate the operation.

The general outcomes of the 2020 Rehabilitation Monitoring Report are:

- Overall the condition of rehabilitation at LCO is moderate and trending towards the target.
- Most areas have a good ground coverage which is preventing substantial erosion.
- Due to a recent substantial increase in rainfall there has been a substantial increase in exotic species throughout the rehabilitation which LCO is actively managing. In the case of woodland vegetation, ground coverage is provided by non-target species (particularly Rhodes grass (Chloris gayana)) and vegetation has not been established for lengths of time in which substantial soil organic matter (leaf litter) has had the time to accrue.
- Prolonged drought conditions have hindered the development of rehabilitation, however with recent climatic conditions this is looking to improve.
- In terms of pasture areas, height and density are typically good for grazing.

3.1.2.1 Rehabilitation Maintenance

Mountain Block Remediation Project

As per the MOP and associated approval modifications (DA 305-11-01 Modification 7 and ML 1597), remedial maintenance was undertaken during in the Mountain Block rehabilitation area. The works commencing early 2020 addressed instability issues, slip faces and gullying of the former highwall. Activities were completed November 2020 and included:

- Bulk shaping
- Soil amelioration
- Rock drain construction
- Revegetation
- Surface erosion protection
- Follow up maintenance
- Establishment of ongoing monitoring program.

LCO will continue to monitor the rehabilitated slope and conduct maintenance activities as required.

Tailings Emplacement Rehabilitation Strategy

Capping and rehabilitation of the Antiene Tailings Storage Facility (TSF) commenced in 2016, including an initial capping layer of 23 ha. The capping was put on hold part way through the rehabilitation program to allow for further consolidation of the tailings.

During 2020, rehabilitation recommenced with the landform design phase and materials characterisation. In January 2021, LCO commenced the rehabilitation execution phase. This includes landform construction - capping, shaping, drainage and revegetation. Approximately 30 ha in the southern half of the Antienne TSF has been shaped; awaiting drainage and revegetation.

4. Offsetting of Residual Impacts

4.1 Biodiversity Offsets

The Biodiversity Offset Management Plan (BOMP) guides ongoing management of the LCO biodiversity offset areas, to maintain and enhance biodiversity values, particularly those relating to threatened species and threatened ecological communities (TECs) within the LCO biodiversity offset areas.

The objectives of the BOMP are to provide direction for the short to long-term management and enhancement of the biodiversity values of the LCO biodiversity offset areas. It provides a description of the measures implemented to achieve the objectives over the next three years.

Although the EPBC reporting period begins in May 2020, annual objectives detailed in the BOMP are measured from the approved date of the BOMP i.e. Year 6 commences August 2020.

Error! Reference source not found. summarises the performance criteria set for year 5 of operation of the BOMP, and actions completed to date. The performance against Year 5 performance criteria is outlined in this section.

Table 4-1 - Year 5/6 Biodiversity Offset Management Plan Implementation Summary

Relevant Offset Area	Action	2020 Performance Indicator (Year 5/6)	Compliance	Performance Comment
Pathogen Management				
All BOAs	If reasonable potential for pathogens is identified in the BOAs, appropriate pathogen monitoring and management protocols are developed and implemented.	If reasonable potential is identified, pathogens are considered in design and implementation of monitoring works. If identified (or potential identified), management actions for specific pathogens are developed and implemented.	Compliant	No signs likely to be associated with Phytophthora, myrtle rust or chytrid fungus observed in any of the BOAs. Sampling for *Phytophthora cinnamomi* undertaken by Umwelt in 2020 with none detected.
Fencing and Signage				
All BOAs	Repair boundary fences, restricting unauthorised access to property and controlling livestock movements	All boundary fences in place and gates are secured.	Compliant	Boundary fences and gates appeared secure during monitoring event. Fences are additionally monitored during BOMP inspections completed by LCO.
All biodiversity offset areas	Any new fencing does not have barbed wire on upper strands and as little barbed wire generally as possible. The bottom strand will be plain wire and elevated to allow	New fences are installed without barbed wire on upper strands and an elevated plain wire bottom strand.	Not applicable	No new fences installed.

	faunal passage (while maintaining cattle exclusion).			
All BOAs	Inspections of fences every two months to identify condition.	Inspections every two months. Damaged critical fences to be repaired within one week (temporary if needed), final repairs and non-critical repairs to be completed in one month.	Compliant	Fence inspections undertaken every two months in accordance with commitments of the BOMP.
All BOAs	Information signage for the spotted-tailed quoll.	Informational signage (for the spotted-tailed quoll) is maintained.	Compliant	Signage is installed and in good condition.
Cultural Heritage				
Bowmans Creek Riparian Corridor	Detailed rehabilitation planning for the Bowmans Creek Riparian Corridor managing outcomes of cultural heritage assessment.	Implement plan as required.	Compliant	Planning and due diligence surveys completed where required.
All biodiversity offset areas	Implement protocols for identification of potential cultural heritage issues, including how to avoid or mitigate impacts.	Implement protocol.	Compliant	Implemented as per the approved ACHMP.
Grazing Management				
All BOAs	All stock to be removed from BOAs	No stock grazing unless required based on monitoring results.	Compliant	No evidence of cattle grazing was evident during 2020 in any BOA.

All BOAs	Minimum bi-monthly inspections to determine presence of rogue stock and assess condition of fences.	To be completed bi-monthly.	Compliant	Cattle inspections undertaken bi-monthly in accordance with commitments of the BOMP.
All BOAs	Remove reported rogue stock and repair damaged fences.	Action and remove reported rogue stock and repair damaged fences.	Compliant	No rogue stock removed.
Track Maintenance				
All BOAs	New access tracks (only where necessary) are subject to due diligence assessments.	Complete due diligence assessments for new access tracks to minimise impact on biodiversity, where possible.	Not applicable	To be assessed on an ongoing basis. No new tracks installed.
All BOAs	Minimum twice yearly (nominally in March and September) inspections to identify track conditions.	Inspections undertaken nominally in March and September. Action and repair track damage.	Compliant	Access track inspections undertaken bi-annually in accordance with commitments of the BOMP.
All BOAs	Rehabilitation of unnecessary access tracks.	Tracks no longer required will be rehabilitated.	Not applicable	All tracks present are considered necessary.
Pest Management				

All biodiversity offset areas	Complete feral animal inspections of BOAs every two months to document sighting and abundance records. This will then inform ongoing control actions (as needed), including timing, frequency, target species and methods to be used.	Inspections completed every two months, followed by implementation of required control methods, as required.	Compliant	Feral animal inspections undertaken every two months in accordance with commitments of the BOMP. Feral cats and dogs were identified in low numbers and will continue to be key species for management in 2021.
All BOAs	Develop and implement an annual pest animal action plan.	Develop and implement pest animal action plan. Stable or downward trend in population size recorded.	Compliant	Annual pest action plan developed and implemented during 2020 as discussed below.
All BOAs	Particular action is paid to managing foxes, feral cats and feral dogs in order to protect the spotted-tailed quoll population in this area.	Implementation of favoured fox, feral cat and feral dog control measures.	Compliant	Feral fauna identified in low numbers and not appear to be significantly increasing in abundance. Feral dogs, foxes and cats were observed throughout the year and during monitoring. Control activities undertaken included two 1080 dog/fox baiting rounds, one soft jaw trapping event and one shooting control event Further implementation of control measures to occur during 2021 as per annual action plan.
All biodiversity offset areas	Presence of pest animals	As evidenced by monitoring, pest animal presence in revegetation/ rehabilitation areas does not pose a risk to establishment of vegetation.	Compliant	Feral rabbit, hare, black rat and house mouse were identified in all BOAs.

				Further control measures for these species to be implemented during 2021 as per annual action plan.
All BOAs	Develop a vertebrate pest control register to document when and where each control method is implemented.	Update and maintain vertebrate pest control register.	Compliant	Existing vertebrate pest control register implemented.
Weed Management				
All BOAs	Complete weed inspections every two months to document diversity and abundance of noxious weed records.	Inspections completed every two months, followed by implementation of required control methods, as required.	Compliant	Inspections completed in accordance with the BOMP. Weeds identified in all BOAs. Evidence of spraying and wick wiping that appeared successful.
Natural Regeneration				
Mountain Block and Mitchell Hills South	Mapping of areas naturally regenerating and subject to revegetation works to track if natural/assisted regeneration is on track to meet final hectare goals.	Revised in ongoing monitoring works, as needed.	Compliant	Regenerating areas appear to be progressing. Mapping to be completed in future after additional growth to capture recent plantings.
Mountain Block and Mitchell Hills South	Management of regeneration progress is responsive to monitoring outcomes.	Monitoring of regeneration areas.	Compliant	Monitoring of regeneration progress occurred in 2020 and appear to be progressing.

Assisted Regeneration				
Mountain Block and Mitchell Hills South	Review need for assisted regeneration where outcomes of natural regeneration is deemed lacking.	Assess progress/outcomes of natural regeneration and assess and implement assisted regeneration measures as required.	Compliant	Natural regeneration was identified in BOAs. Undertake supplementary plantings in areas of poor revegetation success (as identified in monitoring report).
Rehabilitation				
Mountain Block	Modification 7 Area transferred back under BOMP management	-	Not applicable	Rehabilitation completed in 2020. Transfer back under BOMP management will occur once further monitoring deems rehabilitation of this area a success.
Bowmans Creek Riparian Corridor Mountain Block Offset Area	Develop detailed performance criteria for all management zone types.		Not applicable	2019 monitoring results reviewed and no changes to performance criteria for 2020.
Bowmans Creek Riparian Corridor	Implement rehabilitation / revegetation program.	Implementation of plan.	Compliant	Additional plantings (tubestock and seed) occurred in Bowmans Creek Riparian Corridor and Mitchell Hills South. Continue to feed in results of monitoring of supplementary planting

Mountain Block Offset Area				into ongoing vegetation establishment and maintenance program.
Bowmans Creek Riparian Corridor	Positive feedback loop from monitoring results.	Feedback from monitoring is incorporated into ongoing review and improvement of plan.	Compliant	To be updated in response to these works.
Habitat Augmentation				
Bowmans Creek Riparian Corridor	Salvage of habitat features (particularly for the spotted-tailed quoll) such as hollow-bearing trees, logs, stumps, large rocks and boulders.	Suitable habitat features identified during the pre-clearing process are salvaged. Salvaged features are either re-instated into areas with low levels of habitat features or stockpiled appropriately for later use. Timber or boulder piles will be constructed in riparian areas and areas of regeneration, revegetation and/or rehabilitation (as appropriate) to provide potential quoll den habitat.	Compliant	Little clearing occurred in 2020 so no salvaged habitat trees installed in the offsets. Additional nest boxes installed. Additional boulder piles installed in Bowmans Creek Riparian Corridor and Mountain Block.
Bowmans Creek Riparian Corridor	Nest boxes are providing habitat value for native fauna.	Established nest boxes are subject to regular monitoring.	Compliant	Nest box installation conducted. Signs of presence and actual occupation of nest boxes is occurring.

