LIDDELL

GLENCORE

EPBC Approval 2013/6908

Annual Report 2020

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Table of Contents

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 addressin:

- 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 2019 to 18 May 2020 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.	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 During the reporting period (19 May 2019 to 18 May 2020) LCO has cleared 9.47ha of land within the referral area, which consisted of: • 0.44ha of Central Hunter Box – Ironbark Woodland (Regrowth) • 0.36ha of Central Hunter Box – Ironbark DNG • 0.03ha of Central Hunter Box – Ironbark Woodland • 8.62ha of Central Hunter Bull Oak Forest Regeneration	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	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 submitted on26 February 2020 in accordance with Condition 22. Operations have continued to be implemented as per the Biodiversity Management Plan detailed in **Section 3.1**.	Compliant

Condition	Actions During Reporting Period	Status
h. Adaptive management.		
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. During the reporting period a revised BMP submitted on 26 February 2020 in accordance with Condition 22. 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;	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 submitted on 26 February 2020 in accordance with Condition 22.	Compliant

Condition	Actions During Reporting Period	Status
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.		
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 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.	LCO undertook rehabilitation in accordance with the Rehabilitation Environmental Management Plan (RMP/MOP). A revised copy of the RMP/MOP was forwarded to the Department on the 31 December 2017. Further detail is provided in **Section 3.1.3**	Compliant
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	Offsets lands specified under this approval are owned by LCO and are managed in accordance with the Biodiversity Offset Management Plan (BOMP). During the reporting period, LCO finalised the required content and details of the CA documentation in consultation with representatives from the NSW Biodiversity Conservation Trust (BCT). The Chief Executive of NSW OEH signed the Agreements on 9 May 2019 on behalf of the Minister administering the NSW NPWS Act. They were registered on the property title in Aug/Dec 2019.	Compliant

Condition	Actions During Reporting Period	Status
d. require the approval of a State Planning or Environment Minister to be changed or revoked.		
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 areas. Consequently LCO submitted revised attribute data to the Department on 24 December 2018.	Compliant
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;	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 26 February 2020 in accordance with Condition 22.	Compliant

Condition	Actions During Reporting Period	Status
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.		
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 and September 2019. 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	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.	Compliant

Condition	Actions During Reporting Period	Status
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 QuoII; 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.	During the reporting period a revised IOP submitted on 26 February 2020 in accordance with Condition 22.	
11. The approved Indirect Offset Plan must be implemented.	The IOP was originally approved on 5 May 2016 and revision subsequently approved in September 2017. A revised IOP submitted on 26 February 2020 in accordance with Condition 22. 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 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	Compliant

Condition	Actions During Reporting Period	Status
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 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.	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 26 February 2020.	

Condition	Actions During Reporting Period	Status
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.	LCO did not conduct any discharge event under the Hunter River Salinity Trading Scheme during the reporting period. Further information is provided in **Section 5**.	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 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.	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
16. If groundwater monitoring identifies groundwater drawdown in the alluvium of Bowmans Creek of more than 2 metres, the approval holder must:	The Bowmans Creek groundwater drawdown ITARP was not triggered during the reporting period. Further information is provided in **Section 5**.	Compliant

Condition	Actions During Reporting Period	Status
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.		
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

Condition	Actions During Reporting Period	Status
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 2020 Annual report was published on the LCO public website on 11 August 2020. Notification was provided to the Department on 11 August 2020.	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 Minister and the audit report must address the criteria to the satisfaction of the Minister.	Not triggered during the reporting period.	Compliant
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:	During the reporting period LCO made revisions to the following management plans and submitted to the revised plans on the 26 February 20208 to the department in accordance with Condition 22: • Biodiversity Management Plan; • Indirect Offset Management Plan; • Water Management Plan; and	Compliant

Condition	Actions During Reporting Period	Status
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.	• Biodiversity Offset Management Plan	
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. 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.	Not triggered during the reporting period.	Compliant

Condition	Actions During Reporting Period	Status
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.	Not applicable (NA)	NA
23. Revoked.	NA	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.	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 4 performance criteria during this reporting period. **Table 3-1** summarises the performance criteria set for Year 4 of operation of the BMP; and actions completed to date.

Table 3-1 - Biodiversity Management Plan Implementation Summary

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
Year 4 2019			
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 rehabilitation success.	Weeds are managed in line with Weed Action Plan. Preclearance survey identifies any weed infestations requiring further management.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
Creek and Drainage Line Protection			
Fencing/protection of LCO controlled side of riparian corridor (as part of Offset Management Plan).	Refer to fencing action items above in table.		
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 2019 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.	Complaint.	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.	Compliant.	LCO implements pre-clearing as part of Ground Disturbance Permit process with outcomes recorded and recommendations implemented.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
	Outcomes of pre-clearing process are recorded and recommendations are implemented.		
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 translocated to Mountain Block BOA and has been subject to monitoring as required. Translocation is thus far deemed successful.
Remnant Vegetation and Habitat Management			

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
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.
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.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
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.	Compliant.	Annual monitoring included assessing degree of regeneration of native trees. Native regeneration was identified and considered adequate at R02, W01 and W03.
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.
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	Inspections completed every two months, followed by implementation of required control methods, as required.	Compliant	Feral animal inspections are undertaken every two months in accordance with commitments of the BMP.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
needed), including timing, frequency, target species and methods to be used.			Foxes (Vulpes vulpes) were identified in low numbers and subsequently should be key species for management in 2020. Unlike previous monitoring years, the pig (Sus scrofa) was not detected and presence appears to be declining.
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 2019. 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 2019.
Blue-billed Duck Management			
Complete habitat enhancement, maintenance and monitoring works (as required) for the blue-billed duck	Ongoing habitat enhancement and management works within Dam 3 and two Triangle Dams. Monitoring works as required.	Compliant	Recommendations for enhancement measured are provided for supplementary planting however no works are recommended until drought conditions ease.
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	Compliant	Habitat material is identified during the pre-clearance process and salvaged where possible to reinstate into BMP areas.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
	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.		
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 A"program conducted in 2019.
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.

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
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. Ongoing habitat augmentation works will continue with clearing in 2020.
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	Supplementary plantings include foraging plant resources recommended by monitoring programs.
Grazing Management			
Stock rotation	Cattle are grazed within improved pasture areas within mine rehabilitation >3years where practical	Compliant	LCO coordinate cattle grazing and rotate stock between paddocks with advice of district agronomist

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
	Stocked will be managed to allow pasture recovery and maintain pasture availability and sufficient groundcover.		
Bushfire Management			
Bushfire Management Plan will be implemented	Implementation of requirements of updated Bushfire Management Plan.	Compliant	Bushfire Management Plan updated in 2018. No signs of bushfire impacts were noted during the 2019 monitoring event.
Ecological Monitoring			
Undertake floristic, fauna, LFA, waterbird, nest box, stygofauna and instream/riparian monitoring program throughout LCO	Monitoring program completed and reported.	Compliant	Monitoring completed in 2019 indicates remnant sites have remained relatively stable since commencing monitoring; however rehabilitation is still young and will not be likely to provide comparable floristic and faunal diversity to reference vegetation for a number of years.
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 this Annual Review.
Native fauna presence in rehabilitation/regeneration areas	Fauna monitoring completed.	Compliant	2019 fauna monitoring completed and indicates native fauna is present in rehabilitated vegetation. Introduced fauna are also present and should be subject to ongoing control to reduce impact on native vegetation and faunal assemblages. Increased structural and

Action/Item	Performance Indicators	Completion Criteria	Performance Comment
			vegetation diversity in rehabilitation areas will increase native fauna diversity in these areas with time. The number of introduced fauna species is higher in rehabilitated area. However, this should decrease with improved niche availability for native fauna.

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 conditions. 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.

Other key findings of the 2019 biodiversity monitoring program were as follows:

- Rehabilitation site WR01 is now considered statistically floristically similar to remnant vegetation. However, remains quite distinct in terms of floristic structure to benchmark vegetation.
- Substantial canopy defoliation was observed at remnant site R02, the cause of this was attributed to prolonged drought.
- Remnant vegetation at sites W01 and W03 are generally in good condition. However, some potentially problematic weed species are present in these areas that should be controlled.
- A decrease in native diversity at W01, WR01 and R02 was observed in 2019.
- An increase in native species diversity at remnant site W03 correlates with a decrease in total native cover and an increase in introduced cover. Care should be taken to control introduced species with increasing coverage.
- Weed infestation (specifically Rhodes grass (Chloris gayana)) at rehabilitation site WR01 was previously problematic, however was not recorded in 2019. This is attributable to drought and weed management works.
- Riparian remnant site R02 is dominated by introduced species which are out-competing natives. Given their prevalence over an extended period, these are unlikely to recover to former levels without intervention.
- Bird diversity was generally much lower than average across all monitoring sites compared to prior years. This is likely to have been a natural fluctuation due to the hot dry conditions present at the time of survey reducing bird activity. Water resources were also limited.
- There has not been a notable increase in the extent of feral species presence, however continued management of predators (particularly fox (Vulpes vulpes)) will increase habitat value for native fauna.
- Stygofauna diversity at all sites were low/absent, this was consistent with most previous monitoring events.
- No signs consistent with myrtle rust, Phytophthora or Chytrid fungus were identified.

LCO will continue to implement the BMP commitments and recommendations detailed in the 2019 BMP monitoring report (Umwelt, 2020). Key recommendations to be implemented during 2020 by LCO will include:

- Continued supplementary plantings to assist in infilling vegetation where gaps in certain strata have been identified.
- Progressive installation of habitat features such as boulders, rocks and logs prior to seeding/planting activities, and/or adjacent to established rehabilitation areas.
- 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 2019 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 2019 rehabilitation targets as specified in the 2018-2020 MOP during the reporting period when considering the cumulative variance of rehabilitation.

Overall, LCO achieved 50.49ha of rehabilitation during 2019 compared to 48.8ha as described in the MOP. LCO remain at +7.7ha variance for the planned rehabilitation during the MOP term due to the additional 7ha completed in 2017 and additional 1.7ha in 2019. LCO will continue to implement the MOP/RMP and BMP to progressively rehabilitate the operation.

The general outcomes of the 2019 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. In the case of woodland vegetation however, 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 has additionally hindered the development of rehabilitation.
- In terms of pasture areas, height and density are typically good for grazing.

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 5 commences 5th January 2019.

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

Table 4-1 - Year 4 Biodiversity Offset Management Plan Implementation Summary

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
Pathogen Management				
All biodiversity offset areas	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. Additional investigation scheduled in 2020 to definitively rule out.
Fencing and Signage				
All biodiversity offset areas	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 noted secure during monitoring events.
	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 faunal passage (while maintaining cattle exclusion).	New fences are installed without barbed wire on upper strands and an elevated plain wire bottom strand.	Compliant	All new fencing conforms to required standard.
	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	Fenceline inspections are undertaken every two months in accordance with the BOMP
	Information signage for the spotted-tailed quoll.	Informational signage (for the spotted-tailed quoll) is maintained.	Compliant	Signage is installed and in good condition. New offset signage also present.

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
Grazing Management				
All biodiversity offset areas	All stock to be removed from BOAs	No stock grazing	Compliant	No evidence of cattle grazing was evident during 2019 in any BOA
	Minimum bi-monthly inspections to determine presence of rogue stock and assess condition of fences.	To be completed bi-monthly.	Compliant	Cattle inspections are undertaken bi-monthly in accordance with the BOMP.
	Remove reported rogue stock and repair damaged fences.	Action and remove reported rogue stock and repair damaged fences.	Compliant	Fence reparation works are undertaken in accordance with the BOMP.
Track Maintenance				
All biodiversity offset areas	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.	Compliant	No new access tracks required.
	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.	Complaint	Access tracks inspections are undertaken bi-annually in accordance with BOMP commitments
	Rehabilitation of unnecessary access tracks.	Tracks no longer required will be rehabilitated.	Compliant	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,	Inspections completed every two months, followed by implementation of required control methods, as required.	Compliant	Feral animal inspections are undertaken every two months in accordance with commitments of the BOMP.

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
	frequency, target species and methods to be used.			Feral fauna was identified however in low numbers and do not appear to be increasing in abundance Foxes (Vulpes vulpes), fallow deer (Dama dama) and a cat (Felis catus) were identified in low numbers and subsequently should be key species for management in 2020.
	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 2019. Pest numbers appeared to be stable during monitoring events.
	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. Monitoring of impacts of fox, feral cat and feral dog control on spotted-tailed quoll population.	Compliant	No feral dogs were recorded in any BOAs during 2019, however foxes were identified in both Mountain Block and Bowmans Creek Riparian Corridor and a cat was identified in Mitchell Hills South during 2019. Feral fauna were identified in low numbers and do not appear to be increasing in abundance.
	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 developed and implemented.
Weed Management				
All biodiversity offset areas	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. Evidence of galenia and introduced grass spraying was evident and appeared successful.

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
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 however drought conditions have hindered development. Mapping to be completed in future when conditions have improved.
Mountain Block and Mitchell Hills South	Management of regeneration progress is responsive to monitoring outcomes.	Assess progress/outcomes of natural regeneration and assess and implement assisted regeneration measures as required.	Compliant	Monitoring of regeneration progress was made in 2019 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.	Natural regeneration.	Compliant	Natural regeneration was identified in BOAs. Additional supplementary planting deemed required.
Rehabilitation				
Mountain Block	Modification 7 Area transferred back under BOMP management	-	N/A	Mountain Block rehabilitation area works commenced in 2019 and offset area is to be transferred back into the BOMP once complete.
Bowmans Creek Riparian Corridor Mountain Block Offset Area	Develop detailed performance criteria for all management zone types.	Detailed criteria developed based on annual monitoring of analogue sites.	Compliant	BOMP criteria updated in 2018 in response to progressive monitoring results.
Bowmans Creek Riparian Corridor	Implement rehabilitation/ revegetation program.	Implementation of plan.	Compliant	Log stockpiles to increase habitat value were identified in central Bowmans Creek Riparian

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
Mountain Block Offset Area				Corridor (not present in monitoring sites). Revegetation works commenced in Bowmans Creek Riparian Corridor and Mountain Block. Nest boxes have been installed in both BOAs.
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	Large log piles and rock piles have been installed in central Bowmans Creek Riparian Corridor.
Bowmans Creek Riparian Corridor	Nest boxes are providing habitat value for native fauna.	Continue staged installation of nest boxes.	Compliant	Nest box installation is taking place in this BOA. Signs of presence and actual occupation of nest boxes is occurring.

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
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	Nest boxes have been installed in all BOAs. Log pile installation continuing along Bowmans Creek Riparian Corridor.
Translocation				
All biodiversity offset areas	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	One tiger orchid successfully translocated to Mountain Block in 2018. This orchid was still alive in 2019
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	Need for fencing reparation works were not identified.
Bowmans Creek Riparian Corridor	Rehabilitation works to address stabilisation and erosion issues, as necessary.	Implementation, as needed.	Compliant	No stabilisation and erosion issues required to be addressed in reporting period.
Seed Collection				

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
All biodiversity offset areas	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	No substantial seeding resources identified during 2019 monitoring. Seed collection has been occurring as resources are available.
Erosion Sedimentation and Salinity				
Mountain Block	Control of erosion in southern paddocks	Commence hydromulch trials of gullies in southern paddocks.	Compliant	Trial completed in late 2019 and results for success are being monitored.
	Monitor completed erosion works and action repairs if required.	Monitor completed erosion works and action repairs if required.	Complaint	Undertaken as part of separate program
Bushfire				
All biodiversity offset areas	The current Bushfire Management Plan will be updated according to the approved modification. Bushfire Management Plan will be implemented.	Implementation of requirements of updated Bushfire Management Plan.	Compliant	Bushfire Management Plan implemented.
Monitoring				
All biodiversity offset areas	Undertake floristic, fauna, LFA and nest box monitoring program	Monitoring program completed and reported	Compliant	Ecological monitoring program completed. Results summarised in Section 4.1.1.

Relevant Offset Area	Action	2019 Performance Indicator	Compliance	Performance Comment
	Undertake annual inspections of LCO rehabilitation and active regeneration areas	Annual inspections completed	Compliant	Annual Rehabilitation Inspection completed.
	Native fauna presence in rehabilitation/regeneration areas	Fauna monitoring completed	Compliant	Native fauna recorded within rehabilitation and regeneration areas during annual ecological monitoring program.

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. Of particular note was the decline in occurrence of African lovegrass (Eragrostis curvula) across all BOAs as a result of targeted weed spraying works. This should allow for recovery of small native herbs and grasses that had potential to be out competed by this invasive species.

Works have been targeted areas in greatest need of management. A summary of management actions completed in 2019 include:

- Supplementary planting of target vegetation in Bowmans Creek Riparian Corridor;
- Weed and pest management throughout all BOAs;
- Seed collection to supplementary seeding resources for regeneration purposes;
- Hydromulching of an area of erosion containing sensitive aboriginal cultural heritage items;
- Installation and repair of nest boxes; and
- Remediation of Mountain Block slope failures (2020).

The 2019 monitoring, identified low utilisation of monitoring sites by feral fauna. This low utilisation may be attributable to management actions of these species or could correlate with a poor breeding season as a result of reduced resources. This result may lead to an increased usage of some areas by spotted-tailed quolls (Dasyurus maculatus maculatus) during the 2020 monitoring event. Ongoing management of these feral species is recommended as a priority to retain these low levels of occurrence.

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 planted begin to grow and provide improved habitat value (canopy coverage and foraging resources).

Key findings of the 2019 biodiversity offset monitoring program were as follows:

- Remnant vegetation is generally in good condition (considering drought), however some potentially problematic weed species are present in areas close to the Bowmans Creek (R02 and W07).
- Signs of drought-related stress, particularly canopy defoliation were evident throughout most areas (particularly riparian vegetation).
- Of the fauna groups monitored, bird diversity has undergone the greatest decrease of the fauna groups in 2019 from baseline. Bird diversity can greatly fluctuate from year to year due to the mobility of this group and these increased bird diversities do not appear to correspond to any substantial changes in habitat (other than declines in availability of surface water due to prolonged drought).
- Levels of observed feral fauna remain low, likely because of management actions being undertaken. These actions may be assisting in the ongoing presence of the spotted-tailed quoll (Dasyurus maculatus maculatus).
- Although many are yet to be colonised (some less than two years old), substantial nest box installation activities have been undertaken in all BOAs. Nest boxes are currently showing moderate signs of occupation. Ongoing monitoring should see an increase in presence of hollow dependent species in BOAs.

- Revegetation sites along Bowmans Creek Riparian Corridor are highly disturbed and require substantial intervention. Active revegetation has been undertaken with varying levels of success that will be assisted by infill planting and reduced water stress. These should start to show progress in subsequent monitoring. Several areas require entire re-planting efforts.
- Revegetation sites in Bowmans Creek Riparian Corridor are largely devoid of recruiting canopy species and require additional plantings.
- Observed levels of threatened species during the 2019 monitoring were low across all sites (remnant and regenerating), except for micro-bats which did not discriminate between low- and high-quality vegetated areas, instead preferring areas in proximity to water resources.
- No signs consistent with myrtle rust, Phytophthora or Chytrid fungus were identified.

Recommendations for the enhancement of existing ecological values and improved rehabilitation/ regeneration were received as part of the 2019 monitoring program; refer to the full offset monitoring report Umwelt 2019.

Liddell has actioned on 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 agreed to be 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 most recent version updated in September 2019 included minor updates to reflect DA Modification 7 approval and updates to project timeframes because of project progress.

4.2.1 Management Actions during the reporting period

The reporting period

Although the EPBC reporting period begins in May 2020, annual objectives detailed in the IOMP are measured from 1 July 2019 to 30 June 2020. 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). IAL have reported that the software is ready for release in in a MATLAB™ format. The task summary provided below in ***Table 4-2*** provides an updated list of actions.

Table 4-2 - Quoll Identification Toolkit Development Progress

Action No.	Action Description	Status
1.	Continue to refine Matlab based version (address issues raised in initial testing).	Complete
2.	Conduct user testing with NSW OEH Saving our Species and UNE/NSW Dept. Primary Industries project groups.	Complete
3.	Undertake refinements to QIT once testing is complete	Complete
4.	Prepare scientific paper for publication	In progress
5.	Develop user manual	In progress
6.	Release of QIT for use	In progress

4.2.1.2 Task 2 Surveying/Monitoring STQ Populations

Middle Foybrook Area

A PHD student has been engaged since early 2019 to oversee the completion of the project and successfully implemented the camera trapping program throughout the reporting year. The program was condensed to the Glencore Hillcrest/Mitchells Hill/Mt Block offset areas. In summary, there were 19 individual quolls detected from 505 camera events, refer Table 2 below. Unfortunately, during the surveys (October 2019 to February 2020) two cameras traps (LC13 and LC39) were stolen with the data lost as a result.

Each existing camera was paired with an additional lured camera to provide additional information about local prey species and additional opportunities to detect quolls Information from these additional, in-kind cameras will be presented in future reports as further data is collected. A summary of quoll identification results at Liddell between October 2019 and May 2020 are in ***Table 4-3***.

Table 4-3 - Quoll identification results from Liddell Coal site (Oct 2019 to May 2020)

Survey period	Camera Type	Quoll camera events/detections	% of images ID to individual quolls	Individual quolls identified
Survey 1 (Oct 2019 – Feb 2020)	Quoll cameras	258	94%	12
Survey 2 (Feb – May 2020)	Quoll cameras	182	92%	16
Total		440	93%	19 (cumulative)

During May 2020, the camera trapping program was expanded into adjacent private property with 42 cameras now deployed.

Cage trapping was also completed throughout the Offset areas to collect additional demographic data as per the IOMP objectives. Since June 2019, trapping has been completed over 24 nights, with 56 captures of 19 individual quolls.

Mt Royal National Park
As reported last year, the camera trapping program was successfully implemented in Mt Royal National Park in August 2019. Results to date have 946 camera detections. The data is still being processed, with 30 individual quolls identified to date.

A cage trapping program was also implemented in June 2020, with 10 nights completed. This resulted in 24 captures and release of 13 individual quolls.

Wollemi National Park
Deployment of the program into Wollemi National Park was delayed by bushfire activity and more recently COVID-19 restrictions.

4.2.1.3 Task 3 Assess Habitat Use by Female STQ

Following successful capture and collaring six female quolls reported last year, the GPS/VHF collars have proven unreliable with little useful data collected. The camera trapping has been expanded as an alternative means to assess habitat use by female quolls. The camera have been proportionally allocated across various habitat types to assess use and preference. The IOMP is being updated to reflect the alternative methodology.
The details the invoices issued and payments completed by LCO to fund the project to date are shown in***Table 4-4***. The funding is being utilised to purchase necessary cameras and consumables to establish the project.

Table 4-4 - Payments Completed 2019-20 FY

Payment	Amount (AUD excl GST)	Cumulative Amount (since 2016)	Date Paid
6	11,050	169,773	30/4/2020

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

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 Water Management Plan (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.

The WMP sets impact assessment criteria for both Bayswater and Bowmans Creek. The criterion has been determined based on a statistical analysis of data collected over a 5 year period. In accordance with ANZECC (2000) guidelines a 90th percentile concentration is appropriate for maintaining water quality. Due to the disturbed nature of both catchments and ephemeral nature of each creek, this is deemed to be an appropriate statistical criterion to adopt whilst mining operations are ongoing. Additionally, since the creeks are known to cease surface flow naturally at different points due to climatic variances, different trigger levels are adopted to reflect the flow state at each

location. This reflects the natural ponding and varying quality of both creeks. The creek trigger levels are presented in ***Table 5-1***.

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

	pH lower limit[4]	pH upper limit		EC 90th %tile[1]	EC Max[2]	TDS 90th %tile[1]	TDS Max[2]	TSS 90th %tile[1]	TSS 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

[1] whole creek 90th percentile
[2] maximum recorded value for whole creek
[3] ANZECC criteria for TSS
[4] ANZECC criteria for pH lower limit

Trigger Level when creek is flowing
Trigger Level when no flow in creek

Figure 5-1 shows the locations of each of the surface water monitoring sites.

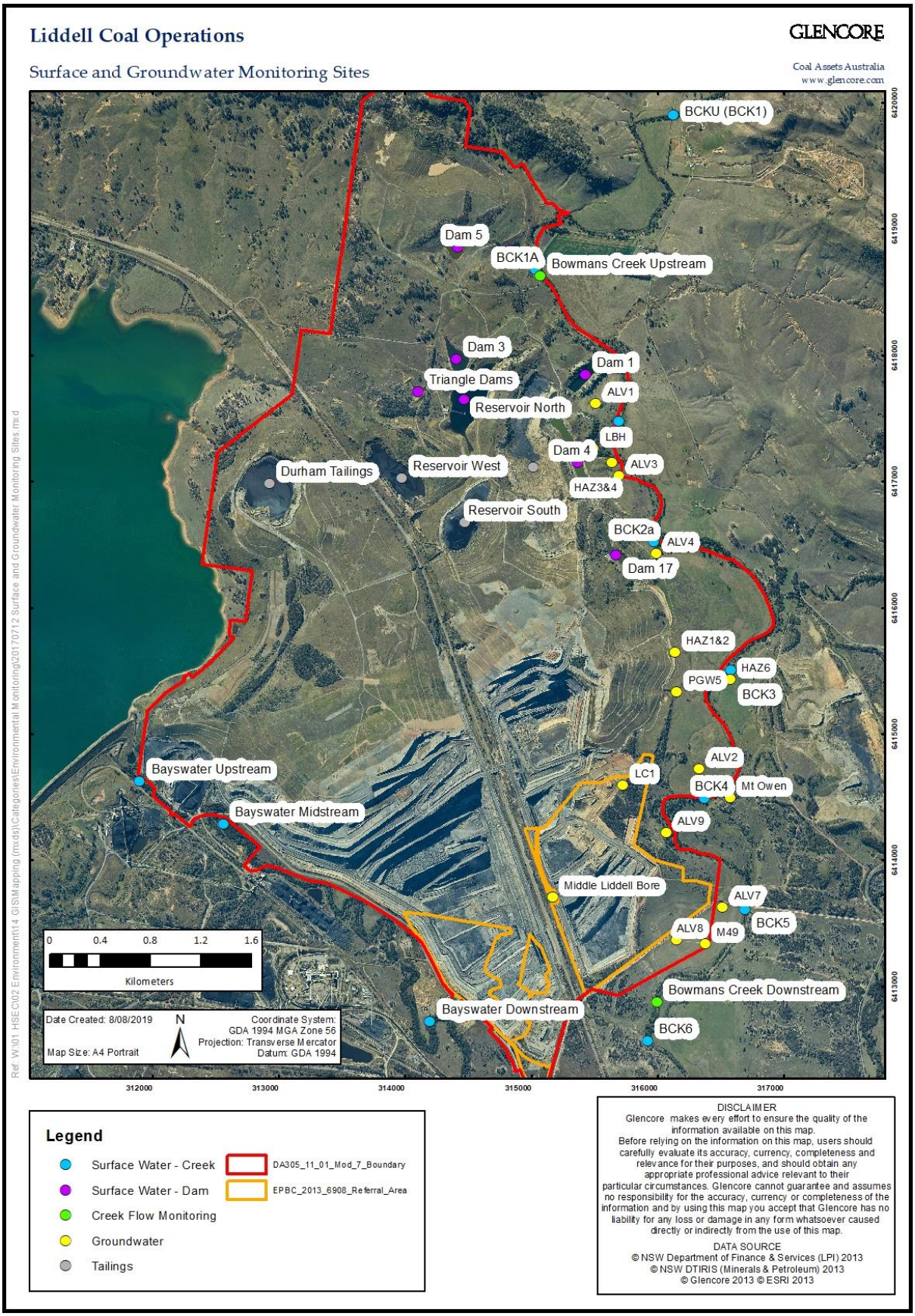

Figure 5-1 - Location of surface and groundwater monitoring sites

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 trigger limits were exceeded in Bayswater Creek during the reporting period.

Table 5-2 - Bayswater Creek Trigger Limit Summary

Bayswater Creek Water Quality Results														
Month	**Bayswater Creek Upstream**					**Bayswater Creek Midstream**					**Bayswater Creek Downstream**			
	pH	**EC (µS/cm**	**TSS (mg/L)**	**TDS (mg/L)**	**Flow**	**pH**	**EC (µS/cm**	**TSS (mg/L)**	**TDS (mg/L)**	**Flow**	**pH**	**EC (µS/cm)**	**TSS (mg/L)**	**TDS (mg/L)**
Jun-19	8.07	3530	<5	2130	Trickle	8.16	5100	<5	3220	Still	Dry			
Jul-19	7.7	3430	8	2290	Trickle	7.91	4220	<5	2920	Still	Dry			
Aug-19	8.01	3250	8	2130	Trickle	7.8	4030	15	2850	Still	Dry			
Sep-19	7.91	3400	16	2150	Trickle	7.93	4130	12	2590	Still	Dry			
Oct-19	7.74	3330	6	2230	Trickle	7.75	4290	6	2820	Still	Dry			
Nov-19	7.72	3380	10	2150	Trickle	7.78	4140	17	2520	Still	Dry			
Dec-19	7.75	3400	<5	2250	Trickle	7.71	4490	<5	2880	Still	Dry			
Jan-20	7.64	3480	6	2220	Trickle	7.83	4730	10	3170	Still	Dry			
Feb-20	7.47	1960	23	1240	Trickle	7.78	3220	6	1980	Still	Dry			
Mar-20	7.64	3100	8	2130	Slow	7.89	4030	<5	2540	Still	Dry			
Apr-20	7.72	3540	<5	2270	Trickle	7.99	4510	<5	3050	Still	Dry			
May-20	7.68	3320	<5	2040	Slow	7.95	4130	<5	3150	Still	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. With these considerations (as detailed in the WMP), trigger limits are dependent on the flow conditions at time of monitoring. ***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 Trigger Limit Summary

Bowmans Creek Water Quality Results																				
Month	BCK1 (Upstream)					BCK 1A					BCK2					BCK2A				
	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow
Jun-19	7.97	1210	<5	726	Still	8.06	4630	<5	2920	Trickle					Dry					Dry
Jul-19	7.55	1150	5	714	Still	7.66	3610	<5	2220	Trickle					Dry					Dry
Aug-19	8.1	1180	<5	652	Trickle	7.70	2780	23	1840	Trickle					Dry					Dry
Sep-19	7.89	1240	11	728	Still	7.78	3900	14	2600	Still					Dry					Dry
Oct-19	7.85	1220	11	738	Still	7.61	5650	12	4080	Trickle					Dry					Dry
Nov-19	8.1	1250	11	629	Still	7.50	5300	7	3540	Still					Dry					Dry
Dec-19	7.72	1230	29	726	Still	7.47	5490	<5	3470	Still					Dry					Dry
Jan-20	7.48	1260	207	744	Still	7.38	5840	102	4230	Still					Dry					Dry
Feb-20	7.3	1720	7	1150	Still	7.47	6820	69	4790	Trickle					Dry					Dry
Mar-20	7.62	1320	20	900	Still	7.54	7050	25	5590	Still					Dry					Dry
Apr-20	7.4	1190	8	695	Still	7.6	1790	10	1030	Trickle					Dry	6.92	1260	6	640	Still
May-20	7.24	1310	6	756	Slow	7.67	2520	<5	1490	Slow					Dry					Dry

Orange Shading – Denotes an exceedance of the 90%ile or maximum trigger limit as applicable for the flow conditions

Bowmans Creek Water Quality Results

Month	BCK3					BCK4					BCK5					BCK6 (Downstream)				
	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Flow
Jun-19					*	8.20	2890	17	1820	Still					Dry					Dry
Jul-19					*	7.82	2460	44	1560	Still					Dry					Dry
Aug-19					Dry					Dry					Dry					Dry
Sep-19					Dry					Dry					Dry					Dry
Oct-19					Dry					Dry					Dry					Dry
Nov-19					Dry					Dry					Dry					Dry
Dec-19					Dry					Dry					Dry					Dry
Jan-20					Dry					Dry					Dry					Dry
Feb-20	6.92	1180	29	788	Still					Dry					Dry					Dry
Mar-20	6.85	1860	22	1390	Still					Dry					Dry					Dry
Apr-20	7.62	1880	8	1150	Still	6.84	1540	<5	967	Still	7.35	1560	<5	984	Still	7.35	1560	<5	984	Still
May-20	7.55	1970	8	1250	Still	7.26	1890	<5	1090	Still					Dry					Dry

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

During the reporting period, there were a number of isolated water 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 trigger levels are required to be sustained to initiate an investigation. During the reporting period, surface water observations at BCK1A triggered a number of investigations, each at the same monitoring location BCK1A. In accordance with the surface water trigger action response plan, DPE, DOE and DoI were notified in May 2019 and August 2019; after each consecutive exceedance continued for at three month intervals. Investigations were undertaken for each and a summary of findings is provided below. A copy of the ITARP investigations can be provided upon request.

5.1.2.1 BCK1A TARP Investigation

Surface water monitoring at BCK1A identified various exceedances of the 90th%ile trigger limits for EC and TDS The following summarises the investigation findings:

- No change to management or mining activities in the area.
- There is no discernible impacts to flora or fauna in the immediate area.
- It is unlikely that potential harm has occurred or will occur based on the current observations.
- The climate, creek flow and water quality monitoring observations corroborate the understanding the monitored EC & TDS levels are predominately naturally driven. This is demonstrated most recently by the decreasing EC & TDS trend as rainfall during the last six months normalises.
- The upstream and downstream monitoring locations have recorded ‘still’ or ‘dry’ flow conditions during the same trigger period indicating that the creek is behaving in an ephemeral manner and likely transitioning slowly to the ‘no flow’ applicable investigation trigger levels.
- Water was identified expressing from the western creek bank upstream of BCK1A.The source of the observed seepage is not clear based on the current information; hence it cannot be determined whether the observations are the result of historical mining activities.

Based on the current information, LCO does not consider there to be potential environmental harm however it is not clear if observations are the result of historical mining activities. Hence, as per the WMP investigation protocol, LCO has progressed to undertake further investigations to determine the source of the seep observations by commencing a Management/Mitigation TARP. LCO has taken management/mitigation measures through the dewatering an adjacent water management structure (Dam 6) to create a local groundwater sink to redirect and capture any potential groundwater flow from the historical mining and conducting further studies in consultation with DPIE. These studies are continuing in 2020.

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). There were no discharge events from LCO under the HRSTS during the reporting period

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 LCO Water Management Plan (WMP) documents the processes and responsibilities of all aspects of the site water management system.

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 based on historical measurements. Currently, investigations into potential impacts are conducted if there are three consecutive exceedances of the nominated triggers.

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 and.
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, 2018) 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.

The WMP groundwater monitoring program was implemented during the reporting period with the results indicating that no potential mining impacts occurred. Monitoring results observed during the reporting period are summarised in following Section 5.2.1 and Section 5.2.2 with the breakdown of:

- Section 5.2.1 Groundwater quality monitoring
    - Groundwater quality of alluvial and shallow bedrock aquifers
    - Groundwater quality of hard rock (Coal Measures) aquifer
- Section 5.2.2 Groundwater level monitoring
    - Groundwater levels of alluvial and shallow bedrock aquifers
    - Groundwater levels of hard rock (Coal Measures) aquifer

Table 5-4 - 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)							

Groundwater Impact Assessment Criteria							
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.

5.2.3 Groundwater Quality Monitoring

5.2.3.1 Groundwater quality of Alluvial and Shallow Bedrock Aquifers

Groundwater quality monitoring results and trigger limits for the alluvial and shallow bedrock aquifers during the reporting period are shown in ***Table 5-5*** (pH) and ***Table 5-6*** (EC) below.

LCO has generally received below average rainfall (with a recent increase in 2020) and experienced above average evaporation during the reporting period. The following was recorded at the LCO meteorological station during the reporting period:

- May 2019 – December 2019:
    - Evaporation – 686.2mm
    - Rainfall – 136mm
- January 2020 – May 2020:
    - Evaporation – 361.8mm
    - Rainfall – 401.6mm

The review of climate data during ITARP investigations identified high evaporation rates and below average rainfall during the reporting period. It is considered that the observed changes in pH and EC across the monitoring locations are a result of these prolonged dry conditions and directly related to changes in depth of the bores caused by these climatic conditions.

During the reporting period there were no investigations triggers relating to pH. During April 2020, the lower limit for pH of 6.5 was exceeded at a ALV4L. The exceedance represent the lowest pH data for the alluvial and shallow bedrock monitoring bores since data collection began. The exceedances occurred over one data point and were not sustained; the pH level at those sites have since returned the relatively stable trend.

There have been 48 exceedances of the EC upper limit. As required by the WMP, ITARP investigations have been triggered and completed where monitoring has identified there consecutive exceedances of the upper EC levelThe conclusions of each investigations are summarised in below in ***Table 5-5***. A copy of the relevant ITARP reports are provided in the Appendices.

Noteworthy, the LCO groundwater impact assessment (SKM, 2014) states there are no known fresh or saline groundwater supported wetlands or recognised aquifer ecosystems present in the area (Umwelt, 2001; Ecological, 2013).

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

Month of 3rd exceedance	Site	Conclusions
August 2019	ALV7S	• During the previous 24 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 elevated levels are believed to be related to the anomalous water level decline observed at ALV7 and ALV8. The decreased recharge from the alluvium is considered to have resulted in the observed increase in salinity with the current levels of salinity considered to be more representative of the shallow bedrock aquifer. • No potential or actual environmental harm due to mining activities is indicated as a result of the elevated EC. The elevated EC is considered to be representative of the natural salinity of the shallow bedrock without the diluting influence of seepage from the overlying alluvium. • Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.

November 2019	ALV7S	• Generally, groundwater level trends in ALV7, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. Periods of groundwater level decline in ALV7S have been observed during previous periods of below average rainfall and this period of elevated EC coincides with the current period of below average rainfall and above average evaporation. • The EC measurements are caused by the water level decline observed at ALV7S. • While the maximum reference EC trigger has been exceeded, the possibility of potential or actual environmental harm due to mining activities is low. The groundwater depths measured at ALV7S reflect natural variability due to climatic factors and it is unlikely that the EC increase is a mining-related impact. The elevated EC is considered to be representative of the natural salinity of the coal measures without the diluting influence of seepage from the overlying alluvium. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment. • The lack of groundwater in the alluvium precludes further investigation. When there is significant recharge to the alluvium, further investigation could be conducted to determine whether connectivity between the alluvial and fractured rock aquifers has altered.
December 2019	ALV1L ALV2S	• EC observations at ALV1L and ALV2S have not exceeded reference maximums to date. • During the previous 24 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. It is not expected that there is potential for harm to the environment as the system is varying naturally.
February 2020	ALV7S	• Continued decline of the water level and increased EC measured at ALV7S sustains the conclusion of previous three-month, six-month and nine-month trigger exceedance investigation reports of natural climate variability being sustained drought conditions are influencing the heightened EC results at this monitoring site. • During the previous 24 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. Hence it is not expected that there is potential for harm to the environment as the system is varying naturally. • the elevated EC level is considered to be representative of the natural salinity of the coal measures which is not being diluted through recharge seepage from the overlying alluvium which has been measured as dry since March 2019. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.
March 2020	ALV1L ALV2S ALV4S LBH	• Groundwater level trends in the triggering bores; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. • The decline of water levels and increased EC measurement at ALV1L, ALV2S, ALV4S and LBH sustains the conclusion of the previous three month trigger exceedance investigation at ALV1L and ALV2S and previous investigations conducted for LBH and ALV4S that there is a clear link between the reduced rainfall CRD, increased evaporation CRD and the measured 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. 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 2020	ALV7S	• The continued decline of the water level and increased EC measured at ALV7S sustains the conclusion of previous three-month, six-month, nine-month and 12-month trigger exceedance investigation reports of natural climate variability being sustained drought conditions are influencing the heightened EC results at this monitoring site.

		• 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 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. • Whilst the maximum reference EC trigger has been exceeded for ALV7S, the potential for environmental harm due to mining activities is low. The demonstrated direct relationship between the alluvium and rainfall, and the low vertical connectivity between the alluvium and underlying fractured rock, reduces the risk of harm to the alluvium (Jacobs, July 2020). The approved depressurisation of the fractured rock aquifers (such as ALV7S) has changed the hydraulic gradient towards the open cut, which further reduces the risk of harm to the environment associated with the ALV7S EC values.

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												
Jun-19	6.96	7.60	7.14	7.61	7.07	7.42	6.69	7.34	*	7.29	*	*	6.90
Jul-19	6.85	7.57	7.17	7.68	6.94	7.32	6.59	7.27	*	7.38	*	*	6.74
Aug-19	7.00	7.76	7.32	7.76	7.07	7.47	6.72	7.45	*	7.43	*	*	6.94
Sep-19	7.07	7.72	7.43	7.90	7.17	7.58	6.84	7.41	*	7.52	*	*	7.03
Oct-19	6.96	7.67	7.26	7.71	7.15	7.62	6.78	7.45	*	7.41	*	*	6.96
Nov-19	6.94	7.61	7.20	7.64	7.06	7.50	6.73	7.41	*	7.30	*	*	6.90
Dec-19	6.95	7.39	7.16	7.56	6.73	7.35	6.68	7.25	*	7.20	*	*	6.70
Jan-20	6.89	7.53	6.98	7.63	*	7.52	6.71	7.35	*	7.38	*	*	6.79
Feb-20	6.94	7.62	*	7.71	7.05	7.60	6.77	7.32	*	7.50	*	*	6.81
Mar-20	6.96	7.69	*	7.80	7.08	7.59	6.87	7.36	*	7.42	*	*	6.82
Apr-20	6.72	7.22	6.75	7.43	6.74	7.06	6.39	7.00	6.96	7.15	*	*	6.58
May-20	6.87	7.56	7.03	7.68	7.06	7.39	6.62	7.31	7.24	7.39	*	*	6.84

* - unable to obtain a sample due to lack of water present

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

Alluvial and Shallow Bedrock Groundwater Quality - EC													
Site	ALV1L	ALV1S	LBH	ALV3L	ALV3S	ALV4L	ALV4S	ALV2L	ALV2S	ALV7L	ALV7S	ALV8L	ALV8S
80th %ile	1.37	1.56		1.39	7.26	6.73	7.42	2.83	2.82	1.78	2.23	1.31	1.99
20th %ile					5.99	5.56	6.28		2.56				1.54
Jun-19	1.36	1.34		1.35	1.86	1.56	5.31	1.95	2.74	*	2.83	*	*
Jul-19	1.47	1.42		1.45	1.98	1.64	5.66	2.28	3.12	*	2.60	*	*
Aug-19	1.44	1.39		1.42	1.93	1.59	5.53	1.99	3.00	*	3.04	*	*
Sep-19	1.32	1.25		1.29	1.78	1.45	5.15	1.83	2.80	*	2.99	*	*
Oct-19	1.41	1.36		1.40	1.91	1.57	5.34	1.92	2.95	*	2.73	*	*
Nov-19	1.59	1.51		1.54	2.17	1.70	6.01	2.27	3.26	*	3.07	*	*
Dec-19	1.38	1.33		1.35	1.89	1.51	5.12	2.30	2.90	*	3.51	*	*
Jan-20	1.49	1.50			2.25	1.72	5.95	2.50	3.26	*	3.14	*	*
Feb-20	1.56	1.52		1.48	2.37	1.65	6.02	*	3.24	*	3.50	*	*
Mar-20	1.40	1.38		1.40	2.23	1.51	5.48	*	3.03	*	3.53	*	*
Apr-20	1.42	1.28		1.18	1.78	1.30	4.44	3.16	2.67	1.55	3.25	*	*
May-20	1.53	1.47		1.50	2.17	1.51	5.71	3.67	3.09	1.72	2.83	*	*

Orange Shading – Denotes an exceedance of the 80th%ile trigger limit

Yellow Shading – Denotes an exceedance of the 20th%tile trigger limit

* - unable to obtain a sample due to lack of water present

5.2.3.2 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.

5.2.3.3 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.

5.2.4 Groundwater Level Monitoring

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. 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. LCO monitor the groundwater level of the Bowmans Creek Alluvial and Shallow Bedrock Aquifers to identify any potential impacts from mining such as depressurisation.

A review of full historical monitoring results identified that 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.

Similarly to the groundwater quality, 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 groundwater level, further investigations into potential impacts are conducted using the ITARP and MTARP process as described previously. No potential mining impacts were identified during the reporting period.

During the reporting period there has been no exceedances of the Definition 1 Impact (draw down) triggers. There have been numerous exceedances of the groundwater level Definition 2 and 3 investigation trigger levels. Investigations were undertaken for each trigger and each have determined that the observed monitored levels are likely the result of natural climatic variations and not related to mining activities. Further, the number of exceedances are due to a constrained baseline historical data set and prolonged drought conditions. LCO investigated each event and reported to the relevant government departments during the reporting period. No notifications were made to the DoE as environmental harm was not considered to have occurred.

A summary of each investigation conducted during the reporting period is provided below in ***Table 5-8***. A copy of each individual ITARP report can be provided on request. The monthly monitoring results and trigger limits for the alluvial and shallow bedrock aquifers during the reporting period are shown in ***Table 5-9*** with results triggering the relevant criteria identified.

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

Month of 3rd exceedance	Site	Conclusions
June 2019	ALV4L	• The conclusion drawn by the previous trigger report for ALV4L still apply. The groundwater levels measured at ALV4L are considered to reflect natural variability due to climatic factors and there are no mining related impacts identified. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the Bowmans Creek alluvium. • The groundwater level at ALV4L has not declined below the maximum range recorded and is not of sufficient magnitude to lead to a downgradient impact on beneficial use. No environmental harm due to mining activities is indicated.
July 2019	ALV1L ALV2S ALV3L ALV3S	• The conclusion drawn by the previous trigger report (3 month exceedances) for ALV1L, ALV2S, ALV3L and ALV3S still apply. The 12-month groundwater level trigger exceedances observed at ALV1L, ALV2S, ALV3L and ALV3S are considered to reflect natural variability due to climatic factors and there are no mining related impacts identified. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the Bowmans Creek alluvium. • The groundwater levels at ALV1L, ALV2S, ALV3L and ALV3S remain above their respective maximum range recorded. No environmental harm due to mining activities is indicated.
August 2019	ALV4S LBH	• Regarding the groundwater level triggers at ALV4S and LBH, the conclusions drawn by the previous trigger reports (3-month exceedances) still remain relevant. The 12-month groundwater level trigger exceedance observed at these sites are considered to reflect natural variability due to climatic factors and there are not considered to be mining related. • The groundwater level at both these sites remain above their respective reference maximum range. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the system. No environmental harm due to mining activities is indicated.
September 2019	ALV8L ALV1S ALV2L	• Regarding ALV1S and ALV2L - The conclusions drawn by the previous trigger reports (3-month exceedances) remain relevant. The WMP Component 1 (drawdown) Trigger has not been exceeded. The 12-month groundwater level trigger exceedance (WMP Component 2 Trigger) observed at these sites (and other Bowmans Creek area monitoring bores) are considered to reflect natural variability due to climatic factors and are not considered to be mining related. The groundwater level at both these sites remain above their respective reference maximum range. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the system. No environmental harm due to mining activities is indicated. • Regarding ALV8L - Generally, groundwater level trends in ALV8L, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. Periods of groundwater level decline in ALV8L have been observed during previous periods of below average rainfall, including the Millennium Drought, when ALV8L ran dry. ALV8L has been dry since April 2018, coinciding with a period of below average rainfall and above average evaporation. The period of below average evaporation has been observed since 2012. ALV7L (the ALV8L reference bore) has a water level trend similar to ALV8L, and ALV7L ran dry 12 months after ALV8L. Also, a number of other Bowmans Creek monitoring bores have exceeded their respective triggers but have not yet triggered the WMP response protocol.

		• Assessments carried out prior to and as part of the MOD5 GIA concluded that the recharge to the coal measure fractured rock aquifer is likely very low. This is primarily 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 ALV8 area. • The mining consent has approved some impacts to the Bowmans Creek alluvium and the groundwater model showed that these impacts are predominantly driven by the removal of the Davis Creek Fault and Dyke and the dewatering of the former Liddell M49 underground workings. The mining of the Davis Creek Fault and Dyke below the Lemington seams and the dewatering of the M49 workings have not occurred to date, nor have there been any containment failures of water stored in the underground; therefore, they are unlikely to have impacted the water level in ALV8L. • The groundwater depths measured at ALV8L reflect natural variability due to climatic factors and it is unlikely that the decline is a mining-related impact. The lack of groundwater in the alluvium precludes further investigation. When there is significant recharge to the alluvium, further investigation could be conducted to determine whether connectivity between the alluvial and fractured rock aquifers has altered. The trigger exceedance in ALV8L is not outside of the maximum range recorded, considering it has run dry previously, and it is unlikely that future beneficial use of the alluvial resource will be impacted
January 2020	ALV7S ALV7L ALV8S	• Generally groundwater levels in ALV7S, ALV7L and ALV8S, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. • Assessments carried out prior to and as part of the MOD5 GIA concluded that the recharge to the coal measure fractured rock aquifer is likely very low. This is primarily 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 ALV8/ALV7 area. • The mining consent has approved some impacts to the Bowmans Creek alluvium and the groundwater model showed that these impacts are predominantly driven by the removal of the Davis Creek Fault and Dyke and the dewatering of the former Liddell M49 underground workings. The mining of the Davis Creek Fault and Dyke below the Lemington seams and the dewatering of the M49 workings have not occurred to date, nor have there been any containment failures of water stored in the underground; therefore, they are unlikely to have impacted the water level in ALV8L. • Groundwater depths measured at ALV7L, reflect a natural variability due to climatic factors and is unlikely that the decline is a mining-related impact. Groundwater declines at ALV7S and ALV8S are likely influenced by a combination of the current severe drought conditions and mining in the south-east portion of the Entrance Pit. Mining has likely cause depressurisation of the surrounding fractured rock aquifer with subsequent vertical drainage of the overlying formations. The depressurisation of the fractured rock aquifer is approved under the consent to mine. • As there is a direct relationship between the alluvium and rainfall, it is not expected that there is potential for farm to the environment as the system is varying naturally.

Table 5-9 - Groundwater Level Monitoring Results and Trigger Exceedances

Site	ALV1L	ALV1S	LBH	ALV3L	ALV3S	ALV4L	ALV4S	ALV2L	ALV2S	ALV7L	ALV7S	ALV8L	ALV8S	ALV9L*
10th %ile	4.97	4.75	5.05	5.7	5.99	5.56	6.28	4.8	4.67	6.75	10.21	6.96	9.03	N/A
Max	6.31	6.84	6.24	7.08	7.26	6.73	7.42	6.76	8.53	7.34	11.38	8.36	11.08	N/A
Jun-18	4.40	4.13	4.55	5.41	5.71	5.45	6.14	4.60	4.48	7.00	11.70	Dry	12.48	3.90
Jul-18	4.68	4.37	4.40	5.60	5.90	5.65	6.21	4.64	4.63	7.09	12.21	Dry	13.94	4.03
Aug-18	4.98	4.58	5.02	5.87	6.17	5.60	6.28	4.72	4.74	7.14	12.68	Dry	14.61	4.10
Sep-18	5.15	4.70	5.21	6.12	6.43	5.72	6.37	4.77	4.77	7.23	12.94	Dry	14.85	4.13
Oct-18	5.30	4.81	5.36	6.63	6.29	5.80	6.48	4.87	4.87	7.29	13.13	Dry	14.91	4.17
Nov-18	5.43	5.04	5.46	6.41	6.78	5.94	6.58	4.98	4.95	7.35	13.32	Dry	15.07	4.27
Dec-18	5.57	5.25	5.57	6.48	6.92	6.01	6.70	5.09	5.14	7.45	14.21	Dry	15.67	4.32
Jan-19	5.45	5.09	5.59	6.53	7.00	6.14	6.79	5.28	5.36	7.63	15.12	Dry	18.59	4.48
Feb-19	5.66	5.39	5.70	6.61	7.07	6.28	6.89	5.30	5.38	7.85	16.55	Dry	Dry	4.69
Mar-19	5.80	5.56	5.62	6.70	7.16	6.38	6.95	5.42	5.40	8.29	17.37	Dry	Dry	4.84
Apr-19	5.27	4.99	5.33	6.45	7.04	6.32	6.96	5.02	5.21	Dry	17.39	Dry	Dry	4.56
May-19	5.27	4.94	5.22	6.43	6.98	6.31	6.95	5.01	5.17	Dry	18.17	Dry	Dry	4.86

* - Piezometer installed in December 2017. Drawdown criteria limit derived from ALV2L minus 5.0 (AHD).

5.2.5 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

5.2.6 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*
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*
ARRP 2017	*Liddell Coal Operations Annual Rehabilitation Monitoring Report 2017*
Jacobs 2015	*Liddell Coal Operations Investigation Trigger Action Response Plan October 2015*
Jacobs 2016	*Liddell Coal Operations Investigation Trigger Action Response Plan May 2016*

Appendix A - August 2019 - ALV7S Electrical Conductivity ITARP

JACOBS

Memorandum

Subject	**ALV4S & LBH water level & ALV7S EC Groundwater Investigation- August 2019**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA131807
From	Greg Sheppard		
Date	1 October 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) have been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of groundwater monitoring results at piezometers ALV4S, LBH and ALV7S; specifically in regard to whether the water level and water quality exceedances present a potential to harm the environment and determine whether the triggers are mining related.

