ENVIRONMENT COURT OF NEW ZEALAND
WELLINGTON REGISTRY

I MUA I TE KOOTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA

ENV-2023-WLG-000005

Under	the Resource Management Act 1991
In the matter of	the direct referral of applications for resource consent and notices of requirement under sections 87G and 198E of the Act for the Ōtaki to North of Levin Project
By	Waka Kotahi NZ Transport Agency

STATEMENT OF EVIDENCE OF DR JOHN (JACK) ALLEN McCONCHIE ON BEHALF OF WAKA KOTAHI NZ TRANSPORT AGENCY

HYDROLOGY, FLOODING, HYDROGEOLOGY AND GROUNDWATER

Dated: 4 July 2023

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INTRODUCTION

1. My full name is **Dr John (Jack) Allen McConchie.**

2. I am the Technical Director (Hydrology & Geomorphology) at SLR Consulting (NZ).

3. I prepared Technical Assessment G: Hydrogeology and Groundwater (**Technical Assessment G**) as part of Volume IV of the Assessment of Environmental Effects (**AEE**), which accompanied the application for resource consents and notices of requirement for designations (**NoRs**) lodged with Manawatū–Whanganui Regional Council (**Horizons**), Greater Wellington Regional Council (**GWRC**), Horowhenua District Council (**HDC**) and Kāpiti Coast District Council (**KCDC**) (together, the **Councils**) in November 2022 in respect of the Ōtaki to north of Levin highway Project (**Ō2NL Project** or **Project**).

4. I also provided expert technical advice and feedback to Mr Andrew Craig as he prepared Technical Assessment F: Hydrology and Flooding (**Technical Assessment F**). My formal peer review memorandum of Technical Assessment F (and the work underpinning it) is included as Appendix F.3 to Technical Assessment F.

5. My qualifications and experience are set out in paragraphs 22 to 31 of Technical Assessment G and in the 'background' section of Appendix F.3. My evidence is supplementary to Technical Assessments F and G.

6. I have provided hydrological advice on matters related to the Project to Waka Kotahi NZ Transport Agency since May 2021.

7. Since the consent applications and NoRs were lodged I have:

   (a) Provided information on the effect of the Project on hydrology and flooding and groundwater at hui with Ngāti Ngārongo and Ngāti Takihiku at Kereru Marae, and Ngāti Tukorehe at Tukorehe Marae;

   (b) Reviewed those submissions relating to hydrology and flooding, and hydrogeology and groundwater and provided technical responses to the matters raised;

   (c) Met with some submitters, to discuss their concerns with the Project and explain its impact on hydrology and groundwater matters;

(d) Had discussions with Jon Williamson (Horizons and GWRC's groundwater technical expert) and Peter Kinley and John McArthur (Councils' hydrology and flooding technical experts) to clarify and resolve areas of uncertainty from Technical Assessments F and G;

(e) Had separate discussions with Mike Thompson (Senior Hydrologist, GWRC) and Michaela Stout (Water Allocation Scientist, Horizons) regarding the proposed abstraction of water from Waitohu Stream and Koputaroa Stream and provided memoranda discussing how the proposed management of the abstraction would ensure that any effects on those waterways could be considered '*less than minor*'; and

(f) Had additional discussions with Mike Thompson (Senior Hydrologist, GWRC) regarding how the Project might manage the abstraction of water to support construction, to further minimise any even small potential environmental effects.

8. I assisted with the response to a number of questions in the section 92 further information requests from the Councils related to Technical Assessments F and G.

Code of conduct

9. I confirm that I have read the Code of Conduct for expert witnesses contained in section 9 of the Environment Court Practice Note 2023. This evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my area of expertise. 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 the evidence

10. Technical Assessment F assesses the effects of the Project on hydrology and flooding. It concludes that any effects of the Project on flooding can be considered 'less than minor'. Technical Assessment G reviews the hydrogeological setting and its implications for the Project. It also discusses the investigations undertaken to inform the Project. Finally, it discusses how the Project has been developed to avoid, wherever practical, interaction with the groundwater. I conclude that any effects of the Project on groundwater can be considered 'less than minor'.

11. My evidence does not repeat in detail the matters discussed in Technical Assessments F and G. Rather, in this evidence I:

    (a) Present the key findings of Technical Assessments F and G in an executive summary, updated to include any additional work carried out since lodgement;

    (b) Provide a more detailed description of the additional work carried out, information obtained, discussions held since lodgement, and their implications for my assessment;

    (c) Comment on issues raised in submissions received in respect of the Project; and

    (d) Comment on the section 87F/198D reports prepared by the Councils (**Council reports**).

EXECUTIVE SUMMARY

12. The Ō2NL Project involves the construction, operation, use, maintenance, and improvement of approximately 24 kilometres of new four–lane median divided state highway (two lanes in each direction) and a shared use path (**SUP**) between Taylors Road, Ōtaki (and the Peka Peka to Ōtaki Expressway (**PP2Ō**)) and State Highway 1 (**SH1**) north of Levin.

Hydrology and flooding

13. The existing topographic and hydrological environments of the proposed designations are dominated by the Tararua Range. These mountains, when interacting with prevailing westerly weather systems, cause orographic enhancement of rainfall. High rainfall in the steep mountains gives rise to rapidly responding rivers, streams and overland flow paths that drain predominantly westwards towards the sea. The orientation of the existing SH1, and the proposed designations nearer the base of the foothills, means that the highways cross many of these watercourses. The landscape traversed by SH1 and the Project consists of coalescing alluvial fans and floodplains formed by these watercourses. Consequently, the existing SH1 is subject to occasional but persistent flood hazard and erosion. These issues will become worse over time because of the predicted effects of climate change.

14. Despite the proposed designations interacting with these watercourses, the effects of the Ō2NL Project on hydrology and flooding will, in my opinion, be 'less than minor'. The Project will result in a small reduction in the existing flood hazard, increased safety and security, and greater resilience of the state highway network. The methods followed to reach these conclusions and assessment of effects, presented by Mr Craig in Technical Assessment F, are provided below. That is followed by a summary of my peer review assessment of Technical Assessment F, as presented in Appendix F.3.

Methodology

15. The assessment of hydrology and flooding was informed by the development of hydrological and two–dimensional computational hydraulic models that represent the baseline condition, and an indicative Ō2NL Project 'concept' design within the proposed designations.

16. The design and assessment generally consider an extremely large design rainfall/flood event, i.e., the 1% AEP (Annual Exceedance Probability) or 100–year ARI (average recurrence interval) rainfall or flood.

17. A 1% AEP event is a flood which, on average, would occur or be exceeded once every hundred years, over a very long period of many hundreds of years under constant climatic conditions. It is conceivable for two floods larger than a 1% AEP event to occur in consecutive years, or even in the same year, although this would be extremely rare.

18. This already extreme event has been adjusted to include the predicted effects of climate change over the asset's design life, i.e., extending to 2130. This has increased the magnitude of the design rainfall or flood by approximately 35%. Smaller and more frequent events were used for calibration and validation of the models as such events are more likely to have been experienced. An extremely large design event (1,500–year ARI) was used to test the resilience of the concept design to what might be considered an 'over–design' event. The increase in the magnitude of the already extreme 1,500–year ARI event to allow for climate change was 47%. These climate change adjustments provide considerable conservatism to the assessment of the potential effects of the Project and resilience to the final design.

19. It is noted that this approach, while consistent with best practice, differs from that suggested by the Council's external peer reviewers in their technical

reporting appended to the Section 87F and 198D reports. The reason why the approach adopted by the Project is considered correct, and more conservative (i.e., considers a larger design flood with consequently greater potential environmental effects) is discussed in detail in paragraphs 160–170 below.

20. Climate change forecasts were approached on a moderately–conservative basis, by adjusting rainfall for predicted increases in temperature over the life of the asset. This is considered appropriate given the long design life and high cost to upgrade culverts or bridges during the Project's operational life. Predicted impacts of climate change on flood generating storms are considered part of the baseline case when assessing the potential effects of the Project. This is because any effects of climate change will occur irrespective of whether the Ō2NL Project is present or not.

21. Rainfall adjustment factors for future climate are based on the High Intensity Rainfall Design System (**HIRDS**) version 4 report for a medium–high Representative Concentration Pathway (**RCP**) 6.0 emissions scenario. This is considered a conservative (i.e., high, but not the highest) emissions scenario. HIRDS v4 RCP scenarios are derived from the Intergovernmental Panel on Climate Change (**IPCC**) Fifth Assessment (2014).

22. The selection of hydrological and hydraulic modelling software, the model boundary conditions (including the effects of climate change), the level of detail applied, and the resolution of the model domain are consistent with industry best practice when assessing the effects of a project of this scale and nature.

23. The baseline modelling report was provided to Iwi Project Partners (Muaūpoko Tribal Authority and hapū of Ngāti Raukawa ki te Tonga), Horizons, HDC, KCDC and GWRC. Discussions, initially with Jon Bell at Horizons, and their expert reviewer (who is also acting on behalf of GWRC) suggested agreement in principle that this approach is reasonable when assessing the actual and potential effects of the Ō2NL Project. A summary of these discussions is attached as Appendix A.

24. An indicative Ō2NL Project concept design was modelled to evaluate a with–scheme scenario. The potential effects were evaluated by comparing the difference in flooding during the baseline and with–scheme scenarios. The hydraulic modelling indicates that the Ō2NL Project will have ‘less than minor’ effects on hydrology and flooding, as discussed below.

25. The potential effects of the Ō2NL Project were assessed from the difference in water surface elevation and flow velocity between the with–scheme and the baseline models. Any changes in flood level (for 1% AEP with climate change RCP 6.0 to 2130) that are greater than 0.05m (50mm) were identified and the potential effect of the increase in water level assessed against potentially impacted receptors. This detection threshold is informed by the topographic, morphological, and land–use context of the Ō2NL Project, as well as the computational accuracy and resolution of the hydraulic model. This does not imply that an increase in water level greater than 0.05m will be unacceptable to a particular receptor. However, this threshold is used when presenting the results on maps and when discussing potential effects. I understand the Flood Protection Department of GWRC uses an informal guideline of 0.1m for rural areas and 0.05m for urban areas[1], when assessing significance of flood effects. I consider these thresholds appropriate when testing the potential effects of the Ō2NL Project.

26. The assessment also considered flood events of different magnitudes and frequencies, and changes in flow velocity as an indicator of the potential for increased scour and erosion.

Assessment of effects

27. Any effects of the Project on flooding, assuming the conceptual design, are limited to the vicinity of potential waterway crossings. This is because of the need to direct currently dispersed overbank flow across the floodplains of the various waterways through the culverts and bridges of the Project.

28. Changes in peak water levels upstream of crossings greater than 0.05m relative to the baseline (for 1% AEP with climate change RCP 6.0 to 2130) have been mapped and evaluated, with the following findings:

    (a) No buildings outside the proposed designations are impacted by the Project from any modelled increase in water levels during the 1% AEP design event, including climate change RCP 6.0 to 2130;

    (b) Increases in flood levels upstream of bridges and culverts are generally contained within the proposed designation. Modelled increases dissipate to less than 0.1m within 50m upstream of the proposed designation boundaries (70m in the case of the Ohau River). This is

[1] I was informed of this by Mr Andrew Craig, after a conversation between Andrew Craig and James Flanagan, Senior Engineer, Flood Protection, GWRC.

commensurate with the landscape and land–use context and the extreme nature of the design event. The short durations of increased water levels, less than six hours, are considered unlikely to have any material effect on pasture growth or crop recovery;

(c) Therefore, given the rural context, the extreme nature of the design event (1% AEP with climate change RCP 6.0 to 2130), the short duration, and small footprint of impacts, I consider these effects to be 'less than minor'; and

(d) In more frequent flood events, such as the 10% AEP event under the current climate, any changes in water levels are contained within the proposed designations, except for backwater effects on the Ohau River that dissipate to less than 0.1m within approximately 50m of the proposed designation. Obviously, since this event is smaller than the 1% AEP design event discussed above, no buildings outside of the designation are affected.

29. Within the proposed designations, the design philosophy for bridges and culverts allows for the uninterrupted passage of water and sediment past the Ō2NL Project.

(a) Localised increases in velocity within the proposed designations are small and will be managed using scour protection if required.

(b) Flows redistribute laterally to conform to their original floodplain pattern within a very short distance downstream of the structures, and generally within the proposed designation.

(c) Fish passage is provided, except for some culverts on ephemeral flow paths where no fish are present, and no viable habitat exists upstream.

(d) Stormwater from the highway will be managed within the proposed designations, including treatment and attenuation of any discharge. Scour protection will be provided where necessary, so that any effects of the Project on hydrology and flooding will be less than minor.

30. Downstream of the bridges and culverts:

(a) Flows redistribute laterally to conform to their original floodplain pattern (<0.05m relative to the baseline) within the proposed designations or

approximately 100m downstream (115m in the case of the Ohau River for the 1% AEP design event with climate change).

(b) In the 10% AEP design event, the only locations to show possible increased water levels downstream of the proposed designations are the Ohau River, a tributary of Waikawa Stream, and the Manakau Stream. These are all because of small changes in the lateral distribution of flow across the floodplains. Any effect is totally redistributed to the main channel within a short distance downstream.

(c) There are no cumulative effects passed further downstream, and no existing buildings are exposed to an increase in flood risk.

31. Overall, any adverse effects of the Ō2NL Project on hydrology and flooding will, in my opinion, be 'less than minor'.

32. It is noted that this opinion differs from that of the Council's external peer reviewers presented in the Section 87Fand 198D reports. The justification for my opinion is provided in detail in paragraphs 179–206.

33. An increase in heavy rainfall anticipated from climate change is predicted to exacerbate flooding along the existing SH1. The proposed Ō2NL Project will lower risk exposure and provide greater regional resilience benefits to emergency responders, operators, and users of the road network, compared to the existing SH1.

My peer review findings

34. In my peer review report, I concluded that:

> "*Based on the information and materials that I have reviewed, and numerous discussions with Mr Craig, I believe that Technical Assessment F – Hydrology and Flooding:*
>
> - *Has adopted industry standard methods and measures, and that these have been applied in an appropriate manner;*
> - *Has included appropriate, although likely conservative (i.e., high), hydrological inputs to the computational hydraulic modelling;*
> - *Has provided appropriate consideration of the future potential effects of climate change; and*
> - *By considering a conceptual design, provides a realistic, although likely conservative (i.e., high) assessment of potential effects of the Project on*

hydrology and flooding. This assessment provides a realistic envelope of effects within which the final design and construction of the Project can be developed.

In summary, in my professional opinion, the methodologies, results and conclusions provided in Technical Assessment F – Hydrology and Flooding are realistic, but likely conservative i.e., high. That is, in my professional opinion and experience the effects of the Ō2NL Project on hydrology and flooding are likely to be less than assessed."

35. That conclusion remains an accurate summary of my views.

Hydrogeology and groundwater

36. The Ō2NL Project will traverse several coalescing alluvial fans and flood plains, formed by highly mobile rivers and streams of various sizes. The alluvium deposited by these rivers and streams ranges from coarse gravel to clay; depending on the size of the stream and the relative position of the thalweg (the deepest and fastest part of the channel) when the sediment was deposited. This already complex mosaic of alluvium is further complicated by the mobile nature of the rivers and streams, potential truncation of some stream channels by strike–slip motion on faults, historic fluctuating sea level, and changes in sediment supply from the headwaters.

37. This three–dimensional mosaic of largely sedimentary deposits hosts a groundwater system that contains both unconfined and confined aquifers and water–bearing units.

38. The design of the Ō2NL Project has been informed by several cultural, hydrological, and hydrogeological principles to avoid any potential adverse effects, and to maximise environmental and community outcomes.

39. To identify and avoid any potential adverse effects of the Ō2NL Project on groundwater, and where this is not possible, to mitigate potential adverse effects, comprehensive investigations were undertaken to gain a better understanding of the groundwater system beneath and adjacent to the proposed highway. Those investigations are summarised in Appendix G.1 to Technical Assessment G.[2]

40. The investigations included 63 boreholes, 77 test pits, 36 Cone Penetration Tests (**CPTs**), 57 monitoring bores, 10 hand auger holes, eight slug tests and

[2] That appendix should be read in conjunction with Technical Assessment G if additional detail and explanation of specific matters is required.

nine soil infiltration tests. The findings were generally consistent with previous hydrogeological investigations and no atypical or unique conditions were identified.

41. In general, the water table mimics the topographic surface and ranges in depth from the ground surface to deeper than 20m. Springs and some wetlands occur where the water table intersects the ground surface, especially towards the northern and southern ends of the Ō2NL Project. The deepest groundwater levels generally occur at locations east of Levin (near Tararua Rd). The highest groundwater levels ranged from 0.5m to 2m below the ground surface in areas near Queen Street East (east of Levin), east of Manakau Township, and adjacent to Manakau Stream.

42. Because of the stratified and variable nature of the alluvial sediment, there are often at least two water–bearing units at different depths. These water–bearing units are separated by aquitards of lower permeability material, generally silt or clay. The effective groundwater levels, i.e., pressures, in these water–bearing units can be significantly different.

43. At any location, both the deep and shallow bores screened in different water bearing units follow a very similar seasonal trend. This suggests that, despite its apparent complexity, the groundwater is acting as an interconnected system.

44. Comprehensive modelling, calibrated against the measured groundwater levels, predicts daily groundwater levels back to 1971. This allows estimation of the maximum groundwater level likely to have been experienced over the past 50 years, and a range of design groundwater levels. This information was used to assist with the concept design of the Project to avoid any potential adverse effect on the groundwater system.

45. The incorporation of the hydrological and hydrogeological principles into the detailed design and construction of the Ō2NL Project avoids any potential adverse effects on the groundwater system, while also maximising environmental and community outcomes. Appropriate design of the selected Ō2NL highway will ensure:

    (a) There will be no change in the existing water balance (rainfall or evapotranspiration) and therefore no adverse effect on groundwater supported wetlands and forests.

(b) That any direct interaction with groundwater is avoided by constructing the Ō2NL highway above the maximum height of the water table, determined by comprehensive and detailed monitoring and modelling, wherever practicable.

(c) Existing hydraulic connections will be maintained through the design of the stormwater system and surface hydraulic connections past the proposed Ō2NL highway. Also, the construction of the Ō2NL highway above the maximum elevation of the water table wherever practicable will avoid any effects on the existing groundwater flow paths. Maintaining both surface and subsurface hydraulic connections will therefore avoid adverse effects on groundwater and groundwater–supported wetlands and forests.

(d) Any potential effect on the hydraulic connection between surface water and groundwater under the immediate footprint of the proposed Ō2NL highway, caused by the 'sealing' of the existing ground surface, will be offset by the construction of stormwater swales and wetland treatment devices. These devices, adjacent to the Ō2NL highway, will maintain and potentially enhance the existing hydraulic connections. The devices will allow the infiltration and percolation of any excess rainfall to recharge the groundwater system. Consequently, there will be no adverse effect on groundwater and groundwater–supported wetlands and forests.

(e) Improved water quality, with respect to nutrient and pathogen loading, will occur through the change in land use from pastoral farming and specially designed and constructed wetlands to treat runoff from the proposed Ō2NL highway. This will result in a small improvement in the quality of both surface runoff and groundwater over time.

(f) Stormwater from the proposed Ō2NL highway will be collected by the network of swales, retention basins and wetlands to ensure no excess runoff will occur onto adjacent land containing existing private bore(s), wetlands, or streams.

46. There are 69 wetlands identified along the proposed highway alignment. The hydrological regime and sensitivity of each to the Project were assessed. Analysis of the proposed highway alignment, both vertical and lateral, identified seven wetlands or forest remnants that are connected to

groundwater and within a zone where road cuts may intercept and reduce groundwater levels.

47. This analysis showed that overall, any potential effects of the Project on those wetlands are likely to be ‘less than minor’. In the few instances (seven small areas of degraded wetland) where more than minor effects are possible, these will be offset by the measures discussed in the evidence of **Mr Nick Goldwater** (terrestrial and wetland ecology).

48. Furthermore, while road cuts may reduce groundwater levels at these seven wetlands, it must be recognised that wetlands can be formed either from discharges of groundwater or from acting as recharge pathways to groundwater. Where the latter is true, reducing groundwater levels will not affect the water balance at the wetland.

49. Two sites in the concept design may potentially be affected temporarily by dewatering required for culvert construction. Analysis of the potential effects of temporary dewatering on wetlands and forest remnants, and any neighbouring bores, shows that any effects will be temporary, of short duration, and can be mitigated by standard construction techniques. Any effects of temporary dewatering can therefore be regarded as ‘less than minor’.

50. Detailed analysis of the potential effects of groundwater mounding under and adjacent to the stormwater treatment devices east of Levin shows that any effects during events less than the maximum design event, i.e., the 1% AEP rainfall increased to allow for climate change, can be considered ‘less than minor’. For larger events, it is likely that the entire ground would be saturated, and overland flow would occur. The proposed works will not exacerbate the existing situation.

51. The current conceptual earthworks design of the Ō2NL Project relies on a significant amount of additional fill, >1.5Mm^3, above that anticipated to be won through cut activities.

52. From a list of approximately 36 potential material supply sites along the length of the Ō2NL Project, four were chosen for a more detailed assessment. Selection was on the basis of the site's proximity to the Project, geotechnical properties and conditions, and performance against a range of environmental, cultural, and economic criteria, including potential legacy outcomes.

53. Preliminary analysis shows that each of these four sites could be potentially developed to supply additional material for the Project without any adverse effect on surface water or groundwater resources, and without exacerbating the existing flood hazard. In most situations, the potential works would provide some small amount of flood mitigation. This 'mitigation' would be proportionately greatest during smaller and more frequent flood events.

54. At least two of the sites, because of their hydrological characteristics, could be rehabilitated as open–water ponds and wetlands. This would increase hydrological diversity in these areas and potentially further offset any adverse effects of the Project.

55. While the investigations have allowed the identification and avoidance of potential adverse effects of the Ō2NL Project on the groundwater system, as with any hydrogeological investigation, there remains some small residual uncertainty. This uncertainty will be reduced as further investigations are undertaken, additional data collected, and the design of the Project refined.