All biodiversity offset areas	Habitat and hollow augmentation will occur in Mountain Block and Mitchell Hills South offset areas if monitoring identifies a dearth of key habitat features such as log piles or boulder piles.	Habitat augmentation, if required.	Compliant	Additional boulder piles installed in Bowmans Creek Riparian Corridor and Mountain Block.
Translocation				
All BOAs	Translocation of tiger orchids or other threatened flora species (if identified in pre-clearing process) to BOAs. Methods to be adopted are detailed within the BMP.	Tiger orchids are salvaged and translocated according to the process in the BMP as needed.	Compliant	No translocations conducted. Orchid translocated in 2018 monitored and alive.
Creek and Drainage Line Protection				
Bowmans Creek Riparian Corridor	Fencing / protection of LCO controlled side of riparian corridor.	Riparian corridor will be fenced from human and livestock access.	Compliant	Offsets remain fenced and stock excluded.
Bowmans Creek Riparian Corridor	Rehabilitation works to address stabilisation and erosion issues, as necessary.	Implementation, as needed.	Compliant	
Seed Collection				

All BOAs	Where suitable remnant vegetation is available, implementation of seed collection and handling program for use in revegetation/rehabilitation works.	Pre-clearing surveys identify potential seed sources. Seeds are collected, stored and handled according to appropriate program. Collected seed resources are used in revegetation/rehabilitation works.	Compliant	Seed collection occurred early 2020 in Mitchell Hills South.
Erosion Sedimentation and Salinity				
Mountain Block	Control of erosion in southern paddocks	Continue hydromulching of remainder of eroded areas if trials are successful.	Compliant	2019 trial area monitored. No additional substantial erosion although limited seed strike.
Mountain Block	Monitor completed erosion works and action repairs if required.	Monitor completed erosion works and action repairs if required.	Compliant	2019 trial area monitored. No additional substantial erosion although limited seed strike.
Bushfire Management				
All BOAs	Bushfire Management Plan implementation	The current Bushfire Management Plan will be updated to address the approved modification. Implementation of requirements of updated Bushfire Management Plan.	Compliant	Bushfire Management Plan implemented.
Monitoring				

All BOAs	Undertake floristic, fauna, LFA and nest box monitoring program	Monitoring program completed and reported	Compliant	Monitoring program completed. Summary of monitoring provided in ***Section 4.1.1***
All BOAs	Undertake annual inspections of LCO rehabilitation and active regeneration areas	Annual inspections completed	Compliant	Monitoring program completed. Summary of monitoring provided in ***Section 4.4.1***
All BOAs	Native fauna presence in rehabilitation/regeneration areas	Fauna monitoring completed	Compliant	Monitoring program completed. Summary of monitoring provided in ***Section 4.1.1***

4.1.1 Biodiversity Offset Monitoring Program

In general, the remanent vegetation of Mitchell Hills South has the highest habitat values of the biodiversity offset areas, with high hollow densities, rock on rock habitat, moderate log presence, abundant shrubs, low introduced species although they key lacking habitat is permanent water. Bowmans Creek Riparian Corridor requires the greatest amount of ongoing active management, particularly for high introduced groundcover species, to improve recruitment of canopy species and increase of habitat features such as logs and boulders. Quality habitat was also noted in Mountain Block, however much of the vegetation within the offset is regrowth and has not yet developed hollows or other habitat complexity (such as logs). Permanent water resources in this BOA are also limited. Although remnant vegetation at the BOAs was in good/moderate condition and the general coverage of weed species was low (monitoring sites had invasive species present that require active management to prevent reduction in ecological value over time.

Although not necessarily within monitoring plots and subsequently may not be reflected within quantitative monitoring results, LCO has been undertaking extensive management actions within the Mountain Block, Mitchell Hills South and Bowmans Creek Riparian Corridor since 2017.

A summary of management actions completed in 2020 include:

- Rehabilitation of 1.5 ha in Mountain Block within the DA 305-11-01 Modification 7 rehabilitation area (***Section 3.1.2***).
- Active regeneration works in Bowmans Creek Riparian Corridor, including strip seeding approximately 10 ha and tubestock (400 plants).
- Supplementary tubestock planting of target vegetation in existing Bowmans Creek Riparian Corridor (3,320 plants) and Mitchell Hills South (5,400 plants).
- Weed and pest management throughout all BOAs.
- Seed collection to supplementary seeding resources for regeneration purposes.
- Installation of nest boxes
- Future monitoring will determine whether revegetation in these areas is successful.

It is anticipated that floristic and fauna value provided by the BOAs will increase with time as more management actions required by the BOMP are initiated and as tubestock/seed planted begin to grow and provide improved habitat value (canopy coverage and foraging resources).

Key findings of the 2020 biodiversity offset monitoring program were as follows:

- Some declines were evident in floristic and fauna diversity in 2020 from baseline events, however these declines are not likely to be long- term or significant.
- Substantial revegetation and weed control works have been undertaken in 2020 in Bowmans Creek Riparian Corridor. With an increase in rainfall in 2020, weed coverage has increased substantially, and ongoing weed control works will be necessary.
- Remnant vegetation is generally in good condition, however some potentially problematic weed species are encroaching in these areas (particularly riparian vegetation and grassland areas which has particularly high occurrence of exotic grass in patches (despite management activities).

- Substantial increases in the occurrence of the introduced house mouse (*Mus musculus*) were recorded in 2020, likely in response to increased rainfall and resource availability. These numbers are likely to reduce again in response to climatic conditions and no management is recommended at this stage.
- The threatened spotted-tailed quoll (*Dasyurus maculatus*) was recorded again in 2020.
- Feral cat (*Felis catus*) was recorded at all three offsets during 2020. This is a highly destructive predator that may impact upon the recovery of the spotted- tailed quoll. Management is recommended.
- Substantial nest box installation has been undertaken in all three offsets. Preliminary monitoring of these nest boxes are promising for colonisation by local hollow-dependent fauna, including threatened species the brush-tailed phascogale (*Phascogale tapoatafa*), recorded in 2018 and 2019.
- No signs of pathogens, myrtle rust, *Phytophthora cinnamomi* or chytrid fungus were identified.

Recommendations for the enhancement of existing ecological values and improved rehabilitation/ regeneration were received as part of the 2020 monitoring program; refer to the full offset monitoring report Umwelt 2020.

Liddell continue to action the recommendations of the monitoring report and will continue remediation implementation.

4.2 Indirect Offsets

The State and Commonwealth approvals both require the provision of an indirect offset to augment the agreed land-based biodiversity offsets to address the impacts of the project. The indirect offset was a financial contribution towards recovery actions for the spotted-tailed quoll (*Dasyurus maculatus maculatus*), as part of the:

- Final Draft National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus* (Long and Nelson 2008);
- and/or Management actions identified for the spotted-tailed quoll as part of the Office of Environment and Heritage (OEH) Saving Our Species Project Species Action Statement.

An Indirect Offset Plan (IOP) satisfies this condition and was approved by the DoE on 2nd March 2016. The objective of this IOP is to specify how the $243,000 indirect offset (by way of financial contribution over not more than five years) will be used to support recovery actions for the quoll. The IOP has since been reviewed on a regular basis by:

- Biodiversity Conservation Division - Department of Planning, Infrastructure and Environment (formally the Office of Environment and Heritage)
- Department of Environment & Energy (DoEE);

The IOP was reviewed and reapproved by under ***DA Mod 7*** and ***EPBC 2013/6908*** during the reporting period and details the tasks required to facilitate the implementation of the above requirements.

Agreed funding for this reporting period has been supplied to the University of New England (UNE) as per an executed Research Agreement for Tasks 2 and 3. Funding for Task 1 was completed in 2017.

4.2.1 Management Actions during the reporting period

Although the EPBC reporting period begins in May 2020, annual objectives detailed in the IOMP are measured from 1 July 2020 to 30 June 2021. Management actions summarised below are for that reporting period.

4.2.1.1 Task 1 - Development of Individual Recognition Software for Quolls

Task 1 involves the development and sharing of computer software that enables the identification of individual quolls from remote camera data. The 2017 Annual Report LCO advised that the software development was successful, with the initial build of the Quoll Identification Toolkit (QIT) completed utilising $80,000 funds providing by LCO under research agreement with Invasive Animals Limited (IAL).

During the reporting period further work was completed to refine the identification algorithm in the Quoll Identification Toolkit (QIT). Invasive Animals Limited have reported that the QIT has been successfully moved across from the initial build supported by MATLAB™ to a standalone software format as:

A biometric recognition algorithm and corresponding software system has been developed for individual quoll identification. Current results indicate a high level of accuracy is feasible with detailed algorithm benchmarking on-going. The software system has been developed as open source, freely available as a Windows executable file and a graphical user interface. This software processes sequences of motion-activated camera images of quolls and returns the likely matches of individuals from a database. Extensive software testing has been completed with additional reviews on-going, a user guide has been completed, and a draft manuscript under development compiling methodology and key results. (Associate Professor Greg Falzon, June 2021).

4.2.1.2 Task 2 Surveying/Monitoring STQ Populations

Middle Foybrook Area

A revised camera trap array was deployed May 2020 to April 2021 incorporating private land adjacent to the Glencore offset area. A total of 42 cameras detected 36 individual quolls from 1,282 captures. The camera array was reduced to 25 cameras in April 2021 focussing on the private landholder as sufficient data had been collected in the offset areas.

Live trapping also commenced in the expanded project area in November 2020, with an additional 6 individual quolls caught. In total for the Middle Foybrook Area since June 2019, 36 nights of trapping has been completed with 68 captures of 26 individual quolls achieved. Various data collected from each quoll captured in this program will be compared with those collected from Mt Royal and Wollemi National Parks.

Mt Royal National Park

The 25 site camera trap program continued in Mt Royal during the reporting period with 62 individual quolls identified from 2465 detections to date. Live trapping also commenced in June 2020, resulting in 76 captures of 35 individual quolls. Lured camera traps were also paired with the existing sites to collect information of local prey species for comparison with the Middle Foybrook Area data previously collected.

In line with project objectives, the additional lured cameras were set up as ‘predator’ (meat based lure) and ‘prey’ (general mammal lure of peanut butter, honey and oats) to collect data to enable comparison of detectability for quoll survey methodology.

Wollemi National Park

After delays due to bushfire and COVID-19 the program was successfully implemented during March 2021 in Wollemi NP. Of the 25 camera installed, 10 detections of 2 individual quolls has been recorded to date.