1.1 Overview

The investigation has been undertaken in accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908. Specifically, ALV4S and LBH piezometers which have recorded exceedances of groundwater level trigger Definition #2 continuously for 12 months since September 2018; and ALV7S which recorded exceedances in Electrical Conductivity (EC) continuously for 6 months since March 2019.

As per the Water Management Plan (WMP), LCO has previously investigated trigger exceedances at each of these bores. These investigations were notified to the Department of Environment and Energy and both the NSW Department of Planning, Industry and Environment- Planning & Assessment division and the Water division of the: 3-month groundwater level exceedance of ALV4S and LBH; and the 3-month EC exceedance of ALV7S. The previous investigations concluded:

- ALV4S and LBH groundwater levels are likely reflecting natural variability due to climate factors and is seen across the monitoring network. There is no mining related impact or likely potential of environmental harm.
- ALV7S EC levels despite exceeding the reference maximum is a natural occurrence. The direct relationship between monitoring observations and rainfall imply climatic variation as the cause and there is no potential harm the environment.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedances to confirm that the exceedance remains unrelated to mining activity and pose no potential harm to the environment.

1.2 Scope of Work

The Scope of Work for this groundwater investigation comprises:

- Investigation of over 12 consecutive months of groundwater trigger level exceedances at groundwater monitoring site ALV4S and LBH.
- Investigation of over 6 consecutive months of EC trigger exceedances at groundwater monitoring site ALV7S.
- Assessment of whether there is potential harm to the environment from the exceedances and determine whether it is a mining related impact.

2. Groundwater level trigger exceedances (ALV4S and LBH)

The ALV4 monitoring site comprises a paired piezometer installation targeting the alluvial aquifer (ALV4L) and the underlying shallow bedrock (ALV4S). The LBH monitoring site comprises a single piezometer targeting the alluvial aquifer, installed as part of the WMP in 2015. The 12-month groundwater level trigger exceedances at ALV4S and LBH are shown the monitoring results in **Table 1.**

Groundwater elevations (mAHD) at monitoring sites (ALV4S and LBH) are presented on **Figure 1**. A residual mass curve with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

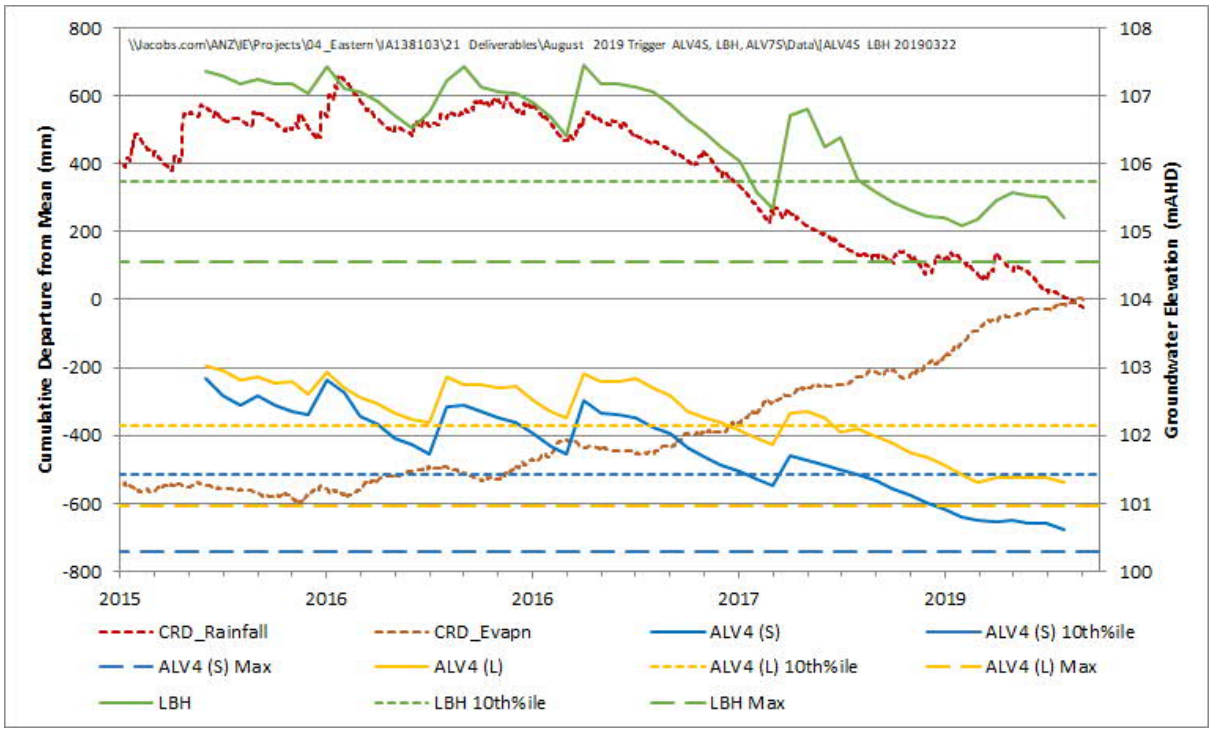

Figure 1: Groundwater elevation (mAHD) observations, 10th percentile trigger value and minimum groundwater elevation at monitoring site ALV4S and LBH.

Table 1: Site specific trigger values for groundwater level and monthly observations

Well ID	Unit	Trigger Values Depth to water (mbgl)		Monitoring Results Depth to water (mbgl)												
		10th Percentile Trigger Limit (mbgl)	Reference Maximum (mbgl)	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019
ALV4S	Shallow Bedrock Aquifer	**6.28**	7.42	6.28	**6.37**	**6.48**	**6.58**	**6.70**	**6.79**	**6.89**	**6.95**	**6.96**	**6.95**	**6.99**	**7.00**	**7.08**
LBH	Alluvial Aquifer	**5.05**	6.24	5.02	**5.21**	**5.36**	**5.46**	**5.57**	**5.59**	**5.70**	**5.62**	**5.33**	**5.22**	**5.26**	**5.29**	**5.58**

As per Figure 1 there is a significant decline in the residual mass curve (rainfall) commencing January 2017 and a corresponding increase in the slope of the residual mass curve (evaporation). This implies a combination of below average rainfalls and higher than average evaporation. The drier climatic conditions correspond with a general decline in groundwater level trends at ALV4S and LBH since 2017.

A similar regional declining trend is observed at the majority of monitoring locations along Bowman's Creek (Figure 2) since 2017.

The observed declines in water levels within both the Bowman's Creek Alluvium and shallow bedrock aquifer systems continue to show similar trends as noted in the previous report investigations. This supports the understanding that both systems recharge and respond in a similar fashion. The consistency of these observations with results from other monitoring sites indicates that the groundwater response at ALV4S and LBH is driven by climate and not by mining activity.

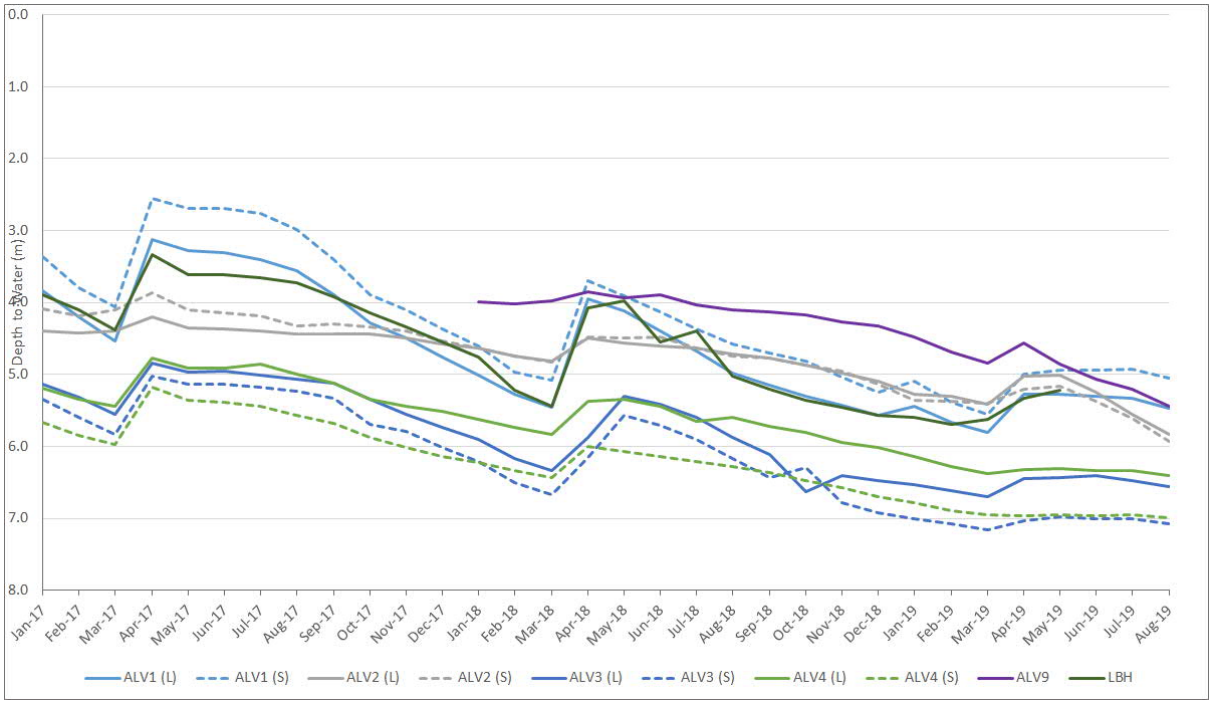

Figure 2: Depth to water observations at alluvial aquifer and shallow bedrock aquifer monitoring locations at Bowman's Creek

Despite the ongoing water level decline, brief periods of groundwater recharge are still observed in the data indicating that a change in rainfall to above average conditions would alleviate the declining trend.

Generally, the water level trends at these sites show a close correlation to the CRD trend. The reference timeframe (from July 2005 to May 2017) used to calculate the site-specific trigger values, captured a period of prevailing above average rainfalls conditions and climatic maximums. Since 2017 the residual mass rainfall curve has had the longest declining trend observed during the period of monitoring.

The most recent groundwater levels (April to August 2019) are the lowest on record since weekly monitoring commenced in 2008 but are still within the reference maximum trigger levels.

Previous Investigation Trigger Action Response Plans (ITARP) investigations supported the understanding that rainfall is the primary driver influencing groundwater level recharge in both the alluvium and underlying shallow bedrock which outcrops up gradient. The most recent trends and observations continue to support the notion that the regionally declining groundwater levels in the past 12 months can be attributed to drier climatic conditions with limited recharge rather than mining operations.

3. Electrical Conductivity (EC) exceedance (ALV7S)

Paired piezometers are installed at ALV7, with ALV7S installed in the shallow bedrock aquifer and ALV7L installed in the overlying alluvial aquifer. Observed groundwater elevations and relevant trigger levels at ALV7 are shown below in Figure 3. Observed groundwater EC measurement and relevant trigger levels at ALV7 are shown in Figure 4.

The 6-month EC trigger level exceedance at ALV7S is shown below in Table 2.

Table 2: Site specific trigger values for groundwater EC and monthly observations

Well ID	Unit	Trigger Values EC (mS/cm)		Monitoring Results Electrical Conductivity (mS/cm)						
		80th Percentile Upper Limit	Reference Maximum	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019
ALV7S	Shallow Bedrock Aquifer	**2.23**	**2.54**	2.11	**2.78**	**3.02**	**2.83**	**2.60**	**3.04**	2.99

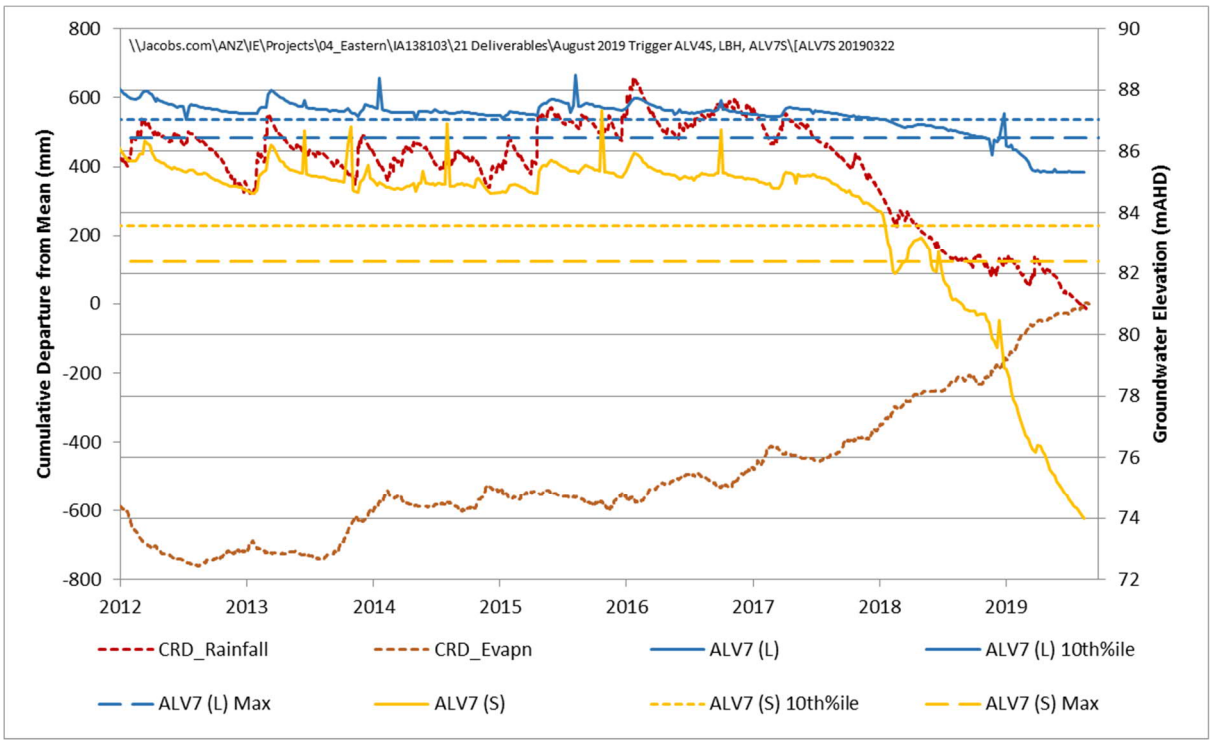

Figure 3: Groundwater elevation (mAHD) monitoring observations at ALV7 and climatic CRDs

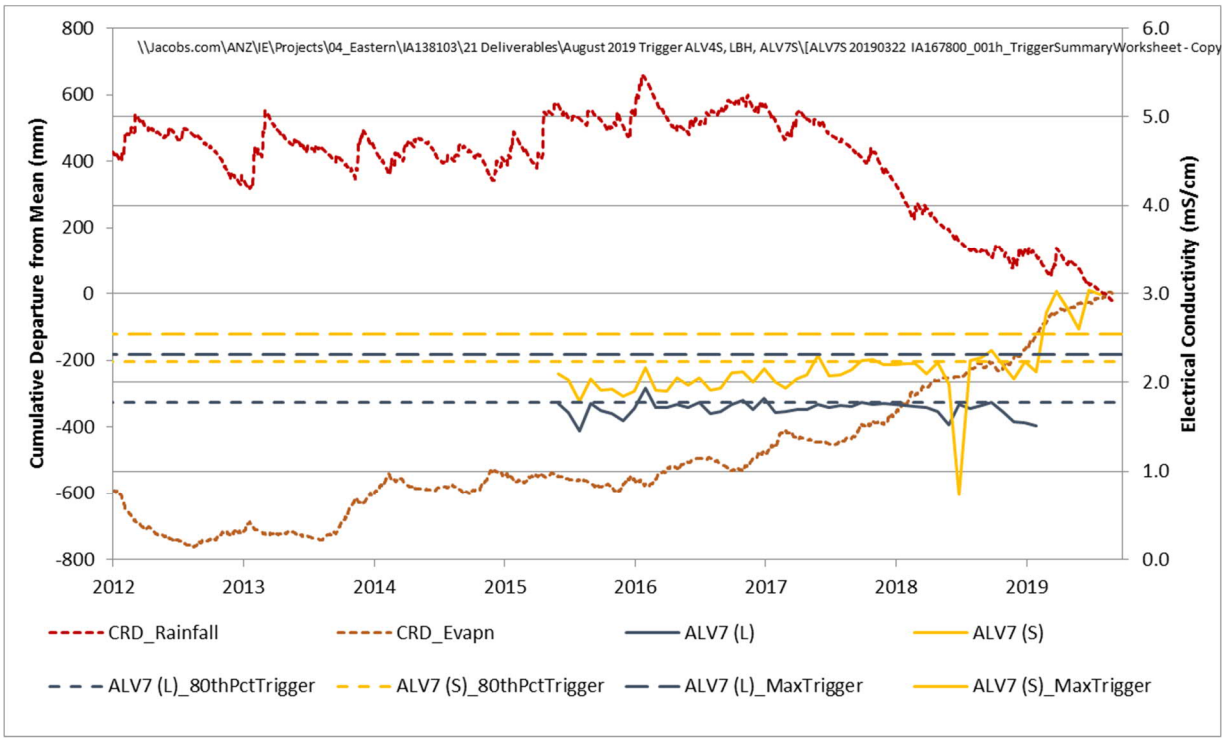

Figure 4: Electrical conductivity (mS/cm) observations at ALV7 and climatic CRDs

3.1 Previous report findings

The previous EC investigation trigger report for ALV7S suggested the EC levels were increasing due to increased evaporation and accumulation of salts associated with below average rainfall. The report noted that out of the multiple trigger sites, EC only exceeded the reference maximum at ALV7S. Further monitoring and increases in EC have resulted in a re-evaluation of this earlier finding.

3.2 Data review

The water levels at ALV7 have declined significantly since the beginning of 2019 with water levels in the alluvium piezometer ALV7L falling below the base of the piezometer, and the shallow bedrock piezometer ALV7S is still showing a strong declining trend. ALV7S water levels have decreased more than 5m since January 2019 to approximately 74mAHD, which is 8.4m below the reference maximum.

EC observations show an inverse relationship to water levels at ALV7S, with EC measurements showing a corresponding increase, rising above the reference maximum in March 2019. The last measurement in August 2019 recorded a concentration of 2.99mS/cm, which is 0.45mS/cm (450µS/cm) above the reference maximum. It is noted that other sites, including alluvial and shallow bedrock monitoring sites, have higher reference maximums, such as AVL4S at 6.43ms/cm, ALV2L at 4.16ms/cm.

The increasing EC observed at ALV7S is attributed to the reduced contribution of the relatively fresher alluvial groundwater following the drying of the alluvium at that location. As the alluvium above ALV7S is currently unsaturated, the contribution of water from the alluvium is reduced in comparison to the more saline water from the shallow bedrock.

Water quality within the overburden lithologies will also exhibit a salinity gradient, ranging from shallow salinities equivalent to the overlying alluvial aquifer and increasing with depth.

With the declining water levels at ALV7S, there is an increased interaction with the more saline overburden lithologies and the increased dominance of the more saline waters from the shallow bedrock resulting in the increased EC concentrations.

While the declining regional water levels will be contributing, it is considered that it is the decline in water levels within the shallow overburden that is the primary cause of the increased salinity.

4. Review Findings

Regarding the groundwater level triggers at ALV4S and LBH, the conclusions drawn by the previous trigger reports (3-month exceedances) still remain relevant. The 12-month groundwater level trigger exceedance observed at these sites are considered to reflect natural variability due to climatic factors and there are not considered to be mining related. The groundwater level at both these sites remain above their respective reference maximum range. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the system. No environmental harm due to mining activities is indicated.

In accordance with the Water Management Plan, the exceedance of the Groundwater Level Trigger Definition #2 at ALV4S and LBH has been investigated following a 12-month monitoring period and concluded to be unrelated to mining. No further action is required but it is recommended routine monitoring continues.

Regarding the EC concentration triggers at ALV7S, the elevated levels are believed to be related to the anomalous water level decline observed at ALV7 and ALV8. The decreased recharge from the alluvium

is considered to have resulted in the observed increase in salinity with the current levels of salinity considered to be more representative of the shallow bedrock aquifer.

While the cause of the water level decline is still under investigation, no potential or actual environmental harm due to mining activities is indicated as a result of the elevated EC. The elevated EC is considered to be representative of the natural salinity of the shallow bedrock without the diluting influence of seepage from the overlying alluvium. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.

It is recommended to continue monitoring in accordance with the WMP to assess ongoing salinity levels at ALV7S.

Reference

Glencore Liddell, 2017, Water Management Plan, Reference number: LIDOC-90533967-3694

Glencore Liddell, 2019, Groundwater Investigation Trigger Report (ALV1L, ALV2S, ALV3L, ALV4S, ALV7S and LBH), June 2019

Glencore, 2018, ALV4S & LBH Groundwater Trigger Investigation, December 2018

Glencore, 2019, ALV7L, ALV7S & ALV8S Groundwater Trigger Investigation, February 2019

Appendix B - November 2019 – ALV7S Electrical Conductivity ITARP

Jacobs

Memorandum

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Subject	**ALV7S 9 Month EC Trigger Review**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA131807
From	Quan Bui		
Date	20 December 2019		
Copies to	**Ben Desomer**		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) have been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of groundwater monitoring results at piezometer ALV7S. Specifically, ALV7S piezometer which has recorded exceedances of the 80th percentile and recently the maximum reference. Electrical Conductivity (EC) trigger continuously for 9 months, since March 2019. This investigation was undertaken to determine whether the causes of the EC trigger exceedances are mining related and to determine whether the measured levels present potential to harm the environment. The investigation has been undertaken in accordance with the LCO Water Management Plan (WMP) (Glencore, 2018a), which was approved within NSW DA305-11-01 and EPBC Approval 2013/6908.

1.1 Overview

As per the WMP, LCO has previously investigated trigger exceedances at the monitoring location. These investigations were notified to the Department of Environment and Energy (DoEE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division and included the: three-month EC exceedance; and the six-month EC exceedance. The conclusions of the previous investigations are as follows:

- The three-month review (Jacobs 2019a) concluded the EC trigger occurred due to the drier average climate resulting in a reduction of net recharge. No potential environmental harm was identified.
- The six-month investigation (Jacobs 2019b) concluded the elevated EC is related to the water level declines in the upper alluvium. There is no potential environmental harm as the hydraulic gradient precludes seepage into the surrounding alluvial aquifer or the downstream environment.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedance and aims to determine if the causes of the exceedances continue to be unrelated to mining activity and pose no potential harm to the environment.

1.2 Scope

The scope of this groundwater investigation comprises:

- Investigation of the nine-month groundwater EC exceedances at groundwater monitoring site ALV7S, which targets the underlying shallow bedrock.

- Assessment of whether there is potential harm to the environment from the exceedances and determine whether the exceedance is mining related.

2. Background

2.1 Monitoring bore details

Monitoring location ALV7 is a clustered monitoring location that consists of two monitoring bores that target separate water bearing units. ALV7L and ALV7S target the Bowmans Creek alluvium and the shallow coal measure overburden, respectively. Monitoring bore construction details are provided in Table 2.1. The groundwater monitoring network is shown in Figure 2.1, with the approximate location of ALV7L highlighted in a turquoise box.

Table 2.1: ALV7 construction details

Monitoring Bore	Easting	Northing	Collar (mAHD)	Bore Base (m)	Bore Base (mAHD)	Target Aquifer
ALV7L	316511.5	6413623.5	93.77	8.44	85.33	Alluvium
ALV7S	316511.5	6413623.5	93.77	23.55	70.22	Overburden underlying the alluvium

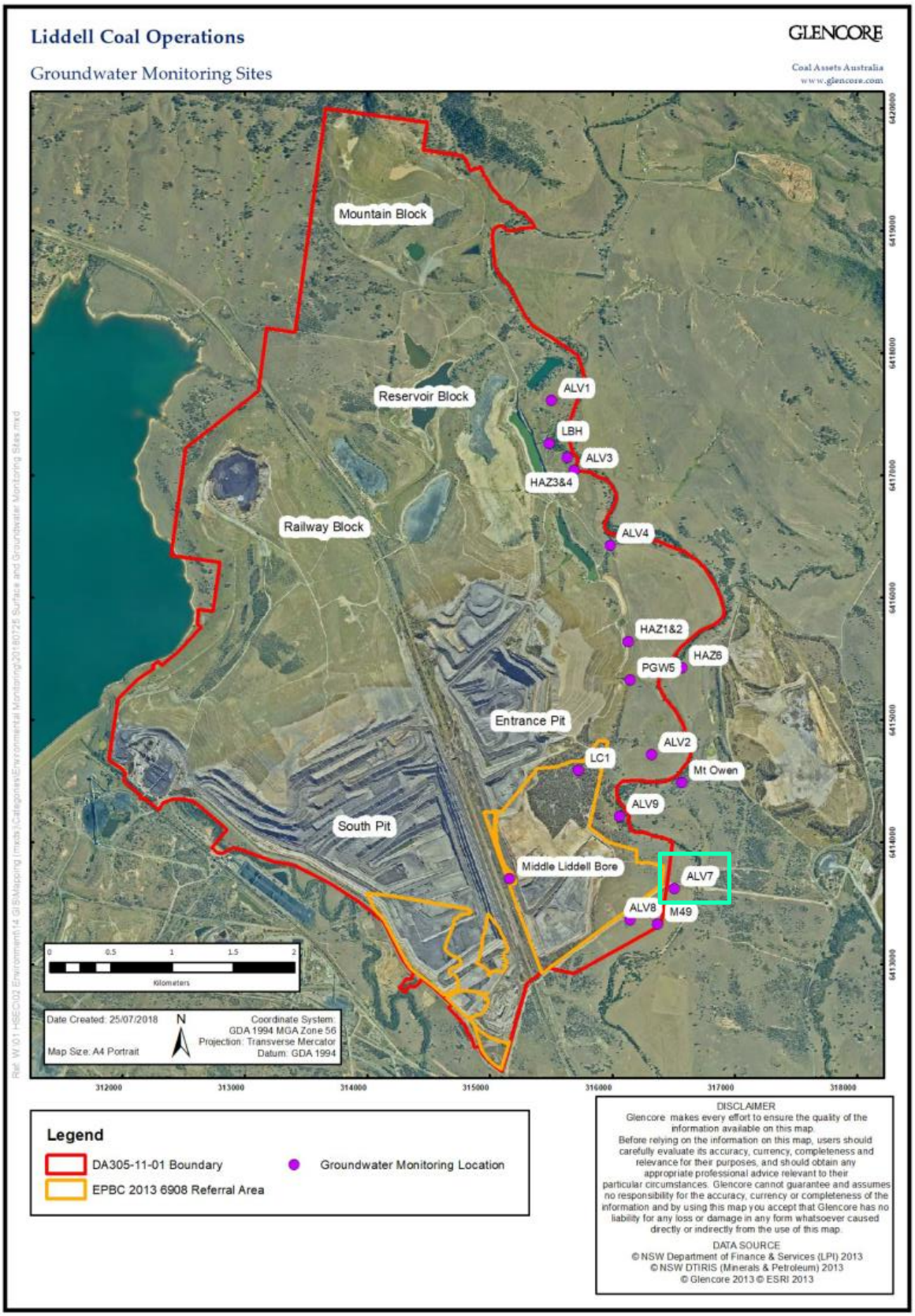

Figure 2.1: LCO - Groundwater monitoring locations (Glencore 2018b)

2.2 Climate

Long-term climate trends can be characterised using the cumulative relative departure (CRD) method. CRD shows trends in rainfall and evaporation relative to the long-term monthly averages and provides a historical record of wetter/drier periods and periods of elevated evaporation. A rising trend in slope in the CRD plot indicates periods of above average rainfall or evaporation, horizontal trends indicate average conditions, while a declining slope indicates periods of below average rainfall or evaporation. CRD for rainfall and evaporation has been used in this study to give context to variations in groundwater levels.

Figure 2.2 indicates the following in relation to rainfall and evaporation at Liddell:

- 2005 to mid-2007 was characterised by a period of below average rainfall (this period is referred to as the Millennium Drought), with a slightly above average evaporation rates compared to historic data;
- Mid-2007 to 2012 was characterised by a period of above average rainfall, with below average evaporation rates;
- 2012 to mid-2015 was characterised by above average evaporation rates that are increasing together with slightly above average rainfall. This is in contrast to other periods of above average rainfall which are normally accompanied by below average evaporation rates;
- mid-2015 to late-2016 was characterised by above average evaporation rates that are increasing together with average rainfall, causing a relatively drier period than the previous period;
- Late-2016 to late-2019 (present day) is characterised by severe drought conditions with on-going below average rainfall and above average evaporation since 2012.

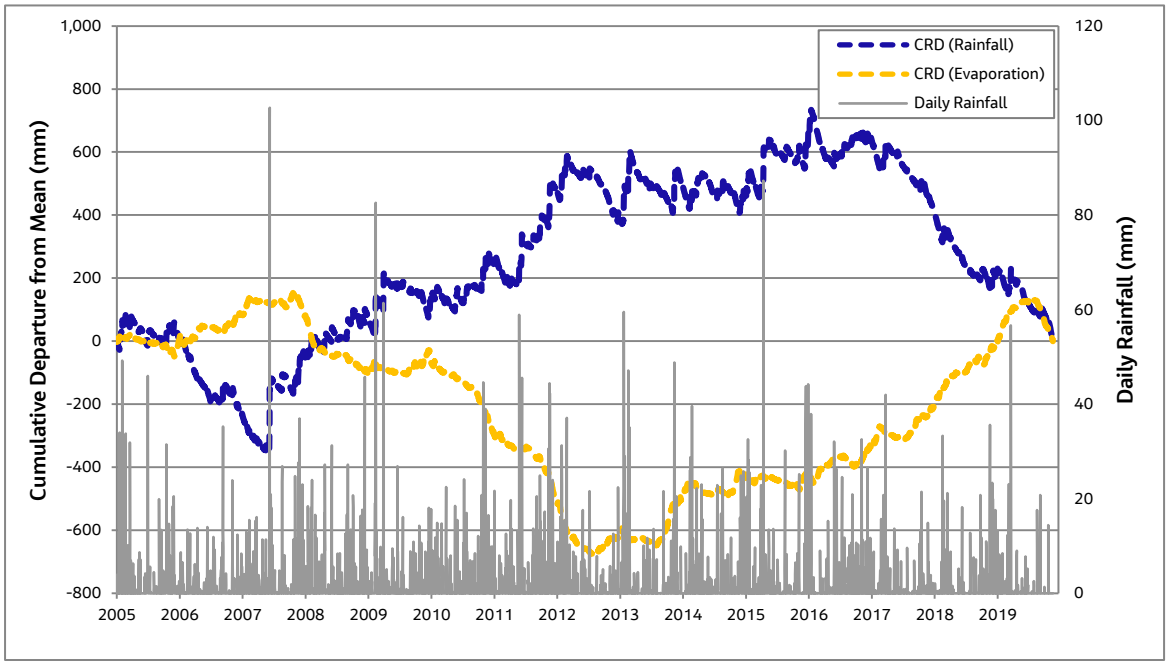

Figure 2.2: Cumulative departure - rainfall and evaporation

A single rainfall event can influence the CRD rainfall trend. It is important to note that overall groundwater trends are influenced by prevailing climatic conditions, more so than a single large rainfall event. Three events that should be noted are those in early September (86 mm) and November (91 mm) 2006, which were significant rainfall events that can be seen in the record during the Millennium Drought. This is also the case for the recent rainfall event of late-February (82 mm) 2019, during the current drought. Each of these events have cause a peak in the CRD curve but it is likely the majority of the precipitation was runoff and only a small proportion was recharged to groundwater.

3. Electrical Conductivity (EC) exceedance (ALV7S)

Observed groundwater elevations and relevant trigger levels at ALV7S are shown below in Figure 3.1. Observed groundwater EC measurement and relevant trigger levels at ALV7S are shown in Table 2.1 and Figure 3.2. The data is presented with the paired bore - ALV7L which is screened in the alluvium.

The 9-month EC trigger level exceedance at ALV7S is shown below in Table 3.1.

Table 3.1: Site specific trigger values for groundwater EC and monthly observations

Well ID	Target Unit	Trigger Values EC (mS/cm)		Monitoring Results Electrical Conductivity (mS/cm)									
		80th Percentile Upper Limit	Reference Maximum	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19
ALV7S	Shallow Bedrock Aquifer	**2.23**	**2.54**	2.11	**2.78**	**3.02**	**2.83**	**2.60**	**3.04**	**2.99**	**2.73**	**3.07**	**3.51**
ALV7L	Alluvium	**1.78**	**2.31**	1.51	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

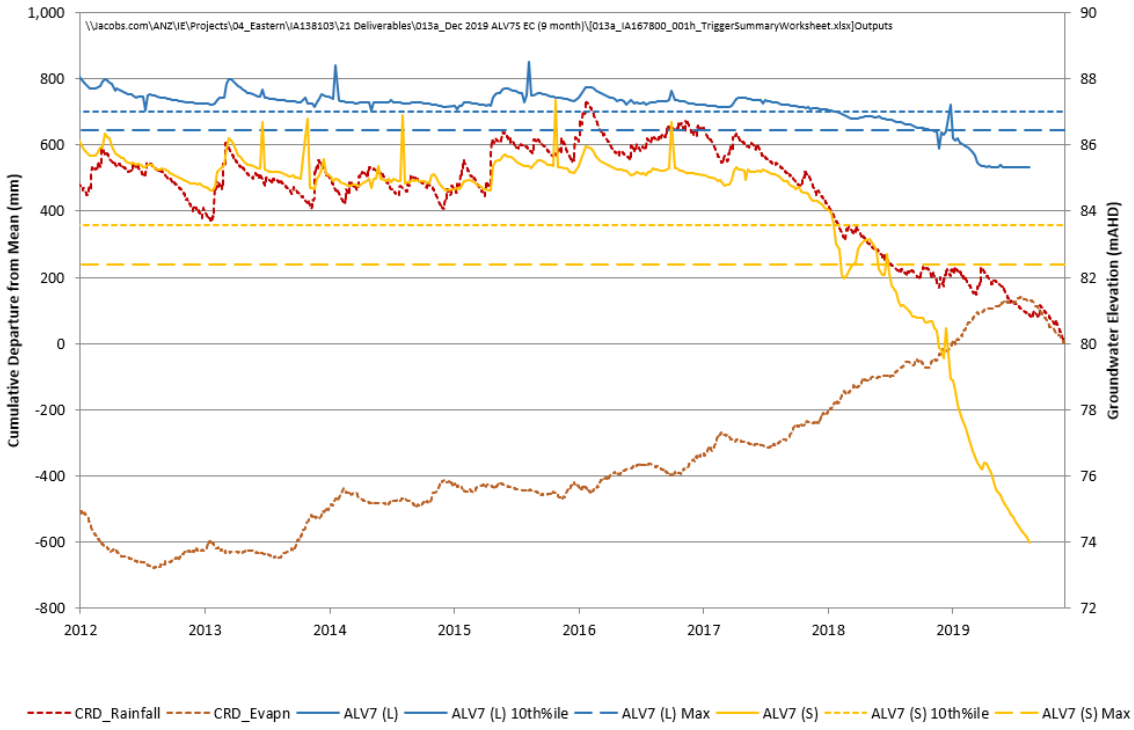

Figure 3.1: Groundwater elevation (mAHD) monitoring observations at ALV7 and climatic CRDs

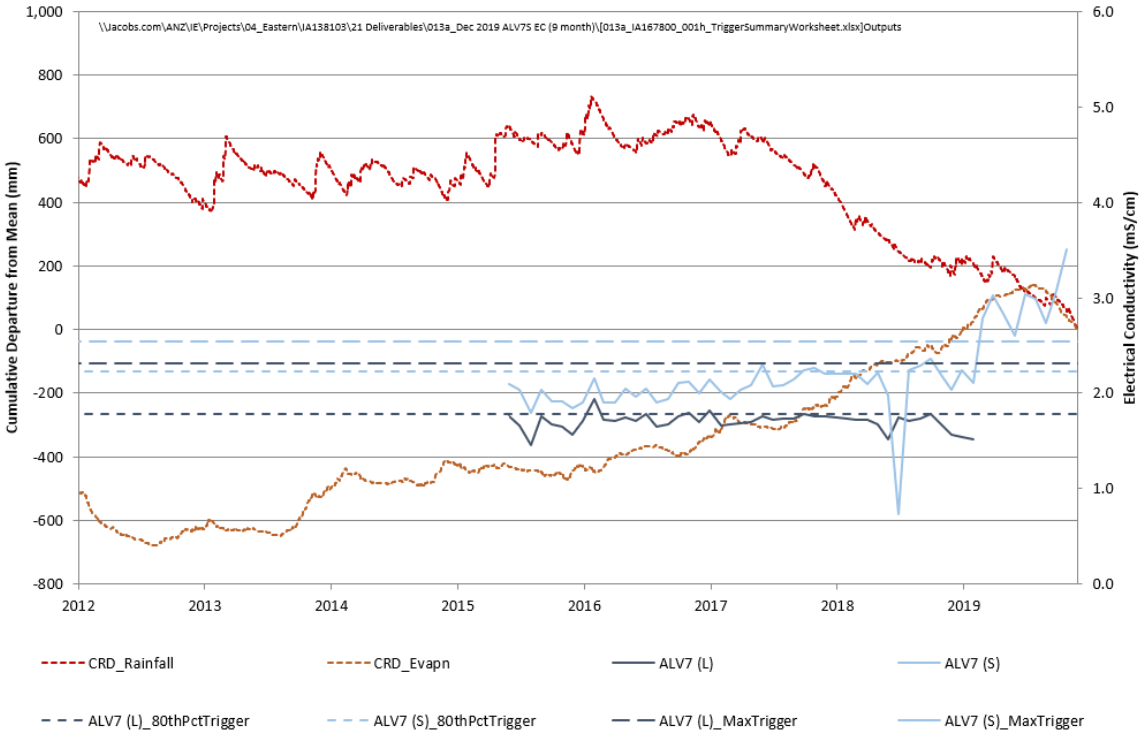

Figure 3.2: Electrical conductivity (mS/cm) observations at ALV7 and climatic CRDs

3.1 Previous report findings

The previous EC investigation trigger reports for ALV7S determined the EC levels were increasing due to climatic factors. Comparisons between the rainfall CRD and EC show an inverse relationship, where an increase in rainfall resulted in a decrease in EC measurements. This response is expected, as reduced groundwater recharge from the alluvium in recent years has led to a dominance of recharge from the more saline coal measures.

3.2 Data review

The water levels at ALV7 have declined significantly since the beginning of 2019 with water levels in the alluvium piezometer ALV7L falling below the base of the piezometer and the shallow bedrock piezometer ALV7S is still showing a strong declining trend. ALV7S water levels have decreased more than 5 m since January 2019 to approximately 74 mAHD, which is 8.4 m below the reference maximum. The water level decline in this area has previously been investigated and water levels are monitored regularly.

EC observations show an inverse relationship to the rainfall CRD at ALV7S, with EC measurements showing a corresponding increase, rising above the reference maximum in March 2019. The latest measurement in November 2019 recorded a concentration of 3.51 mS/cm, which is 0.97 mS/cm above the reference maximum. It is noted that other sites, including alluvial and shallow bedrock monitoring sites, have higher reference maxima, such as ALV2L at 4.16 mS /cm and, AVL4S at 6.43 mS /cm respectively.

The increasing EC observed at ALV7S can be attributed to the reduced contribution of the relatively less saline alluvial groundwater, due to the drying of the alluvium at that location. ALV7L, targeting the overlying alluvium, became dry in March 2019, coinciding with the EC trigger exceedance and suggesting the recharge contribution from the alluvium is reduced in comparison to the more saline water from the shallow bedrock

Water quality within the overburden lithologies will also exhibit a salinity gradient, ranging from shallow salinities, that are in-line with the overlying alluvial aquifer, and increasing with depth. With the declining water levels at ALV7S, there is an increased interaction with the more saline overburden lithologies and the increased dominance of the more saline waters from the shallow bedrock resulting in the increased EC concentrations. While the declining regional water levels will be contributing, it is considered that it is the decline in water levels within the shallow overburden that is the primary cause of the increased salinity.

4. Review Findings

The EC measurements that passed the nine-month trigger exceedance are caused by the water level decline observed at ALV7, sustaining the conclusions of the three-month and six-month trigger exceedance reports. Generally, groundwater level trends in ALV7, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. Periods of groundwater level decline in ALV7S have been observed during previous periods of below average rainfall and this period of elevated EC coincides with the current period of below average rainfall and above average evaporation.

While the maximum reference EC trigger has been exceeded, the possibility of potential or actual environmental harm due to mining activities is low. The groundwater depths measured at ALV7S

reflect natural variability due to climatic factors and it is unlikely that the EC increase is a mining-related impact. The elevated EC is considered to be representative of the natural salinity of the coal measures without the diluting influence of seepage from the overlying alluvium. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.

The lack of groundwater in the alluvium precludes further investigation. When there is significant recharge to the alluvium, further investigation could be conducted to determine whether connectivity between the alluvial and fractured rock aquifers has altered. It is recommended to continue monitoring in accordance with the WMP and collect more data for the ongoing investigation into the water level decline observed at ALV7.

It is recommended that routine monitoring continues at ALV7S and other Bowmans Creek monitoring locations, and that investigation be carried out as required by the WMP.

5. Reference

Glencore (2018a). *Liddell Coal Operations - Water Management Plan.* Glencore-Liddell reference number: LIDOC-90533967-3694.

Glencore (2018b). *Liddell Coal Operations - ALV4L & ALV8L Groundwater Investigation Trigger*. October 2018.

Jacobs (2019a*). Liddell Coal Operations – Liddell Coal Operations, Ravensworth, Groundwater Trigger Assessment*. 30 November 2018

Jacobs (2019b). *Liddell Coal Operations – ALV4S & LBH water level & ALV7S EC Groundwater Investigation August 2019.* October 2019

Jacobs (2019c). *Liddell Coal Operations – ALV8L water level Groundwater Investigation November 2019.* November 2019

Appendix C - December 2019 – ALV1L and ALV2S Electrical Conductivity ITARP

LIDDELL

GLENCORE

Groundwater Investigation Trigger Report
January 2020

1. Introduction

1.1 Overview

In accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908, LCO has undertaken an investigation as a result of groundwater triggers at monitoring piezometers ALV1L and ALV2S. Specifically, Groundwater Quality Definition #1 triggers have occurred and these are defined as three consecutive months of Electrical Conductivity (EC) observations above the 80th%ile trigger limits, from October 2019 to December 2019.

As per the WMP, LCO notified the Department of Environment and Energy (DoEE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division of the exceedance on the 14 January 2020. This notification stated, "It is considered that the observations are not of potential harm to the environment based on our current knowledge." Further, LCO has previously investigated trigger exceedances at each of these bores in June 2019 due to the same Groundwater Quality Definition #1 trigger activation. These investigations were notified and investigated as per the WMP and concluded that the declining groundwater levels and EC observations are likely reflecting variability due to current climate factors, a trend which is seen across the monitoring network. There was no mining related impact determined nor likely potential of environmental harm.

1.2 Scope

The scope for this groundwater ITARP investigation consists of:

- An investigation into consecutive groundwater quality, specifically EC, exceedances at groundwater monitoring sites ALV1L and ALV2S.
- An assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

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2. Groundwater Investigation

The monitoring results that triggered this investigation, as well as the applicable trigger levels for the ALV1L and ALV2S are shown in **Table 1** below.

Table 1: Site-specific trigger values for groundwater EC and monthly observations

Well ID	Unit	Trigger Values Electrical Conductivity (ms/cm)													
		20th percentile trigger limit	80th percentile trigger limit	Reference Maximum	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sept 2019	Oct 2019	Nov 2019	Dec 2019
ALV1L	Alluvial	N/A	1.37	2.02	1.11	1.53	1.49	1.53	1.36	1.47	1.44	1.32	1.41	1.59	1.38
ALV2S	Shallow Bedrock	2.56	2.82	3.37	2.45	3.27	3.24	3.33	2.74	3.12	3.00	2.80	2.95	3.26	2.90

Specific aspects of the investigation detailed within this report include current mining activities, groundwater level observations, EC observations and streamflow observations.

Monitoring locations ALV1 and ALV2 are clustered monitoring locations that consists of two monitoring bores that target separate water bearing units. ALV1L and ALV2S target the Bowman's Creek alluvium and the shallow coal measures overburden respectively. The groundwater monitoring network is shown on **Figure 1**.

2.1 Current mining activities

During the last 12 months, mining activity has progressed generally in accordance with the approved Mining Operations Plan (MOP). Mining in South Pit has reached the southern limits and continuing down with ongoing development of the overburden emplacement to the north of the active mining area.

Mining in the northern section of the Entrance Pit has completed and now an overburden emplacement. Mining activities have continued in the southern portion of the Entrance Pit. Strip progression is moving towards the north. **Figure 1** identifies the groundwater monitoring network spatially with respect to mining operations. Noteworthy, no significant changes to the extent of mining operations have occurred.

There has been no failures or changes to the mine water management system near either triggering bore.

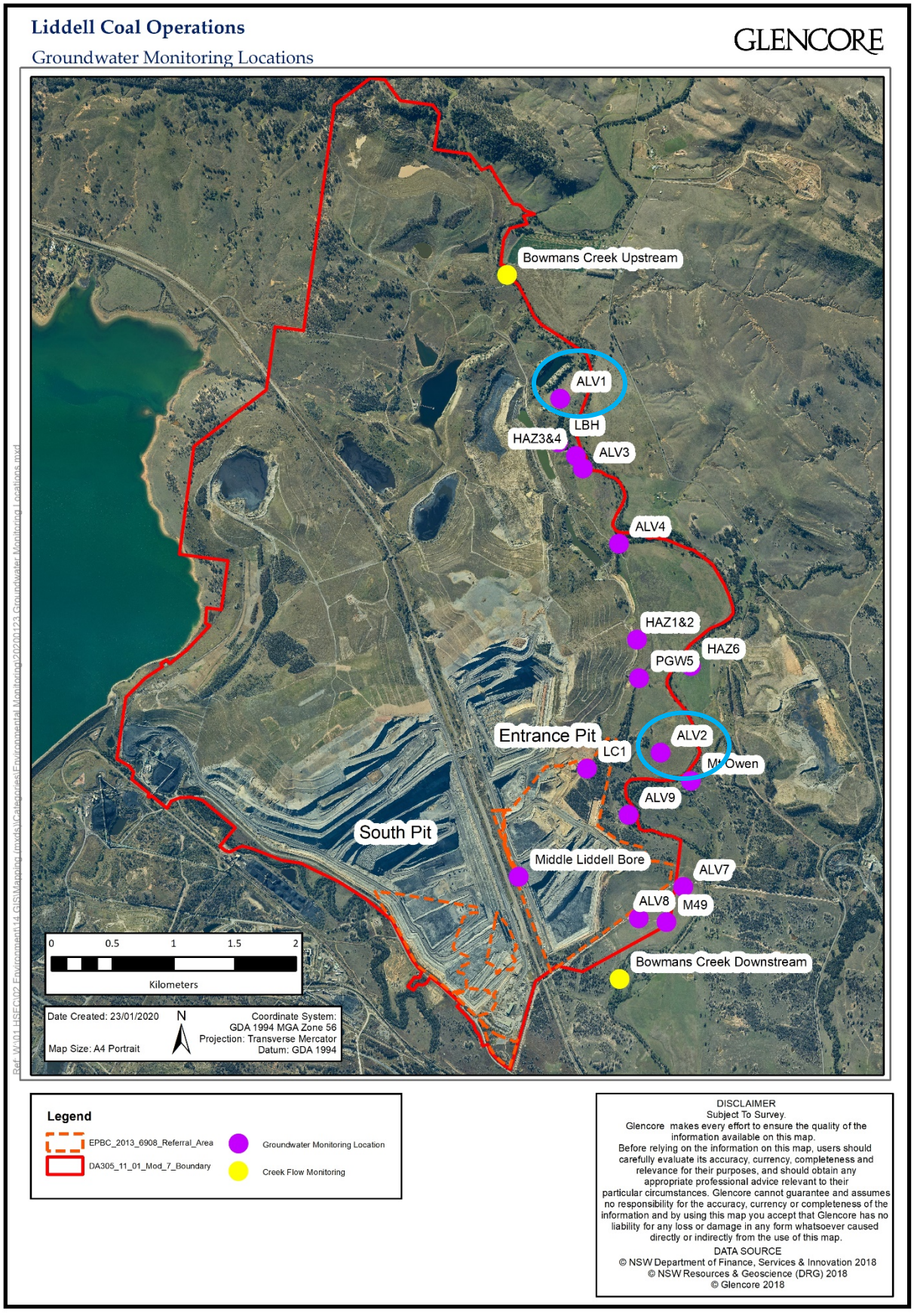

Figure 1 – Groundwater Monitoring Locations

2.2 Groundwater elevations

Paired piezometers are installed at each of the ALV monitoring locations targeting the alluvial aquifer (ALV 'L' bore) and the underlying shallow bedrock (ALV 'S' bore). Observed groundwater elevations and relevant trigger levels at the northern sites (ALV1, ALV3 and ALV4) are shown below in **Figure 2**. The southern locations (ALV2, ALV7 and ALV8) are shown in **Figure 3**. A residual mass curve, cumulative relative difference (CRD), with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

Regarding groundwater levels along the Bowman's Creek system, previous ITARP investigations have occurred at each monitoring site and it have determined that there is clear link between climatic variations and low groundwater levels. It is understood that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops up gradient. Further, a review of long term historical monitoring shows that with progression downstream along Bowman's creek, the interaction between the alluvial and shallow bedrock can be characterized as a gaining, through near equilibrium pressure to loosing stream under normal flow conditions.

