Before the Hearing Panel appointed by Canterbury Regional Council and Selwyn District Council

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Applications CRC184166, CRC200500, CRC201366, CRC201367, CRC201368, CRC203016, CRC214320 and CRC214321 by Bathurst Coal Limited for a suite of resource consents to operate, rehabilitate and close the Canterbury Coal Mine.

SUMMARY STATEMENT

SECTION 42A REPORTING OFFICER
CANTERBURY REGIONAL COUNCIL
CONTAMINATED LAND AND WATER – MICHAEL MASSEY

DATED: 28 OCTOBER 2021

INTRODUCTION

1. My full name is Michael Stanley Massey. I am employed by Environment Canterbury Regional Council as Principal Science Advisor on the Contaminated Land and Waste team. I have been in this role since February 2020, and prior to this role I was a university professor.

2. My colleague Stephen Gardner has previously provided advice on this application, but is leaving Council employment so I have been asked to provide evidence in his stead. I advised Mr Gardner in the preparation of his s42A report, included as Appendix 7 of the Officer's Report prepared by Adele Dawson. I will discuss Mr Gardner's report in due course.

3. I am a Certified Environmental Practitioner (no. 1361) under the scheme managed by the Environment Institute of Australia and New Zealand (EIANZ), and am a member of both EIANZ and the Australasian Land and Groundwater Association. For approximately fifteen years, I have also been a member of the American Chemical Society, the Soil Science Society of America, and the American Association for the Advancement of Science.

4. I hold a Doctor of Philosophy degree in Environmental Earth System Science from Stanford University in Stanford, California, United States. I also hold a Master of Science degree in Soil Science from Colorado State University in Fort Collins, Colorado, United States. My areas of expertise include soil and water chemistry, and contaminant biogeochemistry and transport.

5. As part of Environment Canterbury's Contaminated Sites Team, I provide technical advice and undertake technical reviews on matters relating to contaminated land and water quality. We serve a variety of internal and external customers, including consents planners, compliance officers, and members of the public.

6. While this is a Council Hearing, I acknowledge that I have read the Environment Court's Code of Conduct for Expert Witnesses as contained in section 7 of the Environment Court Practice Note 2014, and have complied with it in the preparation of this summary. All my evidence is within my expertise and I have considered and stated all material facts known to me which might alter or qualify the opinions I express.

SCOPE OF REPORT

7. As previously noted, this report is an addendum to Mr Stephen Gardner's Section 42A report which is included as Appendix 7 of the Section 42A Officer's Report circulated on 24 September 2021. The purpose of this addendum is to provide a summary of the previous report and respond to matters raised in the Applicant's evidence and evidence provided by submitters.

8. In preparing my report, I have reviewed the following information:

   a. Application for consent to discharge treated mine water into Tara Stream; and to take, use and divert surface water and groundwater, dated 20 September 2019;

   b. Bathurst Coal Limited, Canterbury Coal Mine Addendum AEE for Closure and Rehabilitation, dated 6 April 2021;

   c. Canterbury Coal Mine Environmental Management Plan, dated March 2021;

   d. Section 42A Officer's Report, Report of Stephen Gardner, dated 17 September 2021;

   e. Draft Summary Statement of Don Macfarlane (Geotechnical), dated 15 October 2021;

   f. Statement of Evidence of Paul Antony Weber (Mine Waste Management) for Bathurst Coal Limited, dated 1 October 2021;

   g. Memorandum 1 by Paul Weber, Canterbury Coal Mine Closure – Tara Mussel Shell Reactor Treatment System Design, document number J-NZ0130-002-M-Rev0, dated 19 March 2021;

   h. Memorandum 2 by Paul Weber, Canterbury Coal Mine Closure – No 2 Pit Pond Water Quality Forecast, document number J-NZ0130-003-M-Rev0, dated 19 March 2021;

   i. Memorandum 3 by Paul Weber, Canterbury Coal Mine Closure – Tara catchment discharge water quality, document number J-NZ0130-004-M-Rev0, dated 19 March 2021;

   j. Memorandum 4 by Paul Weber, Canterbury Coal Mine Closure – AMD closure criteria, document number J-NZ0130-005-M-Rev0, dated 19 April 2021;

   k. Several published scientific studies, listed in the References section of my evidence; and

   l. Evidence and questioning presented at the hearing on 26 and 27 October 2021, including revised conditions proposed by the Applicant.