56. To monitor for any unforeseen residual adverse effects on the groundwater system, Condition RGW3 is proposed to continue monitoring at all bores installed as part of the Project. A summary of monitoring results will be provided to the regional councils as part of the Annual Report (Condition RGA3).

Abstraction of surface water

57. The application proposed abstracting water to support the construction of the Project from various rivers and streams within the area. A strategy was presented where abstraction would be both minimised, and from the existing core allocation from each catchment. Supplementary allocations were also proposed when flow in the relevant river exceeds its median. Total daily abstraction across the Project would be limited by both a maximum and average rate. The proposed abstraction is consistent with the relevant policies and rules in the respective Regional Plans. A suite of draft conditions was proposed to manage any minor effects.

58. Despite stopping all abstraction at the minimum flow for each river or stream, the GWRC and Horizons technical advisers, in their Section 87F reports, raised concern regarding the inherent uncertainty of the flow regimes of the rivers and streams throughout their long profile. Consequently, an alternative suite of conditions has been developed (RWT1), in consultation, to reduce

the already very small effects of abstraction even further. These are discussed in detail in paragraphs 258 through 277.

WORK SINCE LODGEMENT

Response to section 92 requests for further information

59. I assisted with the responses to further information requests from the Councils related to Technical Assessments F and G. In particular, I provided technical input to support the following responses:

    (a) The surface water takes to support construction of the Project, including rationale, effects, and operational management (Horizons questions 1–10 and GWRC questions 11–14);

    (b) The potential effects of vegetated swales on constructed wetlands and groundwater conditions (Horizons & GWRC questions 55–57);

    (c) The potential effects of temporary dewatering to install two culverts (Horizons & GWRC question 62);

    (d) The potential effects of 'high' groundwater conditions on the efficiency and effects of soakage devices (Horizons & GWRC questions 63–64);

    (e) Explanation of the rationale for the design events and scenarios modelled when quantifying the potential effects of the Project on the existing flood hazard (Horizons & GWRC questions 74–75);

    (f) Discussion of the quantification of the scale, extent, and duration of any potential effects on the flood hazard and flooding outside of the designations (Horizons & GWRC questions 76–81);

    (g) Justification for the lack of a geomorphological assessment (Horizons & GWRC question 82);

    (h) Justification for the thresholds adopted when considering any potential effects of the Project on the velocity of floodwater (Horizons & GWRC question 83);

    (i) Discussion of the potential effects of the risk of 'blockage' of structures used to convey flood events (Horizons & GWRC questions 88–90);

    (j) Discussion of the potential effects of 'borrow sites' on the flood hazard (Horizons & GWRC question 92); and

(k) Additional information on the extent and duration of flooding on active pasture and crop land beyond the designation. I also ensured that an updated version of the Technical Assessment F, including the relevant legends to various figures, was provided to the Councils (HDC & KCDC question 178–179).

Engagement with stakeholders

60. I have been involved in ongoing post-lodgement engagement with the Councils and other stakeholders. Since the consent applications were lodged, this has included:

(a) Discussions with Mike Thompson (Senior Hydrologist, GWRC) regarding the proposed abstraction of water from Waitohu Stream to support construction of the Project. I subsequently provided a memorandum that reviewed available data relating to the flow regime of this river, the potential effects of the proposed abstraction, and how the proposed management of the abstraction would ensure that any effects could be considered '*less than minor'*;[3] Following receipt of Mr Thompson's section 87F report, I have had additional discussions with him regarding how the Project might manage the abstraction of water to support construction to further minimise any even small potential environmental effects.

(b) A discussion with Michaela Stout (Water Allocation Scientist, Horizons) regarding the proposed abstraction of water from Koputoroa Stream to support construction of the Project. I subsequently provided a memorandum that outlined the proposed abstraction regime, including various constraints, that would ensure any effects of the abstraction could be considered '*less than minor';*[4]

(c) A hui with Ngāti Ngārongo and Ngāti Takihiku on Kereru Marae to discuss the potential interaction of the Project with Koputoroa Stream. This included the potential effects of the Project on hydrology and flooding, groundwater, the abstraction of water to support construction, and the potential ecological enhancement of Te Ripo o Hinemata (wetland). This led to agreement in principle to a potential abstraction

[3] Effect of proposed abstraction of construction water from Waitohu Stream. Memorandum to Mike Thompson GWRC, 26 January 2023. (Attached as Appendix B)

[4] Clarification of proposed abstraction of construction water. Memorandum to Michaela Stout, Scientist – Allocation, Horizons Regional Council, 31 January 2023. (Attached as Appendix C).

regime for water from Koputoroa Stream to support construction of the Project;

(d) Provided information on the effects of the Project on hydrology and flooding, and groundwater, at a hui with Ngāti Tukorehe at Tukorehe Marae. This included discussing the existing flood hazard to the Marae, which is not affected by the Project, and how this might be managed and mitigated through inter-party engagement;

(e) Had discussions with Jon Williamson (Technical Expert advising Horizons and GWRC on groundwater-related matters) to clarify and resolve areas of uncertainty from Technical Assessment G; and

(f) Had a discussion with Peter Kinley and John McArthur (Technical Expert advising Horizons, GWRC, HDC and KCDC on hydrology and flooding) to clarify and resolve areas of uncertainty from Technical Assessments F.

COMMENTS ON SUBMISSIONS

Overview

61. Eighty-nine submissions were received following public notification of the applications for the resource consents and NoRs necessary for the construction of the Project.[5] Of these, 19 identified concerns relating to either hydrology and flooding or groundwater.

62. The Project will cross a number of waterways which are subject to flooding. A conceptual design (and any final design) has been (or will have been) developed to accommodate both the existing flood hazard, and any increase in the hazard because of climate change.

63. While a number of submitters are affected by flooding currently, the Project will not exacerbate this situation. Since this flooding is an existing problem for these submitters, I do not believe that this RMA consenting process is the appropriate forum for addressing this issue.

64. In a few instances, the Project will provide some mitigation of the existing flood hazard. This is the result of the attenuation and moderation of runoff from the proposed highway via the stormwater treatment devices. While

[5] This number accounts for each of the Ngā Hapū o Ōtaki submitters separately.

mitigating the existing flood hazard was not a goal of the Project, in a few situations it is an indirect consequence of what is proposed.

65. Five submissions raised specific concerns regarding groundwater.

66. In general, the Project, because of its location relative to existing bores, proposed construction, and management of stormwater and runoff, will have no effect on either the quality or yield of water from the bores. In two cases, (the submissions of John & Jenny Brown and Merie Cannon & Trevor Guy) a property owner's bore will likely need to be decommissioned for the Project. In each case, the Project is proposing to replace the existing bore, but this is still to be agreed with the landowner. These situations are discussed in more detail below.

67. As long as the final design of the Project has effects that are no greater than those from the current conceptual design, there will be no adverse effects on either the potential flooding of various submitter's properties, or the quality and yield of water from existing groundwater bores.

Submissions relating to flooding

Sjaan Henry, 82 Waihou Road, Levin

68. As stated in the submission, this property has an existing flood hazard. This is confirmed by the computational hydraulic modelling undertaken to inform the development of the Project. There is a small swale along the side of the road that provides local drainage of road runoff. Of more significance, however, is the topographic depression running NE-SW which passes 'through' the garage and behind the house. This depression becomes an overflow channel during relatively small events, certainly those more frequent than a 10% AEP (10-year ARI) event under the current climate. Consequently, this property is affected by an infrequent but persistent flood hazard under the existing environment.

69. When the potential effect of the Project on the existing flood hazard is modelled, there is no change; i.e., the Project has no effect on the existing flood hazard. Therefore, while the flood hazard will persist during and after completion of the Project, the Project has no effect on either the magnitude or frequency of flooding.

Neil and Sheryl Whyte, 24 Koputaroa Road, Levin

70. Mr and Mrs Whyte raised concerns over an existing flood hazard on their property which emanates from a bordering property that will be acquired for the Project. The Project will not affect this existing hazard.

Gary Williams, 107 South Manakau Road, Otaki

71. Mr Williams appears to support what is proposed and makes a number of 'observations' rather than criticisms.

72. Mr Williams' comment regarding the need for a '*diversion cut*' is exactly what has been proposed in the current concept design. It is assumed that this will remain, or something very similar and with the same effect, in the final design.

73. Regarding his comment that *"the narrowness of the opening may mean some more flooding of the road in intense flood events",* computational modelling of the current concept design during the 1% AEP event plus climate change shows no discernible adverse effect on the depth of flooding on South Manakau Road. There may be a slight reduction in the depth of flooding during some events because the realigned stream is shorter than the existing 'loop' to the south. The precise performance of the realigned stream will be subject to further analysis during detailed design of the Project.

Adam & Joanne McCallum, 213a Muhunoa East Road, Ohau

74. The computational hydraulic modelling undertaken for the Project has identified an existing flood hazard to the lower terrace of the submitter's property. This is confirmed by the submitters who state that *"the lower level of our property can flood from overland discharge currently."* There is no risk to the house or other buildings on the submitter's property. This flood hazard is because the lower terrace contains overland flow paths which operate during 'out of channel' events in the Ohau River.

75. As can be seen in *Figure **1*** (with the submitters property highlighted), the Project will reduce the existing flood hazard by about 100mm during the 1% AEP design event, including the potential effects of 100–years of climate change. This is because some overland flow that currently enters the property from the east will be intersected by the proposed highway and re–routed, via swales, down its eastern side. Similar behaviour will occur during

‘medium’ magnitude events such as the 10% AEP design event under the current climate.

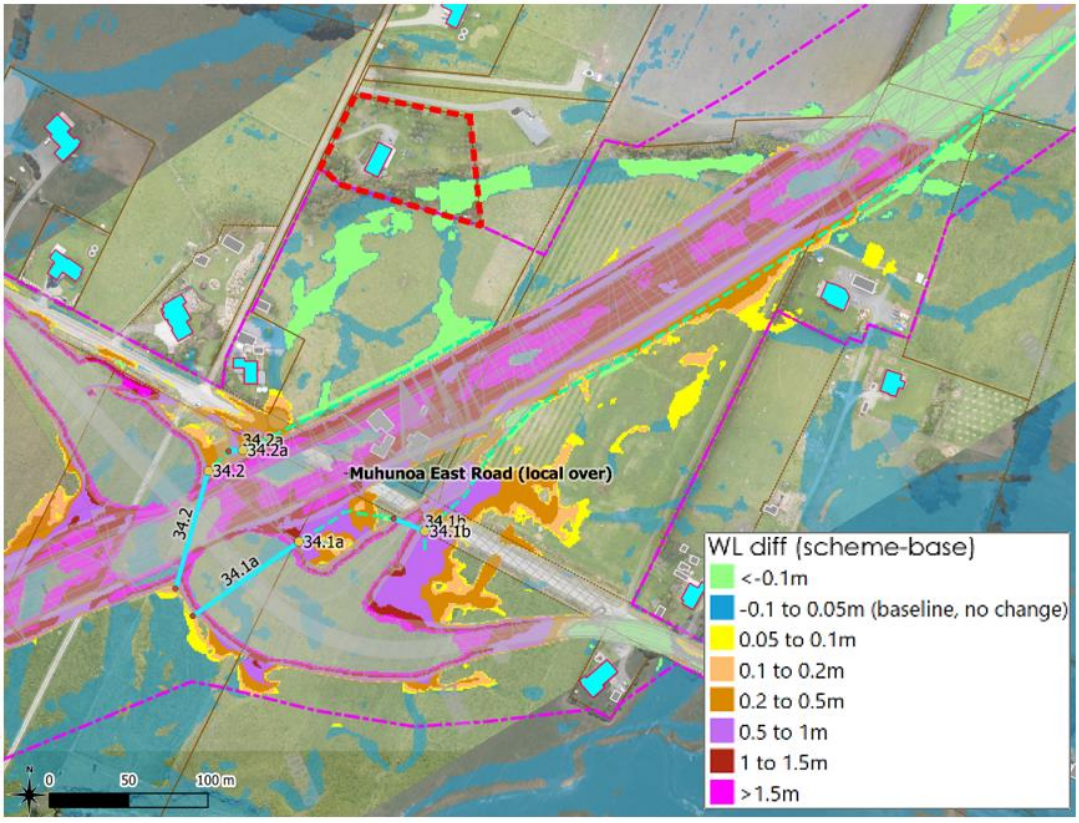

Figure 1: Location of Submitter 11's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

Louise Miles, Mokena Kohere Street, Manakau

76. One of the issues raised by this submitter is the potential for the Project to increase the frequency and magnitude of flooding to the north of Manakau Village. There are two well–defined stream channels that flow through the submitter’s property. These channels have well–vegetated riparian margins and contain several small ponds.

77. While the submitter describes the occurrence and possible causes of flooding at several locations, these are part of the existing environment. It should also be noted that these areas where flooding is currently problematic are a significant distance downstream of the Project.

78. As shown in *Figure **2***, even under the very large design event modelled, i.e., the 1% AEP flood increased to allow for 100–years of climate change, the Project has no effect on the frequency and magnitude of flooding on the submitter’s property, and to the north of Manakau Village. Likewise, because of the stormwater treatment ponds that will be constructed as part of the

Project, the Project will have no effect on flows delivered to the culverts under Honi Taipua Street and the railway.

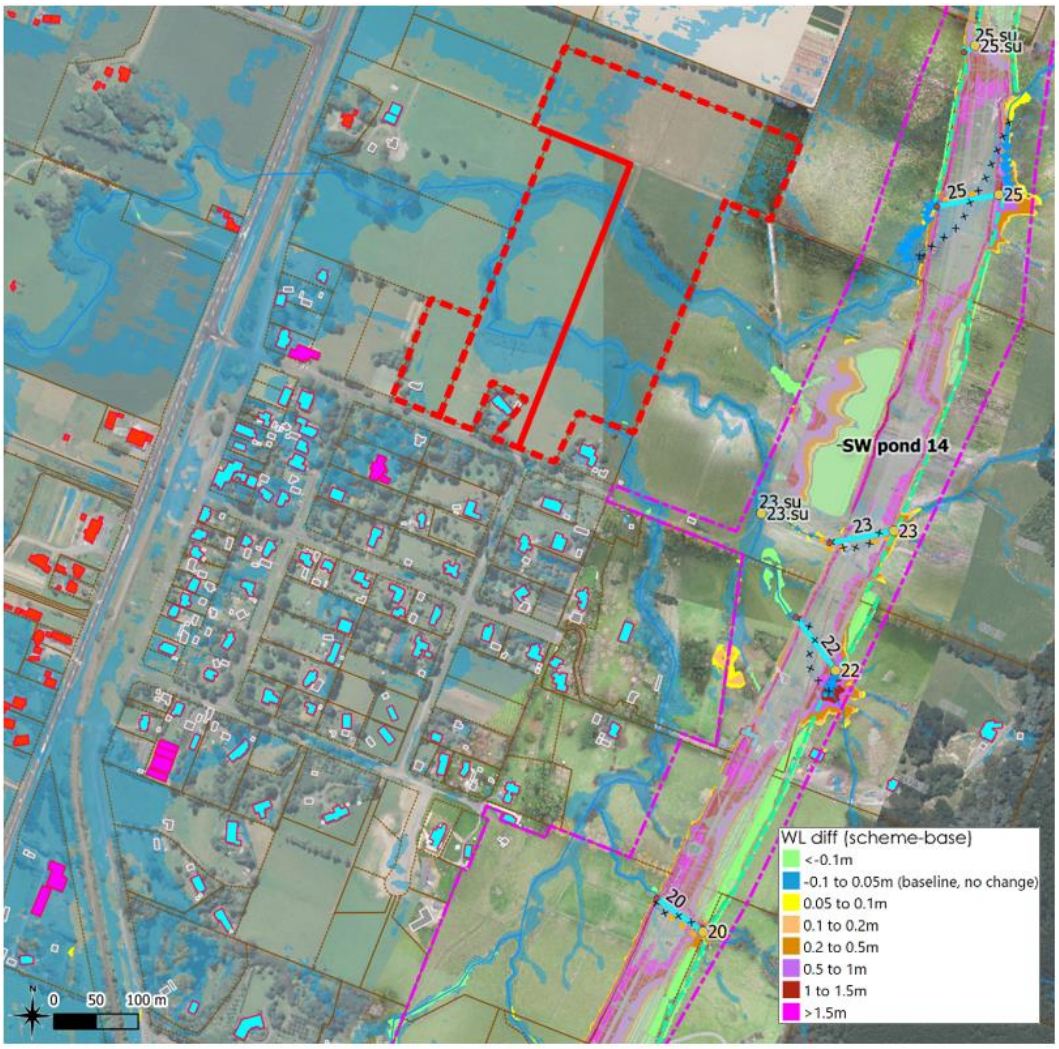

Figure 2: Location of Submitter 20's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

79. Based on the current concept design and two–dimensional computational hydraulic modelling, most flood events show a small benefit (a very slight reduction in flooding) from the Project. This is because of the capture and attenuation of runoff from the Ō2NL Project within stormwater management devices. These devices will both reduce and delay the peak discharge from the Project. The exact quantum of this benefit will be better defined following detailed design.

Glenys Anderson, 413 Arapaepae South Road, Levin

80. The computational hydraulic modelling undertaken for the Project has identified an existing flood hazard during the 1% AEP plus climate change design event affecting the submitter's property. This is caused principally by the impeded drainage of water in an overflow channel past Arapaepae South

Road. This small topographic depression has been 'blocked' by the formation of the road. There appears to be no risk to the house or other buildings on the submitter's property (*Figure **3***).

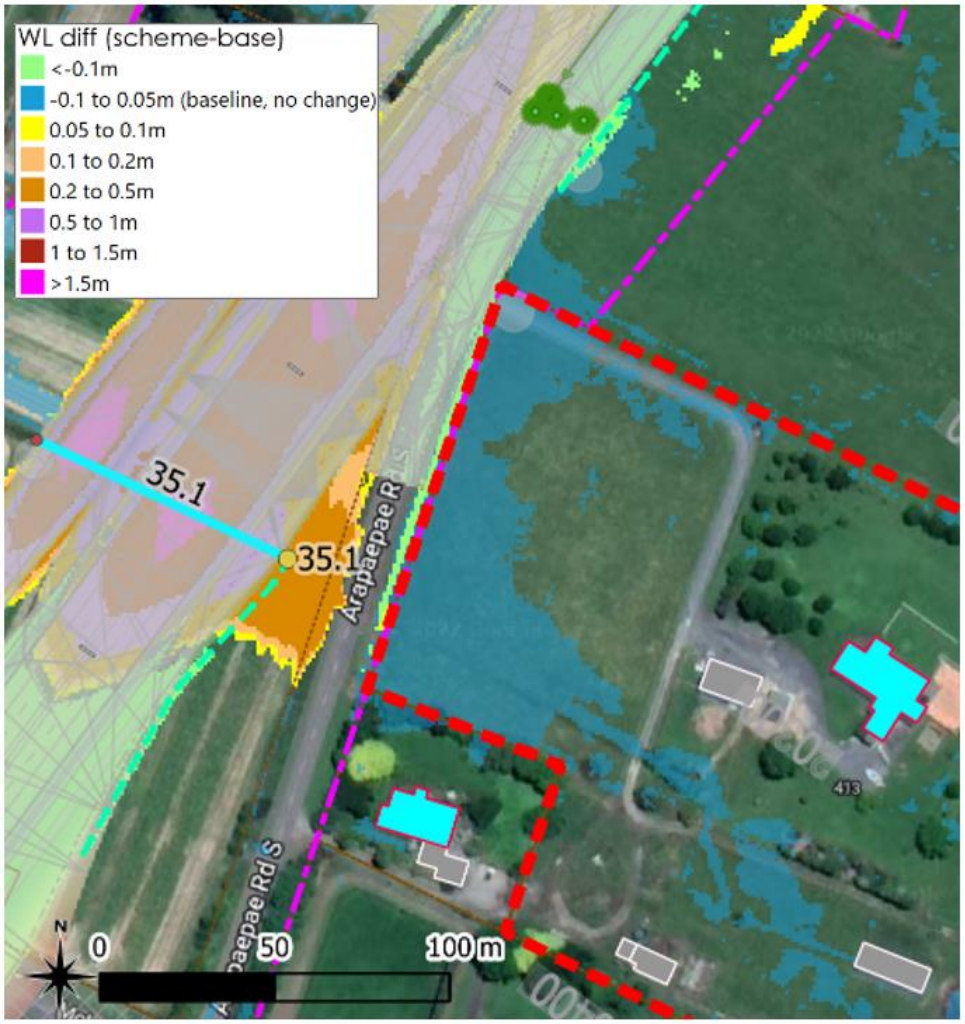

Figure 3: Location of Submitter 22's property relative to the Project and effect of the Project on the flood hazard during the 1% AEP design event.

81. The hydraulic modelling of the concept design indicates that the Project will have no adverse effects on the submitter's property from a flooding and drainage perspective. The existing roadside swale and drainage under Arapaepae Road at this location (which is upstream of the proposed highway) will be retained, so there is no adverse impact in terms of overland flow. The part of Arapaepae Road heading north that is modified by the Project (running adjacent to the proposed highway) has a downhill gradient heading away from the submitter's property. This area will be drained in the same (northerly) direction as the downhill gradient, with stormwater management designed to capture and treat runoff from the new impervious areas away from the submitter's property.

82. Consequently, the Project will have no adverse effect on this submitter's property from either overland flow management or runoff from any new paved areas.

John and Jenny Brown, 218 McLeavey Road, Levin

83. I met with John Brown on 1 March 2023. I understand Waka Kotahi and Mr and Mrs Brown are in discussions to seek a property solution to matters of concern, i.e., a new bore, access to the 'back paddock', and new stock yards. It also appeared that, apart from discussing the effects of the Project on his farm, Mr Brown wanted to share his 60–years of local knowledge. Mr Brown is concerned about potential changes in both surface water and groundwater flow because of works associated with the Project.

84. The proposed highway at this location is on the interfluve (a ridge or catchment boundary). Consequently, there is no catchment upstream of the Project from which runoff needs to be considered. While the current design proposes a short length of fill in a gully–head, any effects of this on runoff will be negligible. A subsurface 'drain' could be installed underneath the highway to maintain continuity of any groundwater flow, although given the location of the highway this should not be required. This is because the head of the gully is around 65–70m in elevation compared to the Ohau River at less than 55m, i.e., the depth to groundwater is likely to be a significant distance below any effects of the Project. The need for a subsurface drain can be considered during detailed design.