4.2.1.3 Task 3 Assess Habitat Use by Female STQ

As noted in the last annual update and updated in the current approved IOMP, the expanded camera trapping with the Middle Foybrook Area has been utilised as an alternative means to assess habitat use by female quolls. The cameras have been proportionally allocated across various habitat types to assess use and preference. Data analysis is ongoing. Preliminary results suggest both male and female quolls preference grassy woodland, dry rainforest and dry Sclerophyll forests as compared to other habitat types identified in the study area. Female specific analysis will be completed once all fieldwork and data collection is complete.

Payments completed by LCO to fund the project are shown in ***Table 4-2***. The funding is being utilised to purchase necessary cameras and consumables to implement the project.

Table 4-2 - Payments Completed 2020-21 Financial Year

Payment	Amount (AUD$ excl GST)	Cumulative Amount (AUD$ excl GST since 2016)	Date Paid
7	25,618	206,441	30/10/2020

In accordance with the requirements of the IOP, an annual progress report was submitted July 2020 and should be read in conjunction with this report.

5. Water Resources

This section outlines surface water and groundwater monitoring program findings during the reporting period pertaining to the determination of mining related impacts. ***Figure 5-1*** shows the locations of each of the surface and groundwater monitoring sites. The LCO Water Management Plan (WMP) documents the processes and responsibilities of all aspects of the site water management system. There were no changes to the LCO Water Management Plan (WMP) during the reporting period.

5.1 Surface Water

Surface water monitoring is undertaken along the two creek lines adjacent the operation (Bayswater and Bowmans) as well as at onsite water storages. During the reporting period, LCO undertook the approved WMP surface water monitoring program. This monitoring program utilises specific surface water quality monitoring trigger limits which provide for the identification of potential adverse impacts; results from the reporting period are summarised in this Section 5.1.

Bayswater Creek is considered to be a highly disturbed system with respect to ANZECC 2000 with low ecological value and a flow regime which is controlled by discharges from Lake Liddell with the remaining catchment not sufficient to maintain flow within the creek adjacent to LCO. Bowmans Creek is considered to be a moderately disturbed system with respect to ANZECC 2000 with moderate ecological value. Based on long term streamflow monitoring, flow within Bowmans Creek is intermittent adjacent to LCO although consistent flow is recorded further downstream nearer to the Hunter River.

The ephemeral nature of flow within the creeks adjacent to LCO means that stagnant pools of water are sometimes monitored which may have higher/atypical concentrations of the key parameters (pH, Total Suspended Solids (TSS) and Electrical Conductivity (EC) and Total Dissolved Solids (TDS)) than during periods of flow. To reflect the natural ponding and varying quality of both creeks, the WMP sets site specific and flow determinant impact assessment criteria for both creeks. This criterion has been determined based on a statistical analysis of data collected over a 5 year period in accordance with ANZECC (2000) guidelines.

LCO's interpretation and response to monitoring results is detailed in the WMP Section 10 Surface Water and Groundwater Response Plan, which has been implemented during the reporting period to investigate exceedances of determined criteria. It is important to note that before an exceedance is to be considered to have been reached, monitoring will continue for up to two observations beyond the initial exceedance measurement (i.e. a total of three consecutive exceedances of a trigger value). This is to check that the exceedance is repeated, ongoing, and not erroneous. Notwithstanding, a decision is made whether the initial exceedance requires immediate investigation.

The creek trigger levels are presented in

Table 5-1.

Table 5-1 – Water Managemnt Plan trigger values for surface water quality

Location	pH lower limit[4]	pH upper limit		EC	EC	TDS	TDS	TSS	TSS
		90th %tile[1]	Max[2]	90th %tile[1]	Max[2]	90th %tile[1]	Max[2]	90th %tile[1]	Max[2]
Bayswater	6.5	8.3	8.5	5130	7300	3230	5180	50[3]	302
Bowmans Creek	6.5	8.3	8.8	2020	4570	1210	3460	50[3]	97

Notes to table:

Trigger Level when creek is flowing

Trigger Level when no flow in creek

[1] whole creek 90th percentile

[2] maximum recorded value for whole creek

[3] ANZECC criteria for TSS

[4] ANZECC criteria for pH lower limit

5.1.1 Bayswater Creek

Monitoring of the three sites within the creek (upstream, midstream and downstream) was completed monthly during the reporting period in accordance with the WMP.

It should be noted that Bayswater Creek is a highly modified watercourse and regularly experiences periods of low or no flow. The measured pH, Electrical Conductivity (EC) Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) levels were typical of historical results. There was no exceedance of flow or no flow applicable water management plan trigger levels,

Table 5-2 below summarises the monitoring program results and identifies that no flow applicable trigger limits were exceeded in Bayswater Creek during the reporting period.

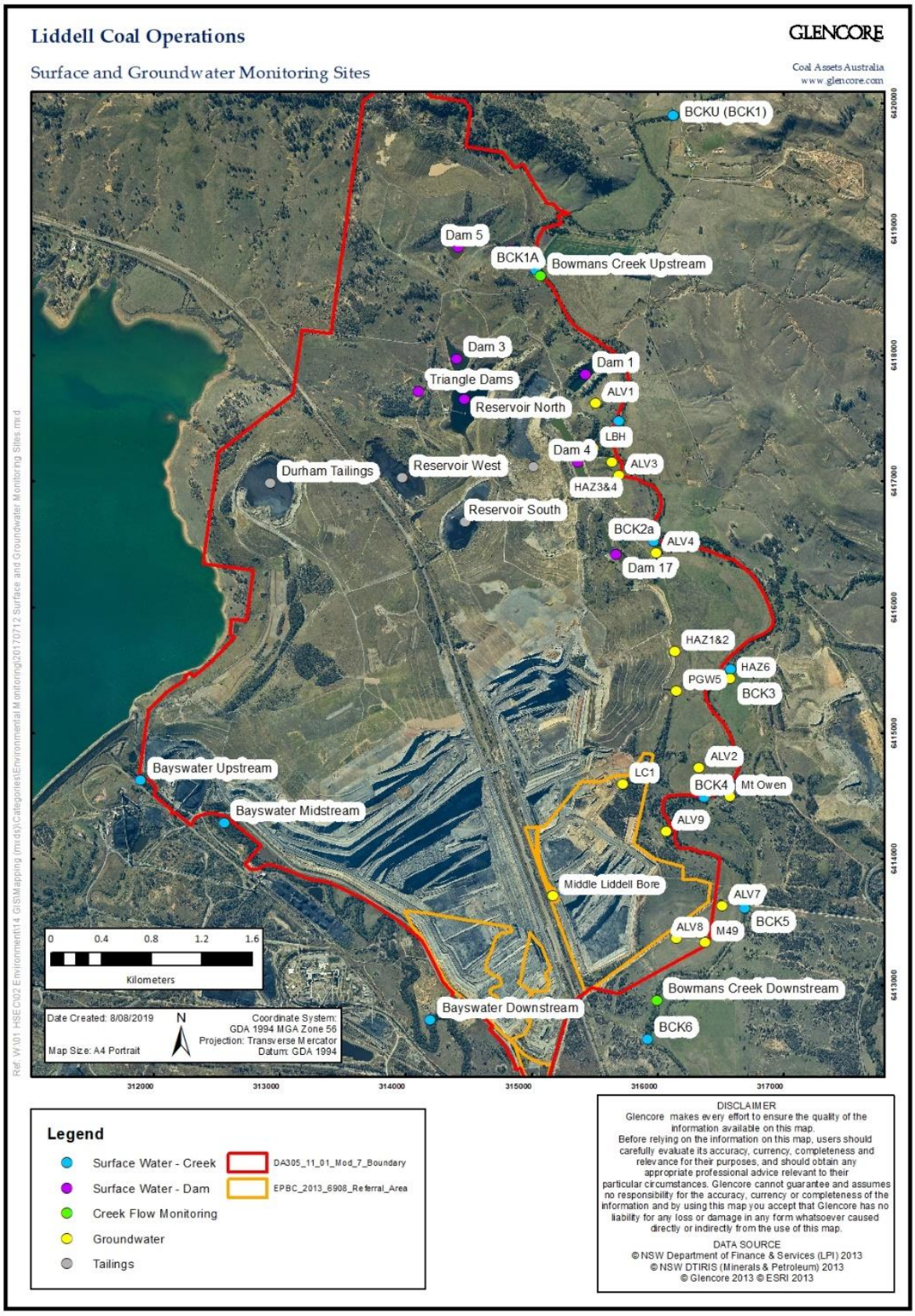

Figure 5-1 - Location of surface and groundwater monitoring sites

Table 5-2 - Bayswater Creek Trigger Limit Summary

Bayswater Creek Water Quality Results															
Month	**Bayswater Creek Upstream**					**Bayswater Creek Midstream**					**Bayswater Creek Downstream**				
	Flow	**pH**	**EC (µS/cm**	**TDS (mg/L)**	**TSS (mg/L)**	**Flow**	**pH**	**EC (µS/cm**	**TDS (mg/L)**	**TSS (mg/L)**	**Flow**	**pH**	**EC (µS/cm**	**TDS (mg/L)**	**TSS (mg/L)**
Jun-20	Trickle	7.67	2980	1910	8	Still	8.04	3620	2420	<5	Dry	-	-	-	-
Jul-20	Trickle	7.76	3390	2320	<5	Still	8.14	4130	2850	<5	Dry	-	-	-	-
Aug-20	Trickle	7.80	3180	2120	9	Still	8.06	3760	2560	<5	Dry	-	-	-	-
Sep-20	Slow	7.83	3420	2360	11	Still	7.91	4560	3160	16	Dry	-	-	-	-
Oct-20	Trickle	7.94	4620	3000	5	Still	8.02	5800	3880	8	Dry	-	-	-	-
Nov-20	Trickle	7.96	3310	2160	25	Still	7.89	3920	2610	24	Dry	-	-	-	-
Dec-20	Trickle	7.59	4620	3190	28	Still	8.00	6120	4270	11	Dry	-	-	-	-
Jan-21	Trickle	7.70	3640	2570	13	Still	7.94	4190	2910	5	Still	7.76	2830	1820	8
Feb-21	Slow	7.79	2800	1810	5	Still	7.96	5040	3430	5	Dry	-	-	-	-
Mar-21	Slow	7.86	3950	2530	6	Still	7.93	5380	3420	<5	Dry	-	-	-	-
Apr-21	Slow	7.89	4430	2950	12	Still	8.21	5520	3760	15	Dry	-	-	-	-
May-21	Slow	7.90	4500	3080	5	Still	7.94	5760	4000	33	Dry	-	-	-	-

5.1.2 Bowmans Creek

Monitoring of the eight sites within the creek (upstream BCK1, BCK1A, BCK2, BCK2A, BCK3, BCK4 BCK5 and downstream BCK6) was completed monthly during the reporting period in accordance with the WMP.

It should be noted that historical disturbance (grazing, mining, etc) has modified the catchment of Bowmans Creek significantly; it is ephemeral in nature and often pool or have very low flow leading to potential stagnant conditions which influences water quality. ***Table 5-3*** summarises the monitoring results and identifies any trigger limit exceedances in Bowmans Creek during the reporting period.

