Strata Geoscience Ltd

Evidence – Buller Plateaux Continuation Project: Geochemistry

Date: **August** 2026

To: Bathurst Resources Ltd

From: Strata Geoscience Ltd

Dr James Pope Principal Geochemist

EXECUTIVE SUMMARY

1. This evidence statement document includes a high-level review of environmental geochemistry work that has been completed related to the Buller Plateaux Continuation Project (BPCP or Project) by Bathurst Resources Ltd (BRL) and their consultants. The author has reviewed a suite of reports prepared by BRL staff and their consultants, mostly Mine Waste Management Ltd (MWM), that are related to the impact of the Project on water quality. This evidence statement is accompanied by a plain English review of reports that rely on environmental geochemistry and the reader should consult this document for additional details.

2. For the purpose of this statement the Project is split into two areas

2.1 The Stockton sub-area

The Mount Frederick South, Escarpment Extended and Upper Waimangaroa Haul Road sub-areas (MFS ESE & UWHR respectively)

3. Approaches to geochemical interpretations and measures of rehabilitation are different in these areas. The Stockton sub-area has a large database of water quality measurements collected over the last ~20 years of mine operations and utilises an empirical data model for understanding future conditions. Stockton targets environmental improvement based on ecological thresholds and betterment of areas relatively highly impacted by legacy mining compared to other areas in the Buller Plateaux. The ESE, MFS & UWHR sub-areas have limited previous mining, a smaller water quality dataset and utilise a combined empirical, interpretive and probabilistic approach to obtain future water quality scenarios under proposed mine operational regime. Proposed mining in these sub-areas will operate under a standard ecological impact assessment water quality criteria.

INTRODUCTION

4. My full name is James Gordon Pope. I am an owner and principal geochemist at Strata Geoscience Ltd.

5. This technical assessment addresses the reports listed below proposed for the Buller Plateaux Continuation Project and provides an independent review of the Geochemistry aspects of the Project.

Qualifications and experience

6. I have the following qualifications and experience relevant to this assessment:

PhD Environmental Geochemistry

BSc Hons Geology

Since January 2023 I have owned and operated Strata Geoscience Ltd. Prior to that:

(i) I worked for almost 20 years at CRL Energy Ltd (rebranded to Verum Group Ltd ~2020). I started as a research geochemist and for the last ~ 4 years I was CEO.

I specialise in geochemistry and have provided consultancy, laboratory services and research work to many organisations.

This work has included, but is not limited to:

(ii) Geochemistry consultancy and management of consultants at:

- Oceana Gold, Macraes. Management of geochemistry aspects for resource consent application.
- Oceana Gold, Globe. Water treatment conceptual work and management of consultants delivering water passive treatment implementation.
- Francis Mining, Echo, Water treatment conceptual work and management of consultants delivering passive water treatment implementation.
- Bathurst Resources, Stockton. Water treatment mineralogy.
- MBIE, Endeavour Fund Research Programmes. Delivery of the New Zealand Mine Environment Life Cycle Guide and other projects.

- Solid Energy, Stockton. Cement kiln dust for remediation application.
- Oceana Gold Waihi. Annual peer review for Waikato Regional Council.
- Bathurst Resources, Escarpment. Delivery of environmental geochemistry work for resource consent.
- Stevenson Group, Te Kuha environmental geochemistry and coal resource estimate for resource consent application.

Code of conduct

7. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

8. The purpose of this assessment is to provide an independent review of and comment on:
    - Environmental geochemistry for the Buller Plateaux Continuation Project

Assumptions and exclusions in this assessment

9. I reviewed more than 33 documents including consultancy and internal reports related to the BPCP. In this evidence statement I have taken a high level approach and synthesised key information (in my professional opinion) across related reports rather than provide a complete summary of all details. I believe there is benefit in this approach because often the linkages between several detailed concepts (in each report) are important but difficult to identify. The evidence statement is not a complete summary of all of the information that I have reviewed. I have attached a plain English summary report as an appendix that includes additional details, and is more complete with respect to the work I have reviewed.

THE BULLER PLATEAUX CONTINUATION PROJECT

10. The full description for the Project is provided in the AEE. I do not repeat it in my assessment.

METHODOLOGY

Introduction

11. My approach has been to review Project reports supplied by BRL. From these reports I have developed an understanding of the likely environmental effects of the Project construction, operation and closure. In addition, I have considered whether the extent and nature of the effects have been correctly and fully assessed, documented and addressed. I have reviewed aspects of the proposed management strategy for construction, operation and closure of the Project.

12. The reports reviewed include:

Author	Title
BRL	Acid Mine Drainage. History of AMD Management and Proposed Future Management. Stockton Mine
BRL	Stockton Mine 80-year water quality forecast
BRL	Millerton water and AMD management report
BRL	Stockton Operational AMD and Sludge Management

Author	Document Number	Title
MWM	J-NZ0453-001-R	Upper Waimangaroa Haul Road Site Visit
MWM	J-NZ0453-009-M	Upper Waimangaroa Haul Road Acid Base Accounting Summary
MWM	J-NZ0453-003-M	BPCP AMD Hazard Classification Summary
BRL	BRL Memo	• Denniston ABA Block Model As part of the Escarpment Extension Project
BRL	BRL Memo	• MFS ABA Block Model - Buller Plateaux Continuation Project
MWM	J-NZ0377-001-R	Factual Report: Geoenvironmental Hazards. Mt Fred South Project
MWM	J-NZ0453-010-M	Cypress pXRF Summary
MWM	J-NZ0377-005-R	Column Leach Test Report
MWM	J-NZ453-011-M	BPCP Annual Overburden Material Schedule
MWM	J-NZ0349-008-R	Barren Valley ELF Water Quality Model
MWM	J-NZ0433-004-R	Water and Load Balance Model - Source Term Definition
MWM	J-NZ0472-001-R	Background Water Quality Report

Author	Document Number	Title
MWM	J-NZ0453-004-R	Engineered Landform Design Philosophy
MWM	J-NZ0349-004-M	Cover System Field Investigation
MWM	J-NZ0349-013-R	Cover System Technical Report

Author	Document Number	Title
MWM	J-NZ0480-004-R	Water Treatment Report: MFS and ESE
MWM	J-NZ0453-005-R	Passive Treatment System Design Toolkit
		• Passive Treatment of AMD: Options Assessment
MWM	J-NZ0349-003-R	• Mussel Shell Reactor Performance Review
MWM	J-NZ0349-012-M	• Escarpment Mine - Mussel Shell Reactor Manganese Removal Efficiency
MWM	J-NZ0349-010-M	• MSR – Secondary Contaminants
MWM	Letter (MWM)	• Escarpment Mine MSR Maintenance Summary
MWM	J-NZ0349-019-M	• MSR Sludge Trials
BRL	BRL Memo	• Whareatea Mussel Shell Bioreactor Design
MWM	J-NZ0349-020-M	• MSR Polishing Pond Secondary Contaminant Treatment
MWM	J-NZ0349-015-R	AMD Sludge Management

Author	Document Number	Title
MWM	J-NZ0453-006-R	ELF Water Quality and MSR Design Summary
MWM	J-NZ0453-007-R	Construction Phase Report
MWM	J-NZ0377-003-R	MFS - Water and Load Balance Model
MWM	J-NZ0433-003-R	ESE - Water and Load Balance Model Report

13. Document review commenced in mid-2025. Review comments have been provided to BRL and their consultants via two methods. Where reports were near finalised prior to review, short sets of notes were provided with feedback and recommendations. Where reports were provided as advanced drafts, comments were provided as tracked notes in the margin of draft reports. With both feedback mechanisms, comments were collated and amendments related to the comments were checked back against the revised text to ensure that they had been addressed adequately. Comments have been provided to BRL at three levels.

- Plain English overview – designed to enable a non-geochemist to quickly understand the purpose of the work and approach taken (Appendix 1).
- High level review comments related to aspects of scientific interpretation.
- Technical comments related to improved clarity or additional detail.

COMMENT ON THE METHODOLOGY USED TO ASSESS THE SITE ENVIRONMENTAL GEOCHEMISTRY

14. Environmental geochemistry with respect to the BPCP is primarily focussed on the impact of the disturbance required to complete mining activities on water quality downstream of the mine. The Project would create irreversible changes to the rocks and soils (position, grain size, landform, hydrogeology, etc.) within the disturbance footprint. The purpose for environmental geochemists working on the Project prior to consent is to accurately understand the extent of these changes within the disturbance footprint, measure where possible or predict the likely impact of these changes within the disturbance footprint, propose mitigations or management processes and model the level of disturbance to the downstream environment.

15. The work of environmental geochemists requires integration with mine planning from early stages of data gathering with input into identification of drill hole samples, selection of analysis methods, interpretation of background water quality samples, identification of prior disturbances and related work. This work takes place with other scientists and engineers (such as, hydrogeologists, mine engineers, geologists, rehabilitation specialists, aquatic ecologists, climate scientists and internal company (BRL) experts) to understand the physical and chemical impacts of Project evolution through time and space. With adequate understanding of the Project and its evolution as well as inherent uncertainties, the environmental geochemist is able to predict the likely impact of the Project on water quality within the site footprint and propose mitigation or management measures to minimise downstream disturbance. In many cases, the mitigations and management processes can be designed to meet criteria or conditions for downstream disturbance that are considered to be acceptable, or sometimes disturbances within the Project footprint have minimal effect downstream.

16. The primary concern for environmental geochemistry on water quality at the BPCP is prediction and management of acid and metalliferous drainage (AMD), although mining also has the potential to increase suspended sediment in surface waters. Suspended sediment is not addressed further in this evidence statement because management and mitigations are relatively widely understood and applied compared to AMD. Additional details on BPCP suspended sediment prediction and management is

provided in the summary report (Appendix 1). The BPCP mostly disturbs Brunner Coal Measures (BCM; with smaller amounts of other rock units such as Kaiata Mudstone, Granite and colluvium) and there have been many studies on AMD from these rocks completed at nearby mine sites (Stockton, Cypress, Escarpment and others). The information collected at these adjacent mine sites combined with BPCP specific datasets, enables a level of accuracy and detailed mine planning with respect to AMD and downstream water quality that is un-paralleled in mine consenting history for a project of this type in New Zealand.

17. The key methodological elements that enable high levels of certainty with respect to mine planning for AMD are slightly different at the Stockton sub-area compared to the ESE, MFS & UWHR sub-areas. At the Stockton sub-area, there is a large water quality dataset that has been collected during operations over the last ~20 years and extensive work related to medium-long term liabilities because of change in ownership of the operation about 10 years ago. In addition, at Stockton the rock geochemistry has relatively high pyrite (higher pyrite causes more concentrated AMD) and extensive historical underground mines that cause highly impacted aquatic ecosystems.

18. At ESE, MFS and UWHR there is a large, well monitored, and characterised engineered landform (ELF; the Barren Valley ELF), as well as a monitored passive treatment system (the Barren Valley ELF mussel shell reactor (MSR)). In addition, there is a database of water and rock geochemistry for the ESE sub-area. At the ESE, MFS and UWHR sub-areas there are historic underground mines and roading infrastructure that cause lower levels of impact to aquatic ecosystems (in general) compared to historic underground mine workings at Stockton – especially Millerton where the BPCP is focussed.

19. In general, these datasets at the ESE, MFS and UWHR sub area enable predictions of water quality impacts within the BPCP disturbance area that have high accuracy and low uncertainty compared to predictions of water quality where there is no adjacent or previous mine. For the remainder of the evidence summary related to methods applied to environmental geochemistry and interpretations that have been made, I will separate approaches taken in the Stockton sub-area from those taken in the ESE, MFS and UWHR sub-areas. The division is convenient because different methods have been used for water quality predictions at these two parts of

the BPCP. Despite differences, there are also common factors to water quality predictions in these different parts of the Project, such long term acid decrease rates, rapid decrease in acid release on landform closure and preference for empirical and measured data where available.

Stockton sub-area

20. The Stockton sub-area is active and has operational circumstances that are different to other sub-areas of the BPCP. Much of the future activity in the Stockton sub-area takes place in the Millerton area, with some aspects of water management utilising infrastructure in the Mangatini or other parts of the Stockton mine. The Millerton area of the Buller Plateaux contains rocks that have high potential to form acid (on average more acid forming potential than most other parts of the Buller Plateaux) as well as underground workings in this area that release highly acidic AMD and have contained many mine fires with several still burning. The planned Millerton part of the mine will operate until 2033 with final landform completion in 2046. There is complex ownership of legacy mining AMD issues in this area as outlined in one of the Stockton reports that focuses on the history and future AMD management at Stockton. In this part of the mine, legacy impacts are severe; they are attributable to previous mine operators (historic underground/opencast operators, State Coal Mines, and more recently Solid Energy) and there are also historic underground workings that fall outside but adjacent to the planned operations. In these areas the criteria for continued operation by BRL recognise that current mining must leave improvement of water quality with a trajectory toward improvement of aquatic ecosystems. To this end the key parameter that has been identified (through aquatic ecology surveys) as signalling aquatic ecosystem improvement is dissolved aluminium (Al). Much of the assessment of aquatic ecosystem health and success with respect to a trajectory for improvement is described in terms of achievement of threshold concentrations of dissolved Al that relate to health of aquatic ecosystems.

21. The approach taken by BRL in the Stockton sub-area is to analyse a large data set of monitoring data, many thousands of measurements and analyses often including physiochemistry, flow rates and water quality data. With input from ecological experts, this data is distilled down to the impact of proposed future operations based on Al concentrations and loads delivered to the downstream environment. The measured data are complex, have low uncertainty but sometimes high variability, and BRL have treated

this data in a statistical manner to interpret previous trends as well as step changes in the data relating to different approaches to mine drainage management and treatment.

22. There are many details to consider and implications to assess within this approach. Below is a high-level (not exhaustive) list of key aspects from the point of view of the witness, additional details related to expert peer review of this material can be found in Appendix 1.

The robustness of the statistical approaches taken.

23. Continuous monitoring data for electrical conductivity (EC) along with flow measurements as well as chemical monitoring data (typically weekly) of acidity and aluminium concentrations have been used to generate relationships that can provide forecasts for Al into the future. Aluminium is the focus of this work because it is used to determine thresholds for ecological recovery. The geochemical basis for statistical relationships between EC, acidity and aluminium concentration are sound because, components of acidity (pH, Fe, Al) deliver EC (along with related anions – SO42-). These relationships have been calculated on a catchment specific basis using similar methodology at each site and modified to accommodate the monitoring data available.

24. Future predictions for Al concentration are made by relating the correlations from measurements to the projections for acid release and decline that were completed for Stockton Mine at the time of the ownership change about 10 years ago. Overall, this approach is likely to be the most accurate method available for future predictions because it maximises the application of field measurements and minimises extrapolation from small scale trials and modelling. Overall, the match between projection and measured data is acceptable where displayed.

Projections of acid load during operational and rehabilitation period.

25. The data that has been collected is mostly for the purpose of monitoring and managing activities at the Stockton mine site and has been processed and adapted for long term projections to understand the trajectory of disturbed catchments toward ecological recovery or stream betterment. The result of collection of an individual sample on site is subject to many variables including, flow rate, recent rainfall (flushing), upstream mining operations, pumping operations, fire suppression and water treatment by

various methods. The BRL onsite experts have adequately completed analysis of site conditions and previous mining activity along with the monitoring data to enable these variables to be integrated into interpretation of the acidity and Al concentration and loads for the future mine scenario.

26. Use of the current monitoring data along with the Stockton mine plan for the remaining operational period and rehabilitation period, means predictions of acid loads for treatment over the next 20 years can be made. This mostly relates to understanding the acid load that will be generated in each catchment over the remaining operational years including the implications of the mine plan, fire suppression, water treatment and rehabilitation. In general, the approach taken for acid load projections throughout this period are internally consistent with current information.

The accuracy and credibility of long term projections for mine water chemistry.