85. Because the proposed highway is on the interfluve, road runoff will be directed via the stormwater management system away from the property, i.e., it will not exacerbate any existing flood hazard. The concept design has the stormwater being collected and conveyed southwest along the alignment to a stormwater treatment facility near the Ohau River. Consequently, the Project will have no effects on the existing hydrology and flooding. There may be a small positive effect by diverting a small amount of potential runoff away from the property.

86. During previous works on his property, Mr Brown has observed changes to groundwater flow from the placement and compaction of fill. He has also observed 'unique' groundwater / saturation conditions which can change significantly over short distances. These varying groundwater conditions, including lenses of both significantly higher and lower permeability material over short distances (both vertically and horizontally), have been observed

throughout the Project area. The inherent uncertainty caused by this natural variability of hydraulic properties and groundwater behaviour will be managed during construction.

Prouse Trust Partnership, 1024 Queen Street East, Levin

87. In their wide–ranging submission, the Prouse Trust Partnership raise the potential for the Project to change stormwater flow patterns and cause flooding to their property.[6]

88. *Figure **4*** shows the potential effects of the current conceptual design for the Project on the existing flood hazard to this property. While there are several overflow channels (i.e., the blue 'splotches' across *Figure **4***), generally flowing from SE to NW, flooding of these is not affected by the Project even during the large design event that was modelled (i.e., 1% AEP plus the effects of climate change). While there is an existing flood hazard during large events from these overflow channels, this will not change because of the Project.

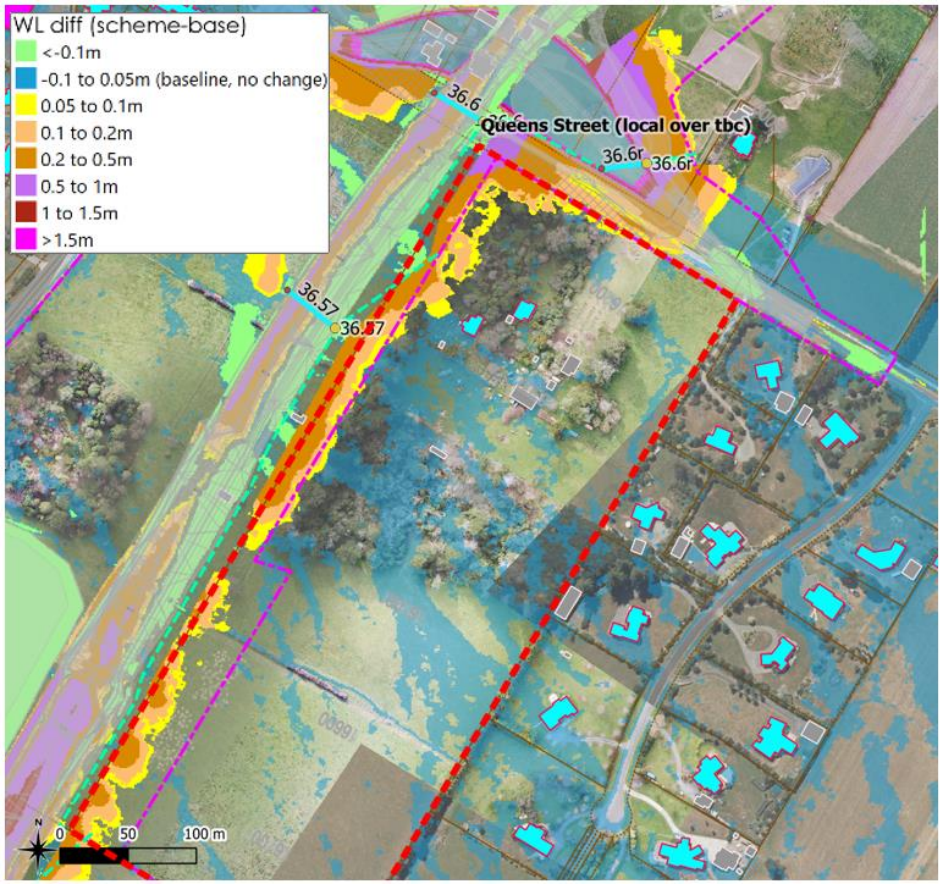

Figure 4: Location of Submitter 49's property relative to the Project and effect of the Project on the flood hazard during the 1% AEP event increased to allow for climate change.

6 In addition to the Trust, Mr and Mrs Prouse have also joined the proceedings as section 274 parties.

89. Under the current concept design, there is a small increase in the depth of inundation adjacent to the proposed highway and Queen Street East. This is because overland flow across the Prouse property upstream is intercepted by the bunds associated with the swales proposed adjacent to the highway and the highway itself. Any potential effects are greatest where the two roads intersect, i.e., the NW corner of the Prouse property.

90. Most of this increase in the depth of flooding during this large design event is within the designation. Generally, the increased flooding is <0.2m, although there are currently two small areas on the boundary where it could be up to 0.5m.

91. There is no increase in the depth of flooding near any of the buildings on the property, and their exposure to the existing flood hazard is unchanged, i.e., the Project does not increase the risk to these buildings.

92. There are several things to note:

    (a) The flood hazard to the various buildings on the property is not affected by the Project;

    (b) Most of the effects of the Project are retained within the designation;

    (c) The area which appears to be affected by an increased flood hazard is within the forest on the boundary of the property. The accuracy of the LiDAR in this area is likely to be less than elsewhere and therefore there is increased uncertainty regarding the results from the computational hydraulic modelling in this area;

    (d) The water causing the flooding in this area is derived from the Prouse property;

    (e) The areas affected outside of the designation are small and subject to generally small changes in the depth and duration of inundation;

    (f) The potential increase in flooding outside of the designation appears to be a result of the intersection of the Project with Queens Street East, and the interaction of the Project with the natural flow of water across the Prouse property.

Cher McCartney, 1 Koputaroa Road, RD5, Levin

93. This property is just north of the northern interchange as shown in *Figure **5***. This area is on the interfluve (ridge/catchment boundary) and consequently there is little natural relief to facilitate drainage.

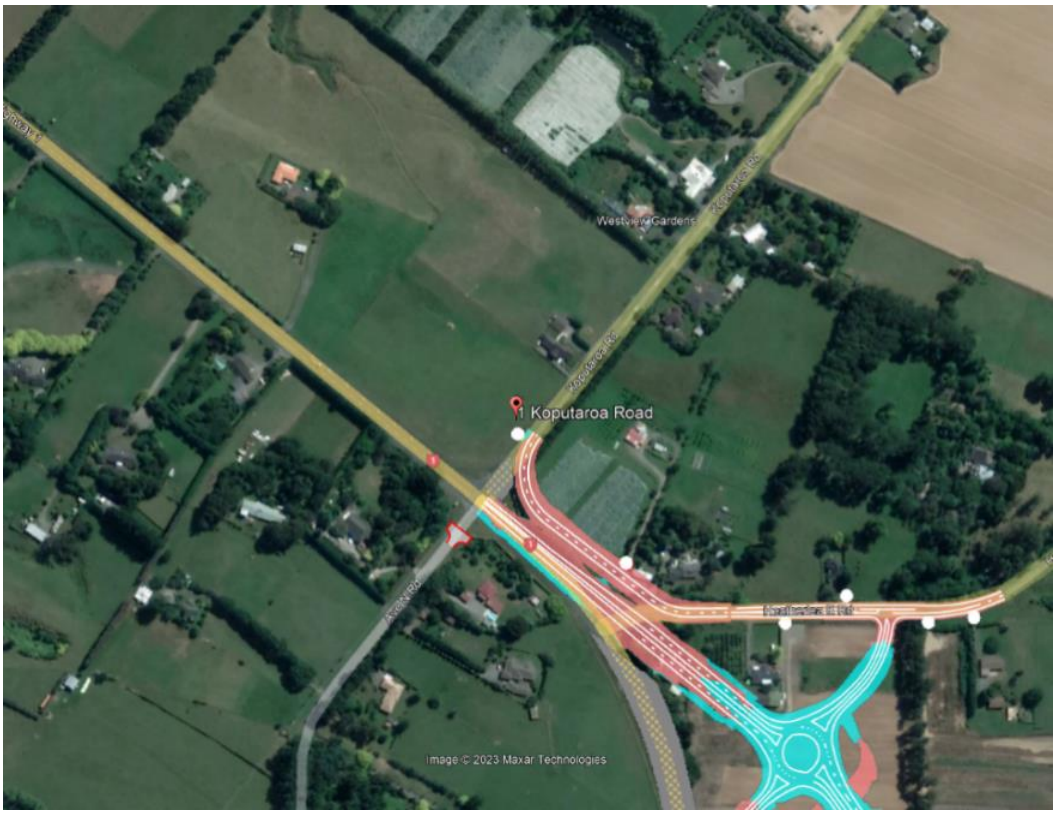

Figure 5: Location of Submitter 50's property relative to the Project.

94. The applicant is particularly concerned about *"road water and road pollution leaching onto our paddocks. I can't see on this plan how this is going to be resolved."*

95. It should be noted, therefore, that this is an existing problem and not an effect of the Ō2NL Project. The ground elevation of this property slopes toward the north and is predominantly beyond the extent of any works associated with the Project. Runoff from the new or enlarged impervious (paved) areas south of the property will be captured and treated in roadside swales and released in a controlled manner to the roadside drain on the eastern side of Koputoroa Road. This drains to the north–east and therefore avoids the submitter's property.

96. On the south–western side of the property, the existing SH1 will be largely unmodified (apart from integrating pavement layers).

97. Since this is an existing problem, it is not an effect of the Project.

Roger McLeay, Wanganui

98. This submitter expresses his concern regarding the design events used to inform both the development of the Project and the assessment of potential effects.

99. The Ō2NL Project concept design is based on a design philosophy of remaining serviceable to traffic in both directions, during a 1% AEP design event, including an allowance for the effects of climate change. This is a very large design event but is considered appropriate for a project of the scale and nature of Ō2NL.

100. This does not mean that the road will not be serviceable during larger events although during very large events there may be some short interruption to traffic. The structural resilience of the Project has been tested during a 1,500–year ARI event, including an allowance for 100–years of 'extreme' climate change (based on RCP 8.5 extrapolated to 2130). This extremely conservative scenario allows the minimisation of damage to the highway during 'over-design' events so that the highway can re-open quickly, following minor repairs, should they be necessary.

101. The risk of large rainfall and flood events has therefore been considered and accommodated within the Project design. Very large design events, with high magnitude and low frequency, have been used in the design of the Project.

102. Minimising the risk of the new highway being prone to flooding, and the effect of runoff from the highway on the flow regimes of the rivers and streams traversed by the Project, have been considered in detail.

103. The concept design includes the use of open channels and bunds, upstream of all cut faces and fill face toes, to collect all overland flow generated during the large design event. Runoff is directed into culverts that pass underneath the highway.

104. Modelling of the concept design shows that impacts of the Project on the receiving waters are 'less than minor' and the overland flow remains within the same receiving catchments. Technical Assessment F provides a detailed assessment of the effect of the Project on hydrology and flooding.

Errol Christiansen, Whanganui

105. While this submission is very general, it raises two potential issues:

    (a) Flooding from the Tararua Range and how this will interact with the Project; and

    (b) Stormwater runoff from the Project and its management and treatment.

106. Regarding the first issue, the current and future flood hazard throughout the area, and its interaction with the Project, has been investigated using a two dimensional computational hydrological and hydraulic model. This model considers runoff from the hills, via the rivers and streams, as well as direct rainfall over the 'plain'. The modelling also considered the potential impact of climate change.

107. The design event adopted is the 1% AEP rainfall/flood, increased to allow for the potential effects of 100–years of climate change. This design event is considered appropriate for a project such as Ō2NL. The various maps and figures in Technical Assessment F, and its appendices, show clearly that the effect of flooding from all sources, and its interaction with the Project has been addressed in detail.

108. The design event used to inform the drainage design is the 1% AEP rainfall, increased to allow for the potential effects of 100–years of climate change. The stormwater capture, treatment, and attenuation devices detailed in the current concept design can manage runoff from the highway in an efficient and effective manner.

109. While the drainage and treatment of runoff from the highway is addressed in detail by **Mr Nick Keenan** in his evidence, the plan set illustrating the concept design (notably the drainage plan set 310203848-01-300) shows not only roadside swales for conveyance of stormwater but also the indicative locations of open collector channels above cuts and the toes of fill. Where appropriate, the channels above cuts will also have bunding as indicated in "Typical cleanwater diversion channel and earth bund" in drawing 310203848-01-300-C9100.

110. The exact size and geometry of the channels and bunds will be subject to further detailed design to ensure sufficient conveyance capacity. However, the concept design has confirmed that there is sufficient space within the proposed designation for a functional and effective drainage system.

Carl and Emma Chalmers, 366 Arapaepae South Road, Levin

111. This submitter is concerned about the potential effects of the Project on the stream that flows through their property. Although not articulated in the submission, one assumes that their concerns relate to both water quantity (i.e., the frequency and magnitude of flooding) and water quality (from earthworks associated with the Project).

112. The submitter's property lies to the west of Arapaepae Road which will be unchanged by the Project, and which will continue to provide a 'buffer' against any potential effects in the upper catchment (*Figure **6***). Drainage across/under Arapaepae Road will continue to be the principal control on streamflow onto and across the submitter's property.

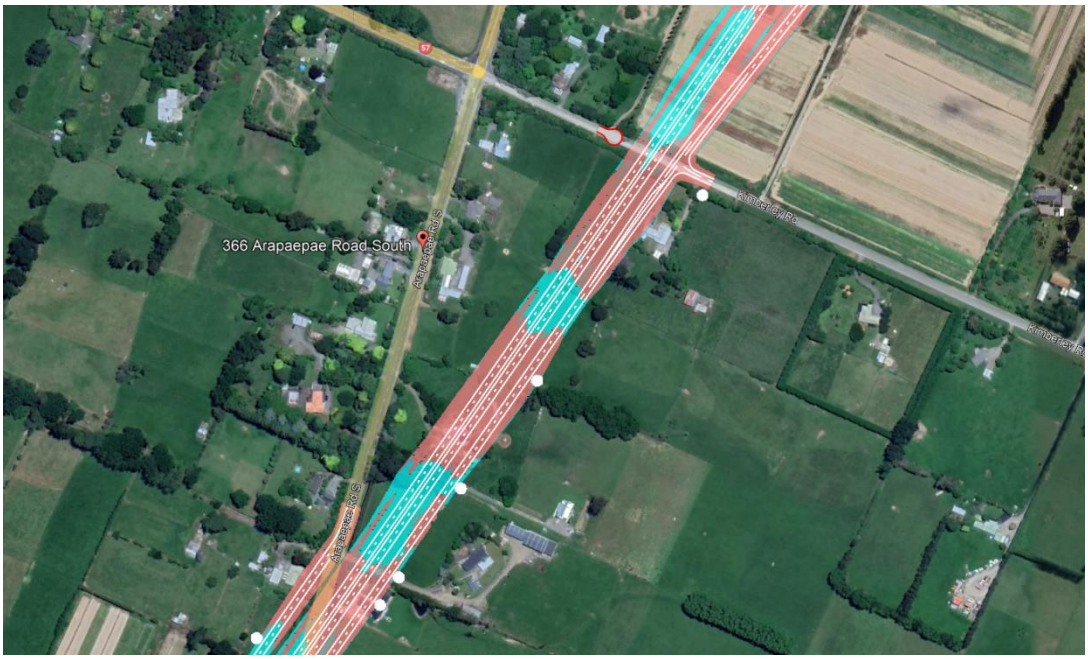

Figure 6: Location of Submitter 60's property relative to Arapaepae Road and the Project.

113. As shown in *Figure **7***, the submitter's property will not experience any increase in the frequency and magnitude of flooding because of the Ō2NL Project.

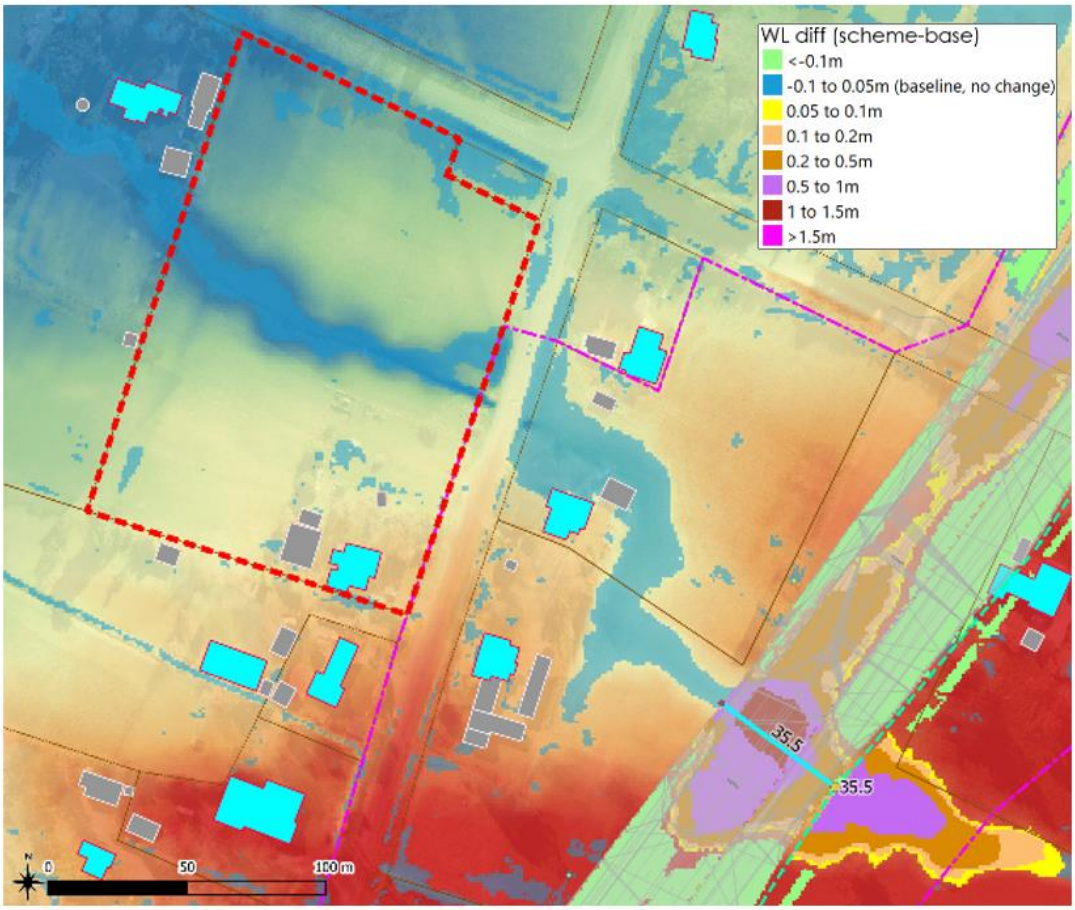

Figure 7: Location of Submitter 60's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

114. The existing watercourse (ID 35.5 on the drainage plan set) will pass underneath the proposed highway via a culvert. It is likely that during the very large design event modelled, i.e., 1% AEP flood increased to allow for 100–years of climate change, a small amount of ponding may occur upstream of this culvert for a short period. This would moderate and attenuate the peak discharge passed downstream of the Project.

115. Therefore, the same, and potentially less, flow will continue to approach the Arapaepae Road culvert. Consequently, the existing flood hazard to 366 Arapaepae Road will not be exacerbated by the Project. The flood hazard may be reduced slightly by the Project moderating and attenuating any flood peak.

Alauta and Frederick Paul von Iddekinge, 679A SH1, Kuku, Levin

116. This submission raises concerns about the lack of detailed stormwater design and treatment devices, and the potential for the Project to develop/support a wetland adjacent to their property (*Figure **8***). In general, the submitter identifies a number of possible 'enhancements' to the Project and not any specific adverse effects that need to be addressed.

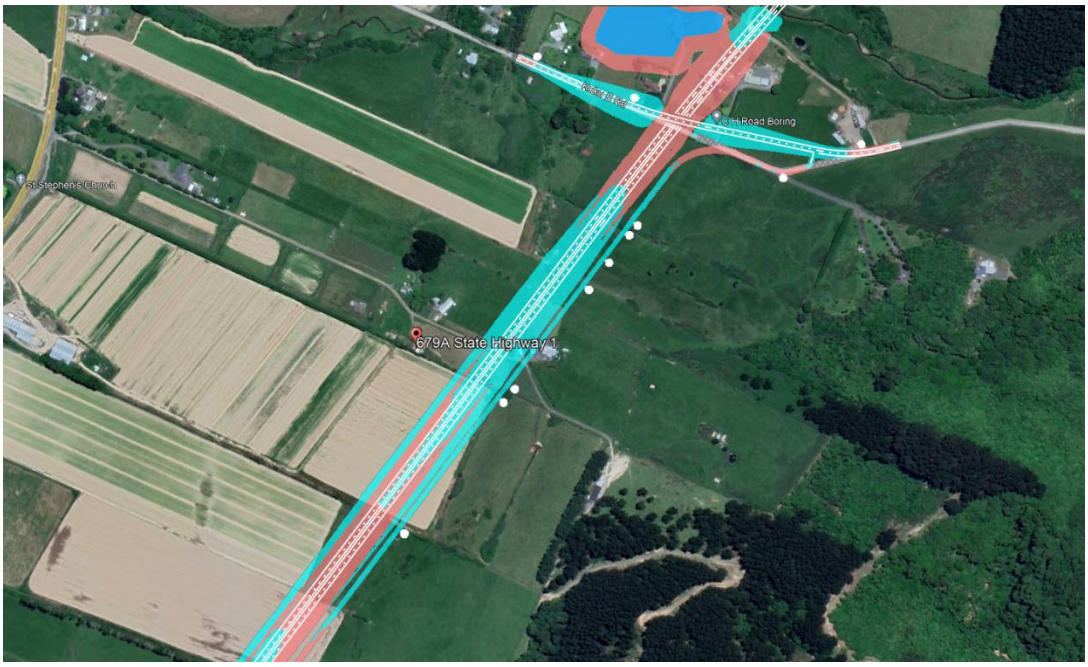

Figure 8: Location of Submitter 68's property relative to the Project.