SECTION 42A REPORT SUMMARY

9. Mr Gardner's s42A report discussed the potential for contaminant discharges from material that had been emplaced at the site, with a focus on discharges from coal combustion residuals.

10. The report concluded that there were insufficient data provided to understand the materials that had been deposited at the site, specifically the coal combustion residuals.

11. Mr Gardner's report also stated that the leachate testing provided by the Applicant was not sufficient to evaluate the potential environmental risks associated with contaminant discharges from the waste rock and coal combustion residuals emplaced at the site, and that a robust plan will be required to manage water quality in streams impacted by site leachate.

12. In his report, Mr Gardner specifically recommended sampling for a wider suite of contaminants than are currently measured in monitoring activities. Mr Gardner recommended sampling for a variety of trace elements, as well as polycyclic aromatic hydrocarbons (known as PAHs), in future monitoring activities, in order to assess potential water quality impacts from site activities.

13. Mr Gardner also wrote, "The applicant has stated that on average the capping layer over the engineered landforms is around 0.5 metres thick, with 0.1 metres of topsoil placed over the top." However, during his site visit, "Observations…indicate[d] that the thickness of the capping layer is highly variable, ranging from 0.5 – 1.5 metres."

14. The report also raised issues regarding recording of activities and site management plans, and potential future land uses. Depending on future land use, there is a risk of the loss of land integrity (i.e., increased permeability), which might result in increased mobilisation of contaminants due to the intrusion of oxygen or water.

15. I agree with the conclusions of Mr Gardner's s42A report, as they are aligned with the advice that I provided to Mr Gardner in the preparation of the report.

MATTERS RAISED IN EVIDENCE

16. In keeping with my colleague Mr Gardner's evidence, my evidence here will focus primarily on matters of post-closure management and monitoring at the Canterbury Coal Mine site. Other matters raised in evidence during the hearing process relate to my areas of expertise, so I have endeavoured to respond to those matters in this supplementary evidence.

Adaptive Management Approach

17. In the evidence of Dr Weber, regarding the geochemical aspects of mine waste management, key monitoring points were identified, including the CC02 underdrain, in Tara Stream (CC02-tele) the N02 Pit Pond, and the North Engineered Landform (including monitoring points CC20 and CC24). Dr Weber noted that, "At CCM ongoing performance monitoring is needed to confirm the management approaches, developed for specific risks, are appropriate. With time this leads to a reduction of monitoring requirements and eventually cessation of monitoring once key closure objectives have been achieved."

18. In general the "adaptive management" process (i.e., "Trigger Action Response Plans" or "TARPs") proposed by the Applicant resembles management and monitoring approaches at other contaminated sites in Canterbury, such as at petrol

stations where contaminant discharges have occurred, or at landfill sites where waste material such as contaminated soil has been emplaced.

19. In terms of our day-to-day work, review of compliance with management plans, and review of proposals to alter management plans, represents a significant workload for Regional Council staff. This creates additional costs for consent holders, since the cost of compliance review or management plan review are borne by the consent holder.

20. In the case of petrol stations, I have generally seen around ten years of water quality monitoring data showing consistent trends before reductions in monitoring are considered. In the case of waste disposal sites such as landfills, monitoring including assessment of engineered mitigation such as capping, as well as water quality analysis, continues throughout the closure and aftercare period, potentially in perpetuity. For example, inspections of closed landfill cap integrity might be required on an annual or five-yearly basis. Mr Macfarlane has recommended geotechnical inspection of the engineered landforms at the Canterbury Coal Mine site for five years following completion of mine closure activities, for example.