27. Once the operational and rehabilitation period is complete, acid load projections for a longer period (~80y) are made to understand water treatment requirements to deliver improved water quality downstream of mining. In addition, Al concentrations are calculated to understand ecological recovery and a betterment baseline value is determined to ensure the effects of future operations do not make water quality worse. Ecological recovery assessment utilises the 75th percentile values for projected Al concentrations rather than median values to align with ecological recovery criteria.

28. Future mine drainage chemistry projections rely on several key paradigms that have been established during the assessment of historic and Solid Energy liabilities as well as the effectiveness of current water treatment technologies and future technologies. Key aspects of the liabilities assessment include water quality improvement related to construction and rehabilitation of final landforms as well as long term projections of depletion of acid release by sulphide minerals. These aspects of water quality improvement and long-term sulphide depletion were established and reviewed at the time liabilities were established for change of ownership and have not been re-reviewed for the BPCP. They are credible with respect to subsequent and related measurements that have been made in some of the catchments over the last 10 years and/or with respect to published literature. Water treatment effectiveness details are presented through analysis of data collected over the last 20 years and are robust.

ESE, MFS and UWHR sub-areas

29. The approach taken at the ESE, MFS and UWHR for projections of future mine water quality rely mostly on data sets collected from non-operational parts of the Project. These areas therefore rely on establishment of background water quality conditions, geochemical analysis of drill holes samples from areas to be mined, analogue data for seepage from waste rock placed into ELFs, water treatment effectiveness (active and passive) and probabilistic modelling. This methodology relies on some key underpinning assumptions including (but not limited to) the following:

Background water quality assessment.

30. The assessment of background water quality identifies the conditions that commonly occur in each of the catchments that are will be disturbed by the BPCP. Sites selected for sample collection in these areas are appropriately positioned for three purposes, monitoring for compliance, monitoring for performance and monitoring of natural conditions. Datasets collected and presented demonstrate that much of the variability of stream chemistry is related to rainfall induced changes in stream flow. The results and interpretations presented for background water quality assessment demonstrate site specific characteristics within the range of variability that would be expected for datasets collected in the Buller Plateaux area, where there is a large historical dataset.

Drillhole data collection and interpretation.

31. There are an appropriate number and distribution of samples collected for the areas to be mined and the block modelling approach to interpretation is robust for pre-mine planning.

Analogue seepage model utilising the Barren Valley ELF (BVELF).

32. The BVELF seepage data along with the construction details that are available make this a credible tool for the prediction of future water quality data at similarly constructed landforms. The important datasets for this landform are seepage quality, oxygen ingress studies, runoff coefficients, geochemical characterisation, bulk tonnages and construction processes. This dataset has been processed into a model that can be scaled for future ELFs in the ESE, MFS and UWHR sub-areas providing a robust tool for prediction of AMD seepage quality should the BPCP proceed. In addition, the model that has been developed enables the evolution of mine drainage

chemistry (particularly acid and trace element concentrations and loads) to be predicted into the future once ELFs are complete and rehabilitated. This process delivers source terms for seepage that evolve with time and are used in probabilistic modelling processes.

Development of source terms for water from different parts of the mine.

33. In addition to the seepage water characteristics, source terms are developed for surfaces (pit walls and floors), unrehabilitated surfaces, rehabilitated surfaces, non acid forming (NAF) materials. Water quality evolution factors are applied where there is empirical data to support changes in these terms with time. These additional source terms are applied to mine drainage chemistry (along with the seepage source terms) to determine water quality that must be treated as the mine progresses and then they are used in the probabilistic model framework.

Water treatment effectiveness

34. Active water treatment effectiveness parameters are taken from chemical engineering studies for water treatment. In addition, the chemical water treatment processes are similar to those that have been developed at Stockton over the last 10-20 years.

35. Passive water treatment effectiveness parameters are taken from full scale mussel shell reactors (MSR) installed at Escarpment mine as well as at the Canterbury coal mine and development systems installed at the Stockton mine site. Overall, the data presented are positive covering many aspects of MSR operation and there remain some studies to complete during the early phase of the BPCP. The level of studies related to the transition from active treatment to passive treatment for the BPCP is at an advanced level for a mine that is yet to operate. In general, it is unusual to have the transition from active to passive treatment laid out in the manner provided for the BPCP at the consenting stage and it provides certainty that the operator is planning for closure in a robust manner.

Probabilistic modelling

36. The probabilistic modelling approach is relatively standard for mine consent processes and includes typical approaches to climate variability and assessment of the impact of climate change. The data set that is utilised provides for low uncertainty modelling because the approaches listed above (especially the BVELF seepage model) enable relatively confident

predictions of water quality, compared to other mine consent applications where sometimes only laboratory tests are available. Base case scenarios are appropriate and stress testing of the for climatic extremes or unexpected mine drainage quality (± 30% concentrations for AMD water quality) provide confidence that the mine water management/treatment projections are robust.

COMMENT ON ENVIRONMENTAL GEOCHEMISTRY EFFECTS AND EFFECTS MANAGEMENT MEASURES

37. The key results of the methodological processes outlined above are summarised for the Stockton area separately from the ESE, MFS and UWHR sub-areas in this section.

Stockton sub-area

Measurements of rehabilitation success

38. Results of the BPCP at Stockton are complex because the different parts of the Stockton mine have different ages and contributions of acid to down-stream environments. Some parts of the Stockton mine will not have all historic workings removed during the BPCP and so legacy aspects continue regardless of the BRL workplan for the BPCP. Other parts of the mine have catchments that collect surface water and seepage from areas that are completely rehabilitated. In addition, the complex water management process of commissioning/decommissioning sumps & pumps, fire suppression, and completion of rehabilitation makes it challenging to keep up with all the processes that are in use and underpinn water quality assumptions and projections.

39. For this reason, Stockton workplan has two sets of criteria against which to measure success.

- Comparison to ecological thresholds for 75th percentile Al concentrations.
- Comparison of modelled effects with BPCP operation to betterment reference values for the Millerton sub-catchments if historic underground mines continued to discharge.

Results of long term modelling.

40. For catchments where rehabilitation is complete when the BPCP is finished, at the end of the modelling period such as St Patricks, Mangatini and

others, median concentrations projections for Al sit just below 1mg/L. However, to achieve the ecological recovery outlined by ecological surveys the 75th percentile projected Al concentration must be below 1mg/L. The projected 75th percentile Al concentrations generally sit just above the 1mg/L threshold a with a decreasing concentration trajectory at the end of the modelling period.

41. For catchments where there remains some underground mining AMD discharges that cannot be captured during the BPCP, long term projections for water quality are compared to catchment specific betterment reference values. In almost all simulations the projected water after the BPCP sits below the Betterment reference values. However, in these catchments there is untreated AMD from historic workings discharging and the concentrations of Al (and acidity) are higher than in the completely rehabilitated catchments, they are projected to contain between about 4 and 15 mg/L of Al at the end of the modelling period.

Ngakawau River

42. In addition to the catchments that drain the Stockton sub-area, the effect of discharges of upstream catchments is assessed for the Ngakawau River. This assessment is complicated by tidal effects in the zone where this should be measured by sampling. Information from the NR sampling site indicates the projected 75th percentile Al concentrations for the Ngakawau River sit below 1mg/L and a dilution model indicates the river will remain below this threshold throughout the BPCP.

Summary and Management measures

43. I have reviewed the management measures that are reported for Stockton in the above documents. These are a complex set of processes that come on-line and offline throughout the Project as indicated above. Overall, the assumptions underpinning the geochemical interpretations for this complex operational, rehabilitation and closure scenario are reasonable. The best element of this work is the large volume of monitoring data that can be incorporated into predictions. Overall, the interpretations are balanced and for critical aspects of this work the geochemical data supports the projections.

44. In addition, should measured results of acid load or Al concentration prove higher than projections, there is capacity for additional water treatment should it be required.

ESE, MFS and UWHR Sub-areas

BVELF analogue model

45. Interpretation of the BVELF water quality along with studies related to oxygen ingress enable separation of (stored acidity) AMD release related to disturbance of rocks in ELF structures that are under construction, partial oxidation and have relatively free access of oxygen and rain water to AMD release from ongoing sulphide oxidation (potential acidity) once construction methods limit oxygen/rain water access to the ELF. This is completed based on interpretation of the BVELF water quality dataset tied in with oxygen ingress studies that have been completed along with measured values for infiltration.

46. The results from the BVELF analogue model demonstrate that there are three important phases for mine water chemical evolution from ELFs.

1) A construction phase, where generally seepage AMD water quality gets poorer with time because stored acidity and potential acidity are increasingly released.

2) A stabilisation phase where seepage water reaches peak acidity and trace element concentrations and stabilises as the impact of ELF construction methods deliver decreased oxygen and water contact with waste rock. Stored acidity is released in a relatively stable manner and potential acid release is limited by diminishing oxygen ingress.

3) A decay phase where the hydrogeology of the ELF stabilises, water ingress is limited to final rehabilitated runoff co-efficient and oxygen ingress is limited to diffusion through rehabilitated surface to the outer 10m of the ELF.

47. Overall, this BVELF analogue model is a robust interpretation of empirical datasets, scale factors related to pyrite content (based on block modelling) and site-specific factors related to size and construction timelines are applied to each ELF. It is difficult to imagine a better method for predicting seepage water quality projections for this part of the BPCP.

Water treatment effectiveness.

48. Overall, the combined water quality treatment effectiveness studies for the ESE, MFS and UWHR sub-area deliver results for mitigated mine water quality after treatment (active or passive) that are integrated into the catchment water flows for a probabilistic assessment of water quality at compliance points. This modelling steps through operations, active closure and post closure phases of mine activity. Water treatment effectiveness is adequate to deliver compliance with respect to proposed downstream water monitoring. There remain some elements related to passive treatment that require further study during the early phases of the BPCP, however, initial work has been completed on these and an adaptive approach is appropriate for these aspects. Many mine sites that are currently operating in New Zealand have less detailed plans for a transition from active treatment to passive treatment than the BPCP application.

Probabilistic modelling.

49. The results of probabilistic modelling in the ESE and MFS sub-areas are presented for different scenarios, base case, climatic extremes and ± 30% for AMD concentrations. Overall, the most important result to be taken from this work is that modelling indicates that the ESE and MFS sub-areas will be compliant with respect to water quality thresholds determined through ecological assessment (not included in geochemical review). Another key aspect of the probabilistic modelling is the amount of time that the water management system will be required to bypass (report to the downstream catchment untreated) or spill from the water treatment (report to the catchment partially treated). Under base case scenarios the bypass/spill threshold is 5% or less, and under the wet scenario up to 18% of the time. However, modelling indicates that the site is expected to remain compliant with respect to the water quality parameters at the proposed compliance sites under bypass/spill conditions.

50. The reason for bypass/spill modelling is to recognise that the Buller Plateaux areas receive relatively frequent high intensity rainfall events compared to many other parts of New Zealand and therefore mechanisms are required to manage these events in a manner that does not damage or cause failure of infrastructure or safety risk for operators.

Summary and Management Measures

51. I have reviewed the management measures that are reported for ESE, MFS and UWHR sub-areas that are captured in the above documents. Although this sub-area has less empirical data that the Stockton sub-area (because it is not an active mine) the overall management process is simpler because the catchments are not as complex and historical AMD is of lower importance. In addition, the as-built aspect of current mining does not influence the proposed operation for ESE, MFS and UWHR sub-areas to the same extend as the Stockton sub-area.

52. In the ESE, MFS and UWHR sub-areas the geochemical interpretations underlying proposed management activities within the sub-areas are balanced, and reasonable. Critical aspects of the water quality projection sare supported by geochemical datasets or acceptable assumptions.

In addition, should measured results of acid load or trace element concentrations prove higher than projections, there is capacity for additional water treatment should it be required. The projected water chemistry has been tested by changes in climate and an estimated uncertainty of ± 30% of concentrations.

James Pope

13 August 2026

APPENDIX ONE

Strata Geoscience

Peer Review – Environmental Geochemistry

Rehabilitation chases mining - Stockton

Author:	Dr James Pope
Reference:	2025 0018
Client:	[redacted]
Client Address:	BRL Westport
Additional recipients:	As Required – BRL

Review:	Reviewed by	Date	Updated
1	Client	16/6/2026	JP
2	Planning/legal	27/7/2026	JP
3	Final	7/8/2026	JP

Contents

1 Introduction

Strata Geoscience Ltd has completed a peer review of environmental geochemistry work as well as selected laboratory, water treatment and hydrogeology work by Bathurst Resources Ltd (BRL) and their consultants to support the Buller Plateaux Continuation Project (BPCP or Project). This report is a plain English review of the documents prepared to support the BPCP and all documents covered by this review can be found in technical information supplied within the application prepared by BRL. These documents;

1) characterise materials that will be impacted by mining;
2) predict geochemical processes that will occur should mining proceed;
3) identify likely water quality impacts that will arise; and
4) deliver technical and management solutions that result in acceptable outcomes for the environment downstream of mining.

An important aspect of this environmental geochemistry work is to understand how the geochemical processes change throughout the area proposed to be mined and how these processes will change through time. Geochemical studies therefore include extensive data acquisition within the proposed mining area and adjacent mines as well as modelling and predictions that extend beyond the end of mining. Modelling for the BPCP incorporates data from historic underground mines as well as opencast mines at Stockton that have operated since the 1950s and estimates trends from this information into the future to provide confidence that mining does not leave a negative legacy on water quality into the foreseeable future.

Overall, it is the opinion of Strata Geoscience that the work completed for the BPCP represents the most comprehensive geochemical study submitted for resource consent application for any mining project of this type in New Zealand, and that the studies are high quality with respect to data collected and interpretation. The proposed mining takes place adjacent to opencast mines that remain active at Stockton and Cypress and overlap underground mines that operated from the late 1800s. The proposed BPCP mine sites have about 25 years of leading practice geochemical investigations that are collated to support the application and provide comprehensive understanding of likely geochemical processes and impacts during operations and well into the closure and post closure time periods.

Mining is a global industry and there are many techniques used by geochemists to predict and manage the impact of mining activity on water quality. Often these techniques have a history of international development, and the job of an environmental geochemist is to select and apply techniques that are appropriate for site specific factors at the mine site. In some circumstances, the role of the geochemist is to innovate and apply site specific management or techniques to deliver the desired engineering or rehabilitation outcome. Site specific factors are important in this process and some key specific factors for the Buller Area include:

- Geology – stratiform sedimentary deposit.
- Geochemistry – mostly acid forming rock types with some non-acid forming rocks and variations related to geology throughout the site.
- Climate – temperate with high rainfall (5-7m annually).
- Topography – hilly terrain with steep gorges or valleys.

- Physiography – high runoff coefficient in undisturbed terrain and rapid report of most rainfall to streams.
- Regulatory regime – discharges are consented and monitored downstream, conditions are effects based.

Mining delivers irreversible changes to the area in which it takes place so there is a need for quantification of geochemical processes and predictions of likely future environmental conditions at mine sites. However, this sits within a dynamic operational environment that must have flexibility to respond to new information on the deposit (as resources are converted to reserves) and positive or negative market conditions appropriately. Therefore, the conditions under which any mining operation is consented must be appropriate to protect against environmental risks but also adequately flexible to deliver positive environmental outcomes as mine sites respond to change.

1.1 Background

Environmental impacts from coal mining on water quality are well understood. At open cast mines, like those planned in the BPCP, overburden (rock above the coal) is removed to enable mining of coal. Overburden is placed in engineered landforms (ELFs) that differ from waste rock dumps in that ELFs are designed to minimise AMD (acid and metalliferous drainage) forming reactions through limiting oxygen and water contact with waste rock. Construction of ELFs are part of a step-change process in waste handling that is currently underway at Stockton and will be standard practice in the BPCP. Typically ELFs are constructed in previously mined areas (mine pits) although sometimes temporary or permanent ELFs are required outside of mine pits.

