IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of an application by Meridian Energy Limited for the resource consents related to the construction of a new channel to enable a permanent diversion of part of the flow of the Waiau Arm and the associated removal of bed material and gravels, together with any maintenance and ancillary activities.

EVIDENCE OF BRYDON NICHOLAS HUGHES

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INTRODUCTION

1. My name is Brydon Hughes. I am currently a director of LWP Ltd, an environmental and natural resources management consultancy based in Christchurch.

2. I am a Hydrogeologist with 30 years professional experience working in local government and private consultancy in New Zealand. I hold qualifications of Bachelor of Science (Geology) and a Master of Science in Engineering Geology (1st Class) from the University of Canterbury.

3. My areas of expertise include hydrogeological and groundwater quality investigations including aquifer testing, water supply evaluation, groundwater resource definition and assessment of land use impacts on water quality. I have significant experience in the technical assessment of resource consent applications to abstract groundwater and discharge wastewater to land.

4. I am familiar with the hydrogeological setting of the Southland Region having been involved with groundwater investigations, monitoring and management in this area since 1999. This involvement included establishment of regional groundwater monitoring and investigation programmes as well as input into the drafting of groundwater management provisions in the Regional Water Plan for Southland while employed by Environment Southland between 1999 and 2005. Over the subsequent period I have had ongoing involvement with a range of groundwater management, resource consenting, and regional plan development processes in the Southland Region.

5. I was engaged by Meridian Energy Limited (Meridian) to prepare the Groundwater Assessment (which I will refer to as the **Groundwater Report** or **my Report**) attached as Appendix G to Meridian's resource consent applications for the Manapōuri Lake Control Structure Improvement Project (**MLC:IP** or **the Project**).

6. The existing configuration of the Waiau Arm, the Manapōuri lake control structure (**MLC**) and the Lower Waiau River, as well as the proposed Project are described in Sections 2, 4 and 5 of the Assessment of Effects on the Environment (**AEE**) and in Mr Andrew Feierabend's evidence and are not repeated here.

CODE OF CONDUCT

7. Although this is a council level hearing, I confirm that I have read the 'Code of Conduct for Expert Witnesses' contained in the Environment Court Consolidated Practice Note 2023. I agree to comply with this Code of Conduct. In particular, unless I state otherwise, this evidence is within my sphere of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

8. My statement of evidence relates to the potential effects on groundwater from the Project, and largely summarises the contents of my Report. My evidence includes:

    (a) A brief description of the proposed activity, and dewatering activities in particular;

    (b) A summary of the general geological and hydrogeological setting of the Project Site;

    (c) A brief description of the generalised estimates of flow rates, drawdown and groundwater mounding associated with the proposed abstraction;

    (d) Assessment of the potential effects of the proposed drawdown and discharge on the receiving environment;

    (e) A response to any relevant issues in the Officer's Report; and

    (f) A summary of my conclusions.

EXECUTIVE SUMMARY

9. A thin layer of highly permeable alluvial gravels underlying the Project site hosts a highly permeable unconfined aquifer into which the proposed parallel channel will be excavated. Due to the high degree of hydraulic connection with both the Waiau Arm and the lower reaches of the Mararoa River, groundwater levels in the unconfined aquifer occur at, or close to, river level.

10. Partial dewatering is an option which may be utilised to improve the efficiency of the parallel channel excavation. The decision to undertake dewatering (and accompanying discharge of dewatering flows to land) will ultimately depend on a range of factors including water levels in the Waiau Arm at the time and whether the selected contractor considers it to be a viable and necessary option.

11. The proposed dewatering methodology involves pumping from sumps excavated adjacent to the parallel channel excavation. Due to natural filtration through the alluvial materials, this will significantly reduce the suspended sediment load in discharge water. Dewatering flows generated for the Project will vary according to the magnitude of water level reduction in the parallel channel excavation sought. Estimated dewatering rates range from 120 L/s for a 1-metre reduction in standing water level in the parallel channel excavation to around 220 L/s for a 2-metre reduction in water level.

12. Dewatering flows will be returned to the Mararoa River via infiltration to ground from a seepage pond constructed along the river margin. The volume of dewatering flows able to be accommodated by ground seepage varies according to river stage and seepage pond area.

13. Based on available information, I consider it reasonable to conclude that the potential dewatering of the parallel channel excavation will result in **less than minor** effects on water quantity, water quality and natural hydrological variation in wetland areas identified on the Project site.