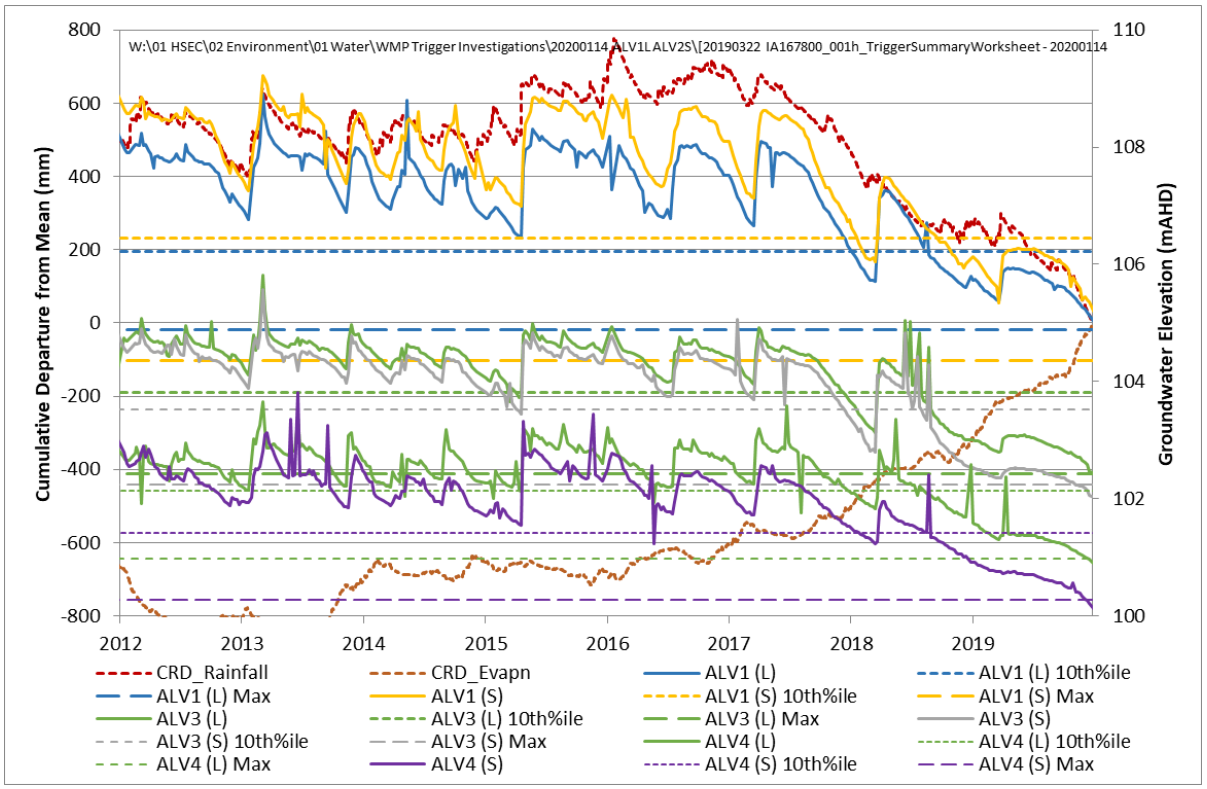

Figure 2 - Groundwater elevation (mAHD) observations at northern locations and climatic CRDs

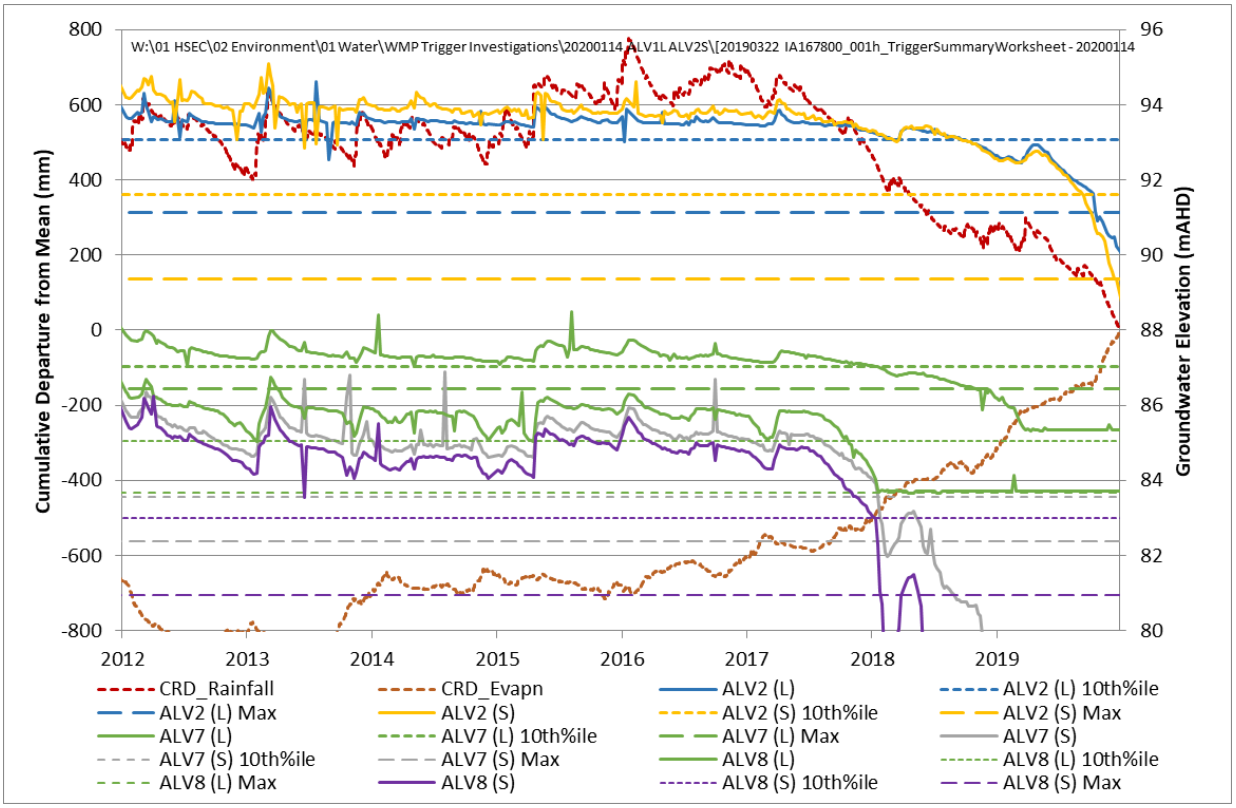

Figure 3 - Groundwater elevation (mAHD) observations at southern locations and climatic CRDs

As per **Figures 2 & 3**, there is a significant drop in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). This implies below average rainfall combined with higher than average evaporation was experienced. Further the evaporation mass curve has seen prolonged steady increase since 2016 to present indicating that the above average evaporation has been sustained without break. This combination of below average rainfalls and higher than average long-term evaporation characterises the current drought conditions.

Generally, the water level trends at these sites are similar to the CRD trend where residual mass curve rainfall has the longest declining trend since 2005 at the commencement of the reference timeframe. This implies that LCO is measuring groundwater levels in climate conditions at maximums measured in the reference period and therefore observations within reference maximums are likely to occur in a system driven by rainfall.

Review of groundwater elevation measurements at each monitoring location continue to support the existing understanding of the hydraulic mechanisms along the system that influences the groundwater quality. Specifically, monitoring demonstrates a slight upward hydraulic gradient from shallow bedrock into the alluvial at ALV1 and a neutral gradient at ALV2.

Review of the relationship trend between the alluvial and shallow bedrock generally shows that decreases in water levels within the alluvium and shallow bedrock aquifer are similar, this is consistent with previous investigation reports. This supports the understanding that both systems recharge and respond due to the same primary driver, climatic conditions. The consistency of these observations along the whole system indicates that the groundwater response at ALV1L and ALV2S is driven by climate and not by mining activity.

Periodic dewatering of the underground workings occurs as required for mining operations. A review of the groundwater level observations at the underground workings (measured at Hazeldene, M49, MLB & Mount Owen) have shown a general steady trend with recent extraction from Hazeldene and M49 to actively dewater and manage inrush risk whilst mining the northern entrance pit areas. There appears to be no clear correlation between the levels measured at the EC triggering bores with that of the underground workings inferring continued lack of connectivity.

2.3 Groundwater quality

Groundwater quality observations along the system are reviewed herein with comparison to other sites in the same system; i.e. ALV1L EC levels compared with other alluvial site EC levels and ALV2S levels compared with other shallow bedrock EC sites. Observed groundwater Electrical Conductivity (EC) measurement and relevant trigger levels at the alluvial sites nearest ALV1 are shown below in **Figure 4**. The southern triggering locations (ALV4, ALV2 and ALV7) are shown in **Figure 5**.

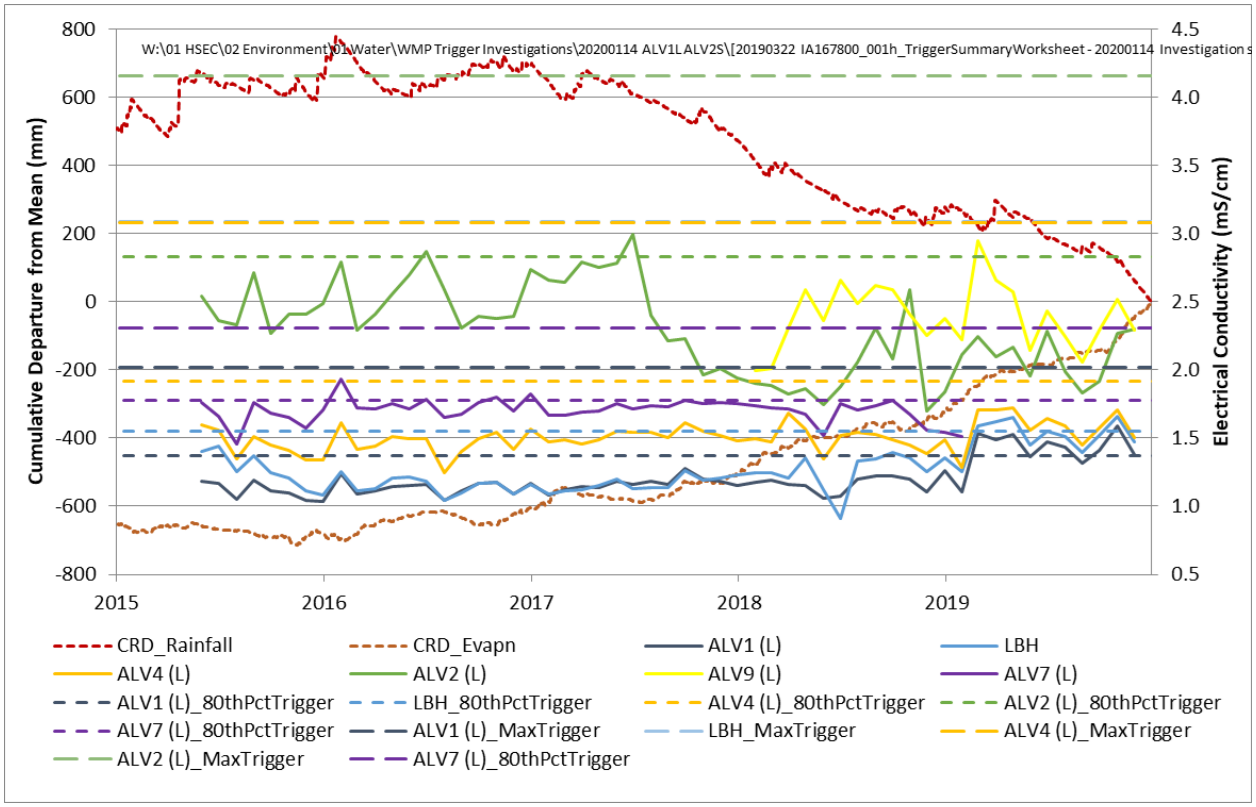

Figure 4 – Electrical conductivity (mS/cm) levels at alluvial bores nearest ALV1L & climatic CRDs

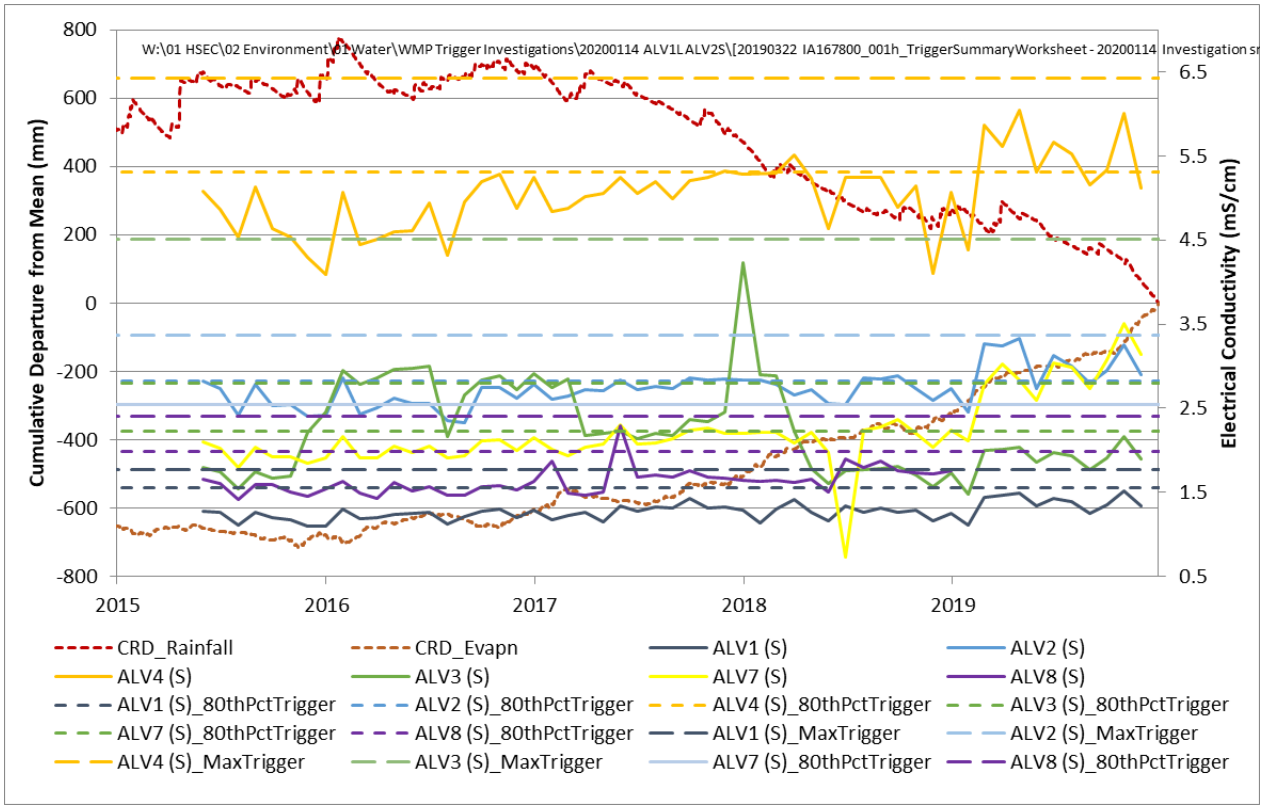

Figure 5 – Electrical conductivity (mS/cm) levels at shallow bedrock nearest ALV2S & climatic CRDs

Regarding EC levels at ALV1L, **Figure 4** shows that the levels trend upwards since March 2019 and the other alluvial bores show very similar changes. With the upward hydraulic gradient at AVL1, it is expected that the increasing EC levels within ALV1L are due to the increased dominance of recharge from the underlying shallow bedrock due to declining rainfall/freshwater influences input. The decreasing alluvial pressures (water levels) that are now at equilibrium with the shallow bedrock below corroborate this understanding.

Regarding EC levels at ALV2S, **Figure 5** shows that the levels trend upwards since March 2019; the trend is very similar at the other shallow bedrock sites. At these locations it is expected that the EC levels are increasing due to the increased interaction with saline bedrock material and decreased rainfall/freshwater influence. .

The consistency of the increasing EC trend throughout the system aligning directly with the rainfall CRD infers that the dominant influencing factor for the observed EC levels is rainfall recharge.

2.4 Streamflow monitoring

Observed streamflow gauge monitoring results and residual mass curves for rainfall and evaporation are shown in **Figure 6** below.

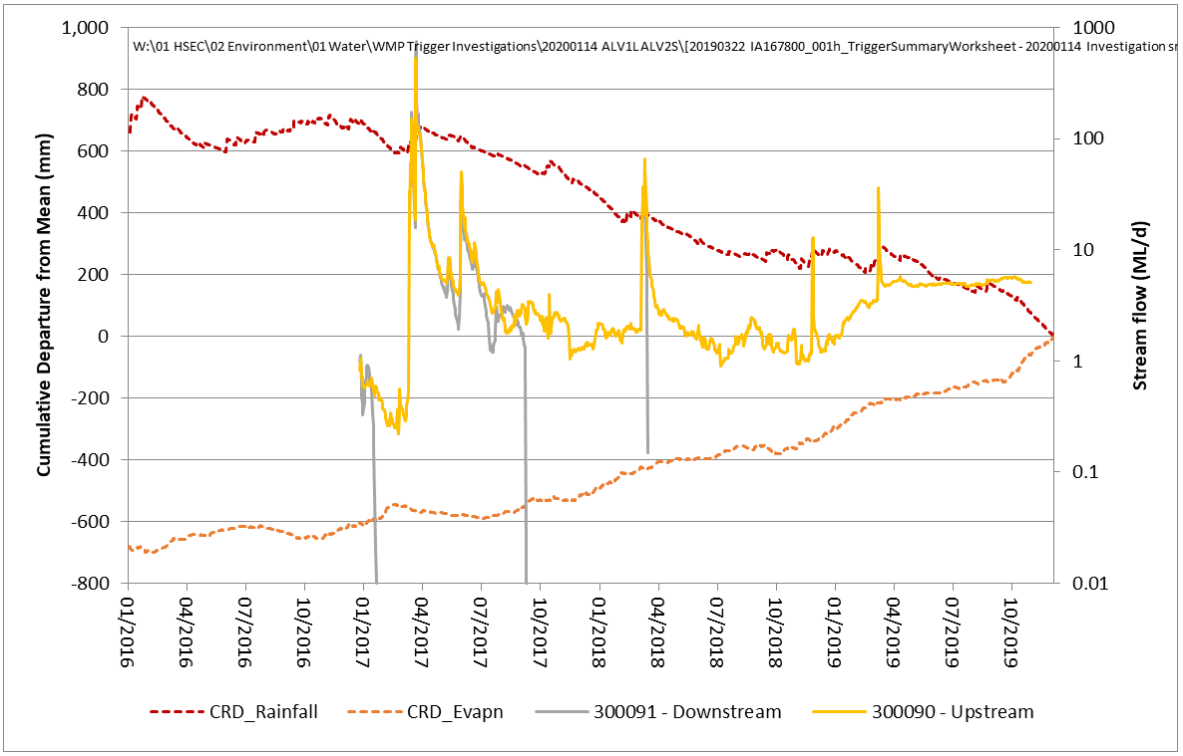

Figure 6 - Bowman's Creek streamflow observations

Bowman's Creek is an ephemeral watercourse that naturally ceases surface flows. From **Figure 6**, the streamflow (ML/d) observed at Bowman's Creek gauging stations downstream and upstream correlates reasonably with the declining trend observed in the residual mass curve (rainfall). For instance, the short rainfall events of March 2017 resulted in increased flows along the whole system for a short period of time. Rainfall in March and November 2018 resulted in increased flows at the upstream monitoring location however to a much lesser extent than March 2017 as expected.

Monitoring observations at Bowman's Upstream are calculated using a rating table from depth and a natural rock control. Since June 2019, calculated flowrates appear to be inaccurate (too high) due to measured levels at the base of the rating table for the control and plant growth fouling the riffle edge of the monitored creek pool lifting the pool spill level. Once normal creek base flow returns, this issue is expected to resolve naturally. LCO also record visual flow observations at each surface water monitoring location along Bowman's Creek. These observations corroborate the expected and understood creek flow behavior; decreasing to no flow as the drought continues. The streamflow observations support the groundwater level and EC monitoring observations confirming the conclusion that there is reduced rainfall recharge to shallow bedrock recharge occurring, where it outcrops up gradient, and the alluvium.

3. Conclusion

Regarding groundwater levels along the Bowman's Creek system, previous ITARP investigations have occurred at each site monitored along the system. Each investigation has yielded clear link between climatic variations and measured groundwater levels.

EC observations at ALV1L and ALV2S have not exceeded reference maximums to date.

During the previous 24 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. Hence it is not expected that there is potential for harm to the environment as the system is varying naturally.

LCO propose to continue monitoring in accordance with the WMP. Consequently, for each bore individually, if groundwater levels continue to be measured below the trigger level for 3 months, such that the exceedance has been continuous for 6 months, then a subsequent investigation shall be undertaken to confirm the exceedance remains unrelated to mining activity.

Appendix D - February 2020 – ALV7S Electrical Conductivity ITARP

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Groundwater Investigation Trigger Report
March 2020

1. Introduction

1.1 Overview

In accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908, LCO has undertaken an investigation as a result of groundwater triggers at monitoring piezometer ALV7S. Specifically, Groundwater Quality Definition #1 triggers have occurred and these are defined as 12 consecutive months of Electrical Conductivity (EC) observations above the 80th%ile trigger limits, from March 2019 to February 2020.

As per the WMP, LCO notified the Department of Agriculture, Water and the Environment (formally Department of Agriculture, Water and the Environment (DAWE)) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division of the exceedance on the 18 March 2020. This notification stated, "It is considered that the observations are not of potential harm to the environment based on our current knowledge." Further, LCO has previously investigated trigger exceedances at this bore in June, September and December 2019 due to the same Groundwater Quality Definition #1 trigger activation. Investigations in June and September 2019 were notified and investigated as per the WMP and concluded that the declining groundwater levels and EC observations are likely reflecting variability due to current climate factors, a trend which is seen across the monitoring network. A further investigation conducted in December 2019 concluded that the EC observations were the result of decreased water levels in the shallow bedrock and the dry alluvium. Therefore meaning that the measured levels are reflective of the natural EC levels in the shallow bedrock without the diluting effect from the less saline alluvium above. All investigations concluded there was no mining related impact determined nor likely potential of environmental harm.

1.2 Scope

The scope for this groundwater ITARP investigation consists of:

- An investigation into consecutive groundwater quality, specifically EC, exceedances at groundwater monitoring site ALV7S.
- An assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

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2. Groundwater Investigation

The monitoring results that triggered this investigation and relevant trigger levels for the shallow bedrock bore ALV7S, which are presented in **Table 1** below. Additionally, the data is presented with the paired bore ALV7L which is screen in the alluvium.

Table 1: Site-specific trigger values for groundwater EC and monthly observations

Well ID	Unit	Trigger Values Electrical Conductivity (ms/cm)															
		20th percentile trigger limit	80th percentile trigger limit	Reference Maximum	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sept 2019	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Feb 2020
ALV7S	Shallow Bedrock	N/A	2.23	2.54	2.11	2.78	3.02	2.83	2.60	3.04	2.99	2.73	3.07	3.51	3.14	3.50	3.53
ALV7L	Alluvial	N/A	1.78	2.31	1.51	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

Specific aspects of the investigation detailed within this report include current mining activities, groundwater level observations, EC observations and streamflow observations.

The groundwater monitoring network at LCO targeting the Bowmans Creek alluvium and the shallow coal measures overburden is shown on **Figure 1**.

2.1 Current mining activities

During the last 12 months, mining activity has progressed generally in accordance with the approved Mining Operations Plan (MOP). Mining in South Pit has reached the southern limits and continuing down with ongoing development of the overburden emplacement to the north of the active mining area.

Mining in the northern section of the Entrance Pit has completed and now an overburden emplacement. Mining activities have continued in the southern portion of the Entrance Pit. Strip progression is moving towards the north with final clearing for mining progressing completed in February 2020. **Figure 1** identifies the groundwater monitoring network spatially with respect to mining operations. Noteworthy, no significant changes to the extent of mining operations have occurred.

There has been no failures or changes to the mine water management system near either triggering bore.

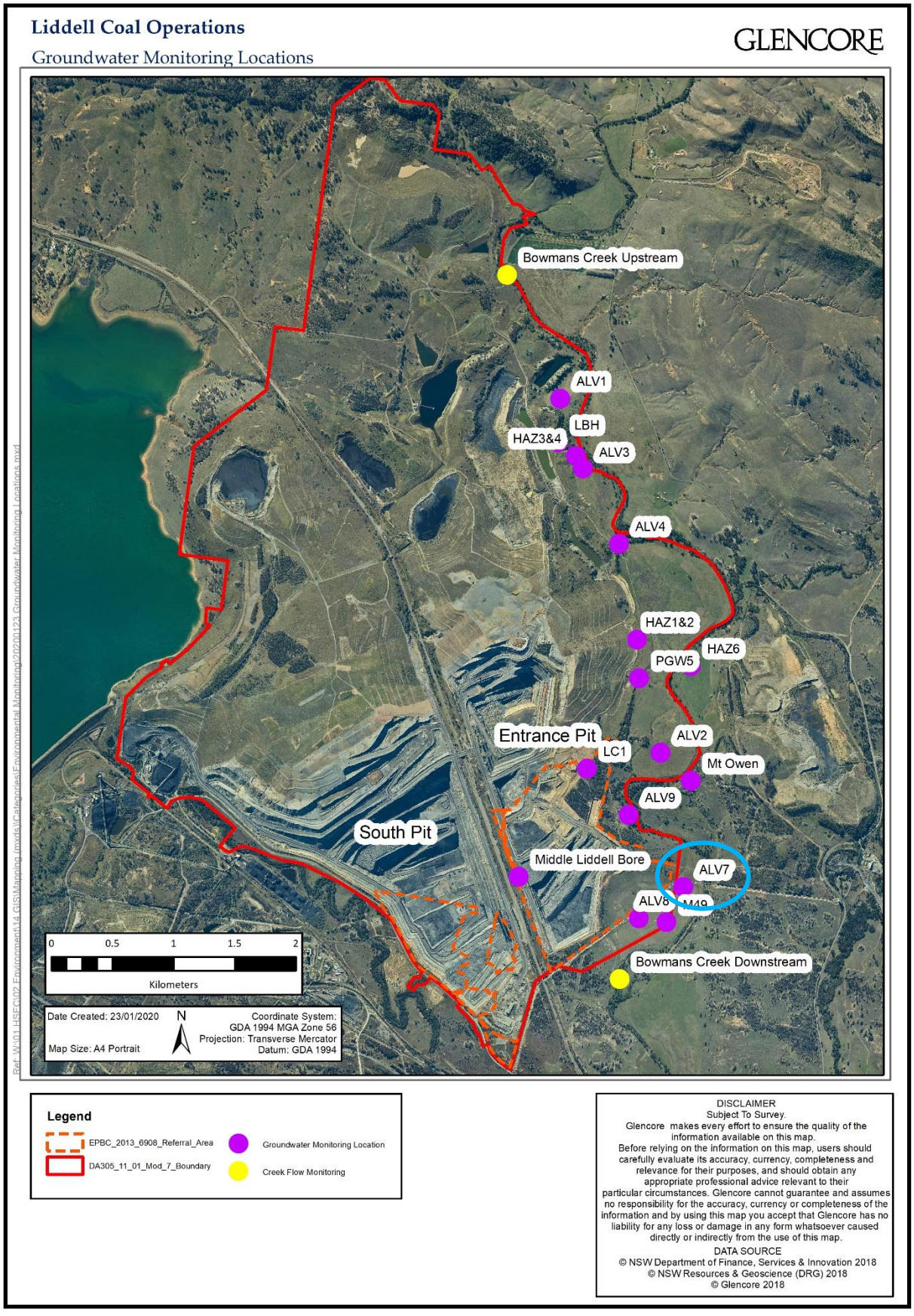

Figure 1 – Groundwater Monitoring Locations

2.2 Previous report findings

Previous EC investigation trigger reports for ALV7S determined that the EC levels were increasing due to climatic factors opposed to impact from mining operations. Comparison between the rainfall CRD and EC shows an inverse relationship, where a decrease in rainfall results in an increase in EC measurements. This response is expected, as a reduction in groundwater recharge from the alluvium due to prolonged drought conditions, has led to more recharge from the more saline coal measures.

Jacobs (March 2020) report on ALV7S groundwater level trigger investigation noted that the most notable decline in levels at this site occurred mid-2017, coinciding with the decline in rainfall and increase in evaporation rates. This decline also coincides with the increased depth in mining in the south-west extend of the LCO Entrance Pit which was considered likely to have depressurised the coal measures and resulted in vertical drainage of the overlying fractured rock units. Depressurisation of the fractured rock aquifer has been approved under DA305-11-01 Environmental Assessment.

2.3 Groundwater elevations

Paired piezometers are installed at each of the ALV monitoring locations targeting the alluvial aquifer (ALV 'L' bore) and the underlying shallow bedrock (ALV 'S' bore). To provide an overview of the entire network, observed groundwater elevations and relevant trigger levels at the northern sites (ALV1, ALV3 and ALV4) are shown below in **Figure 2**. The southern locations (ALV2, ALV7 and ALV8) are shown in **Figure 3**. A residual mass curve, cumulative relative difference (CRD), with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

Regarding groundwater levels along the Bowman's Creek system, previous ITARP investigations have occurred at ALV7S and have determined that there is clear link between climatic variations and low groundwater levels. It is understood that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops up gradient. Further, a review of long term historical monitoring shows that with progression downstream along Bowman's creek the interaction between the alluvial and shallow bedrock can be characterized, from upstream to downstream as gaining, through near equilibrium pressure to loosing stream under normal flow conditions.

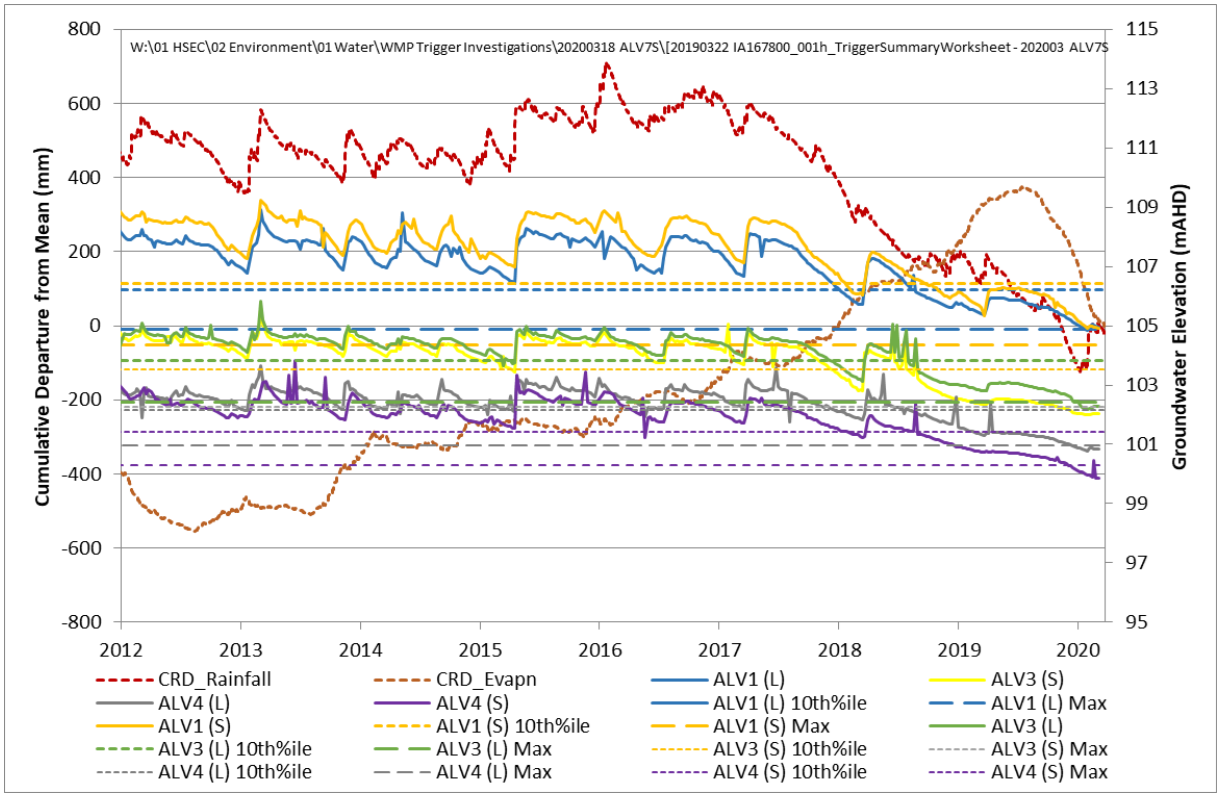

Figure 2 - Groundwater elevation (mAHD) observations at northern locations and climatic CRDs

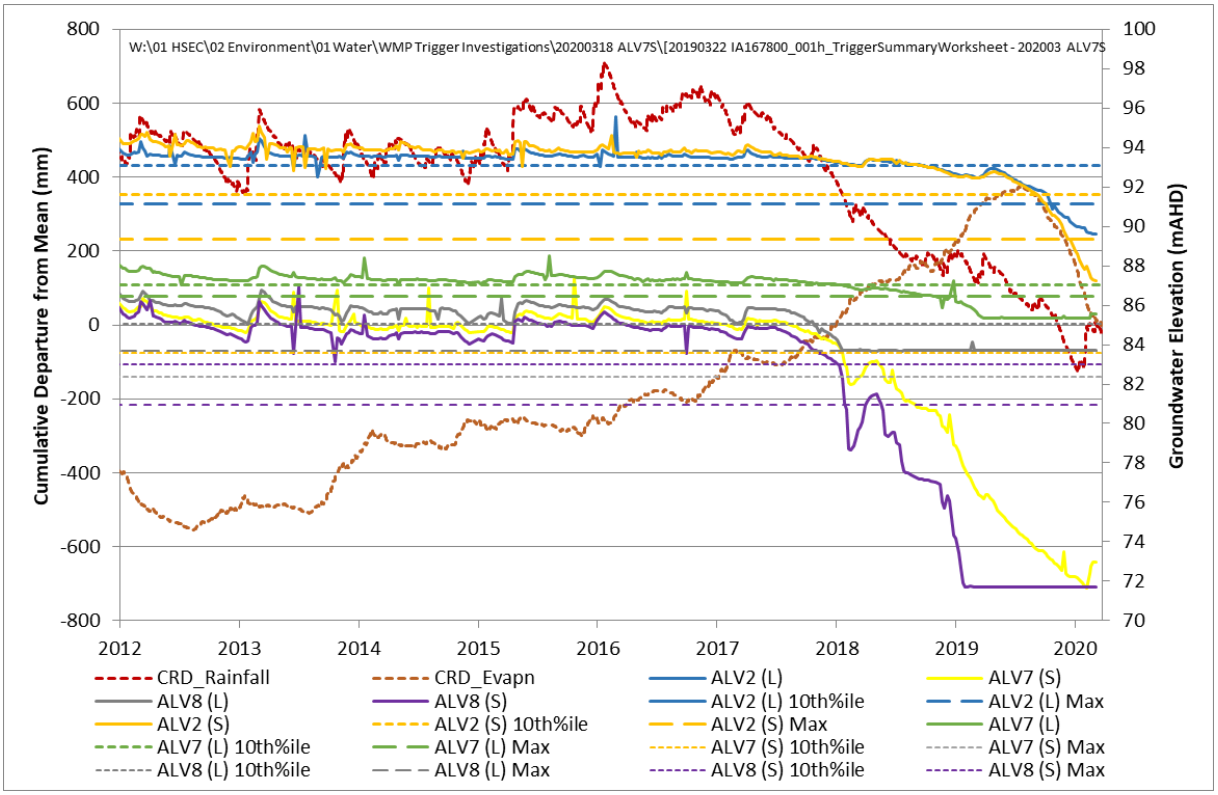

Figure 3 - Groundwater elevation (mAHD) observations at southern locations and climatic CRDs

As per **Figures 2 and 3**, there is a significant drop in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). This implies below average rainfall combined with higher than average evaporation was experienced. Further the evaporation mass curve has seen prolonged steady increase since 2016 to present indicating that the

above average evaporation has been sustained without break. This combination of below average rainfalls and higher than average long-term evaporation characterises the current drought conditions. Recent rainfall in early 2020 has resulted in an increasing rainfall CRD and a decrease in the evaporation CRD. However, despite this rainfall event, conditions remain significantly varied to normal conditions. Additionally as discussed in Section 2.5 below, stream flow observations have not shown material change in creek flow/conditions despite the recent rainfall.

Generally, the water level trends at these sites are similar to the CRD trend where residual mass curve rainfall has the longest declining trend since 2005 at the commencement of the reference timeframe. This implies that LCO is measuring groundwater levels in climate conditions at maximums measured in the reference period and therefore observations within reference maximums are likely to occur in a system driven by rainfall. This connectivity is further reinforced by the short period of rainfall experienced in early 2020, which resulted in a steadying of the rate of decrease in groundwater elevation in some bores or a minor increase in response in some instances.

Review of groundwater elevation measurements at ALV7S continue to support the existing understanding of the hydraulic mechanisms along the system that influences the groundwater quality. Specifically, ALV7S has shown a significant decline of water levels since the beginning of 2019 and have decreased more than 5 m since February 2019. The decrease in water level in this area has been previously investigation (see Section 2.2) and are monitored regularly.

Review of the relationship trend between the alluvial and shallow bedrock generally shows that decreases in water levels within the alluvium and shallow bedrock aquifer are similar, this is consistent with previous investigation reports. This supports the understanding that both systems recharge and respond due to the same primary driver, climatic conditions. The consistency of these observations along the whole system indicates that the groundwater response at ALV7S is driven by climate and not by mining activity.

Periodic dewatering of the underground workings occurs as required for mining operations. A review of the groundwater level observations at the underground workings (measured at Hazeldene, M49, MLB & Mount Owen) have shown a general steady trend with recent extraction from M49 to actively dewater and manage inrush risk whilst mining the northern entrance pit areas. There appears to be no clear correlation between the levels measured at ALV7S with that of the underground workings inferring continued lack of connectivity.

2.4 Groundwater quality

Groundwater quality observations along the system are reviewed herein with comparison to other sites in the same system. Observed groundwater EC measurement and relevant trigger levels at the southern alluvial sites nearest ALV7S are shown below in **Figure 4**.

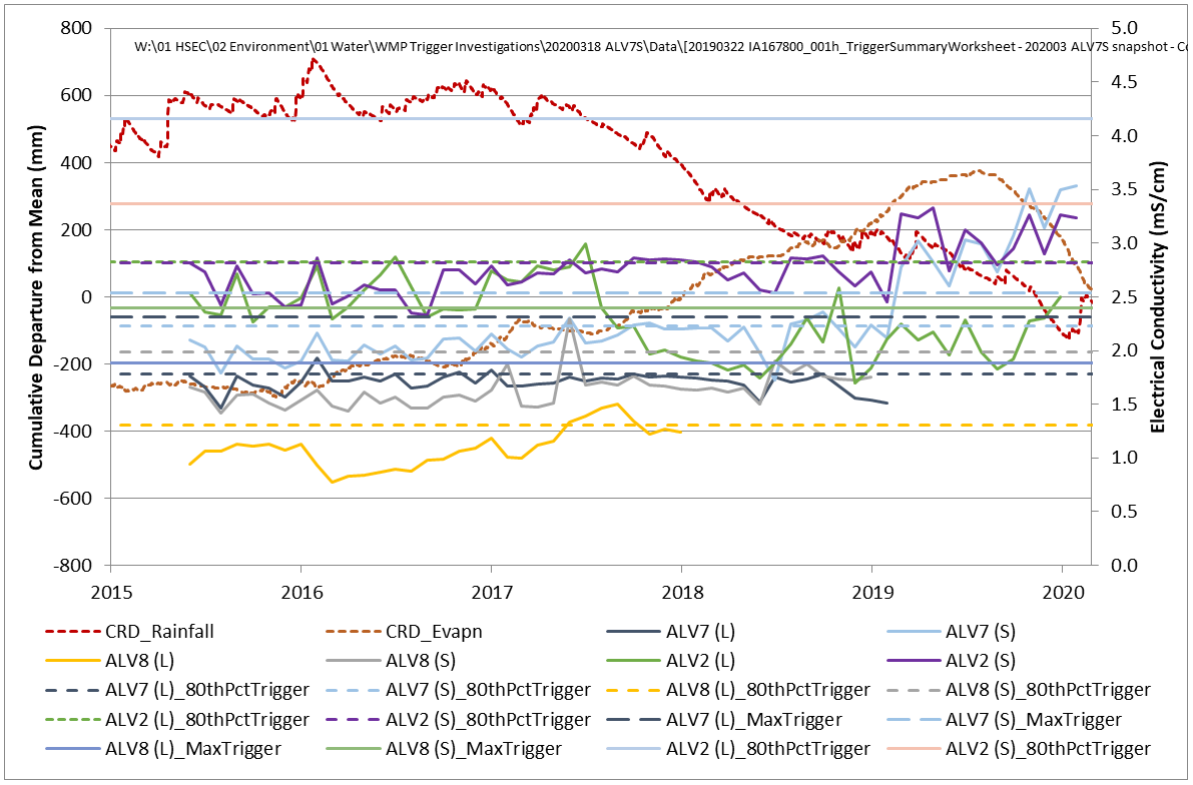

Figure 4 – Electrical conductivity (mS/cm) levels at alluvial bores nearest ALV7S and climatic CRDs

EC levels at ALV7S (**Figure 4)** shows that the levels trend upwards since March 2019 and the other alluvial bores show very similar changes. Measured EC results show an inverse relationship to the rainfall CRD at ALV7S, with EC measurements showing a corresponding increase, rising above the reference maximum in March 2019. The latest measurement in February 2020 at ALV7S recorded a concentration of 3.53 mS/cm, which is 1.51 mS/cm above the reference maximum with most of the other monitoring bores demonstrating similar rising EC trends.

The increase in EC levels measured at ALV7S is likely to be attributed to the reduced recharge contribution from the less saline alluvial groundwater due to the drying of the alluvium in this location ALV7L. ALV7L became dry in March 2019, which correlates with the EC trigger at ALV7S in March 2019, suggesting the reduction in recharge from the alluvium has resulted in more saline water from the shallow bedrock without the diluting effects of the fresher water above. As the water level at ALV7S continues to decline, there is an increased interaction with the more saline overburden lithologies and the increased dominance of the more saline waters from the shallow bedrock resulting in the observed increase EC concentration.

The consistency of the increasing EC trend throughout the Bowmans Creek monitoring system aligning directly with the rainfall CRD infers that the dominant influencing factor for the observed EC levels is rainfall recharge.

2.5 Streamflow monitoring

Observed streamflow gauge monitoring results and residual mass curves for rainfall and evaporation are shown in **Figure 5** below.

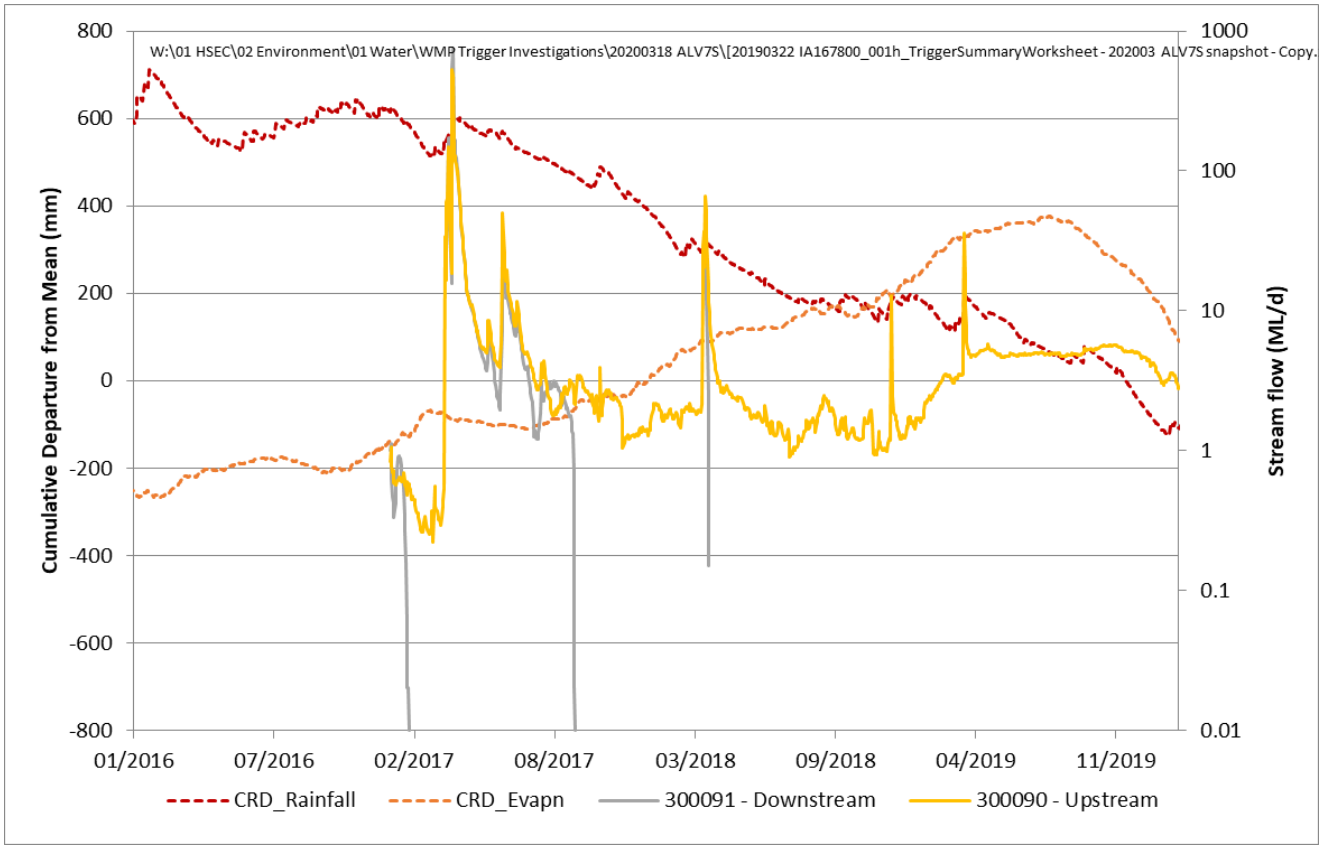

Figure 5 - Bowman's Creek streamflow observations

Bowman's Creek is an ephemeral watercourse that naturally ceases surface flows. From **Figure 5**, the streamflow (ML/d) observed at Bowman's Creek gauging stations downstream and upstream correlates reasonably with the declining trend observed in the residual mass curve (rainfall). For instance, the short rainfall events of March 2017 resulted in increased flows along the whole system for a short period of time. Rainfall in March and November 2018 resulted in increased flows at the upstream monitoring location however to a much lesser extent than March 2017 as expected.

Monitoring observations at Bowman's Upstream are calculated using a rating table from depth and a natural rock control. Since June 2019, calculated flowrates appear to be inaccurate (too high) due to measured levels at the base of the rating table for the control and plant growth fouling the riffle edge of the monitored creek pool lifting the pool spill level. Once normal creek base flow returns, this issue is expected to resolve naturally. LCO also record visual flow observations at each surface water monitoring location along Bowman's Creek as a component of its monitoring program (see **Table 2** below). These observations both upstream and downstream corroborate the expected and understood creek flow behavior; decreasing to no flow as the drought continues. The streamflow observations support the groundwater level and EC monitoring observations confirming the conclusion that there is reduced rainfall recharge to shallow bedrock recharge occurring, where it outcrops up gradient, and the alluvium.

Table 2: Bowmans Creek Streamflow Observations

Date	BCK1 (Upstream)	BCK6 (Downstream)
Feb-19	Trickle	Dry
Mar-19	Still	Dry
Apr-19	Slow	Dry
May-19	Still	Dry
Jun-19	Still	Dry
Jul-19	Still	Dry
Aug-19	Trickle	Dry
Sep-19	Still	Dry
Oct-19	Still	Dry
Nov-19	Still	Dry
Dec-19	Still	Dry
Jan-20	Still	Dry
Feb-20	Still	Dry

3. Conclusion

The continued decline of the water level and increased EC measured at ALV7S sustains the conclusion of previous three-month, six-month and nine-month trigger exceedance investigation reports of natural climate variability being sustained drought conditions are influencing the heightened EC results at this monitoring site.

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 24 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. Hence it is not expected that there is potential for harm to the environment as the system is varying naturally.

Further, whilst the maximum reference EC trigger has been exceeded for ALV7S, the potential for environmental harm due to mining activities is low. This conclusion has been drawn as the elevated EC level is considered to be representative of the natural salinity of the coal measures which is not being diluted through recharge seepage from the overlying alluvium which has been measured as dry since March 2019. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.

LCO propose to continue monitoring in accordance with the WMP. Consequently, if ALV7S EC continues to be measured above the trigger level for a further three months (total of 15 months measuring above trigger levels), a subsequent investigation shall be undertaken to confirm the exceedance remains unrelated to mining activity.

Appendix E - March 2020 - ALV1L, ALV2S, ALV4S and LBH Electrical Conductivity ITARP

LIDDELL

GLENCORE

Groundwater Investigation Trigger Report
April 2020

1. Introduction

1.1 Overview

In accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908, LCO has undertaken an investigation as a result of groundwater triggers at monitoring ALV1L, ALV2S, ALV4S and LBH. Specifically, Groundwater Quality Definition #1 triggers have occurred and these are defined as six consecutive months of Electrical Conductivity (EC) observations at ALV1L and ALV2S (October 2019 to March 2020) and three consecutive months of EC observations at ALV4S and LBH (January 2020 to March 2020) above the 80th%ile trigger limits.

As per the WMP, LCO notified the Department of Agriculture, Water and the Environment (formally Department of Agriculture, Water and the Environment (DAWE)) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division of the exceedance on the 17 April 2020. This notification stated, "It is considered that the observations are not of potential harm to the environment based on our current knowledge." Further, LCO has previously investigated trigger exceedances at ALV1L and ALV2S for the period of October – December 2019 following the same Groundwater Quality Definition #1 trigger activation. These triggers we were notified and reported in January 2020 as per the WMP and the investigation concluded that the declining groundwater levels and EC observations are likely reflecting variability due to current climate factors, a trend which is seen across the monitoring network. Furthermore, LCO has previously conducted investigations into groundwater depth and EC at bores along the Bowmans Creek system and have yielded a clear link between climatic variations, measured groundwater levels and the impact to EC levels.

This report also includes incorporates expanded statistical analysis recommended by DPIE – Water (letter ref OUT20/3921) following their review of the last ITARP submitted in March 2020.

1.2 Scope

The scope for this groundwater ITARP investigation consists of:

- An investigation into consecutive groundwater quality, specifically EC, exceedances at groundwater monitoring sites ALV1L, ALV2S, ALV4S and LBH.
- An assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

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Manager and Agent of the Liddell & Foybrook Joint Ventures

2. Groundwater Investigation

The monitoring results that triggered this investigation and relevant trigger levels for the shallow bedrock bores, ALV2S and ALV4S and alluvial aquiver bores, ALV1L and LBH are presented in **Table 1** below. Additionally, the data is presented with the paired bore ALV2L and ALV4L which is screened in the alluvium and ALV1S which is to the shallow bedrock.

Table 1: Site-specific trigger values for groundwater EC and monthly observations

Well ID	Unit	Trigger Values Electrical Conductivity (ms/cm)															
		20th percentile trigger limit	80th percentile trigger limit	Reference Maximum	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sept 2019	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020
ALV1S	Shallow Bedrock	N/A	1.56	1.77	1.44	1.47	1.49	1.34	1.42	1.39	1.25	1.36	1.51	1.33	1.50	1.52	1.38
ALV1L	Alluvial	N/A	1.37	2.02	1.53	1.49	1.53	1.36	1.47	1.44	1.32	1.41	1.59	1.38	1.49	1.56	1.40
ALV2S	Shallow Bedrock	2.56	2.82	3.37	3.27	3.24	3.33	2.74	3.12	3.00	2.80	2.95	3.26	2.90	3.26	3.24	3.03
ALV2L	Alluvial	N/A	2.83	4.16	2.24	2.10	2.17	1.95	2.28	1.99	1.83	1.92	2.27	2.30	2.50	dry	dry
ALV4S	Shallow Bedrock	N/A	5.31	6.43	5.87	5.61	6.04	5.31	5.66	5.53	5.15	5.34	6.01	5.12	5.95	6.02	5.48
ALV4L	Alluvial	N/A	1.92	3.08	1.71	1.71	1.72	1.56	1.64	1.59	1.45	1.57	1.70	1.51	1.72	1.65	1.51
LBH	Alluvial	N/A	1.55	3.09	1.59	1.62	1.65	1.45	1.55	1.51	1.39	1.52	1.66	1.47	1.67	1.60	1.56

Specific aspects of the investigation detailed within this report include current mining activities, groundwater level observations, EC observations and streamflow observations.

The groundwater monitoring network at LCO targeting the Bowmans Creek alluvium and the shallow coal measures overburden is shown on **Figure 1**.

2.1 Current mining activities

During the last 12 months, mining activity has progressed generally in accordance with the approved Mining Operations Plan (MOP). Mining in South Pit has reached the southern limits and continuing down with ongoing development of the overburden emplacement to the north of the active mining area.

Mining in the northern section of the Entrance Pit has completed and now an overburden emplacement. Mining activities have continued in the southern portion of the Entrance Pit. Strip progression is moving towards the north with final clearing for mining progressing completed in February 2020. **Figure 1** identifies the groundwater monitoring network spatially with respect to mining operations. Noteworthy, no significant changes to the extent of mining operations have occurred.

There has been no failures or changes to the mine water management system near any of the triggering bores.