The process of removing overburden and construction of a new landform breaks up large volumes of intact rock into particles that range in size from boulders (>1m diameter) to clay (<0.001mm) and this causes accelerated weathering. Weathering is a collective term for the release of macro- and micro-nutrients from rocks into the biosphere and it commonly includes physical, chemical and microbial processes and requires water, air and reactive rock surfaces. Mining directly impacts the physical break up of rock increasing reactive surface area by many orders of magnitude so that chemical and microbial processes accelerate and this can lead to release of components at concentrations that cause degradation of downstream aquatic environments. The term that is used to describe degradation of aquatic environments by mining is acid and metalliferous drainage (AMD). In addition, small particles of disturbed rock can be entrained by surface water leading to increased suspended sediment in water from mine sites.

Previous operation of mines in the Stockton and Denniston areas by Bathurst, BRL and predecessors provides an analogy for the likely range of potential impacts on water quality at planned mine sites. The BPCP area contains historic mining activity where AMD management was not implemented and downstream degradation of water quality occurs. Recent and current operations proceed within consented water quality limits through application of AMD management and treatment processes. In these areas, regional geological and geochemical studies as well as analogy to current mine operations provide important information that assist with the planning of future mines.

2 Methods

This environmental geochemistry peer review was completed by desktop review only. No additional field assessment (mapping, sampling or laboratory analysis) was completed to deliver this peer review. The author has visited the Buller Plateaux region on many (>50) occasions, however, no site-specific field work was considered necessary for this peer review process.

Document review commenced in mid 2025. Review comments have been provided to BRL and their consultants via two methods. Where reports were near finalised prior to review, short sets of notes were provided with feedback and recommendations. Where reports were provided as advanced drafts, comments were provided as tracked notes in the margin of draft reports. With both feedback mechanisms, comments were collated and amendments related to the comments were checked back against the revised text to ensure that they had been addressed adequately. Comments have been provided at three levels.

1. Plain English overview – designed to enable a non-geochemist to quickly understand the purpose of the work and approach taken
2. High level review comments – broad issues of interpretation
3. Technical comments – issues of additional detail or clarity of explanation

Almost all comments have been provided in written form directly to BRL although discussion of some details which took place on a peer-to-peer basis directly with consultants or technical specialists within BRL.

2.1 Limitations

An overview of the appropriateness of laboratory procedures, analysis methods has been completed and any concerns were included in the review process. This peer review report assumes that analysis information are represented accurately. No systematic audit of laboratory reports compared to data used in reports has been completed. Where there has been a reason to check laboratory data in appendices throughout the review, no inconsistencies between report content and appendices have been identified.

Values reflecting geochemical data in tables in the report have had a cursory review and calculations supporting derived values have not been systematically checked. However, the geochemistry of Brunner Coal Measures and other rocks that will be disturbed by the BPCP as well as leachate and downstream impacts are well understood and have been the subject of many reports, conference papers and peer reviewed publications. The reviewer is familiar with the literature that is publicly available and has reviewed many site-specific reports from coal mines hosted in the Brunner Coal Measures. In addition, the reviewer has worked relatively continuously in the BPCP area and surrounds for > 20 years and is familiar with many of the water management and water treatment processes that are applied. It is likely that any anomalous data or incorrect calculations that might lead to substantially erroneous interpretation have been identified.

This document is designed to deliver a plain English summary of reports of technical studies that are completed with a view to ensuring best management of acid and metalliferous drainage risk related to planned operations in the Buller Plateaux area. In addition, technical issues related to interpretation or reporting of information have been identified and communicated to the technical experts at BRL and their consultants.

2.2 Peer Review Structure

Overall, the peer review of data for the BPCP is split into three sections:

1. Stockton reports on geochemical interpretation and long-term projection for water quality improvement in catchments disturbed by historical, contemporary, and proposed future BPCP activities.
2. ESE (Escarpment Extended), MFS (Mount Frederick South) and UWHR (Upper Waimangaroa Haul Road) AMD reports. The review of ESE, MFS and UWHR AMD reports follows the structure outlined in the AMD overview report (J-NZ0480-001-R).
3. ESE, MFS and UWHR suspended sediment reports.

3 Review – Stockton AMD Documents

3.1 Introduction

Legacy aspects at the Stockton Mine make it a difficult site for environmental management and also a challenging site to regulate and monitor. Many of the Northern Stockton catchments have a long history of poor quality and highly impacted aquatic ecosystems caused by free draining historic underground coal mining and outdated waste management practices by early open cast mine operators. This has led to long term AMD issues that would be likely to continue for centuries without remediation. The current Stockton Mine Operation is mining through historic underground workings in Millerton Block and will deliver a single large engineered landform, the Millerton ELF when mining is complete. This activity enables the mine site to remove many sources of AMD and deliver water quality that is adequately improved so that a relatively un-impacted or less impacted aquatic ecosystem will develop. Targets for water quality at the Stockton mine site relate to ecosystem function and adequate improvement (betterment), rather than a long list of thresholds for major components and trace elements based on ANZG documentation or similar guidelines.

The Stockton Mine site has made large improvements to environmental practices over the last 25 years. Water treatment, waste rock management, sediment control and rehabilitation practices have been subjects of laboratory and field experimentation with internal experts and external consultants playing important roles. The datasets provided from these studies enable good decision making by operational and management staff at Stockton. In some instances, technologies and approaches that have been developed at Stockton are world leading, for example, vegetation direct transfer (VDT) and mussel shell reactors for AMD treatment. In other areas of environmental management Stockton has adapted technology from other sources and added innovation as required, for example, AMD dosing treatment.

3.2 Stockton – acid and metalliferous drainage

Acid and metalliferous drainage issues at Stockton Mine are complicated for several reasons:

- Geologically the area in which the Stockton Mine occurs has a stronger influence of estuarine depositional environments and this leads to a higher sulphur content in coal measures in this area compared to other parts of the BPCP. Within coal measures rocks, most sulphur is present as sulphide minerals (pyrite) and so the Stockton area is more acid forming than other parts of the BPCP area.
- There is an extensive historical underground mining network at Stockton. These historic workings are strongly acid forming and contain multiple mine fires that must be extinguished before mining. There are old workings and mine fires within and close to the other parts of the BPCP mine areas, however at Stockton these issues are more extensive and complex.
- There is a history of relatively recent (post 1950s) open cast mining that has generated overburden which has not been managed in a manner to minimise water and oxygen ingress. This produces a legacy of AMD that arises from open cast mining (as well as underground mining) that must be included in future management plans.
- Many of the techniques and practices that are planned for the BPCP have been developed and pioneered at Stockton. For some aspects of AMD management there are opportunities for improvement compared to management of combined complex legacy and current conditions at Stockton.

- Liability and ownership of responsibilities for legacy and future AMD issues involve multiple parties at Stockton.

Overall, water quality and geochemistry at Stockton Mine is complex to manage currently and to plan for into the future, because of the multiple overlapping legacy and current mining related activities. However, in general the datasets collected related to mine drainage chemistry, mine drainage management and water management are relatively complete and are suitable to develop robust plans for future operations. In general, the catchments around the Stockton Mine must be some of the most studied, analysed, and well understood in New Zealand.

3.2.1 Documents Included

The reviewed documents for the Stockton Mine site were authored by BRL staff and draw on the large database of analyses that is present for this mine site. The extensive network of sample sites, large database of analyses and concurrent measurements of flow and concentration (load and load change) that are used for interpretations in these documents provide confidence that the geochemistry of the catchments in the Stockton and Millerton areas are well understood.

Table 5. Reviewed documents related to assessment of potential effects of AMD

Author	Title
BRL	Acid Mine Drainage. History of AMD Management and Proposed Future Management. Stockton Mine
BRL	Stockton Mine 80-year water quality forecast
BRL	Millerton water and AMD management report
BRL	Stockton Operational AMD and Sludge Management

3.2.2 Review

<u>History of AMD Management and Proposed Future Management</u>

The document, History of AMD Management and Proposed Future Management, provides an overview of the complex mining history and drivers for environmental improvement at the Stockton Mine site. This includes diverse factors such as:

- the extensive underground workings with complex geotechnical issues and mine fires.
- qualitative to semi-quantitative environmental improvement targets (for example whitebait passage in the Ngakawau River).
- diverse community input and engagement with nearby residents, Iwi, regulators, central government, non-government organisations and regulators.
- responsibilities and management of liabilities through ownership changes.
- development of targets for improvement guided by ecological thresholds and long-term objectives with input from Iwi partners
- complexity of the minerals permit position. BRL does not have mineral permits or mine plans over all of the coal or legacy mine sites in the Stockton/Millerton area.

The History of AMD Management and Proposed Future Management document also includes details on the long-term planning for improvement of water quality and a recognition that partially this can be achieved by mining out historic underground mine areas and delivering stable rehabilitated landforms in their place. The concept of ‘betterment’ is described in this document, where the goal for current operations after completion is to set up the postmining landscape for a trajectory of improving water quality over several decades compared to the legacy impacts from historic mining where severe impacts would be likely to last for several centuries. This concept avoids the expectation that pre-mining water quality conditions are the target for current operations on closure. Although not stated in the report, it is likely that placing the entire historic legacy on the current operation would not be economically sustainable. The concept of 'betterment' enables current mining activity to operate and make environmental improvement and is a pragmatic solution to environmental degradation that is a result of about 130 years of mining history. In addition, some of the legacy AMD issues do not occur either within the BPCP area or within the Stockton mining permit area.

In addition, this document provides an introduction to how environmental improvement will be targeted and managed to achieve ecological recovery. Broad water quality guideline values such as Al < 1mg/L and pH > 4.5 are applied as targets for treatment and management. This recognises that improvement of water quality to these broad criteria is an indicator of predictable ecological improvement and also an indicator that other water quality parameters are likely to be improving as well. The length of the trajectory for ecological recovery is currently planned to be decades and modelling is completed out to 80 years. It is anticipated that as the trajectory plays out over the coming decades, more conventional and detailed water quality targets and compliance values will be implemented.

<u>Stockton Mine 80-year Water Quality Forecast</u>

The Stockton Mine 80-year Water Quality Forecast compiles all available water quality data for key catchments in the Stockton footprint and generates projections for long term water quality. This includes St Patricks catchment, Mangatini catchment and Mine Creek which are tributaries to the Ngakawau River as well as Granity Stream and its Miller Stream catchment that drain to the coast. Projections for long term water quality at mine sites with historic disturbance and legacy effects are difficult because there are many factors that can influence long-term trends. Ultimately in these circumstances the best approach is to merge geochemical data with related peer reviewed literature, and modify by relevant site-specific factors to provide a best approximation for the likely future scenario. At Stockton this process occurred in a rigorous manner for the sale of the Stockton Mine in 2015-2016 and was completed by New Zealand Treasury using a mix of site-specific data and reports along with input from national and international experts. The key outputs from this process are to identify the rates of change for water quality as the Stockton mine rehabilitation progresses and include:

1. Rehabilitation of disturbed landforms within the Stockton Catchments as at 2017 would deliver a 50% reduction in acid load over 10 years.
2. Activities related to closure that occur within the last 10 years of operation would contribute another 25% reduction in acid load over the subsequent 10 years.
3. A constant acid load decay rate of 0.62% is applied for long term.

These three outputs are averaged over complex mine site datasets where many different physiochemical processes operate in close association and are projected through a variable climate regime. There is uncertainty in these long-term projections and this is best minimised through performance monitoring and adaptive management. Overall, the three outputs above produce a relatively rapid decrease in acid (and trace element load) once mining related disturbance ceases and rehabilitation is complete, then a long period of gradual improvement as reactive components within mining related disturbance are consumed. This pattern matches expectation as well as national and international experience in similar circumstances. Eventually, it would be expected that the weathering rates and water quality in the mined landscape approach natural conditions, although some permanent changes to streams will occur.

The Stockton Mine 80-year Water Quality Forecast also incorporates the environmental improvement approach introduced in the History of AMD Management and Proposed Future Management. Key objectives for water quality improvement as the liabilities from previous mining are minimised include chemical indicators of ecological recovery. These indicators have been developed over a long history of monitoring aquatic ecology and improvements in aquatic ecology at Stockton Mine and surrounding areas. They include.

1. Severely impacted ecosystems occur when the dissolved Al concentration is >2.8mg/L.
2. Between 2.8 and 1 mg/L dissolved Al a recovering ecosystem occurs.
3. A natural ecosystem can occur when the dissolved concentration Al < 1mg/L.

It is accepted that this approach is incomplete and that there will be nuance in terms of additional water quality parameters that are important and variable sensitivity of specific biota within the ecosystem. However, with a target of developing a trajectory toward ecological recovery of severely degraded ecosystems toward unimpacted, these indicators are sufficient to measure and predict progress. Throughout The Stockton Mine 80-year Water Quality Forecast an approach of exceeding the water quality thresholds 75% of the time is considered to be achievement of the standard.

Relationships between acidity and Al have been measured in a statistical manner for each catchment using long term monitoring datasets (often with hundreds to thousands of datapoints) and these data have been annualised so that long term trends can be identified without the noise of rainfall driven changes in load or concentration. Concentrations of Al have been projected into the future using a complex mix of information including:

- Recent and current water quality information compared to mine operations
- Future operational elements of mining such as water treatment, fire suppression, and projected flow or pump rates
- Current and planned rehabilitation processes
- Current and future flow rates for the catchment
- Acid decay rates from the NZ Treasury liability assessment process

The projections have been completed for acidity loads and concentrations and statistically converted into Al concentrations then compared to thresholds at 2.8mg/L and 1mg/L. The comparisons to Al are made at median and 75th percentile Al concentration for 80 years to 2106.

Overall, a large data set is presented to support the interpretations, the statistical treatment of data is adequate, and credible calculations for future trends are completed. The comparisons are made to ecological recovery thresholds in a rigorous manner and results are clearly presented in a series of annotated plots and in summary form on a map. The annotated plots are informative and changes in water quality trajectories are related to changes in mining activity, water management or acidity decay rates through time.

<u>Millerton Water and AMD Management Report</u>

The Millerton Water and AMD Management Report provides details of AMD management process and operations in the Millerton Block of Stockton Mine for the approaching operational period from 2027-2033. This report provides additional details related to interpretations and statistical treatment of data used to produce long term trends in acidity out to 2106. Aspects included in this report that are not covered in the Stockton Mine 80-year Water Quality Forecast include:

- Development and utilisation of relationships between EC water chemistry (Al or acidity) when analytical data are incomplete.
- Trends in water chemistry with time in measured data and simplification of measured data to annual median values.
- Correlations between predicted annual acidity load, median acidity concentrations and median Al concentrations.

These calculations and correlations are made for each catchment. The catchments outlined in this report are those that will be mined in the next operational period (2027-2033) including Twins Stream, Granity Stream, Miller Stream and Mine Creek. In addition, the impact of Mine Creek discharge into the Ngakawau River (in addition to contributions from Mangatini and St Patricks Catchments) is estimated through a mixing model because tidal influence makes sampling difficult in this part of the catchment.

Water quality improvement (betterment) is more difficult to estimate in these catchments because they will be left with a mix of contemporary and legacy mine drainages and mined out historic workings. In each of these sub catchments betterment is assessed based on measurements and estimates of water quality from a 2010 benchmark. The 2010 year is selected because it pre-dates opencast mining in Millerton Block and measured data from after this time are compromised by opencast mining and fire suppression activities that have taken place throughout the Millerton catchment. This enables a clear assessment of the impact of current mine practices which partially remove historic underground mines and replace them with stable engineered landforms or in some cases pit walls and pit floor areas. This contrasts with water quality assessments related to water chemistry factors that are linked to recovery of aquatic ecosystems that are presented in the Stockton Mine 80-year Water Quality Forecast.