PROPOSED ACTIVITIES

14. The MLC Waiau Arm Channel Excavation Methodology (Damwatch, 2023) outlines a proposed methodology for the parallel channel excavation. This methodology is intended to enable most of the proposed works to be completed remote from surface water (the Waiau Arm and Mararoa River) thereby minimising the need for in-stream works and the associated potential for suspended sediment release to the Lower Waiau River (LWR).

15. The proposed works will proceed in three stages:

(a) Stage 1 involves excavation of the highest areas along the proposed channel alignment, with the most suitable material utilised to construct haul roads and bunding along the true-left bank of the Waiau Arm. During this phase, vegetation along the alignment will be cleared and topsoil removed and stockpiled for later use.

(b) Stage 2 includes the bulk of the excavations required for construction of the parallel channel.

(c) Stage 3 involves in-river works to deepen the approach, inlet and outlet to the parallel channel, followed by removal of bunding, haul roads and general site remediation.

16. Excavations during Stage 2 will likely encounter groundwater at, or close to, river level. Depending on this level, partial dewatering of the excavation (ie, reducing water surface level by up to 2 metres) may be undertaken to ensure that the target excavation depth can be reached and that a significant proportion of the excavation can be undertaken using more efficient standard-arm excavators.

17. If determined as being necessary to facilitate construction, dewatering will be undertaken by pumping from sumps excavated adjacent to the parallel channel. Dewatering flows will be discharged to ground via a seepage pond constructed adjacent to the Mararoa River.

GEOLOGICAL AND HYDROGEOLOGICAL SETTING

18. The surficial geology of the Project site comprises a thin layer of post-glacial alluvium overlying a relatively thick sequence of glaciolacustrine sediments (clays, silts and sand) which accumulated within a glacial lake formed during the Late Quaternary behind the prominent moraine terrace (Ramparts 1 advance) evident along the margins of the Waiau Valley, downstream of the MLC.

19. The surficial alluvial deposits comprise glacial outwash materials deposited and subsequently reworked during entrenchment of the Mararoa River and Waiau Arm over the post-glacial period (last 14,000 years). Test pits excavated for the Project along the margin of the Waiau Arm indicate these materials typically comprise loose, sandy, fine to coarse gravels containing a varying proportion of cobbles which are

interspersed with irregular (possibly lensoidal) layers of fine to coarse sand containing gravels and occasional silt.

20. The underlying glaciolacustrine sediments (collectively referred to as the Damsite Formation) are typically 30 to 40 metres thick, overlying older lakebed sediments at depth. The Damsite Formation comprises 6 separate units (Members A to F) which generally comprise accumulations of silty fine sand, silt and clay, with occasional sand, fine gravel and clasts up to boulder-size.

21. The surficial alluvial deposits underlying the Project area host a thin unconfined aquifer which is hydraulically connected to the Waiau Arm and the Mararoa River. The saturated thickness of the aquifer will vary according to river stage but is typically of the order of 5 to 6 metres.

22. The likely range of hydraulic conductivity in the unconfined aquifer was estimated using grainsize analysis undertaken on samples from 10 test pits excavated across the Project site. Results of this analysis indicate hydraulic conductivity values ranging from 62 to 526 m/day, with a geometric mean value of 304 m/day. Given the overall variability of hydraulic conductivity estimates, I consider a value of the order of 250 m/day is likely to reflect the bulk permeability of the alluvial materials. Assuming a saturated thickness of 6 metres (which will vary depending on river stage), this equates to an aquifer transmissivity value of the order of 1,500 m^2/day.

CALCULATION OF DEWATERING AND SEEPAGE FLOWS

23. To calculate the likely magnitude of dewatering flows generated during the initial phase of Stage 2 excavations, the W_15 function described by Hunt (2011) was utilised to develop a simple model to calculate the abstraction rate required to achieve a target drawdown below static groundwater level across the parallel channel excavation. This model calculates depletion of flow from a stream adjacent to a grid of pumping wells (representing the parallel channel excavation). Pumping rates from individual wells are adjusted to achieve the target drawdown in the excavation and the cumulative surface water depletion effect estimated by summing the effect calculated for each individual pumping well.

24. To account for potential effects of stage height variation in the Waiau Arm, two dewatering scenarios were assessed. Scenario 1 simulates the pumping rate required to achieve a drawdown of 2 metres across the full width of the parallel

channel excavation after 14 days continuous pumping (representing high stage conditions). Scenario 2 simulates the pumping rate required to achieve a 1 metre drawdown over the same period (representing moderate to low stage conditions).