21. Environmental impacts from petrol stations may persist for decades, and environmental impacts from waste disposal sites like landfills may persist for decades to centuries. I consider the Canterbury Coal Mine site most similar to a waste disposal site, due to the mass and volume of overburden waste rock and coal combustion residuals that have been discharged to the site. A monitoring and management approach of similar frequency and duration seems prudent in the case of the Canterbury Coal Mine site.

22. I recommend a monitoring program commensurate with the scale and extent of activities at the site, the history of contaminant discharges, the presence of existing effects, and the proximity of ecological receptors in nearby surface water, such as the Tara Stream.

23. As noted by Dr Weber, it is proposed in the Mine Closure Management Plan that water quality monitoring for treatment system performance continue only until 2024. Other monitoring may cease after an even shorter period. To me, such a short monitoring period is not commensurate with the activities at the site, especially given the proximity to surface water and potential changes or variability in impacts or treatment system performance.

24. I recommend a water quality monitoring program lasting at least some decades, and a management program to match, in order to ensure appropriate management of contaminant discharges from the site in both the closure and post-closure periods. Such a program would be consistent with other large contaminated sites in the Canterbury Region.

25. Dr Weber "recommend[s] that the water quality trends and flow rate trends be reviewed in 2024 and a decision made as to the continuation of monitoring, which will be predicated on water quality trends and evidence of stable and/or decreasing concentrations and loads." In general, I do not consider such a short period of time adequate for establishing trends in treatment. As I noted previously, for other contaminated sites of considerably smaller scale, a period of ten years or more would be more reasonable to evaluate trends in water quality data. For this site, I would expect at least as much, if not more.

26. I recommend an initial water quality monitoring period of at least ten to twenty years, to obtain a reasonable baseline of system performance and validate predicted effects versus actual effects. This length of time would enable monitoring through periods of at least some climatic variability. Additionally, the initial monitoring period should allow for assessment following replenishment of the mussel shell reactor and

removal of sludge (discussed below), in order to validate treatment system performance both before and after replenishment.

27. The revised Assessment of Environmental Effects notes, "Over time it is anticipated that the contaminant loads relating to AMD will reduce, and the PTS [passive treatment system] treatment can be discontinued. Actual monitoring data will be used to determine when this treatment will no longer be required at the site following closure." Dr Weber's evidence also states, "Management and treatment of CC02 Underdrain waters is likely to be for years to decades."

28. Dr Weber's Memorandum 4, entitled, "Canterbury Coal Mine Closure – AMD Closure Criteria," which states, "…[O]nce the North ELF is fully rehabilitated an exceedance of CRC173823 water quality criteria at CC24 due to North ELF AMD discharge is unlikely and surrender of North ELF AMD-related water quality consents could be considered at the end of the initial ~12-18 month post closure period." As with the monitoring of the passive treatment system performance, this monitoring period seems very short, both when compared to other large contaminated sites in Canterbury, and when considering the uncertainties in performance moving forward.

29. The Applicant therefore seems prepared to continue monitoring the site for some time after closure, and I recommend regular, frequent long-term monitoring at all existing monitoring points be codified as a condition of consent. A period of two years or less, as suggested in some of the Applicants' documents, and the evidence of Dr Weber, seems to me to be exceedingly short.

30. A short monitoring period may not be sufficient to detect changes in the system resulting from more recent material deposition.

31. I recommend a combination of both continuous water quality monitoring, and periodic sampling and laboratory analysis (currently monthly, as noted in the Environmental Management Plan, under the existing resource consent), in order to corroborate continuous monitoring data and provide information regarding contaminant concentrations in water.