With the statistical treatment of water quality and the benchmark 2010 water quality parameters for each catchment, the impact of operations throughout the remaining mine life is predicted in each sub catchment. Long term estimates for water quality are made in a similar manner to water quality predictions for other catchments at Stockton Mine where all historic workings will be removed (Stockton Mine 80-year Water Quality Forecast). The projections throughout the operational phase are complicated in some of these catchments because of the impact of loss or gain of water from fire suppression activities, pump and treat operations, and changes to water quality that result from fire suppression. In some cases, the mine operations can be optimised to deliver water quality that does not exceed the 2010 betterment reference values and in addition the length of time that pump and treat activities are required beyond the end of mine life (2033) for each of the sub catchments can be calculated.

In addition to the assessments for the Twin Stream, Granity Stream, Miller Stream, Mine Creek and Ngakawau River mixing model, the Millerton Water and AMD Management Report delivers details on the final engineered landform that will be left in the Millerton catchment. This includes acid loads and treatment requirements throughout the operational and closure phases and based on this assessment water treatment will be required on site until beyond 2106 at the MW16 sump.

Stockton Operational AMD and Sludge Management

The Stockton Operational AMD and Sludge Management Report describes current practice for AMD treatment and sludge management that is mostly completed in the Mangatini Catchment and Fly Creek/St Patricks Catchment. Both active water treatment plants in these catchments dose CaO into AMD and then the dosed water flows into large sump structures where precipitates and sediment settle and are managed prior to disposal. The mine site intends to switch to a MgO dosing reagent in 2032 because sludge volumes generated with this reagent are lower and the sludge is denser. In addition to the current Mangatini and Fly Creek/St Patricks catchment AMD management sumps a new sump will be constructed in Mine Creek catchment (MW16 Sump) for treatment of mine drainages in the long term with projections of water quality and sludge volumes out to 2106.

In the Mangatini Catchment up to 10,000t of acid are treated per year through CaO dosing and settlement in Mangatini Sump. High flow events (>70th percentile flows) are dosed with CaO but can bypass Mangatini Sump to report directly to the downstream catchment and eventually Ngakawau River. Retained precipitate and sediment within the sump are transferred to filter beds in ELFs that enable dewatering of the sludge leaving a ~10% solid material that can be moved to co-disposal sites in ELFs. Monitoring of the receiving environment indicates that there is no noticeable impact from the treated mine drainage water that bypasses the Mangatini Sump.

The assessments on the down-stream impact of bypass are made through comparison of data from the Ngakawau River under different water treatment and sludge management regimes including:

1. between pre-water treatment (before 2007)
2. water treatment by ultrafine limestone
3. water treatment by CaO with bypass of >90th percentile flow
4. water treatment by CaO with bypass of >70th percentile flow.

Key parameters such as Al and turbidity in the Ngakawau River receiving environment do not show negative changes in water quality related to bypass of the 70th percentile flows.

The treated AMD in the Fly Creek/St Patricks catchment flows into McCabes Sump. This sump operates under a similar management regime including bypass of >70 percentile flows. This sump has been operating since 2024 and currently sludge levels in this sump do not require management or dewatering.

The Stockton Operational AMD and Sludge Management Report also describes future scenarios for water treatment and sludge management at the Stockton Mine site. This includes future acid loads, flow rates, and sludge generation estimates on an annual basis for key catchment zones and sumps. With this information plans can be made to optimise the use of the available infrastructure to deliver the mix of water quality objectives at Stockton and betterment objectives that apply throughout the Millerton mining area.

4 Review – ESE, MFS and UWHR AMD reports

4.1 Introduction

The ESE, MFS and UWHR are different to the Stockton area in terms of geochemistry (less potential for AMD formation) and severity of legacy impacts. Legacy mine drainages are fewer, less acidic and generally with lower acid loads at the ESE, MFS and UWHR areas than in the Stockton area. This lower intensity of old workings combined with planned modern approaches to waste rock management at ESE, MFS and UWHR enable these areas to be developed with a different approach compared to Stockton Mine. The consenting and compliance approach at the ESE, MFS and UWHR sub-areas follow a more conventional processes (compared to those at Stockton) including assessment of background chemistry, assessment of water quality limits that will protect the local aquatic ecosystems and development of conditions to ensure the desired outcomes. The assessment of background chemistry enables mine operators to either identify site specific guideline values or adopt published generic values for protection of aquatic ecosystems. This contrasts with the environmental targets that are applied at Stockton where current mining activity provides ecological recovery thresholds or betterment of waterways degraded by legacy activity.

4.2 Prediction

Predictive studies with respect to AMD seek to identify the likely physiochemistry and composition of mine drainages before mining commences. This typically includes suites of laboratory tests on rocks that will be disturbed by mining (acid base accounting - ABA) and chemical analysis of solutions that have reacted with these rocks (such as column leaching tests). Often patterns in the results of lab testing are interpreted using geological correlations that range from links between analysis results and different geological formations to completing three-dimensional stratigraphic correlations of laboratory data from drill hole samples.

The most accurate predictions for future mine drainage chemistry are made through appropriate analogy. This might include large scale field trials at active mines or monitoring of mining related disturbance at neighbouring mines with similar geology and geochemistry. In this circumstance and with robust interpretation, the physiochemistry and composition of mine drainages that will form at the proposed mine can be predicted with a much higher level of certainty than predictions based on lab tests alone. The key difficulty for studies based on laboratory data alone is how to scale laboratory test data to field site scale, robust use of analogy avoids this difficulty.

BRL have utilised internationally recognised approaches to laboratory testing of rocks and leachate linked with geological correlations at several scales (regional differences between geological formations, changes in geochemistry within geological formations and correlation of detailed drill hole stratigraphy). In addition, BRL have used analogy of the chemistry of mine drainages at adjacent mine sites to develop predictions for mine drainage chemistry for the BPCP.

Overall, there is little more that could be done to predict mine drainage geochemistry for the BPCP, the interpretations are robust, supported by the data, and are consistent with AMD studies over the last 25 years at the neighbouring operations. In general, assumptions, where required, are well considered and adequately conservative.

4.2.1 Documents included

The reviewed documents that provide information on the prediction of mine drainage chemistry include nine reports authored by Mine Waste Management Ltd (MWM) and several appendices provided by MWM and BRL.

Table 1. Reviewed document related to prediction of mine drainage chemistry

Author	Document Number	Title
MWM	J-NZ0453-001-R	Upper Waimangaroa Haul Road Site Visit
MWM	J-NZ0453-009-M	Upper Waimangaroa Haul Road Acid Base Accounting Summary
MWM	J-NZ0453-003-M	BPCP AMD Hazard Classification Summary
BRL	BRL Memo	• Denniston ABA Block Model As part of the Escarpment Extension Project
BRL	BRL Memo	• MFS ABA Block Model - Buller Plateaux Continuation Project
MWM	J-NZ0377-001-R	Factual Report: Geoenvironmental Hazards. Mt Fred South Project
MWM	J-NZ0453-010-M	Cypress pXRF Summary
MWM	J-NZ0377-005-R	Column Leach Test Report
MWM	J-NZ453-011-M	BPCP Annual Overburden Material Schedule
MWM	J-NZ0349-008-R	Barren Valley ELF Water Quality Model
MWM	J-NZ0433-004-R	Water and Load Balance Model - Source Term Definition
MWM	J-NZ0472-001-R	Background Water Quality Report

4.2.2 Review

<u>Upper Waimangaroa Haul Road Site Visit</u>

This document contains a survey of geology and environmental geochemistry of the proposed haul road route between Denniston and Stockton Plateaux. The purpose of this document is to assess whether the environmental geochemistry of rocks along the proposed haul road route fall within the range of geochemical properties that occur elsewhere within the BPCP or adjacent mine sites.

Overall, this document finds that the rock types within the UWHR corridor fall within the range of rock types that are managed elsewhere within the BPCP or adjacent mining operations (Stockton and Cypress). The data sets for water quality and rock geochemistry presented within this document are relatively small and preliminary, however, the geological analogy is strong and additional data for managing the impacts of disturbance in this area is covered in other documents (J-NZ0453-009-M, J-NZ0453-007-R).

In general, the level of disturbance that will be created along the haul road is smaller (lower volumes of material) than mining operations and the geology is variable including partially weathered materials as well as fresh rock.

<u>Upper Waimangaroa Haul Road Acid Base Accounting Summary</u>

The purpose of this document is to compile rock geochemistry data that are available for the Upper Waimangaroa Haul Road sub-area. The datasets collected are acid base accounting data and overall, the data handling and approach to interpretation are in line with international standard methodologies for classification and risk assessment for acid release from rock types that will be disturbed by mining (or in this case infrastructure to support mining). The classification of rocks in the Upper Waimangaroa Haul Road area and risks associated with their excavation is similar to those identified in mining areas of the BPCP including at Stockton and Cypress Mine.

Two main formations of rocks will be intersected during construction of the proposed UWHR Brunner Coal Measures and Kaiata Mudstone and these have been mapped with sufficient detail for the BPCP at this stage. In general, the acid base accounting data sets for these rocks have characteristics that are similar to the properties identified in other studies of Bruner Coal Measures and Kaiata Mudstone (J-NZ0453-003-M, J-NZ0453-010-M) for the BPCP or Stockton and this includes:

- Brunner Coal Measures are mostly weakly to strongly acid forming (PAF). Less commonly Brunner Coal Measures are non acid forming (NAF).
- Brunner Coal Measures can release acid rapidly because partial oxidation leads to acidity that is stored in soluble minerals. BCM also contain potential acidity that is stored in sulphide minerals that is released more slowly through oxidation processes, although pyrite is often present as highly reactive framboidal pyrite that can generate acidity within weeks
- Kaiata Mudstone contains a mix of potentially acid forming and acid neutralising rock types.
- In some Kaiata Mudstone rocks there is sufficient acid neutralising capacity that there will be a lag period until acid formation occurs. Kaiata Mudstone higher in the stratigraphic sequence can be NAF.

The distribution of samples presented in this report is skewed toward the ends of the haul road and there is less data from the central parts of the haul road. As further studies are completed additional waste rock classification data will be collected to enable selective handling and placement of overburden as required (J-NZ0453-007-R).

BPCP AMD Hazard Classification Summary

The BPCP AMD Hazard Classification Summary provides background information on test methods and analysis approaches to interpretation of geochemistry in areas that will be disturbed by mining. The test methods that have been selected are used globally for characterisation of the rock that will be disturbed by mining. The objective of waste rock analysis is to characterise geochemical hazards and classification enables the development of waste rock management strategies to minimise downstream water quality impacts. This might include separate management processes or selective placement of rocks that produce large amounts of acid compared to rocks that do not produce acid. For example, at the BPCP non-acid forming rocks will be selectively placed as a cap over waste rock that is more likely to produce acid.

Within this document, interpretation of waste rock characterisation data for the BPCP has been completed to deliver two important outcomes:

1. Processes for waste rock classification that can be operationalised during mining. This enables mine operators to rapidly assess waste rock geochemistry and classify different types of waste rock without waiting for laboratory turnaround on a complete ABA dataset for all rocks. The operationalisation of waste classification is based on an underpinning and complete characterisation dataset. The three classification schemes provided include:
    - A classification scheme using portable XRF for Kaiata Mudstone (which will be encountered along the UWHR transport corridor).

- A classification scheme for Brunner Coal Measures at ESE using total S and NAG pH analysis.
- A classification scheme for Brunner Coal Measures at MFS using total S and NAG pH analysis.

These classification schemes consistent with the supporting datasets in other documents (J-NZ0453-010-M, J-NZ0377-005-R, J-NZ0377-001-R).

2. Interpretation of data using drill hole correlations and geostatistical methods to quantify the amounts of different types of waste rock that will be encountered during mining at ESE and MFS. The correlated drill holes have been converted into block models provide confidence that the materials balance required to construct engineered landforms for waste rock have been assessed, and further, to identify areas where additional data are required to improve certainty during mining.

   This information is contained in two attachments to the BPCP AMD Hazard Classification Summary that were prepared by BRL:
   - Denniston ABA Block Model As part of the Escarpment Extension Project.
   - MFS ABA Block Model - Buller Plateaux Continuation Project.

   Overall, the detail contained in these attachments is at a higher level than would normally be expected prior to any consent application, many operational mines would not have this level of interpretation complete. These attachments provide confidence, not only that the data collected is appropriate, but that the data will be utilised in an effective manner to deliver the water quality outcomes that are predicted in subsequent reports. The documents also identify the level of certainty with which the block model can be applied, and therefore, can be used to prioritise areas for additional data collection.

<u>Factual Report: Geoenvironmental Hazards. Mt Fred South Sub-area</u>

The main purpose of the report on Geoenvironmental hazards for the MFS sub-area is to assess the potential for AMD to form during proposed mining of the MFS sub-area through analysis of rock geochemistry. The analysis methods selected include acid base accounting tests that are internationally recognised, the results are within the range of values that might be expected for the proposed MFSsub-area based on similar studies of Brunner Coal Measures from the Buller area.

This report interprets rock geochemical data by internationally recognised standard approaches and through use of purpose build site specific classification criteria (J-NZ0453-003-M). This contains site specific rock geochemical interpretation criteria for waste rock management and proposes these for future mine operations (J-NZ0377-005-R, J-NZ0453-003-M). Quality control of laboratory results has been completed through the use of standards and duplicates and this demonstrates that outsourced laboratory analysis is performed to a high standard.

This report contains a geological interpretation that the MFS (and ESE) sub-areas have lower risk and different indicators for AMD compared to current Stockton and Cypress mine sites. This interpretation is appropriate with the datasets available, also supported by other published geochemical data. These geological and geochemical interpretations are backed up by published regional sedimentological studies that provide important context to support the use of different waste rock classification schemes in different project areas.

Based on analysis of the acid base accounting data collected (about 470 samples) a site specific waste rock classification process is derived. This classification is similar to waste rock classification processes adopted at the Escarpment Mine and fits the dataset adequately. The adoption of process flow classification cannot be justified by rock geochemistry alone and requires leachate testing to ensure that different classes of rock generate different types of leachate. Leachate information presented from the different types of rock at the proposed MFS and ESE mines has been collected and collated (J-NZ0377-005-R) and in supports the proposed classification. The use of process flow classification has the advantages of:

- no use of 'uncertain' as a rock-type classification.
- additional resolution – identification of HAF and LR (low risk) materials.
- likely optimised laboratory costs during future mining operations.

This report also presents an analysis of the results of block modelling with respect to mine scheduling. Block modelling is a more advanced interpretation of geochemical data than statistical analysis of drill core samples. It includes correlation between drill holes so the proportions of materials assigned to different waste categories changes and becomes more accurate by interpreting which types of rocks are present between the drill holes. Additional data will be collected during operations to ensure the accuracy of block modelling and provide detailed information for scheduling. Scheduling ensures that the appropriate quantities of different materials are known in advance to meet ELF construction requirements and can be used to create a plan to deliver all materials required in the most timely and efficient manner.

Cypress pXRF Summary

The Cypress pXRF Summary report brings in additional information to that supplied as Attachment A in the BPCP AMD Hazard Classification Summary document (J-NZ0377-001). The purpose of these two documents is to provide supporting background data on the approach to classification of Kaiata Mudstone that will be utilised when these rocks are disturbed. Kaiata Mudstone will be encountered during construction of the UWHR.

In general, the dataset collected is suitable for the interpretations that have been made, 318 samples with a robust acid base accounting dataset as well as coincident pXRF analysis. The classification scheme that has been developed uses a correlation between total Ca (by pXRF) and acid base accounting characteristics of the Kaiata Mudstone such as acid neutralising capacity and net acid production potential. Relationships are relatively strong and there is a negligible chance that significant misclassification can occur using the thresholds that have been developed.