117. It should be noted that Waka Kotahi is seeking to consent a 'concept design' and an umbrella of potential effects. The final design might be different to what is currently illustrated, but any effects will be no greater than indicated. The final design will provide additional, specific detail regarding stormwater management and treatment. The current design includes potential spoil sites on the western side of the new highway. The landowner is keen to make these as large as possible, and discussions regarding this option are ongoing with Waka Kotahi.

118. The Project will have no effect on the existing flood hazard to the submitter's property, i.e., the frequency and magnitude of flooding will not change because of the Project. This is the case even during the very large design event modelled i.e., 1% AEP event increased to allow for 100–years of climate change (*Figure **9***).

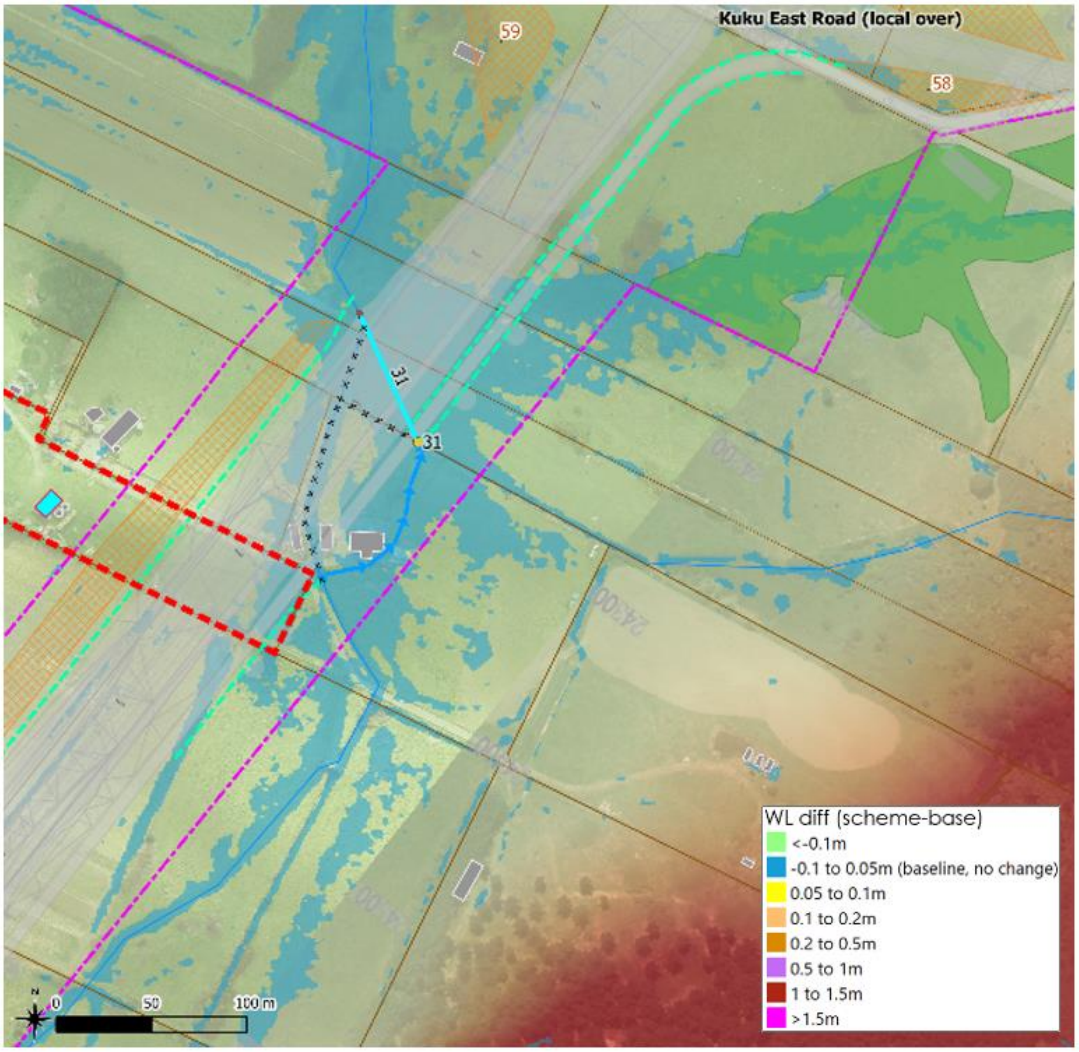

Figure 9: Location of Submitter 68's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

119. An overland flow path, which operates during larger rainfall/flood events, runs essentially south-north to the east of the submitter's property. Because the Project crosses this channel at an oblique angle, the current concept design includes re-routing this channel adjacent to, and east of, the new highway before passing the flow under the highway through culvert 31. This will maintain the *status quo* regarding any flood hazard to the submitter's property.

120. It is apparent from *Figure **9*** that there is diffuse and impeded drainage across the wider area, with a number of small and poorly defined channels/drains. There is an existing 'seepage wetland', indicated in green, to the south of Kuku East Road which is a 'response' to this impeded drainage. Much of this is within the designation and is contiguous with the impeded drainage, also largely within the designation, to the east of the proposed highway and connector road to Kuku East Road. From a hydrological perspective, it could

be possible to extend the existing seepage wetland across this wider area as suggested by the submitter.

121. The conceptual nature of the current design means that the relationships between the proposed roads, spoil site geometry, and drainage are not well developed.

Sarah Hodge, 11 Ihaka Hakuene Street, Manakau

122. This submitter has observed flooding of the surrounding farmland and is concerned that the Project may exacerbate this situation.

123. Computational hydraulic modelling undertaken for the Project shows that there will be no change to the existing situation and flood hazard, even during the very large design event modelled; i.e., the 1% AEP event increased to allow for the effect of climate change (*Figure **10***). The submitter's property is a significant distance from any stream or watercourse with the potential to flood. The modelling, however, does show flooding of the surrounding farmland which is consistent with the submitter's observation. This is indirect validation of the results of the computational hydraulic modelling.

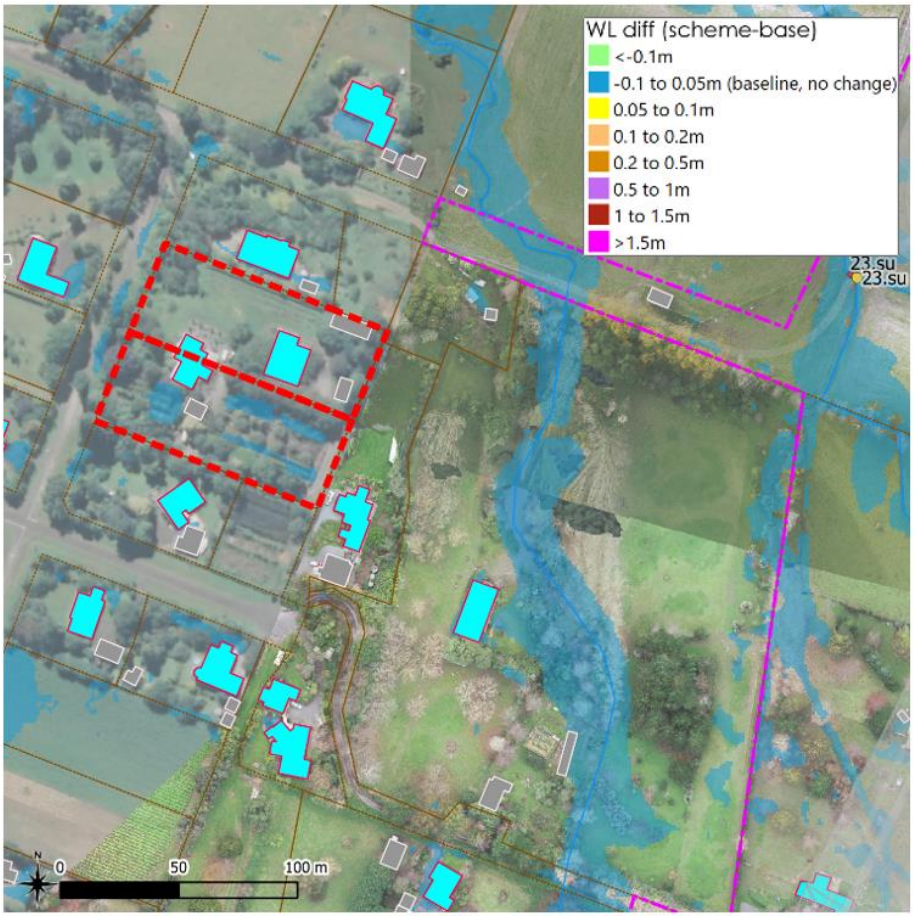

Figure 10: Location of Submitter 71's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

124. It should also be noted that the submitter's property is on relatively high ground (red tones in *Figure **11***) relative to the surrounding terrain. Consequently, any existing flood hazard to the submitter's property is likely to be low and this will not change as a result of the Project.

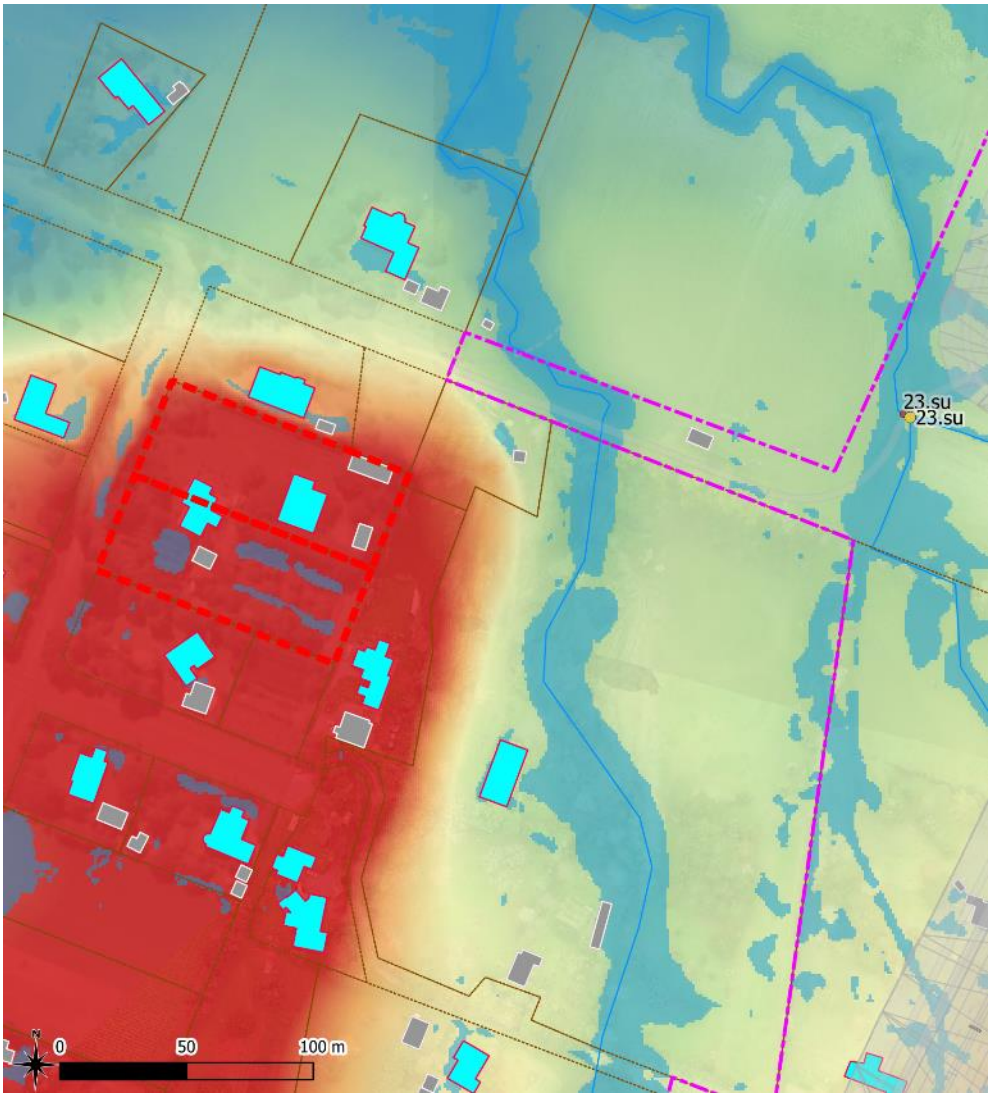

Figure 11: Changes in flooding as a result of the Project during the 1% AEP design event. The 'yellow' through 'red' colours show increasing elevation with Submitter 71's property outlined.

125. The results from computational hydraulic modelling, and the elevated terrain of the submitter's property, indicate that there will be no change to the existing flood hazard because of the Project.

KiwiRail

126. KiwiRail raises two matters regarding flooding, and managing the impacts of the Project on the flood hazard and their assets:

    (a) The design and size of culverts associated with the stormwater. Careful consideration will need to be given to the design and size of

culverts to ensure that any culverts downstream are not adversely impacted by flows that are generated or redirected as a result of the project.

(b) The interaction between the Project and the existing level crossing at Tararua Road.

127. This submission does not raise any specific issue or potential adverse effect but expresses KiwiRail's wish to be involved in discussions during the development of the final design of the highway. They wish to ensure that there are no adverse effects or unintended consequences to KiwiRail infrastructure and assets.

128. The computational hydraulic modelling shows that, even during the large design event considered (i.e., the 1% AEP flood increased to allow for the effects of climate change), no KiwiRail culverts, bridges or other waterway crossing will receive any increased flow because of the Ō2NL Project. Consequently, the Project will have no adverse effects on the hydrology and flood hazard to any KiwiRail infrastructure.

129. The current concept design shows that at the Ō2NL bridge over the NIMT (Ō2NL chainage 10685, at the northwest bridge abutment), there is a proposed Ō2NL culvert (ID 42.2) that interfaces closely with a KiwiRail culvert (KR asset 2250063). At this preliminary design stage, it is anticipated that the new culvert endpoint will 'join' onto the existing KiwiRail culvert inlet, via a constructed manhole, and integrate with the headwall of the existing culvert. Other than this case, no KiwiRail culverts will undergo any structural modification or potential change in hydraulic performance.

130. Regarding the existing Tararua Road intersection, Technical Assessment F states at paragraphs 192 & 193 that:

192. The proposed improvements to the Tararua Road intersection with existing SH1 include a new level crossing of the NIMT. The proposed works will be essentially 'at grade' with the existing terrain. The NIMT railway line is the highest local hydraulic control at this location, and the works will not change the elevation or drainage of the NIMT railway.

193. The detailed design of the new road works will minimise any modification of existing overland flows in flood events and therefore any effect on hydrology and flooding will be less than minor.

131. The current conceptual design of the Project therefore has no adverse effects on any KiwiRail infrastructure. Ongoing discussion between the Project

Team and KiwiRail during the development of the final design of the highway will ensure that this remains the case. Such discussions may also allow the development of integrated solutions to reduce the existing flood hazard from some waterways (e.g., Kuku Stream downstream of the designation). This would enhance and extend the positive legacy of the Project.

Chris Corke, 19 Avenue North Road, Levin

132. This submission raises two issues:

(a) That approval will include permission to pollute the local soil with "discharge of contaminants" – which we vehemently disagree with being a Truffle growing property and on general environmental concerns; and

(b) That unfettered access be provided to NZTA and supporting contractors to water sources and the underlying water table – as a primary bore owner, we are unconvinced that due care or consideration would be applied to the management of this by either party and long-term damage would be caused – again which we object to either access to the interconnected water table and/or our bore).

The first issue is discussed below, while that relating to the groundwater is discussed in the following section of this evidence.

133. The primary 'vector' for transporting contaminants/pollutants in this environment is water. As shown in *Figure **12***, SH1 in this area is located on the interfluve or boundary between two catchments. The stormwater pond that will treat any runoff from the road in this area is located on the east side of the highway which drains away from the submitter's property. The Ō2NL Project therefore has no potential to affect either the surface water or groundwater in the submitter's property, and therefore their truffle growing operation.

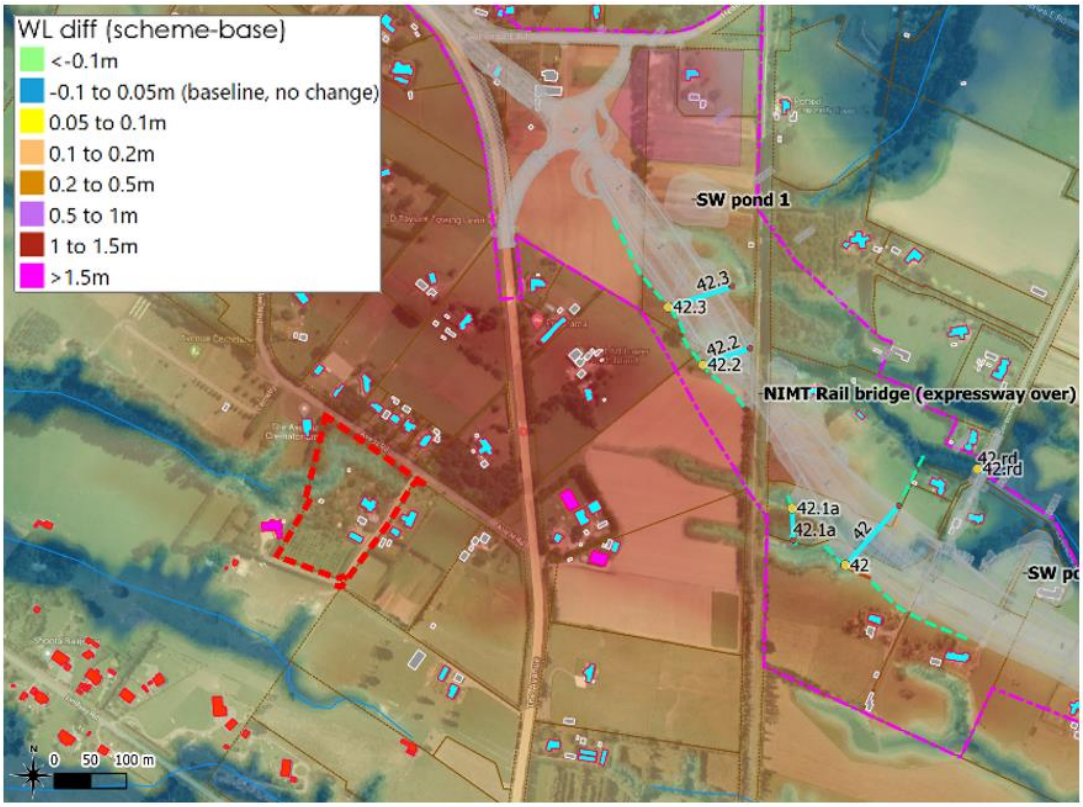

Figure 12: Location of Submitter 75's property relative to the Project and the effect of the Project on the flood hazard during the 1% AEP design event.

134. In any event, the stormwater collection and treatment devices are designed to remove the contaminants from runoff from the highway during all events up to and including the 1% AEP design rainfall, increased to allow for the potential effects of 100–years of climate change. This means that any contaminants will not be discharged to the wider environment. All effects will be contained within the designation. Consequently, the Project has been designed to avoid the discharge of contaminants.

Simon Austin, 63 Arapaepae Road, Levin

135. This submitter raises his concern regarding the potential effect of the Project on the frequency and magnitude of flooding of Kimberley Reserve.

136. As shown in *Figure **13***, Kimberley Reserve is approximately 4km upstream of the proposed new bridge over the Ohau River and the designation.

Figure 13: Kimberley Reserve is approximately 4km upstream of the Project.

137. Because of the moderately steep gradient of the Ohau River, and the proposed design of the bridge, which has no piers within the active channel, any backwater effects of the bridge will dissipate within approximately 100m of the proposed designation (*Figure **14***). This is still over 3.5km downstream of Kimberley Reserve. It should also be noted that the design event used in the assessment of potential effects is a very large flood, i.e., the 1% AEP event increased to allow for 100–years of climate change.

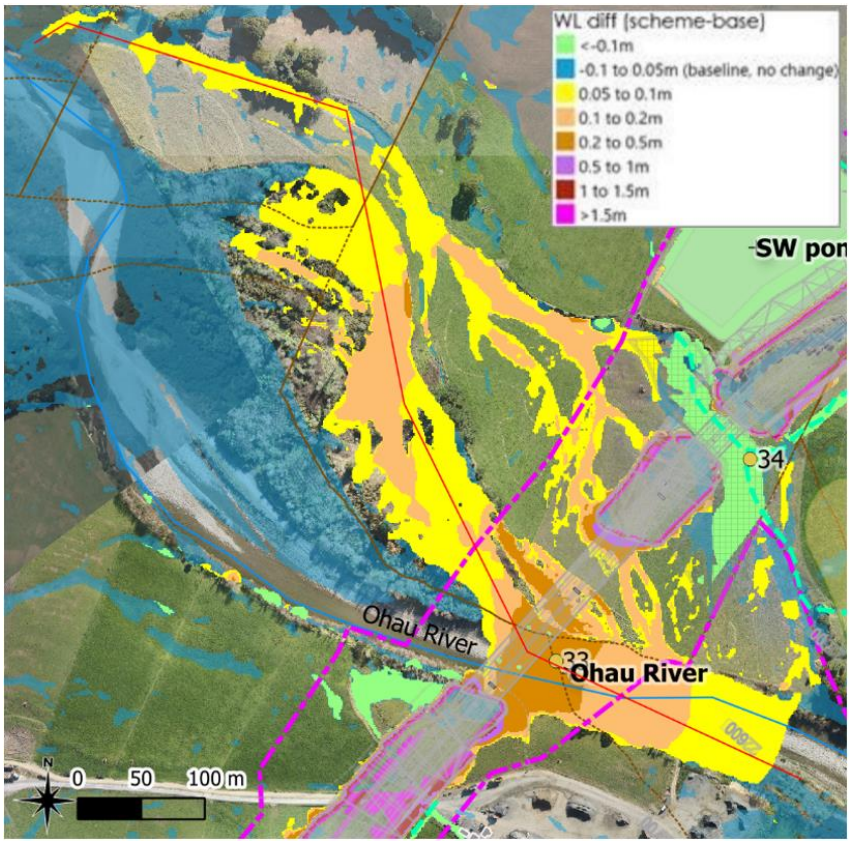

Figure 14: Effect of the proposed bridge over the Ohau River on the flood hazard during the 1% AEP design event.