32. I note that the requirement of resampling (as proposed by the Applicant in the most recent draft conditions) to confirm an exceedance may not be appropriate for surface water, as system residence times may be shorter than the resampling may be able to detect. From a practical perspective, by the time resampling and analysis occurs, contamination may already have been flushed downstream. So from my perspective, any exceedance should be considered an exceedance, unless the exceedance is demonstrated to be caused by a technical fault. But on this matter I defer to surface water experts.

Contaminants of Concern

33. Regarding potential contaminants of concern, Dr Weber noted in his evidence that, "Results indicated that in December 2019 the potential soluble B reserve in total waste rock was four times greater than the total soluble reserve in the CCR." Dr Weber further reported that, "Water quality data for CC08, a historic underground mine, unrelated to this consenting application discharging into Bush Gully Stream, has boron concentrations of up to 3.77 mg/L (average 2.73 mg/L), which demonstrates that local rocks can also generate elevated boron concentrations where no CCR has been placed."

34. Much has been said in the application and over the past few days regarding boron. I note only that among the uses of boron is that of a nonspecific pesticide. So while it may be an essential nutrient for some organisms, as Dr Hickey noted, boron can also be toxic to vertebrates (as Dr Hickey also noted) as well as invertebrates, at

some dose. Dr Hodgson in response to questioning by Commissioner McGarry noted the importance of the invertebrate food supply to the aquatic ecosystems. Potential effects of boron toxicity therefore do seem an important factor to consider.

35. While my colleague Mr Gardner previously chiefly considered potential contaminant discharges from the coal combustion residuals which had been emplaced at the site, after considering Dr Weber's evidence, it is reasonable that potential contaminant discharges from the waste rock should also be considered.

36. Even though the waste rock is from the site itself, the shift from acidic drainage to what Dr Weber referred to as "neutral metalliferous drainage" is an example of how different processes can act on the same material and produce markedly different outcomes. To me, this underscores the importance of considering the waste rock in addition to the coal combustion residuals as a potential contaminant source.

37. Only limited chemical characterisation of the material emplaced at the site has been provided for review. To my knowledge, there is not a good understanding of where coal combustion residuals came from (Dr Weber noted at least two different sources), or the characteristics or variability of the material. Nor have I seen a characterisation of the waste rock. The characterisation that has been provided has been very limited, with only aluminium, boron, calcium, iron, magnesium, mercury, nickel, zinc, and sulphate. Limited data are available regarding other contaminants of concern.

38. Since the material has already been emplaced, and further material will reportedly not be accepted at the site, uncertainty regarding the characteristics of that material cannot practically be remedied.

39. Contaminant discharges from the waste rock would occur in a manner analogous to releases from other materials, such as coal combustion residuals. Water or air moving through the material will interact with it, and any contaminants mobilised through water-rock interactions would subsequently be transported.

40. Dr Weber stated that he considers additional monitoring parameters as recommended by my colleague Mr Gardner largely unnecessary, citing toxicity characteristic leaching procedure (TCLP) extract data to support his claims. For example, Dr Weber stated that he considers monitoring for arsenic to be unnecessary. Arsenic concentrations were simply reported as "< 0.021 g/m^3." For comparison, a relevant toxicant guideline value for the protection of aquatic species for arsenic would be 0.024 g/m^3, just a few parts per billion above the limit in the TCLP test results. The test therefore provides little usable information regarding the presence or absence of arsenic in potential leachate.

41. Generally one would use a method with a detection limit of perhaps 10% or 20% of the relevant guideline values or trigger limits, in order to provide some level of certainty that concentrations are not approaching those thresholds.

42. As noted by Mr Gardner in his evidence, the class B landfill TCLP waste acceptance limits are likely not suitably protective of ecological values. The ANZECC or more recent ANZG water quality guidelines for the protection of aquatic species are more relevant, as stated by both Mr Gardner and Dr Meredith. For example, the class B landfill leachate limit for arsenic is 0.5 g/m^3, whereas a potentially appropriate guideline value for arsenic is 0.024 g/m^3, about twenty times lower than the class B landfill leachate limit. Dr Hickey also cited the ANZG (similar to the ANZECC guidelines) for comparison in his evidence. Class B landfill leachate therefore seems like an inappropriate comparison.