Factual Report: Column Leach Testing Mt Fred South Sub-area

The Column Leach Testing Report for MFS sub-area presents information to assess the chemistry of leachate from rocks at the proposed MFS mine site. This report also summarises data from earlier column leach testing reports related to the existing Escarpment Mine consent processes. Both sets of data are generated from similar testing procedures and are mass balanced to the amount of rock that is leached and the volume of water that is collected as leachate. The results from both sets of testing are complementary and can be interpreted in a similar manner.

Samples that have been tested in column leach testing represent a well spread selection of different acid base accounting properties that have been identified at the proposed mine sites. The key factor demonstrated by this leach testing is that the rock types identified through the classification processes (J-NZ0453-003-M) based on ABA data generate leachate chemistry and compositions that match the classification schemes.

1. Leachate chemistry for rocks that are classified as Non Acid Forming (NAF) by the classification scheme in BPCP AMD Hazard Classification Summary have low concentrations of acidity, similar to background in streams draining BCM. The NAF rocks also generate lower concentrations of trace elements than rocks that are classified as Low Risk (LR), Potentially Acid Forming (PAF) or Highly Acid Forming (HAF).
2. Leachate chemistry for rocks that are classified as Low Risk by the classification scheme have a mixed result with respect to leachate chemistry. One of the LR samples produces acid concentrations similar to NAF rocks and one produces acid concentrations similar to PAF rocks. Trace elements concentrations in leachate from LR samples are lower then PAF and HAF rocks.
3. In general, leachate chemistry for rocks that are classified as PAF and HAF generate higher concentrations of acid and trace elements than NAF or LR samples.

The classification scheme that is developed for Brunner Coal Measures rocks at the proposed ESE and MFS sub-areas is supported by the column leach test data. Overall, the trends in the data from the column leach testing are useful to demonstrate that the classification scheme works. The concentrations measured in these leach tests are used to support further interpretations at the proposed mine sites, however, most predictions for mine drainage chemistry come from monitoring data collected at the Barren Valley Engineered Landform or from data collected at mining related disturbance in the Stockton Mine area (J-NZ0349-008-R, J-NZ0433-004-R).

BPCP Annual Overburden Material Schedule

The BPCP Annual Overburden Material Schedule document presents the projected availability of different types of materials on an annualised basis throughout the mine life for MFS, ESE and for the construction phase of the UWHR. These projections are based on mine plans and block models provided as attachments in the BPCP AMD Hazard Classification Summary (J-NZ0453-003-M, J-NZ0453-007-R).

The BPCP Annual Overburden Material Schedule provides confidence that the block models that have been prepared are suitable to develop a materials balance for mine planning. This document also indicates that the first year of operations at MFS and first four years of operation at ESE do not encounter substantial quantities of NAF materials (NAF < 10%). Some additional planning will be required for these periods to ensure ELF construction matches design criteria (J-NZ0453-004-R, J-NZ0349-013-R, J-NZ0453-004-R, J-NZ0349-013-R). This might include delayed construction of caps, quarrying of NAF material ahead of stripping schedule, rehandling or limestone addition. The overall balance of NAF material to other materials for the MFS and ESE appears to be favourable. However, prior to operations, the demand for NAF materials required to meet design should be balanced against the availability of NAF materials from BPCP Annual Overburden Material Schedule.

Barren Valley ELF Water Quality Model

The Barren Valley ELF Water Quality Model summarises field information and analysis from an engineered landform at the Escarpment Mine (currently under care and maintenance). Water quality information has been collected since the Barren Valley ELF was constructed in 2014 and monitoring continues. The Barren Valley ELF is well characterised, it contains almost 750K tonnes of waste rock with an average sulphur content of 0.18%. The surface area is 3.3Ha and the average thickness is about 10.7m. The ELF was constructed in lifts with a central underdrain that exits through the pond to minimise oxygen ingress. About 960 tonnes of limestone were added to the ELF during construction to partially neutralise acidity. In addition, climate data are available along with flow measurements of seepage from the underdrain and so the Barren Valley ELF can be considered a large-scale trial for construction of ELFs for the BPCP project.

The monitoring data and field information from the Barren Valley ELF are used to build a conceptual model for seepage water chemistry at the proposed ELFs that will be constructed if the BPCP proceeds. This conceptual model recognises three phases of seepage water quality related to ELF development, a construction phase, a stabilisation phase and a decay phase. In general,

- the construction phase sees increasing concentrations of components in mine seepage as waste rock is added to the ELF.
- the stabilisation phase sees a period of time where peak concentrations occur in seeps while water levels stabilise in the ELF until it is capped. Once capped, water levels will decrease in the ELF as capping will be designed to shed surface water.
- the decay phase sees a decrease in the dissolved components in seepages as oxidation of the outer portions of the ELF occurs while the internal part of the ELF remains sub-oxic and does not react.

A scale factor is applied to the water chemistry data from the Barren Valley ELF to enable it to be transferred to other ELFs for prediction of seepage chemistry. The scale factor is applied based on the average S content of rocks that will be contained within the ELF from the BPCP Annual Overburden Material Schedule and mine plan documentation during the construction and stabilisation phases. After stabilisation the S content of the outer 10m of the ELF is used for calculation of the ongoing acid load from the ELF. It is assumed that that the average value of NAF rocks applies for the outer 10m of the ELF or values from locally derived acid base accounting data have been applied where possible. Relationships between total S and acidity release are established for Brunner Coal Measures based on column leach testing and typically acidity and trace element concentrations in mine drainages are positively correlated.

The acid load from each ELF is then split into two components

1. The acid load from ongoing sulphide oxidation.
2. The acid load from stored oxidation products.

This interpretation is based on detailed analysis of the acid release pattern from the Barren Valley ELF and is applied to each cubic metre of waste rock. The load from sulphide oxidation is applied to the whole ELF until it is stabilised and then to the outer 10m of the ELF after the stabilisation phase. This is based on oxygen ingress measurements made into ELFs constructed with short lifts. The acid load from stored oxidation products is applied to all rock that is place in the ELF. The load from stored oxidation products is mobilised until the end of the stabilisation period after which time the ELF will be sealed and acidity from stored oxidation products will be depleted.

Water and Load Balance Model - Source Term Definition

Typically, at mine sites a probabilistic water quality model is developed to assist with mine planning and mine water management. The probabilistic model can be used to predict water quality outcomes at different locations on a mine site through time and through changes in management (mixing, waste rock interaction, water treatment, offtake, dilution etc). There are many different types of water on a mine site and the Water and Load Balance Model – Source Term Definition report explains the approach used to derive the values adopted for water quality modelling.

These source terms utilise concentration and flow monitoring data from various seeps or drainage points as well as analysis of the landscape features upstream (waste rock, pit wall, catchment) to calculate release rates of waterborne components in load units. Load units incorporate concentration, time and either area or volume so that the values can be scaled to reflect the projected areas and volumes in a mine plan. Load units of $mg/m^3/day$ or $mg/m^2/day$ are used to build the predictive models for planned mines to determine the rates of release of waterborne components from different mined landforms. These load values are then related to expected water flows and converted back into concentrations to establish if the load will be acceptable compared to compliance regulations or performance monitoring expectations.

In addition, the chemical evolution of different types of mine water through time can be estimated through comparison to long term monitoring datasets, for example seepage concentrations evolve with time as reactive components are used within waste rock. The source term for seepage is not a static value based on an instantaneous concentration (or load), but instead diminishes with time based on analogy to changes in long term monitoring data.

In detail this report derives source terms (initial chemical value) for water from:

- Streams.
  - Based on average background water quality in ESE, MFS and UWHR areas.
- ELF seeps – PAF.
  - Calculated for each seep based on the Barren Valley ELF water quality model (J-NZ0349-008-R) supported by data from column leach tests (J-NZ0377-005-R) and Stockton AMD site data.
- ELF seeps – NAF.
  - Use data from Column Leach testing (J-NZ0377-005-R) for pH and alkalinity, and the Barren Valley ELF model for concentrations of trace elements and sulphate.
- Runoff from and high walls.
  - Empirical data and published data have been used develop a source term from surfaces. Different terms are derived for granite, Kaiata Mudstone, and coal measures and these values are adjusted by S content based on block models presented in (J-NZ0453-003-M). Static values for release are used during operational mine phases then a decay process is applied to decrease concentrations with time. This decay process is derived from literature and supported by empirical data. Dilution modelling is included in these source terms because the trace element and acid load from these areas dilutes quickly in high rainfall events.
- Active mine areas and running surfaces.
  - Empirical data from the Escarpment mine (currently in care and maintenance). Two end member water quality datasets are derived based on high and low flow conditions and a mixing model is developed so that concentrations from active areas are dynamic between the two end members based on flow.
- Runoff from rehabilitated ELFs.

    - Rehabilitated ELFs have a NAF cap and so source terms are derived from NAF column leach data (J-NZ0377-005-R) and combined with average stream water quality data.
- Hardstand areas.
    - NAF and PAF hardstand areas are identified within the mine site and runoff from these areas are similar to run off from PAF and NAF highwalls.
- Underground mine drainages.
    - Empirical datasets from major adits have been collected and these are averaged to provide source terms for these contributions to the water balance for the BPCP area.

There is high variability in water quality datasets from mined environments. However, for BPCP a large database of empirical monitoring data from near-by mines is available and many targeted case studies have been completed that can be used to derive source terms with a relatively high degree of certainty. Where assumptions are required to interpret these datasets, a conservative approach has been taken to develop source terms. The source terms adopted here benefit from the many years data collection and study by the BRL environment team and their consultants.

At mine sites opening in new areas, the level of certainty related to source terms for water quality is much lower, and often two or three water quality scenarios (possibly with loads values that span up to an order of magnitude) are required to capture the potential variation. The BPCP is fortunate that source terms can effectively be measured at adjacent mines and transferred to new Project sub-areas with a high degree of certainty. Where uncertainty remains, conservative assumptions can be made and water quality scenarios, if required can be limited to percentage level variability or left out in favour of slightly conservative water quality projection.

<u>Background Water Quality Report</u>

Prior to the commencement of the proposed BPCP the water quality of receiving environments must be assessed so that impact of discharges during mining can be measured. To complete this assessment typically water sample sites are selected for at least three purposes, performance monitoring, compliance monitoring and reference sites. Performance monitoring sites are often close to mining activities and enable mine operators to monitor impacts on water quality of specific aspects of the Project. Compliance monitoring sites are selected downstream of the mine footprint so that the impact of the entire operation can be assessed in an objective manner. Reference sites are positioned where background conditions (geology, soils, mining history) are similar to those within the Project area but these sites will not be disturbed during mining or receive discharges from mining.

The Background Water Quality Report presents sites that have been selected as compliance, performance and reference water quality monitoring for the BPCP (a total of 16 sites). Overall, the location of sites selected are fit for purpose and appropriate. In addition to these sixteen sites about 45 sites have had water quality data collected over the last ~20 years for various purposes related to previous mining or environmental studies. Based on other BRL mine operations (Stockton, Escarpment, Cypress and others) there will be many (likely 10s to 100) more water sample sites that will have data collected throughout the course of operations and closure as the company measures water quality impacts of specific activities. For the 16 sites selected to characterise the BCPCP the datasets collected to date are presented within the Background Water Quality Report.

The purpose of background sampling is to measure water quality variability prior to commencement of mining as well as water quality that might commonly occur (median water quality). Water quality in streams and rivers is not static and there are many sources of variation which are often seasonal or can be driven by events (rainfall, dry period). Based on many years of data collection in the Buller region the main driver of water quality variation is rainfall. The interaction of rainfall with stream water quality in these headwater catchments is not simple, some components dilute, some components build up between rainfall events and are flushed, some components might be relatively conservative and have stable concentrations through flow events. Historic mining disturbance can deliver additional complications such as extreme concentrations and lag periods between flow increases and concentration increases.

The datasets collected for proposed compliance sites provide an adequate assessment of background chemistry and the datasets provided for reference and performance monitoring sites are well advanced. The datasets presented indicate the number of samples collected to date (with monitoring ongoing) and compare the concentrations measured to water quality reference values that are based on commonly used water quality compliance concentrations. Many of the sample sites have measured concentrations of one or more analysed components that are close to or exceed the water quality reference values. This reflects high naturally occurring concentrations and high variability of some components or sometimes high concentrations relate to the impact of historic mining on water quality. This information is important as it demonstrates that before the proposed BPCP commences the water quality in these catchments is variable and simplistic application of generic guideline values is not appropriate for these catchments.

In addition, to the chemical data that is presented, flow measurements are available for most sample collection times and an assessment of the range of flow conditions when samples have been collected is presented. This dataset provides confidence that chemical variability related to flow within the catchments has been assessed. In general, the combined flow and sample collection time information demonstrates that a wide range of flow conditions have been included in the assessment of background chemistry. The impact of flow on chemistry is also presented for monitoring datasets from Stockton to demonstrate the relative importance of this factor on variability in the BPCP catchments. Changes in chemistry with time and flow is presented numerically and graphically in the Background Water Quality Report for the 16 sites that are selected to represent the BPCP and some of the other sites where data is available. In addition, continuous monitoring datasets for flow, pH, EC are presented at three sites and demonstrate that the influence on chemistry from rainfall events as well as the complexity of responses.

Overall, the water quality dataset collected to measure background conditions captures variability adequately. This enables certainty for the regulator with respect to the range of chemical conditions that can occur prior to operations of the proposed BPCP. For the operator, measurement of concentrations throughout a range of flow conditions ensure that any naturally elevated concentrations or elevated concentrations from historic mine activity will not be incorrectly attributed to BPCP related disturbance should the Project proceed.

4.3 Prevention and Minimisation

A variety of techniques can be applied to prevent or minimise formation of AMD at mine sites. In general, these techniques relate to minimising contact between the reactive potentially acid forming (PAF) waste rock with water and oxygen. Critical processes that will be applied in the ESE, MFS and UWHR (and Stockton) include:

- Construction of ELFs in short lifts rather than large end-tips.

- Encapsulation of acid forming waste rock in non-acid forming (NAF) waste rock.
- Construction of underdrains within NAF waste rock zones.
- Application of toe bunds or water cover to provide a seal for underdrains.
- Use of low permeability capping materials.
- Development capping zones with predictable oxygen and water ingress properties.
- Prevention of grainsize segregation within ELFs and ensuring a matrix supported grainsize distribution.
- Limestone addition.
- Progressive establishment of rehabilitation.

Application of these techniques from the commencement of operations at the ESE, MFS and UWHR will prevent and minimise AMD to a level where all AMD can be managed on site during operational and early post closure phases and long term legacy issues are avoided. Some of these processes have been applied at Stockton over the last 25 years, however the legacy of previous mining activity is more severe at Stockton and, while improvements have been made the legacy issues remain a strong influence on future water quality projections.

4.3.1 Documents included

The reviewed documents that provide information on the prevention and minimisation of acid and metalliferous drainage include three reports authored by Mine Waste Management Ltd (MWM). The three reports collate field data collected at the Barren Valley ELF (an analogous site to ELFs that will be built if the BPCP proceeds), the results of unsaturated zone hydrogeological modelling as well as experience from international literature into a design philosophy (J-NZ0453-004-R) for future engineered landforms at ESE and MFS. In general, the design philosophy covers all critical aspects of ELF construction from foundation to cap and from underdrainage to rehabilitation. It includes recommendations related to management of grainsize segregation through construction in short lifts as well as limestone addition to neutralise and prevent acid production.

Table 2. Reviewed document related to prevention and minimisation of AMD

Author	Document Number	Title
MWM	J-NZ0453-004-R	Engineered Landform Design Philosophy
MWM	J-NZ0349-004-M	Cover System Field Investigation
MWM	J-NZ0349-013-R	Cover System Technical Report

4.3.2 Review

<u>The Engineered Landform Design Philosophy</u>

The purpose of this report is to recommend ELF design objectives that can be used during the BPCP to minimise the formation of AMD by minimising the interaction of water, oxygen and waste rock that must be moved to access coal. The recommendations in this report are sourced from:

1. Long term international research and development studies to minimise AMD.
2. Field trials and monitoring data collected at other mines in Brunner Coal Measures.