138. The Ō2NL Project will therefore have no effect on the frequency and magnitude of flooding at Kimberley Reserve. Flooding of the Reserve will continue to be a 'natural process', as it is within the existing environment.

Submissions relating to groundwater

Wendy McAlister–Miles and Dion Miles, 195 Muhunoa East Road, Ohau

139. This submitter raises various matters including the security of their water supply from a groundwater bore. The property is relatively close to the proposed Project alignment, as shown in *Figure **15***.

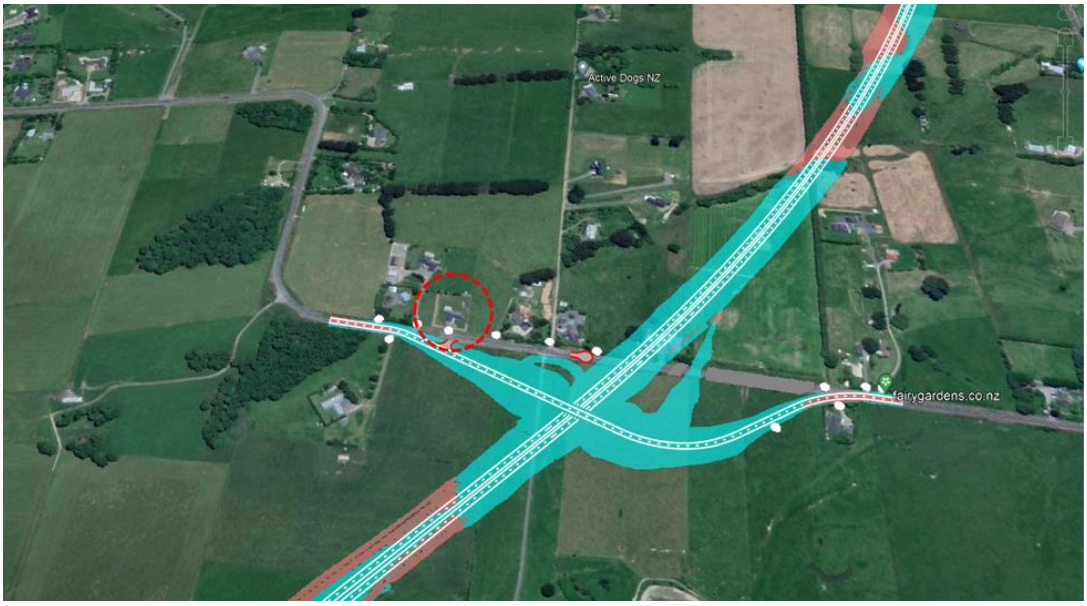

Figure 15: Location of Submitter 8's property relative to the proposed alignment of the Project.

140. While there are some basic details of the bore (e.g., location and when drilled), there is no information on its depth, screen, pump location or other details. However, from information available for other bores in the area, the submitter's bore is likely to be relatively shallow and tapping the surficial unconfined aquifer. Since there does not appear to be a water permit for this bore, it is likely for domestic use under the Permitted Activity Rule.

141. The current design of the proposed highway in this location shows it to be slightly elevated above current ground level, rather than in a cutting. This means that there is little potential for the highway to affect groundwater in the area.

142. The existing road will continue to provide a buffer between the Project (and any effects) and the submitter's property and bore. Since runoff from the road will be directed to swales, where it will infiltrate the ground, the water

balance in the area will be maintained. Consequently, there will be no change to groundwater levels and dynamics, or the yield from the submitter's bore. The treatment provided by the swales will also ensure that the water quality is the same or better than at present.

143. During construction of the Project, any risk of contamination will be avoided by the proposed erosion and sediment control measures. These measures are discussed in detail in the evidence of **Mr Gregor McLean**.

144. Consequently, in my opinion, the Project will have no adverse effects on either the yield or quality of water from this submitter's bore.

John and Jenny Brown, 218 McLeavey Road, Levin

145. As noted above, I met with John Brown on 1 March 2023.

146. There is currently a groundwater bore located on the eastern boundary of Mr Brown's property, with a pipe network distributing water to various stock-water troughs. This stock water distribution network will be disrupted by the Project that will cross between the bore and most of the water supply area.

147. I understand that the Project is proposing to replace the existing bore, to the west of the designation to avoid the Project affecting the security of Mr Brown's stock water supply.

148. The bore supplies stock-water, so providing a bore with the appropriate yield and quality should not be a major constraint. Since the bore is only for stock-water, and for a maximum of 60 head, it is likely that abstraction will be permitted by Rule 16–2 of the One Plan (the Permitted Activity Rule for minor takes and uses of groundwater).

Merie Cannon and Trevor Guy, 84 SH1, Otaki

149. Groundwater flow in the vicinity of the submitter's property is generally east–west, with the water table mimicking the topographic surface. Groundwater flow will be normal to the topographic contours.

150. The submitters have a groundwater bore between the new local road and SH1. This will be 'buried' under the footprint of the proposed physical works (*Figure **16***). I understand that Waka Kotahi has therefore agreed (in principle) with the landowner to relocate the bore, upgradient of the proposed highway. Consequently, there will be no effects from the Project on either the yield or quality of water from this submitter's bore.

Figure 16: Potential configuration of the Project near Submitter 56's property.

Sarah Hodge, 11 Ihaka Hakuene Street, Manakau

151. This submitter is concerned about any effects the Project may have on their bore water supply.

152. The submitter's property and bore lie at least 300m from the proposed highway. The concept design shows that the highway at this location will be 'at grade' and so will involve no cuts with the potential to affect groundwater flow. Furthermore, the water balance in the area will be maintained by the proposed stormwater detention pond. This will treat any runoff from the impermeable road and then facilitate infiltration and percolation of this to groundwater. Consequently, there will be no change to either the quality or yield of groundwater from this submitter's bore.

153. It should also be noted that the groundwater system beneath Manakau is complicated by the distinctive geology of this area. This is discussed in detail in a paper I co-authored.[7] Detailed monitoring and field investigations showed that groundwater flow is generally 'around', rather than 'through', Manakau Village. Groundwater flow is preferential within gravel units rather than the dense marine sand.

154. Therefore, because of its distance from the proposed highway, the highway being at grade, the maintenance of the existing water balance, and the distinctive geology, the Project will have no effect on either the water quality or yield from this submitter's bore.

[7] McLarin, W.; Bekesi, G.; Brown, L.; McConchie, J.A. 1999: Nitrate contamination of the unconfined aquifer, Manakau, Horowhenua, New Zealand. Journal of Hydrology (NZ) 38(2): 137–148.

Chris Corke, 19 Avenue North Road, Levin

155. This submission suggests that the Project is seeking:

> *"unfettered access be provided to NZTA and supporting contractors to water sources and the underlying water table – as a primary bore owner, we are unconvinced that due care or consideration would be applied to the management of this by either party and long-term damage would be caused – again which we object to either access to the interconnected water table and/or our bore)."*

156. This statement is not correct. The Project is seeking a permit to abstract the water necessary to construct the Project from several sources throughout the area. However, in each case the abstraction will be only from either the core or supplementary allocations available currently, and as permitted by Horizons' One Plan. The effects of each abstraction will be controlled by a range of conditions to ensure that any effects on the environment and existing users are 'less than minor'. Rather than being '*unfettered*', the abstraction of construction water will be controlled heavily and managed rigorously.

157. It should also be noted that no abstraction of water or any works that might affect the water balance are proposed in the catchment in which the submitter's bore is located. Therefore, the Project will have no effect on the yield or water quality from the submitter's bore.

COMMENTS ON THE COUNCIL REPORTS

Hydrology & Flooding

158. The sections 87F and 198D reports relating to hydrology and flooding raise similar issues and appear to be under the same misunderstandings regarding both the nature of the consent application and the technical information provided in support.

159. Consequently, it is considered more efficient to address these overarching issues before responding to the specific details of the reports. The overarching issues, addressed in turn below, are:

(a) The appropriate design event when assessing flooding effects;

(b) Quantifying effects and the concept design;

(c) What is hydraulic neutrality in a practical sense;

(d) What level of effect is appropriate; and

(e) How the anticipated effects should be quantified (in light of my assessment that the effects will be 'less than minor').

Design event

160. The Councils' technical advisers have questioned the magnitude of the design event adopted for the assessment of potential effects of the Project, and when developing the concept design of the highway. There are both planning and technical aspects when establishing the design event.

161. While most Councils throughout New Zealand use the 1% AEP event, increased for the potential effects of climate change, Horizons adopted a different approach in the One Plan. This was perhaps to avoid the 'changing nature' of climate change predictions and their consequential effects.

162. Policy 9–2 of the One Plan guides the development of areas prone to flooding. The information provided for Territorial Authorities[8] states that:

"It is predicted that a flood protection design that would protect against the current 0.5% annual exceedance probability (or AEP, also often called a 1 in 200–year flood) flood event will only be effective against 1.0% AEP (1 in 100 year) flood in 2050, because of the effects of climate change.

One Plan Policy 9–2 therefore uses 0.5% AEP as the minimum level of flood protection for development in flood prone areas in the Region. Requiring mitigation or protection against a 0.5% AEP flood event now will maintain a standard of not less than 1.0% AEP protection into the future."

163. In the Horizons' region, therefore, the recommended minimum design event is the 0.5% AEP (200 year) event as this includes the potential effects of climate change out to 2050 on the 1% AEP flood. It should be noted that the use of the 0.5% AEP event, as referenced in the One Plan, therefore already accounts for the potential effects of climate change and they do not need to be considered separately.

164. To be transparent regarding the nature of the potential flood hazard, and the potential effects of climate change, the Project has adopted the 1% AEP design event, increased to allow for the potential effects of 100–years of

[8] Flood hazards and the One Plan. Information for Territorial Authorities in the Manawatu–Wanganui Region. https://www.horizons.govt.nz/HRC/media/Media/One%20Plan%20Documents/Natural–Hazards–Guidance–for–TAs–updated–2015.pdf?ext=.pdf.

climate change (assuming RCP 6.0). This is discussed in detail in Technical Assessment F.

165. The difference (orange arrow) in the magnitude of the design event defined in this manner (1% AEP flood + climate change to 2130), relative to that required by Horizon's Policy 9–2 (0.5% AEP flood under current climate), is shown in *Figure* ***17.***

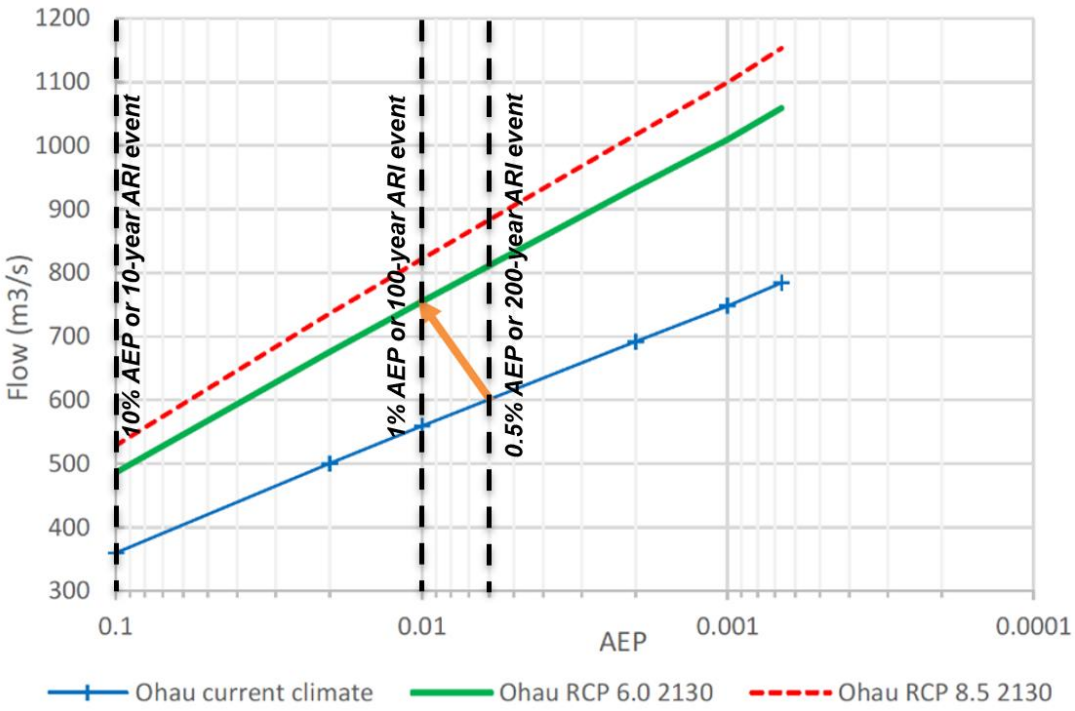

Figure 17: Comparison of the magnitudes of the 1% AEP event, increased to allow for the effect of climate change, and the 0.5% AEP event required by Horizons' One Plan.

166. As can be seen with respect to the Ohau River, the magnitude of the 0.5% AEP design event under the current climate is about 600m³/s. The 1% AEP design event, increased to allow for the potential effects of 100–years of climate change, is about 750m³/s, or 25% larger.

167. The adoption of the design flood used by the Project when assessing the potential effects of the Project is therefore significantly more conservative (i.e., higher) than that required by the One Plan. This is discussed at paragraph 55 of Technical Assessment F.

168. It should be noted that this same reasoning for adopting a 1% AEP design event, increased to allow for the potential effects of 100–years of climate change, rather than a 0.5% AEP event under the current climate was presented during the hearings related to Te Ahu a Turanga; where it was accepted by both Horizons and the Environment Court. The comment was

made by Jon Bell (Horizons, Flood Protection at that time) that *if you want to adopt a higher standard, we do not have a problem with that.*

169. The 'growth factors' used to account for the potential effects of climate change on both flow and rainfall by 2130 were 35% and 47%, assuming RCP 6.0 and RCP 8.5 respectively. It should be noted that these increases in the drivers of flooding are significantly higher than those adopted for the PP2Ō Expressway (26.4%) and Te Ahu a Turanga (~20%). In my opinion, the adjustments for the potential effects of climate change reflect a precautionary approach.

170. Tests using 1% AEP design events in the rainfall-runoff models showed that the percentage change in rainfall results in an almost identical percentage change in flow. The high intensity and depth of rainfall during the design event mean that antecedent rainfall and catchment condition are less relevant to the flood response because the small steep hill country catchments traversed by the Project respond rapidly.

Quantification of effects and the concept design

171. Both Mr Kinley and Mr McArthur have sought more information on the scale of effects of the Project at specific locations. However, the conceptual design that has been used to inform the consent process may not be constructed. While the final design will be similar to the conceptual design, there will also likely be a range of changes. These changes will further optimise the final design and construction but will have a scale of effects that are no greater than those assessed using the current conceptual design. It is likely that the final design will reduce the already small environmental effects even further. Consequently, in my opinion, the focus should be on the scale of the effects (which the final Project will not exceed) and not necessarily the factors in the conceptual design that currently cause those effects.

172. The development and testing of the conceptual design has shown that a highway can be built within the umbrella of effects identified and quantified. It is this umbrella of effects which the Project is consenting, rather than the specific design. Further, and as discussed below, the assessed effects are very small in scale.

Hydraulic neutrality

173. Extensive hydrological assessment and computational hydraulic modelling have been carried out to inform the Project's design, which has sought to

achieve ‘hydraulic neutrality’ (in other words, no worsening of the existing flood situation or, where this is not achievable, keeping areas of increased flood hazard away from people).

174. Despite complexities arising from the nature of the Project area and the existing flood hazard, in practical terms, hydraulic neutrality has been achieved through the Project design process. The goal of hydraulic neutrality will be advanced further during the final design process.

175. However, as described previously in this evidence, and detailed in Technical Assessment F, the Ō2NL Project cuts across a number of watercourses and interacts with their current drainage function. This requires that the highway be elevated above existing ground levels to achieve the required level of service (from a hydrology perspective). The elevation of the highway above natural ground levels makes the achievement of the strict definition of hydraulic neutrality difficult to achieve.

176. The strict definition of hydraulic neutrality, suggested by Horizons, GWRC, HDC and KCDC, would require that peak flows and flood levels cannot be increased at any location and under any circumstances. As illustrated in Technical Assessment F, various lengths of the Project would be inundated during the design flood if the highway was at the existing grade. Therefore, for peak flood levels not to be increased by the elevated highway, the highway would need to be bridged across at least the entire width of the extent of flood inundation predicted for each floodplain. This would be impractical and prohibitively costly in terms of construction and would likely give rise to other adverse environmental effects (e.g., visual effects).

177. Therefore, in practical terms, the Project does achieve hydraulic neutrality. The Project largely achieves no worsening of the existing flood situation and where this is not practical, areas where flooding may be marginally greater are uninhabited areas of farmland. Any effects will be infrequent and of extremely short duration.

178. The extent of flood inundation shown in Technical Assessment F is for the 1% AEP event, including the effects of 100–years of predicted climate change. As discussed, a flood of this magnitude or greater could be expected to occur on average once every hundred years. Therefore, the extent of flood inundation shown would be a very rare occurrence. The extent of flood inundation on these floodplains in more frequent events would be much less.

Acceptable scale of effects

179. Following consideration of the results of computational hydrologic and hydraulic modelling of the potential effects of the Project, using a conceptual design, it was my opinion that any effects on hydrology and flooding would be 'less than minor'. The rationale and analysis supporting this opinion is provided in Technical Assessment F.

180. The technical reviewers acting for the Councils, however, argue in their section 87F and 198D reports that no effects outside of the proposed designation are acceptable. They believe that the final design, yet to be developed, must ensure that all effects of the Project are contained within the designation.

181. It is my professional opinion that such an approach is both unrealistic (given the existing environment) and impractical (given construction and cost implications). My reasons for my opinion are summarised below.

182. Paragraphs 90 & 91 of Technical Assessment F summarise the framework adopted when considering the potential effects of the Project on hydrology and flooding.

183. In New Zealand, criteria for assessing the potential effects of large infrastructure projects are often based on 'context'. For example:

    (a) Te Ahu a Taranga highway hydrology assessment (2020) states:

    "To recognise the uncertainty within the hydraulic model, and the fact that shallow flooding of short duration does not pose a hazard, all areas where the depth of flooding is less than 0.1m were removed. It should also be recognised that a depth of flooding of only 0.1m would not present a risk to either people or property. When comparing different scenarios, any change in depth less than ±0.1m or velocity less than ±0.5m/s was not considered significant."[9]

    In discussion of results at Manawatū bridge;

[9] https://www.nzta.govt.nz/assets/projects/sh3–manawatu/rma–consenting/Technical–Assessment–D–Hydrology.pdf (paragraph 261).

"*the 'bow-wave' upstream of Pier 2 results in a local water level increase of up to 1.4m in the design event … an increase in velocity, up to 1.5m/s, within the centre of the active channel*"[10],

while at the Mangamanaia Stream Bridge;

"*the construction of the bridge will cause water levels to increase by more than 0.5m over approximately 4600m² … these changes are within the existing floodplain… flooding exceeds 0.3m in this location for only 2.2-hours*"[11].

(b) The Flood Protection Department of GWRC use an informal guideline when assessing the significance of flood effects determined from computational hydraulic modelling. They generally consider a change in water level of no more than 0.1m for rural areas and 0.05m for urban areas when considering 'acceptable effects'.[12]

(c) The hydraulic assessment developed to support the consenting of the PP2Ō Expressway (2013) states:

"A fundamental principle … is that of hydraulic neutrality. What this means is that the impact of flood hazards from the Expressway should in general be no worse than in the current situation. This objective can sometimes be extremely difficult to achieve while still maintaining the required level of service for the Expressway. Where it has not been possible to achieve this desired objective, a fall-back position has been adopted whereby flood hazards that have been made worse are kept away from residential properties and instead redirected towards uninhabited rural areas." [13]

Regarding Mangapouri Stream the report states;

"*Where the predicted flood level for the 0.2% AEP flood adjusted for possible future climate change effects exceeds house floor levels in the primary flood storage basin with the Expressway, the 0.12m increase in floor level inundation would be modest in a relative sense for six of the affected properties as the predicted inundation depths in the existing situation are already large (0.31–0.98m). … In summary then, the effects of the*

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10 https://www.nzta.govt.nz/assets/projects/sh3–manawatu/rma–consenting/Technical–Assessment–D–Hydrology.pdf (paragraphs 35 & 36).

11 https://www.nzta.govt.nz/assets/projects/sh3–manawatu/rma–consenting/Technical–Assessment–D–Hydrology.pdf (paragraphs 50–54).

12 Conversation with James Flanagan, Senior Engineer, Flood Protection, GWRC.

13 Peka Peka to North Ōtaki Expressway – Assessment of hydraulic effects for major watercourse crossings. PP2O_vol3_TR9_Hydrology overview, January 2013 (paragraph 1.2).

Expressway crossing of the Mangapouri Stream and its ancillary features are minimal and acceptable."[14]

Regarding the Ōtaki River,

"*in a larger 0.2% AEP flood adjusted for possible future climate change effects to 2090 … the upstream flood levels in the basin would be about 0.3m higher than in the existing situation meaning that the depth of stopbank overtopping would be 0.3m greater in the Expressway situation over a distance of about 200m upstream of the bridge approach embankment for the Expressway. In summary, the effects of the proposed PP2Ō Expressway crossing of the Ōtaki River on flood levels in the Ōtaki River ….will be minimal and acceptable.*" [15]

184. These examples relate to major developments to the state highway network north and south of the Ō2NL Project respectively. These major infrastructure projects are also within the Horizons and Greater Wellington regions respectively. In both situations, the potential effects of the projects were greater than those assessed for the Ō2NL Project's conceptual design. Despite this, the argument presented regarding the interaction of the projects with the flood hazard was accepted by either the Board of Inquiry or the Environment Court.