Table 5-3 - Bowmans Creek Monitoring Summary

Bowmans Creek Water Quality Results																				
Month	BCK1 (Upstream)					BCK 1A					BCK2					BCK2A				
	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)
Jun-20	Slow	7.36	1270	754	7	Trickle	7.81	2300	1180	<5	Dry	-	-	-	-	Dry	-	-	-	-
Jul-20	Trickle	7.69	1260	787	<5	Trickle	7.82	1740	1070	<5	Dry	-	-	-	-	Dry	-	-	-	-
Aug-20	Steady	7.88	644	396	8	Steady	7.98	670	397	<5	Slow	8.59	684	410	<5	Steady	8.07	713	434	<5
Sep-20	Steady	7.65	913	559	8	Steady	7.83	1060	596	9	Still	7.74	1030	626	12	Trickle	7.81	1220	740	12
Oct-20	Trickle	7.57	1040	555	<5	Trickle	7.99	1570	919	<5	Still	8.57	1140	668	9	Still	7.19	1430	884	<5
Nov-20	Trickle	7.85	694	391	8	Moderate	8.04	748	474	7	Still	8.26	769	460	8	Still	7.74	820	430	10
Dec-20	Trickle	7.55	885	561	8	Trickle	7.9	1360	949	12	Still	8.66	846	557	15	Trickle	7.16	1230	826	<5
Jan-21	Slow	7.85	487	316	10	Slow	7.88	516	314	8	Slow	8.09	522	322	19	Steady	7.91	545	338	7
Feb-21	Slow	7.84	571	310	19	Steady	7.91	621	362	20	Steady	8.02	627	400	24	Steady	7.91	672	403	19
Mar-21	Slow	7.74	636	360	6	Steady	7.84	724	382	15	Steady	8.02	737	406	15	Steady	7.88	815	460	24
Apr-21	Slow	7.85	601	391	9	Steady	7.94	656	428	14	Steady	8.03	642	420	10	Steady	7.9	658	443	11
May-21	Slow	7.9	677	414	<5	Steady	8.02	753	482	<5	Steady	7.87	753	444	<5	Steady	7.89	785	470	<5

Notes to Table:

Denotes an exceedance of the 90%ile trigger limit as applicable for the flow conditions

Denotes an exceedance of the maximum trigger limit as applicable for the flow conditions

\- unable to obtain a sample due to water level being too low to sample

Bowmans Creek Water Quality Results																				
Month	BCK3					BCK4					BCK5						BCK6 (Downstream)			
	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)	Flow	pH	EC (µS/cm)	TDS (mg/L)	TSS (mg/L)
Jun-20	Still	7.63	1790	1110	6	Still	7.31	1720	1060	12	Dry	-	-	-	-	Dry	-	-	-	-
Jul-20	Still	6.88	1770	1280	5	Still	7.45	1840	1120	<5	Dry	-	-	-	-	Dry	-	-	-	-
Aug-20	Slow	7.97	753	434	<5	Slow	7.92	750	446	5	Slow	7.98	763	452	<5	Steady	7.91	770	440	<5
Sep-20	Still	8.39	1180	680	<5	Trickle	7.96	1120	612	10	Still	7.72	1250	709	7	Slow	7.03	1250	733	19
Oct-20	Slow	7.96	1360	722	<5	Still	7.87	1370	839	12	Trickle	7.95	1600	976	<5	Slow	6.92	1240	747	<5
Nov-20	Still	7.74	850	480	12	Still	7.7	852	462	398	Still	7.8	884	462	15	Trickle	7.82	876	493	10
Dec-20	Slow	7.89	1120	788	34	Trickle	7.82	1130	768	20	Trickle	7.69	1300	874	58	Trickle	7.08	1090	761	18
Jan-21	Slow	8	569	351	23	Slow	7.81	570	356	9	Slow	7.91	586	370	11	Steady	7.86	586	372	14
Feb-21	Slow	7.73	703	470	32	Steady	7.81	703	460	22	Slow	7.9	734	452	27	Steady	7.81	746	440	25
Mar-21	Slow	7.8	828	446	15	Slow	7.83	825	460	14	Slow	7.78	812	491	11	Steady	7.63	833	479	11
Apr-21	Slow	7.84	723	456	12	Steady	7.86	732	474	13	Slow	7.97	753	501	10	Steady	7.9	742	466	21
May-21	Slow	7.84	829	510	5	Slow	7.87	836	529	6	Steady	7.93	868	536	<5	Steady	7.82	842	496	<5

Notes to Table:

Denotes an exceedance of the 90%ile trigger limit as applicable for the flow conditions

Denotes an exceedance of the maximum trigger limit as applicable for the flow conditions

\- unable to obtain a sample due to water level being too low to sample

During the reporting period, there were a number of isolated exceedances at varying sites, reflecting the ephemeral nature of the creek. These isolated exceedances occurred during periods of low flow and often just prior to periods of no flow.

As per the WMP monitoring program and Trigger Action Response Plan (TARP), exceedances of surface water trigger levels are required to be sustained for three consecutive months to initiate an investigation and therefore were no investigations or notifications to DPIE, DoE or DOI required by the surface water TARP during the reporting period.

5.1.2.1 BCK1A and Mountain Block Dam 6 Investigation

In the last Annual Report, LCO stated that exceedances of the 90th%ile trigger limits for EC and TDS had occurred at BCK1A triggering investigation into whether the increased salinity in the creek was associated with adjacent historical mining areas, circa 1980-early 2000's. These exceedances continued into early 2020. The investigation findings were reported noting that as per the WMP investigation protocol, LCO had progressed to undertake further investigations to determine the source of the seep observations by commencing a management/mitigation TARP. Management/mitigation measures occurred including dewatering an adjacent water management structure (Dam 6) to create a local groundwater sink to redirect and capture potential groundwater flow from the historical mining area and conducting further studies in consultation with relevant NSW Government agencies.

On the 9 September 2020, LCO submitted a BCK1A Management TARP investigation report detailing the results of management/mitigation investigation TARP. Stage 1 of the investigation comprised of developing a conceptual site model (CSM) to assess the mechanisms that may be causing the elevated salinity. This hydrogeological assessment identified the complexity of the groundwater within which a number of potential mechanisms ('natural' processes and 'man-made stressors') for the elevated salinity were identified and hence recommended that further works, Stage 2, be undertaken to confirm or negate potential mechanisms.

Stage 2 work was completed to address the identified knowledge gaps and included installation of a targeted groundwater-monitoring network, testing relative hydraulic conductivity of strata, a review of groundwater quality in the area and further refinement of the CSM.

LCO additionally commissioned studies to characterise the ecological health of Bowmans Creek and identify potential impacts to ecological health, which may be associated with observed changes in water quality.

The overall findings of the mitigation TARP studies completed by LCO can be summarised as follows:

- Groundwater within the spoil, alluvium and bedrock is discharging to Bowmans Creek;
- It is expected that pre-mining groundwater flow (or flux) in the area of interest will be the same post mining;
- Dewatering of Dam 6 has minimised the flow of brackish groundwater to Bowmans Creek;
- Reduced rainfall and increased evaporation also contributes to elevated salinity to Bowmans Creek;
- The elevated salinity within Bowmans Creek is localised; and
- Aquatic ecology monitoring has not shown sustained impact to aquatic health of Bowmans Creek.

Follow up review of monitoring data collected until end January 2021 was undertaken to determine whether:

- there are any further refinements to the conceptual site model
- the conclusion that the electrical conductivity (EC) trigger exceedances are anticipated to be predominantly a result of the adverse climatic conditions remains valid.

The elevated EC in Bowmans Creek persisted until mid-2020 and has subsequently reduced to below trigger values, expectedly the result of the cessation of drought conditions in the region. Currently the EC remains below the trigger values.

The elevated EC is expected to have been a result of the following:

- groundwater flow discharging to Bowmans Creek, particularly from the west and north
- low rainfall, resulting in limited surface flow and less dilution of the brackish groundwater discharging to Bowmans Creek
- high evaporation.

The above conclusion did not change with the updated assessment.

Groundwater discharge to Bowmans Creek is not evident during the current monitoring period. Groundwater is still expected to discharge, however the differing climatic conditions of below average evaporation and above average rainfall has resulted in the dilution of brackish groundwater discharging to Bowmans Creek.

Determining whether the EC exceedance in Bowmans Creek prior to mid-2020 was a result of mining is difficult to definitively ascertain without baseline monitoring data since mining in this area occurred from the 1980s. However, the following is a summary of the key aspects we know or can surmise:

- groundwater flow direction, in the area of interest, is expected to be similar now as it was prior to mining
- groundwater within spoil is anticipated to flow at a higher rate than within the in-situ pre-mined bedrock, with the potential for higher rates of discharge than in a pre-mining situation
- in the approximately ten years prior to the recent EC exceedances in Bowmans Creek (BCK1A), during a period of predominantly above average rainfall, the EC has been mostly below the trigger level
- there have been no recent activities in the Mountain Block rehabilitated area that would cause the consecutive exceedances in the EC trigger
- since mid-2020 and the return of above average rainfall and below average evaporation, there have been no EC exceedances.

Whilst the studies evidence that the elevated salinity is not directly linked to historical mining activities and Dam 6, groundwater flows are interacting with soil in backfilled extraction areas and out of pit dumps before exiting to Bowmans Creek. In line with investigation recommendations, LCO intends to continue monitoring to inform mine closure planning and ability to progress this area for mining title relinquishment in the future.

5.1.3 HRSTS Discharge Monitoring

Any discharges from the Liddell Coal must be undertaken in accordance with the Hunter River Salinity Trading Scheme (HRSTS). During the reporting period LCO discharged mine water under the provisions of the HRSTS during March and April. There was no exceedance of any compliance limits applicable to the discharge events. ***Table 5-4*** summarises the discharge events.