This report does not deliver a design to completely prevent AMD at the BPCP, which would be impossible with the geochemistry of the rocks that must be handled. Instead, it provides approaches to minimise AMD using practical waste rock handling and management practices combined with an engineered design for all structures that contain waste rock.

The design philosophy report covers several critical aspects of ELF construction including:

- Underdrainage.
    - To be developed under all ELFs to control seepage flow directions and enable collection ponds or toe-bund to prevent oxygen ingress up drains.
- Clean water diversion.
    - Developed to minimise the volume of mine influenced water.
- Construction processes.
    - Short lifts of 2-5m are recommended to prevent grainsize segregation and minimise advection of oxygen into the ELF. Vehicle compaction between lifts develops a permeability and advection barrier.
- Mitigations.
    - Encapsulation/covering of PAF materials by broad NAF or low S zones (10m).
    - Limestone addition to minimise oxidation and prevent formation of acidic salts
- Geotechnical stability.
    - Ensure stability of ELFs so that they are not prone to erosion or mass movement that may exposed PAF materials.
- Capping.
    - Development and deployment of a capping regime where oxygen diffusion and water ingress are design features and become predictable and manageable (J-NZ0349-013-R).
- Rehabilitation
    - Establish rehabilitation as quickly as practical during and after ELFs are constructed. Rehabilitation will be completed in a progressive manner.
- Performance monitoring
    - Develop a network of monitoring tools including oxygen probes inside ELFs to ensure design criteria limit oxygen ingress to diffusion as much as possible.
- Sign off
    - Quality control for construction process is required.

These ELF design criteria and other details included in the report incorporate a selection of best practice aspects for construction of ELFs that are applicable at the ESE and MFS sites. This document includes reasons and recommendations for implementation of design parameters into ELF construction for the ESE and MFS proposed sub-areas. Delivery of ELFs constructed to using the methodology above have been proven to deliver a stable landform with relatively stable flow from underdrains and diminishing AMD load (J-NZ0349-008-R).

<u>Cover System Field Investigation</u>

The purpose of this report is to provide and summarise factual information used to support design for ELFs that will be built if the BPCP is approved. Several datasets were collected from the Barren Valley ELF which is used as an analogy for the likely geochemical and hydrologic behaviour of ELFs that are planned by the BPCP. The data sets include:

- Test pits and collection of waste rock samples for grainsize and moisture testing.
- Water infiltration tests.

A testing regime has been completed on the Barren Valley ELF to provide particle size distribution and permeability values for ELFs that will be constructed should the BPCP proceed. The testing was completed to assess likely variation in permeability conditions that could arise on the upper surface of an ELF constructed of Brunner Coal Measures. Test pits were completed in areas that had been well compacted by traffic and areas that were less compacted. Samples were collected from the test pits to complete grainsize measurements of materials within the ELF.

The results are in line with expectation, lowest permeability is at the surface of the well trafficked site, second lowest permeability is at the surface of the less well compacted site, and the permeability of material deeper in the ELF is higher. The permeability values are roughly in line with expectation and previous studies. Grainsize and moisture content values are also in line with expectation, soil has finer grainsize and higher moisture content than rock samples. All samples have a well spread grainsize and analysis indicates that the waste rock inside the ELF is matrix supported.

In general, this data and interpretations match expectations and this report provides measured values for modelling of ELFs at the BPCP. The dataset collected provides some certainty for modelling the hydrogeological behaviour of ELFs made from Brunner Coal Measures (BCM) throughout the ESE and MFS sub-areas where rock types are similar to those deposited in the Barren Valley ELF.

Cover System Technical Report

The objective and purpose of the Cover System Technical Report is to use scenario modelling and conceptual modelling to provide information on the movement of water and oxygen through proposed cover systems that are to be used at the surface of ELFs in the BPCP. The reason this is important is that oxygen and water are key parameters that influence the formation of AMD at mine sites. The modelling is based on field measurements of grainsize and permeability of materials that occur at Stockton and Escarpment Mines (J-NZ0349-004-M) and these materials are used to represent what is expected for areas to be mined in the BPCP. In addition, local climate data is used over a period of about 10 years to provide representative climate conditions for modelling. Overall, this approach is relatively standard and can be used to inform implementation of cover systems and rehabilitation strategies.

Processes that control water and oxygen movement in the upper few metres of ELFs at mine sites are a complex mix of interactions between material properties, hydrogeological properties, climate conditions and vegetation effects. This report includes scenario modelling to simulate water and oxygen movement in the upper few meters of engineered landforms. Key outputs from this complex system that impact planning at mine sites include:

- the amount of rainfall that seeps into ELFs.
- the amount of rainfall that runs off the landform.
- the amount of rainfall that is utilised by vegetation.
- the amount of oxygen diffusion into the landform.

The modelling includes two proposed cover systems with scenarios for different permeabilities and thickness where appropriate. The cover systems are:

1) Non-acid forming cap with soil applied and shrubland vegetation.
2) Non-acid forming cap with soil applied and forest vegetation.

The modelling is one dimensional and covers the most likely circumstances that will occur at the mine site. It does not include factors such as lateral flow of water within ELFs, the impact of ephemeral perched water tables. It does not include the advection of oxygen into waste rock because this should be minimal when construction methods that are recommended are applied.

Overall, the dataset employed is appropriate, the treatment of the data and use of scenarios is also appropriate and covers the likely variability that could arise under typical climate conditions.

4.4 Control and treatment

At the ESE and MFS sub-areas acid loads and trace element concentrations in mine influenced water can be predicted with a degree of certainty that was not available for previous mine consenting processes within the Brunner Coal Measures. The Barren Valley ELF monitoring study (J-NZ0349-008-R) enables estimation of acid loads from yet to be constructed ELFs at MFS and ESE sub-areas along with the decrease in acid loads into the future. With this information and supporting information on acid release from other landforms, water treatment can be scaled to the needs of the site and projections can be completed to a level of detail that the transition from active to passive treatment can be planned before the operation commences.

At all other large mine sites in New Zealand, the transition from active water treatment to passive treatment is not completely planned until detailed closure planning takes place often towards the end of operations. At the ESE and MFS sub-areas detailed mine drainage chemistry predictions enable sizing and preliminary designs for passive treatment systems to be developed prior to approval for operations. To the knowledge of the reviewer this level of planning for a transition from active water treatment to passive treatment is world leading.

The documents included in this section provide detailed planning for most aspects of water treatment for the ESE and MFS sub-areas. There remains uncertainty for the timing of the transition from active water treatment to passive treatment, mostly related to water quality projections, efficiency of removal processes in mussel shell reactors (MSR) or trace elements mobility. However, there is sufficient time available to improve knowledge in these areas while active treatment operates.

4.4.1 Documents included

The reviewed documents that provide information on the control and treatment of AMD include reports and memorandums authored by Mine Waste Management Ltd (MWM).

Table 2. Reviewed document related to control and treatment of AMD

Author	Document Number	Title
MWM	J-NZ0480-004-R	Water Treatment Report: MFS and ESE
MWM	J-NZ0453-005-R	Passive Treatment System Design Toolkit • Passive Treatment of AMD: Options Assessment
MWM	J-NZ0349-003-R	• Mussel Shell Reactor Performance Review
MWM	J-NZ0349-012-M	• Escarpment Mine - Mussel Shell Reactor Manganese Removal Efficiency
MWM	J-NZ0349-010-M	• MSR – Secondary Contaminants
MWM	Letter (MWM)	• Escarpment Mine MSR Maintenance Summary
MWM	J-NZ0349-019-M	• MSR Sludge Trials
BRL	BRL Memo	• Whareatea Mussel Shell Bioreactor Design
MWM	J-NZ0349-020-M	• MSR Polishing Pond Secondary Contaminant Treatment

MWM	J-NZ0349-015-R	AMD Sludge Management

4.4.2 Review

Water Treatment Report: MFS and ESE

The Water Treatment Report: MFS and ESE provides details on the approaches to water treatment that will be taken throughout the Project from construction work, through operational work phases to closure. Each phase of the Project will have different water treatment strategies relating to the size of the disturbance and flow rate of mine impacted water as well as the chemistry of the flow. Both key factors, calculations of flow rate and, predictions of chemistry of mine impacted water are summarised in other documents (J-NZ0453-006-R, J-NZ0349-008-R, J-NZ0433-004-R, J-NZ0377-003-R, J-NZ0433-003-R, and others).

The approaches to water treatment include a suite of processes that are already in use at Buller Plateaux mine sites. This includes:

- Small, portable active, caustic (or lime) dosing plant with floc addition systems for management of sediment and water treatment products (sludge). These systems will be deployed during break in and construction phases of work, while large scale active treatment plant infrastructure is built.
- Calcium oxide based active treatment plants will be constructed that are based on water treatment plant systems that are operated at Stockton Mine. These plants will also have flocculant systems with lamella clarifiers and filter press facilities for sludge management. Large scale active treatment is expected to operate throughout the active mining phase and for up to a total of about 30 years.
- Passive treatment systems will be deployed as rehabilitation processes minimise and stabilise the flow rate of mine impacted water and as the acid and trace element load in the mine impacted water diminishes with time. Current plans include deployment of Mussel Shell Bioreactors (MSR) based on technology that has been developed at Escarpment Mine and operates at several other coal mines (J-NZ0453-005-R). MSR are expected to operate into the future until a point where seepage chemistry can be directly discharged into the environment.

As well as an overview of water treatment processes that will occur should the BPCP proceed, the Water Treatment Report: MFS and ESE includes important details related to water treatment processes that are proposed for the sub-areas. All equipment and infrastructure has had initial design work completed, based on mine design and ELF design. This means water treatment infrastructure can be sized and designed with high levels of confidence including plant capacity, surge pond and sump capacity, scale and position of passive treatment systems and many other factors. Overall, the level of precision and detail in the water treatment report for the required infrastructure to deliver desired water quality outcomes is at a high level.

Suspended sediment and precipitates formed during water treatment has also been projected and predicted for each phase of work and treatment or management processes are described in detail for flow and chemistry (J-NZ0349-015-R). This includes, near source mitigations (ponds, fences, dams etc) as well as chemical treatments such as flocculants or chelating agents as well as engineered solutions such as lamella clarifiers, mechanical dewatering and polishing ponds. All with flow and chemistry driven design criteria applied to an appropriate level of certainty. Total sludge delivered through acid treatment have been calculated and deposition sites have been assigned.

The level of detail that can be achieved for the BPCP with respect to water management for the different phases of operation and into the long-term is enabled by studies of the evolution of mine drainage chemistry that have been progressed over the last 20 years. These studies enable relatively robust predictions for water quality from mined landscapes and in turn relatively precise predictions for the transition from active to passive treatment are possible. As the sub-areas operate over the next 10 years the accuracy of predictions can be refined and the projected transition to passive treatment can be trialled and adjusted if necessary. Should it prove necessary, active treatment can be extended and operated until such time as passive treatment can be implemented.

Passive Treatment System Design Toolkit

The passive treatment system design toolkit summarises relevant studies on passive treatment of AMD for the BPCP. Overall, for the BPCP sites, the water load balance modelling and geochemistry indicate that a transition from active water treatment to passive treatment is achievable based on international literature, case studies and experience of BRL with these technologies. Current planning focuses mostly on MSR largely because of their successful deployment at the Escarpment mine site (currently under care and maintenance) and other sites.

The objective of passive treatment system design toolkit is to provide the current state of knowledge with regard to the effectiveness of deploying mussel shell reactors at sites on a mine where a transition from active to passive water treatment is desired. This document provides a clear set of design criteria that are fit for use early in mine planning to ensure passive treatment fits into mine operations. Simple things like the area required for passive treatment based on the projected flow/chemistry from underdrains and the direction of fall (drainage) of underdrains are not left to chance and are planned into the mine operation before mining commences.

The information included in the design toolkit document cover many of the key aspects for deployment of passive treatment technology including

- Sizing of MSR related to flow rates, depth and residence time.
- Downflow configuration.
- Maintenance (sludge removal).
- Downstream polishing pond.
- Prevention of sediment in inflow (only use MSR for seepage).

The performance of the Escarpment MSR over 8 years (and other MSRs) provides confidence in this technology for treatment of AMD. The effectiveness, low maintenance requirements and improvement to downstream water quality through alkalinity addition are all relatively well understood for this technology. In order, to improve certainty with respect to MSR design and performance several detailed studies have been completed on operating MSR including:

- Concept level design based on operational criteria for MSR that will be deployed in the BPCP (J-NZ0480-004-R, Internal Memo - Whareatea Mussel Shell Bioreactor Design).
- Removal of trace elements, Mn, Zn and Ni (J-NZ0349-003-R and appendices, J-NZ0349-012-M).
- Identification and management secondary components (J-NZ0349-010-M, J-NZ0349-020-M)
- Sludge stability (J-NZ0349-019-M).

- Operation of polishing pond downstream of the MSR (J-NZ0349-020-M, J-NZ0349-003-R).

There remain some uncertainties with deployment of MSR (or other selected passive treatment technologies), however, the Project has time to address these while active treatment is operational. Key uncertainties include, operation of the polishing pond for removal of trace elements or secondary components and long-term handling, stability or remediation of spent MSR treatment media. Key uncertainties are identified in the design toolkit report, and future work programmes are identified for completion early during the BPCP to improve certainty and design parameters.

Passive Treatment Options Assessment

The Passive Treatment Options Assessment includes an assessment of potential passive treatment solutions that might be fit for purpose at the time when water treatment progresses from active to passive toward rehabilitation and closure phases of mine operation. At the operation, this process will include deployment of passive treatment on completion early ELFs such as the ESC ELF. The approach taken in the report for this assessment is to use a standardised process for options assessment to consider merits of different passive treatment technologies.

Overall, several technologies have been identified as potential options for passive treatment that could be deployed at the BPCP. Mussel shell reactors are selected as the preferred option based on water quality improvement that has been achieved with these technologies at other sites operated by BRL as well as other favourable factors. The report highlights the risk that mussel shell availability is not guaranteed in the future as it relies on the continued success of another industry. So, there is reassurance in this report that other technologies might also deliver acceptable results.

The Passive Treatment Options Assessment, although not an exhaustive literature review on this topic, provides some indication that alternative passive treatment strategies would also be suitable for the BPCP if required.

Escarpment Mine - MSR Performance Review

This Escarment Mine – MSR Performance Review report draws together literature and datasets on the performance of mussel shell bioreactors for the treatment of AMD. The objective of this report is to summarise the information available on these kinds of passive water treatment systems so that it can be used as design information for water treatment systems in the BPCP.

MSRs were first developed at Stockton Mine through student and industry based experimental studies. Subsequently these systems with varying configurations have been deployed at full scale at several West Coast Coal Mine sites. Overall, these systems are responsible for significant improvements in water quality downstream of active and inactive mine sites on the West Coast.

The removal of trace elements (such as Zn and Ni) is variable in the MSRs that have been studied to generate this report. In general, additional study and monitoring is required to confirm that design criteria will deliver treatment of trace elements. There are several processes that could be important for the removal of trace elements including sulphate reduction, adsorption by Fe(III) - precipitates or adsorption by Al-precipitates. Optimisation studies for each of these processes is required during operational phases of the BPCP to ensure that MSR deliver the required water quality at the time they are implemented. This Escarpment Mine – MSR Performance Review report also includes new experimental data presented on trace element removal that might be required in some circumstances should mussel shell bioreactors be deployed.

Escarpment Mine – Mussel Shell Reactor Manganese Treatment Efficiencies

The purpose of this review is to compile data from MSR to assess the effectiveness of Mn treatment within these systems. The data retrieved shows variable treatment of Mn within these reactors from 58% removal to -6% supply of Mn. This range of treatment effectiveness is not surprising as Mn is a relatively difficult element to remove from water with passive treatment technologies. In some circumstances, Mn specific reactors are built that rely on a combination of oxidising conditions, elevated pH and microbial processes.