185. It is therefore critical that any assessment of the potential effects of the Project on flooding considers the land–use context of the effect (i.e., the vulnerability or otherwise of potential receptors), the dynamic morphological context, and the potential impacts of local and downstream effects in terms of duration and spatial extent. These considerations were used to inform the adopted criteria.

186. As discussed at paragraph 115 of Technical Assessment F, the thresholds applied when considering the actual and potential effects of the Ō2NL Project on hydrology and flooding were influenced by the following factors:

    (a) Land-use and receptor type, which is predominantly rural especially close to the Project and proposed designation. Any existing building in an area potentially affected by the Ō2NL Project was given careful analysis.

[14] Peka Peka to North Ōtaki Expressway – Assessment of hydraulic effects for major watercourse crossings. PP2O_vol3_TR9_Hydrology overview, January 2013 (paragraph 1.4).

[15] Peka Peka to North Ōtaki Expressway – Assessment of hydraulic effects for major watercourse crossings. PP2O_vol3_TR9_Hydrology overview, January 2013 (paragraph 1.5).

(b) Topography, which is dominated by moderate gradients. This means that upstream backwater effects are short, and any downstream redistribution of flow occurs over a short distance of the floodplains.

(c) Duration of flooding, which is typically short because of the quick catchment response times and relatively steep topography. Most plant species are not expected to be sensitive to minor changes in the depth of inundation over such short durations.

(d) Extent or spatial scale of potentially impacted areas.

(e) Considering the core principles of the Project, which include Kaitiakitanga and to 'Tread Lightly, with the whenua'.

(f) Accuracy of the hydrological and computational hydraulic modelling used to assess the potential effects.

(g) Other factors, such as fluvial processes, sediment inputs and mobility, and channel dynamics and change.

All these factors provide context for the dynamic environment in which the potential effects of the Ō2NL Project must be evaluated.

Actual scale of potential effects

187. As discussed above, while the Project has maintained hydraulic neutrality in a practical sense, the current conceptual design would have a small effect on the existing flood hazard just outside of the designation in very few locations. While it is my professional opinion that these effects across the Project are 'less than minor', the Councils' technical advisers in their Section 87F and 198D reports, question this conclusion. It appears, that they believe that there should be no effects (irrespective of their magnitude) outside of the designation.

188. To inform the proposed NoR designations and decision-making around the resource consents necessary to construct the Ō2NL Project, a conceptual design for the highway has been developed within the proposed designations. This conceptual design has been used to provide an 'envelope' of potential effects to which the final design and construction of the highway must be in general accordance with.

189. The Ō2NL Project may cause a slight change in the existing flood hazard just outside of the designation in a few very small locations. These locations are

related to possible structures that have been proposed to allow the highway to cross various waterways.

190. Following detailed and comprehensive computational hydraulic modelling of the potential effects of the Ō2NL Project on Hydrology & Flooding (summarised in Technical Assessment F) it was concluded that the final highway could be constructed so that any effects outside of the designation could be considered '*less than minor*'. The reasons for this conclusion were that those few areas potentially affected:

    (a) Are small and of limited extent;

    (b) Are under pastoral land use with no significant capital investment;

    (c) Are generally already prone to flooding, or immediately adjacent to areas prone to flooding;

    (d) Any increase in the depth of flooding would be small, generally only a few centimetres;

    (e) Any increase in the duration of flooding would be short, generally less than an hour or two;

    (f) Given the above, the areas will recover rapidly from any increased inundation; and

    (g) The potential effects of the increased flood risk will be infrequent and only during very extreme events.

191. To provide further information and clarification of the small scale and magnitude of potential effects of the Project outside of the designation, results are provided below with respect to the Ohau River and a tributary of Waikawa Stream. These are two areas where any effects of the Project are greatest in terms of changes to the extent or depth of flooding, although still small and of short duration.

Ohau River

192. *Figure **18*** shows the flood hydrographs during two design events (i.e., 10% AEP under current climate and 1% AEP increased for the potential effects of predicted climate change). It also shows the channel of the Ohau River and the adjacent floodplain at the upstream extent of the designation. This is the area where any potential effects of the Project outside of the designation

would be greatest. This figure highlights the potential effects of the current conceptual design of the Project by comparing flooding under the current environment with that once the Project is constructed. The effects of the final design, and following construction, will have to be 'in general accordance' with the effects shown. The reason the initial water level is about 36mRL is because this is the ground elevation near the edge of the channel under median flow conditions where the results were extracted.

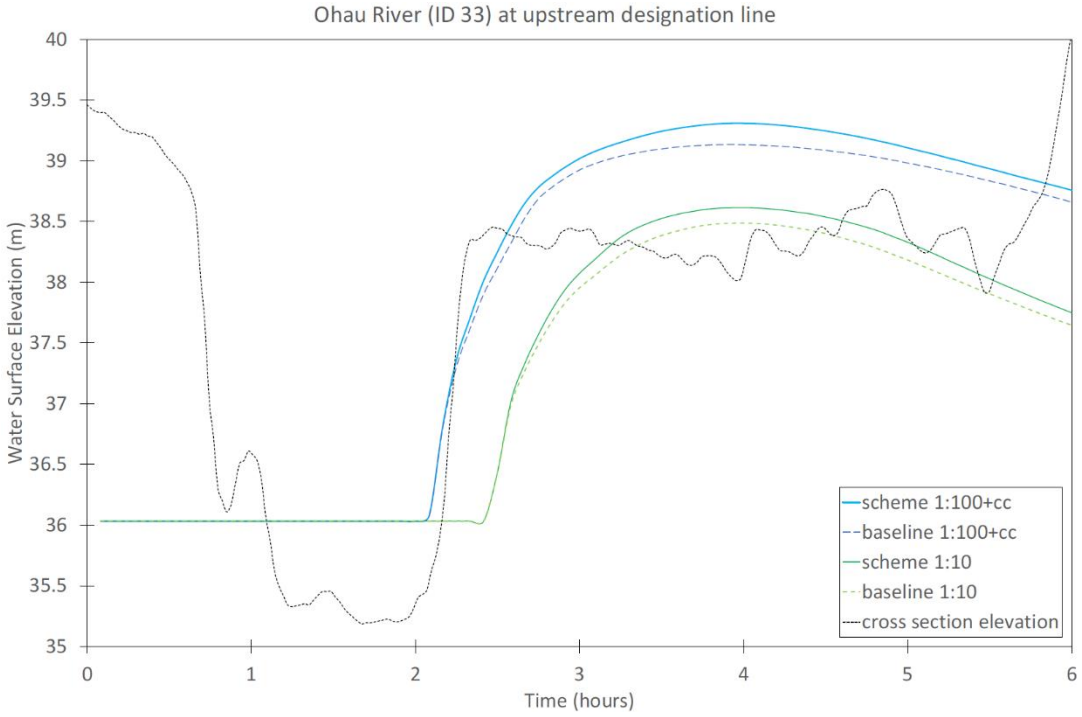

Figure 18: Hydrographs during two design events in the Ohau River and over the adjacent floodplain at the upstream extent of the designation.

193. The floodplain on the true right bank, i.e., the right bank looking downstream which is lower than the adjacent bank, because of the rapid onset of flooding, gets inundated about 5–minutes earlier following construction of the Project. The slower rate of recession, which rapidly reaches a constant rate caused by the drainage properties of the floodplain, means that inundation persists for about 15–minutes longer after the Project is constructed. Therefore, the total increase in the duration of inundation on this cross-section is approximately 20–minutes. The maximum increase in depth of inundation is about 200mm and this is within an area that already floods under the existing environment. Both these measures of inundation, although already small, decrease rapidly with increasing distance upstream of the designation.

194. These changes to inundation at this cross–section are placed in a spatial context in *Figure **19*** & *Figure **20***.

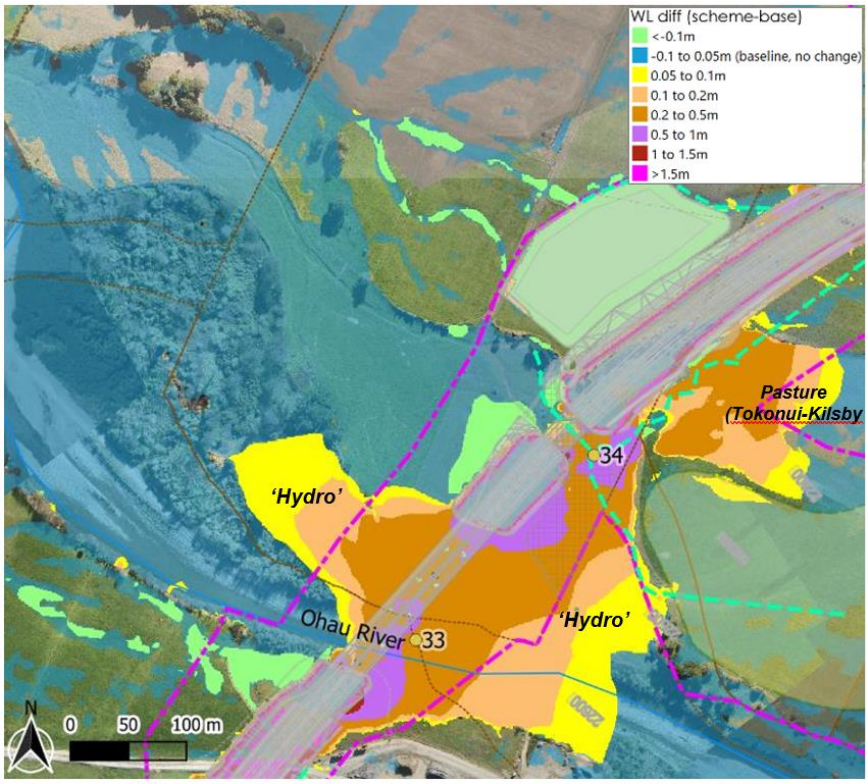

Figure 19: Change in the depth of inundation from the Project adjacent to the Ohau River during the 1% AEP design event. The designation is shown by the 'purple' dashed line.

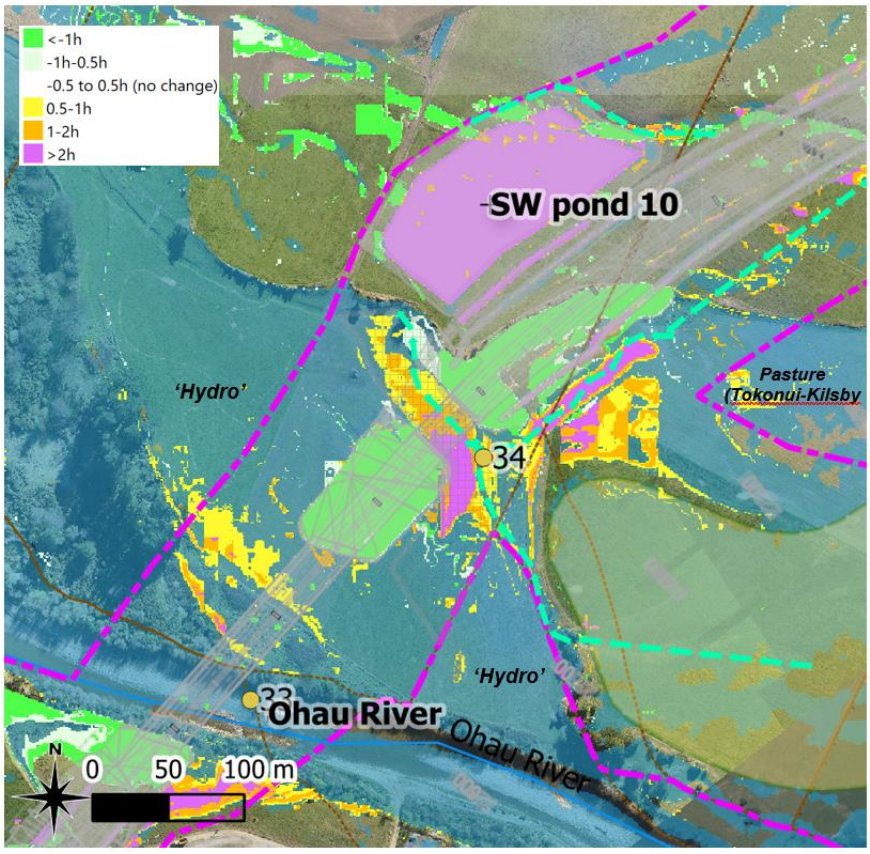

Figure 20: Change in the duration of inundation from the Project adjacent to the Ohau River during the 1% AEP design event. The designation is shown by the 'purple' dashed line.

195. The maximum increase in the depth of inundation is about 200mm, consistent with that shown in Figure **18**, but this decreases rapidly to <100mm. Most of the potentially impacted pasture outside of the designation on the floodplain of the Ohau River appears to have no ownership listed on the LINZ database. This is labelled 'hydro' and is likely in Crown ownership relating to the river corridor. The increased duration of inundation in this area is less than 30–minutes.

196. There is a small area to the east in the figures shown as 'pasture' owned by Tokonui/Kilsby. While the maximum increase in the depth of inundation is still only 200mm, flooding of this area could persist for up to 1–hour longer than under the current environment. This is because of perched overland flow attenuation against the highway embankment. Given the extreme nature of the design event, these small changes to the depth and duration of inundation in a few small areas are considered 'less than minor'.

Waikawa Stream tributary

197. The same analysis as described above was also undertaken for a tributary of Waikawa Stream (ID 27.1) where the potential effects of the Project outside of the designation have been shown to be greatest. Figure **21** shows the hydrographs during two design events (i.e., 10% AEP under current climate and 1% AEP increased for the potential effects of predicted climate change). It also shows the channel of Waikawa Stream and the adjacent floodplain at the upstream extent of the designation. This figure highlights the potential effects of the current conceptual design of the Project by comparing flooding under the current environment with that once the Project is constructed. The effects of the final design and following construction will have to be 'in general accordance' with the effects shown.

198. Because of the topography in this area, and particularly the overflow channel and depression on the floodplain, there is a localised area where the increased depth of inundation is up to 0.5m. Because this depression on the floodplain fills with water in such an extreme event, it also takes longer to drain. The duration of existing inundation in parts of this area is up to six hours, although the period of increased inundation is only about three hours.

199. The spatial extent of any change in the duration of inundation (Figure **23**) is similar to the pattern of water level change (*Figure **21***), as would be expected. This forms a relatively narrow band (about 25m) upstream of the designation. Apart from the small area discussed above relating to the

tributary and overflow channel on the floodplain, the increased duration of inundation is up to three hours along the designation but decreases rapidly upstream (Figure **23**).

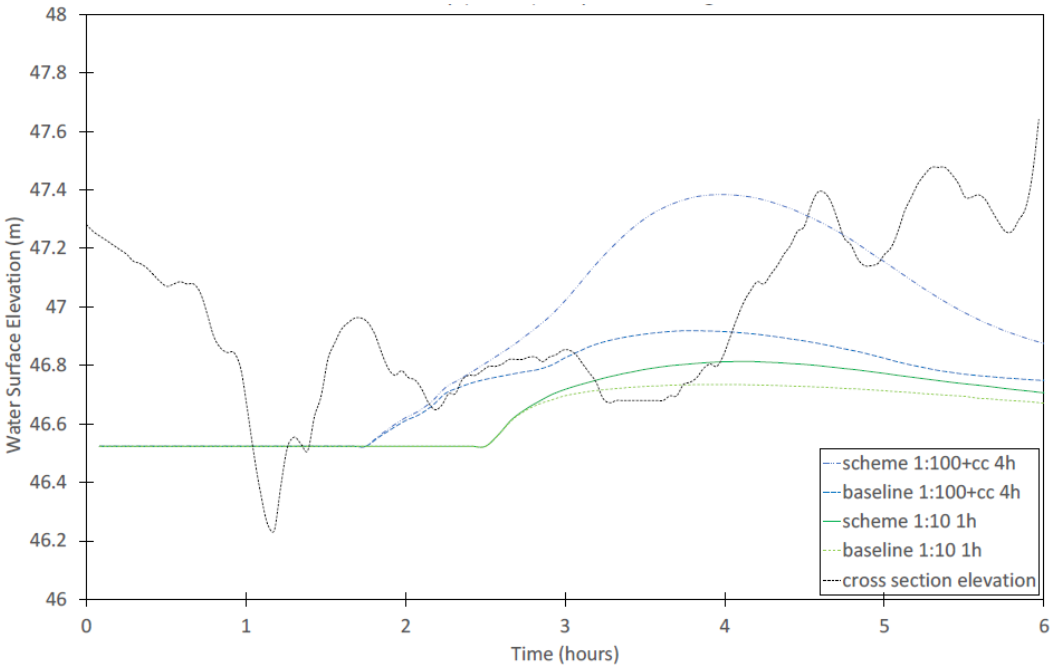

Figure 21: Hydrographs during two design events in the Waikawa Stream tributary and over the adjacent floodplain at the upstream extent of the designation.

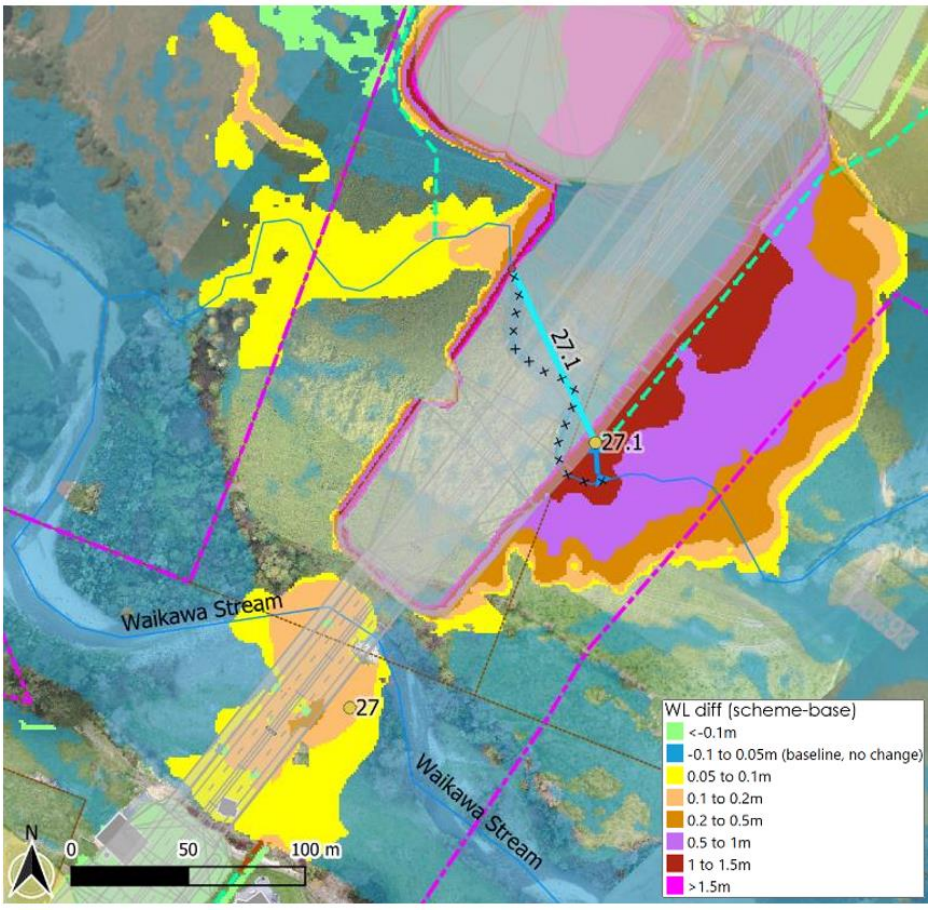

Figure 22: Change in the depth of inundation from the Project adjacent to Waikawa Stream during the 1% AEP design event. The designation is shown by the 'purple' dashed line.

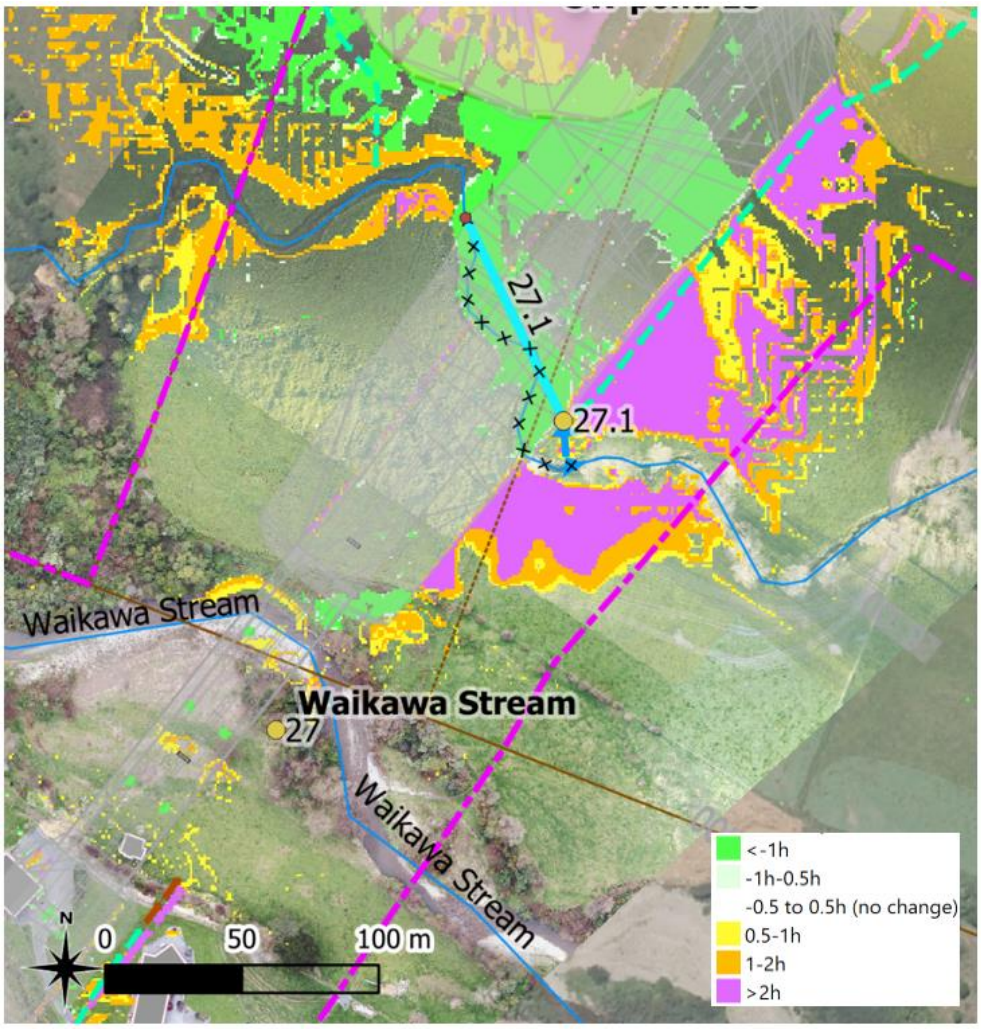

Figure 23: Change in the duration of inundation from the Project adjacent to Waikawa Stream during the 1% AEP design event. The designation is shown by the 'purple' dashed line.