25. Results of the assessment indicate dewatering at a rate of approximately 220 L/s is likely to be required for Scenario 1 (2 metre drawdown across the parallel channel excavation). At lower river stage, dewatering requirements under Scenario 2 reduce to around 120 L/s.

26. To accommodate dewatering flows, it is proposed to construct a seepage pond adjacent to the Mararoa River approximately 400 metres north-east of the parallel channel excavation. Infiltration of water from the seepage pond into the underlying aquifer will be limited by the head difference between the pond invert and the underlying water table.

27. Stage height in the adjacent reach of the Mararoa River is typically maintained by MLC operation in the range of RL 177.0 to 178.6 m. The seepage pond will be constructed with an invert at approximately RL 180 m, with bunds formed to facilitate a head of up to 2 metres in the pond. This provides a maximum separation of between 1.4 and 3.0 metres between the pond invert and the underlying water table.

28. The dewatering rate will be managed by a pump control system to prevent overtopping. Regular monitoring of pond level will also be undertaken to identify any significant changes in pond level which may indicate a reduction in seepage rate due to accumulation of suspended sediment on the pond base.

29. The indicative seepage rate able to be achieved from the pond was calculated using the W_6 function described by Hunt (2012) which models the rise of a groundwater mound around a recharge basin. This model was set up with the same aquifer hydraulic properties utilised for the dewatering assessment and was run to identify the infiltration rate corresponding to a 1.4 and 3.0 metre rise in the water table under the pond invert (effectively simulating potential seepage rates at the upper and lower end of the normal operating range of the Mararoa River). Scenarios were run simulating potential seepage rates achievable from a 50 x 50 m (2,500 m^2) pond and a 100 x 100 m (10,000 m^2) pond.

30. Results of the modelling indicate potential pond seepage rates ranging from 53 to 113 L/s depending on Mararoa River stage for a 50 x 50 m seepage pond, increasing to between 65 and 139 L/s for a 100 x 100 m seepage pond.

31. Overall, the assessment indicates that rates of seepage achievable from a single pond are likely to be lower than projected dewatering flows required to achieve a 2-metre reduction in water level in the parallel channel excavation[1], even if river stage is close to the lower end of the normal operating range. Dewatering flows required to achieve a 1 metre drawdown in groundwater level can potentially be accommodated by a seepage pond with an area exceeding 2,500 m^2 if river stage is close to the bottom end of the normal operating range but are likely to exceed seepage capacity at high river stage.

32. However, it is acknowledged that the analytical modelling techniques utilised are not able to account for a number of factors that will inevitably exert a significant influence on dewatering and seepage rates. For example:

(a) Drawdown of groundwater levels surrounding the parallel channel excavation will reduce the effective saturated thickness of the aquifer. This reduction in saturated thickness will reduce aquifer transmissivity reducing the rate of groundwater inflow to the excavation.

(b) Significant suspended sediment will be generated within the parallel channel excavation. This suspended sediment will settle on the base of the channel creating a '*clogging layer*' which will reduce the hydraulic connection between the pond and surrounding aquifer. Accumulation of this layer of fine sediment is likely to significantly reduce the rate of groundwater inflow and, consequently, the rate of dewatering required to achieve the target drawdown.

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[1] This is entirely consistent with the principle of superposition which requires that the magnitude and extent of groundwater mounding have the same spatial extent but opposite magnitude to drawdown occurring in response to dewatering (assuming equivalent aquifer parameters). Due to the proposed dewatering methodology, drawdown in excess of 2 metres is required over a relatively wider area to achieve a 2-metre reduction in water level across the full width of the parallel channel. Consequently, seepage of an equal discharge to ground will result in mounding of greater than 2-metres over an equally extensive area.

(c) Mounding calculations do not account for the presence of the Mararoa River adjacent to the seepage pond. Due to the high degree of hydraulic connection between the unconfined aquifer and the river, the river will act as a constant head effectively reducing the magnitude of groundwater mounding thereby enabling higher rates of seepage than those calculated.

33. Consequently, while the assessment undertaken indicated the overall viability of the proposed construction methodology, dewatering rates (and accompanying seepage capacity) can only reliably be determined through practical implementation. Therefore, if required, dewatering will be implemented to assist construction at a rate determined by either pumping rates required to lower water levels in the excavation or the maximum infiltration capacity of the seepage ponds.