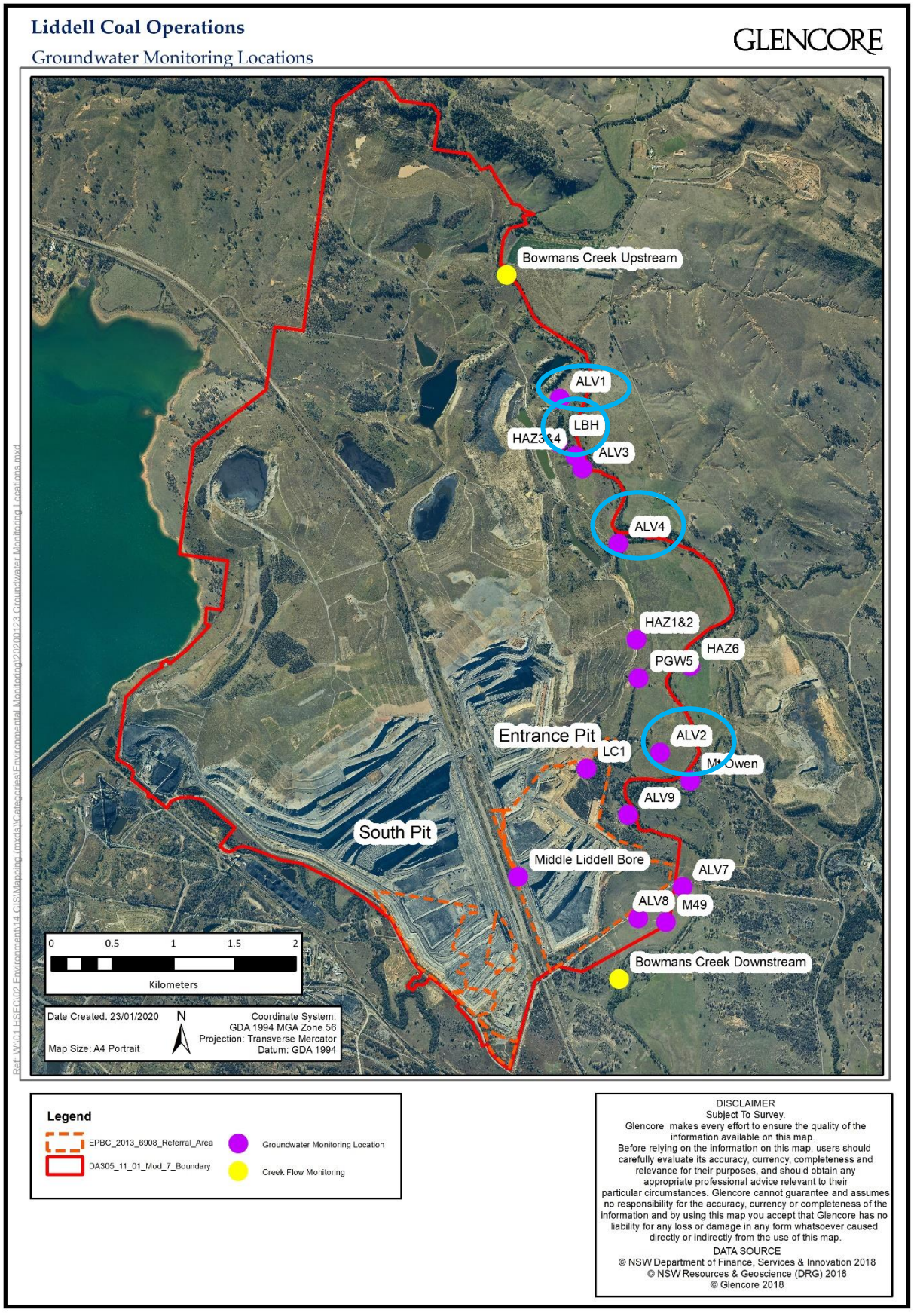

Figure 1 – Groundwater Monitoring Locations

2.2 Previous report findings

Previous EC investigation trigger reports have been completed for each of the triggering bores, ALV1L, ALV2S, ALV4S and LBH in June 2019 after each of the identified piezometer above measured three months of EC level above the 80th%ile trigger limits from March 2019 to May 2019. During this investigation it was determined through a comparison between the rainfall CRD and EC that there was an inverse relationship, where a decrease in rainfall results in an increase in EC measurements. The direct relationship between the monitoring observations and rainfall implies that the measurements were due to climatic variations opposed to a mining related impact.

Previous groundwater depth investigations have been undertaken at each of the triggering bores ALV1L, ALV2S, ALV4S and LBH since late 2018 in accordance with the WMP. Groundwater Definition #2 trigger investigations completed include:

- December 2018 LBH and ALV4S - three consecutive groundwater depth trigger exceedances.
    - Investigation determined that there was a clear link between climatic variations and low groundwater levels throughout the Bowmans Creek system.
    - There was no clear correlation identified between the levels measured at these bores with that of the underground workings, inferring continued lack of connectivity or depressurisation at these bores. ALV4 and LBH are also not within the extent of predicted drawdown impacts from mining operations at LCO.
- October 2019 LBH and ALV4S – additional nine month trigger exceedances.
    - The 12-month groundwater level trigger investigation for ALV4S and LBH determined that previous investigation report conclusions remain relevant with the measured levels being considered to reflect natural variability due to climatic factors and there are not considered to be mining related.
- December 2018 ALV1L - three consecutive groundwater depth trigger exceedance.
    - Investigation (Jacobs, December 2018) determined that the dry climatic conditions and subsequent reduced net recharge are inferred to have caused the decline in groundwater levels.
- March 2019 ALV2S - Definition #2 groundwater level trigger exceedance over the period of August 2018 to February 2019 (Jacobs, March 2019).
    - Investigation similarly determined that the groundwater levels measured at ALV2S reflect natural variability due to climatic factors and there is not a mining related impact.
    - Further, this report noted the observed decline being consisted for both the shallow bedrock and alluvium along the Bowmans Creek system.
- August 2019 ALV1L and ALV2S - additional nine month consecutive trigger exceedances
    - The 12-month groundwater level trigger investigation for ALV1L and ALV2S determined that the previous three-month trigger investigation report conclusions remained relevant with the natural variability was due to climatic factors and there was no mining related impacts.

2.3 Groundwater elevations

Paired piezometers are installed at each of the ALV monitoring locations targeting the alluvial aquifer (ALV 'L' bore) and the underlying shallow bedrock (ALV 'S' bore). To provide an overview of the entire

network, observed groundwater elevations and relevant trigger levels at the northern sites (ALV1, ALV3 and ALV4) are shown below in **Figure 2**. The southern locations (ALV2, ALV7 and ALV8) are shown in **Figure 3**. A residual mass curve, cumulative relative difference (CRD), with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

Regarding groundwater levels along the Bowman's Creek system, previous ITARP investigations have occurred at ALV1L, ALV2S, ALV4S and LBH and have determined that there is clear link between climatic variations and low groundwater levels. It is understood that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops up gradient. Further, a review of long term historical monitoring shows that with progression downstream along Bowman's creek the interaction between the alluvial and shallow bedrock can be characterized, from upstream to downstream as gaining, through near equilibrium pressure to loosing stream under normal flow conditions and average rainfall.

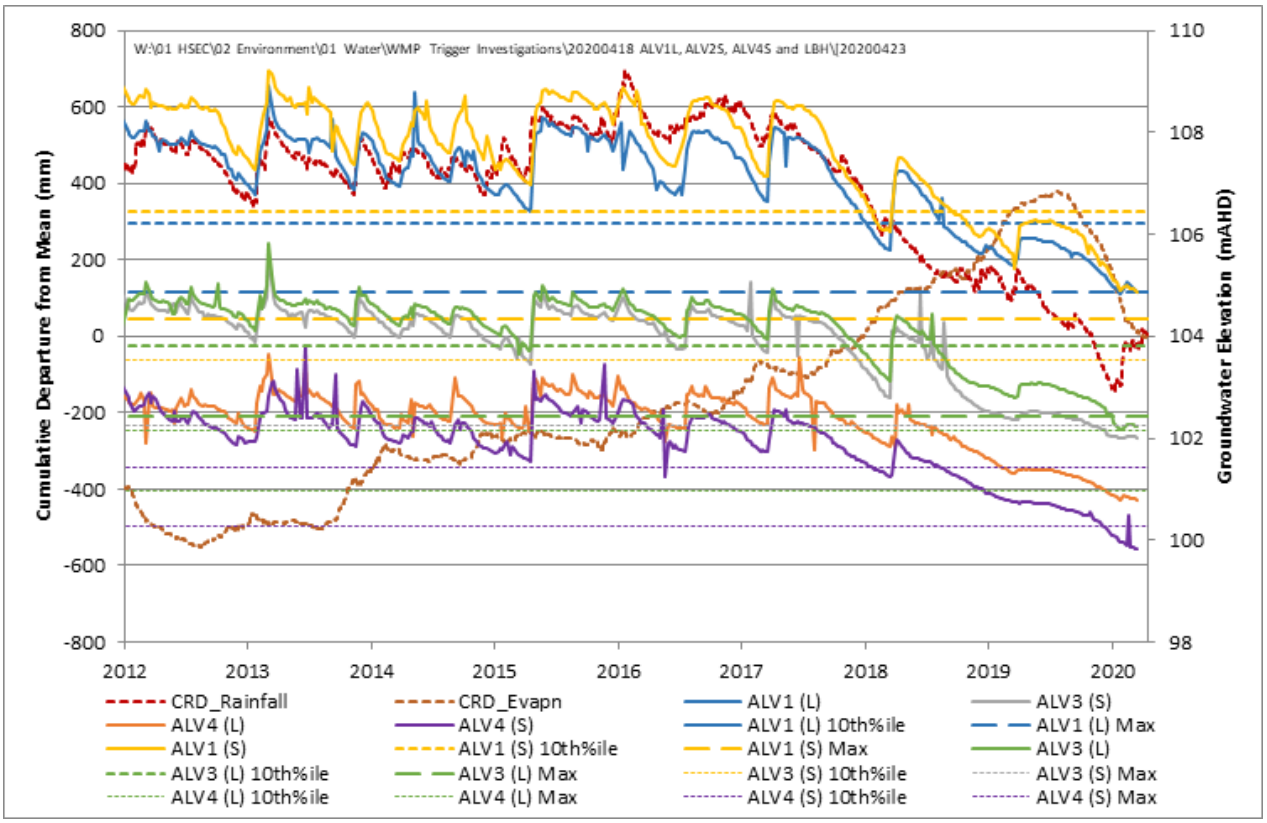

Figure 2 - Groundwater elevation (mAHD) observations at northern locations and climatic CRDs

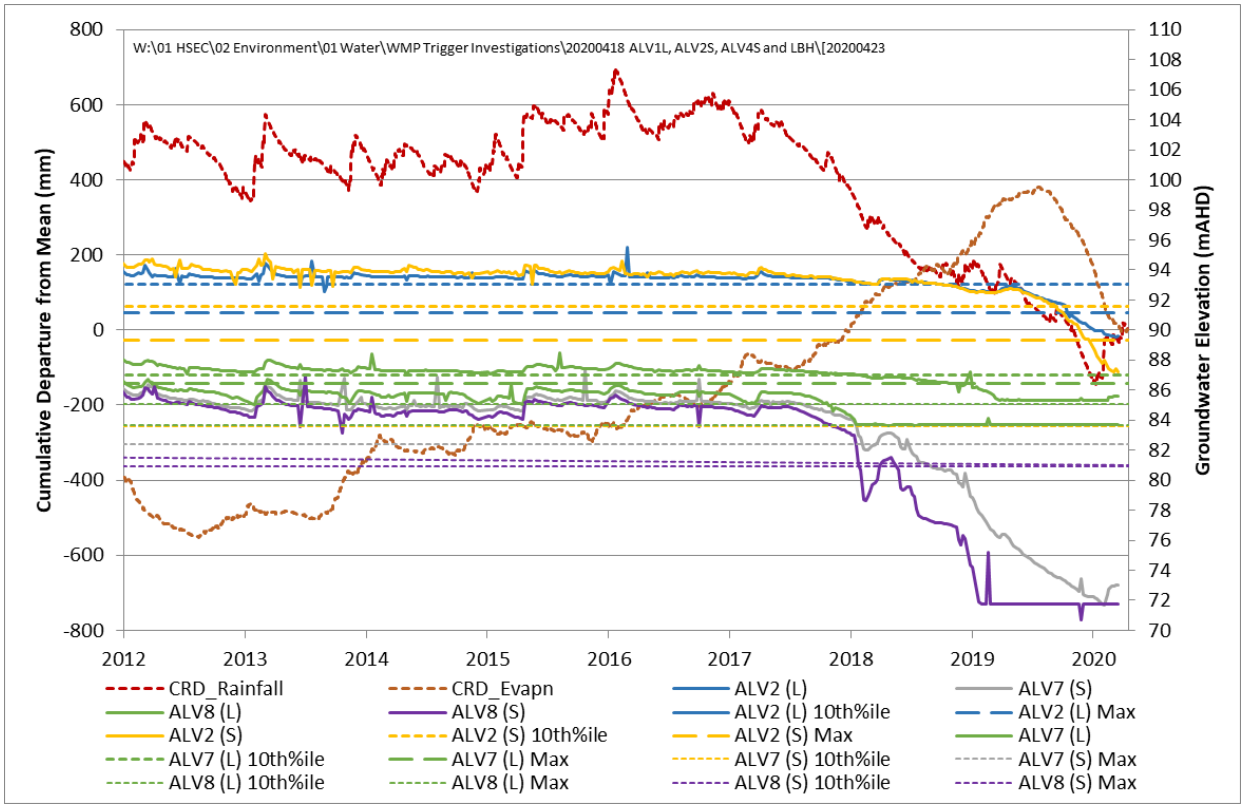

Figure 3 - Groundwater elevation (mAHD) observations at southern locations and climatic CRDs

As per **Figures 2 and 3**, there is a significant drop in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). This implies below average rainfall combined with higher than average evaporation was experienced. Further the evaporation mass curve has seen a prolonged steady increase since 2013 to present indicating that the above average evaporation has been sustained without break. This combination of below average rainfalls and higher than average long-term evaporation characterises the current drought conditions. Recent rainfall in early 2020 has resulted in an increasing rainfall CRD and a decrease in the evaporation CRD. However, despite this rainfall event, conditions remain significantly varied to normal conditions. Additionally as discussed in **Section 2.5** below, stream flow observations have not shown material change in creek flow/conditions despite the recent rainfall highlighting the lack of impact the rainfall has had on recharging the alluvium and shallow bedrock.

Generally, the water level trends at these sites are similar to the CRD trend where residual mass curve rainfall has the longest declining trend since 2005 at the commencement of the reference timeframe. This implies that LCO is measuring groundwater levels in climate conditions at maximums measured in the reference period and therefore observations at or exceeding reference maximums are likely to occur in a system driven by rainfall. This connectivity is further reinforced by the short period of rainfall experienced in early 2020, which resulted in a steadying of the rate of decrease in groundwater elevation in some bores or a minor increase in response in some instances.

Review of the relationship trend between the alluvial and shallow bedrock generally shows that decreases in water levels within the alluvium and shallow bedrock aquifer are similar; this is consistent with previous investigation reports. This supports the understanding that both systems recharge and respond due to the same primary driver, climatic conditions. The consistency of these observations along the whole system indicates that the groundwater response at ALV1L, ALV2S, ALV4S and LBH is driven

by climate and not by mining activity.

Review of groundwater elevation measurements at ALV1L, ALV2S, ALV4S and LBH continue to support the existing understanding of the hydraulic mechanisms along the system that influences the groundwater quality. All triggering bores have shown a significant decline in water levels since the end of 2018. The decrease in water level has been previously investigated as per water level Definition #2 WMP triggers (see Section 2.2) and are monitored regularly.

Periodic dewatering of the underground workings occurs as required for mining operations. A review of the groundwater level observations at the underground workings (measured at Hazeldene, M49, MLB & Mount Owen Bore) have shown a general steady trend with recent extraction from M49 to actively dewater and manage inrush risk whilst mining the northern entrance pit areas. There have been no recent extractions from Hazeldene or Mount Owen Bore. There appears to be no clear correlation between the levels measured at ALV2S with that of the underground workings inferring continued lack of connectivity.

2.4 Groundwater quality

Groundwater quality observations along the system are reviewed herein with comparison to other sites in the same system. Observed groundwater EC measurement and relevant trigger levels at ALV1L, ALV2S, ALV4S and LBH are shown below in **Figure 4.** Noteworthy, no triggering bore has exceeded its reference maximum.

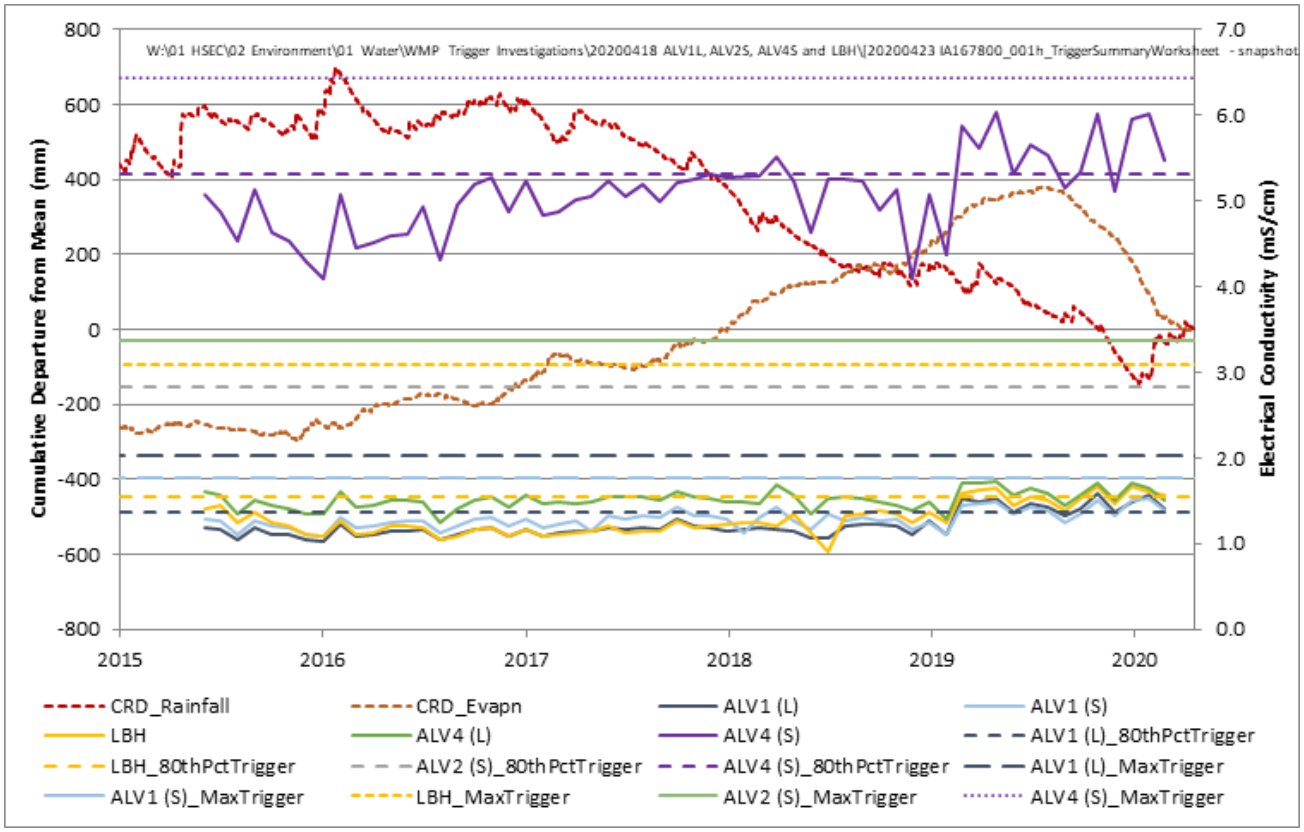

Figure 4 – Electrical conductivity (mS/cm) levels in alluvial and shallow bedrock bores at triggering locations and climatic CRDs

As per **Figure 4,** the consistency of the increasing EC trend throughout the Bowmans Creek monitoring system aligns directly with the rainfall CRD and infers that the dominant influencing factor for the observed EC levels is rainfall recharge.

With the downwards hydraulic gradient at ALV4 and ALV2 shown in **Figure 2**, it is expected that the increasing EC levels in ALV4S & ALV2S are due to the reduced recharge from the overlying alluvium freshwater; hence the EC monitored is expected to represent natural saline bedrock levels.

With the alluvial investigation bores ALV1L and LBH, EC trends consistent with the other monitored alluvial sites. EC levels monitored are only marginally above the reference 80th%ile levels during the current drought conditions and have become relatively stable. It is understood that the EC levels have increased as a result of decreased rainfall

2.5 Statistical analysis

As requested from DPIE – Water (letter ref OUT20/3921) LCO has engaged specialist support to incorporate statistical analysis for further ITARP investigation reports.

Statistical analysis was undertaken by Jacobs (May, 2020) on the monitoring data for four monitoring bores that have exceeded their respective EC triggers over the past 12 months. The intent of the analysis was to quantitatively establish relationship between groundwater measurements and climatic factors during differing climatic periods.

The monitoring bore water quality data set for the period from 2003 to the end of 2019 was reduced and subdivided into five time periods characterised by climatic conditions. **Table 2** below identifies the climate periods as defined by rainfall characteristics; **Figure 5** shows the rainfall and evaporation cumulative departures and climate periods for reference.

Table 1 – Summary of assessed climate periods

Period	From	To	Climate
0	31/07/2003	31/12/2019	Whole data set
1	31/07/2003	3/12/2005	Mid-Millennium Drought with steady to declining rainfall
2	3/12/2005	6/06/2007	Steeply declining rainfall (Millennium Drought)
3	6/06/2007	3/03/2012	Increasing rainfall
4	3/03/2012	21/08/2017	Steady average rainfall
5	21/08/2017	31/12/2019	Drought

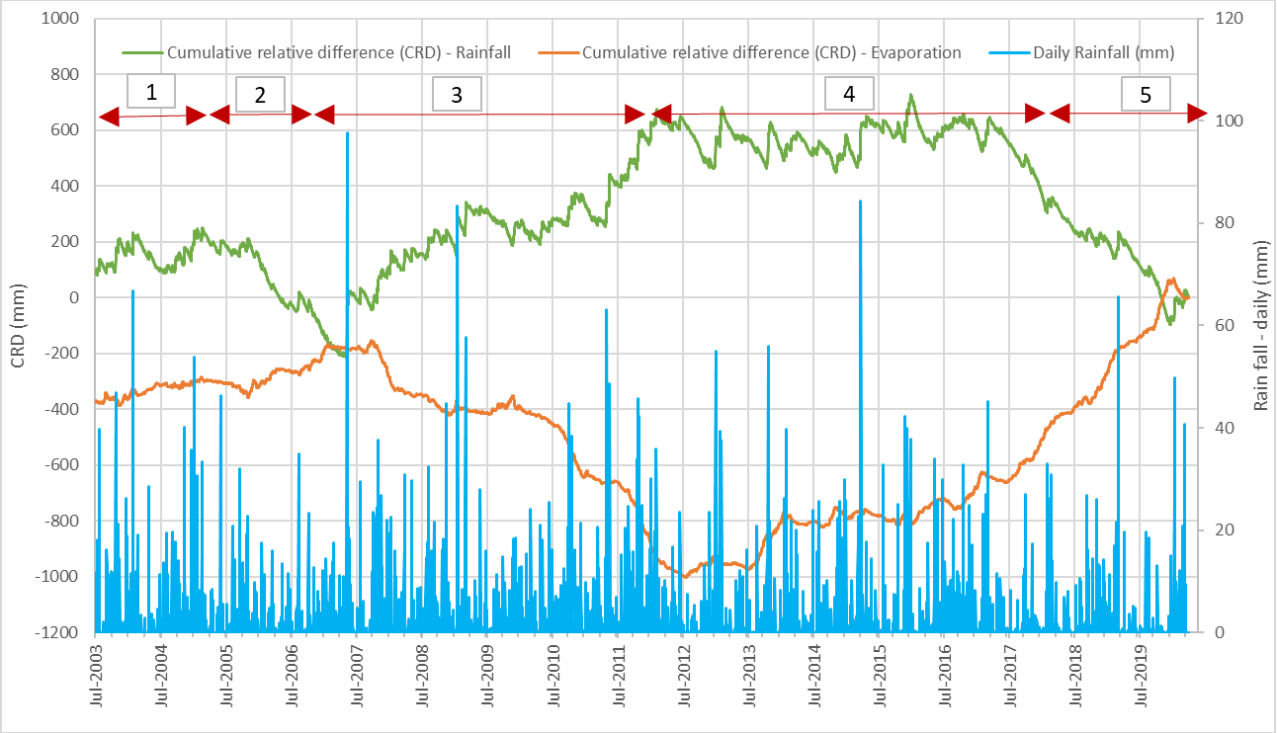

Figure 5 – Climate periods - Cumulative departure rainfall and evaporation

The water level (WL), EC and cumulative rainfall departure (CRD) data was normalised (to 100%) for each of the periods and JASP[1] was used to undertake a correlation coefficient analysis between the three parameters. Spearmans' Coefficient (rho) analysis method was chosen over Pearson's Coefficient as the data was not linear but monotonic. The rho values are also supplemented with a p-value, which indicates the statistical significance of the correlation. Low p-values show the greatest statistical significance, with values below 0.1 confirming that the correlation value is valid 99% of the time.

The results of the statistical analysis (rho and p-values) are summarised in the figures below. The interpretation of the correlation coefficients is based on the divisions as suggested by The Political Science Department at Quinnipiac University. Spearman's rho values of 0, 0.5 and 1 indicates none, strong and perfect correlation. The statistical analysis results are shown graphically in **Figure 6** to **Figure 8** below.

1 JASP is a free and open-source graphical program for statistical analysis supported by the University of Amsterdam. Initially developed in 2018 by the university's Department of Psychological Methods, the current version was published on 16 April 2020.

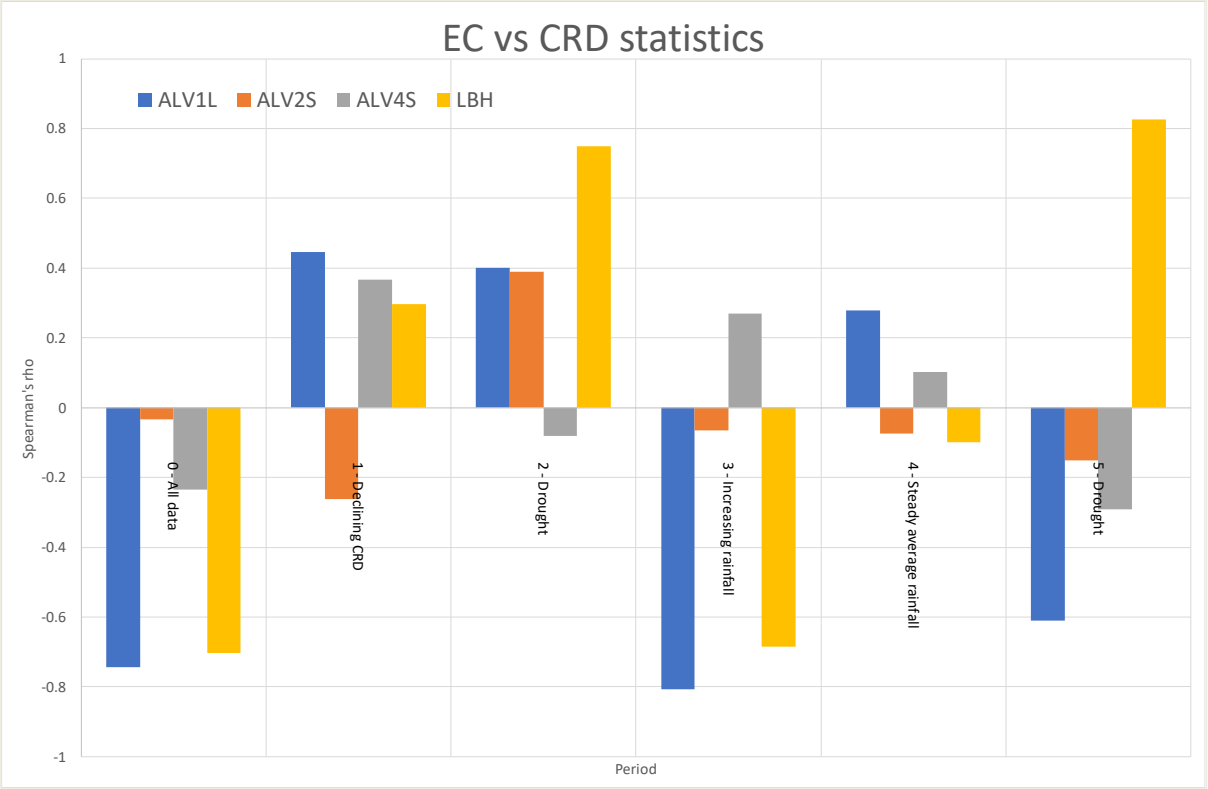

Figure 6 – of EC vs CRD correlation coefficients for the five climate periods

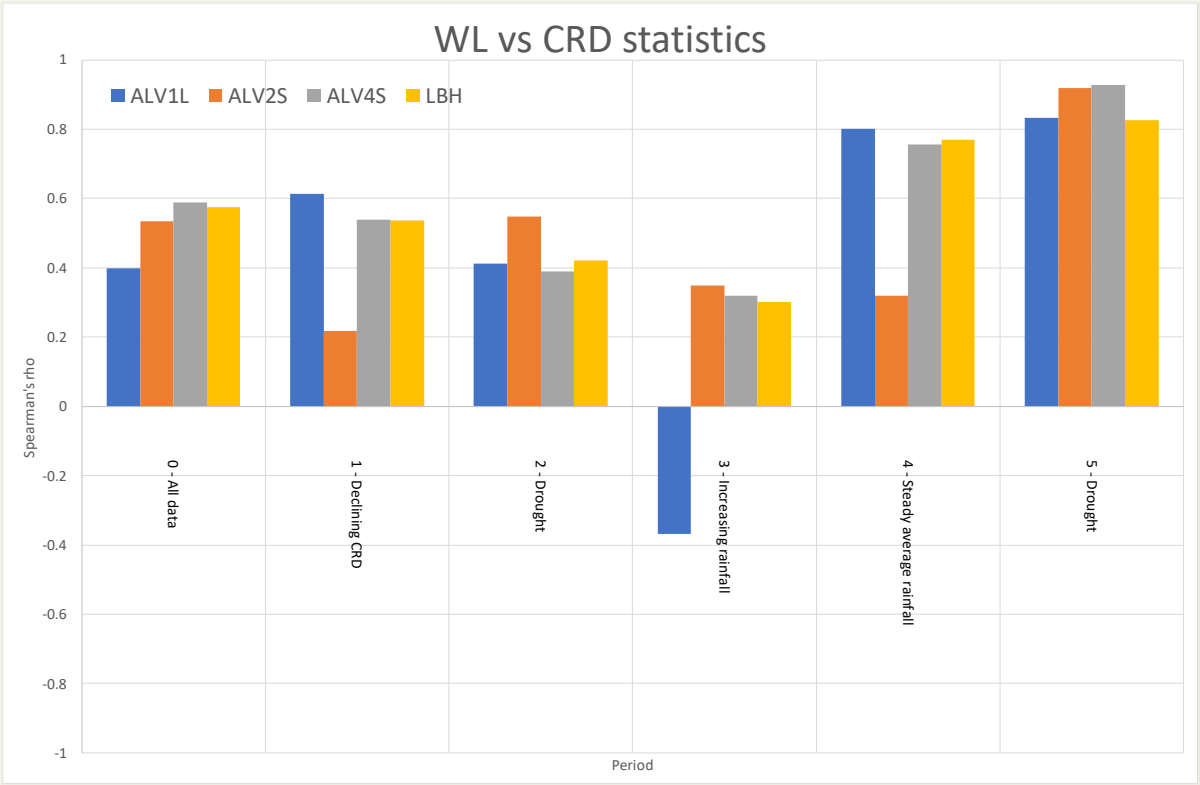

Figure 7 –water level vs CRD correlation coefficients for the five climate periods

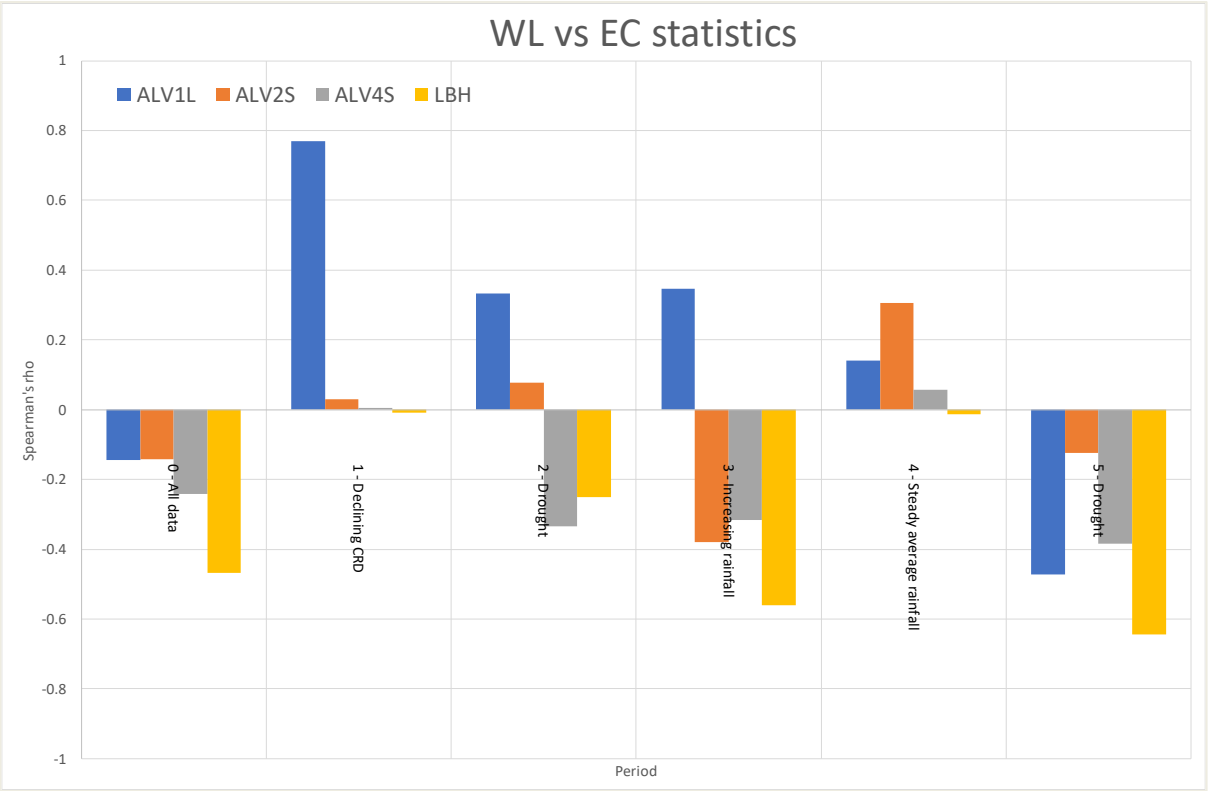

Figure 8 – EC vs water level correlation coefficients for the five climate periods

The following observations can be made based on the results:

- All bores (refer **Figure 6**) show a consistent correlation between CRD and EC and between CRD and WL in Period 0 (over the whole dataset), with negative and positive trends, respectively. The exception to this is ALV2S, which shows a consistent correlation albeit with a lower correlatability. Overall, this indicates that EC tends to increase with declining CRD and WL increases with increasing CRD on the whole.

- There is a strong to very strong correlation between CRD and WL (refer **Figure 7**) across all of the assessed climate periods, with the exception of ALV1L in Period 3. Period 3 is a climate period characterised by increasing CRD and ALV1L is located in the upper part of the Bowmans Creek catchment, which is likely to receive less consistent recharge from rainfall. The increasing CRD trend following a drought, coupled with the bore's location is the likely reason for the negative trend.

Further relating to **Figure 7**, the two most comparable periods to current conditions are Periods 2 and 5, which are both periods of severe drought. This most recent drought period was characterised by a longer and larger departure from the average rainfall. This can be seen by the 700 mm of CRD decline between 2017 and 2019, compared to the 400mm decline during the severe drought period between 2005 and 2007. During these periods of drought (Periods 2 and 5), there is a strong correlation between CRD and WL.

- EC data shown on **Figure 6** from the investigated alluvial ALV1L and LBH have a moderate to very strong correlation to CRD across all time periods, whereas in the investigated shallow bedrock bores, ALV2S and ALV4S, there is a predominantly negligible to no correlation. It is

likely that the local groundwater recharge process and hydrogeological environmental at each monitoring site strongly influences the correlatability.

- **Figure 8** summarises the EC to WL correlation results, which have predominantly moderate to no correlatability. This is due to the complexity and variability of the groundwater recharge/discharge processes that influence groundwater EC.

In summary, the results show that groundwater levels are strongly influenced by rainfall and that the current understanding of how the system varies with the climate is valid. The groundwater system recharge/discharge mechanisms and hydraulic gradients drive the EC variability, primarily, and is more a more complex mechanism. Hence, the correlation of EC to CRD is variable between sites and between climate periods.

These results also show that the method of assessment is suitable for identifying potential deviations of water level trends when compared to CRD. This may be useful for differentiating climate related impacts when compared to mining impacts. That said, the use of this method for comparing EC to CRD is limited.

2.6 Streamflow monitoring

LCO record visual flow observations at each surface water monitoring location along Bowman's Creek as a component of its monitoring program (see **Table 3** below). These observations both upstream and downstream corroborate the expected and understood creek flow behavior; decreasing to no flow as the drought continues. The streamflow observations support the groundwater level and EC monitoring observations confirming the conclusion that whilst there has been a recent increase in rainfall generally there has been a reduction in rainfall recharge to shallow bedrock occurring, where it outcrops up gradient, and the alluvium and the observed results are a result of natural climatic variability.

Table 3: Bowmans Creek Streamflow Observations

Date	BCK1 (Upstream)	BCK6 (Downstream)
Feb-19	Trickle	Dry
Mar-19	Still	Dry
Apr-19	Slow	Dry
May-19	Still	Dry
Jun-19	Still	Dry
Jul-19	Still	Dry
Aug-19	Trickle	Dry
Sep-19	Still	Dry
Oct-19	Still	Dry
Nov-19	Still	Dry
Dec-19	Still	Dry
Jan-20	Still	Dry
Feb-20	Still	Dry
Mar-20	Still	Dry

3. Conclusion

Groundwater level trends in the triggering bores; and generally, in the Bowmans Creek monitoring bore network more widely show a correlation to the rainfall and evaporation CRD trends. The decline

of water levels and increased EC measurement at ALV1L, ALV2S, ALV4S and LBH sustains the conclusion of the previous three month trigger exceedance investigation at ALV1L and ALV2S and previous investigations conducted for LBH and ALV4S that there is a clear link between the reduced rainfall CRD, increased evaporation CRD and the measured 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. 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.

LCO propose to continue monitoring in accordance with the WMP. Consequently, EC measurements continues to be measured above the trigger level for a further three months a subsequent investigation shall be undertaken to confirm the exceedance remains unrelated to mining activity.

Appendix F - May 2020 – ALV7S Electrical Conductivity ITARP

LIDDELL

GLENCORE

Groundwater Investigation Trigger Report
July 2020

1. Introduction

1.1 Overview

In accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908, LCO has undertaken an investigation as a result of groundwater triggers at monitoring piezometer ALV7S. Specifically, Groundwater Quality Definition #1 triggers have occurred and these are defined as 15 consecutive months of Electrical Conductivity (EC) observations above the 80th%ile trigger limits, from March 2019 to May 2020.

As per the WMP, LCO notified the Department of Agriculture, Water and the Environment (DAWE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division of the exceedance on the 17 June 2020. This notification stated, "It is considered that the observations are not of potential harm to the environment based on our current knowledge." Further, LCO has previously investigated trigger exceedances at this bore in June, September and December 2019 and March 2020 due to the same Groundwater Quality Definition #1 trigger activation. Recent investigations in 2019 and 2020 concluded that the declining groundwater levels and EC observations are likely reflecting variability due to current climate factors, a trend which is seen across the monitoring network. As a result of decreased water levels in the shallow bedrock and the dry alluvium, the monitoring results are reflective of the natural EC levels in the shallow bedrock without the diluting effect from the less saline alluvium above. All investigations concluded there was no mining related impact nor likely potential of environmental harm.

This report includes statistical analysis of monitoring data, an analytical tool recommended by DPIE – Water (letter ref OUT20/3921) following their review of a trigger investigation report submitted in January 2020.

1.2 Scope

The scope for this groundwater ITARP investigation consists of:

- An investigation into consecutive groundwater quality, specifically EC, exceedances at groundwater monitoring site ALV7S.
- An assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

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Liddell Coal Operations Pty Ltd ABN 40 058 857 882
Manager and Agent of the Liddell & Foybrook Joint Ventures

2. Groundwater Investigation

The monitoring results that triggered this investigation and relevant trigger levels for the shallow bedrock bore ALV7S, which are presented in **Table 1** below. Additionally, the data is presented with the paired bore ALV7L which is screen in the alluvium.

Table 1: Site-specific trigger values for groundwater EC and monthly observations

Well ID	ALV7S	ALV7L
Monitored Unit	Shallow Bedrock	Alluvial
Electrical Conductivity Trigger Values		
80th percentile trigger limit	2.23	1.78
Reference Maximum	2.54	2.31
Monthly Observations		
Feb-19	2.11	1.51
Mar-19	2.78	Dry
Apr-19	3.02	Dry
May-19	2.83	Dry
Jun-19	2.60	Dry
Jul-19	3.04	Dry
Aug-19	2.99	Dry
Sep-19	2.73	Dry
Oct-19	3.07	Dry
Nov-19	3.51	Dry
Dec-19	3.14	Dry
Jan-20	3.50	Dry
Feb-20	3.53	Dry
Mar-20	3.25	Dry
Apr-20	2.83	1.55
May-20	3.58	1.72

Specific aspects of the investigation detailed within this report include current mining activities, groundwater level observations, EC observations, statistical analysis and streamflow observations.

The groundwater monitoring network at LCO targeting the Bowmans Creek alluvium and the shallow coal measures overburden is shown on **Figure 1**.

2.1 Current mining activities

During the last 12 months, mining activity has progressed generally in accordance with the approved Mining Operations Plan (MOP). Mining in South Pit has reached the southern limits and continuing down with ongoing development of the overburden emplacement to the north of the active mining area. Mining in the northern section of the Entrance Pit has completed and now an overburden emplacement. Mining activities have continued in the southern portion of the Entrance Pit. Strip progression is moving towards the north with final clearing for mining progressing completed in February 2020. Noteworthy, no significant changes to the extent of mining operations have occurred since 2017 and extraction is within the approved limits. There has been no failures or changes to the mine water management system near the triggering bore.

LCO has historically been the site of extensive underground board and pillar, longwall and open cut mining. The ALV7 area overlies the mined Upper Liddell seam of the former M49 underground. Jacobs

(July 2020) note that previous investigations have been based on open cut mining approaching the proposed maximum limit footprint and total dewatering of the underground. It is considered likely that the coal measures above the Entrance Pit floor elevation (outside of the active mine footprint) will have depressurised to a level equivalent to the outcrop in the Entrance Pit, with subsequent vertical draining of the overlying formations. Therefore, it is likely that groundwater gradients in the fractured rock aquifer units will be toward the open cut area.

Figure 1 identifies the groundwater monitoring network spatially with respect to mining operations.

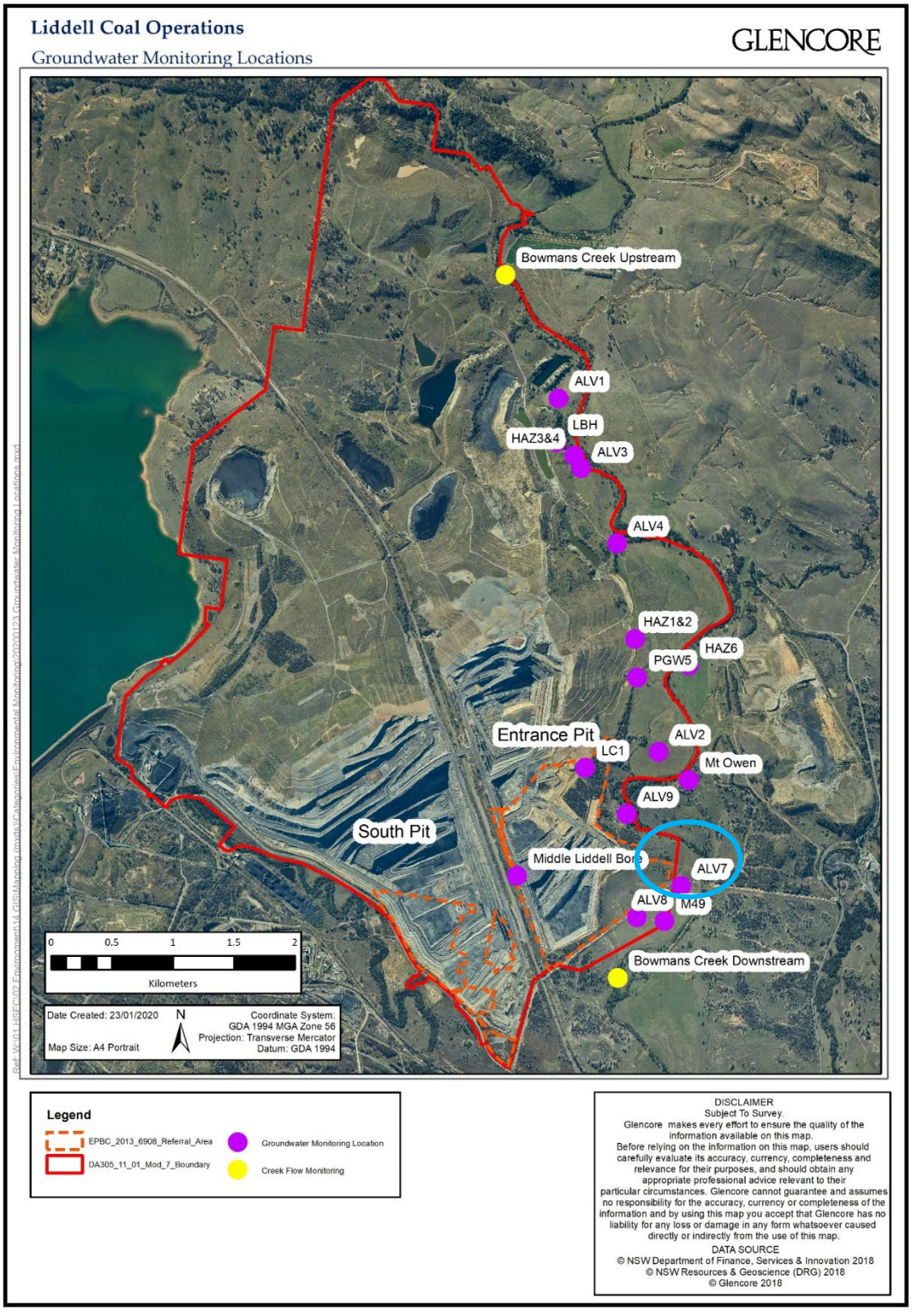

Figure 1 – Groundwater Monitoring Locations

2.2 Previous report findings

Previous EC investigation trigger reports for ALV7S determined that the EC levels were increasing due to climatic factors rather than direct impact from mining operations. Comparison between the rainfall CRD and EC shows an inverse relationship, where a decrease in rainfall results in an increase in EC measurements. This response is expected, as a reduction in groundwater recharge from the alluvium due to prolonged drought conditions, has led to more recharge from the more saline coal measures.

Jacobs (March 2020) report on ALV7S groundwater level trigger investigation noted that the most notable decline in levels at this site occurred mid-2017, coinciding with the decline in rainfall and increase in evaporation rates. This decline also coincides with the increased depth in mining in the south-west extend of the LCO Entrance Pit which was considered likely to have depressurised the coal measures and resulted in vertical drainage of the overlying fractured rock units. Depressurisation of the fractured rock aquifer has been approved under DA305-11-01 Environmental Assessment.

2.3 Groundwater elevations

Paired piezometers are installed at each of the ALV monitoring locations targeting the alluvial aquifer (ALV 'L' bore) and the underlying shallow bedrock (ALV 'S' bore). To provide an overview of the entire network, observed groundwater elevations and relevant trigger levels at the northern sites (ALV1, ALV3 and ALV4) are shown below in **Figure 2**. The southern locations (ALV2, ALV7 and ALV8) are shown in **Figure 3**. A residual mass curve, cumulative relative difference (CRD), with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017. Generally, all monitoring bores show a significant decline in groundwater levels during the recent drought, with the down-hydraulic gradient monitoring bores (ALV7L, ALV7S, ALV8L and ALV8S) showing the most change. Groundwater levels shown below (**Figure 2** and **Figure 3**) demonstrate some recovery to pre 2017-2019 drought following recent rainfall across the monitored network. ALV7L and ALV7S have shown less recovery as the alluvium ran dry during the drought at ALV7 and ALV8, this is likely to have contributed to the decline in water levels and slower recovery in ALV7S.

Regarding groundwater levels along the Bowman's Creek system, previous ITARP investigations have occurred at ALV7S and have determined that there is clear link between climatic variations and low groundwater levels. It is understood that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops up gradient. Further, a review of long term historical monitoring shows that with progression downstream along Bowman's creek the interaction between the alluvial and shallow bedrock can be characterized, from upstream to downstream as gaining, through near equilibrium pressure to loosing stream under normal flow conditions.

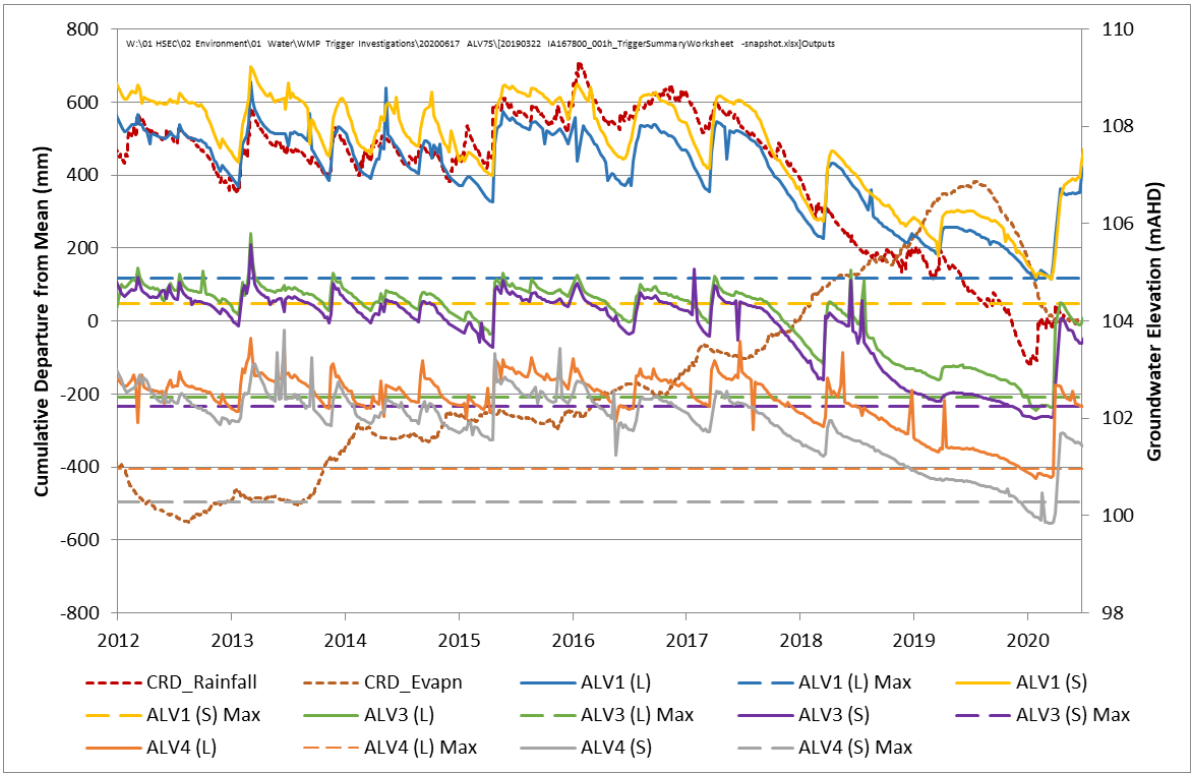

Figure 2 - Groundwater elevation (mAHD) observations at northern locations and climatic CRDs

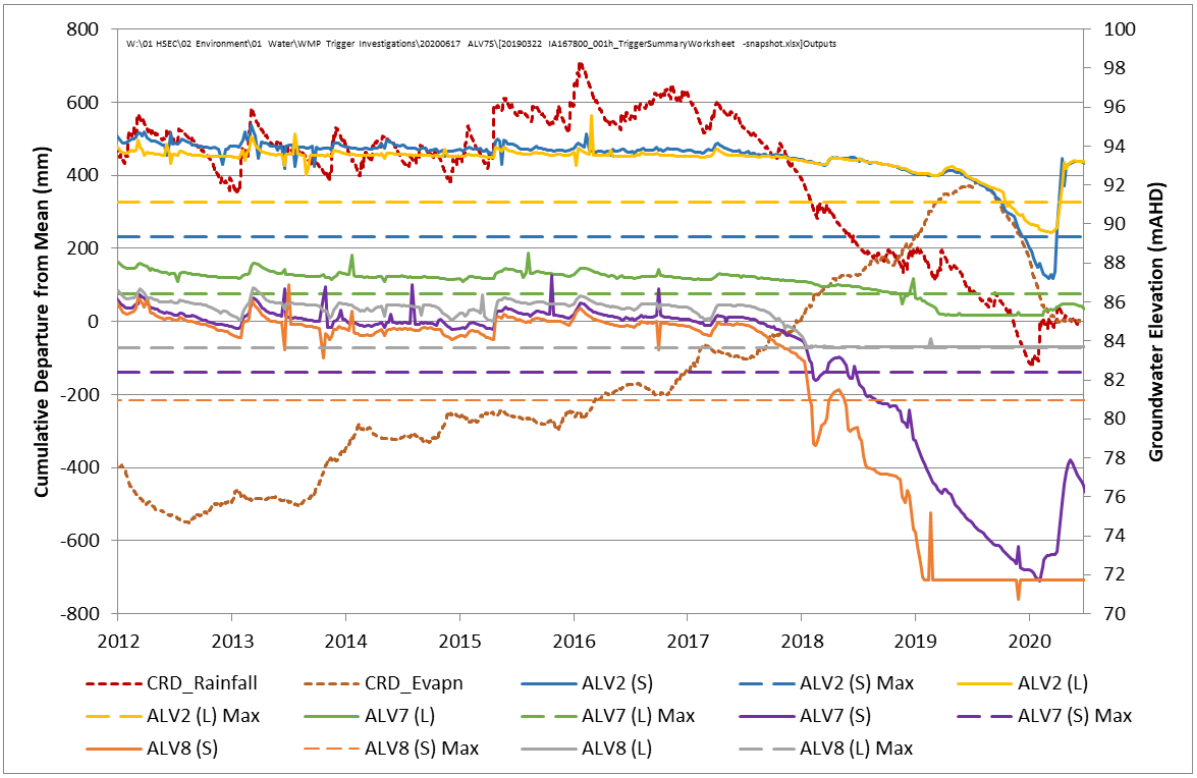

Figure 3 - Groundwater elevation (mAHD) observations at southern locations and climatic CRDs

As per **Figures 2** and **3**, there is a significant drop in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). This implies below average rainfall combined with higher than average evaporation was experienced. Further the evaporation mass curve has seen prolonged steady increase since 2016 to present indicating that the above average evaporation has been sustained without break. This combination of below average

rainfalls and higher than average long-term evaporation characterises the current drought conditions. Recent rainfall in early/mid 2020 has resulted in an increasing rainfall CRD and a decrease in the evaporation CRD towards an equilibrium. Whilst these rainfall events have seen a recent increase in the depth to water in some bores, conditions remain significantly varied to normal conditions and have not been substantial enough to offset years of prolonged drought conditions. Additionally as discussed in Section 2.6 below, stream flow observations have not shown material change in creek flow/conditions despite the recent rainfall.