200. Running the model simulations for longer would not alter the above results and conclusions for any areas outside of the designation. This is because after a run-time of 6 hours, all the effects of the Project are contained within the designation. The duration of flooding outside of the designation is therefore less than 6 hours, and probably no more than 2–3 hours.

201. The above examples were chosen to represent areas where the potential effects of the Project, assuming the current conceptual design, are greatest. In all other areas showing increased flood levels upstream of the proposed designation, the increased duration of inundation will be generally less than one hour.

Refinement of design

202. As discussed, a concept design for the Project has been developed to establish an umbrella of potential effects under which the final design must be in general accordance with. The final design will need to meet the minimum specifications required by various conditions including those in:

    (a) NZTA P46 Stormwater Specification (2016), and the Agency's Stormwater Treatment Standard for State Highway Infrastructure' (2010) required by condition RSW1;

    (b) The Agency's Bridge Manual (2013, V3 with amendments up to May 2022) required by condition RBS1; and

    (c) The Agency's Bridge Manual (2013, V3 with amendments up to May 2022), P46 Stormwater Specification (2016), and Stormwater Treatment Standard for State Highway Infrastructure' (2010) required by condition RWB1.

203. The adoption of these minimum requirements to inform the final design of the Project will ensure that any effects on hydrology and flooding are no greater than assessed in Technical Assessment F and this evidence.

Summary

204. Despite complexities arising from the nature of the Project area and the existing flood hazards, in practical terms, hydraulic neutrality has been achieved through the Project design process. Any residual effects of the Project are likely to be reduced further during detailed design.

205. The current conceptual design of the Project ensures that existing flooding risks to people and buildings are made no worse. The few small areas where the effects from the conceptual design are marginally greater are all uninhabited areas of farmland. Any effects will be infrequent and of very short duration.

206. Based on the above analysis and discussion, it is considered reasonable to regard any potential effects of the Project outside of the designation as 'less than minor'.

Response to section 87F report of Peter Kinley

207. At paragraph 23 of his report, Mr Kinley agrees that the hydrological and computational hydraulic modelling undertaken and presented in Technical Assessment F is consistent with current industry best practice. He also agrees with how the various boundary conditions were managed, including the consideration of the potential effects of climate change over the life of the Project.

208. Mr Kinley's concerns relate primarily to the interpretation of the significance of the scale of effects identified in Technical Assessment F and addressed in this evidence, as well as the nature of the design event selected to assess effects.

209. At paragraphs 25–26 of his report, Mr Kinley questions the choice of the design event used in developing the design of the Project and the assessment of environmental effects. It is suggested that the design event should have been the 0.5% AEP event, increased to allow for the predicted effects of climate change.

210. As discussed in paragraph 160–170 of this evidence, and the planning evidence of **Mr Grant Eccles**, the design event adopted by the Project is 25% larger than that required by the One Plan.

211. Mr Kinley refers to the Australia Rainfall and Runoff Guidelines, but in my view those guidelines are arbitrary in the New Zealand context.

212. At paragraph 27–33 of his report, Mr Kinley argues that a suite of storm events should have been analysed to fully understand the range of effects of the Project.

213. As discussed in Technical Assessment F, the development of the design and assessment of effects of the Project were considered against three design events, i.e., 10% AEP (current climate), 1% AEP (with 100–years of climate change) and 0.07% AEP (1,500–year with 100–years of extreme climate change, i.e., RCP 8.5).

214. I consider that this range of design events, as explained in Technical Assessment F, provides for a realistic assessment of the potential effects of the Project. It also provides an umbrella within which the potential effects of any other design event will lie. The assessment has shown that the potential effects, even under the 1% AEP event including climate change, will be less

than minor (as I have discussed above). Therefore, in my opinion, consideration of other smaller scale events will add no additional information relevant to the assessment.

215. At paragraphs 34–45 of his report, Mr Kinley questions the thresholds used to identify effects. However, as stated in Technical Assessment F, these thresholds were simply used to identify areas where the potential effects of the Project were investigated in more detail. These detailed investigations considered both the magnitude of any potential effect and the receptor, i.e., the 'environment', that is impacted.

216. As discussed at paragraph 160 of this evidence, with respect to the magnitude of the design event, assessing the potential effects of the Project involves both planning and technical contexts. **Mr Eccles** provides a summary of the planning context within his evidence.

217. A summary of the technical approach adopted when assessing potential effects, and the actual scale of the potential effects at two locations where these are shown to be greatest are provided in paragraphs 171–201 of this evidence.

218. The result of the technical assessment is provided at paragraphs 204–206 of this evidence. I therefore consider it is reasonable to regard any potential effects of the Project outside of the designation as negligible and in my opinion 'less than minor'.

219. At paragraphs 51–56 of his report, Mr Kinley questions the assessment of freeboard and the implications of debris. However, this largely ignores two key considerations:

    (a) Currently, there is only a conceptual design for the Project. This has been developed to show that a final design can be developed for the highway within a maximum umbrella of effects. Consequently, to focus on key design parameters of potential structures which may be modified during final design, or not built at all, is in my opinion, not appropriate.

    (b) All 'hydraulic structures' built as part of the Project will have to meet the minimum requirements of various 'specification documents' as required by conditions RBS1 and RWB1 and summarised in paragraph 202 above.

220. At paragraphs 57–62 of his report, Mr Kinley questions the assessment of the provision of scour protection and its potential effects. This issue is similar to that relating to freeboard. The response of the Project to the issue of freeboard is summarised in paragraph 219 of this evidence. Scour will be considered and mitigated in a manner consistent with the requirements of condition RBS1.

221. At paragraphs 63–70 of his report, Mr Kinley questions the assessment of the effects of the proposed works on the flooding of buildings. As acknowledged by Mr Kinley in his paragraph 63, referring to paragraph 115(a) of Technical Assessment F, *"[a]ny existing building in an area potentially affected by the Ō2NL Project was given careful consideration."* This indicates that a precautionary approach was taken when assessing the potential effect of the Project on the flooding of buildings.

222. This detailed assessment showed, also quoted by Mr Kinley, that *"[n]o buildings outside of the proposed designations are impacted by the modelled increase in flood levels for the 1% AEP event with climate change RCP 6.0 to 2130."* It is worth noting that this conclusion is not inconsistent with the other statement quoted by Mr Kinley that *"[t]here are no existing buildings with discernible increases in flood risk"*. In this case, 'discerning' the increase in flood risk has been undertaken using the computational hydraulic model and the comparison of the baseline and 'developed' scenarios.

223. At paragraphs 71–76 of his report, Mr Kinley discusses the use of debris arrestors. Again, this is asking for a level of detail relating to the final design of the Project which is currently not available. The response of the Project to the issue of debris arrestors is summarised in paragraph 219 of this evidence. The need for debris arrestors, their design and construction, and the mitigation of any potential effects will all be in a manner consistent with the NZTA Bridge Manual.

Response to section 198D report of John McArthur

224. At paragraph 23 of his report, Mr McArthur agrees that the hydrological and computational hydraulic modelling undertaken demonstrates best practice.

225. Mr McArthur raises a number of same issues as Mr Kinley. I do not propose repeating the information already provided above, however, the appropriate paragraphs of this evidence are referenced for clarity.

226. The issues raised by Mr McArthur are:

(a) The magnitude of the design flood event used in developing the conceptual design and assessing the potential effects of the Project. This matter is discussed fully in paragraphs 160–170 of this evidence.

(b) The scale and 'acceptability' of effects of the Project on flooding. This matter is discussed fully in paragraphs 171–201 of this evidence.

(c) Insufficient information being provided on which to provide an informed opinion. This matter is discussed in paragraphs 187–201 of this evidence.

227. Having considered the section 87F and 198D reports provided by Mr Kinley and Mr McArthur, I believe that the issues raised have been fully addressed. In my opinion, there are no matters which require more detailed investigation or analysis.

228. Despite complexities arising from the nature of the Project area and the existing flood hazards, in practical terms, hydraulic neutrality will be achieved through the Project design process.

229. The current conceptual design of the Project ensures that there are no increased risks of flooding to people and buildings. The few small areas where the effects from the conceptual design are marginally greater are all uninhabited areas of farmland. Any effects will be infrequent and of very short duration.

230. I therefore believe that it is reasonable to regard any potential effects of the Project outside of the designation as 'less than minor'.

Hydrogeology & Groundwater

231. The section 87F report to Horizons and GWRC on matters relating to the effect of the Project on hydrogeology and groundwater, and *vice versa*, was prepared by Mr Jonathan Williamson.

232. At paragraph 18, Mr Williamson states that:

"*In my opinion, the activities that have the greatest potential to cause environmental effects have all be identified and considered by Waka Kotahi, with the exception of dewatering timeframes for culverts and the spoil and borrow areas, The development of management plans by Waka Kotahi, to be certified by the regional councils, coupled with monitoring and reporting requirements, will provide assurance*

that the effects on groundwater can be appropriate managed during both construction and operation of the Ō2NL Project."

233. Mr Williamson is therefore generally in agreement with the information, analyses, and conclusions provided in Technical Assessment G, and summarised in this evidence.

234. I therefore propose to only address those areas where Mr Williamson either seeks further clarification or amendments to the proposed conditions.

235. At paragraphs 30–37 of his report, Mr Williamson discusses the potential effects of excavations below the groundwater table. At paragraph 41 of Technical Assessment G, a number of hydrological and hydrogeological principles that have informed the development of the conceptual design of the Project are listed. These include:

    (a) Maintaining the existing water balance, i.e., the input, output and storage of water;

    (b) Avoiding any direct interaction with the groundwater system, where practical;

    (c) Maintaining existing hydraulic connections in both surface water and groundwater;

    (d) Maintaining, and where practical enhancing, the existing hydraulic connections between surface water and groundwater;

    (e) Improving the quality of groundwater, where practical; and

    (f) Maintaining, and where practical improving, the quality and quantity of groundwater entering Punahau / Lake Horowhenua.

    These same principles will be applied to the final design of the Project.

236. It should be noted that, to meet these principles, the Project will avoid any direct interaction with groundwater. This does not preclude the possibility of cuts in areas where the maximum level of the groundwater is below the bottom of the cut, and the cut will have no interaction with groundwater.

237. Irrespective of this approach to the final design of the Project, Mr Williamson believes that the proposed conditions RGW1 and RGW3 should address any residual issues.

238. At paragraph 37 of his report, Mr Williamson suggests an amendment to the proposed condition RGW2 to include wetlands. In my opinion, however, this amendment is not required. The very few small wetlands potentially affected by the Project in a manner that cannot be considered 'less than minor' have been assumed to be 'lost'. This loss of wetland habitat will be compensated for within the terrestrial and wetland ecology offset and compensation package discussed by **Mr Goldwater**. This is acknowledged by Mr Williamson in his paragraph 33. It should also be noted that this is an extremely conservative assumption since in most cases, while these wetlands might be impacted, they will not be lost or destroyed.

239. RGW2 also specifically aims to protect the *'quality, maximum quantity and maximum rate of abstraction*' from bores. To include consideration of wetlands within this condition is therefore not appropriate.

240. At paragraph 38–41 of his report, Mr Williamson addresses dewatering, and particularly the duration of any dewatering to allow the installation of culverts. While I recognise the apparent 'open-ended' nature of dewatering permitted under RGW1, there are a number of practical considerations that will avoid dewatering persisting for longer than necessary. These include the cost of both plant and pumping. There is an implicit incentive for the contractor to keep these costs as low as possible, i.e., the duration of dewatering as short as possible.

241. Also, it is impossible to anticipate the weather conditions that might be experienced during installation of any culvert. Therefore, while best endeavours will be made to keep the duration of pumping as short as possible, a maximum acceptable duration is impossible to define which would accommodate the vagaries of the weather.

242. Consequently, I do not believe that a limitation on the duration of dewatering is required. A limit of two months as suggested by Mr Williamson is likely to be 'excessive' and therefore redundant. Such a limitation would provide no practical limitation on the potential environmental effects.

243. At paragraph 41 of his report, Mr Williamson suggests amending RGW3 a)ii to read *"at a sampling and reporting frequency agreed with the consent authorities that is appropriate to the scale, intensity and duration of the works programme."* I believe this to be a reasonable suggestion as it explicitly links the monitoring required to the scale of potential effects.

244. At paragraph 42–50 of his report, Mr Williamson addresses both the functioning and effects of the disposal of stormwater to ground. Given the conceptual nature of the current design for the Project and stormwater treatment devices, there is some residual uncertainty. The location and effectiveness of these devices can only be resolved during final design.

245. It should be noted that stormwater treatment and discharge to ground has only been proposed on the 'Ohau fan', i.e., from the north bank of the Ohau River to approximately Queens Street East. In this area there are few streams, and the generally coarse gravel allows effective soakage. Soakage is also the preferred means of stormwater treatment and management in this area to maintain, and potentially enhance, groundwater flow to Punahau / Lake Horowhenua.

246. Therefore, I agree with Mr Williamson at paragraph 48 of his report, that a new clause b) could be added to RSW1 that explicitly states that the stormwater treatment devices must not cause or exacerbate flooding. For example, *"[t]he dedicated stormwater management devices required by clause (a) must be designed, located and operated in a manner that will not cause or exacerbate flooding."*

247. I also agree with Mr Williamson at paragraph 49 of his report that a new clause be added to RSW2. A clause b) v should be added which requires description of *"natural groundwater level in metres below finished ground level, where soakage to ground is practiced."*

248. At paragraph 50 of his report, Mr Williamson suggests that a Stormwater Soakage Device Management Plan be developed for the Ō2NL Project. However, the final design and placement of soakage devices must be consistent with best practice as defined in Waka Kotahi NZ Transport Agency's '*Stormwater Treatment Standard for State Highway Infrastructure'* dated May 2010 and P46 Stormwater Specification (2016) as required by condition RSW1.

249. Additional information on the design principles and specifications is also provided in the evidence of **Mr Nick Keenan**. I therefore do not think that the Stormwater Soakage Device Management Plan suggested by Mr Williamson is required.

250. At paragraph 61 of his report, Mr Williamson identifies that the bore supplying the Glenmorgan Water Supply Scheme lies within the proposed designation.

It is not proposed to decommission this bore. However, to ensure the continued supply of water to the east of the Project, the principal demand area, provision will be made in the final design for the associated pipework to pass under the highway. Waka Kotahi is in discussion with the Glenmorgan Water Supply Scheme as to the best option to maintain their existing water supply.

251. Mr Williamson has identified the current lack of detailed information relating to potential borrow pits. I agree with Mr Williamson that further information and a detailed Council certification process are required with respect to the design and proposed monitoring of these sites.

252. At paragraph 67–81 of his report, Mr Williamson discusses the potential effects of the proposed abstraction of water to support the construction of the Project on groundwater.

253. His conclusion is that any effects of what was proposed within the consent application on groundwater would be 'immeasurable'. Despite this, following the section 87F reports from Mr Thompson (GWRC) and Ms Stout (Horizons), some changes have been suggested below regarding how the abstraction of surface water to support construction of the Ō2NL Project will be managed. These changes will reduce any potential effects, which were already unlikely to be measurable, even further.

254. At paragraph 87–92 of his report, Mr Williamson discusses the submissions received relating to the potential effects of the Project on groundwater.

255. Mr Williamson's conclusions are consistent with those presented in paragraphs 139–157 of this evidence. There are only two submitters where Mr Williamson considers that the Project may have adverse effects of their bores and groundwater supplies.

256. I accept Mr Williamson's conclusion that any effects on the McAlister/Miles bore will only be during the construction phase of the Project. However, I believe that the existing road and distance from the Project will provide a sufficient buffer to avoid any potential effects. Irrespective of these factors, any inherent uncertainty regarding potential effects on water quality and yield are addressed by condition RGW2. Consequently, in my opinion, no additional measures are required.

257. With regard to the bore of Merie Cannon and Trevor Guy, the Project has agreed (in principle) with the landowner to relocate the bore, upgradient of

the proposed highway. Consequently, there will be no effects from the Project on the yield or quality of water from the submitter's bore.

Abstraction of surface water

258. During construction of the Ō2NL Project, water will be required to support several activities relating to the earthworks and pavements. The demand for water is expected to be considerably smaller at the start of construction and increase as the Project progresses. It is anticipated that water will be required:

    (a) For dust suppression to meet compliance requirements, and for the health and safety of workers;

    (b) To achieve maximum compaction density of pavements and fills;

    (c) To condition any fill to meet geotechnical requirements;

    (d) To hydrate and activate cement for stabilisation processes; and

    (e) For lubrication of machine rollers so that the material does not stick.

259. Given that that the precise construction methodology has not been specified, and the demand for construction water is intimately related to weather conditions, there is some uncertainty as to the exact volume of water that might be required, and considerable daily variability is expected. It is noted that only the minimum volume of water required to meet very specific purposes will be abstracted and that water will only be abstracted over the duration of the Project construction period.

260. The overall strategy for managing water demand is to firstly minimise requirements and then to utilise water that becomes available to the Project through existing consented takes (from boreholes or takes that are authorised to occur on land that is acquired to allow construction of the Ō2NL Project). Additional opportunities to recycle water collected on site through dewatering and erosion and sediment control devices will also be explored. However, it is unknown how much water will become available through these sources.

261. Given the inherent uncertainty of the requirement for construction water, the risk associated with balancing the supply and demand for water, potential periods of restricted abstraction caused by low flows, and the nature of resource consents which specify maximum rates of abstraction, a water

permit for the maximum potential volume that may be required is being sought. This will ensure that the Project can be practicably constructed.

262. It is estimated that an average daily abstraction of 2,350m^3 of water, with a maximum daily abstraction of 3,900m^3, across all water sources will be required to support construction of the Ō2NL Project. These volumes equate to continuous average abstraction rates of 27L/s and 45L/s, respectively.

263. The total abstraction will be taken from a combination of the water available from five rivers and streams in the Project area. The abstraction from any specific stream will be consistent with the requirements of the relevant planning policies and rules.

264. To place this water demand in context, it represents between 0.46% and 0.76% of the combined median daily flow of these rivers and streams. Also, the average daily demand is equivalent to that considered 'reasonable', by GWRC and Horizons, to irrigate only 47ha of pasture (i.e., 5mm per day).

265. It should also be noted that abstraction will also be limited by the availability of storage to hold the water, and actual demand for construction. These constraints make this abstraction distinctly different to that used to support irrigation, for example.

266. The following strategy has been proposed to reflect the core principles developed for the Ō2NL Project and described in the CEDF:[16]

    (a) Seek to minimise water requirements for construction by careful selection of methodology and programming work (Tiaki – Preserve what we have).

    (b) Use of water that is currently available by reusing water that is collected through Erosion and Sediment Control (ESC) devices including dewatering activities (associated with earthworks including material supply sites) (Whakaora – Restore to whenua where resource derived).

    (c) Use water that is available currently on land that is occupied by the Project, notably roof rainwater collection and using water from bores and other industrial activities underway (Whakaora – Restore to whenua where resource derived).

[16] Cultural and environmental design framework (Appendix Three to Volume II of the application).

(d) Take water from streams and rivers as a last resort and on the following basis:

i. Low rates of abstraction to storage facilities to meet residual Project requirements *(rangātiratanga and kaitiakitanga)*;

ii. Store water for use during the dry periods so as to be able to continue working during the summer (prime construction season) *(rangātiratanga and kaitiakitanga)*;

iii. This approach allows water to be only taken when there is available resource, i.e., no abstraction below minimum flow so that there is enough water remaining to not adversely affect mauri of the waterways *(kaitiakitanga)*;

iv. Take water using methods that avoids effects on fish (including risk of pollutants entering watercourses) *(kaitiakitanga)*;

v. Use water in the catchment derived (as far as practicable) *(Whakaora – Restore to whenua where resource derived).*

267. Application of the above principles and strategy led to the proposal and draft consent conditions included in the application for resource consents.

268. Both Mike Thompson (GWRC) and Michaela Stout (Horizons) have provided detailed section 87F reports which examine the proposed regimes for the abstraction of construction water from the rivers and streams in their respective regions.

269. These reports identify that the requested volume of water is available from both the core allocation and as a supplementary allocation in the relevant plans. However, despite the precautionary approach adopted by the Project, both Mr Thompson and Ms Stout suggest additional constraints to reduce any potential environmental effects, which are recognised as likely being small, even further.

270. These constraints include the distinctive character of the various rivers and streams, which include both reaches that gain and lose water, and the distance of the flow recorders on the different streams from the point of abstraction. The constraints are the result of the limited hydrometric data available to resolve some of the hydrometric processes to the level considered necessary by the Councils. As a result of the discussion provided

by Mr Thompson and Ms Stout, revised abstraction regimes for the various rivers and streams are proposed.

271. It should be noted that these abstraction regimes aim to:

    (a) Provide the volume of water required to support construction of the Project;

    (b) Be consistent with the principles and strategy described above for the Project;

    (c) Be clear and easy to implement; and

    (d) Be transparent and allow easy compliance monitoring.

Waitohu Stream

272. At paragraph 62 of his report, Mr Thompson argues that he *"considers the existing allocation and minimum flow limits in the Waitohu Stream catchment to be generally appropriate for managing the cumulative adverse effects of all takes."* However, he does, *"not consider that this translates into an automatic assumption that an individual take complying with those limits will have a less than minor effect."* The same inference can be taken from Ms Stout's section 87F report.