ASSESSMENT OF EFFECTS

Effects on Surface Water Quantity

34. Dewatering of the parallel channel excavation will result in the depletion of flow from the adjacent reach of the Waiau Arm at a rate approximating the rate of dewatering. Dewatering flows will be discharged to ground adjacent to the Mararoa River. Due to the high degree of hydraulic connection between the Waiau Arm and the surrounding unconfined aquifer, the proposed take and discharge will effectively occur contemporaneously from and to the same waterbody. It is therefore reasonable to conclude the proposed abstraction and discharge of groundwater represents a non-consumptive use of water, so effects on surface water quantity will be less than minor.

Effects on Surface Water Quality

35. The proposed groundwater abstraction will occur from sumps excavated adjacent to the haul road running along the northern boundary of the parallel channel excavation. Groundwater flowing into the dewatering sumps from the parallel channel excavation will therefore have to flow through the intervening ~20 metres of alluvial materials. Similarly, water discharged from the seepage pond will have to infiltrate through a minimum of 20 metres of alluvium to reach the Mararoa River.

36. Overall, combined with settlement in the seepage pond, the passage of dewatering flows through alluvial materials between the parallel channel excavation and the dewatering sump and from the seepage pond to the Mararoa River mean dewatering flows are likely to result in less than minor effects on the suspended sediment load in the Mararoa River.

Effects on Neighbouring Groundwater Users

37. The Environment Southland Beacon application records a single bore (CE08/0002) within 2 kilometres of the Project site. This bore is assigned '*proposed'* status (indicating it may not yet be drilled), with its indicative location recorded as adjacent to the Mararoa River bridge on Weir Road, approximately 800 metres from the parallel channel excavation. The potential for CE08/0002 (if drilled) to be adversely impacted by the proposed parallel channel excavation is less than minor due to distance from the proposed dewatering location and the high degree of hydraulic connection unconfined aquifer and the Mararoa River (which forms a constant head that will offset any drawdown over this distance).

Effects on Wetlands

38. The Boffa Miskell Wetland Assessment Report (Boffa Miskell, 2023) identifies a total of 12 wetland areas across the Project area. If required, dewatering of the parallel channel excavation will lower natural groundwater levels across a significant proportion of the Project site during the initial phase of Stage 2 excavations. However, given the wetland areas identified are characterised as '*infrequently wet*' containing only '*only weakly hydrophytic vegetation'*, any hydraulic connection between the wetlands identified and the underlying water table is likely to occur on an infrequent basis, associated with periods when lake levels are above their normal operating range.

39. The Boffa Miskell report also identifies three '…*lacustrine channels on the northern bank of the Waiau River*'. However, the areas described appear to be subject to intermittent drying during periods of low lake levels. Consequently, a temporary reduction in groundwater levels associated with the proposed dewatering is unlikely to represent a significant departure from normal hydrological conditions occurring in these areas.

40. Consequently, a temporary reduction in groundwater levels associated with the proposed dewatering of the parallel channel excavation is likely to result in a less than minor effect on the hydrology of wetland features identified on the Project site.

RESPONSE TO MATTERS RAISED IN SUBMISSIONS

41. No matters relating to potential effects on groundwater were raised in submissions.

RESPONSE TO SECTION 42A REPORT

42. I have reviewed the section 42A Officer's Report prepared by Bianca Sullivan, resource management consultant with Environment Matters Limited, on behalf of Environment Southland. There are no issues raised in the Officer's Report relating to groundwater that need addressing.

CONCLUSIONS

43. Partial dewatering may be utilised to improve the efficiency of the parallel channel excavation. The decision to undertake dewatering (and accompanying discharge of dewatering flows to land) will ultimately depend on a range of factors including water levels in the Waiau Arm at the time and whether the selected contractor considers it to be a viable and necessary option.

44. In the event that dewatering is undertaken, this would involve pumping from sumps excavated adjacent to the parallel channel excavation. Due to natural filtration through the alluvial materials, this will significantly reduce the suspended sediment in discharge water. The magnitude of dewatering flows generated for the Project will vary according to the magnitude of water level reduction in the parallel channel excavation sought. Estimated dewatering rates range from 120 L/s for a 1-metre reduction in standing water level in the parallel channel excavation to around 220 L/s for a 2-metre reduction in water level.

45. Dewatering flows will be returned to the Mararoa River via infiltration to ground from a seepage pond constructed along the river margin. The volume of dewatering flows able to be accommodated by ground seepage varies according to river stage and seepage pond area.

46. Based on available information, I consider that, if required, partial dewatering of the parallel channel excavation is likely to result in less than minor effects on water quantity, water quality and natural hydrological variation in wetland areas identified on the Project site.

Brydon Hughes

3 September 2024