Generally, the water level trends at these sites are similar to the CRD trend where residual mass curve rainfall has the longest declining trend since 2005 at the commencement of the reference timeframe. This implies that LCO is measuring groundwater levels within climate conditions that are at the maximum range measured in the reference period and therefore observations within reference maximums are likely to occur in a system driven by rainfall. This connectivity is further reinforced by the short period of rainfall experienced in early/mid 2020, which resulted in a steadying of the rate of decrease in groundwater elevation in some bores or an increase in response in some instances.

Review of groundwater elevation measurements at ALV7S continue to support the existing understanding of the hydraulic mechanisms along the system that influences the groundwater quality. Specifically, ALV7S has shown a significant decline of water levels since the beginning of 2019 and have decreased more than 5 m since February 2019. The decrease in water level in this area has been previously investigated (see Section 2.2) and are monitored regularly. Recent rainfall in 2020 has resulted in ALV7S demonstrating an increase in groundwater elevation in response demonstrating that levels in the system are influenced by climatic conditions. Additionally recharge to the alluvium at ALV7 has been recorded demonstrating the response of rainfall on the measured results.

Review of the relationship trend between the alluvial and shallow bedrock generally shows that the timing of decreases in water levels within the alluvium and shallow bedrock aquifer are similar, this is consistent with previous investigation reports. This supports the understanding that both systems recharge and respond due to the same primary driver, climatic conditions. The consistency of these observations along the whole system indicates that the groundwater response at ALV7S is predominantly driven by climate and not by mining activity.

Periodic dewatering of the underground workings occurs as required for mining operations. A review of the groundwater level observations at the underground workings (measured at Hazeldene, M49, MLB & Mount Owen) have shown a general steady trend with limited extraction from M49 to actively dewater and manage inrush risk whilst mining the central Entrance pit areas. There appears to be no clear correlation between the levels measured at ALV7S with that of the underground workings inferring continued lack of connectivity.

2.4 Groundwater quality

Groundwater quality observations along the system are reviewed herein with comparison to other sites in the same system. Observed groundwater EC measurement and relevant trigger levels at the southern sites nearest ALV7S are shown below in **Figure 4**.

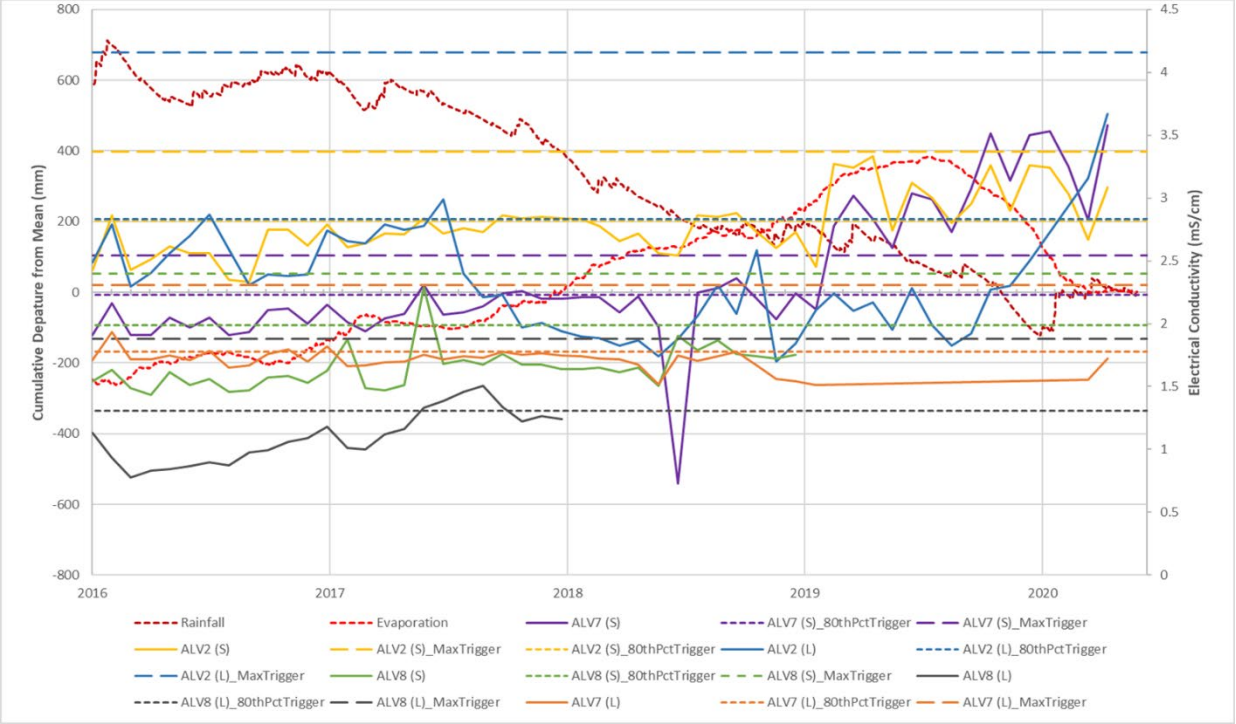

Figure 4 – Electrical conductivity (mS/cm) levels at alluvial bores nearest ALV7S and climatic CRDs

Jacobs (July 2020) note that EC values within the Bowmans Creek area are dependent on local hydrological conditions with the EC measurements being generally in the same relative order when compared between their fractured rock and alluvium bore pairs. Additionally, the EC values of the bore pairs, do not reflect the gradient of the creek alignment as ALV7S EC measurements are mid-range when compared to other fractured rock monitoring bores, despite being located in the down-gradient area of the monitoring network.

EC levels at ALV7S (**Figure 4)** shows that the levels trend upwards since March 2019 and the other shallow bedrock bores show very similar changes. Measured EC results show an inverse relationship to the rainfall CRD at ALV7S, with EC measurements showing a corresponding increase, rising above the reference maximum in March 2019. The latest measurement in May 2020 at ALV7S recorded a concentration of 3.58 mS/cm, which is 1.04 mS/cm above the reference maximum with most of the other monitoring bores demonstrating similar rising EC trends.

When comparing measured EC values at ALV7S between the 2017-2019 drought to historical droughts (such as the Millennium Drought) the measured levels are generally higher. This is expected to be caused by a combination of more severe drought conditions (lower rainfall and higher evaporation) in the 2017-2019 drought and external factors such as geological unit subcrops, discharge rates and concentrations from hydrogeological units and hydraulic gradient changes caused by depressurization (Jacobs, July 2020).

The increase in EC levels measured at ALV7S is likely to be attributed to the reduced recharge contribution from the less saline alluvial groundwater due to the drying of the alluvium in this location ALV7L. ALV7L became dry in March 2019, which correlates with the EC trigger at ALV7S in March 2019, suggesting the reduction in recharge from the alluvium has resulted in more saline water from the shallow bedrock without the diluting effects of the fresher water above.

Recent monitoring at ALV7S has shown an increase in measured EC levels. This is consistent with the other monitoring bores in this network and is likely a result of a flushing effect following rainfalls in

February-March 2020. This flushing event is also likely to have caused mobilization of groundwater from up-gradient where the EC is higher, influencing the measured levels.

The consistency of the increasing EC trend throughout the Bowmans Creek monitoring system aligning directly with the rainfall CRD infers that the dominant influencing factor for the observed EC levels is rainfall recharge. Furthermore, the recent increase in groundwater level and resultant EC levels demonstrates the outcome of rainfall to the system and subsequent recharge.

2.5 Statistical analysis

As requested from DPIE – Water (letter ref OUT20/3921) LCO has engaged specialist support to incorporate statistical analysis for further ITARP investigation reports. Statistical analysis was undertaken by Jacobs (July, 2020) on the monitoring data for ALV7S which has exceeded its EC triggers over the past 15 months. The intent of the analysis was to quantitatively establish relationship between groundwater measurements and climatic factors during differing climatic periods. The monitoring bore water quality data set for the period from 2003 to the end of 2019 was reduced and subdivided into seven time periods characterised by climatic conditions. Table 2 below identifies the climate periods as defined by rainfall characteristics; Figure 5 shows the rainfall and evaporation.

Table 2 – Summary of assessed climate periods

Period	From	To	Climate
0	31/07/2003	31/12/2019	Whole data set
1	31/07/2003	3/12/2005	Mid-Millennium Drought with steady to declining rainfall
2	3/12/2005	8/06/2007	Steeply declining rainfall (Millennium Drought)
3	8/06/2007	24/11/2011	Increasing rainfall
4	24/11/2011	20/04/2015	Steady average rainfall
5	20/04/2015	21/01/2017	Average rainfall, high evaporation rates
6	21/01/2017	16/01/2020	Steeply declining rainfall (2017-2019 drought), high evaporation rates
7	16/01/2020	16/06/2020	Steady average rainfall

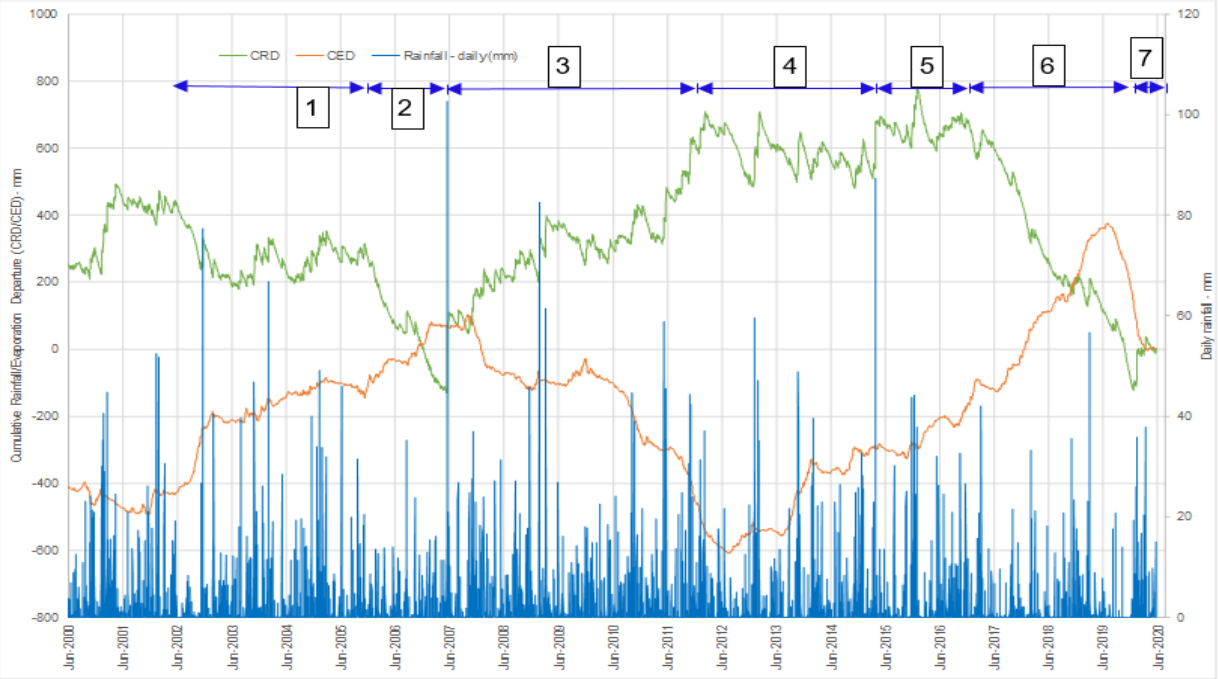

Figure 5 – climate periods – cumulative departure rainfall and evaporation

The water level (WL), EC and cumulative rainfall departure (CRD) data was normalised (to 100%) for each of the periods and JASP[1] was used to undertake a correlation coefficient analysis between the three parameters. Spearmans' Coefficient (rho) analysis method was chosen over Pearson's Coefficient as the data was not linear but monotonic. The rho values are also supplemented with a p-value, which indicates the statistical significance of the correlation. Low p-values show the greatest statistical significance, with values below 0.1 confirming that the correlation value is valid 99% of the time.

The results of the statistical analysis (rho and p-values) are summarised in the figures below. The interpretation of the correlation coefficients is based on the divisions as suggested by The Political Science Department at Quinnipiac University. Spearman's rho values of 0, 0.5 and 1 indicates none, strong and perfect correlation. The statistical analysis results are shown graphically in **Figure 6** below.

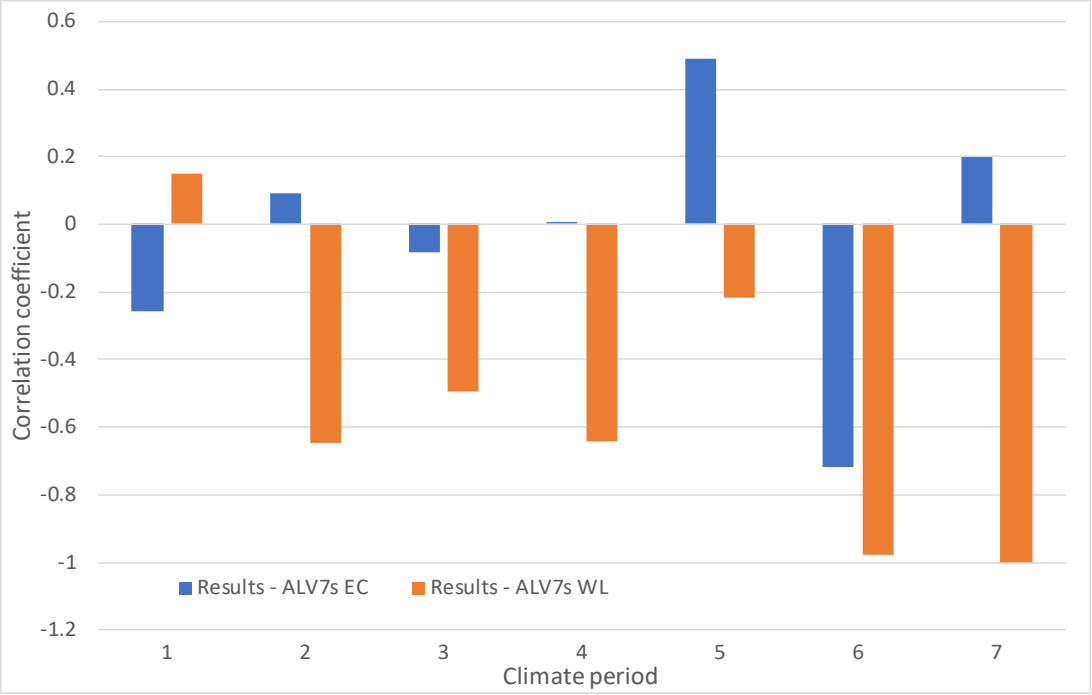

Figure 6 – ALV7S electrical conductivity and water level vs. CRD correlation coefficients

The following observations were drawn from the statistical analysis:

ALV7S shows a weak to moderate correlation between CRD and EC and between CRD and WL over the whole dataset. Both correlations show negative trends, indicating that generally EC and depth to water tend to increase with declining CRD.

- There is a weak to very strong correlation between CRD and WL across all of the separately assessed climate periods, with the exception of Period 1. This indicates that the ALV7S target aquifer is predominately recharged by rainfall and most likely via the alluvium.
    - Correlation for Period 1 is positive however rho is low and the p-value indicated that the correlation has low reliability.
- The EC data from ALV7S generally correlates poorly to CRD with the exception of Period 6 (2017-2019 Drought). The Millennium Drought is the most comparable climatic period to the 2017-2019 drought when it comes to lack of rainfall; however the conditions preceding the 2017-

[1] JASP is a free and open-source graphical program for statistical analysis supported by the University of Amsterdam. Initially developed in 2018 by the university's Department of Psychological Methods, the current version was published on 16 April 2020.

2019 drought was six years above average evaporation and significantly more cumulative deviation than period 2. The correlation for Period 2 is negligible, whereas Period 6 has a very strong correlation. This indicates that the aquifer experienced different conditions during the 2017-2019 Drought and the Millennium Drought.

- The discrepancy between the WL vs CRD and the EC vs CRD correlation coefficient shows that the mechanism driving the EC changes cannot be easily characterized using this statistical analysis method.

2.6 Streamflow monitoring

LCO operate two streamflow gauging stations on Bowman's creek and also record visual flow observations at each surface water monitoring location along Bowman's Creek as a component of its monitoring program (see **Table 3** below). These observations both upstream and downstream corroborate the expected and understood creek flow behavior; decreasing to no flow as the drought continues. The streamflow observations support the groundwater level and EC monitoring observations confirming the conclusion that whilst there has been a recent increase in rainfall generally there has been a reduction in rainfall recharge to shallow bedrock occurring, where it outcrops up gradient, and the alluvium and the observed results are a primarily reflect natural climatic variation.

Table 3: Bowmans Creek Streamflow Observations

Date	BCK1 (Upstream)	BCK6 (Downstream)
Feb-19	Trickle	Dry
Mar-19	Still	Dry
Apr-19	Slow	Dry
May-19	Still	Dry
Jun-19	Still	Dry
Jul-19	Still	Dry
Aug-19	Trickle	Dry
Sep-19	Still	Dry
Oct-19	Still	Dry
Nov-19	Still	Dry
Dec-19	Still	Dry
Jan-20	Still	Dry
Feb-20	Still	Dry
Mar-20	Still	Dry
Apr-20	Still	Still
May-20	Slow	Dry

3. Conclusion

The continued decline of the water level and increased EC measured at ALV7S sustains the conclusion of previous three-month, six-month, nine-month and 12-month trigger exceedance investigation reports of natural climate variability being sustained drought conditions are influencing the heightened EC results at this monitoring site.

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 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.

Further, whilst the maximum reference EC trigger has been exceeded for ALV7S, the potential for environmental harm due to mining activities is low. The demonstrated direct relationship between the alluvium and rainfall, and the low vertical connectivity between the alluvium and underlying fractured rock, reduces the risk of harm to the alluvium (Jacobs, July 2020). The approved depressurisation of the fractured rock aquifers (such as ALV7S) has changed the hydraulic gradient towards the open cut, which further reduces the risk of harm to the environment associated with the ALV7S EC values.

LCO propose to continue monitoring in accordance with the WMP. Consequently, if ALV7S EC continues to be measured above the trigger level for a further three months (total of 18 months measuring above trigger levels), a subsequent investigation shall be undertaken to confirm the exceedance remains unrelated to mining activity.

Appendix G - June 2019 – ALV4L Groundwater Level ITARP

JACOBS

Memorandum

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Subject	**ALV4L 12 Month Water Level Trigger Investigation July 2019**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA131807
From	Greg Sheppard		
Date	26 July 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) has been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of a groundwater level trigger at groundwater monitoring piezometer ALV4L at Liddell Mine, specifically in regard to whether the exceedance presents a potential to harm the environment and determine whether it is a mining related impact.

1.1 Overview

The investigation is in accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908. Specifically, ALV4L piezometer which recorded an exceedance of groundwater level trigger Definition #2 continuously for 12 months since July 2018.

As per the Water Management Plan (WMP), LCO previously notified NSW Department of Industry Lands and Water, NSW Department of Planning & Environment and Department of Environment and Energy of the 3 month exceedance on 15 October 2018. The previous investigation concluded ALV4L groundwater levels are likely reflecting natural variability due to climate factors and there is no mining related impact or likely potential of environmental harm.

This report details the Trigger Action Response Plan (ITARP) investigation of the subsequent 12 month trigger exceedance to confirm that the exceedance remains unrelated to mining activity.

1.2 Scope of Work

The Scope of Work for this groundwater investigation comprises:

- investigation of over 12 consecutive months of groundwater level exceedances at groundwater monitoring site ALV4L.
- assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

2. ALV4L Groundwater Investigation

The trigger exceedances are shown the monitoring results in **Table 1**

Table 1: Site specific trigger values for groundwater level and monthly observations

Well ID	Unit	Trigger Values Depth to water (mbgl)		Monitoring Results Depth to water (mbgl)												
		10th Percentile Trigger Limit (mbgl)	Reference Maximum (mbgl)	Jun 2018	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019
ALV4L	Alluvial Aquifer	**5.56**	6.73	5.45	**5.65**	**5.60**	**5.72**	**5.80**	**5.94**	**6.01**	**6.14**	**6.28**	**6.38**	**6.32**	**6.31**	**6.33**

Figure 1 presents the weekly time series groundwater elevation at alluvial monitoring site ALV4L and the corresponding shallow bedrock monitoring site ALV4S. A residual mass curve with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

As per previous investigation reports and in consultation with Department of Industry Lands and Water, LCO has reviewed the Hydrograph Analysis and Rainfall Time Trends (HARTT) analysis method and found it not suitable for use at LCO. The methodology utilised for this investigation is consistent with previous investigation reports.

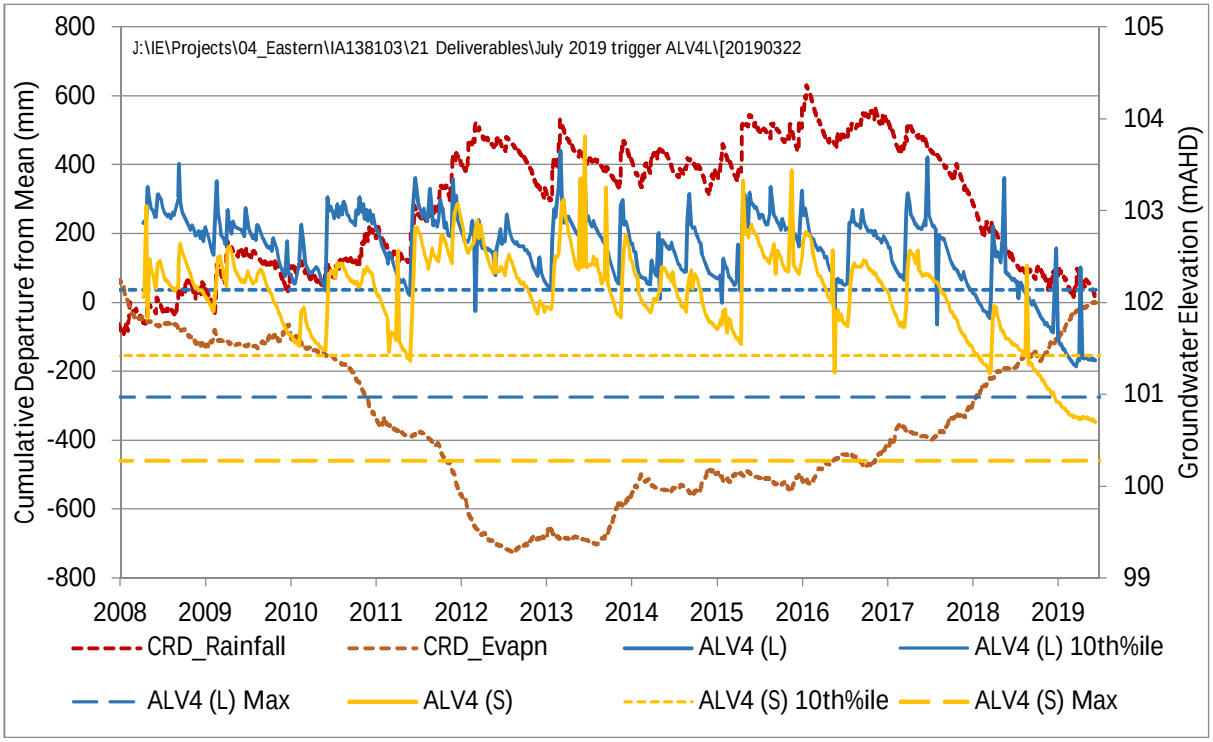

Figure 1: Groundwater elevation (mAHD) observations at site ALV4L and ALV4S

In **Figure 1**, there is a significant decline in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). This implies a combination of below average rainfalls and higher than average evaporation. The drier climatic conditions correspond with a reduction in groundwater level trends at both ALV4 bores which continues through to the end of the dataset. The measured water level at both ALV4 bores have not exceeded the WMP reference maximum range (low water level).

Brief spikes in water levels at ALV4L are observed in December 2018 and April 2019, following elevated rainfall events. During these brief peaks the water level rose above the 10th percentile trigger. These rainfall events are shown by an increase in the residual mass curve (rainfall). Following the April recharge event, water levels at ALV4L have remained relatively stable. Generally, the water level trend at ALV4 shows a close correlation to the residual mass curve (rainfall) trend. Previous ITARP investigations have corroborated the understanding that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops upgradient.

As observed in the previous trigger investigation for ALV4L the depth to water measurements of all monitoring locations along Bowman's creek (**Figure 2**) continue to show a similar declining trend in groundwater levels over the entire measured system since 2017. It is noted that anomalous water level declines at ALV7 and ALV8 are subject to a separate ongoing investigation. The decreases in water within the Bowman's creek system at both the alluvium aquifer and shallow bedrock aquifer demonstrate a similar trend which supports the understanding that both systems recharge the same way. The consistency of these observations along the whole system (excluding ALV7 and ALV8) indicates that the observed groundwater response is driven by climate rather than mining activity.

The current groundwater level trends at ALV4L are consistent with historical observations and it is considered that the trigger exceedance does not present potential harm to the environment due to mining operations.

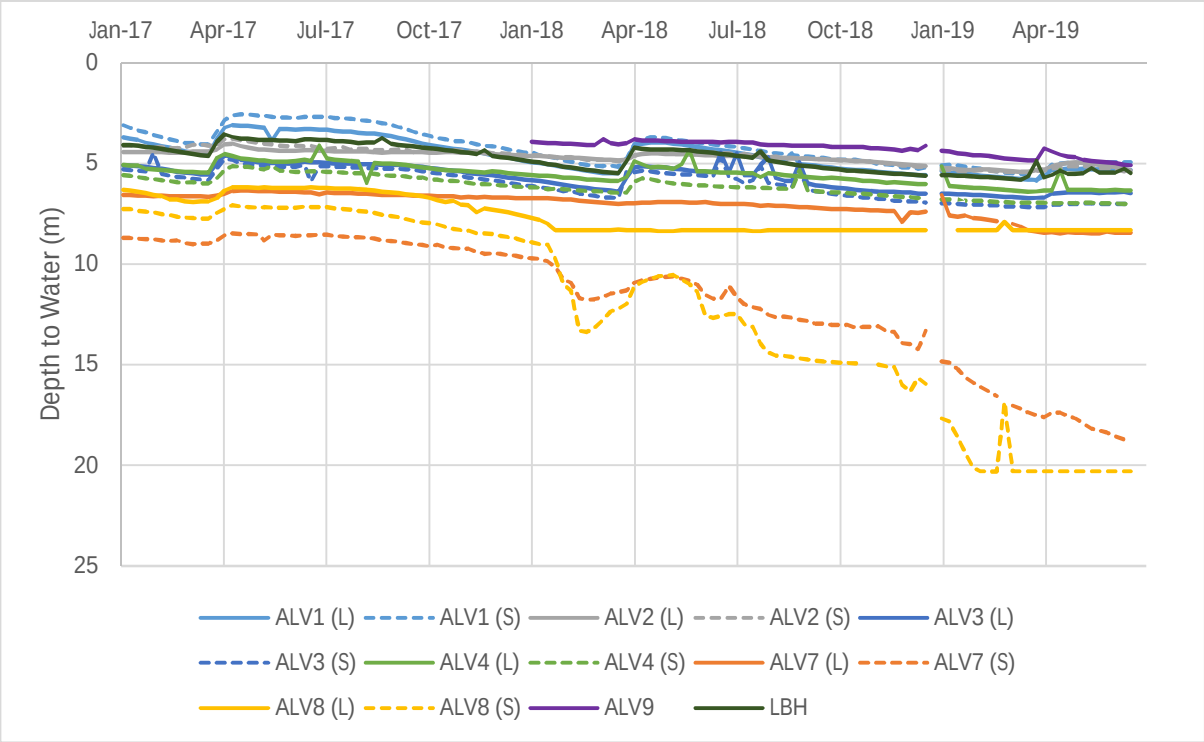

Figure 2: Bowman's Creek alluvium and shallow bedrock depth to water observations

4. Conclusion

The conclusion drawn by the previous trigger report for ALV4L still apply. The groundwater levels measured at ALV4L are considered to reflect natural variability due to climatic factors and there are no mining related impacts identified. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the Bowmans Creek alluvium.

The groundwater level at ALV4L has not declined below the maximum range recorded and is not of sufficient magnitude to lead to a downgradient impact on beneficial use. No environmental harm due to mining activities is indicated.

It is recommended that routine monitoring continues at ALV4L as per the WMP response plan.

5. References

LCO, 2018. *Liddell Glencore | Plan for Water Management*. Management plan prepared by Liddell Coal Operations Pty Ltd. Reference No. LIDOC-90533967-3694, Version 11 (Approved).

LCO, 2018. *Liddell Glencore ALV1L, ALV4L & ALV3S Groundwater Trigger Investigation April 2018*

6. Closing

Should you require additional information then please do not hesitate to contact our office.

Yours sincerely

Greg Sheppard
Senior Hydrogeologist
61 2 9032 1284

Appendix H - July 2019 – ALV1L, ALV2S, ALV3L and ALV3S Groundwater Level ITARP

JACOBS

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Subject	**ALV1L, ALV2S, ALV3L and ALV3S 12 Month Water Level Trigger Investigation July 2019** **Project Name**		Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA131807
From	Greg Sheppard		
Date	27 August 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) has been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of a groundwater level trigger at groundwater monitoring piezometer ALV1L, ALV2S, ALV3L and ALV3S at Liddell Mine, specifically in regard to whether the 12-month exceedances present a potential to harm the environment and determine whether it is a mining related impact.

1.1 Overview

The investigation is in accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908. Specifically, ALV1L, ALV2S, ALV3L and ALV3S piezometers which recorded exceedances of groundwater level trigger Definition #2 continuously for 12 months since July 2018.

As per the Water Management Plan (WMP), LCO previously notified the Department of Environment and Energy and both the NSW Department of Planning, Industry and Environment- Planning & Assessment division and the Water division of the 3-month exceedance of ALV1L, ALV2S, ALV3L and ALV3S. The previous investigations concluded ALV1L, ALV2S, ALV3L and ALV3S groundwater levels are likely reflecting natural variability due to climate factors and there is no mining related impact or likely potential of environmental harm.

This report details the Trigger Action Response Plan (ITARP) investigation of the subsequent 12-month trigger exceedance to confirm that the exceedance remains unrelated to mining activity.

1.2 Scope of Work

The Scope of Work for this groundwater investigation comprises:

- investigation of over 12 consecutive months of groundwater level exceedances at groundwater monitoring site ALV1L, ALV2S, ALV3L and ALV3S.
- assessment of whether there is potential harm to the environment from the exceedance and determine whether it is a mining related impact.

2. Trigger exceedances (ALV1L, ALV2S, ALV3L and ALV3S)

The 12-month groundwater level trigger exceedances at ALV1L, ALV2S, ALV3L and ALV3S are shown the monitoring results in **Table 1**.

The weekly time series groundwater elevation (mAHD) at monitoring sites (ALV1L, ALV2S, ALV3L and ALV3S) are presented individually in Figure 1, Figure 2 and Figure 3. A residual mass curve with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

Table 1: Site specific trigger values for groundwater level and monthly observations

Well ID	Unit	Trigger Values Depth to water (mbgl)		Monitoring Results Depth to water (mbgl)											
		10th Percentile Trigger Limit (mbgl)	Reference Maximum (mbgl)	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019
ALV1L	Alluvial aquifer	**4.97**	6.31	4.68	4.98	5.15	5.30	5.43	5.57	5.45	5.66	5.80	5.27	5.27	5.31	5.33
ALV2S	Shallow bedrock aquifer	**4.67**	8.53	4.63	4.74	4.77	4.87	4.95	5.14	5.36	5.38	5.40	5.21	5.17	5.37	5.61
ALV3L	Alluvial aquifer	**5.70**	7.08	5.60	5.87	6.12	6.63	6.41	6.48	6.53	6.61	6.70	6.45	6.43	6.41	6.47
ALV3S	Shallow bedrock aquifer	**5.99**	7.26	5.90	6.17	6.43	6.29	6.78	6.92	7.00	7.07	7.16	7.04	6.98	7.00	7.01

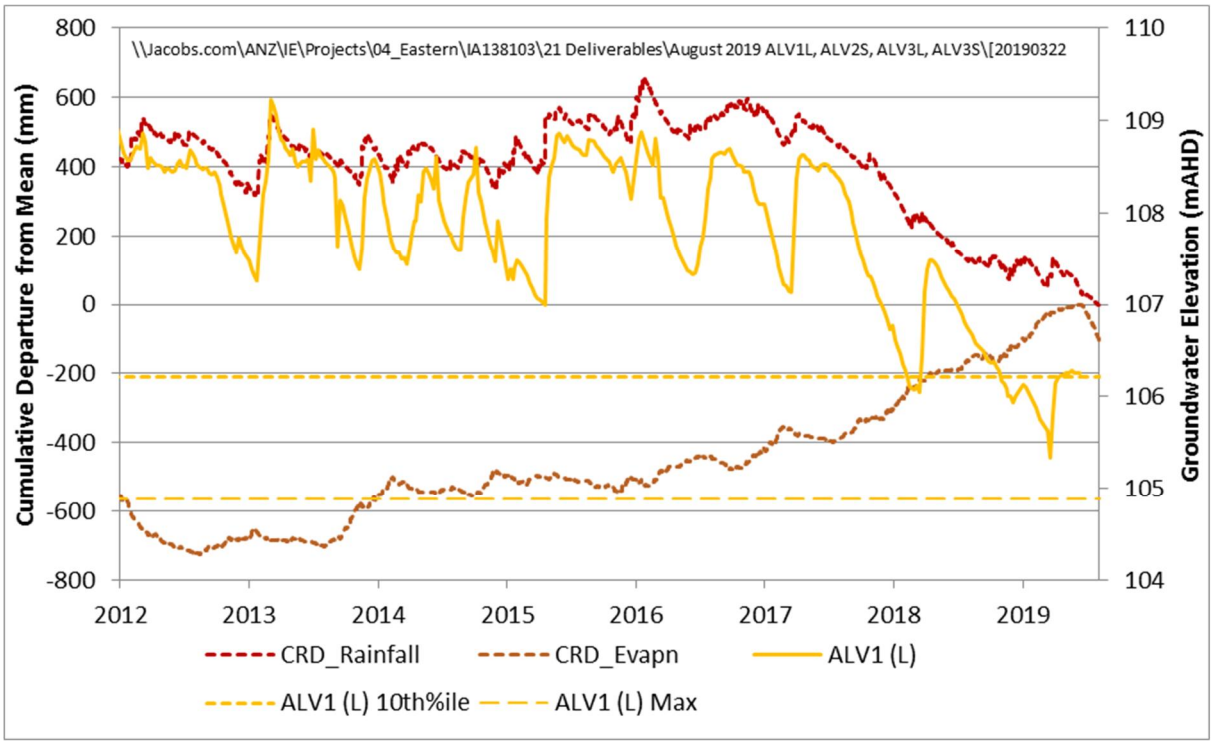

Figure 1 Groundwater elevation (mAHD) observations, 10th %ile trigger value and minimum groundwater elevation at monitoring site ALV1L

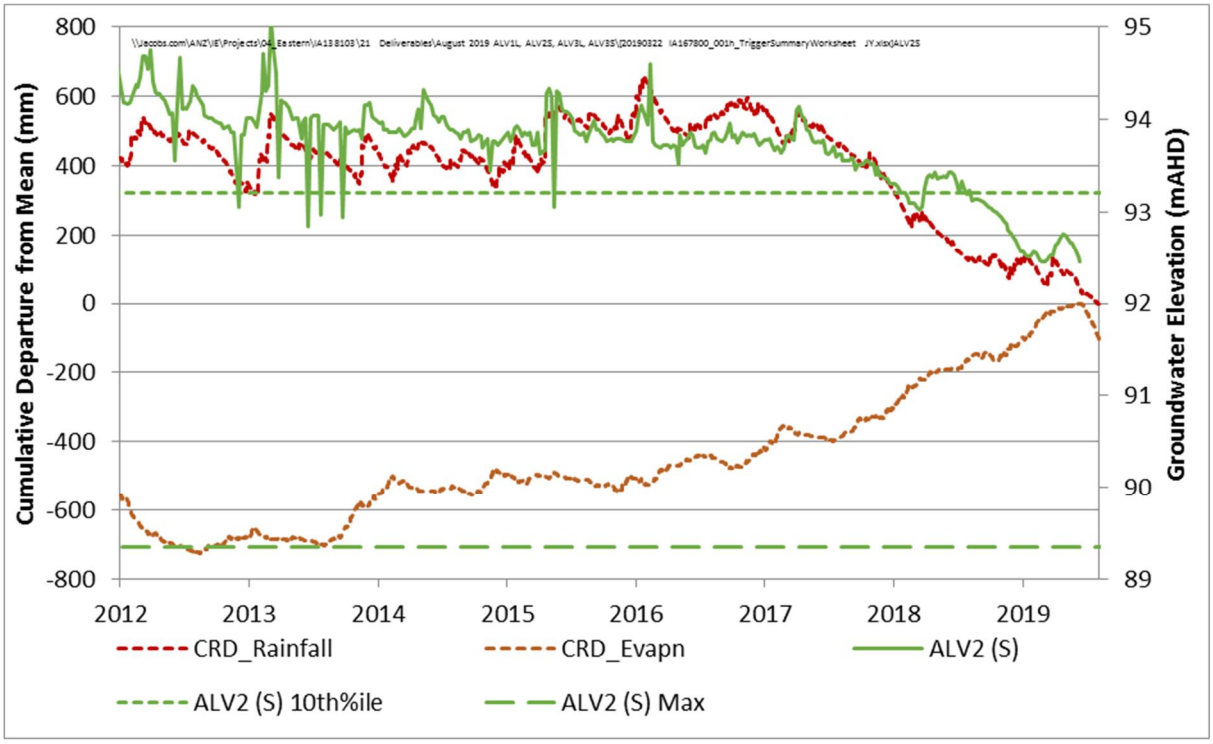

Figure 2 Groundwater elevation (mAHD) observations, 10th %ile trigger value and minimum groundwater elevation at monitoring site ALV2S

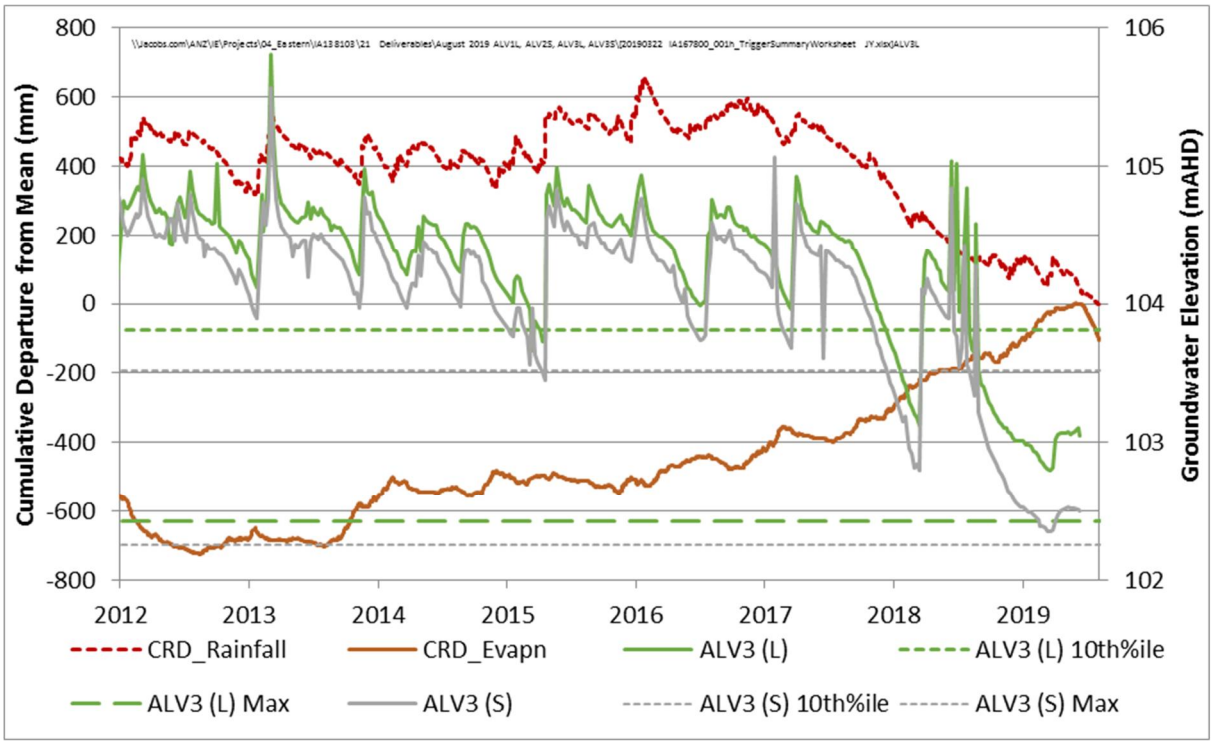

Figure 3 Groundwater elevation (mAHD) observations, 10th %ile trigger value and minimum groundwater elevation at monitoring site ALV3L and ALV3S

There is a significant decline in the residual mass curve (rainfall) commencing January 2017, which is commensurate with an increase in slope in the residual mass curve (evaporation). This implies a combination of below average rainfalls and higher than average evaporation. The drier climatic conditions correspond with a general decline in groundwater level trends at ALV1L, ALV2S, ALV3L and ALV3S since 2017.

Increases in water levels at ALV1L are observed in January 2019, correlating to above average precipitation which is seen as a small increase in the residual mass curve (rainfall) for approximately one month. Water levels are observed to decline to approximately 105.3 mAHD, 0.9 m below the 10th percentile level, in early April 2019 before rising to just below the 10th percentile mark until July, mimicking the residual mass curve (rainfall) albeit with a small lag. The water level at ALV1L remains above the minimum groundwater elevation of 104.88 across the past 12 months.

Water levels at ALV2S display an overall declining trend with small increases in early April, which correspond to the rise in residual mass curve (rainfall) in early April 2019. Water levels continue to decline from May 2019 to the end of June 2019. The water level at ALV2S remains above the minimum groundwater elevation of 89.35 across the past 12 months.

Brief spikes in water level at ALV3L and ALV3S, corresponding to rainfall events, are observed in August 2018. Water levels are observed to decline until the recharge event in April, which saw a rise in water levels by around 0.2m and 0.15m at both ALV3L and ALV3S respectively. The water levels at ALV3L and ALV3S remain above the minimum groundwater elevation of 102.43 and 102.25 respectively across the past 12 months.

Generally, the water level trends at ALV1L, ALV2S, ALV3L and ALV3S demonstrate a close correlation to the residual mass curve (rainfall) trend. Previous ITARP investigations have corroborated the understanding that rainfall is the primary driver influencing water level recharge in both the alluvium and underlying shallow bedrock, which outcrops upgradient.

The depth to water measurements of all monitoring locations along Bowman's creek north of ALV2 (**Figure 4)** continue to show a similar regional trend in declining groundwater levels since 2017. Despite the persistent declining trends since April 2017, recharge events in around late March 2018 to early April 2018 and early April 2019 can be seen to influence rising water levels at all monitoring locations. The correlation between the respective nested alluvial bore and shallow bedrock bore also support the understanding that both aquifer systems are closely hydraulically connected and respond to rainfall in a similar fashion. The observed groundwater response decline in the past 12 months can be attributed to drier climate conditions with limited recharge rather than mining operations.

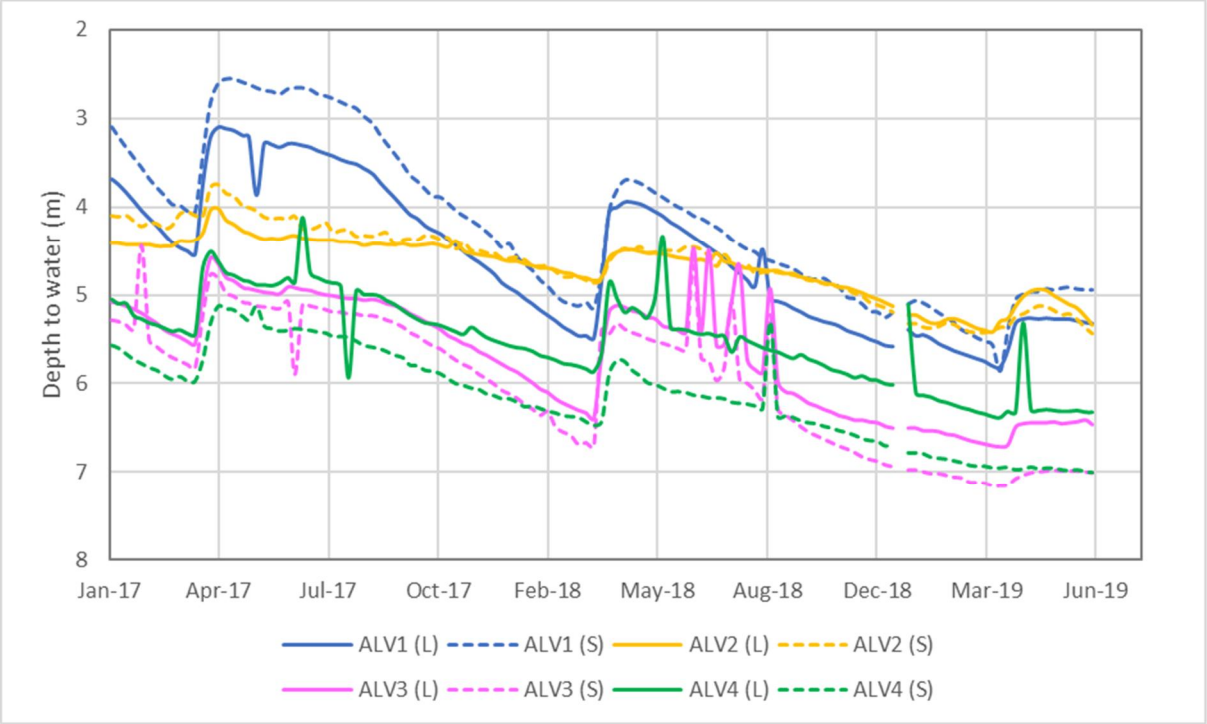

Figure 4: Depth to water observations at alluvial aquifer and shallow bedrock aquifer monitoring locations at Bowman's Creek.

3. Conclusion

The conclusion drawn by the previous trigger report (3 month exceedances) for ALV1L, ALV2S, ALV3L and ALV3S still apply. The 12-month groundwater level trigger exceedances observed at ALV1L, ALV2S, ALV3L and ALV3S are considered to reflect natural variability due to climatic factors and there are no mining related impacts identified. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the Bowmans Creek alluvium.

The groundwater levels at ALV1L, ALV2S, ALV3L and ALV3S remain above their respective maximum range recorded. No environmental harm due to mining activities is indicated.

It is recommended that routine monitoring continues at ALV1L, ALV2S, ALV3L and ALV3S as per the WMP response plan.

4. References

LCO, 2018. *Liddell Glencore | Plan for Water Management*. Management plan prepared by Liddell Coal Operations Pty Ltd. Reference No. LIDOC-90533967-3694, Version 11 (Approved).

5. Closing

Should you require additional information then please do not hesitate to contact our office.

Yours sincerely

Greg Sheppard
Senior Associate Hydrogeologist
61 2 9032 1284

Appendix I - August 2019 – ALV4S and LBH Groundwater Level ITARP

JACOBS

Memorandum

Subject	**ALV4S & LBH water level & ALV7S EC Groundwater Investigation- August 2019**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA131807
From	Greg Sheppard		
Date	1 October 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) have been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of groundwater monitoring results at piezometers ALV4S, LBH and ALV7S; specifically in regard to whether the water level and water quality exceedances present a potential to harm the environment and determine whether the triggers are mining related.

1.1 Overview

The investigation has been undertaken in accordance with the Liddell Coal Operations (LCO) Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908. Specifically, ALV4S and LBH piezometers which have recorded exceedances of groundwater level trigger Definition #2 continuously for 12 months since September 2018; and ALV7S which recorded exceedances in Electrical Conductivity (EC) continuously for 6 months since March 2019.

As per the Water Management Plan (WMP), LCO has previously investigated trigger exceedances at each of these bores. These investigations were notified to the Department of Environment and Energy and both the NSW Department of Planning, Industry and Environment- Planning & Assessment division and the Water division of the: 3-month groundwater level exceedance of ALV4S and LBH; and the 3-month EC exceedance of ALV7S. The previous investigations concluded:

- ALV4S and LBH groundwater levels are likely reflecting natural variability due to climate factors and is seen across the monitoring network. There is no mining related impact or likely potential of environmental harm.
- ALV7S EC levels despite exceeding the reference maximum is a natural occurrence. The direct relationship between monitoring observations and rainfall imply climatic variation as the cause and there is no potential harm the environment.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedances to confirm that the exceedance remains unrelated to mining activity and pose no potential harm to the environment.

1.2 Scope of Work

The Scope of Work for this groundwater investigation comprises:

- Investigation of over 12 consecutive months of groundwater trigger level exceedances at groundwater monitoring site ALV4S and LBH.
- Investigation of over 6 consecutive months of EC trigger exceedances at groundwater monitoring site ALV7S.
- Assessment of whether there is potential harm to the environment from the exceedances and determine whether it is a mining related impact.

2. Groundwater level trigger exceedances (ALV4S and LBH)

The ALV4 monitoring site comprises a paired piezometer installation targeting the alluvial aquifer (ALV4L) and the underlying shallow bedrock (ALV4S). The LBH monitoring site comprises a single piezometer targeting the alluvial aquifer, installed as part of the WMP in 2015. The 12-month groundwater level trigger exceedances at ALV4S and LBH are shown the monitoring results in **Table 1.**

Groundwater elevations (mAHD) at monitoring sites (ALV4S and LBH) are presented on **Figure 1**. A residual mass curve with respect to rainfall and evaporation is also plotted for analysis, which was calculated and applied on a daily basis in accordance with the approach presented in previous investigations completed since 2017.