The understanding of the effectiveness of Mn removal in MSR is at a similar level to other trace elements such as Zn and Ni which have been investigated in some detail. There is some additional work required to optimise the MSR for treatment of Mn should this prove to be a critical element at the time passive treatment is implemented at the mine site.

Overall, continued studies for Mn removal and use of an adaptive management approach at this stage are appropriate with full scale implementation of these reactors completed early in the project (as early as FY29) enabling adequate time for refinement while active treatment remains available.

MSR Treatment - Secondary Contaminants

The objective of this memo is to present information on the potential for biogeochemical processes that operate in MSR to release secondary components that can have a negative impact on water quality at elevated concentrations such as N-species, dissolved organic carbon or reduced S species. Overall, the results indicate that there are some of these components present in the effluent from operating MSR and that the concentrations are variable between the study sites. This memo does not cover methods to manage or remove these components, however, this is the subject of other reports (J-NZ0349-020-M).

Escarpment Mine MSR Maintenance Summary

The purpose of this report is to assess the likely maintenance regime required for mussel shell reactors. Overall, the performance of the MSR at the Barren Valley demonstrates low maintenance and relatively simple to operate. Inputs into MSR must be seepage only and not TSS rich water, previous experience demonstrates that TSS rich water causes permeability reduction for the reactive mussel shell media. Sludge build-up was monitored at the BV ELF and can be predicted based on acid load and removal has been completed once without disturbance to downstream water quality. Sludge that develops will include an upper Fe rich layer as well as a lower Al rich layer and disposal will occur within ELFs as required (J-NZ0349-015-R). The Barren Valley Elf was de-sludged after 5 years and this example was used to develop a predictive model for sludge accumulation based on acid load into each MSR for the BPCP. Sludge accumulation rates for the BPCP MSRs are variable based on these projections (3mm to 363mm) and so this maintenance aspect will require performance monitoring to assess when sludge will need to be removed.

It can be expected that by the time BRL deploys mussel shell reactors for the BPCP, additional experience with de-sludging and any other maintenance issues will available and a detailed maintenance schedule will be able to be completed for each MSR if required.

MSR Sludge Trials

The objective and purpose of this report is to present information to date on sludge management and disposal. Overall, the approach taken is appropriate for sludge disposal trials at this stage of operation of mussel shell reactors. Under current operational conditions at the Escarpment mine site, sludge from MSR can be managed in parallel with sludge from active water treatment, which involves co-disposal with waste rock. However, in future alternatives for sludge disposal will be required. This report delivers results on the potential for elements and compounds to be leached from sludges from mussel shell reactors and for the potential of sludge to be stable under different geochemical conditions.

This report and the data contained is appropriate for the current level of operations and additional information including field trials of sludge disposal can be completed prior to deployment of final sludge disposal solutions.

Overall, the results presented indicate that the sludge is relatively un-reactive in aqueous, oxic conditions. This is demonstrated by mixing sludge from the mussel shell reactor downstream of the Barren Valley ELF with water from the pit lake down-stream from the ELF. In general, the sludge has slightly metal adsorbing properties.

Whareatea Mussel Shell Reactor Design

The purpose of this memorandum is to demonstrate that the physical constraints of deploying mussel shell reactors can be met within mine scheduling and ELF processes. The concept level design is appropriate for the current level of mine planning. The critical parameters are ensuring that there is adequate space for the reactors, polishing ponds as well as adequate working areas around the reactors, and that gravity fed flow constraints can be achieved. This report provides confidence that space for passive treatment can be designed into mine planning and scheduling. The concept design in this memorandum is based on current understanding of the future pit floor topography and likely underdrain network, noting that these parameters will be refined as more detailed information is collected.

MSR Polishing Pond Treatment of Secondary Contaminants

The objective of this document is to deliver proof of concept for removal of components that can become enriched in effluent water from MSR, which are the preferred passive treatment system option for the BPCP. Studies have been completed downstream of MSR that indicate secondary components can become enriched in treated water (J-NZ0349-010-M) including N-species, dissolved organic carbon and reduced S species.

This document presents data for a three-year period over which a scrubber system was installed, trialled and optimised downstream of an MSR. Overall, the results are promising with improvement in water quality to levels that mostly met local compliance standards. This brief report gives confidence that water discharged from MSR can be adjusted to meet downstream criteria as required. Further work will be completed while active treatment is in place at the mine site.

AMD Sludge Management

The AMD Sludge Management report details the projected volumes of sludge that will be generated through AMD treatment processes for each year of the Project. These values rely on flow calculations (J-NZ0377-003-R, J-NZ0433-003-R) and water chemistry projections (J-NZ0349-008-R, J-NZ0433-004-R) and empirical data from treatment processes that characterise sludge generation rates. Estimates of sludge production volumes enable storage, management and disposal options to be assessed. Onsite disposal options are recommended to be developed during operational phases of the Project and continued through to closure phases with some sludge storage facilities remaining open at Stockton Mine after the ESE and MFS sub areas of BPCP is closed. Alternative off site disposal methods might be investigated for the closure phases if required during the course of the Project.

The AMD Sludge Management report summarises many site specific projects that have been completed at Stockton and other mines throughout the last 20 years related to sludge stability and sludge management. These studies include laboratory and field based projects on

- chemistry and mineralogy of sludge,
- settling rates,
- leaching characteristics,
- disposal in ELFs,
- properties after storage in sumps, and
- filtration and dewatering.

In addition, literature on sludge disposal methods adopted at other mines have been assessed so that the data collected can be placed into context for decision making related to sludge management for the BPCP. The objective of this detailed geochemical work, review of Stockton information and literature review is to make sure that sludge management options are assessed with appropriate information at hand so that good decisions related to sludge management are made for the BPCP.

Sludge disposal procedures follow those that are in use at the Stockton Mine and are proven to deliver effective disposal without additional environmental impact for the mine site. These procedures include: construction of cells in ELFs, deposition of sludge from water treatment processes or sediment control features, burial within the ELF and eventually capping and rehabilitation over the top. Mobility of trace elements from sludge on acidification is a risk that is highlighted by some of the test work. In practice the ELF construction method adopted by BRL is likely to prevent acidification of the central parts of ELFs and these materials are unlikely to be in contact with acidic fluids. A key factor in the reports provided is that the sludge volumes can be calculated on a year by year basis in a relatively accurate manner based empirical data and on the projected water treatment flow volumes. This enables sludge management activities to be well planned for the BPCP.

4.5 Assessment of potential effects

Prediction of environmental effects at mine sites often requires a broad set of scenarios because of uncertainty related to water quality projections based on laboratory scale test work. At the ESE, MFS and UWHR sub-areas a narrower range of scenarios can be developed because of studies completed at Stockton and the existing Escarpment mine sites over the last 25 years (for example J-NZ0349-008-R). At the MFS and ESE sub-areas the prediction of environmental effects is completed in two probabilistic water and load balance models. These models are completed with a base case of climate conditions that are typical for the BPCP area and are stress tested with a wet scenario and a highly variable scenario. These scenarios have been compared to recognised climate change scenarios to provide confidence that the possible range of conditions included in the modelling. In addition, probabilistic models have been run with ± 30% of acid and trace element loads to mitigate uncertainty related to water quality projections. Overall, these models indicate that the ESE and MFS sub-areas will be in compliance. The models also indicate the frequency of bypass of water treatment infrastructure in high rainfall events. At the UWHR site smaller earthworks activities are planned and these require flexible arrangements with respect to water management and treatment.

4.5.1 Documents included

The reviewed documents that provide information on the prevention and minimisation of AMD include four reports authored by Mine Waste Management Ltd (MWM).

Table 2. Reviewed documents related to assessment of potential effects of AMD

Author	Document Number	Title
MWM	J-NZ0453-006-R	ELF Water Quality and MSR Design Summary
MWM	J-NZ0453-007-R	Construction Phase Report
MWM	J-NZ0377-003-R	MFS - Water and Load Balance Model
MWM	J-NZ0433-003-R	ESE - Water and Load Balance Model Report

4.5.2 Review

<u>ELF Water Quality and MSR Design Summary</u>

The ELF Water Quality and MSR Design Summary Report ties together two important aspects of the BPCP. This report applies the ELF Water Quality Model (J-NZ0349-008-R) to seepages that are projected from each of the ELFs that will be constructed during the BPCP and projects the seepage water quality over time. The loads of dissolved components from seeps form part of the load of components that must be treated by active water treatment during mine operations. Based on this information and prediction of how this chemistry evolves, as well as identification of the point where oxygen diffusion into the ELF controls oxidation processes, the time where passive mine drainage treatment is a viable water treatment option can be identified.

There are a total of 20 ELF catchments to which the ELF Water Quality Model is applied, and seepage volume, chemistry and chemical evolution is calculated. The flow volumes for each ELF seepage are calculated based on an infiltration rate of 60% for unrehabilitated ELF and 40% for rehabilitated ELF. The chemical evolution of each seepage is also calculated based on the three phases of ELF construction that are identified in the ELF water quality model. These include:

- A construction phase when material is deposited in the ELF.
- A stabilisation phase where the cap has been placed on the ELF reducing permeability/net percolation of the ELF.
- A decay phase once permeability/net percolation of the ELF has stabilised and dissolved components in ELF seepage decrease with time.

Highest concentrations of dissolved components in seepage occur during the construction and stabilisation phase when both the sulphide oxidation and stored oxidation products are contributing acidity to the ELF seepage. After the stabilisation phase is complete the internal part of the ELF will not receive oxygen by advection and can be considered to be sealed, and the external part of the ELF (~10m) will continue to oxidise and release AMD. This is based on measurements of oxygen ingress into ELFs at Escarpment (care and maintenance) and Stockton. AMD release will continue throughout the decay phase with a decreasing load based on empirical data from the Barren Valley Elf. As ELFs are built, there might be mine influenced water from all three phases contributing to seeps from different parts of the ELF. The oldest parts of the ELF might be capped and in the decay phase while other parts of the ELF are in the construction or stabilisation phase.

In the long term, acid release from ELFs will be controlled by diffusion of oxygen through the capping materials into the waste rock. Rates of diffusion for capping materials have been estimated (J-NZ0349-013-R) and once diffusion is the limiting factor there is a maximum amount of acidity that can be released based on oxygen availability through the surface area of the ELF to react with the available sulphide minerals in waste rock. Published data and site-specific data from Stockton indicate that after waste rock is rehabilitated, there is a slow decrease of 0.62% per year in the rate of acid release because reactivity of sulphide minerals declines and sulphide is consumed. For each of the ELFs that are to be constructed, the long term acid release rate has been calculated and the initial rapid acid release rate has been matched up to the long term acid decay rate. This produces complete acid release profiles that have an initial rapid decline in acid release as rehabilitation is completed followed by a long tail of slowly declining acid release. Overall, the acid release profile for each ELF maximises the use of empirical data with oxygen diffusion modelling.

These acid release profiles enable BRL to determine when each ELF might be able to switch from active water treatment to passive water treatment by using international guidance for the capability of passive water treatment to be used. Critical factors to determine when passive treatment is applicable include recommended maximum flow rates (50L/s) and maximum acid loads (50t/y). Overall, all but two ELF seepages can be treated by standard passive treatment processes. The two ELF seepages that will exceed the recommended maximum flow or acid load are the CON and WWH ELFs. At these sites recommendations are made for provision of extra space for passive treatment and splitting of flows to enable multiple passive treatment systems to be constructed.

The ELF Water Quality and MSR Design Summary Report compiles all available data to deliver a Project water treatment framework where a switch from active to passive treatment is possible for the entire Project. The framework for transition from active to passive treatment for the BPCP is plausible and has the benefit of multiple years of operational time for refinement, and also has the potential for active mine water treatment to be extended if required.

<u>Construction Phase Report</u>

The Construction Phase Report covers an approximately two year time period from first disturbance to commencement of mining. This phase of work establishes the minimum infrastructure that is required to commence mining including roading, access to coal, pads for buildings or materials handling and water management and water treatment facilities. It takes place utilising current mine facilities at Escarpment, Stockton and Cypress mines and current roading infrastructure as much as possible. In addition, the construction phase provides access to historic workings that currently degrade downstream water quality and identifies areas (including historic mines) that will be remediated throughout the BPCP operations.

The construction phase activities and their management are similar to mining activities, but in general at a smaller scale than mining related disturbance. This means the critical information required for environmental management is similar to that required for mining with respect to, background conditions, climate, stream water quality, geology and geochemistry. Therefore, in general, similar management processes also apply, materials characterisation, materials handling and placement, sediment management, clean water diversion, water treatment and sludge management. However, the disturbance is smaller and includes a long narrow transport corridor and so these practices must be deployed in a distributed manner that is responsive and adaptable to the immediate surroundings rather than operated in a centralised manner as will occur at the mine sites once operational.

The Construction Phase Report provides a description of the infrastructure that will be constructed during the two year period and includes figures showing the areal extent of the site works. Just over 5Mm^3 of material at ESE and 1.8Mm^3 at MFS and will be moved during the construction phase and BRL has developed a mass balanced cut and fill schedule for these activities. At ESE, most of the cut material (2.7Mm^3) relates to a boxcut to access coal at the ESE coal deposit and most of the fill (3.1Mm^3) material will be deposited into an extension of the Barren Valley ELF. At MFS, most of the cut material relates to construction of the West Sump (1.2Mm^3) and fill materials go into two engineered landforms (1.1Mm^3). The total disturbance of the Construction Phase activities is just over 102Ha at ESE and just over 37Ha at MFS. AMD formation loads for these cut and fill materials and for the new cut surfaces have been calculated and portable water treatment plants will be deployed to manage water impacted by construction phase activity.

The UWHR is a road corridor that links the ESE and MFS mine sites to infrastructure at the Cypress and Stockton Mine sites. It is typically 13m wide, in general it sits closely on the natural topography with 12 areas identified where fill is required that is more than 2m deep and of these, two areas will contain more than 10 000m^3 of fill. Materials that are considered unsuitable for road construction for geotechnical or geochemical reasons will be disposed of at either the ESE or Stockton mine sites and granite or NAF material will be brought in to supplement road construction materials as required. Acidity loads from the BCM fill that will be used in construction of the UWHR have been calculated and for the two largest fill areas a low permeability capping material will be constructed to prevent formation of AMD from these areas. Assessment of the potential environmental impact for smaller areas of fill indicate these will be negligible and an adaptive process has been selected for these areas.

For each of the construction phase areas, assessments of current water quality have been made and monitoring regimes are proposed that include performance and compliance monitoring . Relatively large disturbances outlined within the construction phase (such as ELF construction, or large fill areas on the UWHR) have appropriately detailed management and mitigation plans whereas relatively small disturbances (such as small infrastructure pads, road corridor or small fill areas) are managed in an adaptive manner. The performance monitoring regime will assist with delivery of adaptive management of smaller disturbances during the construction phase work.

Overall, the construction phase report provides certainty the environmental impacts related to break in activities and infrastructure development for the site have been considered and appropriate mitigations, management and monitoring options have been developed. Many of the environmental management processes that have been adopted can be transferred from the mining phase of operations, however where necessary, management techniques that are specific to the construction phase have been adopted such as portable water treatment systems and low permeability capping systems over fill on the UWHR.

<u>MFS - Water and Load Balance Model Report</u>

The MFS – Water and Load Balance Report is an output of many of the previous studies the provides a prediction of water quality throughout the mine site and downstream of operations and through time. It is a probabilistic model that is used by the operator to test if the combination of proposed mining and water treatment/management will deliver downstream water quality that meets proposed regulatory limits. Key inputs for the Water and Load Balance model include but are not limited to:

- Climatic inputs including rainfall, rainfall variability, climate, evapotranspiration and climate change assessment.
- Mine disturbance, tonnes of rock moved, areas stripped, areas rehabilitated.
- Sulphur content of rock from block models
- ELF construction methodologies, permeability, net percolation, capping, unsaturated zone hydrogeology.
- Discharged water quality from different landforms within the mined environment including seeps, surface run off, rehabilitated area run off, background surface water quality, highwall run off etc.
- Water flows, background chemistry and their response to rainfall.
- Water treatment efficiencies and effectiveness for active and passive systems, flows and response of catchment to rainfall downstream of mine activity.