Table 5-4 - HRSTS Discharge Summary

RIVER REGISTER INFORMATION		DISCHARGE RECORD							CREDIT REGISTER INFORMATION
Block ID	**Total allowable discharge**	**Start**		**Finish**		**Volume discharged**	**Mean EC**	**Salt load**	**Number of credits held**
(1 block / line)	Tonnes	Time	Date	Time	Date	ML	uS/cm	Tonnes	
2021-079(1)	588	14:00	19/03/2021	15:40	19/03/2021	0.5	6752.5	2.0	70
2021-080(3)	6008	20:30	19/03/2021	19:30	20/03/2021	13.5	6420.1	53.7	70
2021-081(2)	3335	19:30	20/03/2021	19:30	21/03/2021	15.2	5915.2	54.0	40
2021-082(4)	6859	19:30	21/03/2021	19:30	22/03/2021	16.1	5770.4	55.6	40
2021-083(3)	8546	19:30	22/03/2021	19:30	23/03/2021	18.2	5317.2	57.7	70
2021-084(1)	N/A *in Flood	19:30	23/03/2021	19:30	24/03/2021	37.5	4735.8	106.4	70
2021-085(3)	N/A *in Flood	19:30	24/03/2021	19:30	25/03/2021	34.6	4675	97.1	70
2021-086(2)	1543	19:30	25/03/2021	19:30	26/03/2021	33.0	4674.3	92.7	70
2021-087(2)	6548	19:30	26/03/2021	19:30	27/03/2021	33.1	4639.3	92.2	70
2021-088(2)	3799	19:30	27/03/2021	19:30	28/03/2021	33.2	4683	93.4	70
2021-089(1)	2470	19:30	28/03/2021	19:30	29/03/2021	29.7	4722.4	84.2	70
2021-090(1)	1474	19:30	29/03/2021	19:30	30/03/2021	16.0	4713.7	45.3	70
2021-091(1)	1047	19:30	30/03/2021	19:30	31/03/2021	14.4	4614.7	39.7	70
2021-092(1)	824	19:30	31/03/2021	19:30	1/04/2021	13.2	4540.2	35.8	70

5.2 Groundwater

LCO is located within an area of the Upper Hunter Valley subject to extensive underground and open cut mining activities since the early 20th century. Current and historical mining operations have extensively altered the physical features and environmental setting of the local area, including the region's surface water and groundwater systems.

Mining operations to the west, south and east of LCO, Lake Liddell to the west, and the major geological feature Hunter Thrust to the north, all have major influence on groundwater levels in the region. Due to such operations and features regional groundwater levels largely reflect current and past mining activities, with water levels varying with time and location according to local mining activities.

The WMP groundwater monitoring program adopts site specific trigger levels for impact investigation and assessment. If monitoring results suggest significant and continuous deviation from historical or background trends in water quality, further investigations into potential impacts are conducted. These are either Investigation Trigger Action Response Plans (ITARP) or Management Triger Action Response Plans (MTARP) as per the WMP.

It is highlighted that, due to changes in land-use in the vicinity of LCO through both mining and agriculture, as well as local variability in groundwater conditions, there is limited opportunity for establishment of groundwater reference sites. Hence, the appropriateness site specific trigger levels is based on historical measurements. Currently, investigations into potential impacts are conducted if there are three consecutive exceedances of the nominated triggers. As is detailed in the WMP, LCO has adopted investigation trigger limits for groundwater monitoring bores regardless of whether they are predicted to be impacted due to current approved mining operations or not.

5.2.1 Groundwater quality investigation trigger definitions

There are two components to the groundwater quality trigger definitions. These are described in detail in the WMP and summarised as follows:

1. *EC investigation trigger* – An investigation trigger because of a monthly measurement either below the, baseline (20th%ile) or above the monthly baseline (80th%ile) on three consecutive occasions. Note the 20th%ile triggers levels are designed to identify downward leakage from the alluvium to the shallow bedrock to provide another mechanism to detect potential alluvial impacts in addition to the water level triggers.
2. *pH investigation trigger* - An investigation trigger because of a monthly measurement either above or below the default pH trigger values from ANZECC (2000) for lowland rivers located in NSW.

5.2.2 Groundwater level investigation trigger definitions

Groundwater level monitoring is carried out at least monthly on the shallow, unconfined, water table aquifers of Bowmans Creek alluvium and the underlying shallow bedrock. Water pressure monitoring is carried out at least monthly on the deeper, confined, hard rock aquifers.

There are three components to the groundwater level trigger definitions. These are described in detail in the WMP (LCO, 2021) and summarised as follows:

- *Definition 1. Impact trigger* – An impact trigger is drawdown of 2m in the alluvium compared to the local reference site for the northern and southern impact zone as shown in the WMP, only applicable at ALV9 and ALV8L.

- *Definition 2. Investigation trigger* – An investigation trigger and is measurement below the monthly, baseline (10th percentile) water level on three consecutive occasions. The purpose of this trigger is to identify unexpected changes to groundwater level.

  ALV9 does not have an investigation trigger because these triggers were developed using historical baseline data and ALV9 was a recent installation (December 2017) to provide greater coverage for the identification of alluvial groundwater impacts in the northern drawdown area.

- *Definition 3. Subsequent Investigation Trigger* - A Subsequent Investigation Trigger is designed to address the potential for harm to listed threatened species, communities and migratory species of concern to EPBC Approval 2013/6908. Following an investigation of an exceedance of Groundwater Level Trigger Definition #2 that concludes the exceedance is not mining-related, should groundwater levels continue to be measured below the lower 10th percentile for a further nine months, such that the exceedance has continued continuously for 12 months, then a subsequent investigation shall be undertaken to confirm that the exceedance remains unrelated to mining activity.

Table 5-4 presents the current site specific investigation trigger levels for water level and groundwater quality and shows the data relevant to the reporting period.

In addition to the Investigation Triggers described above, LCO also have Management / Mitigation Triggers. These occurs when a nominated trigger value is exceeded three or more times, and a potential impact to a receptor and or the potential for environmental harm is identified. Action is taken in the form of further detailed hydrogeological studies to investigate the cause of the exceedance, determination of appropriate mitigation strategy for detailed design and implementation. To date, LCO has not identified any applicable Management / Mitigation Trigger observations.

Monitoring results observed during the reporting period are summarised in following Section 5.2.3 and Section 5.2.4 with the breakdown of:

- Section 5.2.3 Groundwater quality monitoring
    - Groundwater quality of alluvial and shallow bedrock aquifers
    - Groundwater quality of hard rock (Coal Measures) aquifer
- Section 5.2.4 Groundwater level monitoring
    - Groundwater levels of alluvial and shallow bedrock aquifers
    - Groundwater levels of hard rock (Coal Measures) aquifer

5.2.3 Impact Assessment Criteria

Groundwater quality monitoring results and trigger limits for the alluvial and shallow bedrock aquifers during the reporting period are shown in ***Table 5-5***.

Table 5-5 - Groundwater Impact Assessment Criteria

Groundwater Impact Assessment Criteria							
		Groundwater Elevation (mAHD) – Definition #2 & #3		EC (µS/cm)			pH
		10th%ile	**Ref. Min**	**20%ile**	**80%ile**	**Max**	
Alluvial and Shallow Bedrock Aquifers							
ALV1	Alluvial aquifer (L)	106.22	104.88	N/A	1370	2020	6.5 – 8.5
	Shallow bed rock (S)	106.44	104.35	N/A	1560	1770	
LBH	Alluvial aquifer (L)	105.74	104.55	N/A	1550	3090	
ALV3	Alluvial aquifer (L)	103.81	102.43	N/A	1390	3080	
	Shallow bed rock (S)	103.52	102.25	N/A	2800	4510	
ALV4	Alluvial aquifer (L)	102.14	100.97	N/A	1920	3080	
	Shallow bed rock (S)	101.42	100.28	N/A	5310	6430	
ALV2	Alluvial aquifer (L)	93.08	91.12	N/A	2830	4160	
	Shallow bed rock (S)	93.21	89.35	2560	2820	3370	
ALV7	Alluvial aquifer (L)	87.02	86.43	N/A	1780	2310	
	Shallow bed rock (S)	83.56	82.39	N/A	2230	2540	
ALV8	Alluvial aquifer (L)	85.06	83.66	N/A	1310	1880	
	Shallow bed rock (S)	82.99	80.94	1540	1990	2400	
Hard Rock Aquifers (Coal Measures)							
PGW5 *	Overburden (L)	N/A	N/A	N/A	N/A	N/A	6.5 – 8.5
	Coal Measure (S)	N/A	N/A	N/A	N/A	N/A	
Groundwater Level Trigger Definition #1 – 2m drawdown in Bowmans Creek Alluvium							
ALV9L	Groundwater elevation of monitoring piezometer ALV2L minus 5.0m (AHD).						
ALV8L	Groundwater elevation of monitoring piezometer ALV7L minus 4.5m (AHD).						

* - Investigation triggers removed from hard rock aquifer bores PGW5S and PGW5L as per consultation and management plan update during 2017.

5.2.4 Groundwater Quality Monitoring

5.2.4.1 Groundwater quality of alluvial and shallow bedrock aquifers

As established by long term monitoring results, climatic variations significantly influence the hydraulic behaviour/interactions and water quality in the shallow groundwater systems being monitored. Further, LCO has undertaken statistical analysis regarding groundwater quality and climatic trends with the intent to quantitatively establish relationship between groundwater measurements and climatic factors during differing climatic periods. The statistical analysis completed for subsequent ITARP investigations have identified that the mechanisms driving changes to groundwater quality (particularly EC) cannot be easily characterised using the Spearmans' Coefficient statistical analysis method (Jacobs, 2020). This is likely due to other external factors, in addition to rainfall recharge, influencing EC of the Bowmans Creek system such as geological unit subcrops, discharge rates and concentrations from hydrogeological units and hydraulic gradient changes (Jacobs, 2020). The varying climatic variations can be readily described as a period of extreme drought conditions (below average rainfall and above average evaporation) during 2016 to late 2019 followed by a gradual return to conditions similar to long term average (average evaporation and rainfall).

Groundwater pH

Groundwater pH monitoring results measured and a comparison with the investigation trigger levels during the reporting period are presented in Table 5-6 below. There were several instances of minor exceedances of the pH however none of which were sustained or triggered a pH investigation trigger. The pH level across both systems appear to have a relatively stable trend that has existed throughout the data collection period as shown in **Table 5-6**.

Table 5-6 - Groundwater pH results for Alluvial and Shallow Bedrock Aquifers

Alluvial and Shallow Bedrock Groundwater Quality - pH													
Site	**ALV1L**	**ALV1S**	**ALV2L**	**ALV2S**	**ALV3L**	**ALV3S**	**ALV4L**	**ALV4S**	**ALV7L**	**ALV7S**	**ALV8L**	**ALV8S**	**LBH**
Trigger	6.50 – 8.50												
Jun20	6.71	7.52	6.72	7.47	6.88	7.31	6.53	7.09	7.16	7.32	*	*	6.56
Jul20	6.12	6.93	6.47	6.91	6.21	6.60	6.01	6.52	*	6.76	*	*	5.95
Aug20	6.87	7.64	6.94	7.77	6.93	7.39	6.60	7.32	7.24	7.49	*	*	6.65
Sep20	6.92	7.77	7.09	7.82	7.05	7.58	6.71	7.39	7.26	7.55	*	*	6.72
Oct20	6.95	7.69	7.11	7.82	7.12	7.70	6.75	7.51	7.31	7.55	*	*	6.76
Nov20	7.42	7.64	7.11	7.79	7.21	7.57	6.82	7.50	7.33	7.57	*	*	6.75
Dec20	6.95	7.66	7.05	7.79	7.05	7.49	6.67	7.42	7.18	7.59	*	6.93	6.76
Jan21	6.91	7.60	7.08	7.44	6.97	7.42	6.69	7.40	7.21	7.55	*	7.06	6.72
Feb21	7.05	7.85	7.01	7.45	7.15	7.62	6.80	7.51	7.13	7.50	*	6.98	6.85
Mar21	6.95	7.68	7.21	7.62	7.15	7.68	6.82	7.52	7.11	7.44	*	6.97	6.91
Apr21	6.85	7.61	6.98	7.44	6.93	7.47	6.67	7.38	7.14	7.47	7.05	6.99	6.74
May21	6.87	7.71	6.77	7.08	6.88	7.41	6.60	7.26	7.16	7.42	6.99	7.07	6.71

Notes to Table:

* bore dry or water level too low to sample

Groundwater EC

Table 5-7 below summarises the Electrical Conductivity (EC) measurements of groundwater, with comparison to the applicable trigger levels. There have been numerous exceedances of the EC upper limit and subsequent investigations undertaken during the reporting period. Investigations into EC levels have determined that EC levels are varying due to climatic factors rather than a direct impact by mining operations.