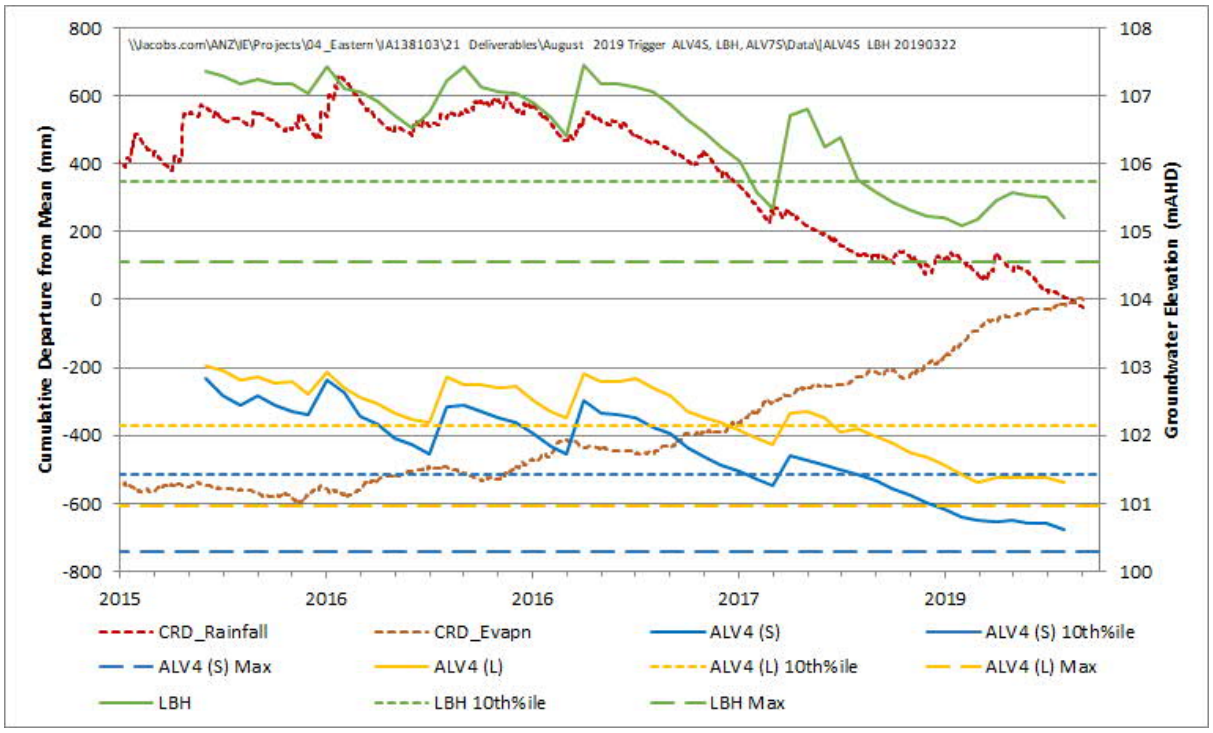

Figure 1: Groundwater elevation (mAHD) observations, 10th percentile trigger value and minimum groundwater elevation at monitoring site ALV4S and LBH.

Table 1: Site specific trigger values for groundwater level and monthly observations

Well ID	Unit	Trigger Values Depth to water (mbgl)		Monitoring Results Depth to water (mbgl)												
		10th Percentile Trigger Limit (mbgl)	Reference Maximum (mbgl)	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019
ALV4S	Shallow Bedrock Aquifer	**6.28**	7.42	6.28	**6.37**	**6.48**	**6.58**	**6.70**	**6.79**	**6.89**	**6.95**	**6.96**	**6.95**	**6.99**	**7.00**	**7.08**
LBH	Alluvial Aquifer	**5.05**	6.24	5.02	**5.21**	**5.36**	**5.46**	**5.57**	**5.59**	**5.70**	**5.62**	**5.33**	**5.22**	**5.26**	**5.29**	**5.58**

As per Figure 1 there is a significant decline in the residual mass curve (rainfall) commencing January 2017 and a corresponding increase in the slope of the residual mass curve (evaporation). This implies a combination of below average rainfalls and higher than average evaporation. The drier climatic conditions correspond with a general decline in groundwater level trends at ALV4S and LBH since 2017.

A similar regional declining trend is observed at the majority of monitoring locations along Bowman's Creek (Figure 2) since 2017.

The observed declines in water levels within both the Bowman's Creek Alluvium and shallow bedrock aquifer systems continue to show similar trends as noted in the previous report investigations. This supports the understanding that both systems recharge and respond in a similar fashion. The consistency of these observations with results from other monitoring sites indicates that the groundwater response at ALV4S and LBH is driven by climate and not by mining activity.

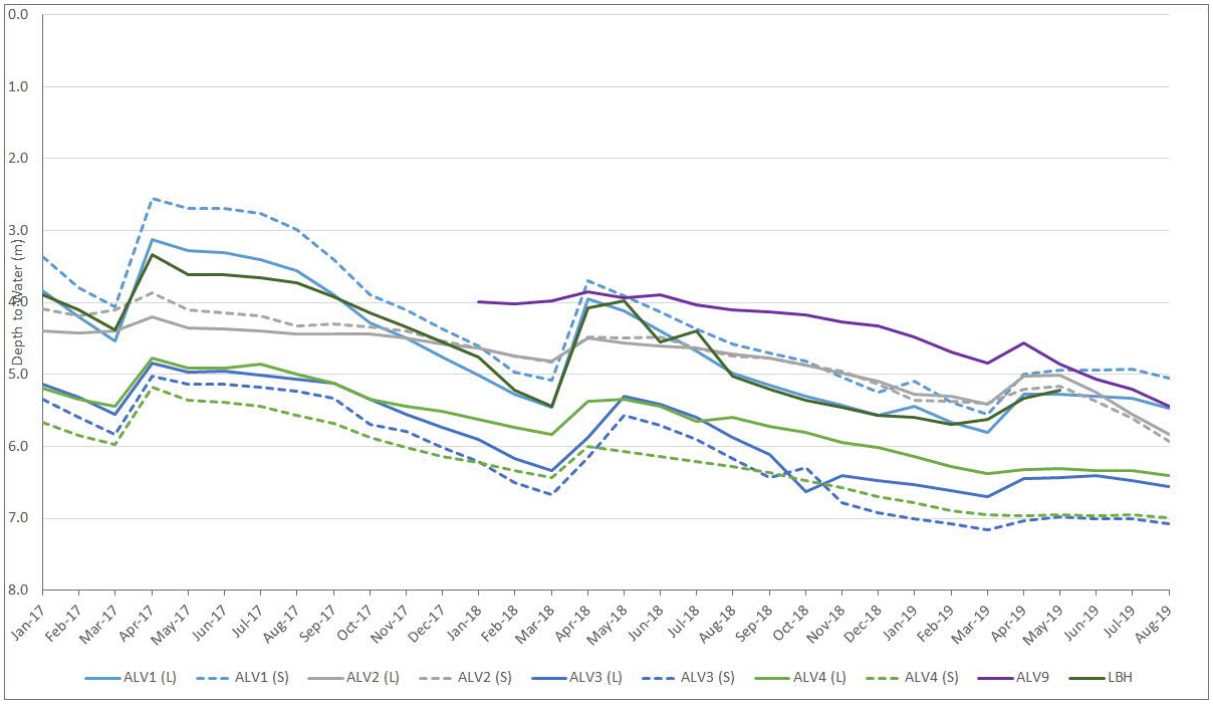

Figure 2: Depth to water observations at alluvial aquifer and shallow bedrock aquifer monitoring locations at Bowman's Creek

Despite the ongoing water level decline, brief periods of groundwater recharge are still observed in the data indicating that a change in rainfall to above average conditions would alleviate the declining trend.

Generally, the water level trends at these sites show a close correlation to the CRD trend. The reference timeframe (from July 2005 to May 2017) used to calculate the site-specific trigger values, captured a period of prevailing above average rainfalls conditions and climatic maximums. Since 2017 the residual mass rainfall curve has had the longest declining trend observed during the period of monitoring.

The most recent groundwater levels (April to August 2019) are the lowest on record since weekly monitoring commenced in 2008 but are still within the reference maximum trigger levels.

Previous Investigation Trigger Action Response Plans (ITARP) investigations supported the understanding that rainfall is the primary driver influencing groundwater level recharge in both the alluvium and underlying shallow bedrock which outcrops up gradient. The most recent trends and observations continue to support the notion that the regionally declining groundwater levels in the past 12 months can be attributed to drier climatic conditions with limited recharge rather than mining operations.

3. Electrical Conductivity (EC) exceedance (ALV7S)

Paired piezometers are installed at ALV7, with ALV7S installed in the shallow bedrock aquifer and ALV7L installed in the overlying alluvial aquifer. Observed groundwater elevations and relevant trigger levels at ALV7 are shown below in Figure 3. Observed groundwater EC measurement and relevant trigger levels at ALV7 are shown in Figure 4.

The 6-month EC trigger level exceedance at ALV7S is shown below in Table 2.

Table 2: Site specific trigger values for groundwater EC and monthly observations

Well ID	Unit	Trigger Values EC (mS/cm)		Monitoring Results Electrical Conductivity (mS/cm)						
		80th Percentile Upper Limit	Reference Maximum	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019
ALV7S	Shallow Bedrock Aquifer	**2.23**	**2.54**	2.11	**2.78**	**3.02**	**2.83**	**2.60**	**3.04**	2.99

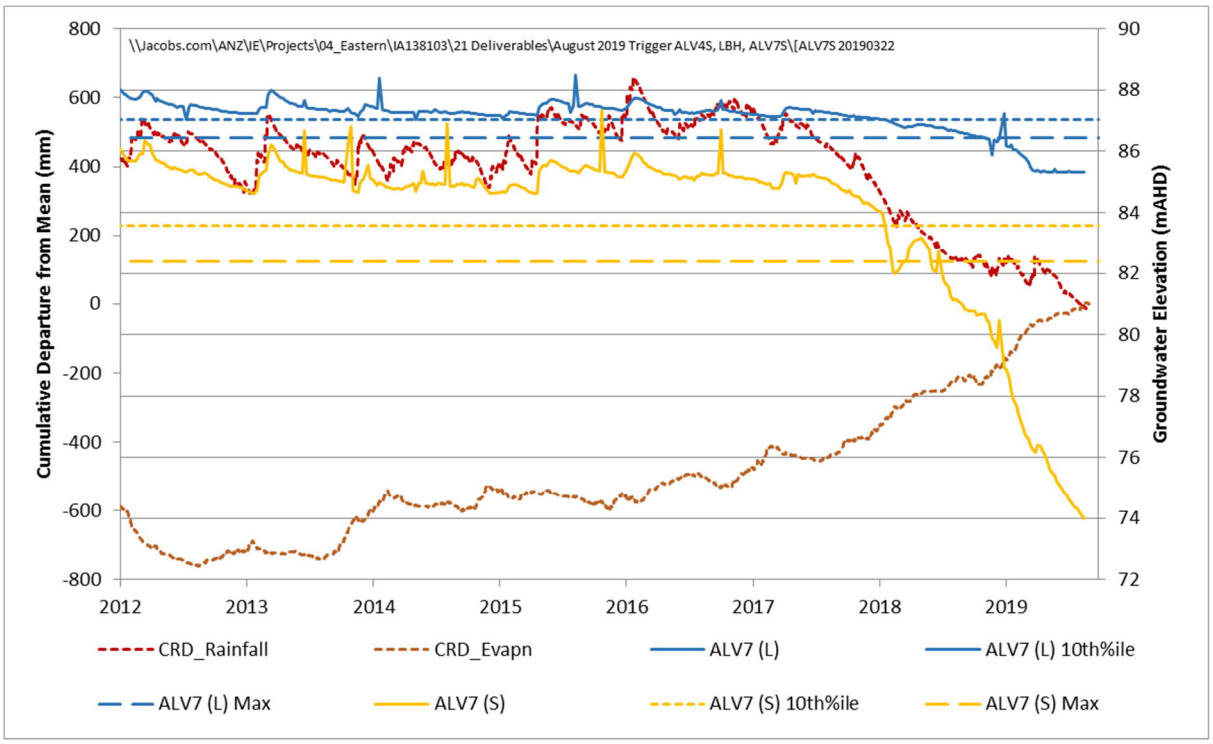

Figure 3: Groundwater elevation (mAHD) monitoring observations at ALV7 and climatic CRDs

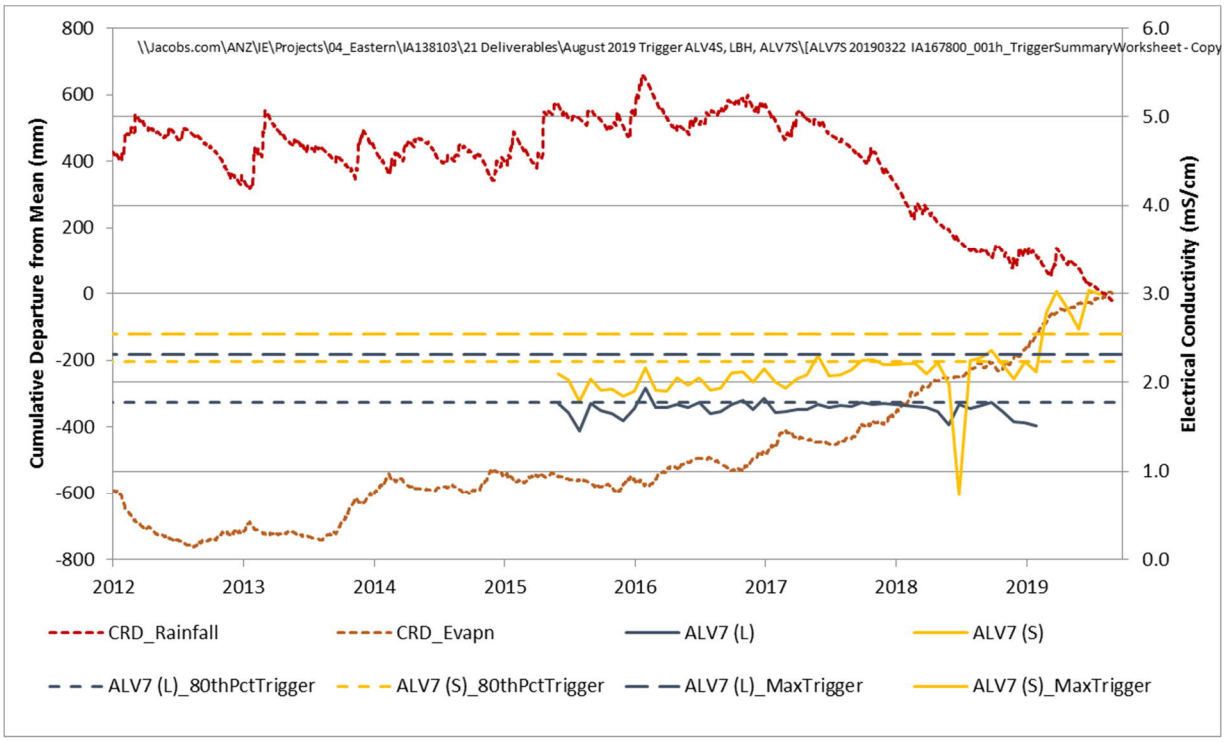

Figure 4: Electrical conductivity (mS/cm) observations at ALV7 and climatic CRDs

3.1 Previous report findings

The previous EC investigation trigger report for ALV7S suggested the EC levels were increasing due to increased evaporation and accumulation of salts associated with below average rainfall. The report noted that out of the multiple trigger sites, EC only exceeded the reference maximum at ALV7S. Further monitoring and increases in EC have resulted in a re-evaluation of this earlier finding.

3.2 Data review

The water levels at ALV7 have declined significantly since the beginning of 2019 with water levels in the alluvium piezometer ALV7L falling below the base of the piezometer, and the shallow bedrock piezometer ALV7S is still showing a strong declining trend. ALV7S water levels have decreased more than 5m since January 2019 to approximately 74mAHD, which is 8.4m below the reference maximum.

EC observations show an inverse relationship to water levels at ALV7S, with EC measurements showing a corresponding increase, rising above the reference maximum in March 2019. The last measurement in August 2019 recorded a concentration of 2.99mS/cm, which is 0.45mS/cm (450µS/cm) above the reference maximum. It is noted that other sites, including alluvial and shallow bedrock monitoring sites, have higher reference maximums, such as AVL4S at 6.43ms/cm, ALV2L at 4.16ms/cm.

The increasing EC observed at ALV7S is attributed to the reduced contribution of the relatively fresher alluvial groundwater following the drying of the alluvium at that location. As the alluvium above ALV7S is currently unsaturated, the contribution of water from the alluvium is reduced in comparison to the more saline water from the shallow bedrock.

Water quality within the overburden lithologies will also exhibit a salinity gradient, ranging from shallow salinities equivalent to the overlying alluvial aquifer and increasing with depth.

With the declining water levels at ALV7S, there is an increased interaction with the more saline overburden lithologies and the increased dominance of the more saline waters from the shallow bedrock resulting in the increased EC concentrations.

While the declining regional water levels will be contributing, it is considered that it is the decline in water levels within the shallow overburden that is the primary cause of the increased salinity.

4. Review Findings

Regarding the groundwater level triggers at ALV4S and LBH, the conclusions drawn by the previous trigger reports (3-month exceedances) still remain relevant. The 12-month groundwater level trigger exceedance observed at these sites are considered to reflect natural variability due to climatic factors and there are not considered to be mining related. The groundwater level at both these sites remain above their respective reference maximum range. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the system. No environmental harm due to mining activities is indicated.

In accordance with the Water Management Plan, the exceedance of the Groundwater Level Trigger Definition #2 at ALV4S and LBH has been investigated following a 12-month monitoring period and concluded to be unrelated to mining. No further action is required but it is recommended routine monitoring continues.

Regarding the EC concentration triggers at ALV7S, the elevated levels are believed to be related to the anomalous water level decline observed at ALV7 and ALV8. The decreased recharge from the alluvium

is considered to have resulted in the observed increase in salinity with the current levels of salinity considered to be more representative of the shallow bedrock aquifer.

While the cause of the water level decline is still under investigation, no potential or actual environmental harm due to mining activities is indicated as a result of the elevated EC. The elevated EC is considered to be representative of the natural salinity of the shallow bedrock without the diluting influence of seepage from the overlying alluvium. Given the localised groundwater sink, there is no risk to the surrounding alluvial aquifers or downstream environment.

It is recommended to continue monitoring in accordance with the WMP to assess ongoing salinity levels at ALV7S.

Reference

Glencore Liddell, 2017, Water Management Plan, Reference number: LIDOC-90533967-3694

Glencore Liddell, 2019, Groundwater Investigation Trigger Report (ALV1L, ALV2S, ALV3L, ALV4S, ALV7S and LBH), June 2019

Glencore, 2018, ALV4S & LBH Groundwater Trigger Investigation, December 2018

Glencore, 2019, ALV7L, ALV7S & ALV8S Groundwater Trigger Investigation, February 2019

Appendix J - September 2019 – ALV8L, ALV1S and ALV2L Groundwater Level ITARP

JACOBS

Memorandum

Subject	**ALV1S and ALV2L Groundwater Level Investigation - October 2019**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young	**Project No.**	IA138107
From	Costante Conte		
Date	05 November 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) have been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of groundwater monitoring results at monitoring bores ALV1S and ALV2L; specifically, in regard to whether the water level and water quality exceedances present a potential to harm the environment and determine whether the triggers are mining related.

1.1 Overview

The investigation has been undertaken in accordance with the LCO Water Management Plan (WMP) approved under NSW DA305-11-01 and EPBC Approval 2013/6908. Specifically, ALV1S and ALV2L monitoring bores which have recorded exceedances of groundwater level trigger Definition #2 continuously for 12 months since October 2018.

As per the Water Management Plan (WMP), LCO has previously investigated trigger exceedances at each of these bores. These investigations were notified to the Department of Environment and Energy (DoEE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment division and the Water division of the 3 month groundwater level exceedance of ALV1S and ALV2L. The previous investigation concluded the declining groundwater levels are likely reflecting variability due to climate factors and is seen across the monitoring network. There is no mining related impact or likely potential of environmental harm.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedances to confirm that the exceedance remains unrelated to mining activity and pose no potential harm to the environment.

1.2 Scope of Work

The Scope of Work for this groundwater investigation comprises:

- investigation of 12 consecutive months of groundwater trigger level exceedances at groundwater monitoring site ALV1S and ALV2L.
- Assessment of whether there is potential harm to the environment from the exceedances and determine whether it is a mining related impact.

2. Monitoring bore details

Monitoring locations ALV1S and ALV2L are clustered monitoring locations that consists of two monitoring bores that target separate water bearing units. ALV1S and ALV2L target the shallow coal measures overburden and the Bowmans Creek alluvium, respectively, and are located approximately 3 km apart. Monitoring bore construction details for shallow coal measures overburden are provided in Table 2.1. The groundwater monitoring network is shown on Figure 2.1.

Table 2.1: Monitoring bore construction details

Monitoring Bore	Easting	Northing	Collar (mAHD)	Bore Base (m)	Bore Base (mAHD)	Target Aquifer
ALV1S	315508.64	6417615.791	111.19	22.1	89.09	Overburden
ALV2L	316327.98	6414720.385	97.88	8.4	89.48	Alluvium

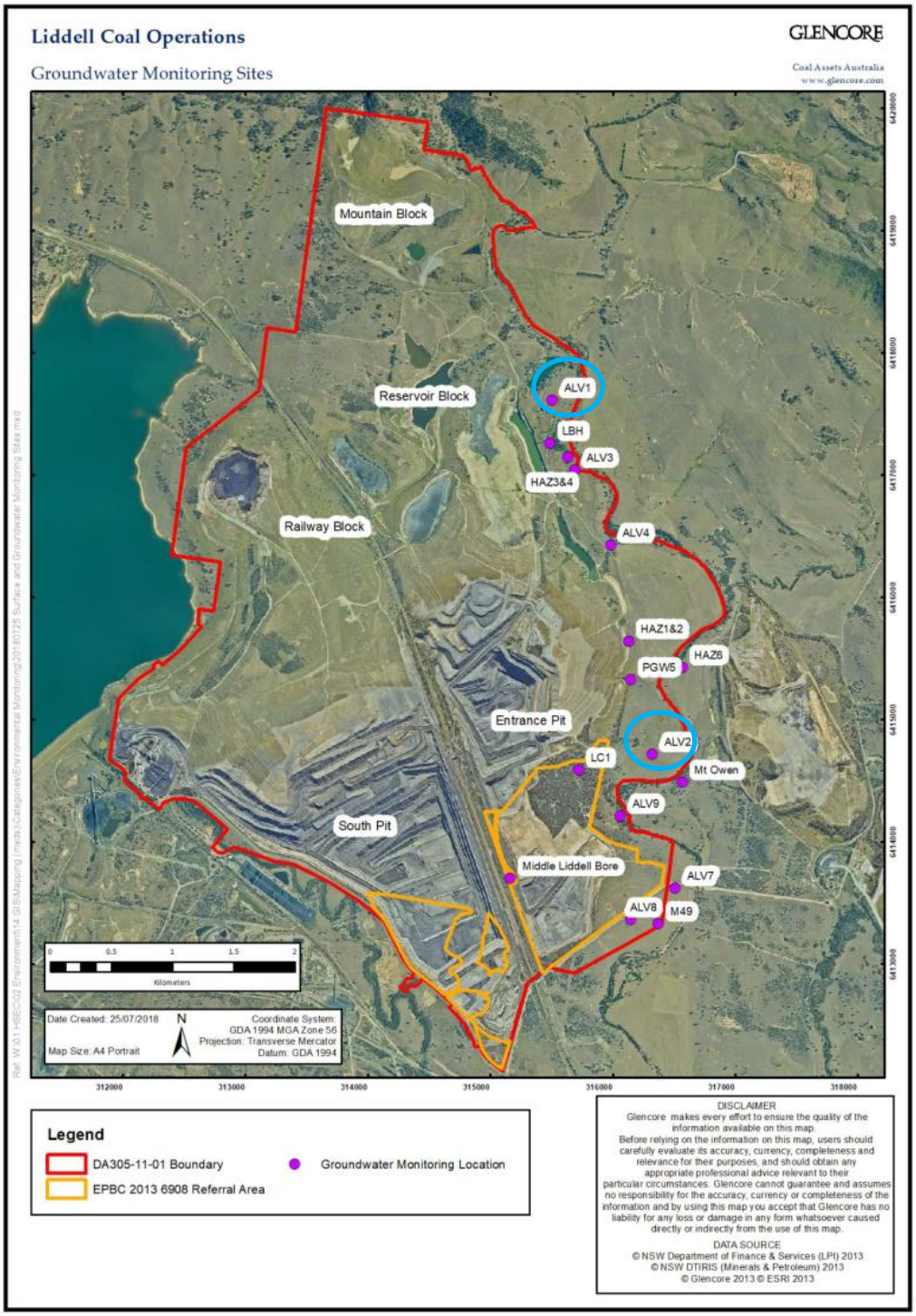

Figure 2.1: LCO – Groundwater monitoring locations (Glencore 2018b)

3. WMP Triggers

The site WMP defines the groundwater triggers for site monitoring bores in three components, including ALV1S and ALV2L. These include:

- The first component is a drawdown of 2m in the alluvium compared to a local reference site. In the case of ALV2L, the reference site is the up-gradient monitoring bore, ALV9L. The trigger is defined as "*the predicted difference in groundwater elevation between these ALV2L and ALV9L is 3 m. The 2 m drawdown is added to the difference in groundwater elevation between the sites*" (Glencore, 2018a) resulting in a trigger of 5 m relative difference between the water level measured in ALV2L and ALV9L.
- The second component is an investigation trigger and *"is a 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"* (Glencore, 2018a). The second component trigger for ALV1S and ALV2L is 4.75 mBGL (106.44 mAHD) and 4.8 mBGL (93.08 mAHD) (Glencore, 2018a).
- The third component is a subsequent investigation trigger and "*addresses the potential for harm to listed threatened species, communities and migratory species of concern to EPBC Approval 2013/6908 due to continuing exceedance of the lower 10th percentile trigger"* (Glencore, 2018a). This trigger is defined as "*Following an investigation of an exceedance of* [component 2] *Groundwater Level Trigger… 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*."

The relevant triggers for ALV1S are Component 2 and 3, and Component 1, 2 and 3 for ALV2L.

4. Groundwater level trigger exceedances (ALV1S and ALV2L)

Monitoring bores ALV1S and ALV2L are located approximately 3 km apart and are installed in the shallow bedrock and alluvial aquifer, respectively. The past 12 months ALV1S and ALV2L have exceeded their respective groundwater triggers as shown inTable 4.1**.**

The weekly time series groundwater elevation in metres above Australian height datum (mAHD) of the shallow bedrock and alluvial aquifers at monitoring sites ALV1 and ALV2 are shown on Figure 4.1. Figure 4.1 also includes a residual mass curve with respect to rainfall and evaporation, which was calculated and applied daily in accordance with the approach presented in previous investigations (completed since 2017).

Generally, the water level trends at these sites show a close correlation to the CRD trend. ALV1S and ALV2L groundwater levels dropped below their respective 10th percentile trigger limit (Component 2) in March 2018, and subsequently recovered briefly after a large rainfall event before returning and remaining below the trigger limit, but above the maximum reference ground water depth from October 2018. The residual mass curve (rainfall) has been decreasing since late-2016/early-2017, while the residual mass curve (evaporation) has been increasing since early 2012. This combination of below average rainfalls and higher than average long-term evaporation characterises the current drought conditions. The drier climatic conditions correspond with a general decline in groundwater level trends at ALV1S and ALV2L. Despite the above, ALV2L has not exceeded the Component 1 (drawdown) Trigger.

A similar declining trend is observed since 2017 in the all the Bowmans Creek alluvium monitoring bores (refer Figure 4.2). The measured changes in water levels within both the Bowman's Creek alluvium and shallow bedrock aquifer systems continue to show similar trends as noted in the

previous report investigations. This supports the understanding that both systems recharge and respond in a similar fashion. The consistency of these observations along the whole system indicates that the groundwater response at ALV1S and ALV2L is driven by climate and not by mining activity.

Despite the ongoing water level decline, brief periods of groundwater recharge are still observed in the data indicating that a change in rainfall to above average conditions would alleviate the declining trend.

The reference timeframe (from July 2005 to May 2017) used to calculate the site-specific trigger values, captured a period of prevailing above average rainfalls conditions and climatic maximums. Since 2017, the residual mass rainfall curve has had the longest declining trend observed during the period of monitoring.

Previous Investigation Trigger Action Response Plans (ITARP) investigations supported the understanding that rainfall is the primary driver influencing groundwater level recharge in both the alluvium and underlying shallow bedrock which outcrops up-gradient. The most recent trends and observations continue to support the notion that declining groundwater levels in the past 12 months can be attributed to drier climatic conditions with limited recharge rather than mining operations.

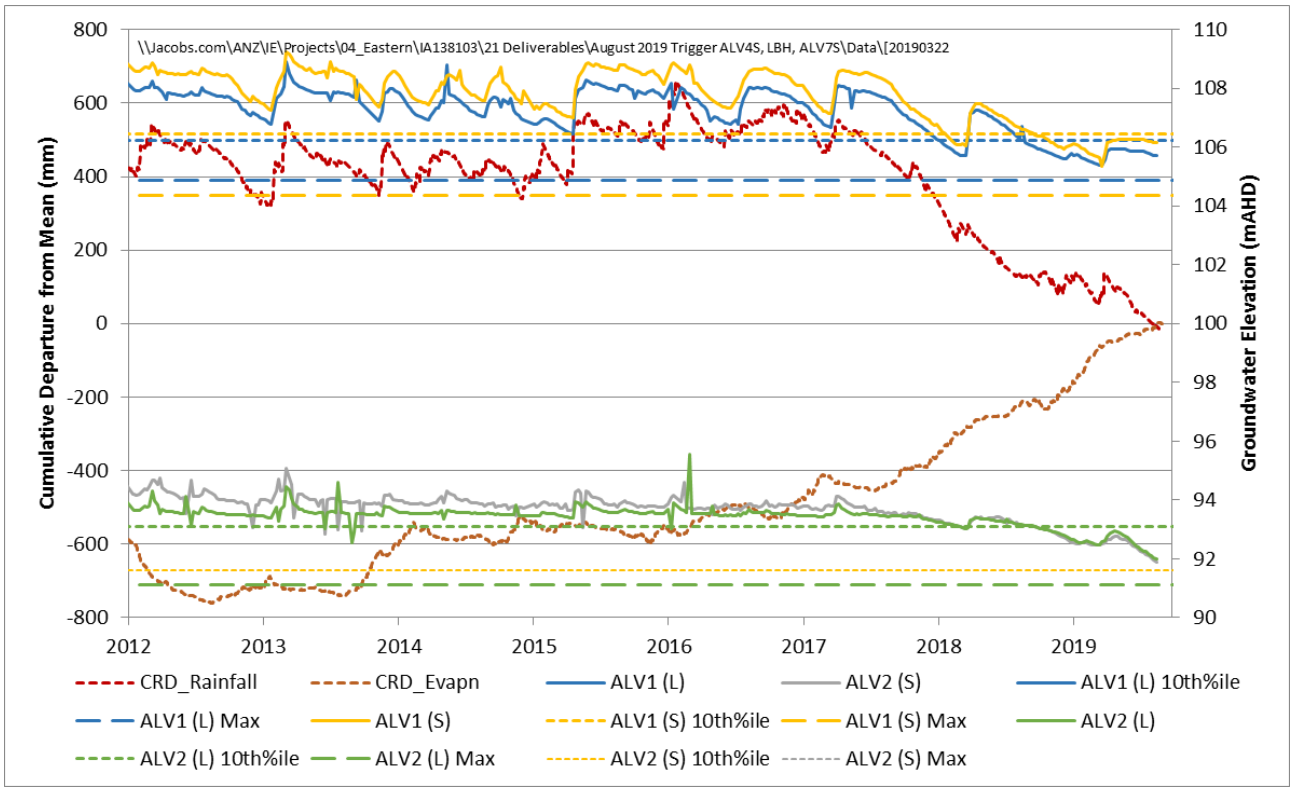

Figure 4.1: Groundwater elevation (mAHD) hydrographs and triggers - ALV1 and ALV2

Table 4.1: Site specific trigger values for groundwater level and monthly observations

Date	ALV1S	ALV2L
	Shallow Bedrock Aquifer	Alluvial Aquifer
	(mBGL)	(mBGL)
10th Percentile Trigger	**4.75**	**4.8**
Oct-18	4.81	4.87
Nov-18	5.04	4.98
Dec-18	5.25	5.09
Jan-19	5.09	5.28
Feb-19	5.39	5.3
Mar-19	5.56	5.42
Apr-19	4.99	5.02
May-19	4.94	5.01
Jun-19	4.94	5.25
Jul-19	4.92	5.55
Aug-19	5.05	5.83
Sep-19	5.12	6.03

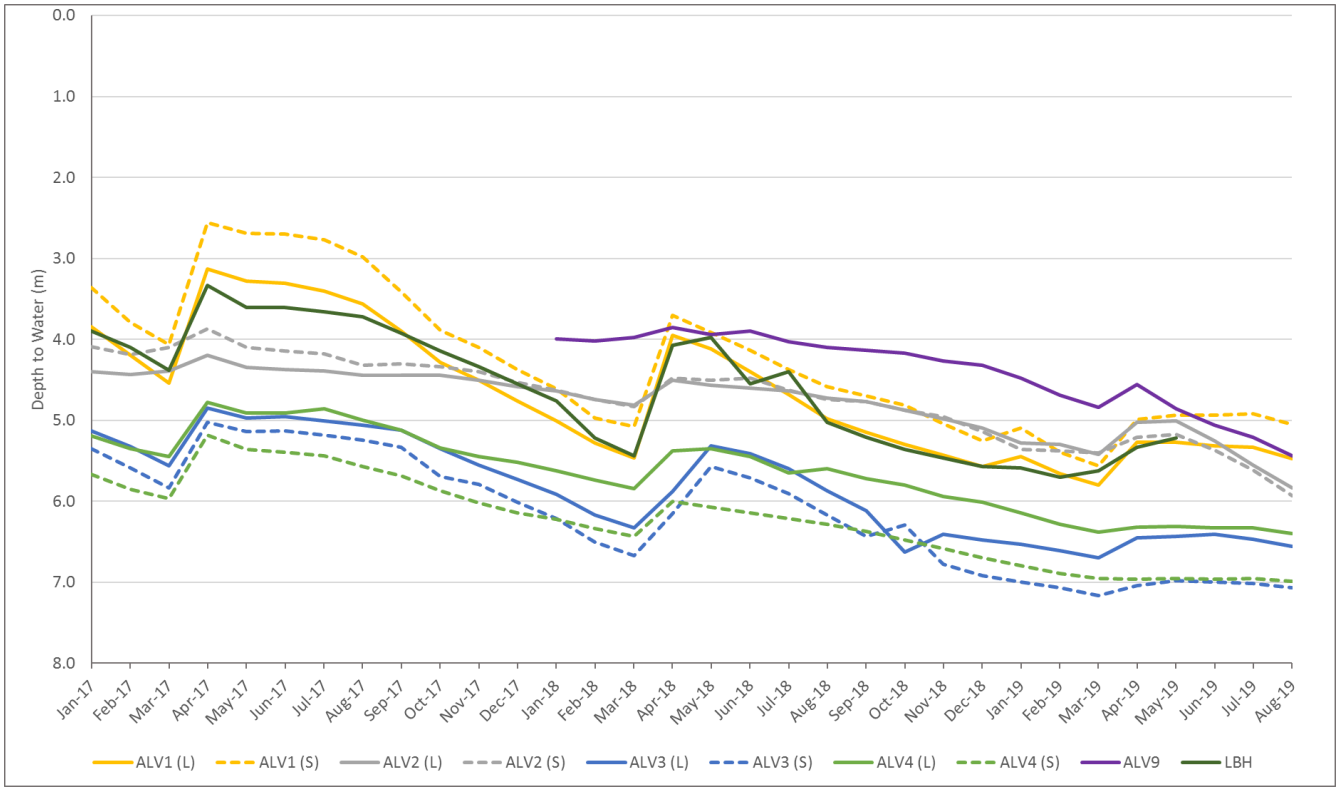

Figure 4.2: Bowmans Creek bore hydrographs (ALV1, ALV2, ALV3, ALV4 and ALV9)

5. Conclusion

The conclusions drawn by the previous trigger reports (3-month exceedances) remain relevant. The WMP Component 1 (drawdown) Trigger has not been exceeded. The 12-month groundwater level trigger exceedance (WMP Component 2 Trigger) observed at these sites (and other Bowmans Creek area monitoring bores) are considered to reflect natural variability due to climatic factors and are not considered to be mining related. The groundwater level at both these sites remain above their respective reference maximum range. The below average rainfall and high evaporation observed since 2017 have resulted in reduced recharge and declining groundwater levels throughout the system. No environmental harm due to mining activities is indicated.

It is recommended that routine monitoring continues at ALV1S and ALV2L as per the WMP response plan.

6. Reference

Glencore Liddell, 2017, Water Management Plan, Reference number: LIDOC-90533967-3694

Glencore Liddell, 2019, ALV1S and ALV2L Groundwater Trigger Investigation, January 2019

JACOBS

Memorandum

Subject	**ALV8L Groundwater trigger exceedance review**	**Project Name**	Liddell Coal Operations
Attention	Jarith Young – Glencore	**Project No.**	IA131807
From	Costante Conte – Jacobs		
Date	05 November 2019		
Copies to	Ben Desomer		

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) have been commissioned by Liddell Coal Operations Pty Ltd (LCO) to undertake an investigation of groundwater monitoring results at piezometers ALV8L. Specifically, ALV8L piezometers which have recorded exceedances of groundwater level trigger Definition #2 continuously for 24 months since October 2017; also, it should be noted that the Definition #1 have not been exceeded. The investigation is to determine whether the causes of the water level trigger exceedances are mining related and determine whether the measured levels present potential to harm the environment. The investigation has been undertaken in accordance with the LCO Water Management Plan (WMP) (Glencore, 2018a), which was approved within NSW DA305-11-01 and EPBC Approval 2013/6908.

As per the WMP, LCO has previously investigated trigger exceedances at each of the monitoring locations. These investigations were notified to the Department of Environment and Energy (DoEE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division and included the three month groundwater level exceedance and the twelve month groundwater level exceedance. The conclusions of the previous investigations are as follows:

- Three month investigation report in January 2018 (Jacobs, 2018) concluded the water decline to be climatically driven.
- Twelve month investigation in October 2018 (Glencore, 2018b) concluded found the decline is likely related to the drought and it expected to be no potential harm to the environment.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedances and if the causes of the exceedances continue to be unrelated to mining activity and pose no potential harm to the environment.

2. Scope

The scope of this groundwater investigation comprises:

- Investigation of long-term groundwater trigger level exceedances at groundwater monitoring site ALV8L, which targets the Bowmans Creek alluvium.
- Assessment of whether there is potential harm to the environment from the causes of the exceedances and determine whether the exceedance cause is mining related.

3. Background

3.1 Monitoring bore details

Monitoring location ALV8 is a clustered monitoring location that consists of two monitoring bores that target separate water bearing units. ALV8L and ALV8S target the Bowmans Creek alluvium and the shallow coal measures overburden, respectively. Monitoring bore construction details for ALV8 are provided on Table 3.1. The groundwater monitoring network is shown on Figure 3.1.

Table 3.1: ALV8L construction details

Monitoring Bore	Easting	Northing	Collar (mAHD)	Bore Base (m)	Bore Base (mAHD)	Target Aquifer
ALV8L	316148.2	6413366.7	92.02	8.30	83.72	Alluvium
ALV8S	316148.2	6413366.7	92.02	20.28	71.74	Overburden

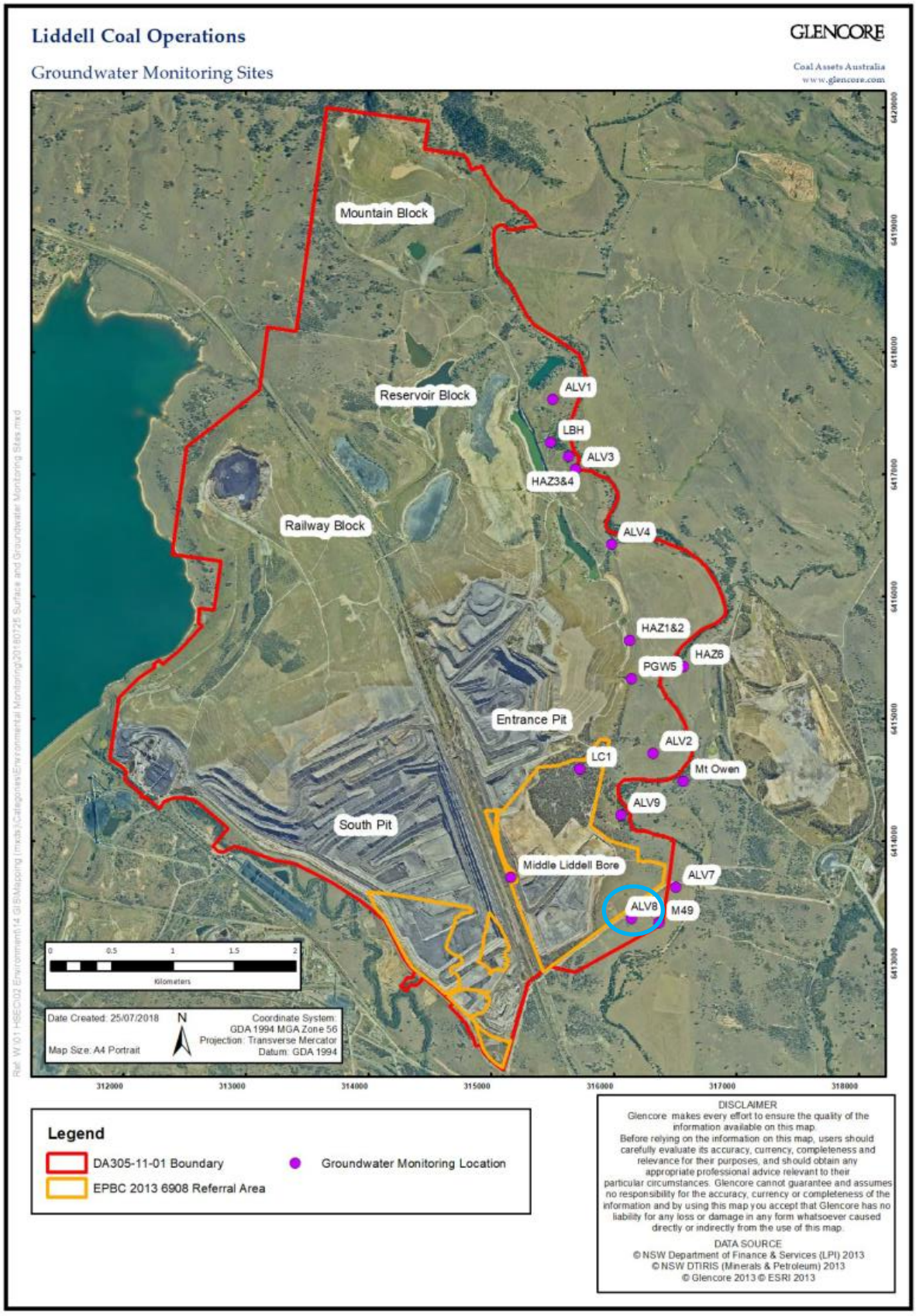

Figure 3.1: LCO – Groundwater monitoring locations (Glencore 2018b)

3.2 Climate

Long-term climate trends can be characterised using the cumulative relative departure (CRD) method. CRD shows trends in rainfall and evaporation relative to the long-term monthly averages and provides a historical record of wetter/drier periods and periods of elevated evaporation. A rising trend in slope in the CRD plot indicates periods of above average rainfall or evaporation, horizontal trends indicate average conditions, while a declining slope indicates periods of below average rainfall or evaporation. CRD for rainfall and evaporation has been used in this study to give context to variations in groundwater levels.

Figure 3.2 indicates the following in relation to rainfall and evaporation at Liddell:

- 2005 to mid-2007 was characterised by a period of below average rainfall (this period is referred to as the Millennium Drought), with a slightly above average evaporation rates compared to historic data;
- Mid-2007 to 2012 was characterised by a period of above average rainfall, with below average evaporation rates;
- 2012 to mid-2015 was characterised by above average evaporation rates that are increasing together with slightly above average rainfall. This is in contrast to other periods of above average rainfall which are normally accompanied by below average evaporation rates;
- mid-2015 to late-2016 was characterised by above average evaporation rates that are increasing together with average rainfall, causing a relatively drier period than the previous period;
- Late-2016 to late-2019 (present day) is characterised by severe drought conditions with on-going below average rainfall and above average evaporation since 2012.

A single rainfall event can influence the CRD rainfall trend. Three events that should be noted are those in early September (86 mm) and November (91 mm) 2006 (during the Millennium Drought) and more recently in late-February (82 mm) 2019. Each of these events have caused a peak in the CRD rainfall curve.

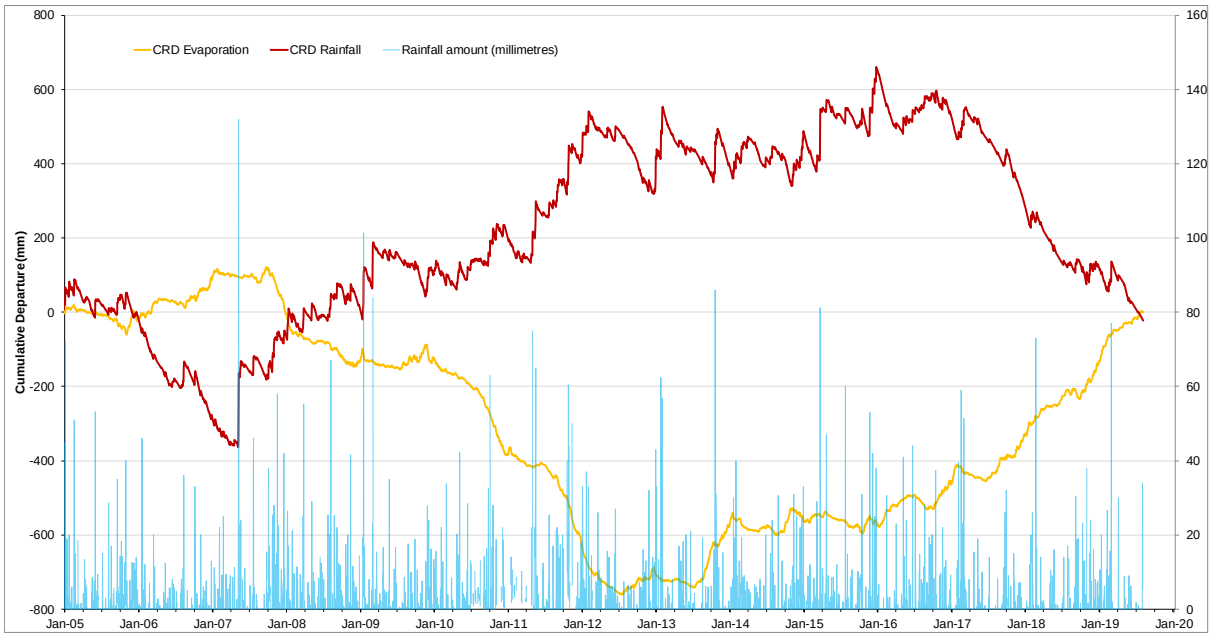

Figure 3.2: Cumulative departure - rainfall and evaporation

3.3 Groundwater modelling

In 2013, the Liddell mine numerical 3-Dimensional groundwater model was updated for the approvals process for MOD5 – the extension of LCO (Entrance Pit). The model conceptual hydrogeological summarised the groundwater system, including the estimated rates of vertical groundwater movement. The rates of recharge through unweathered Permian bedrock are considered to be very low, with estimates varying from near zero to no more than 1% of annual rainfall (SKM, 2013a). This was modelled in the calibration as a vertical to horizontal permeability ratio (kV:kH) of at least 1:100 and up to 1:1000 in the alluvium, 1:10 and up to 1:100 in the regolith (weather rock profile) and 1:10 in the coal measures overburden (SKM, 2013a). The kV:kH of the alluvium and the regolith is indicative of how little water moves vertically between the alluvium and the fractured rock aquifer.

The modelling results (SKM, 2013a) predict that there is likely to be similar leakage rates from, and drawdown in, the Bowmans Creek alluvium as for previous mining operations at LCO; that is, some leakage and drawdown in the alluvium has been approved under the consent. This peak leakage rate and drawdown corresponds to progression of the Entrance Pit into the M49 underground workings, located to the south-eastern side of the dyke and Davis Creek Fault.

The mining of the former Liddell M49 underground workings would require dewatering of the workings, which is considered the main driver for leakage and drawdown in the alluvium (SKM, 2013). Currently, the Entrance Pit does not extend to this point and an unmined barrier remains between the former underground and the open cut below the Lemington seams.

3.4 Mining – former underground and open cut workings

The Liddell mine area has historically been the site of extensive underground bord and pillar, longwall and open cut coal extraction. Figure 3.3 shows the extents of the underground workings and in the ALV8 area, coal was extracted from the ULD and the MLD seam, which are between 100 m and 200 m below ground level.

Former underground workings are located below Bowmans Creek. Assessments carried out in 1990 and 2013 have shown that subsidence impacts associated with the underground workings have since healed (SKM, 2013a). The 1990 assessment is a NSW Department of Land and Water Conservation (DLWC) report that concluded creek flows had re-established and that no long-term loss of flow would result from the former underground (SKM, 2013a). This healing process is further confirmed through the presence of groundwater in the Bowmans Creek monitoring bores (discussed further in the Section 4) and through the observation that significant changes in creek flow or storage within the alluvial lands do not have an observable influence on water levels within the old workings (MER, 2001). The former Liddell underground workings are currently flooded and the stored water is accessed via abstraction bore M49 (refer Figure 3.3). To date, the water stored in the former underground has not been abstracted for any purpose (pers. comm. Jarith Young – October 2019). Therefore, the predicted impacts associated with the dewatering of the former underground area cannot have occurred.

The current extent of Entrance Pit open cut footprint is some 400 m from ALV8 (refer **Error! Reference source not found.**) and in the south-eastern area of Entrance Pit mining has not occurred vertically beyond the Lemington seams (pers. comm. Jarith Young – October 2019). These seams overlie the mined ULD seam of the former underground. The impacts predicted in previous GIAs are based on the open cut approaching the proposed maximum limit footprint in the deeper seams and dewatering the underground. Currently, the Entrance Pit has not mined these seams and no complete dewatering of the underground has occurred; therefore, the impacts are unlikely to have reached the maximum predicted extent.

The flooded workings of the former Liddell underground workings are separated from the Entrance Pit by the Davis Creek Fault and Dyke (refer Figure 3.1). These two structures are considered a barrier to horizontal flow due to the fault's throw and the presence of the dyke (SKM, 2013a), which create a further barrier to seepage between the Entrance Pit and the former underground. These structures are in addition to the unmined barrier below the Lemington seams in the south-eastern portion of Entrance Pit.

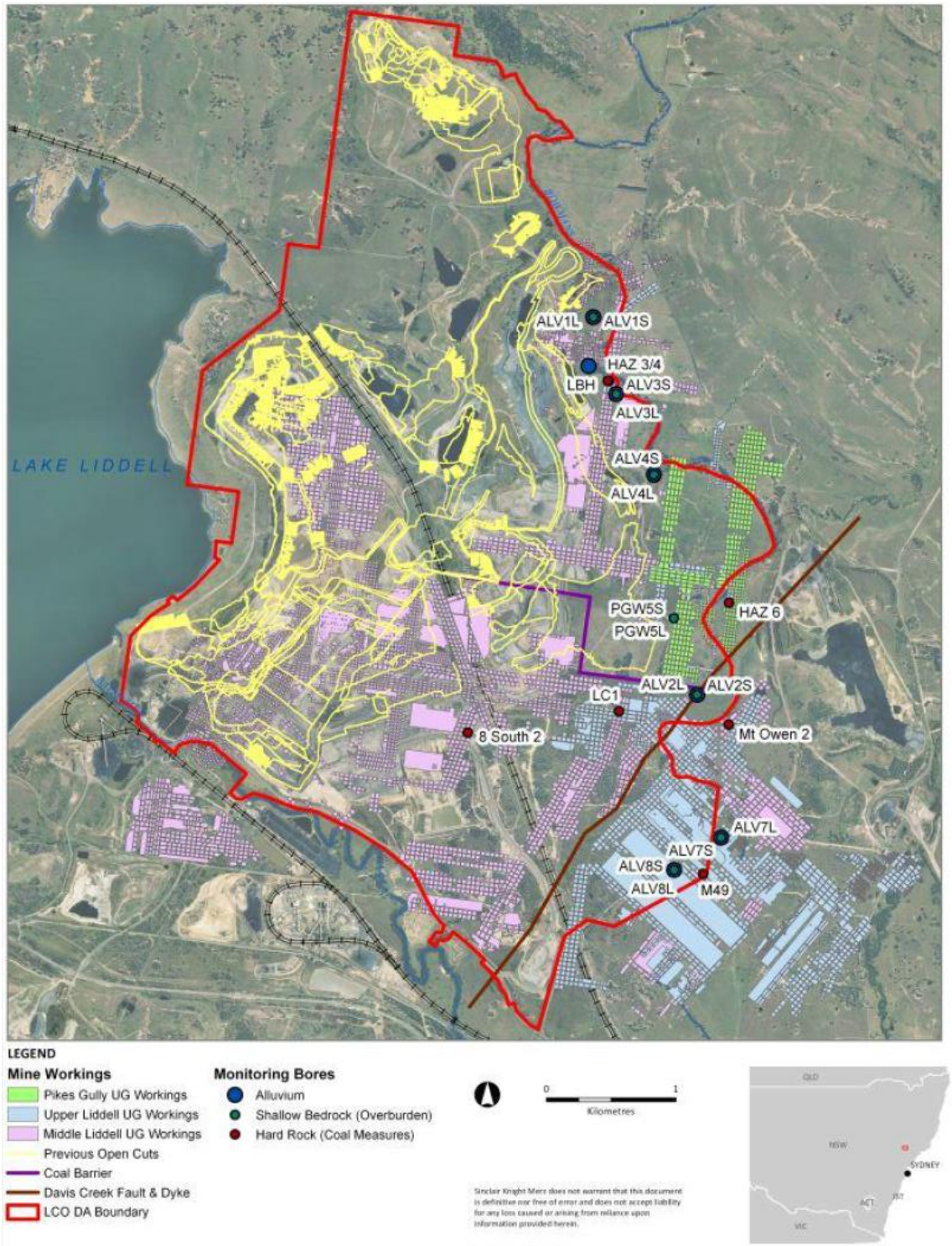

Figure 3.3: Historical underground workings (SKM, 2013)

4. Groundwater level ALV8L

The ALV8 monitoring site comprises a paired piezometer installation targeting the alluvial aquifer (ALV8L) and the underlying shallow bedrock (ALV8S). The groundwater level trigger exceedances at ALV8L over the past 24 months are summarised in Table 4.1 and ALV8S/ALV8L groundwater elevations and triggers (in mAHD) are shown on Figure 4.1. A CRD curve with respect to rainfall and evaporation is also plotted for analysis.