The Water and Load Balance Model provides a framework for simulation of this complex environment in a software platform that can provide a statistical representation of the potential that mining operations can proceed within regulated conditions. Probabilistic models are useful tool for mining companies (and other resource users) to predict environmental impact, manage risk and optimise management scenarios to deliver appropriate outcomes.

Overall, the parameters that have been used by BRL and consultants for Water and Load Balance Modelling have been reviewed in other reports (J-NZ0433-004-R, J-NZ0349-008-R, J-NZ0349-013-R, and others). Most of the values that have been derived are based on interpretation of empirical geochemical datasets that have been collected over the last 25 years and for some of the parameters variability through time is an important factor (eg, evolution of seepage with time, dilution of loads from surfaces).

The Water and Load Balance Model utilises the geochemical predictions that are the subject of earlier reports along with variable scenarios for climate. Climate is a key parameter for the BPCP because rainfall events drive short term variability in: the volume of mine influenced water, the flow velocity of water to entrain sediment, and dilution in the catchment surrounding the sub-area. Management of short term variations in volume and quality of water is one of the most challenging aspects of BPCP operations. Collectively the interaction between the different areas to which the source terms apply and the rainfall pattern determine the water quality that is derived at the mine site.

Water and Load Balance Models match rainfall and source terms typically on daily time-steps and generate large amounts of data. To manage the variability caused by climate data, the probabilistic model uses data sampling techniques and monte-carlo simulations to deliver statistically representative outputs for water quality at nodes within the model. The most consequential nodes are set up to represent downstream compliance monitoring points, while other nodes represent calculations of changes to the hydrological environment such as discharge, mixing, storage or treatment points. Outputs from the model are processed and then compared to regulations to test if the upstream hydrological and geochemical processes deliver a water quality that is compliant or not. Management scenarios for water treatment efficiencies can be run and optimised to meet consent criteria.

In addition to typical variability in climate, the probabilistic models can be operated with input data adjusted to represent different climate scenarios. These scenarios provide a stress test to the Water and Load Balance Model to see if it is resilient and these can also be matched to published climate change projections to assess if the modelling is appropriate for likely future climate regimes. The MFS– Water and Load Balance Report includes about 100 years and incorporates a modelling base case and 4 alternative scenarios to address uncertainty related to data acquisition, climate variability, climate change and geochemistry:

1. Base case scenario.
2. A wet case scenario.
3. A variable rainfall scenario.
4. A 30% increase in dissolved components.
5. A 30% decrease in dissolved components.

Under the base case scenario the site is compliant with the recommended water quality monitoring results throughout the modelled period. Rainfall events can be challenging to manage in the Buller Plateaux areas, because they are often high intensity and the headwaters catchments respond rapidly to rainfall. It is necessary to have contingency processes in place for high intensity rainfall events where mine influenced water can bypass treatment and/or have pumped direct discharge to the catchment for safety and practicality reasons. In the base case model, bypass happens 5% of the time and direct discharge of water happens 10% of the time when surface water flows are too large to maintain within the water management infrastructure. In these circumstances the mixing of untreated water with high flow does not lead to exceedance of proposed water quality guidelines.

The Water and Load Balance Model has also been run for scenarios that are designed to assess if the water management and water treatment processes will deliver a compliant system under challenging climatic or geochemical conditions (points 2-5 above). Under the continuous wet and variable rainfall there is an increase in the requirement to bypass or directly discharge mine water to maximum values of 7% and 12% respectively. Under the scenarios where dissolved components are increased or decreased the concentrations of trace elements are the main source of variance from the base case model.

In each of these circumstances the model indicates that the site is compliant with respect to recommended water monitoring regulation values. Overall, this means that the water management infrastructure has been appropriately specified to deliver a compliant outcome for the site within the range of likely climatic and geochemical conditions. Climate change scenarios have been assessed within the wet and variable rainfall scenarios through comparison of modelled data to published climate model scenarios.

The MFS Water and Load Balance Model also indicates that active treatment will be required for 4 years at the MFS sub-area after rehabilitation has been completed before a transition to passive treatment can be progressed. This model also indicates the impact of changes in runoff vs infiltration on base flow rates in streams before and after mining. The main impact of ELFs on surface water hydrogeology in catchments where they are built is to deliver higher base flows because of steady seepage rates compared to high runoff coefficients for unmined areas. In addition, the catchment for seepage reflects the shape of the pit floor and with any underdrains which might differ from the topographic surface water catchment boundaries.

<u>ESE - Water and Load Balance Model</u>

The ESE – Water and Load Balance Model report provides a similar set of interpretations to those presented in the MFS Water and Load Balance Model. The contributing data sets are site specific and reflect conditions local to the ESE sub-area, and the approach to modelling is similar. Similarly to the MFS Water and Load Balance Model site specific data for the ESE sub-area, a base case model is developed to reflect the ESE mine plan and this is operated on daily time steps for about 100 years. Four additional scenarios are modelled to test how robust the water management plan is for the site compared to proposed downstream water quality regulatory requirements. The scenarios are similar (though site specific) and include a wet scenario, a variable rainfall scenario, a 30% increase in dissolved components and a 30% decrease in dissolved components for geochemical source terms.

Overall, the processes within the ESE – Water and Load Balance Model are similar to those in the MFS model in that site specific source terms, water treatment processes, hydrological conditions are applied to the mined environment as it changes with time. The model indicates that outcomes are compliant compared to proposed regulations in all of the scenarios modelled. Similarly to the MFS Water and Load Balance Model, this provides confidence that the water management and treatment process are scaled appropriately for this sub-area. There are some site specific outcomes from the modelling at the ESE sub-area. The base case water and load balance model requires combined bypass/spill to the downstream environment 5% of the time or less to manage high rainfall events. The maximum combined bypass/spill percentage based on data from the wet and variable rainfall models is up to 18%. In addition to these differences between ESE and MFS, the water treatment plant is expected to operate for 15 years beyond the completion of rehabilitation and into the closure phase before a transition to passive treatment can be completed. Similarly to the MFS sub-area there are changes to base flow conditions in the post mining environment for some catchments related to increased seepage from engineered landforms compare to unmined landscapes and changes to catchment areas for seepage compared to surface topography.

5 Review – ESE, MFS and UWHR Total Suspended Sediment reports

5.1 Introduction

Suspended sediment can be generated any time disturbance to land intersects surface water and management of excess suspended sediment is common to many developments or land uses. So unlike chemical impacts of mining on surface water where the influences on water quality are different between sites, the TSS issues are broadly similar across all sites. So, approaches to management of suspended sediment can be transferred between sites relatively easily and without substantial modification.

At mine sites sediment control often changes relatively quickly close to the active pit as mining operations change topography and expose new surfaces and sumps are moved or new drains are emplaced. Then sediment control becomes more fixed downstream of mine sites and might include an active water treatment plant or large sedimentation structures. There are often relatively simple operational practises that can be emplaced to minimise generation and waterborne transport of suspended sediment around the site.

5.1.1 Documents Included

The documents reviewed that address TSS as the BPCP include three documents prepared by Mine Waste Management Ltd. These documents use data derived from Stockton Mine to make predictions for the BPCP and transfer techniques that have been proved effective in the Buller coastal ranges.

Table 5. Reviewed documents related to predictions of sediment mobility and sediment control measures.

Author	Document Number	Title
MWM	J-NZ0433-013-M	MGIU TSS Review
MWM	J-NZ0433-014-M	Previous TSS Studies
MWM	J-NZ0480-002-R	Sediment Overview Report

5.1.2 Review

<u>MGIU TSS Review</u>

This report compiles total suspended sediment and turbidity data from disturbed parts of the Stockton Mine site. The purpose of compilation of this dataset is to understand the amount of suspended sediment that must be managed in areas of the BPCP that will be disturbed should mining proceed.

This report includes sediment data collected a short distance upstream of water treatment or large settling facilities (where possible) and interprets how much sediment is likely to be required to be removed from water during water treatment. The report examines datasets from 6 sites on the Stockton Mine site with between 3 years and 45 years of monitoring data. The data collected at these sites reflects water that has flowed from the active parts of the mine through primary sediment control (sediment traps, sediment fences or small sumps) towards water treatment infrastructure. Water treatment infrastructure typically includes dosing points for treatment of acidic water and large sumps to trap remaining sediment and precipitates that form as water is neutralised and treated.

These data therefore reflect the sediment load that must be removed by water treatment rather than the entire sediment load from active areas of the mine. The data also reflect the average of various operational regimes in the mine including mined areas, waste rock management areas, fresh rehabilitation sites, road/infrastructure/coal handling areas as well as undisturbed and rehabilitated areas.

The measurements for TSS and turbidity are relatively simple, however correlation of TSS or turbidity to related datasets (rainfall, flow, mining activity) are difficult and detailed prediction of TSS is difficult for several reasons:

- Sediment export from sources with a finite supply of sediment can vary within a single rainfall event. Sediment transport is related to flow and often exhibits hysteresis, so that the waxing flow carries more sediment than the waning flow.
- Sediment release can change rapidly (days to weeks). For example, immediately after mining disturbance, a sloped landform might release sediment on rainfall. However, following several rainfall events that wash available sediment away, the release of sediment can decrease rapidly. Similar relationships can occur with other disturbed or rehabilitated landforms at mine sites.
- The activities at mine sites also change rapidly, from pre-stripping, to mining to backfill to rehabilitation can occur within a period of weeks to months.

For these reasons, averaged data are used for predictions for the suspended sediment relationships in the BPCP area and key components and assumptions within these interpretations are:

1. Based on a large monitoring dataset the worst two years of sediment release data from the MGIU site are used for sediment predictions of suspended sediment in the BPCP area.
2. There is a positive relationship between high flow and high suspended sediment or turbidity. These relationships are best identified with averaged flows and averaged suspended sediment or turbidity.
3. Based on relationships between flow and turbidity, it is assumed that rainfall data can be used to predict suspended sediment release. Therefore, rainfall magnitude-frequency data collected at Stockton is used to predict suspended sediment for the BPCP area.

Overall, in the report, the suspended sediment and turbidity data is managed in an averaged and conservative manner. This means that on average the sediment load that needs to be managed in the BPCP area is likely to be lower than the value derived from the two worst years at the MGIU site.

Previous TSS Studies

The purpose of this report is to compile all information that has been collected by BRL related to sediment release from different types of disturbed environment and with different types of erosion/sediment control. This includes field and laboratory data collected from mine pits, haul roads, ELFSs, rehabilitated ELFs and areas with deployment of different types of erosion/sediment control. The studies collated are useful in a relative sense, they demonstrate that sediment control measures related to rehabilitation and mitigations can deliver substantial benefits for decreasing the mobilisation of sediment from mined environments. However, the studies do not collect data that enable the calculation of TSS value that might be applied to different parts of the mined environments. Instead, it is interpreted in this document that monitoring data that combines and averages areas of active mining is probably the most robust way to obtain values that are of predictive value for future operations.

Overall, this document demonstrates that sediment control measures and rehabilitation prevent mobilisation of fine material into surface runoff water. Results are presented both as values of total suspended sediment concentrations in water from field work or laboratory trials and as erosion rates as mass per unit area (t/ha or kg/m^2). Therefore, this document demonstrates that downstream sediment control measures at sumps or mine water treatment infrastructure benefit from source control. The key outcome of this document is to demonstrate the value of sediment control at active areas of the mine to ensure that operational practices prioritise sediment control when excavation and landform construction occurs.

In addition to the summary of previous studies that is provided in the main text of Previous TSS Studies, appendices contain copies of the key reports to support studies of sediment management at Stockton.

<u>Sediment Overview Report</u>

The Sediment Overview Report includes summaries of previous studies on suspended sediment (J-NZ0433-013-M, J-NZ0433-014-M and supporting documents) and uses the likely concentrations of TSS that will generated by mining activity to enable predictions to be made for downstream concentrations of TSS and to develop management and treatment processes.

Management practises to minimise TSS generation are based directly on monitoring data and empirical studies and include erosion control, storm water management. Treatment methods are split into two types of process, passive treatment and active. Passive management processes include encouraging natural sedimentation by reducing water velocity and providing water detention structures that enable residence time in sumps and sediment retention ponds. The effectiveness of passive processes can be improved by flocculant addition on an as required basis. Active treatment includes suspended sediment removal in combination with AMD treatment methods. Design and process flow diagrams are available for active treatment and the key elements for removal of particulates (TSS and precipitates from AMD neutralisation) include upstream surge ponds, flocculant addition, lamella clarifiers with filter press to deliver a solid waste. Using water quality information provided in (J-NZ0377-003-R, J-NZ0433-003-R, J-NZ0433-013-M) total sediment loads that must be treated can be calculated for each year of mine operation and sediment management infrastructure can be sized appropriately.

The Sediment Overview Report also addresses how TSS will be managed during the construction phase and also after rehabilitation of the mine site. During construction a similar approach to TSS management will be completed to during the operational phase of mining, except the smaller disturbances mean the passive and active treatment methods that are deployed will also be smaller. A modular lamella clarifier technology will be used that can be deployed in a temporary and relatively mobile manner which will be appropriate for manging TSS during ESE, MFS and UWHR construction phase works.

The TSS relationships from other studies are used to develop source terms and are then incorporated in the same probabilistic water and load balance models that is used for prediction, management and treatment of AMD (J-NZ0377-003-R, J-NZ0433-003-R). Based on this model the predicted TSS values do not exceed compliance criteria either for acute or chronic assessment of protection of aquatic ecosystems.

6 Summary

The BPCP is a large and complex project including the Escarpment Extended sub-area, the Mount Frederick South sub-area, extensions of open cast activities in the Millerton Block at Stockton Mine and the Upper Waimangaroa Haul Road. Acid and metalliferous drainage issues within this region are well known and geochemical processes are well understood. The relatively high and often intense rainfall along with relatively reactive overburden materials provide challenges for management of AMD. Over the last ~25 years detailed geochemical and environmental studies have been completed and these have been collated and added to new BPCP datasets to deliver an integrated overburden and mine water management approach for the Project.

The BPCP area has a long and complex mining history spanning at least 130 years and historic underground mines discharge untreated AMD into streams and rivers throughout the Project area. Mining history and practice at the Stockton area creates a legacy that is managed through a water quality improvement process, where the current and proposed operations are consented to deliver an improved water quality compared to the current mine environment that is impacted by legacy issues. Water quality improvement is calculated two ways in the Stockton sub-area. In catchments where planned Stockton Mine operations will remove all historic workings / have a high degree of AMD treatment, water quality targets correspond to ecological recovery thresholds. In catchments where planned Stockton Mine activity partially removes historic workings, water quality targets correspond to betterment compared to 2010 concentrations.

In the ESE and MFS sub-areas a more conventional approach to water management is taken where mining activities are consented to be undertaken in a manner that does not breach specific concentrations for waterborne components. The compliance levels are based on background water quality values and established water quality criteria for protection of aquatic ecosystems.

At the ESE and MFS sub-areas detailed study of analogous conditions enable low uncertainty projections of future water quality that will be produced by mining activities. These are combined with best practice waste rock management and geochemical interpretations to deliver a detailed plan for water management and treatment throughout mine life.

Overall, the datasets presented related to overburden characterisation/management along with mine water quality predictions and treatment/management are comprehensive the interpretations are appropriate. This enables a detailed, robust and relatively low uncertainty mine water load balance model to be developed. Mine water management practise that is included in the model prevent degradation of the downstream aquatic environments for the Project.