Table 5-7 - Groundwater results for EC in Alluvial and Shallow Rock Aquifers

Alluvial and Shallow Bedrock Groundwater Quality - EC													
Site	ALV1L	ALV1S	ALV2L	ALV2S	ALV3L	ALV3S	ALV4L	ALV4S	ALV7L	ALV7S	ALV8L	ALV8S	LBH
80th %ile	1.37	1.56	2.83	2.82	1.39	7.26	6.73	7.42	1.78	2.23	1.31	1.99	1.55
20th %ile				2.56								1.54	
Jun20	1.44	1.37	3.71	3.11	1.35	1.79	1.40	5.38	1.63	3.19	*	*	1.36
Jul20	1.62	1.53	2.80	3.67	1.70	1.96	1.68	6.56	*	4.12	*	*	1.64
Aug20	1.47	1.40	3.40	2.97	1.49	1.65	1.46	5.28	1.54	3.38	*	*	1.75
Sep20	1.64	1.58	4.11	3.62	1.39	1.82	1.61	6.15	1.60	3.96	*	*	2.09
Oct20	1.75	1.69	4.12	3.81	1.38	1.92	1.61	6.15	1.53	3.73	*	*	2.21
Nov20	1.54	1.08	4.07	3.85	1.44	1.92	1.50	6.18	1.53	3.75	*	*	1.93
Dec20	1.57	1.49	3.87	3.61	1.30	1.71	1.50	5.66	1.21	3.64	*	1.87	1.80
Jan21	1.61	1.51	3.86	3.70	1.39	1.89	1.55	5.91	1.13	3.70	*	1.77	1.74
Feb21	1.66	1.58	4.01	3.81	1.21	1.83	1.62	5.94	1.14	3.72	*	1.76	1.68
Mar21	1.68	1.56	3.99	3.74	1.16	1.88	1.59	6.01	1.16	3.65	*	1.80	1.59
Apr21	1.64	1.54	4.00	3.66	1.02	1.86	1.59	5.97	1.51	3.67	1.43	1.81	1.47
May21	1.69	1.60	4.21	3.75	0.92	1.84	1.59	6.00	1.63	3.53	1.43	1.78	1.40

Notes to Table:
Denotes an exceedance of the 80th%ile trigger limit
Denotes an exceedance of the 20th%tile trigger limit
* bore dry or water level too low to sample

As required by the WMP, ITARP investigations have been triggered and completed where monitoring has identified consecutive exceedances of the upper EC level. The conclusions of each investigation (***LCO 2020, LCO 2021***) are summarised in below in ***Table 5-8***.

Table 5-8 - ITARP investigations for quality triggers completed in reporting period

Month of 3rd exceedance	Month exceedance reported	Site	Conclusions
June 2020	July 2020	ALV1L ALV2L	• Groundwater level trends in ALV1L and ALV2L; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. During the previous 36 months, climate data shows high evaporation and below average rainfall with significant variation in residual rainfall mass curve that is the longest downward trend since 2005. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Recent increases in rainfall and subsequent stablisation of the rainfall and evaporation CRD have resulted in a flushing impact to the alluvium and decrease/steadying of the EC results at the triggering bores, ALV1L and ALV2L. These results further implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Noteworthy, measured EC levels at each of the triggering bores have not exceeded reference maximums to date. Hence, it is not expected that there is potential for harm to the environment as the system is varying naturally.
July 2020	August 2020	ALV2S ALV4S	• Groundwater level trends in ALV2S and ALV4S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. During the previous 36 months, climate data shows high evaporation and below average rainfall with significant variation in residual rainfall mass curve that is the longest downward trend since 2005. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Recent increases in rainfall and subsequent stabilisation of the rainfall and evaporation CRD have resulted in an increase of measured water levels producing a flushing effect where water is infiltrating the shallow hard rock and therefore increased interaction with the saline shallow bedrock material is driving elevated salinity for both ALV2S and ALV4S. This implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Whilst, measured EC levels at ALV4S have marginally exceeded reference maximums it is expected that this result is a spike driven from system recovery from the drought through an increase in rainfall.

			Therefore, it is not expected that there is potential for harm to the environment as the system is varying naturally in response to rainfall recharge.
August 2020	September 2020	ALV7S	• Groundwater level trends in ALV7S and ALV7L; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. During the previous 38 months, climate data shows high evaporation and below average rainfall with significant variation in residual rainfall mass curve that is the longest downward trend since 2005. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Further, whilst the maximum reference EC trigger has been exceeded for ALV7S, the potential for environmental harm is low. The demonstrated direct relationship between the alluvium and rainfall, and the low vertical connectivity between the alluvium and underlying fractured rock (being a losing stream), reduces the risk of harm to the alluvium (Jacobs, July 2020). Further, the hydraulic direction at ALV7 remains unchanged from the alluvium to the shallow bedrock, and hence reduces the risk of harm to the environment associated with ALV7S EC values.
September 2020	October 2020	ALV1L LBH	• Groundwater level trends in ALV1L and LBH; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Recent increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. This recent stabilisation of CRD trends has resulted in a flushing impact to the triggering bores, ALV1L and LBH and are expected to also stabilise as rainfall continues to recharge and re-saturate the alluvium. These results further implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Noteworthy, measured EC levels are each of the triggering bores have not exceeded reference maximums to date. Hence, it is not expected that there is potential for harm to the environment as the system is varying naturally.
October 2020	November 2020	ALV2S ALV2L	• Groundwater level trends in ALV2L and ALV2S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and

			evaporation CRD trends. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium and shallow bedrock in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. The stabilisation of the CRD has resulted in an increase in interaction between the saline shallow bedrock and fresh alluvium and subsequent increase in measured EC levels as a result of a flushing impact mobilising salts. These results further implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Noteworthy, measured EC levels are each of the triggering bores have not exceeded reference maximums to date. Hence, it is not expected that there is potential for harm to the environment as the system is varying naturally.
November 2020	December 2020	ALV4S ALV7S	• Groundwater level trends in ALV4S and ALV7S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium and shallow bedrock in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. Recent increases in rainfall and subsequent stabilisation of the rainfall and evaporation CRD have resulted in an increase of measured water levels producing a flushing effect where water is infiltrating the shallow hard rock and therefore increased interaction with the saline shallow bedrock material is driving elevated salinity for both ALV7S and ALV4S. This implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Whilst, measured EC levels at ALV7S have exceeded reference maximums it is expected that this is driven from long term drought conditions and subsequent commencement of system recovery from the drought through an increase in rainfall. Therefore, it is not expected that there is potential for harm to the environment as the system is varying naturally in response to rainfall recharge.
December 2020	January 2021	ALV1L LBH	• Groundwater level trends in ALV1L and LBH; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship between these

			monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Recent increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. This recent stabilisation of CRD trends has resulted in a flushing impact to the triggering bores, ALV1L and LBH and are expected to also stabilise as rainfall continues to recharge and re-saturate the alluvium. These results further implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Noteworthy, measured EC levels are each of the triggering bores have not exceeded reference maximums to date. Hence, it is not expected that there is potential for harm to the environment as the system is varying naturally.
January 2021	February 2021	ALV2L ALV2S	• Groundwater level trends in ALV2L and ALV2S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium and shallow bedrock in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. The change in the CRD has resulted in an increase in interaction between the saline shallow bedrock and fresh alluvium and subsequent increase in measured EC levels as a result of a flushing impact mobilising salts. These results further implies that the measured results at the triggering bores are in response to climatic variations as opposed to mining operations. Whilst the measured EC levels at ALV2S have exceeded reference maximums to date it is not expected that there is potential for harm to the environment as the system is varying naturally in response to an increase in groundwater level and interaction with the saline shallow bedrock material.
February 2021	March 2021	ALV4S ALV7S	• Groundwater level trends in ALV4S and ALV7S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements

			are due to climatic variations rather than a specific mining related impact. • Increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium and shallow bedrock in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. Recent increases in rainfall and subsequent stabilisation of the rainfall and evaporation CRD have resulted in an increase of measured water levels producing a flushing effect where water is infiltrating the shallow hard rock and therefore increased interaction with the saline shallow bedrock material is driving elevated salinity for both ALV7S and ALV4S. This implies that the measured results at the triggering bores are in response to climatic variations opposed to mining operations. Whilst, measured EC levels at ALV7S have exceeded reference maximums it is expected that this is driven from long term drought conditions and subsequent commencement of system recovery from the drought through an increase in rainfall. Therefore, it is not expected that there is potential for harm to the environment as the system is varying naturally in response to rainfall recharge.
March 2021	April 2021	LBH ALV1L	• Groundwater level and EC trends in ALV1(L) and LBH; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. Furthermore, the system is seemingly in a state of flux with the recent onset of above average rainfall and corresponding variability in EC and groundwater levels. The direct relationship between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Recent increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium in this location demonstrate the impact that climatic conditions have on the Bowmans Creek network. This recent uplift in CRD trends has resulted in a flushing impact across the monitored network and as such EC levels are continuing to fluctuate and are expected to also stabilise with stabilisation of rainfall. Noteworthy, measured EC levels are each of the triggering bores have not exceeded reference maximums to date. Hence, it is not expected that there is potential for harm to the environment as the system is varying naturally.
May 2021	June 2021	ALV2S ALV2L	• Groundwater level trends in ALV2(L) and ALV2(S); and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The direct relationship

			between these monitoring observations and rainfall; as well as the trending relationship with EC and residual mass curves, implies that the measurements are due to climatic variations rather than a specific mining related impact. • Increases in rainfall and stabilisation of the CRD trends and subsequent rainfall recharge to the alluvium and shallow bedrock in this location align to indicate that climatic conditions rather than mining activity is driving the observed EC levels. The change in the CRD has resulted in an increase in interaction between the saline shallow bedrock and fresh alluvium and subsequent increase in measured EC levels. • Electrical Conductivity (EC) reference maximum levels have not been exceeded at ALV2(L) however measurements at ALV2(S) have shown a sustained and marginal exceedance of the reference maximum. Whilst the measured EC levels at ALV2(S) have exceeded reference maximums to date it is not expected that there is potential for harm to the environment as the system is varying naturally in response to an increase in groundwater level and interaction with the saline shallow bedrock material.