The site WMP defines the groundwater triggers for site monitoring bores in three components, including ALV8L. These include:

- The first component is a drawdown of 2m in the alluvium compared to a local reference site. In the case of ALV8L, the reference site is the up-gradient monitoring bore, ALV7L. The trigger is defined as "*the predicted difference in groundwater elevation between these ALV7L and ALV8L is 2.5m. The 2m drawdown is added to the difference in groundwater elevation between the sites*" (Glencore, 2018a) resulting in a trigger of 4.5 m relative difference between the water level measured in ALV7L and ALV8L.
- The second component is an investigation trigger and *"is a 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"* (Glencore, 2018a). The second component trigger for ALV8L is 6.96 mBGL (85.06 mAHD) (Glencore, 2018a).
- The third component is a subsequent investigation trigger and "*addresses the potential for harm to listed threatened species, communities and migratory species of concern to EPBC Approval 2013/6908 due to continuing exceedance of the lower 10th percentile trigger"* (Glencore, 2018a). This trigger is defined as "*Following an investigation of an exceedance of* [component 2] *Groundwater Level Trigger… 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 4.1 and Figure 4.1 show the ALV8S/ALV8L groundwater elevations and triggers (in mAHD). These data show that the Component 1 Trigger has not been exceeded despite Component 2 and 3 being triggered. The MOD5 GIA predicted that a 2.5 m drawdown will likely occur at ALV8L in 2022 following the dewatering of the former underground and the mining of the Davis Creek Fault and Dyke. The data shows that the ALV7L and ALV8L follow similar trends and do not differ by the 4.5 m of the Component 1 Trigger. It should also be noted that the recent water level measurements in the majority of Bowmans Creek monitoring bores have exceeded the reference data used to establish the bore trigger levels.

Figure 4.1 shows the groundwater level trend in ALV8L and ALV8S since 2005. The trend shows a good correlation with the rainfall CRD with above average rainfall causing increases in water levels and vice versa for below average rainfall periods. Of particular note, is the impact of the Millennium Drought on ALV8 water levels, where water levels in ALV8L declined to the base of the monitoring bore and ALV8S water levels also decline notably. More recently, the ALV8L and ALV8S water levels have been declining since early 2016, which was a period of above average evaporation coupled with average rainfall. The water levels in ALV8L and ALV8S began to decline most notably from mid-2017, with the decline in rainfall and increase in evaporation rates. That said, the alluvium groundwater level has followed a similar trend and has run dry, as observed during the Millennium Drought.

Also, the Bowmans Creek alluvium more widely also reacts in a similar manner to rainfall and evaporation. The hydrographs for the other Bowmans Creek area bores are shown in Figure 4.2. Significant water level declines can be observed in all bores during the period of the Millennium Drought and the more recent drought. As discussed in Section 3.2, the drought conditions

experienced at site since 2016 are more severe that those of the Millennium Drought. The impact of these conditions can be observed in the Bowmans Creek alluvium bores, all of which have exceeded their reference period-derived investigation trigger levels.

Table 4.1: ALV8L trigger groundwater level value and monthly observations

ALV8L Date	Water Level (mBGL)
10th Percentile Trigger	**6.96**
Oct-17	7.00
Nov-17	7.22
Dec-17	7.51
Jan-18	7.91
Feb-18	8.03
Mar-18	8.30
Apr-18	8.36
May-18	8.36
Jun-18	8.36
Jul-18	8.36
Aug-18	8.36
Sep-18	8.36
Oct-18	8.36
Nov-18	8.36
Dec-18	8.36
Jan-19	8.36
Feb-19	8.36
Mar-19	8.36
Apr-19	8.36
May-19	8.36
Jun-19	8.36
Jul-19	8.36
Aug-19	8.36
Sep-19	8.36

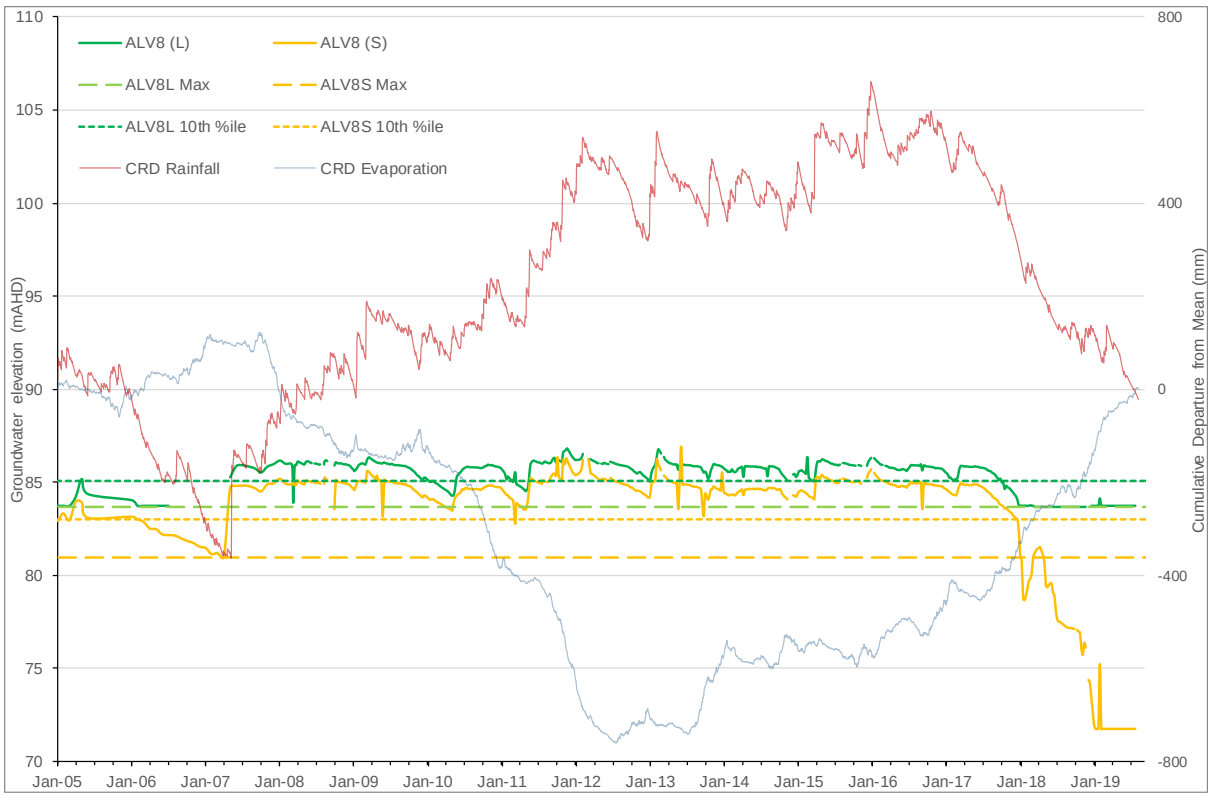

Figure 4.1: ALV8L/S hydrograph and triggers

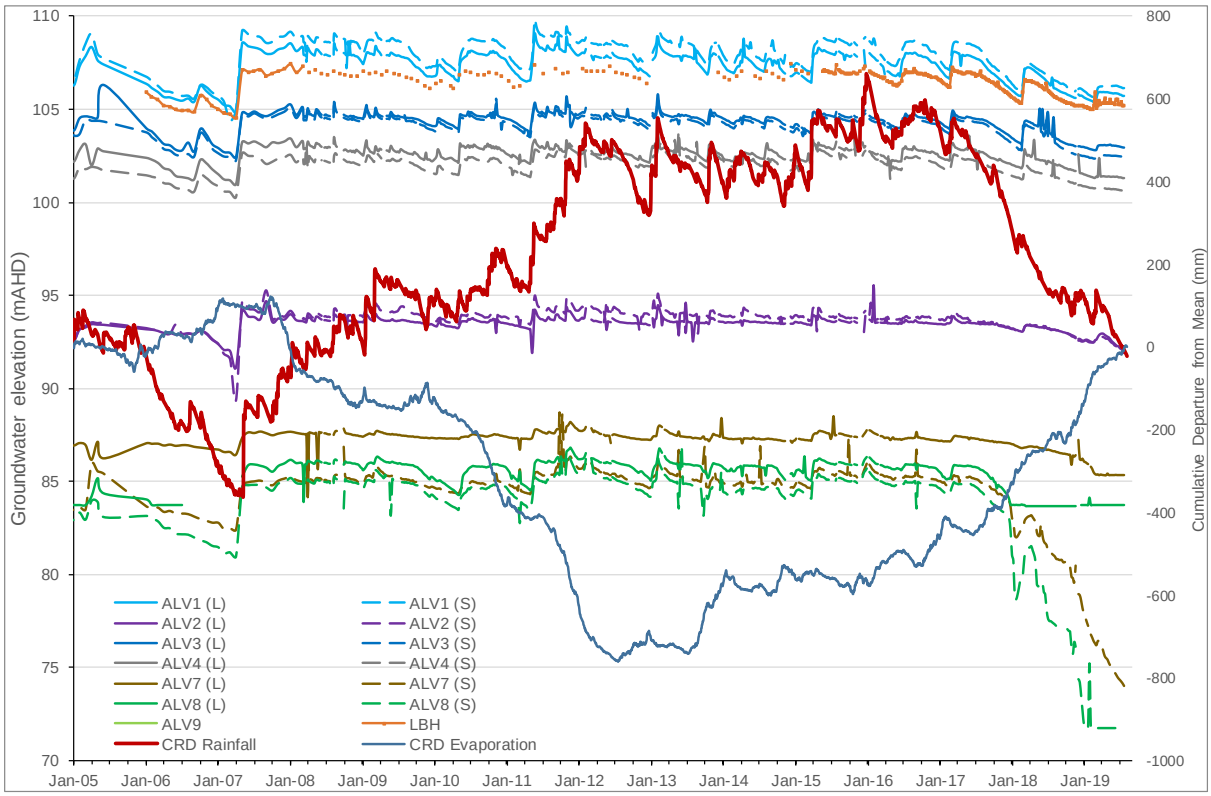

Figure 4.2: Bowmans Creek area monitoring bore hydrographs

5. Conclusion and recommendations

Generally, groundwater level trends in ALV8L, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. Periods of groundwater level decline in ALV8L have been observed during previous periods of below average rainfall, including the Millennium Drought, when ALV8L ran dry. ALV8L has been dry since April 2018, coinciding with a period of below average rainfall and above average evaporation. The period of below average evaporation has been observed since 2012. ALV7L (the ALV8L reference bore) has a water level trend similar to ALV8L, and ALV7L ran dry 12 months after ALV8L. Also, a number of other Bowmans Creek monitoring bores have exceeded their respective triggers but have not yet triggered the WMP response protocol.

Assessments carried out prior to and as part of the MOD5 GIA concluded that the recharge to the coal measure fractured rock aquifer is likely very low. This is primarily 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 ALV8 area.

The mining consent has approved some impacts to the Bowmans Creek alluvium and the groundwater model showed that these impacts are predominantly driven by the removal of the Davis Creek Fault and Dyke and the dewatering of the former Liddell M49 underground workings. The mining of the Davis Creek Fault and Dyke below the Lemington seams and the dewatering of the M49 workings have not occurred to date, nor have there been any containment failures of water stored in the underground; therefore, they are unlikely to have impacted the water level in ALV8L.

The groundwater depths measured at ALV8L reflect natural variability due to climatic factors and it is unlikely that the decline is a mining-related impact. The lack of groundwater in the alluvium precludes further investigation. When there is significant recharge to the alluvium, further investigation could be conducted to determine whether connectivity between the alluvial and fractured rock aquifers has altered. The trigger exceedance in ALV8L is not outside of the maximum range recorded, considering it has run dry previously, and it is unlikely that future beneficial use of the alluvial resource will be impacted.

It is recommended that routine monitoring continues at ALV8L and other Bowmans Creek monitoring locations, and that investigation be carried out as required by the WMP.

6. References

BOM (2019) historical weather data for BOM station Bowmans Creek (Grenell) Number: 61270, accessed on 31 October 2019. http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=061270

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SKM (2013a). *Liddell Coal Operations – Modification 5 to Development Consent DA 305-11-01 – Groundwater Impact Assessment – V05*. April 2013.

SKM (2013b). *Groundwater Model for the Jerrys and Glennies Water Sources*. May 2013.

Appendix K - January 2020 – ALV7S, ALV7L and ALV8S Groundwater Level ITARP

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03 March 2020

Attention: Jarith Young – Glencore
Glencore
Liddell Coal Operations Pty Ltd

Project Name: Liddell Coal Operations Pty Ltd - ALV7S, ALV7L and ALV8S - Groundwater trigger exceedance review
Project Number: IA131807

Subject: Liddell Coal Operations Pty Ltd - ALV7S, ALV7L and ALV8S - Groundwater trigger exceedance review

1. Introduction

Liddell Coal Operations Pty Ltd (LCO) commissioned Jacobs Group (Australia) Pty Ltd (Jacobs) to undertake an investigation of groundwater monitoring results at monitoring bores – ALV7S, ALV7L and ALV8S. Specifically, ALV7S, ALV7L and ALV8S have recorded exceedances of groundwater level trigger Definition #2 continuously for 24 months between February 2018 and January 2020; it should be noted that the Definition #1 groundwater level trigger have not been exceeded.

The site WMP defines the groundwater triggers for site monitoring bores in three components. These include:

- The first component (Definition #1) is a drawdown of 2m in the alluvium compared to a local reference site.
- The second component (Definition #2) is an investigation trigger and "*is a 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*" (Glencore, 2020).
- The third component (Definition #3) is a subsequent investigation trigger and "*addresses the potential for harm to listed threatened species, communities and migratory species of concern to EPBC Approval 2013/6908 due to continuing exceedance of the lower 10th percentile trigger*" (Glencore, 2020). This trigger is defined as "*Following an investigation of an exceedance of [component 2] Groundwater Level Trigger… 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.*"

This report is the summary of the investigation into whether the causes of the water level trigger exceedances are mining related and determine whether the measured levels present potential to harm the environment. The investigation has been undertaken in accordance with the LCO Water

Management Plan (WMP) (Glencore, 2020), which was approved within NSW DA305-11-01 and EPBC Approval 2013/6908.

LCO previously investigated trigger exceedances at each of the monitoring locations, as per the WMP requirements. These investigations were notified to the Department of Environment and Energy (DoEE) and both the NSW Department of Planning, Industry and Environment (DPIE) – Planning & Assessment Division and the Water Division and included the three month groundwater level exceedance and the twelve month groundwater level exceedance. The conclusions of the previous investigations are as follows:

- Three month investigation report in May 2018 (Jacobs, 2018) concluded the water decline to be climatically driven.
- Twelve month investigation in February 2019 (Glencore, 2018b) concluded found the decline is likely related to the drought and potential harm to the environment was not expected.

This report details the Investigation Trigger Action Response Plan (ITARP) undertaken for the subsequent trigger exceedances and if the causes of the exceedances continue to be unrelated to mining activity and pose no potential harm to the environment.

2. Scope

The scope of this groundwater investigation comprises:

- Investigation of long-term groundwater trigger level exceedances at groundwater monitoring site ALV7S, ALV7L and ALV8S.
- Assessment of whether there is potential harm to the environment from the causes of the exceedances and determine whether the exceedance cause is mining related.

3. Background

3.1 Monitoring bore details

Monitoring locations ALV7 and ALV8 are clustered monitoring locations that each consist of two monitoring bores that target separate water bearing units within the one drillhole. ALV7L and ALV8L target the Bowmans Creek alluvium, whereas ALV7S and ALV8S target the underlying shallow coal measures overburden. Monitoring bore construction details for ALV7 and ALV8 are provided in Table 3.1. The groundwater monitoring network is shown on Figure 3.1.

Table 3.1: ALV8L construction details

Monitoring Bore	Easting	Northing	Collar (mAHD)	Bore Base (m)	Bore Base (mAHD)	Target Aquifer
ALV7L	316511.53	6413624.55	93.77	8.44	85.33	Alluvium
ALV7S				23.55	70.22	Overburden
ALV8L	316148.2	6413366.7	92.02	8.30	83.72	Alluvium
ALV8S				20.28	71.74	Overburden

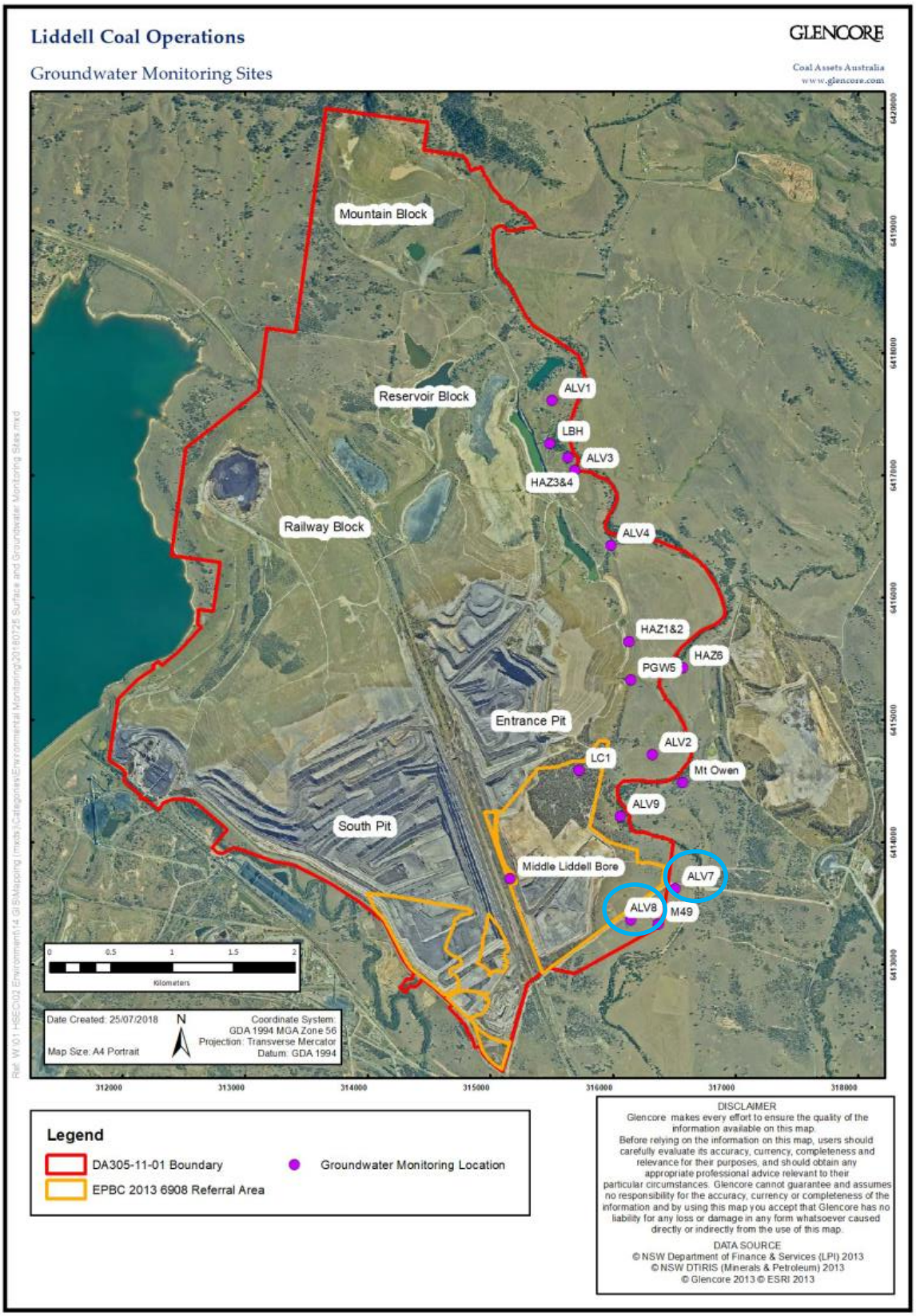

Figure 3.1: LCO – Groundwater monitoring locations (Glencore 2020)

3.2 Climate

Long-term climate trends can be characterised using the cumulative relative departure (CRD) method. CRD shows trends in rainfall and evaporation relative to the long-term monthly averages and provides a historical record of wetter/drier periods and periods of elevated evaporation. A rising trend in slope in the CRD plot indicates periods of above average rainfall or evaporation, horizontal trends indicate average conditions, while a declining slope indicates periods of below average rainfall or evaporation. CRD for rainfall and evaporation has been used in this study to give context to variations in groundwater levels.

Figure 3.2 indicates the following in relation to rainfall and evaporation at LCO:

- 2005 to mid-2007 was characterised by a period of below average rainfall (this period is referred to as the Millennium Drought), with a slightly above average evaporation rates compared to historic data;
- Mid-2007 to 2012 was characterised by a period of above average rainfall, with below average evaporation rates;
- 2012 to mid-2015 was characterised by above average evaporation rates that are increasing together with slightly above average rainfall. This is in contrast to other periods of above average rainfall which are normally accompanied by below average evaporation rates;
- mid-2015 to late-2016 was characterised by above average evaporation rates that are increasing together with average rainfall, causing a relatively drier period than the previous period;
- Late-2016 to August-2019 is characterised by severe drought conditions with on-going below average rainfall and above average evaporation since 2012;
- August-2019 to end-January 2020 is characterised by severe drought conditions with on-going below average rainfall, whereas evaporation rates have decrease moving to below average rates;
- Early February-2020 was a period of above average rainfall with decreasing evaporation rates. These were caused by a number of severe and sudden rainfall events.

A single rainfall event can influence the CRD rainfall trend. Events that should be noted are those in early September (86 mm) and November (91 mm) 2006 (during the Millennium Drought), late-February (82 mm) 2019 and more recently in early-February (35 mm) 2020. Each of these events have caused a peak in the CRD rainfall curve.

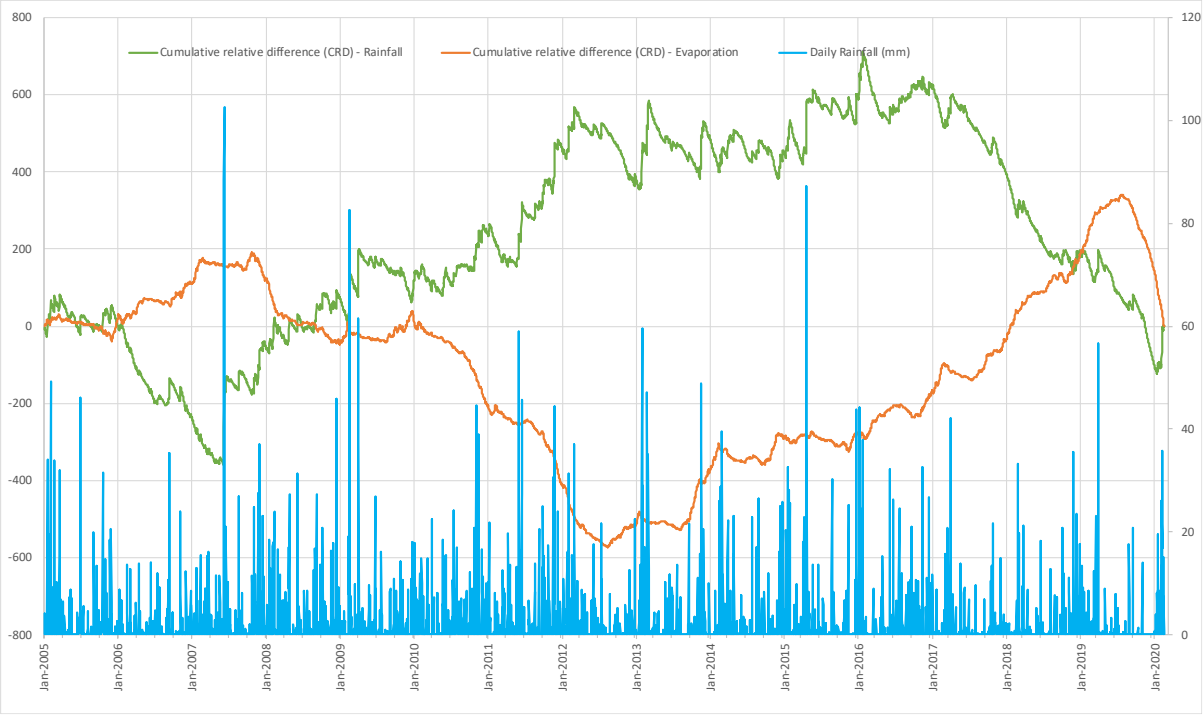

Figure 3.2: Cumulative departure - rainfall and evaporation

3.3 Groundwater modelling

In 2013, the Liddell mine numerical 3-Dimensional (3D) groundwater model was updated for the approvals process for MOD5 – the extension of LCO (Entrance Pit). The conceptual hydrogeological model summarised the groundwater system, including the estimated rates of vertical groundwater movement. The rates of recharge through unweathered Permian bedrock are considered to be very low, with estimates varying from near zero to no more than 1% of annual rainfall (SKM, 2013a). This was modelled in the calibration as a vertical to horizontal permeability ratio (kV:kH) of at least 1:100 and up to 1:1000 in the alluvium, 1:10 and up to 1:100 in the regolith (weather rock profile) and 1:10 in the coal measures overburden (SKM, 2013a). The kV:kH of the alluvium and the regolith is indicative of how little water moves vertically between the alluvium and the fractured rock aquifer.

The modelling results (SKM, 2013a) predict that there is likely to be similar leakage rates from, and drawdown in, the Bowmans Creek alluvium as for previous mining operations at LCO; that is, some leakage and drawdown in the alluvium and depressurisation of the fractured rock aquifer has been approved under the consent. This peak leakage rate and drawdown corresponds to progression of the Entrance Pit into the M49 underground workings, located to the south-eastern side of the dyke and Davis Creek Fault.

The mining of the former Liddell M49 underground workings would require dewatering of the workings, which is considered the main driver for leakage and drawdown in the alluvium (SKM, 2013).

3.4 Mining – former underground and open cut workings

The Liddell mine area has historically been the site of extensive underground bord and pillar, longwall and open cut coal extraction. Figure 3.3 shows the extents of the underground workings and in the ALV7/ALV8 area, coal was extracted from the ULD and the MLD seam, which are between 100 m and 200 m below ground level.

The former underground workings are located below Bowmans Creek. Assessments carried out in 1990 and 2013 have shown that subsidence impacts associated with the underground workings have since healed (SKM, 2013a). The 1990 assessment is a NSW Department of Land and Water Conservation (DLWC) report that concluded creek flows had re-established and that no long-term loss of flow would result from the former underground (SKM, 2013a). This healing process is further confirmed through the observation that significant changes in creek flow or storage within the alluvial lands do not have an observable influence on water levels within the old workings (MER, 2001). The former Liddell underground workings are currently flooded and the stored water is accessed via abstraction bore M49 (refer Figure 3.3). Water from the underground was abstracted for two periods since the recent drought began. The M49 Underground area has not been dewatered, despite the 270 ML abstracted in Q2/Q3 2017 and 545 ML abstracted in late-Q3/Q4 2019 (pers. comm. Jarith Young – February 2020). Therefore, the predicted impacts associated with the total dewatering of the former underground area cannot have occurred.

The current extent of Entrance Pit/Bayswater Pit open cut footprint is some 400 m from ALV8 and 700 m from ALV7 (refer Figure 3.3). In the south-eastern area of Entrance Pit, mining has lowered the pit floor from approximately 103 mAHD in mid-2017 to approximately 25.5 mAHD in late-2019. The pit floor elevation as at late-2019 (25 mAHD) is some 45 m below the base of ALV7S and ALV8S.

The ALV7/ALV8 area overlies the mined ULD seam of the former M49 underground. The impacts predicted in previous GIAs are based on the open cut approaching the proposed maximum limit footprint in the deeper seams (coal seams below the Lemington seams) and total dewatering the underground. That said, it is considered likely that the coal measures above the Entrance Pit floor elevation (outside of the mine footprint) will have depressurised to a level equivalent to the outcrop in Entrance Pit, with subsequent vertical drainage of the overlying formations. It is likely that ALV7S and ALV8S intersect the same hydrogeological units that may act as a conduit for drainage/depressurisation.

The flooded workings of the former Liddell underground workings are separated from the northern portion of the Entrance Pit by the Davis Creek Fault and Dyke (refer Figure 3.3 Figure 3.1). These two structures are considered a barrier to horizontal flow due to the fault's throw and the presence of the dyke (SKM, 2013a), which create a further barrier to seepage between the Entrance Pit and the former underground.

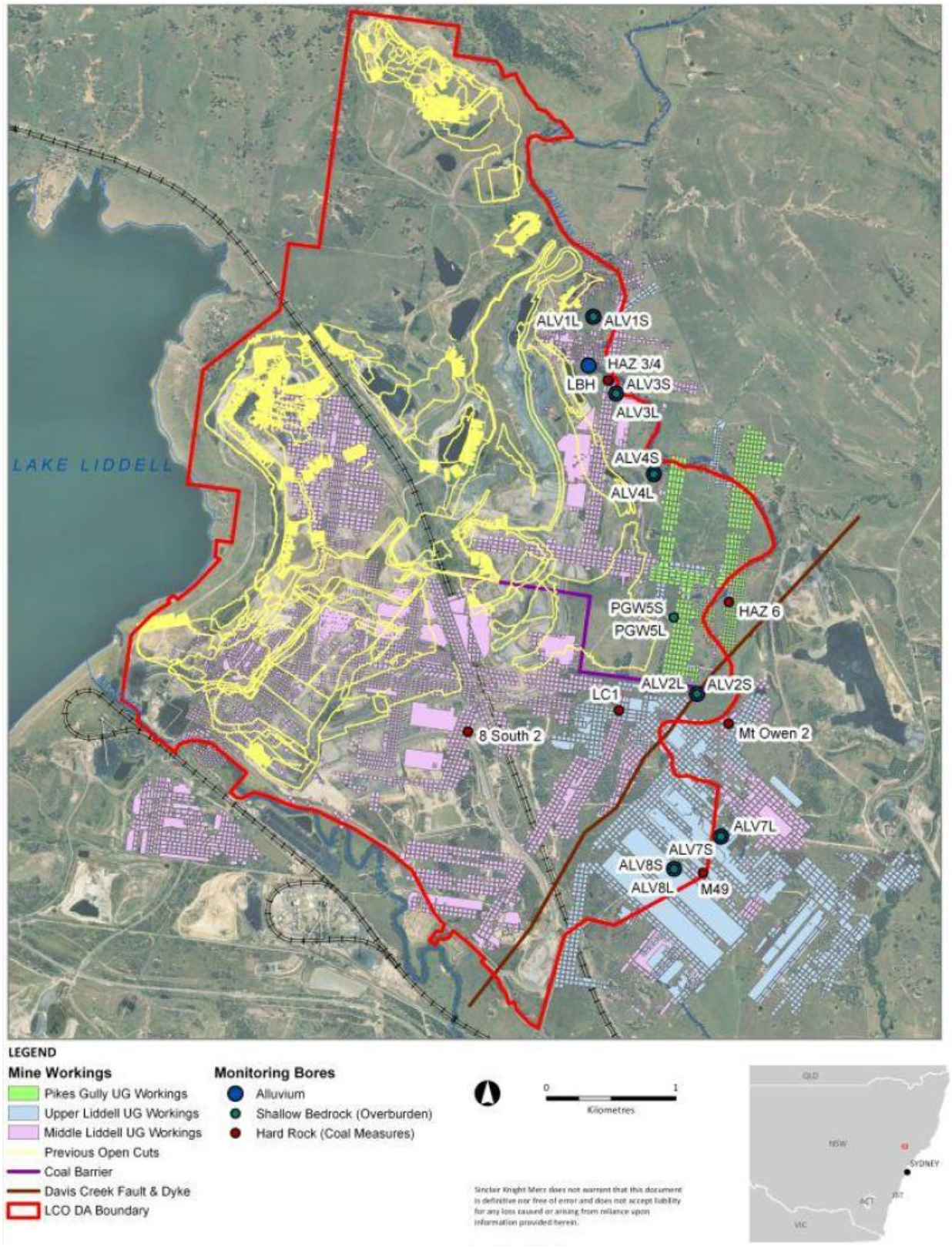

Figure 3.3: Historical underground workings (SKM, 2013)

4. Assessment

4.1 Groundwater levels

The groundwater level trigger exceedances at ALV7L, ALV7S and ALV8S over the past 24 months are summarised in Table 4.1 and the groundwater elevation trends and triggers (in mAHD) are shown on Figure 4.1 and Figure 4.2**Error! Reference source not found.**, respectively. A CRD curve with respect to rainfall and evaporation is also plotted for analysis. All of the Bowmans Creek area monitoring bore hydrographs are plotted on Figure 4.3 and the ALV7L, ALV7S and ALV8S hydrographs plotted against rainfall are shown on Figure 4.4. It should also be noted that the recent water level measurements in the majority of Bowmans Creek monitoring bores have exceeded the reference data used to establish the bore trigger levels.

The ALV7L water level, and the alluvium more widely, show a good correlation with the rainfall CRD with above average rainfall causing increases in water levels and vice versa for below average rainfall periods. The hydrograph for ALV7L and for the other Bowmans Creek area bores are shown in Figure 4.1 and Figure 4.3, respectively. Significant water level declines can be observed in all bores during the period of the Millennium Drought and the current and continuing drought. As discussed in Section 3.2, the drought conditions experienced at site since 2016 are more severe that those of the Millennium Drought. The impact of these conditions can be observed in the Bowmans Creek alluvium bores, all of which have exceeded their reference period-derived investigation trigger levels.

Figure 4.1 and **Error! Reference source not found.** show the groundwater level trends in ALV7S and ALV8S since 2008. The trends, similar to the alluvium, show a good correlation with the rainfall and evaporation CRD. Of particular note, are the water levels in ALV7S and ALV8S, which have been declining since early 2016, which was a period of above average evaporation coupled with below average rainfall. The water levels in ALV7S and ALV8S began to decline most notably from mid-2017, with the decline in rainfall and increase in evaporation rates. The decline in ALV7S and ALV8S also coincides with the increased depth in mining in the south-west of the Entrance pit. As discussed in Section 3.4, it is considered likely that the coal measures above the Entrance Pit floor elevation (outside of the mine footprint) will have depressurised to a level equivalent to the outcrop in Entrance Pit, with subsequent vertical drainage of the overlying fractured rock units. ALV7S and ALV8S intersect those same hydrogeological units, which may act as a conduit for drainage/depressurisation. Following the groundwater level decline, post mid-2017, rainfall recharge events are still visible on the hydrographs and is particularly visible in February and November 2018 (refer Figure 4.4).

Table 4.1: Trigger level value and monthly measurements

Date	Water levels (mBGL)		
	ALV7L	ALV7S	ALV8S
10th Percentile Trigger	**6.75**	**10.21**	**9.03**
Feb-18	6.81	11.50	12.80
Mar-18	6.97	11.46	12.35
Apr-18	6.97	10.71	10.73
May-18	6.93	10.84	10.71
Jun-18	7.00	11.70	12.48
Jul-18	7.09	12.21	13.94
Aug-18	7.14	12.68	14.61

Date	Water levels (mBGL)		
	ALV7L	ALV7S	ALV8S
Sep-18	7.23	12.94	14.85
Oct-18	7.29	13.13	14.91
Nov-18	7.35	13.32	15.07
Dec-18	7.45	14.21	15.67
Jan-19	7.63	15.12	18.59
Feb-19	7.85	16.55	20.28 (dry)
Mar-19	8.29	17.37	20.28 (dry)
Apr-19	8.45 (dry)	17.39	20.28 (dry)
May-19	8.45 (dry)	18.17	20.28 (dry)
Jun-19	8.45 (dry)	18.70	20.28 (dry)
Jul-19	8.45 (dry)	19.14	20.28 (dry)
Aug-19	8.45 (dry)	19.65	20.28 (dry)
Sep-19	8.45 (dry)	20.11	20.28 (dry)
Oct-19	8.45 (dry)	20.39	20.28 (dry)
Nov-19	8.45 (dry)	20.92	20.28 (dry)
Dec-19	8.45 (dry)	21.31	20.28 (dry)
Jan-20	8.45 (dry)	21.54	20.28 (dry)
Feb-20	8.45 (dry)	22.11	20.28 (dry)

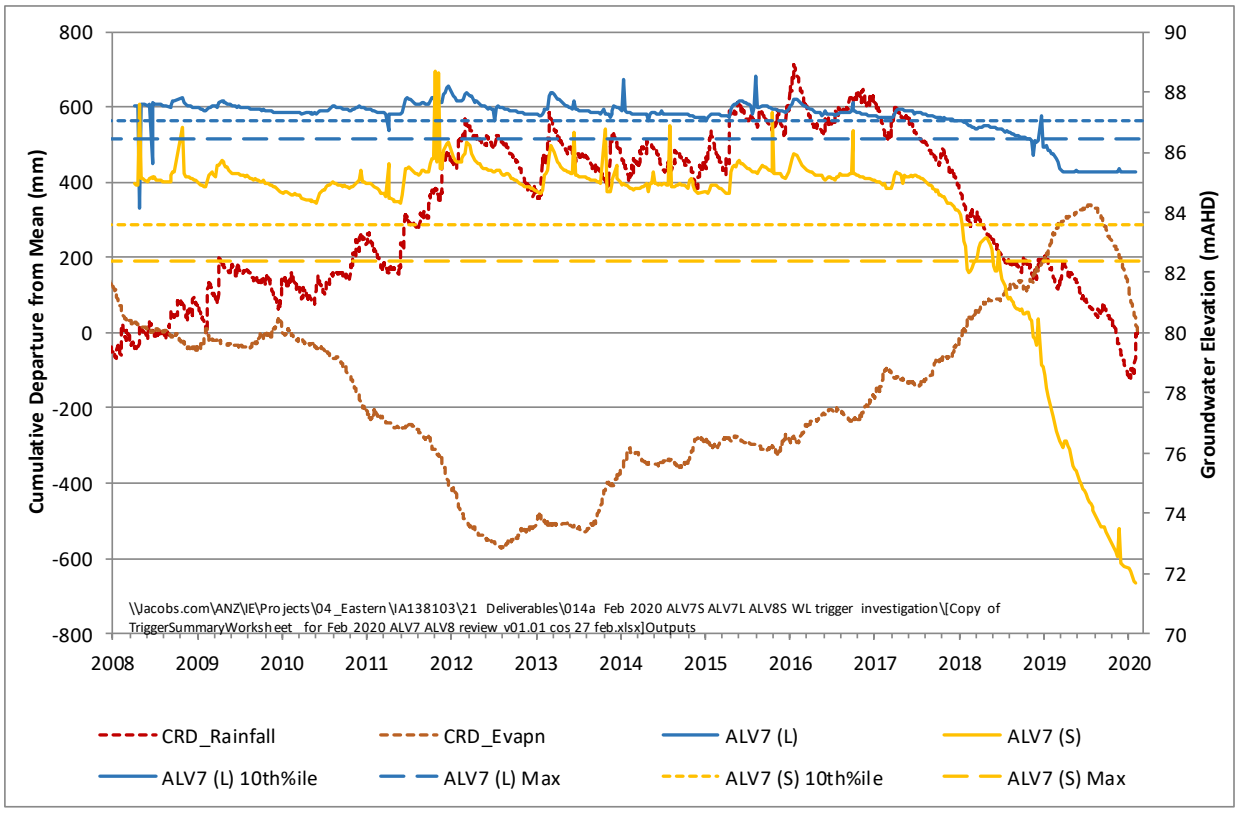

Figure 4.1: ALV7L/S hydrograph and triggers

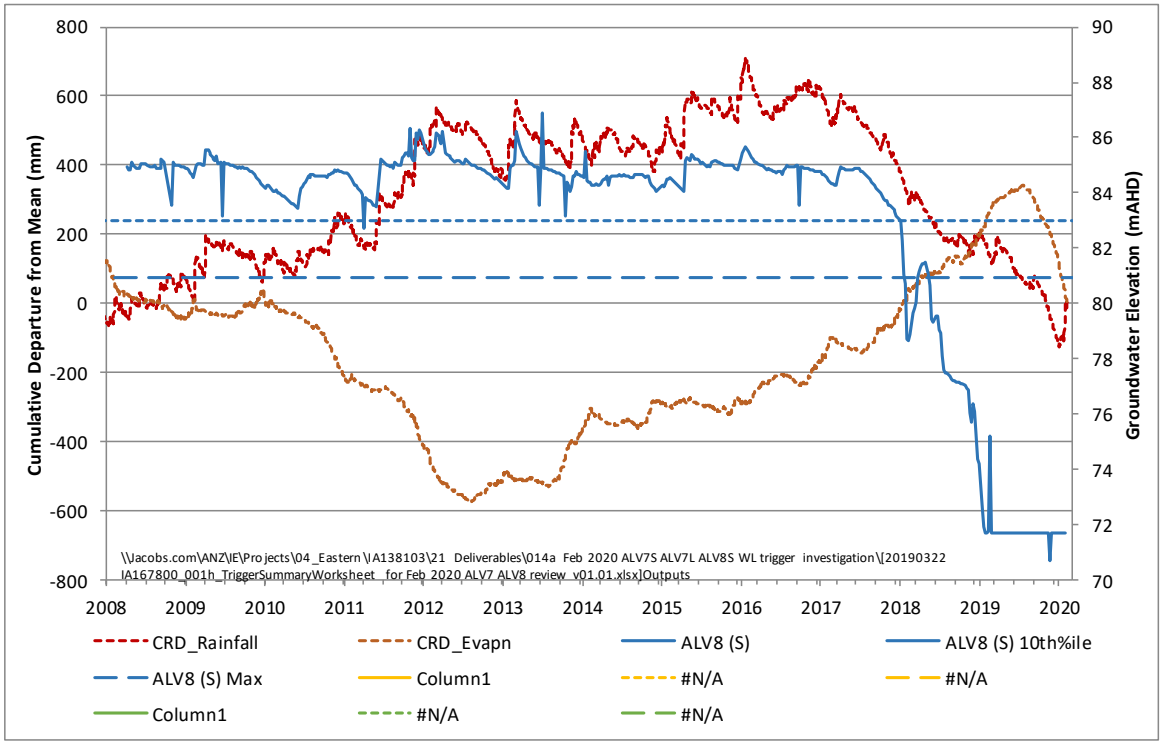

Figure 4.2: ALV8S hydrograph and triggers

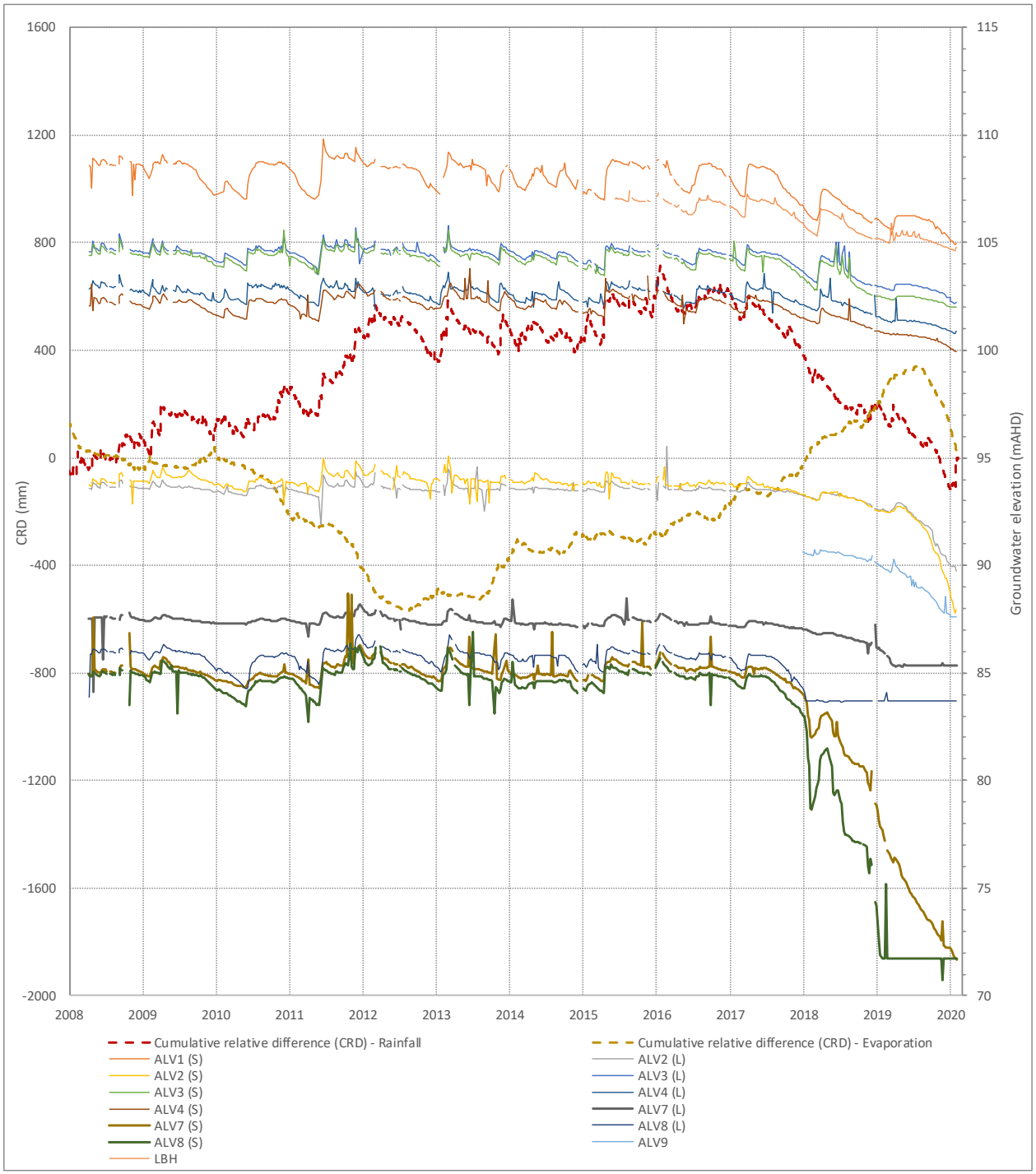

Figure 4.3: Bowmans Creek area monitoring bore hydrographs

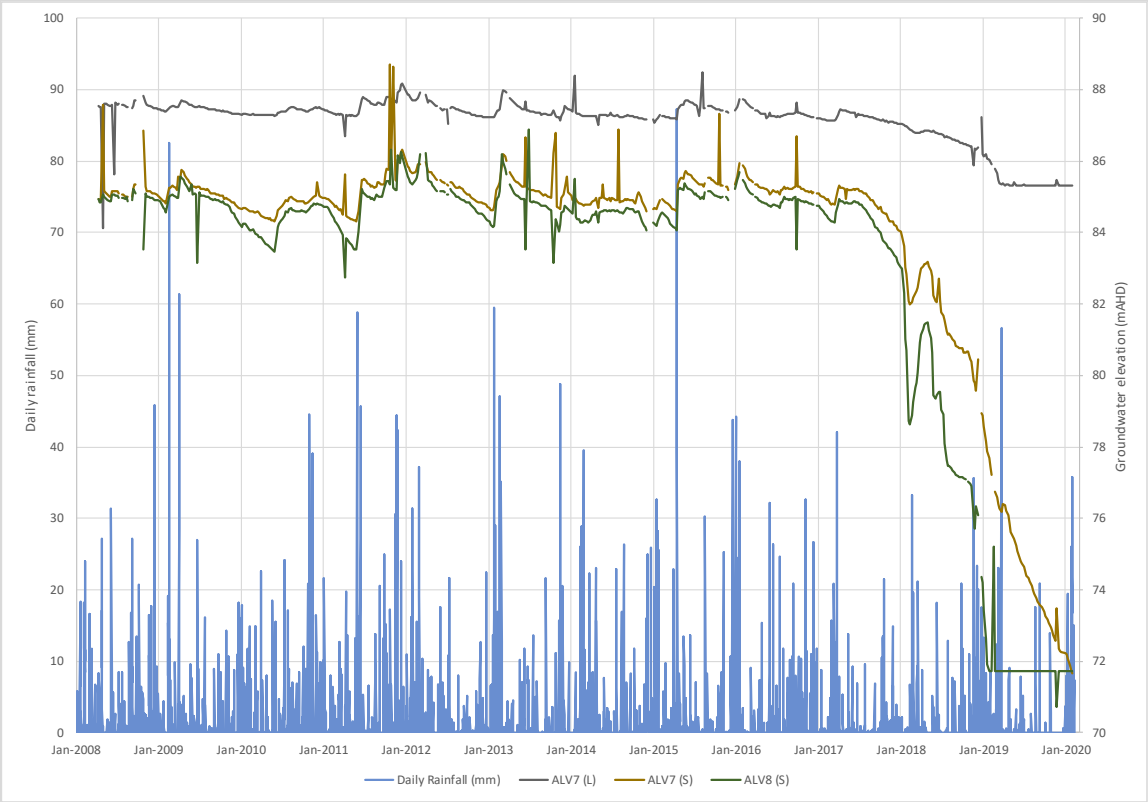

Figure 4.4: ALV7L, ALV7S and ALV8S hydrographs versus daily rainfall

4.2 Bowmans Creek levels

The water level measured at the WaterNSW monitoring station - 210130 - D/S Bowmans is plotted in Figure 4.5 versus vs rainfall. The water level in Bowmans Creek aligns well with the rainfall and spikes in the creek level correspond with significant rainfall events. Observations by LCO monitoring contractor (shown in Table 4.2 and the locations are shown on Figure 4.6) and the WaterNSW monitoring station show that tracts of Bowmans Creek have been dry since around mid-2018.

As the Bowmans Creek alluvium is predominantly recharged from surface flow in the creek, it is not unreasonable for the alluvium to have run dry due to the lack of flow in the creek.