43. Furthermore, extractions such as TCLP cannot account for changes in actual geochemical conditions that might result in mobilisation of contaminants. In the case

of arsenic, for example, even occasional periods of suboxic or anoxic conditions, driven by factors such as a rain event, may lead to changes in arsenic speciation that can result in arsenic release to water.

44. Total contaminant concentrations in the waste rock were not provided for my review, and the contaminants reported for coal combustion residuals were also very limited. I was therefore not able to evaluate the potential reservoir of contaminants deposited at the site. Therefore, in the absence of adequate data, I concur with my colleague Mr Gardner that a wider variety of contaminants should be measured in monitoring activities, in order to address potential uncertainty in contaminant discharge.

45. It is worth mentioning that typical laboratory analyses for metals already measure a broad suite of contaminants, often simultaneously, and that a laboratory usually only charges a small additional fee for reporting of those data. I suspect the addition of six or seven additional elements might cost around $50 per water sample (likely less than $100). Compared to the cost of obtaining the samples, transporting them to the laboratory for analysis, and reporting the results to regulatory authorities, I consider the cost of requiring additional elements in the analysis to be relatively minor. And if they are not found in the water, so much the better. Analysis for polycyclic aromatic hydrocarbons from coal combustion residuals would be a greater additional cost, but on the order of tens of dollars to $100 per sample.

46. Laboratory analysis prices often vary by customer, sample quantity, and frequency, so the exact cost is difficult to estimate, but compared to other costs, the cost of additional laboratory analyses seems reasonable.

47. It is also my opinion that measurement of total contaminant concentrations in water, rather than “dissolved” concentrations (which are measured after filtration) should be specified in the monitoring program. This is because the contaminant load in surface water consists of dissolved, colloidal, and larger solid particles. But I defer to a surface water expert such as Dr Meredith on this point.

48. In my opinion the additional data would provide added assurance regarding the potential adverse effects at relatively low cost, and would be very helpful to inform any future management approach.

Mussel Shell Reactor Treatment

49. The treatment system, referred to as the “mussel shell reactor” or MSR, will also require monitoring and maintenance, as noted in Dr Weber’s evidence and various documents. The revised Assessment of Environmental Effects refers to the mussel shell reactor as a “passive” treatment system, which in a sense is true, because most of the time while it is in operation, no action is required as the dissolution of the mussel shells occurs without any intervention.

50. Briefly, from a geochemical perspective the mussel shell reactor functions by dissolving calcium carbonate (similar to antacid tablets) with the contaminated influent water. This raises the pH of the water, and increases its alkalinity, which provides some resistance to pH change. As an aside, particle size of the mussel shell material may influence the dissolution process—smaller particles have greater surface area and are therefore more available for dissolution; it is important that the shells are crushed to maximise the efficacy.

51. As noted by Dr Weber, at higher pH, particularly in the presence of oxygen, iron and aluminium in the contaminated water precipitate as oxide and hydroxide solids. The precipitation process can drive the pH back down to acidic levels, but if there is suitable neutralising capacity available to buffer that pH change, these solids have very high surface area upon which other contaminants can be retained.

52. Water pH and alkalinity are the crucial parameters which control the removal of many trace metal contaminants, such as zinc, from water. At a high enough pH, trace metals such as zinc either stick to the surface of the iron and aluminium oxide solids in a process called “adsorption,” or precipitate as separate solids (such as zinc hydroxides or zinc carbonates). Some other elements, such as boron, chromium, and arsenic, behave differently, but pH is nonetheless an important controlling factor.

53. For example, a typical study of zinc removal from water (Dyer et al., 2004) showed that, at pH 4, approximately 80% of zinc remained in the water. In contrast, at pH 7, only around 10% of zinc remained in the water.