5.2.4.2 Groundwater Quality of Hard Rock Aquifer

LCO also monitor a number of hard rock aquifers to provide for the ongoing water management onsite; these sites are considered mine water storages and have no applicable investigation limits.

5.2.4.3 Groundwater Quality Summary

Based on the conclusions regarding the various trigger exceedances discussed above, LCO has determined that no environmental harm has occurred as a result of any mining impact during the reporting period.

LCO will continue to monitor the groundwater quality as per the WMP.

5.2.5 Groundwater Level Monitoring

LCO monitor the groundwater level of the Bowmans Creek alluvial and shallow bedrock aquifers to identify any potential impacts from mining such as depressurisation. Hydrographs for piezometers targeting the alluvium and shallow bedrock are displayed ***Figure 5-2*** and ***Figure 5-3*** respectively.

The residual mass curve for rainfall is also presented in Figure 8 6 and Figure 8 7. The residual mass curve for rainfall calculates the difference between observed rainfall and the average amount of rainfall for that time of the year (defined monthly). The CRDs trends for rainfall and evaporation provide the information to understand climatic conditions; for instance, a decreasing rainfall CRD trend indicates measured rainfall is below the long term average and an increasing CRD indicates measured evaporation greater than long term averages. This was developed from the LCO onsite meteorological station to ensure data is most representative of conditions on site.

Groundwater elevations within the water table aquifer decrease with distance downstream. This is because the elevation of the water table within a near surface aquifer (for example, the water table aquifer at LCO), is typically a subdued reflection of surface topography. I.e. in the same way that a surface water course flows from high topographic elevation to low topographic elevation. The steepness of the hydraulic gradient (slope of groundwater elevation with distance down-gradient) reflects other factors including the permeability of aquifer material, differences in propensity for recharge as well as groundwater/surface water interaction.

With reference to full historical monitoring results, the sympathetic response in water levels observed in the paired bores indicate similar processes are driving the recharge for both the alluvial aquifer and shallow bedrock aquifer. The different absolute levels for the paired bores reflect the different hydraulic connectivity between the alluvium and shallow bedrock. Water level relationships show a shift from slight upward pressures (gaining stream) upstream (ALV1), through to equal pressures adjacent to LCO (ALV3, ALV4, ALV2) to slight downward pressures (losing stream) to the south (ALV7, ALV8). Rainfall (recharge) appears to be the dominant driver for groundwater level variability for the Bowmans Creek alluvium and underlying shallow bedrock.

With reference to rainfall and evaporation trends during the previous and current reporting period; the decline in residual mass curve (rainfall) coupled with an increasing residual mass curve (evaporation) suggested that drought conditions (below average rainfall and higher than average evaporation) prevailed until an increase in rainfall was measured throughout 2020 reversing the rainfall CRD gradient. This Increase in rainfall and decrease in evaporation conditions throughout 2020-21 and has resulted in recharge throughout the Bowmans Creek system which is demonstrated through many of the groundwater bores which were dry in 2019 now recovering or have recovered to pre-drought levels with sustained rainfall recharge required to continue to maintain this.

With respect to trigger exceedances, there were no exceedances of the Impact Triggers for alluvial draw down impact assessment (Definition 1). There were a number of Investigation and Subsequent Investigation (Definition 2 & 3 respectively) trigger level exceedances summarised herein.

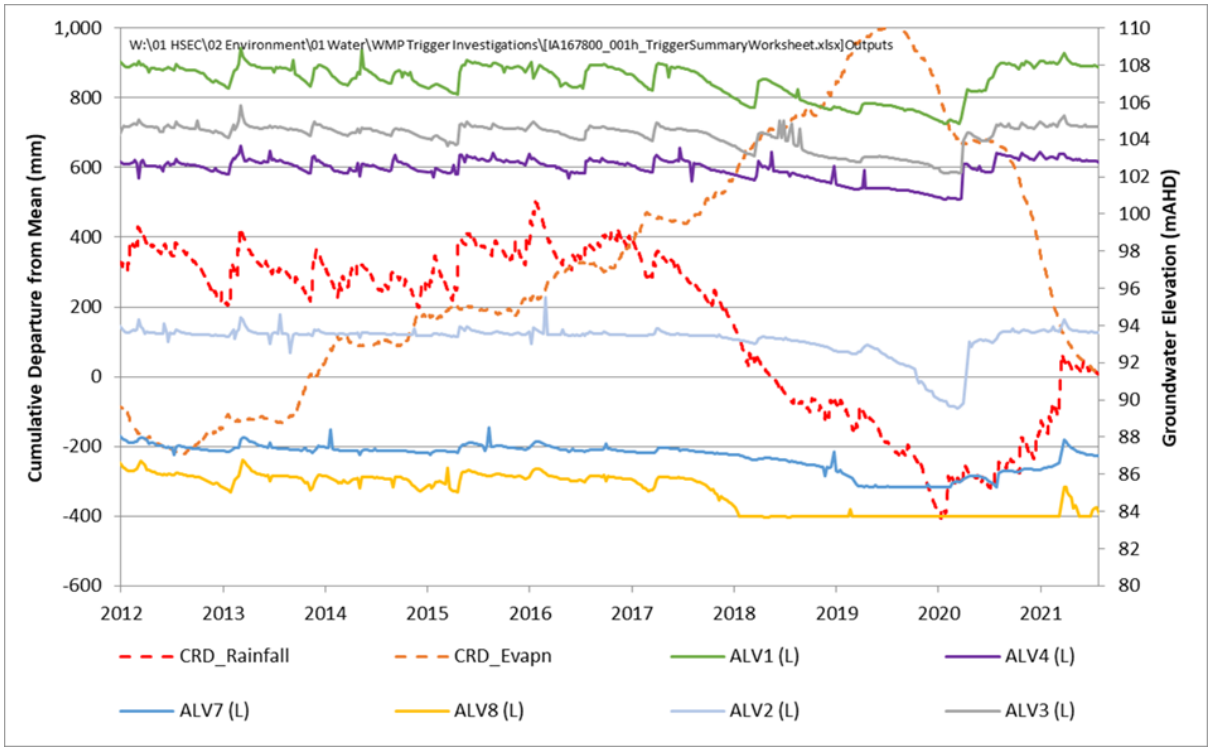

Figure 5-2 – Groundwater - alluvial elevations

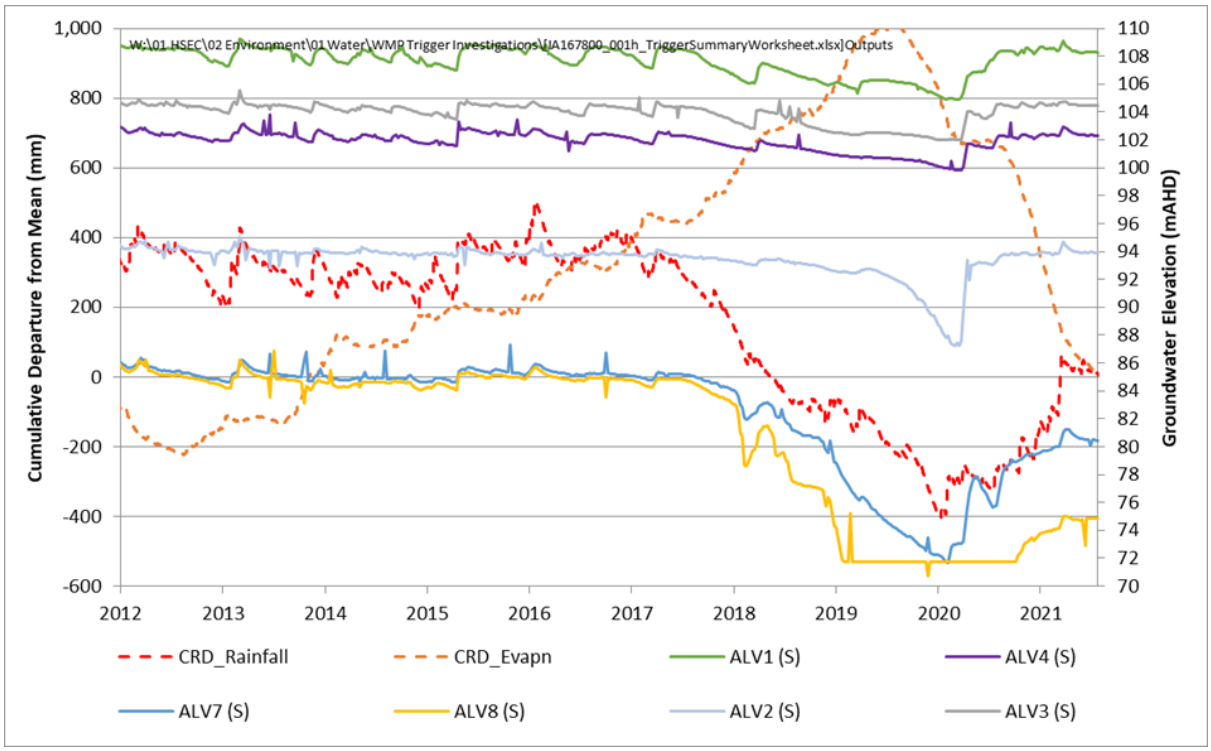

Figure 5-3 – Groundwater – shallow bedrock elevations

Table 5-9 presents recorded groundwater depth to water measurements as well as exceedances of investigation trigger limits during the monitoring period. ***Table 5-9*** presents a summary of the ITARP investigations completed during the reporting period (***Jacobs 2020, Jacobs 2021***). Noteworthy, in accordance with the WMP, where groundwater levels continuously trigger after the initial investigation (triggered on three consecutive months) & it has been determined not to be a mining related impact; subsequent investigations occur at 12 consecutive months and then at 24 consecutive months unless otherwise recommended through the investigation findings. ALV9 does not have an applicable Definition #2 investigation trigger as these triggers were developed using historical baseline date and ALV9 installed in 2017 is in place to detect potential draw down impacts based on measured differences with nearby reference bore ALV2L.

Groundwater investigations completed to date have not concluded that mining activities have resulted in impacts exceeding that approved for LCO.