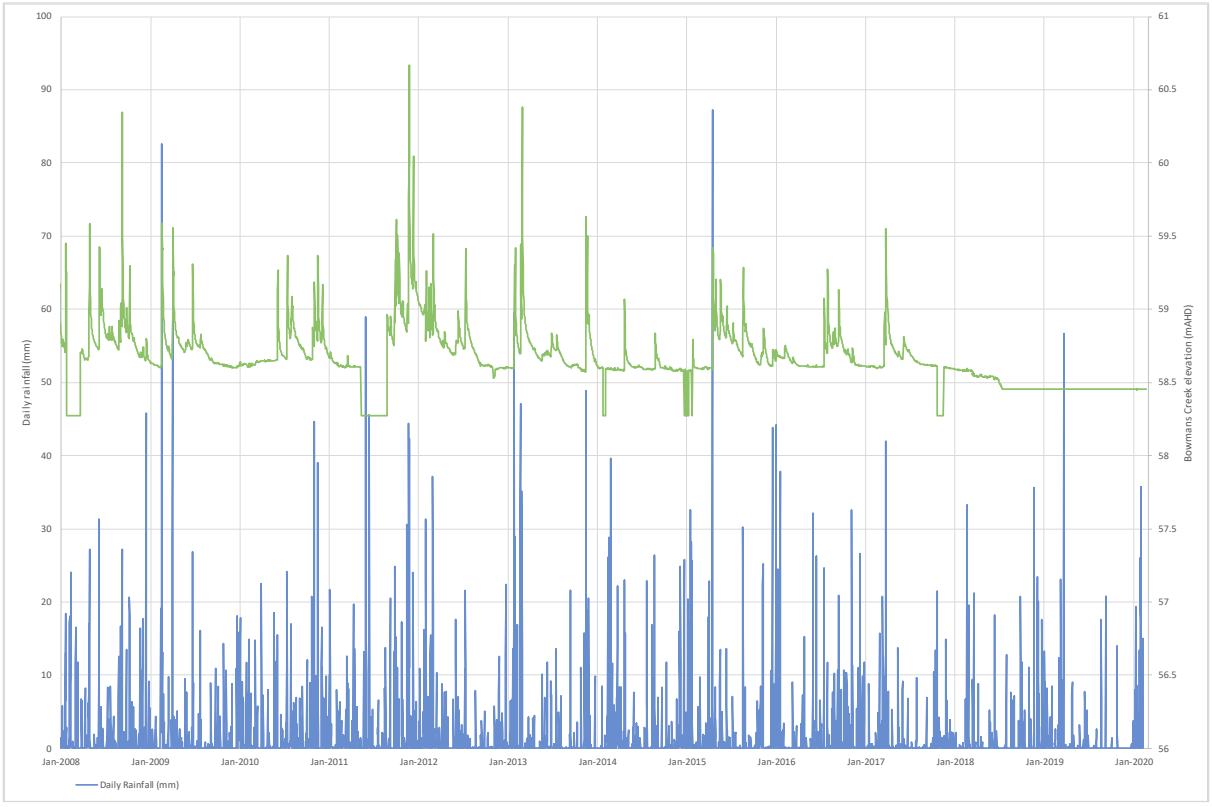

Figure 4.5: Bowmans Creek water elevation (WNSW station 210130 - D/S Bowmans) vs rainfall

Table 4.2: Liddell mine - Bowmans Creek observations

Date	BCK1 (Up-stream)	BCK1A	BCK2	BCK2A	BCK3	BCK4	BCK5	BCK6 (Down-stream)
Jul-15	Slow	Trickle	Slow	Trickle	Slow	Slow	V. Slow	Trickle
Aug-15	V. Slow	Trickle	Slow	Trickle	Slow	Slow	Slow	Slow
Sep-15	Slow	Steady	Slow	Slow	Slow	Slow	Slow	Slow
Oct-15	Slow	Slow	Slow	Trickle	Slow	Slow	Slow	Slow
Nov-15	Slow	Slow	Slow	Trickle	Slow	Slow	Slow	Trickle
Dec-15	Slow	Trickle	Slow	Trickle	Slow	Slow	Slow	Trickle
Jan-16	Steady	Steady	Steady	Steady	Steady	Steady	Steady	Steady
Feb-16	Slow	Trickle	Trickle	Trickle	Slow	Slow	Slow	Slow
Mar-16	Slow	Trickle	Trickle	Trickle	Slow	Slow	Slow	Trickle
Apr-16	V. Slow	Trickle	Slow	Trickle	Slow	Slow	Slow	V. Slow
May-16	Still	Still	Still	Still	Still	Still	Still	Slow
Jun-16	Slow	Slow	Still	Still	Slow	Slow	Slow	Slow
Jul-16	Slow	Trickle	Trickle	Still	Slow	Trickle	Trickle	Slow
Aug-16	Slow	Slow	Slow	Slow	Slow	Slow	Slow	Slow

Date	BCK1 (Up-stream)	BCK1A	BCK2	BCK2A	BCK3	BCK4	BCK5	BCK6 (Down-stream)
Sep-16	Steady	Steady	Steady	Fast	Steady	Slow	Steady	Fast
Oct-16	Slow	Slow	Slow	Slow	Slow	Slow	Slow	Slow
Nov-16	Still	Slow	Slow	Trickle	Slow	Slow	Slow	Slow
Dec-16	Slow	Trickle	Still	Still	Slow	Slow	Slow	Slow
Jan-17	Slow	Trickle	Slow	Still	Slow	Slow	Slow	Slow
Feb-17	V. Slow	Trickle	Pools	Pools	Still	V. Slow	Still	V. Slow
Mar-17	Slow	Slow	Pools	Pools	Slow	Slow	Slow	Slow
Apr-17	Slow	Steady	Slow	Steady	Slow	Slow	Slow	Slow
22-May-17	Slow	Slow	Slow	Slow	Slow	Slow	Slow	Slow
26-Jun-17	Slow	Steady	Slow	Steady	Slow	Slow	Slow	Slow
19-Jul-17	Slow	Slow	Slow	Slow	Slow	Slow	Slow	Slow
21-Aug-17	Slow	Trickle	Slow	Trickle	Slow	Slow	Slow	Slow
18-Sep-17	Slow	Slow	Slow	Still	Slow	Slow	Slow	Slow
23-Oct-17	Slow	Trickle	Pools	Pools	Still	Slow	Still	Trickle
20-Nov-17	Still	Still	Pools	Pools	Still	Still	Still	Still
18-Dec-17	Still	Still	Still	Dry	Still	Still	Still	Still
12-Jan-18	Still	Still	Dry	Still	Still	Still	Still	Still
09-Feb-18	Still	Still	Dry	Dry	Still	Still	Still	Still
12-Mar-18	Still	Trickle	Dry	Dry	Still	Still	Still	Dry
16-Apr-18	Slow	Steady	Still	Dry	Trickle	Still	Still	Still
22-May-18	Slow	Trickle	Dry	Dry	Slow	Still	Still	Still
25-Jun-18	Slow	Trickle	Dry	Dry	Still	Still	Still	Still
24-Jul-18	Slow	Slow	Dry	Dry	Still	Still	Still	Dry
21-Aug-18	Slow	Slow	Dry	Dry	Slow	Slow	Dry	Dry
18-Sep-18	Slow	Slow	Dry	Dry	Slow	Still	Dry	Dry
15-Oct-18	Trickle	Trickle	Dry	Dry	Still	Still	Still	Dry
12-Nov-18	Still	Trickle	Dry	Dry	Still	Still	Still	Dry
10-Dec-18	Still	Trickle	Dry	Dry	Still	Still	Dry	Dry
14-Jan-19	Trickle	Trickle	Dry	Dry	Still	Still	Dry	Dry
20-Feb-19	Trickle	Trickle	Dry	Dry	Too low to sample	Too low to sample	Dry	Dry
18-Mar-19	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry
15-Apr-19	Slow	Slow	Dry	Dry	Still	Still	Dry	Dry
13-May-19	Still	Trickle	Dry	Dry	Still	Still	Dry	Dry
11-Jun-19	Still	Trickle	Dry	Dry	Too low to sample	Still	Dry	Dry
08-Jul-19	Still	Trickle	Dry	Dry	Too low to sample	Still	Dry	Dry
12-Aug-19	Trickle	Trickle	Dry	Dry	Dry	Dry	Dry	Dry

Date	BCK1 (Up-stream)	BCK1A	BCK2	BCK2A	BCK3	BCK4	BCK5	BCK6 (Down-stream)
10-Sep-19	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry
08-Oct-19	Still	Trickle	Dry	Dry	Dry	Dry	Dry	Dry
11-Nov-19	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry
09-Dec-19	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry
08-Jan-20	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry

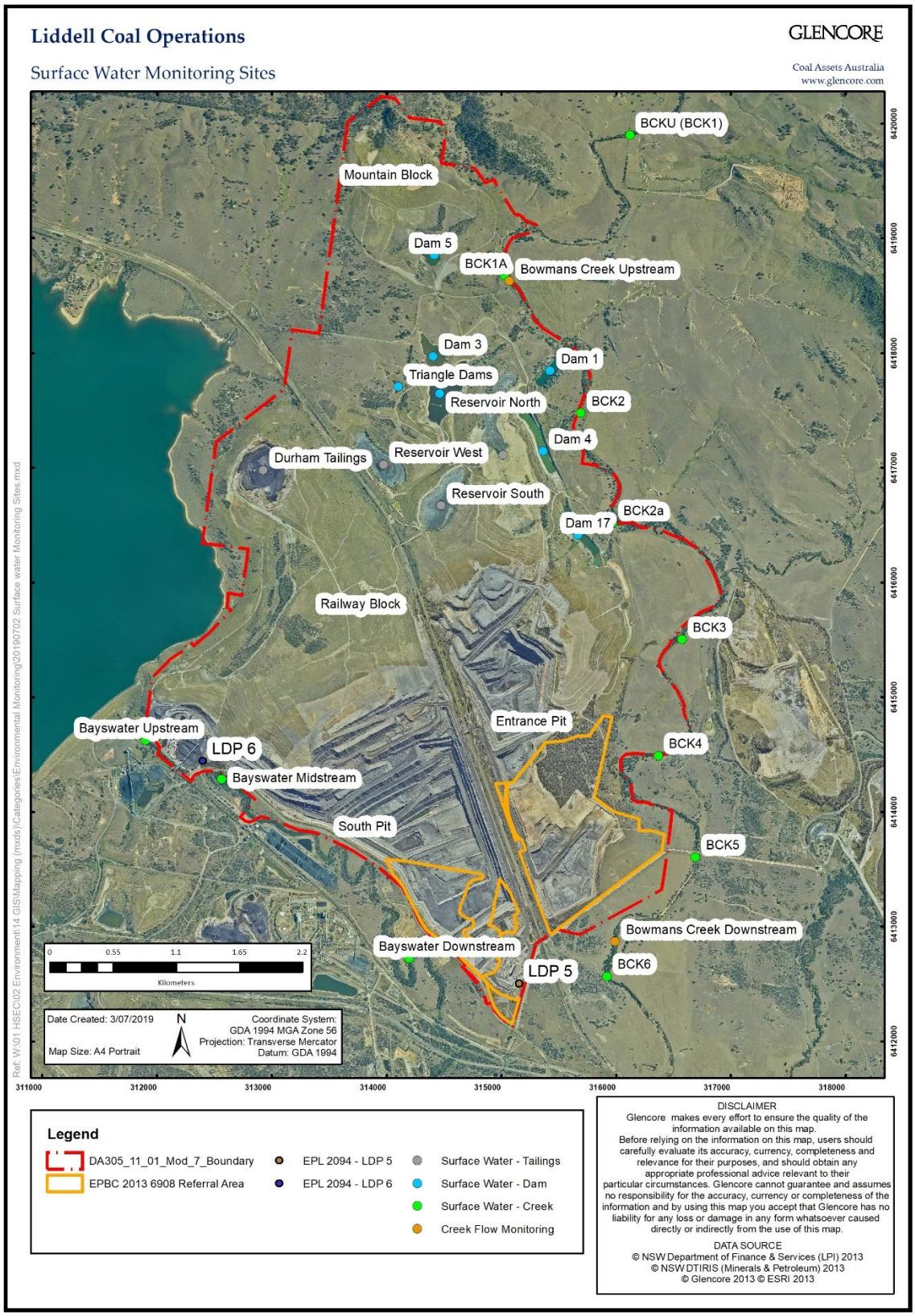

Figure 4.6: LCO Bowmans Creek observation locations

5. Conclusion and recommendations

Generally, groundwater level trends in ALV7S, ALV7L and ALV8S, and in the Bowmans Creek area monitoring bores more widely, show a close correlation to the rainfall and evaporation CRD trends. Since 2017, ALV7S and ALV8S have shown a deviation from historical 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 observed to date under the current severe drought conditions. The more recent ALV7S, ALV7L and ALV8S water levels have been below historic lows, which have coincided with the most recent period of below average rainfall and above average evaporation. The period of above average evaporation was observed between 2012 and late-2019.

Assessments carried out prior to and as part of the MOD5 GIA concluded that the recharge to the coal measure fractured rock aquifer is likely very low. This is primarily 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.

The mining consent has approved some impacts to the Bowmans Creek alluvium and fractured rock aquifer, and the groundwater model showed that these impacts are predominantly driven by the removal of the Davis Creek Fault and Dyke and the total dewatering of the former Liddell M49 underground workings. The total dewatering of the M49 workings have not occurred to date, nor have there been any containment failures of water stored in the underground.

The groundwater depths measured at ALV7L, reflect a natural variability due to climatic factors and it is unlikely that the decline is a mining-related impact. The groundwater declines measured in ALV7S and ALV8S are likely influenced by a combination of the current 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 by mining to some 45 m below the base ALV7S and ALV8S. The mining has caused depressurisation of the surrounding fractured rock aquifer with subsequent vertical drainage of the overlying formations. The depressurisation of the fractured rock aquifer has been approved under the consent to mine.

The absence of groundwater in the ALV7L and ALV8S, precludes further investigation. When there is significant recharge to the alluvium, further investigation could be conducted to determine whether connectivity between the alluvial and fractured rock aquifers has altered.

Since there is direct relationship between the alluvium and rainfall, it is not expected that there is potential for harm to the environment as the system is varying naturally.

It is recommended that routine monitoring continues at ALV7L, ALV7S and ALV8S and other Bowmans Creek monitoring locations, and that investigation be carried out as required by the WMP. Future iteration of the groundwater model should include these groundwater level trends in the model calibration runs.

6. References

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Appendix L - August 2019 – BCK1A Electrical Conductivity and Total Dissolved Solids ITARP

LIDDELL

GLENCORE

SURFACE WATER INVESTIGATION REPORT
BCK1A – EC & TDS

Date : 6 September 2019
Subject : BCK1A Water Management Investigation Trigger

Executive Summary
This report outlines the scope and findings of the investigation into exceedances of the surface water investigation triggers at a monitoring location on Bowmans Creek, BCK1A. The investigation has concluded that the exceedances monitored at this location do not indicate potential or actual environmental harm. Further investigation is recommended to conclusively determine whether the monitored exceedances at BCK1A are a mining related impact.

Introduction
Liddell Coal Operations (LCO) operates in accordance with the approved Water Management Plan (WMP) in accordance with Schedule 3, Condition 23(a) of DA 305-11-01. The WMP requires an Investigation Trigger Action Response Plan (ITARP) to be implemented after the transient exceedance (i.e. three or more consecutive exceedances) of water level or water quality trigger values. The transient approach is a check to determine whether the exceedance is repeated, ongoing and not due to erroneous sampling methods. Investigation action is taken in the form of checking flow conditions within the creek, resampling, and reviewing of data as required.

In response to recent surface water monitoring results, in this instance exceedances spanning twelve consecutive months at BCK1A, LCO has conducted an investigation in accordance with and as defined in the approved WMP. The specific monitoring results triggering the investigation are identified in **Table 1** below. **Figure 1** identifies the surface water monitoring locations as per the WMP.

In accordance with the surface water quality criteria exceedance protocol, detailed in Figure 10-1 of the approved WMP, LCO notified of the exceedance on the 14 August 2019 to the NSW Department of Planning Industry and Environment – Planning & Assessment(DPIE - Planning) as well as the NSW Department of Planning Industry & Environment – Water Division (DPIE-Water) and Department of Environment and Energy. Subsequently, LCO has undertaken an investigation the findings of which are presented in this report.

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Liddell Coal Operations Pty Ltd ABN 40 058 857 882
Manager and Agent of the Liddell & Foybrook Joint Ventures

Table 1 – Investigation TARP Trigger Results

Site	Trigger value				Date	Monitoring Result		
	90th percentile trigger limit (applicable when creek is flowing)		Reference Maximum (applicable when creek is not flowing)			Flow State – Flowing (F) Not flowing (NF)	EC (µs/cm)	TDS (mg/L)
	EC (µs/cm)	TDS (mg/L)	EC (µs/cm)	TDS (mg/L)				
BCK1A	2020	1210	4570	3460	April 2018	F	1980	1200
					May 2018	F	2800	1710
					June 2018	F	3690	2330
					July 2018	F	3550	2420
					August 2018	F	2960	1950
					September 2018	F	3900	3010
					October 2018	F	6650	4480
					November 2018	F	5600	3390
					December 2018	F	6730	4860
					January 2019	F	6410	4880
					February 2019	F	6840	4790
					March 2019	NF	5970	3570
					April 2019	F	4120	2260
					May 2019	NF	3690	2090
					June 2019	NF	4630	2920
					July 2019	NF	3610	2220

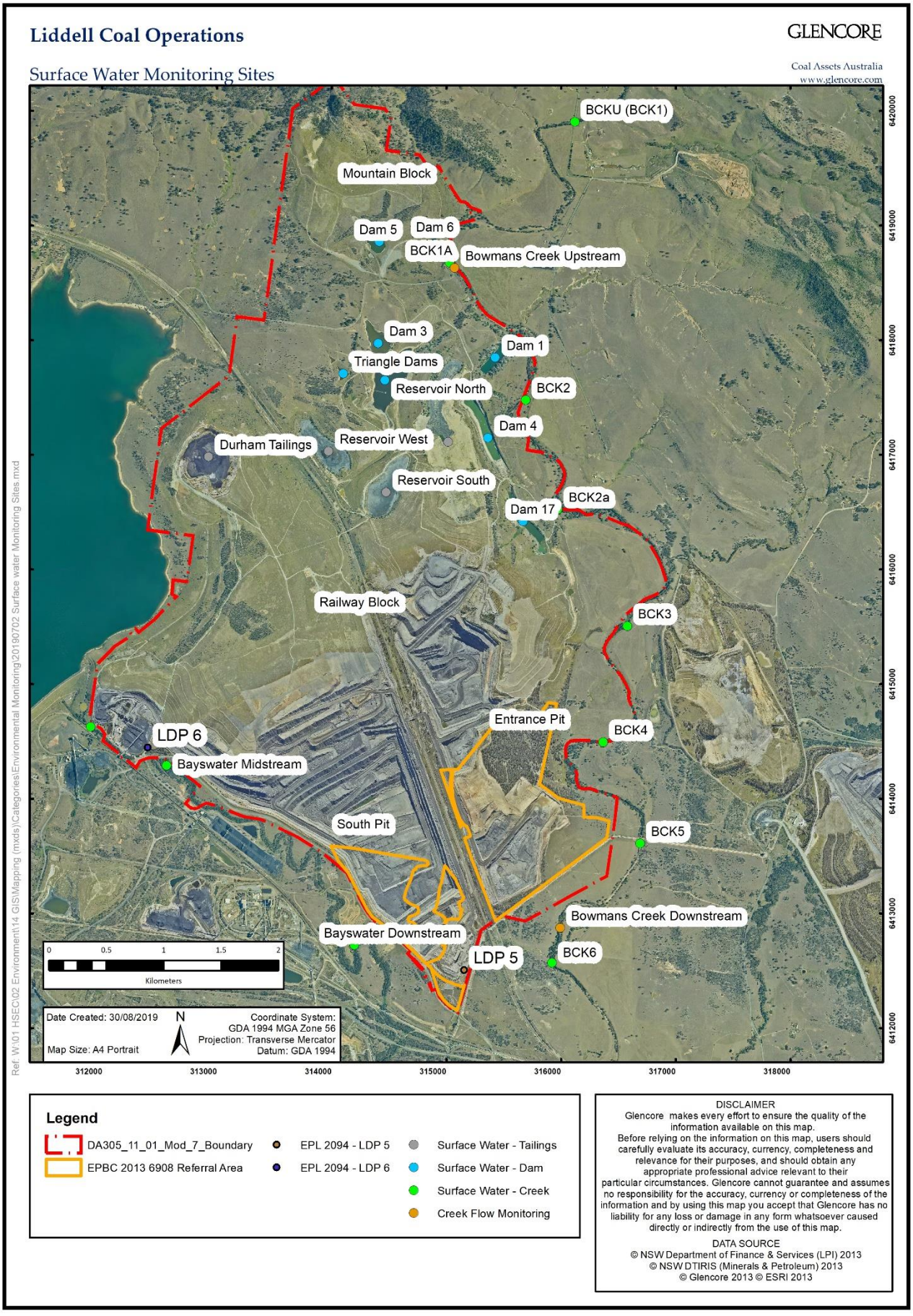


Figure 1 – Surface Water Monitoring Locations

Background - Context

Bowmans Creek is considered to be a moderately disturbed system as defined in ANZECC 2000 with moderate ecological value. A review of flow data within the Groundwater Impact Assessment (SKM, 2014) indicates that flow within Bowmans Creek is ephemeral adjacent to LCO although it is perennial further downstream nearer to the Hunter River.

The ephemeral nature of flow within the Bowman's Creek 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.

Impact assessment criteria for Bowman's Creek has been determined based on a statistical analysis of data collected over a 5 year period. In accordance with ANZECC (2000) guidelines a 90th percentile concentration is appropriate for maintaining water quality. Due to the disturbed nature of the catchment this is deemed to be an appropriate statistical criterion to adopt whilst mining operations are ongoing. Further, quality investigation limits are dependent on the flow state of each monitoring location to reflect the creeks ephemeral nature.

Climatic conditions preceding and enduring for this investigation are characterised by below average rainfall and above average evaporation. The climate observations/trends exceed variances measured during the reference period previously mentioned with persistent drought conditions during the last 24months. This is supported by meteorological records and the changes in flow conditions evident in the monthly ground and surface water monitoring presented in this report.

Background – Previous Investigations

Previous investigations have occurred as required by the WMP when the trigger levels exceeded for three, six, nine and twelve months consecutively; with the most recent occurring in May 2019. Each investigation included field inspections of the site, review of flow conditions within the creek system, review of monitoring results and a review of operational storages and water management controls. The following are observations discussed in previous investigations:

- Exposed sodic soils upstream and downstream was clear with these soils exposed upstream of BCK1A and precipitate deposits visible in the strata above recent water levels. A continuous conglomerate band was visible extending along the creek line with overlying sodic soils. This continuity of exposure indicates that the soils are likely similar along that larger section of the creek line. Hence, it is likely that water leaching/running off these soils will have increased EC/TDS levels when compared with the un-eroded sections of creek up and downstream. Whilst there is minimal leaching/runoff due to prolonged dry conditions, it indicates that the evaporative concentration of naturally saline water flows could be a driving factor in the observations.
- Characterisation of water in the area completed through analysis the ratio of major dissolved constituents support erosion exposed sodic soils upstream of BCK1A could be affecting the water quality of the creek. Further, characterisation did not indicate connectivity between the closest mine water storage, Dam 6, and the creek.
- EC and TDS measurements at BCK1A appear to trend away from readings collected from the other monitoring locations in the system, suggesting local influences affecting water quality. Additionally, the results deviate largely from month to month compared to other sites. This variation is potentially due to local influences unique to BCK1A include neighbouring cattle grazing to the creek line, significant exposure of natural sodic soils along the stream bed and the nearby confluence with Coal Hole Creek upstream.
- Decreases in water levels within the alluvial system, as a result of the continued dry conditions, could reduce the confining pressures of the underlying weathered and hard rock water bodies. Therefore, it is likely that as confining pressures approach equilibrium with the pressure of the underlying water bodies, saline water can be forced to interact with the surface water in the creek increasing EC and TDS levels.

- The trigger limits detailed in the WMP were established based on data collected over a five year reference period for the purpose of assessing mining related impacts. Whilst the reference maximums have been exceeded, the residual mass curves demonstrate that the climatic conditions currently being measured are beyond variances measured during the reference period; implying that exceedances of the reference maximum water quality levels is likely to occur in a system driven by rainfall.

A summary of the key determinations from these previous investigations is as follows;

- It is unlikely that potential harm has occurred or will occur at the observed levels.
- Mine water storages do not appear to indicate leakage or connectivity to the creek system as supported by water quality analysis of the isolated pools surrounding BCK1A and visual observations.
- Mining activities have not caused the observed levels.
- The climate, creek flow and water quality monitoring observations corroborate the understanding the monitored EC & TDS levels are naturally driven.
- The upstream and downstream monitoring locations have recorded 'still' or 'dry' flow conditions during the same trigger period indicating that the creek is behaving in an ephemeral manner and likely transitioning slowly to the 'no flow' applicable investigation trigger levels.

These previous investigation reports are **Attachment 1-4** for reference.

Investigation

This investigation included field inspections of the site, review of flow conditions within the creek system, review of monitoring results and a review of operational storages and water management controls.

Review of routine monitoring results

This section outlines the findings from a review of routine monitoring program results.

Review of meteorological conditions and streamflow

As described in the WMP, the ephemeral nature of Bowman's Creek means that rainfall significantly induces fluctuation in the water quality within the creek. For analysis, streamflow measurements are shown in **Figure 2** along with a residual mass curve (CRD) with respect to rainfall and evaporation that was calculated and applied on a daily basis in accordance with the approach presented in previous ITARP reports. The residual mass curves indicate cumulative relative difference from mean rainfall or evaporation; i.e. a declining trend indicates less rainfall or evaporation when compared to the long term average.

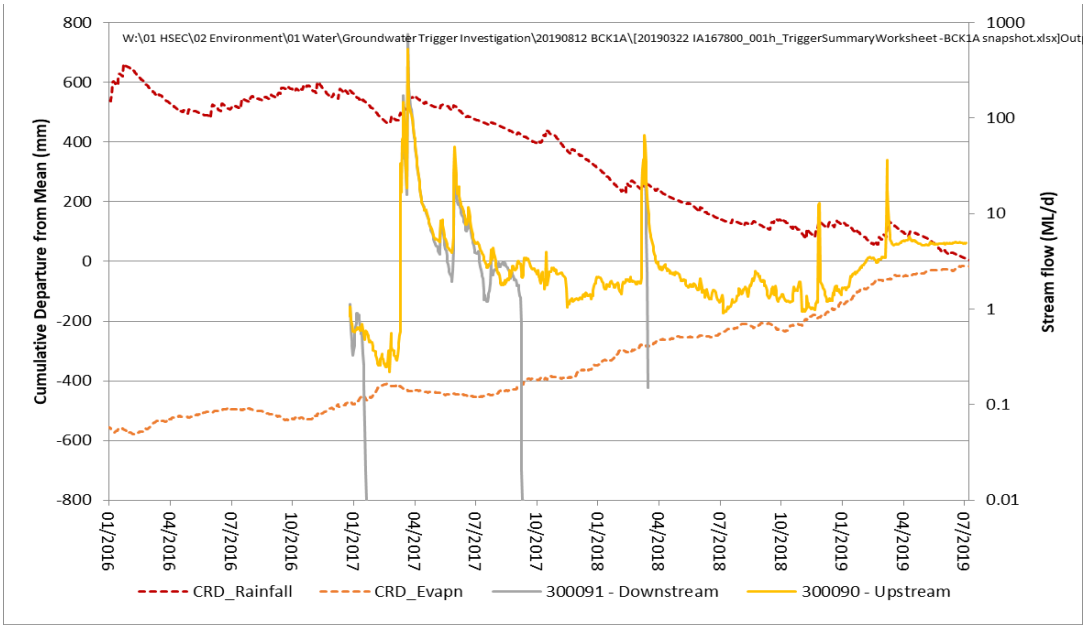


Figure 2 – Bowmans Creek Flow Conditions and Meteorological Indicators

As per **Figure 2**, there is a significant drop in the residual mass curve (rainfall) commencing January 2017, commensurate with an increase in slope in the residual mass curve (evaporation). Since 2017, there is approx. 600mm less rainfall than average, noting that the annual average since 2005 is approx. 640mm. Recently, this declining trend in rainfall and increasing trend in evaporation has persisted to date despite brief stabilisation between November 2018 and March 2019, indicating summer rainfall has been close to long-term average. Streamflow measurements at the two gauging stations correlate with the residual mass curves. For instance, **Figure 2** shows nil observable surface flow at the downstream monitoring location except following periods of rainfall in March 2017 and to a lesser extent in March 2018; there has been negligible downstream flow since September 2017. Streamflow measurements at the two gauging stations show a decrease in creek flow which is further corroborated by the flow observations recorded monthly; refer to **Appendix A** for daily rainfall, evaporation measurements and creek flow observations.

Review of routine surface water quality monitoring

As described in the WMP, the ephemeral nature of Bowman's Creek means that rainfall significantly influences surface water quality. A review of the last 24 months of water quality results at BCK1A show elevated EC & TDS results during periods of low flow, as is expected. Specifically, during summer months flow has been observed to decrease, stagnating during 2017-2018 summer, whilst EC and TDS increase. Recently, after periods of rainfall in Autumn 2019, EC & TDS levels decreased in the months following. The routine surface water testing results along the creek corroborate the direct relationship with climatic conditions and water quality. EC and TDS measurements at BCK1A appear to trend away and deviate more month to month when compared with observations at the other monitoring locations in the system, suggesting local influences affecting water quality. Refer to **Appendix B** for monthly surface water quality results along Bowman's Creek.

Field inspections and LCO response

This section outlines the findings from field inspections undertaken and additional actions undertaken.

Initial field inspection

To further improve the understanding of creek conditions in the area, LCO commissioned non-routine water quality analysis up and downstream of BCK1A. Field water quality testing occurred on the 22 August 2019 of the pools upstream and downstream of BCK1A previously examined in earlier investigations; the results summarised in **Table 2**. During the field testing, general area observations were consistent with previous field inspections; noting exposed sodic soil erosion unrelated to mining and presence of neighbouring landholders cattle.

Table 2 – Field water quality testing results taken 22 August 2019

Field non-routine surface water monitoring results – 22 August 2019								
Approximate Location	500m Upstream	300m Upstream	200m Upstream	50m Upstream	BCK1A	80m Downstream	150m Downstream	300m downstream
Flow rate	Still	Still	Still	Still	Trickle	Trickle	Trickle	Trickle
EC (us/cm)	1423	1481	1471	6410	3270	3670	3690	3380

As evidenced, the pool 50m upstream of BCK1A showed elevated salinity levels compared to the other sampling locations. Upon review of these field results, further water quality sampling and analysis of water along the creek and from Dam 6 was scheduled for the following day in order to characterise dissolved constituents at each location. This to assess whether Dam 6, a residual void in the rehabilitated landform could be the source of the elevated salinity in the creek.

On the 23rd August 2019, whilst undertaking characterisation sampling of surface water in the vicinity of BCK1A, field inspection identified saturated ground along approximately 150m of the western bank upstream of BCK1A. This seepage line was not identified during previous investigation field inspections. **Figure 3** provides an aerial of the area surrounding BCK1A as well as the approximate seepage locations, monitoring points and key features. An example of the saturated ground is shown in **Figure 4**, note the pooled water present in apparent cattle hoof marks in left image.

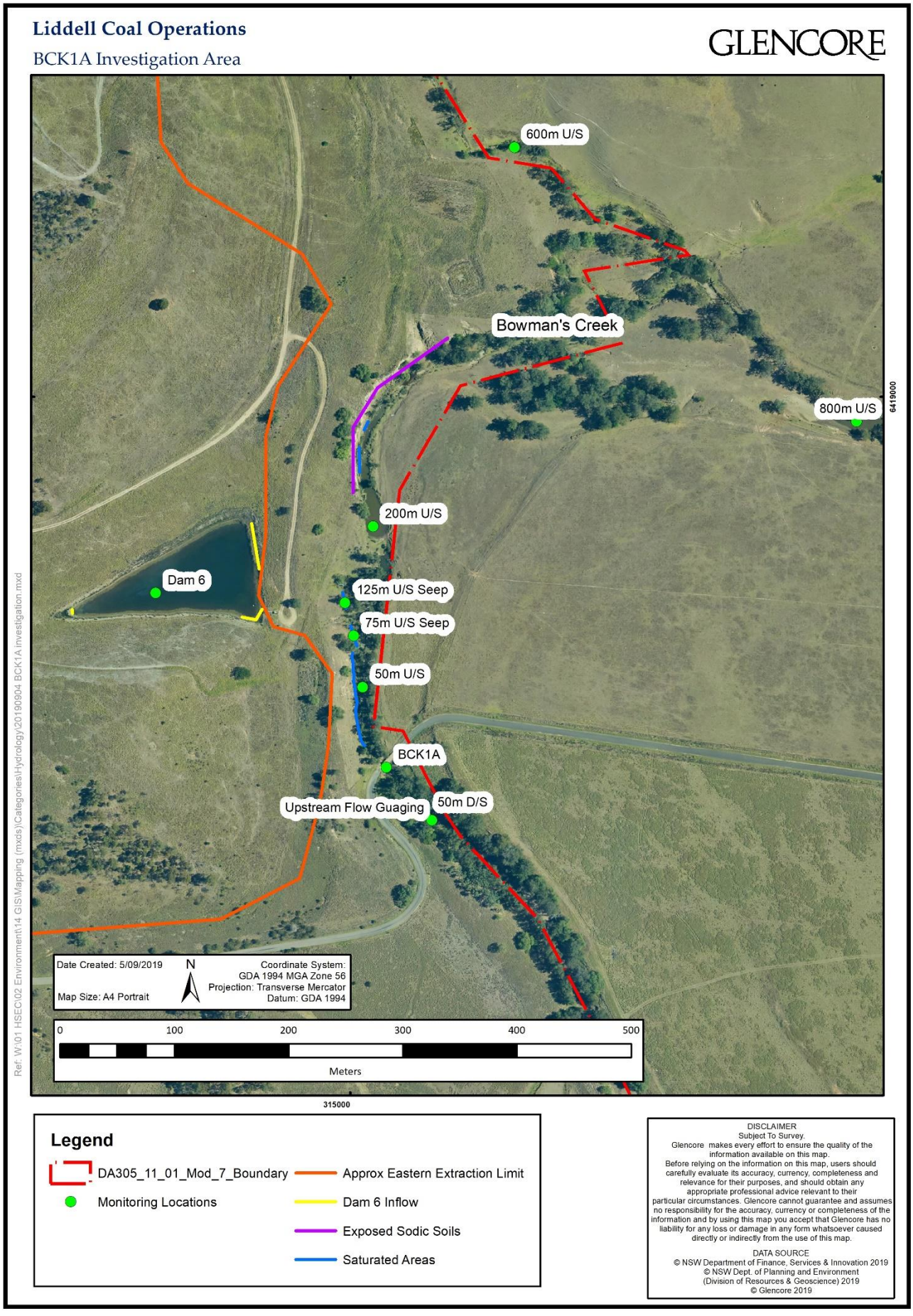


Figure 3 – Aerial of area surrounding BCK1A key features


Figure 4 – Examples of saturated part of western creek bank approx. 100m upstream of BCK1A

LCO Response

On identification of the saturated ground, sample holes were established in the seepage areas and left to settle over the next two days with the plan to analyse water quality on the 26 August 2019. On the basis of the information available at the time, a decision was made to pump down the water level in Dam 6 as a mitigation action to reduce the local groundwater levels and ensure that Dam 6 acted as a sink for groundwater within the rehabilitated spoil and ensure that the dam or spoils were not a seepage source to the creek. Pumping infrastructure was readied on the afternoon of 23 August 2019 and pumping commenced the following morning, 24 August 2019. Further to these actions, LCO commenced interrogation of available historical mining records discussed later in this report.

Following two days pumping, subsequent field investigations identified the following:

- Water inflows into Dam 6 in three discrete areas around the dam banks being the south eastern corner, northern half of eastern bank and western most point. Refer to **Figure 3 and 5.**
- Saturated ground, similar to **Figure 4**, approximately 300m upstream of BCK1A and upstream of Dam 6.

In addition to the non-routine sampling taken on 23 August 2019 of pooled water along the creek, water quality samples were taken of the Dam 6 inflow and the creek bank seepage on the 26 August. Summary results of this water quality analysis are presented in **Table 3.** Calculations for major anion/cation ratio characterisation analysis are provided in **Appendix C** and discussed further on in the report.

Table 3 – Laboratory water quality testing results summary

Laboratory non-routine surface water monitoring results – Sampled 23 August 2019							
Approximate Location	800m Upstream	600m Upstream	200m Upstream	50m Upstream	BCK1A	50m Downstream	Dam 6
pH	7.99	8.00	8.02	8.23	8.22	8.18	8.11
EC (us/cm)	1400	1420	1380	6470	4410	2950	6840
TDS	699	722	694	4260	2380	1710	4840
TSS	10	23	<5	<5	8	<5	<5

Laboratory non-routine surface water monitoring results – Sampled 26 August 2019				
Approximate Location	Dam 6 inflow seep	Western bank seep 125m upstream	50m Upstream	Western bank seep 75m upstream
pH	7.27	7.57	8.10	8.25
EC (us/cm)	6530	6970	6520	6920
TDS	4240	4530	4240	4500
TSS	127	106	6	219

Figure 5 – From the top, photos of Dam 6 facing ENE and SE respectively.

Discussion

Review of the routine monitoring results (metrological, water quality and inspection findings) continue to corroborate the determinations from previous investigations. These determinations include:

- The water quality at BCK1A does not align with the other monitored locations along Bowman's Creek. This variation is potentially due to local influences unique to BCK1A including for instance neighbouring cattle grazing in the creek line, significant exposure of natural sodic soils along the stream bed and the nearby confluence with Coal Hole Creek upstream.
- The influence of rainfall on Bowman's Creek surface water is direct and a significant influence.

Detailed water quality analysis of the pooled water up and downstream of BCK1A was completed during this investigation to further characterise the water composition. This analysis involved characterising the major dissolved constituents at each monitored location, which provides for a greater understanding of the water supply path for each isolated pool. Hence, if there is unique correlation in water quality between two or more locations, it may indicate connectivity of each. A summary of the monitoring data and characterisation analysis is provided in **Appendix C** determinations from a review of the results include:

- An increase in sodium cation dominance and a transition from predominately chloride anions to sulphate anions as the creek progresses downstream; an indication that the erosion exposed sodic soils upstream of BCK1A could be affecting the water quality of the pools. Analysis of composition results downstream of BCK1A show a transition back to that of the sites upstream of the erosion area.
- Comparison of dissolved solids composition at the closest mine water storage (Dam 6), indicates slightly varied composition to that of the creek sites. Comparison of the seepage flows, samples taken on the 26 August, that each seepage expression and Dam 6 inflow had almost the same percent composition indicating similar source.

Historical mining of the Mountain Block area occurred in the late 1990's and early 2000's, the eastern limits of coal extraction is shown in **Figure 3**. At the completion of mining, the void in this vicinity was backfilled in 2005 with Dam 6 remaining at the eastern limit. Hence, Dam 6 is wholly contained within unconsolidated overburden and a high wall is present between the dam and Bowman's Creek. The location of discrete seepage points into Dam 6 does not indicate that water stored in the surrounding overburden is evenly draining into the dam. Further, the spread of observed seepage expressions, up to approximately 300m upstream of BCK1A, indicates a distributed source of water. Review of available geological modelling indicates that the Liddell Seam likely outcrops in the western creek bank at similar elevation and the vicinity of the main observed seep locations.

Decreases in water levels within the alluvial system, as a result of the continued dry conditions, could reduce the confining pressures of the underlying weathered and hard rock water bodies. This can lead to particular sections of creek becoming hydraulically gaining rather than loosing with recharge from underlying strata. The underlying water quality can be more saline than the surface water due to the nature of the soil/rock material it is interacting with. Therefore, it is likely that as confining pressures approach equilibrium with the pressure of the underlying water bodies, saline water can be forced to interact with the surface water in the creek increasing EC and TDS levels.

The trigger limits detailed in the WMP were established based on data collected over a five year reference period for the purpose of assessing mining related impacts. Whilst the reference maximums have been exceeded, the residual mass curves demonstrate that the climatic conditions currently being measured are beyond variances measured during the reference period; implying that exceedances of the reference maximum water quality levels is likely to occur in a system driven by rainfall. There is no discernible impacts to flora or fauna in the immediate area.

Conclusion and recommendations

An investigation was undertaken in accordance with Condition 23c (iv) of DA 305-11-01 and LCO's WMP due to an consistent exceedance of the EC and TDS flowing trigger value at BCK1A between May 2018 and July 2019.

The investigation findings have determined that:

- No change to management or mining activities in the area.
- There is no discernible impacts to flora or fauna in the immediate area.
- It is unlikely that potential harm has occurred or will occur based on the current observations.
- The climate, creek flow and water quality monitoring observations corroborate the understanding the monitored EC & TDS levels are predominately naturally driven. This is demonstrated most recently by the decreasing EC & TDS trend as rainfall during the last six months normalises.
- The upstream and downstream monitoring locations have recorded 'still' or 'dry' flow conditions during the same trigger period indicating that the creek is behaving in an ephemeral manner and likely transitioning slowly to the 'no flow' applicable investigation trigger levels.
- The source of the observed seepage is not clear based on the current information; hence it cannot be determined whether the observations are the result of historical mining activities.

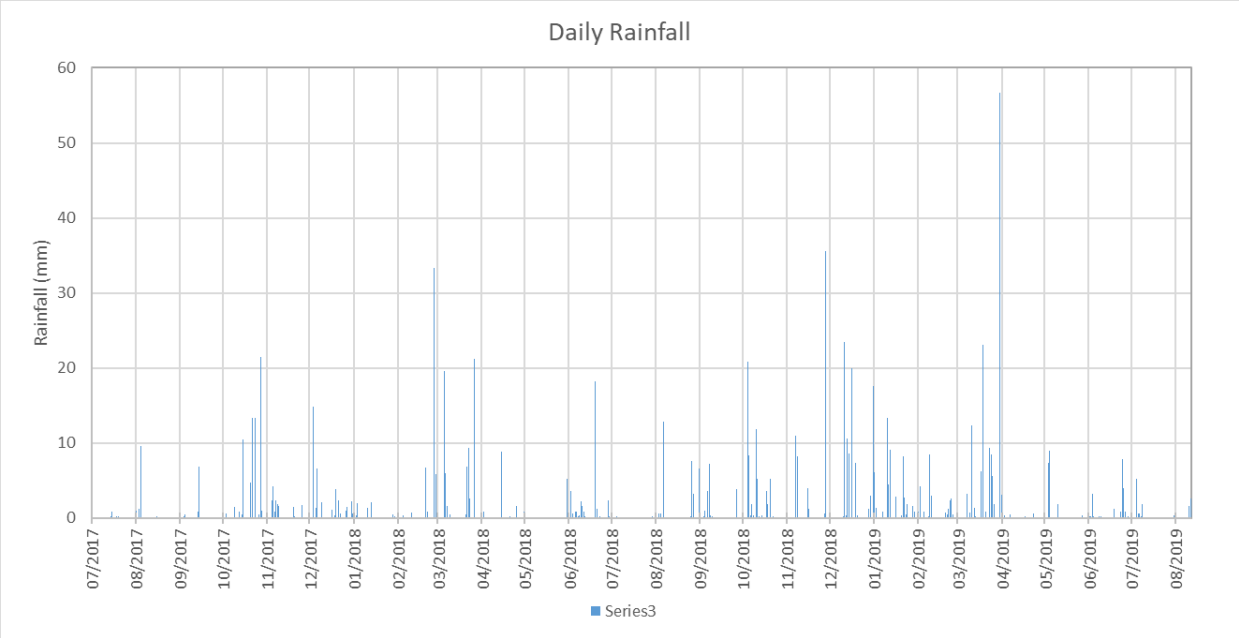
Based on the current information, LCO does not consider there to be potential environmental harm however it is not clear if observations are the result of historical mining activities. Hence, as per the WMP Figure 10-1 Exceedance of surface water quality trigger values protocol, LCO recommends that further investigation is undertaken to determine the source of the seep observations by commencing a Management/Mitigation TARP. LCO has taken management/mitigation measures through the dewatering Dam 6 as low as possible to create a local groundwater sink. This will be maintained until further investigation is completed.

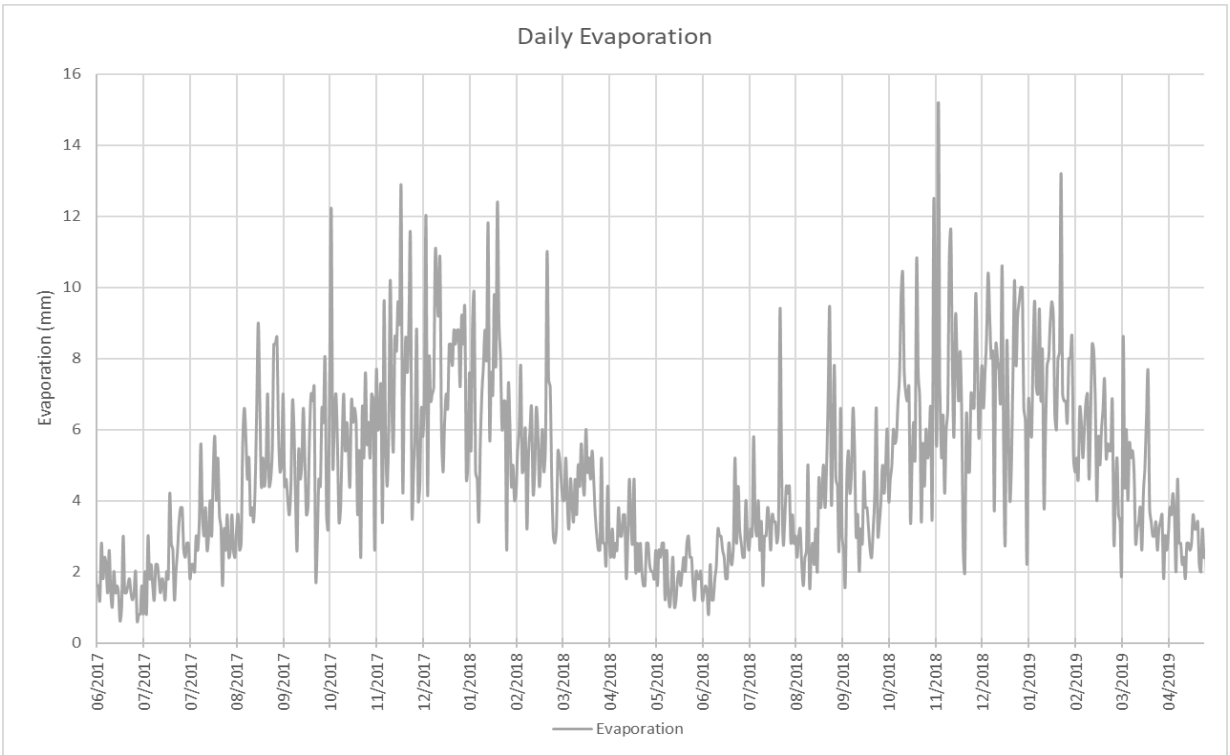
In accordance with the WMP, LCO will advise DPIE and DOEE of timing and proposed scope of the management/mitigation actions once determined.

Attachment 1 – BCK1A Trigger Investigation Report August 2018
Attachment 2 – BCK1A Trigger Investigation Report December 2018
Attachment 3 – BCK1A Trigger Investigation Report February 2019
Attachment 4 – BCK1A Trigger Investigation Report May 2019

Appendix A – Daily metrological records - rainfall and evaporation
Appendix B – Routine water quality monitoring results
Appendix C – Water quality characterisation analysis summary

Appendix A– Daily metrological records - rainfall and evaporation

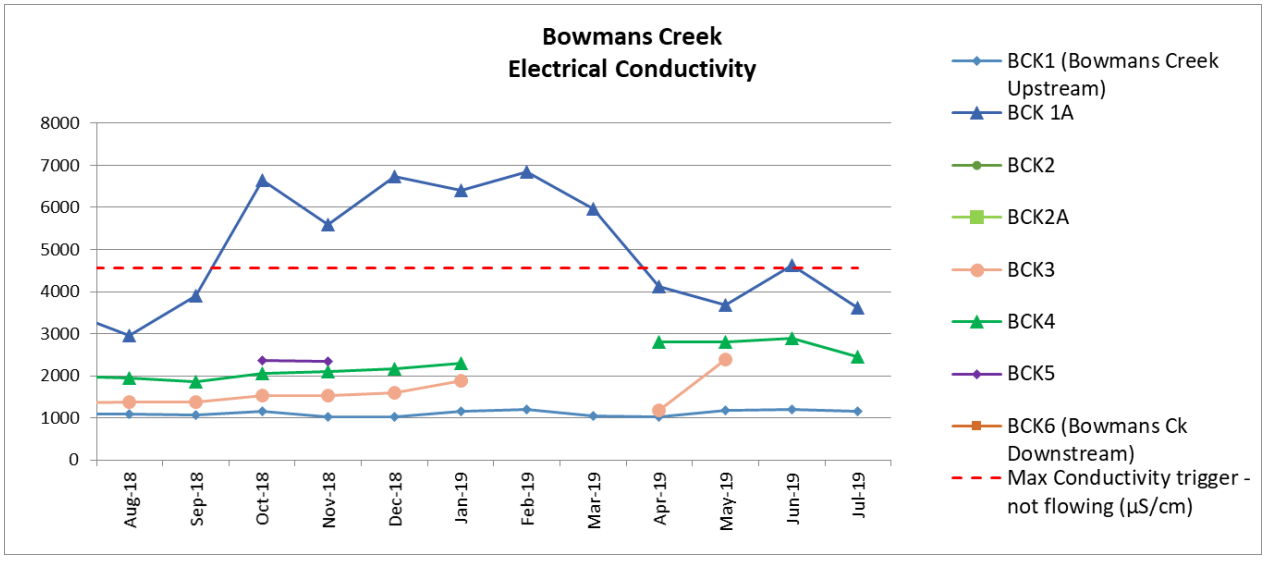




Bowmans Creek - Flow Observations								
Month	**BCK1 (Upstream)**	**BCK1A**	**BCK2**	**BCK2A**	**BCK3**	**BCK4**	**BCK5**	**BCK6 (Downstream)**
March-18	Still	Trickle	Dry	Dry	Still	Still	Still	Dry
April-18	Slow	Steady	Still	Dry	Trickle	Still	Still	Still
May-18	Slow	Trickle	Dry	Dry	Slow	Still	Still	Still
June-18	Slow	Trickle	Dry	Dry	Still	Still	Still	Still
July-18	Slow	Slow	Dry	Dry	Still	Still	Still	Dry
Aug-18	Slow	Slow	Dry	Dry	Slow	Slow	Dry	Dry
Sept-18	Slow	Slow	Dry	Dry	Slow	Still	Dry	Dry
Oct-18	Trickle	Trickle	Dry	Dry	Still	Still	Still	Dry
Nov-18	Still	Trickle	Dry	Dry	Still	Still	Still	Dry
Dec-18	Still	Trickle	Dry	Dry	Still	Still	Dry	Dry
Jan-19	Trickle	Trickle	Dry	Dry	Still	Still	Dry	Dry
Feb-19	Trickle	Trickle	Dry	Dry	Dry	Dry	Dry	Dry
March-19	Still	Still	Dry	Dry	Dry	Dry	Dry	Dry
April-19	Slow	Slow	Dry	Dry	Still	Still	Dry	Dry
May-19	Still	Trickle	Dry	Dry	Still	Still	Dry	Dry
June-19	Still	Trickle	Dry	Dry	Dry	Still	Dry	Dry
July-19	Still	Trickle	Dry	Dry	Dry	Still	Dry	Dry

Appendix B – Routine water quality monitoring results

BCK1A – Monthly Quality Results					
Month	**Flow**	**pH**	**EC (us/cm)**	**TDS (mg/L)**	**TSS (mg/L)**
August-17	Trickle	7.51	1280	826	<5
September-17	Slow	7.83	2270	1310	8
October-17	Trickle	7.70	3060	2100	<5
November-17	Still	7.95	3050	2110	<5
December-17	Still	7.80	4160	2990	11
January-18	Still	7.77	4140	2390	10
February-18	Still	7.64	3860	2630	<5
March-18	Trickle	7.89	6720	5100	<5
April-18	Steady	8.12	1980	1200	<5
May-18	Trickle	7.99	2800	1710	6
June-18	Trickle	7.82	3690	2330	<5
July-18	Slow	7.96	3550	2420	<5
August-18	Slow	7.89	2960	1950	16
September-18	Slow	7.95	3900	3010	7
October-18	Trickle	7.59	6650	4480	11
November-18	Trickle	7.44	5600	3390	<5
December-18	Trickle	7.65	6730	4860	45
January-19	Trickle	7.76	6410	4880	12
February-19	Trickle	8.16	6840	4790	6
March-19	Still	7.99	5970	3570	20
April-19	Slow	8.17	4120	2260	8
May-19	Trickle	8.19	3690	2090	6
June-19	Trickle	8.06	4630	2920	<5
July-19	Trickle	7.66	3610	2220	<5



Appendix C – Water quality characterisation analysis summary

Water quality characterisation results – 23 August 2019														
	Dam 6		US 800		US 600		US 200		BCK 1A		DS50		US50	
pH	8.11		7.99		8.00		8.02		7.99		8.18		8.23	
EC (us/cm)	6840		1400		1420		1380		1400		2950		6470	
TDS (mg/L)	4840		699		722		694		699		1710		4260	
TSS (mg/L)	<5		10		23		<5		10		<5		<5	
Major Anions														
	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L
CO3	765	15	158	20	158	20	181	24	598	22	392	21	874	21
S04	2400	62	82	13	83	13	36	6	956	45	585	40	1800	54
Cl	652	23	297	66	300	66	304	70	504	33	402	38	617	25
Major Cations														
Ca	119	7	75	29	74	28	64	25	136	14	97	17	181	12
Mg	359	35	34	22	34	22	32	21	172	29	91	27	297	32
Na	1130	57	143	48	146	49	159	54	639	57	362	56	1010	56
K	22	1	4	1	4	1	3	1	8	0	5	0	14	0

Water quality characterisation results – 26 August 2019								
	Dam 6 inflow seep		Western bank seep 125m upstream		50m Upstream		Western bank seep 75m upstream	
pH	7.27		7.57		8.10		8.25	
EC (us/cm)	6530		6970		6520		6920	
TDS (mg/L)	4240		4530		4240		4500	
TSS (mg/L)	127		106		6		219	
Major Anions								
	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L	mg/L	%meq/L
CO3	938	19	998	19	913	19	890	18
S04	2370	62	2550	63	2270	61	2430	61
Cl	501	18	527	18	534	20	605	21
Major Cations								
Ca	233	14	187	11	185	12	163	10
Mg	317	32	344	33	306	32	348	34
Na	991	53	1090	55	1040	56	1100	56
K	22	1	23	1	14	0	20	1

GLENCORE