54. At the Canterbury Coal Mine site, discharge pH reportedly increased from roughly pH 3 to 4 in 2016, to pH 6 to 8 more recently, with a corresponding decrease in the concentrations of some contaminants, due to these mechanisms.

55. The maintenance of pH and alkalinity are therefore critical functions of the mussel shell reactor and any other treatment processes, in order to control contaminant discharges to water. Maintaining adequate dissolved oxygen is also necessary for effective treatment prior to discharge, as is settling and retention of iron oxide particles upon which contaminants are retained.

56. To that end, as noted in Dr Weber’s evidence and in the revised Assessment of Environmental Effects dated April 2021, the mussel shells will require periodic replenishment, and sludge will require periodic removal (estimated at once every ten to twenty years).

57. Without such replenishment and sludge removal, performance of the treatment system will presumably decline as the shells dissolve and sludge accumulates. Dr Weber noted this anticipated decline in performance on Tuesday, and also noted the potential negative impact of external sediment on reactor performance.

58. I note that sludge or sediment removed from the treatment system will require testing for a broad suite of contaminants to determine suitably licenced disposal facilities. Contaminant concentrations in the sludge should comply with waste acceptance criteria at the disposal facility. It is my understanding that a consent condition to this effect is standard in consents requiring disposal activities.

59. Dr Weber’s evidence mentions the potential for aeration to be required after treatment in the mussel shell reactor, if reactions during treatment consume dissolved oxygen from the water. Aeration may introduce a more “active” component to the proposed treatment, and require more frequent maintenance and intervention.

60. Due to the potential for oxygen depletion, I recommend monitoring of dissolved oxygen as part of the continuous water quality monitoring program. Dissolved oxygen sensors are available for such a purpose, and are routinely used for monitoring applications. As with all such instruments, dissolved oxygen sensors require proper calibration from time to time, and periodic replacement.

61. As noted previously, I do not concur with Dr Weber’s assessment that a good understanding of treatment system performance will be obtained by 2024, and I recommend a substantially lengthier monitoring period.

62. Dr Weber’s evidence outlines a number of details regarding monitoring the performance of the treatment system, such as weekly assessment for an initial period of three months, followed by monthly monitoring thereafter, in addition to continuous monitoring with the water quality sonde. This recommended initial frequency may be appropriate, depending on system performance.

63. However, this really gets to the heart of one issue: the predicted effects of the proposed activities cannot be validated against actual effects until after many of the

proposed works are already completed. I therefore consider a broad water quality monitoring program necessary to validate actual environmental effects, and that such a monitoring program should continue for a substantial period (i.e., decades) following closure.

64. Of particular interest to me, after listening to Dr Weber's evidence on Tuesday and Dr Hickey's evidence on Wednesday, is what I think of as a "first flush" event, after an extended low-flow or dry period. Elevated concentrations of contaminants in the "first flush" might adversely impact the surrounding environment in ways not considered in average or typical scenarios. I defer to surface water experts regarding the impacts of this type of event.

65. Dr Hickey in his evidence on Wednesday noted the possibility of release of iron from the ponds, and the influence of oxygen availability on iron and manganese oxide dissolution and precipitation. I note that contaminants that are retained on those oxide and hydroxide particles, such as zinc or other contaminants (which may not have been measured), can also be released when the particles are discharged.

66. The potentially dynamic nature of potential contaminant releases in the system underscores the importance, to me, of frequent long-term monitoring in order to assess environmental impacts.

Future Land Use Considerations

67. On Tuesday, a question was asked by Commissioner McGarry to Dr Weber regarding the potential use of nitrogen fertilisers on the site. I find it worth noting that in principle, nitrate can be an alternate electron acceptor to oxygen. There are examples in the scientific literature of microbially-driven pyrite oxidation coupled to nitrate reduction (e.g., Jørgensen et al., 2009).