Table 5-9 - Depth to Water Monitoring Results and Trigger Exceedances

Site	ALV1L	ALV1S	ALV2L	ALV2S	ALV3L	ALV3S	ALV4L	ALV4S	ALV7L	ALV7S	ALV8L	ALV8S	LBH
10th %ile	4.97	4.75	4.8	4.67	5.7	5.99	5.56	6.28	6.75	10.21	6.96	9.03	5.05
Max	6.31	6.84	6.76	8.53	7.08	7.26	6.73	7.42	7.34	11.38	8.36	11.08	6.24
Jun20	4.55	4.23	4.68	4.68	5.56	5.90	5.41	6.19	7.96	16.84	8.36	20.30	4.79
Jul20	3.82	3.50	4.80	4.86	5.29	5.69	5.40	6.26	8.24	18.08	8.36	20.30	4.11
Aug20	3.09	2.80	4.27	4.19	4.64	4.87	4.45	5.39	7.64	16.35	8.36	20.30	3.60
Sep20	3.11	2.80	4.21	4.10	4.79	5.03	4.58	5.47	7.60	15.09	8.36	20.30	3.72
Oct20	3.28	3.03	4.22	4.09	4.82	5.10	4.71	5.57	7.63	14.85	8.36	20.30	3.78
Nov20	3.19	2.99	4.10	3.95	4.69	4.93	4.54	5.31	7.52	14.55	8.36	20.30	3.60
Dec20	3.19	2.85	4.24	4.13	4.88	5.14	4.77	5.51	7.50	14.27	8.36	18.56	3.74
Jan21	2.83	2.41	4.04	3.87	4.48	4.70	4.53	5.26	7.48	14.03	8.36	18.08	3.44
Feb21	3.02	2.61	4.15	4.00	4.72	4.96	4.66	5.31	7.38	13.99	8.36	18.05	3.80
Mar21	3.16	2.82	4.19	4.03	4.74	5.00	4.78	5.39	7.21	13.78	8.36	17.93	3.66
Apr21	2.88	2.52	3.91	3.57	4.61	4.84	4.71	4.94	6.18	12.52	7.02	17.04	3.44
May21	3.17	2.88	4.19	3.93	4.74	4.98	4.82	5.30	6.58	13.10	7.85	17.29	3.57

Notes to Table:

Denotes an exceedance of the 80th%ile trigger limit

Denotes an exceedance of the 20th%tile trigger limit

* bore dry or water level too low to sample

Table 5-10 - ITARP investigations for groundwater level triggers completed in reporting period

Month of 3rd exceedance	Month exceedance reported	Site	Conclusions
July 2020	August 2020	ALV2S	• During the previous 36 months, climate data shows high evaporation and below average rainfall with significant variation in residual rainfall mass curve that is the longest downward trend since 2005. • Whilst ALV2S has continued to exceed water depth triggers, recent rainfall recharge has demonstrated a substantial increase in the measured levels indicating that rainfall is the primary driver for the measured level in the shallow bedrock. Noteworthy, weekly groundwater level monitoring, outside of the monthly WMP monitoring program, at LCO conducted in August 2020 has seen ALV2S water level continue to rise with increased rainfall and is no longer triggering as per water level Definition #2 WMP triggers.
September 2020	October 2020	ALV8L	• The sustained, dry alluvium at ALV8L withstands the conclusions of the previous ITARP reports at ALV8L and the Bowmans Creek monitoring network more widely, with a clear correlation to the rainfall and evaporation CRD trends. Climate data shows high evaporation and below average rainfall with significant variation in residual rainfall mass curve that is the longest downward trend since 2005, with a recent reversal commencing in 2020. The direct relationship between these monitoring observations and rainfall implies that the measurements are due to climatic variations rather than a specific mining related impact. • Groundwater decline in ALV8L (and its reference bore, ALV7L) have been observed during previous periods of below average rainfall, including the Millennium Drought, when ALV8L also ran dry. Whilst the ALV bore monitoring system recorded alluvium response during the Millennium Drought, current climatic conditions measured characterise the most severe drought in the monitoring period and is therefore unprecedented in network response. Therefore, whilst recent rainfall in 2020 has begun to show a response in ALV7L, LCO has not measured rainfall comparable to historic flood events breaking previous droughts nor has there been a long period of average or above average rainfall to re-saturate the alluvium.
January 2021	February 2021	ALV7S ALV7L ALV8S	• Groundwater level trends in ALV7S, ALV7L and ALV8S; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. Periods of groundwater level decline in ALV7S, ALV7L and ALV8S have been observed during previous periods of below average rainfall, albeit not to the extents of the recent severe

			drought conditions. During the recent drought, ALV7 and ALV8 water levels have been below historic lows, which coincided with the most recent period of sustained below average rainfall and above average evaporation. Recent increases in rainfall have resulted in a response in the Bowmans Creek monitoring network including at ALV8S, ALV7L and ALV7S however a continuation of these climatic conditions is required to see further recharge of these monitoring bores. • Assessments carried out prior to and as part of DA305-11-01 Modification 5 concluded that the recharge to the coal measure fractured aquifer is likely very low. This is driven by the relatively high ratio of horizontal to vertical permeability of the alluvium and regolith, which reduces the capacity for water to migrate vertically in the geological profile from the alluvium to the fresh coal measure units, as is the case in the ALV7/ALV8 area (Jacobs, 2020). • DA305-11-01 has approved some impacts to the Bowmans Creek alluvium and fractured rock aquifer. Modelling has demonstrated that these impacts are predominately driven by the removal of the Davis Creek Fault and Dyke and the total dewatering of the former Liddell M49 underground workings. To date, total dewatering of the M49 workings have not occurred nor have there been any containment failures within the underground. • Groundwater depths measured within the alluvium at ALV7L, reflects a natural variability due to climatic factors and the result of prolonged drought conditions. This is reinforced by the recent increase in rainfall and the subsequent recharge in the alluvium at ALV7L. Whilst recharge has commenced within the alluvium, rainfall has not been significant enough to offset the years of prolonged drought conditions therefore these improvements to conditions need sustaining prior to the alluvium returning to pre-drought levels. Therefore, it is unlikely that the measured results at ALV7L are the result of a mining related impact and are a response to climatic conditions. • The decline in measured level in ALV7S and ALV8S is likely influenced by a combination of severe drought conditions and mining in the south-east portion of the Entrance Pit. The pit floor in the adjacent area of the Entrance Pit has been lowered to approximately 45m below the base of ALV7S and ALV8S. The lowering of the Entrance Pit has caused depressurisation of the surrounding fractured rock aquifer with subsequent vertical drainage of the overlying formations. This depressurisation has been approved under DA305-11-01. With the increase in rainfall, ALV7L, ALV7S and ALV8S have commenced recharge and this is predicted to continue as rainfall continues demonstrating that groundwater levels are influenced by climatic factors.

			• As there is a demonstrated direct relationship between rainfall and recharge in the alluvium and the shallow bedrock, it is not expected that there is potential harm for the environment and the system is varying naturally. Additionally as Groundwater Definition #1 triggers have not been exceeded LCO has not had drawdown impacts greater than what has been approved to date.

5.2.6 Groundwater Levels of Hard Rock Aquifer (Coal Measures)

LCO monitor a number of hard rock aquifers to provide for the ongoing water management onsite. The groundwater elevations within these aquifers vary significantly between the piezometers monitored, reflecting differences in groundwater levels between different stratigraphic layers and as a consequence of recent and historical mining and dewatering operations. There are no investigation groundwater trigger levels for monitoring of these water bodies.

Noteworthy findings from the ongoing monitoring indicate that there is no significant connectivity between the Hazeldene workings and the actively mined Liddell Seams below. This is supported by the lack in response of groundwater elevations/pressures in the Hazeldene workings when drawn down of the mined Liddell seams occurs

5.2.7 Groundwater Level Summary

Based on the conclusions regarding the various trigger exceedances discussed above, LCO has determined that no environmental harm has occurred as a result of any mining impact during the reporting period.

LCO will continue to monitor the groundwater levels as per the WMP.

6. Reference Information

Reference information, listed in ***Table 6-1***, is information that is directly related to the development of this document or referenced from within this document.

Table 6-1 - Reference Information

Reference	Title
DP&E 2015	*Independent Audit Guideline. Post-approval requirements for State significant developments*
LIDOC-90533967-2881	*Liddell Coal Operations Mining Operations Plan/Rehabilitation Management Plan*
LIDOC-90533967-3755	*Biodiversity Offset Management Plan*
LIDOC-90533967-3687	*Biodiversity Management Plan*
LIDOC-90533967-3776	*Indirect Offset Management Plan*
LIDOC-90533967-3694	*Water Management Plan*
LCO 2018	*Liddell Coal Operations Annual Review 2017*
LCO 2019	*Liddell Coal Operations Annual Review 2018*
LCO 2020	*Liddell Coal Operations Annual Review 2019*
LCO 2021	*Liddell Coal Operations Annual Review 2020*
Umwelt 2015	*Biodiversity Monitoring Report. Prepared for Liddell Coal Operations Pty. Ltd*
Umwelt 2015	*Biodiversity Offset Monitoring Report Prepared for Liddell Coal Operations Pty Ltd*
Umwelt 2015	*Rehabilitation Monitoring Report Prepared for Liddell Coal Operations Pty Ltd*
Umwelt 2018	*Biodiversity Monitoring Report. Prepared for Liddell Coal Operations Pty. Ltd*
Umwelt 2018	*Biodiversity Offset Monitoring Report Prepared for Liddell Coal Operations Pty Ltd*
Umwelt 2019	*Biodiversity Monitoring Report. Prepared for Liddell Coal Operations Pty. Ltd*
Umwelt 2019	*Biodiversity Offset Monitoring Report Prepared for Liddell Coal Operations Pty Ltd*
Umwelt 2020	*Biodiversity Monitoring Report. Prepared for Liddell Coal Operations Pty. Ltd*
Umwelt 2020	*Biodiversity Offset Monitoring Report Prepared for Liddell Coal Operations Pty Ltd*
ARRP 2017	*Liddell Coal Operations Annual Rehabilitation Monitoring Report 2017*
LCO 2020	*Liddell Coal Operations Groundwater Investigation Trigger Report - June 2020* *Liddell Coal Operations Groundwater Trigger Investigation Report - July 2020* *Liddell Coal Operations Groundwater Trigger Investigation Report - August 2020* *Liddell Coal Operations Groundwater Trigger Investigation Report - September 2020* *Liddell Coal Operations Groundwater Trigger Investigation Report - October 2020* *Liddell Coal Operations Groundwater Trigger Investigation Report - November 2020*

	Liddell Coal Operations Groundwater Trigger Investigation Report - December 2020
LCO 2021	*Liddell Coal Operations Groundwater Trigger Investigation Report - January 2021 EC* *Liddell Coal Operations Groundwater Trigger Investigation Report - January 2021 Depth* *Liddell Coal Operations Groundwater Trigger Investigation Report - February 2021* *Liddell Coal Operations Groundwater Trigger Investigation Report - March 2021* *Liddell Coal Operations Groundwater Trigger Investigation Report - May 2021*

GLENCORE