68. In theory, pyrite oxidation and the resulting generation of sulphate and acidity might be driven by the intrusion of nitrate into the material emplaced at the site, even in the absence of oxygen. Out of an abundance of caution, it might be appropriate to limit the use of nitrogen fertilisers on the site as a condition of consent, and/or in an ongoing management plan.

69. Mr Gardner raised questions in his s42A report regarding the "capping layer," such as it is, in the engineered landforms at the site. I understand from evidence provided at the hearing that no further capping layer or growth layer is planned for the engineered landforms at the site, due to the reportedly low permeability of the material, and the construction of the landform.

70. I am not an expert on forestry, but in my work with Mr Gardner I looked into the potential rooting depth of *Pinus radiata* in order to get a sense of the depth that might be needed for a growth layer atop a capping layer of the engineered landforms for forestry use. Work published in the *New Zealand Journal of Forestry Science* found that juvenile, 8-year old trees had roots extending to up to about 2 m depth, and more mature, 25-year old trees had roots extending up to greater than 3 m (Watson and O'Loughlin, 1990). My understanding is that a typical forestry harvest schedule in New Zealand is around thirty years.

71. I therefore consider that a growth layer of two to three meters of uncontaminated material might be appropriate to protect the integrity of the lower permeability layers (whether a "capping layer" or otherwise) over the waste rock and coal combustion residual material. Mr Macfarlane in his evidence notes that there is 10-15 m of cover over coal combustion residuals, which would prevent their exposure, but nonetheless I am left to wonder about the intrusion of oxygen or water through preferential flow paths introduced into the material by tree roots.

72. A further question I have with regard to future land use is the potential for contaminant mobilisation due to complexation of metals by dissolved organic matter, or the transport of organic contaminants such as polycyclic aromatic hydrocarbons (PAHs) on dissolved organic matter. For example, dissolved organic matter inputs from plant roots and tree litter may contribute to the leaching and mobilisation of metals from the underlying material. I believe a long-term monitoring program can help to assess these potential impacts as the land use changes in the future. But monitoring to assess such potential impacts would likely require decades.

EXPERT CONFERENCING

73. Neither myself nor my colleague Mr Gardner were invited to participate in expert conferencing, so my statements here may not reflect discussions that may have occurred in expert conferencing prior to the hearing.

CONCLUSIONS

74. I recommend that key elements of the post-closure monitoring and management of the Canterbury Coal Mine site be codified as conditions of consent, rather than incorporated by reference as part of a management plan as part of an adaptive management approach. In my experience advising compliance officers, including key monitoring provisions, trigger limits, and responses as conditions of consent increases clarity for both the consent holder and compliance staff, while over-reliance on adaptive management plans does the opposite.

75. Management and action plans in response to events are no doubt also important, in terms of implementing consent conditions from an operational perspective.

76. In my colleague Mr Gardner's s42A report, monitoring of a wider suite of contaminants, including trace metals such as arsenic, cadmium, chromium, copper, nickel, lead, and polycyclic aromatic hydrocarbons, was recommended. These additional parameters were recommended in addition to pH, electrical conductivity, aluminium, iron, boron, nickel, zinc, manganese, and presumably sulphate, which are already part of monitoring activities.

77. Upon reflection, I might also add mercury to this list, given that mercury can have substantial adverse impacts on aquatic organisms, particularly as a result of chemical transformation in aquatic sediments, and potential bioaccumulation. Apparently mercury and arsenic monitoring were removed from the current monitoring program some years ago, but as I noted in my evidence, the additional cost of additional elements in monitoring is minimal and would address uncertainty in potential contaminant discharge.

78. Water treatment via mussel shell reactors can be expected to improve water quality, but system performance will need to be monitored and managed through the post-closure period, including after replenishment.

79. I recommend long-term water quality monitoring, on the order of decades, in order to validate the performance of site management and water treatment procedures. Further monitoring and management may also be appropriate, depending on future land use.

Signed:	[signature]	Date:	
Name:	Michael Massey Principal Science Advisor, Contaminated Land and Waste		

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