273. To address the residual uncertainty regarding even the small potential effects of abstraction identified by Mr Thompson (paragraphs 47–56), the following management regime is proposed for the abstraction of construction water from Waitohu Stream:

    (a) A maximum daily abstraction from the core allocation of 2,160m³ day. This is approximately two-thirds of the allocation available currently and so leaves additional water for future allocation;

    (b) When combined with all other allocations to support construction of the Project, total abstraction must not exceed an average of 2,350m³, and a maximum of 3,900m³;

    (c) All abstraction must cease once the flow measured at GWRC's hydrometric site reaches the minimum flow;

    (d) Between the minimum and median flows, the rate of abstraction should not exceed 10% of the mean daily flow measured at GWRC's hydrometric site over the preceding day, adjusted for losses or gains

between the hydrometric site and the point of abstraction. The rate of abstraction cannot exceed 37.5L/s. This will ensure that abstraction is consistent with the GWRC proposed Natural Resources Plan (pNRP) requirement for abstractions to reduce as the minimum flow is approached. It also ensures that abstraction is consistent with management being related to instantaneous rather than average daily flows;

(e) When flow measured at GWRC's hydrometric site exceeds the median, up to 10% of the 3–hourly average flow can be abstracted as a supplementary allocation for the next 3 hours, once adjusted for travel time between the flow recorder and the point of abstraction.

(f) The maximum abstraction when flow is above the median cannot exceed 100L/s. This will ensure that abstraction has no effect on the FRE3 i.e., the frequency of flows greater than three times the median. The median flow listed in Table 2 of Schedule U of the pNRP is 450L/s so three times this is 1350L/s. Since 100L/s is about 7% of this, the abstraction of this volume would not be able to be measured since open channel flow measurements are generally regarded as being ±8%.

(g) A flow meter must be installed and maintained and must:

i. Be located on the abstraction line;

ii. Have a pulse counter output traceably calibrated to plus or minus (±) five (5) percent or better, and

iii. Be capable of providing daily water use as well as pulse counter data.

(h) A record of the daily volume of water abstracted and rates of water abstracted must be maintained and provided to the Regional Council and Project Iwi Partners on request.

(i) The consent should be surrendered following completion of construction, or after 10–years, whichever comes first.

Manakau / Waiauti Streams

274. To address the inherent uncertainty and small potential adverse effects of the abstraction of water to support construction of the Project identified by Ms Stout, the following is proposed to manage abstraction from Manakau / Waiauti Streams:

(a) A maximum daily abstraction from both streams from the core allocation of 102m³. This is approximately two-thirds of the allocation available currently and so leaves water available for future allocation.

(b) When combined with all other allocations to support construction of the Project, total abstraction must not exceed an average of 2,350m³, and a maximum of 3,900m³.

(c) All abstraction must cease once the flow measured at Horizon's hydrometric site at Gleeson's Road reaches the minimum flow. Since the proposed abstraction will occur upstream of the hydrometric site, this will provide additional mitigation of any potential effects.

(d) Between the minimum and median flows, the rate of abstraction from either site should not exceed 10% of the mean daily flow measured at Horizon's hydrometric site over the preceding day, once adjusted for the effect of catchment area;

(e) When flow measured at Horizons' hydrometric site exceeds the median, up to 10% of the preceding 3–hourly average flow can be abstracted as a supplementary allocation for the next 3 hours.

(f) The maximum abstraction when flow is above the median, across both sites, cannot exceed 50L/s.

(g) A flow meter must be installed and maintained and must:

i. Be located on the abstraction line;

ii. Have a pulse counter output traceably calibrated to plus or minus (±) five (5) percent or better, and

iii. Be capable of providing daily water use as well as pulse counter data.

(h) A record of the daily volume of water abstracted and rates of water abstracted must be maintained and provided to the Regional Council and Project Iwi Partners on request.

(i) The consent should be surrendered following completion of construction, or after 10–years, whichever comes first.

Waikawa Stream

275. To address the inherent uncertainty and small potential adverse effects of the abstraction of water to support construction of the Project identified by Ms Stout, the following is proposed to manage abstraction from Waikawa Stream:

(a) A maximum daily abstraction from the core allocation of 3,100m³. This is approximately two-thirds of the allocation available currently and so leaves additional water available for future allocation.

(b) When combined with all other allocations to support construction of the Project, total abstraction must not exceed an average of 2,350m³,and a maximum of 3,900m³.

(c) All abstraction must cease once the flow measured at Horizon's hydrometric site at North Manakau Road reaches the minimum flow.

(d) Between the minimum and median flows, the rate of abstraction should not exceed 10% of the mean daily flow measured at Horizon's hydrometric site at North Manakau Road over the preceding day, adjusted for losses or gains between the hydrometric site and the point of abstraction.

(e) When flow measured at Horizons' hydrometric site exceeds the median, up to 10% of the preceding 3–hourly average flow can be abstracted as a supplementary allocation for the next 3 hours, once adjusted for travel time between the flow recorder and the point of abstraction.

(f) The maximum abstraction when flow is above the median cannot exceed 100L/s.

(g) A flow meter must be installed and maintained and must:

i. Be located on the abstraction line;

ii. Have a pulse counter output traceably calibrated to plus or minus (±) five (5) percent or better, and

iii. Be capable of providing daily water use as well as pulse counter data.

(h) A record of the daily volume of water abstracted and rates of water abstracted must be maintained and provided to the Regional Council and Project Iwi Partners on request.

(i) The consent should be surrendered following completion of construction, or after 10 years, whichever comes first.

Ohau River

276. To address the inherent uncertainty and small potential adverse effects of the abstraction of water to support construction of the Project identified by Ms Stout, the following is proposed to manage abstraction from the Ohau River:

(a) No abstraction below the median flow since there is no available core allocation.

(b) When flow measured at Horizons' hydrometric site at Rongomatane exceeds the median, up to 10% of the preceding 3–hourly average flow can be abstracted for the next 3 hours, once adjusted for travel time between the flow recorder and the point of abstraction.

(c) The maximum abstraction when flow is above the median cannot exceed 100L/s.

(d) A flow meter must be installed and maintained and must:

i. Be located on the abstraction line;

ii. Have a pulse counter output traceably calibrated to plus or minus (±) five (5) percent or better, and

iii. Be capable of providing daily water use as well as pulse counter data.

(e) A record of the daily volume of water abstracted and rates of water abstracted must be maintained and provided to the Regional Council and Project Iwi Partners on request.

(f) The consent should be surrendered following completion of construction, or after 10 years, whichever comes first.

Koputaroa Stream

277. To address the inherent uncertainty and small potential adverse effects of the abstraction of water to support construction of the Project identified by Ms Stout, the following is proposed to manage abstraction from the Koputaroa Stream:

(a) A maximum daily abstraction from the core allocation of 231m³. This is approximately two-thirds of the allocation available currently and so leaves additional water available for future allocation.

(b) When combined with all other allocations to support construction of the Project, total abstraction must not exceed an average of 2,350m³, and a maximum of 3,900m³.

(c) All abstraction must cease either when:

i. The flow measured at Horizon's hydrometric site on the Manawatū River at Teachers' College reaches the minimum flow; or

ii. The flow measured at the Project's hydrometric site on Koputaroa Stream at Tavistock Road reaches the minimum flow, calculated in manner consistent with that adopted in the One Plan.

(d) Between the minimum and median flows, the rate of abstraction should not exceed 10% of the mean daily flow measured at the Project's hydrometric site at Tavistock Road over the preceding day, adjusted for losses or gains between the hydrometric site and the point of abstraction. Since the proposed abstraction will occur upstream of the hydrometric site, this will provide additional mitigation of any potential effects.

(e) When flow measured at the Project's hydrometric site at Tavistock Road exceeds the median, up to 10% of the preceding 3–hourly average flow can be abstracted for the next 3 hours. Note that the flow recorder at Tavistock Road is downstream of the point of abstraction and so it is impossible to apply any lag.

(f) The maximum abstraction when flow is above the median cannot exceed 30L/s.

(g) A flow meter must be installed and maintained and must:

i. Be located on the abstraction line;

ii. Have a pulse counter output traceably calibrated to plus or minus (±) five (5) percent or better, and

iii. Be capable of providing daily water use as well as pulse counter data.

(h) A record of the daily volume of water abstracted and rates of water abstracted must be maintained and provided to the Regional Council and Project Iwi Partners on request

(i) The consent should be surrendered following completion of construction, or after 10 years, whichever comes first.

CONCLUSION

278. In my professional opinion, the Project will have effects on hydrology and flooding, groundwater, and the continuity of streamflow that will be 'less than minor'. The Project will result in a range of environmental benefits for the water resources of the area, these include the hydraulic connection of surface water and groundwater, augmentation of groundwater, and a small improvement in water quality. The Project will reduce the existing flood hazard to SH1 significantly while increasing the resilience of the transport network.

Dr John (Jack) Allen McConchie

4 July 2023

APPENDICES

Appendix A: Summary of preliminary discussions relating to the methodology used to assess the interaction of the Project with the flood hazard.

Appendix B: Effect of proposed abstraction of construction water from Waitohu Stream. Memorandum to Mike Thompson GWRC, 26 January 2023.

Appendix C: Clarification of proposed abstraction of construction water. Memorandum to Michaela Stout, Scientist – Allocation, Horizons Regional Council, 31 January 2023.

APPENDIX A

The draft Baseline Flood Report was issued to Iwi project partners and all four councils in February 2021.

Meetings were held subsequently with council representatives (including Jon Bell of Horizons and Daniel Haigh of HDC) on 21 April and 1 June 2021. Discussion focused on the baseline flood modelling and an early conceptual design of the Ō2NL Project.

At the June 2021 meeting, specific confirmation was sought from Horizons (Jon Bell) that the general baseline modelling approach was reasonable. This is reflected in the attached minutes.

Subsequent meetings were held on 28 February 2022 and 5 May 2022 (the latter included Andrew Craig and Jack McConchie supporting Waka Kotahi, with Jon Bell and Peter Kinley supporting Horizons). These meetings continued to consolidate and build on the baseline modelling and included discussion around the developing design.

While the early meetings signalled agreement in principle with the approach, there was insufficient certainty about the design to make definitive statements regarding the modelling.

Once the concept design and potential effects were coming into focus ahead of the Consent Application, meeting attendees became hesitant to make definitive statements that might later be quoted or ‘overstate’ their approval. In general, attendees therefore kept their comments to quite high-level remarks or targeted questions about specific details or effects.

(Minutes of meeting 1 June 2021 attached)

APPENDIX B

Memorandum

To:	Mike Thompson	**At:**	Greater Wellington Regional Council
Copy:	Greg Lee & Caitlin Kelly	**At:**	Ō2NL Project Team, Waka Kotahi
From:	Dr John (Jack) McConchie	**At:**	SLR Consulting NZ Limited
Date:	26 January 2023	**Ref:**	720.30017.00000 O2NL Waitohu Abstraction FINAL.docx
Subject:	Effect of proposed abstraction of construction water from Waitohu Stream		

Background

To support the construction of the Ō2NL Project, a resource consent has been lodged with Greater Wellington Regional Council to abstract water from Waitohu Stream. To avoid having any effects that are 'more than minor', and to be consistent with the requirements of the relevant Regional Plan and policies, the following has been proposed:

- Abstraction of up to a maximum of 2,160m^3 a day from the existing core allocation. This will leave at least 1,080m^3 a day available for any other users throughout the duration of the consent;
- Water would be abstracted only when flow in the Waitohu River is above the current minimum flow (140L/s);
- Water would be abstracted at a rate of no more than 14L/s at the minimum flow (i.e., 10%); and
- Abstraction would be increased *pro rata* above the minimum flow to a maximum of 50L/s.

In addition to the above, and to further mitigate any potential 'less than minor' adverse environmental effects, abstraction would also be constrained by:

- Only abstracting for the duration of construction of the Ō2NL Project i.e., estimated at five years;
- Total abstraction across several sites used to support construction of the Ō2NL Project cannot exceed a maximum of 3,950m^3 a day;
- Total abstraction across sites used to support construction of the Ō2NL Project cannot exceed an average of 2,160m^3 a day; and
- Wherever possible, water abstracted from the Waitohu catchment would be used to support construction of the Ō2NL Project within that catchment. That is, as far as practicable there will be no inter-basin transfer of water. This will reduce the duration, and volume of water, that may need to be abstracted from Waitohu Stream.

Following lodgement of the resource consent application for the Ō2NL Project, and because of the distinctive character of Waitohu Stream i.e., it contains both influent (losing water to groundwater) and effluent (gaining water from groundwater) reaches, GWRC requested further information on the natural low flow regime of

Waitohu Stream. A response to the further information request was provided on 23 December 2023 confirming and clarifying the effects of the resource consent applications lodged. Additional gauging data was also supplied subsequently by GWRC. This memorandum provides a detailed assessment of that data with specific focus on the low flow regime and conditions when surface flow might cease downstream of Taylors Road. This memorandum therefore provides context to the lodged RMA applications.

Background

Flow in Waitohu Stream has been measured by GWRC since October 1994, now providing almost 30-years data for characterising the flow regime (Figure 1). While the Waitohu at Water Supply Intake recorder is the only flow gauge in the catchment, it is suitable for assessing the impact of any potential abstraction of construction water from this catchment. The gauge is approximately 4.5km east of Ōtaki and located where Waitohu Stream exits the foothills of the Tararua Ranges. Steep forested land borders the stream to the north of the gauge, with flatter pastoral land to the south.

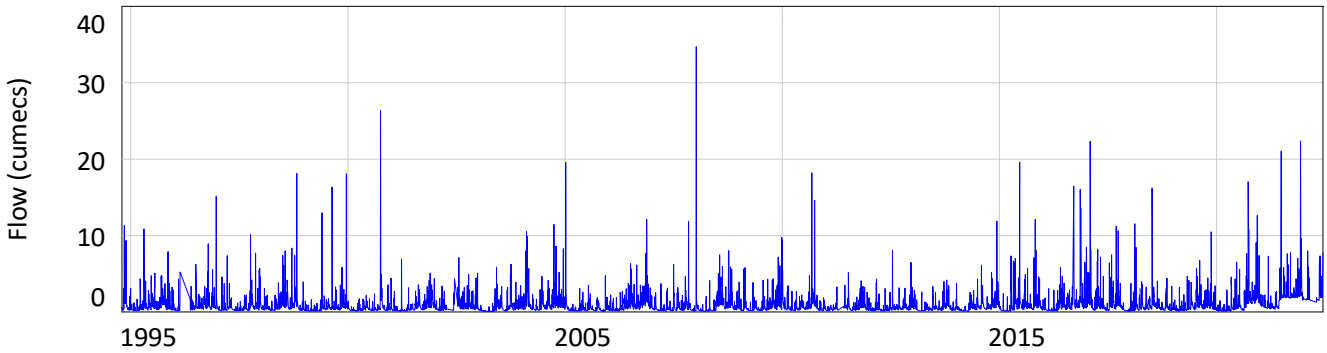

Figure 1: Waitohu at Water Supply Intake mean daily flow series (1994-2022).

The flow regime of Waitohu Streams is typical of a waterway draining pastoral hill-country at the foothills of the Tararua Range. Generally low flows are interspersed with occasional but random large floods. This creates a highly variable flow regime where the maximum flow recorded is two orders of magnitude greater than the median.

Flow in Waitohu Stream has ranged from a minimum of 0.065m^3/s, to a maximum of 34.7m^3/s (Table 1). Waitohu Stream experienced this minimum flow in April 2003, while the maximum flow occurred in January 2008 (Figure 1).

Table 1: Summary statistics of flows recorded in Waitohu Stream (m^3/s).

Site	Min	Max	Mean	Std Dev	L.Q.*	Median	U.Q.**
Waitohu at Water Supply Intake	0.065	34.7	0.98	1.39	0.30	0.54	1.12

* ***L.Q. is the Lower Quartile flow i.e., the flow that is exceeded 75% of the time***
** ***U.Q. is the Upper Quartile flow i.e., the flow that is exceeded 25% of the time***

Because Waitohu Stream contains both influent and effluent reaches, the flow measured at the Water Supply Intake recorder may not represent the flow at other locations accurately. It is possible that flow increases with catchment area over some reaches but decreases over other reaches despite an increase in catchment area. Losses through the bed of Waitohu Stream downstream of SH1 are sufficient, during occasional extended

periods of extremely low flow, that surface flow ceases in the vicinity of Taylors Road until effluent flow then restores, and even augments, flow downstream at the Golf Course. This behaviour makes any assessment of the flow regime at specific locations problematic.

Identifying and quantifying the potential impact of these changes to inflow and outflow from a stream requires concurrent stream gauging i.e., measurements of flow at different locations at essentially the same time. Concurrent gaugings are generally undertaken during periods of low flow when any loses or gains of water from the stream are a greater percentage of the total flow and can be quantified more easily.

Concurrent gaugings

GWRC, as the water resource manager for Waitohu Stream, has undertaken several series of concurrent gaugings (13) of Waitohu Stream (Table 2). Most of these gaugings were undertaken from 1995-2001 (10) and the last gauging was in 2008.

Table 2: Concurrent gaugings available for Waitohu Stream.

Date of gauging	Forest Park	Butterfly Creek	Water Supply Intake	Below Water Supply Intake	Ringawhati Road Bridge	Waitohu Valley Rd Bridge	State Highway One	Taylors Road Bridge	Above Ngatotara Ditch	Below Ngatotara Ditch	Golf Club	Norfolk Crescent	Mouth
Distance (m)	0	1217	1372	1467	3704	5735	6883	8038	9173	9313	10786	13160	14527
16-01-1995			178				228		93	0	133		
25-03-1998			209	203	239		170				97		219
27-01-1999			162	180	165		166				61		224
10-02-1999			162	119	124		110				52		216
29-02-2000			192	138	153		150				66		299
28-03-2000			146	113	126		120				47		
19-04-2000			216	232	253		205				139		852
10-01-2001			244	202	224		190				110		173
08-02-2001			230	192	171		158				63		351
28-02-2001			153	123	126		95				29		304
26-04-2004			241		220		202	116			146		
15-03-2005								62			72		
28-03-2008	71		90		98		76	0	0		16	94	118

The concurrent gaugings were undertaken at various locations along Waitohu Stream, however, the locations varied between the different gauging runs (Figure 2). While 13 different locations have been gauged at some stage, most of the gauging runs only measured flow at six sites, although in 2008 the flow at nine sites was apparently gauged.

The data from the various concurrent gaugings is shown in Figure 3 & Figure 4. Note that the only difference in these figures is the exclusion of the 'extreme' flow measured at the river mouth on 19 April 2000 to enhance the resolution of Figure 4.

Figure 2: Locations of the various concurrent gaugings undertaken on Waitohu Stream.

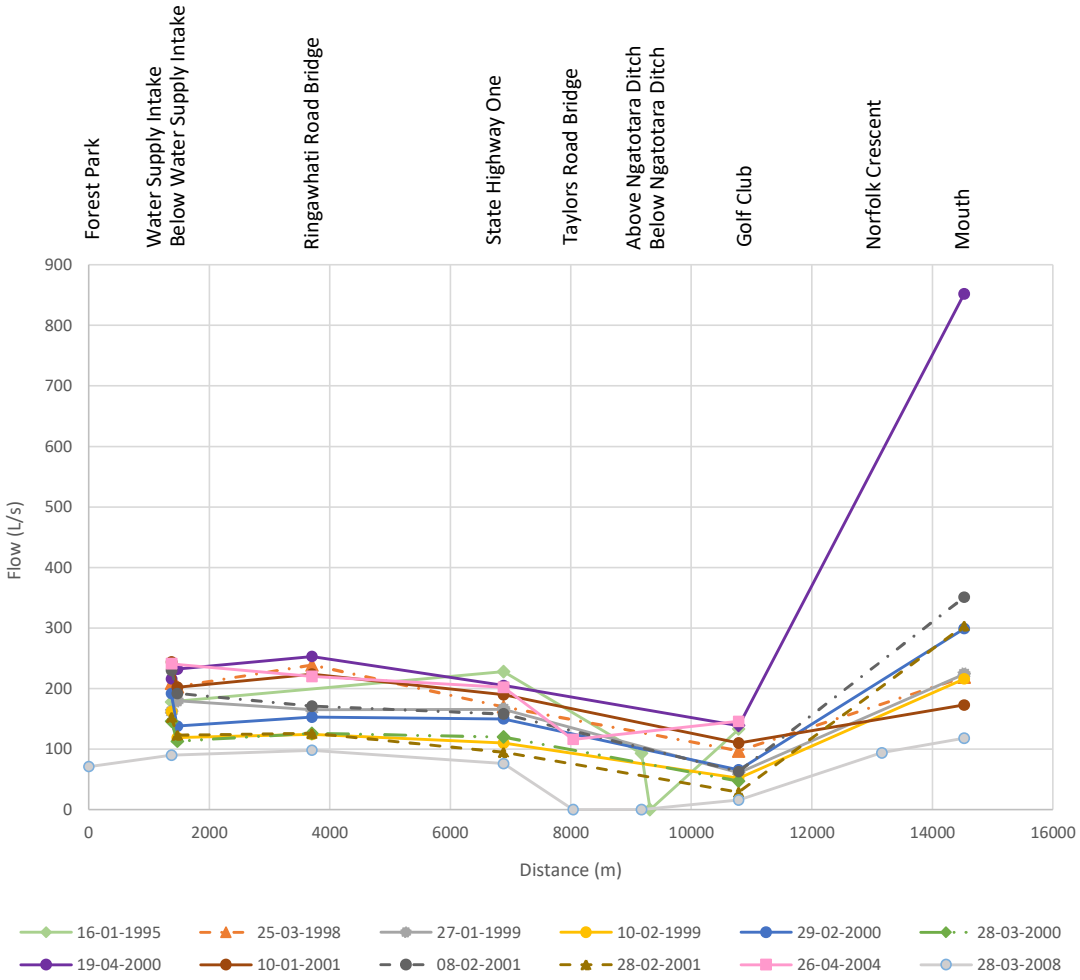

Figure 3: Data from all the series of concurrent gaugings.

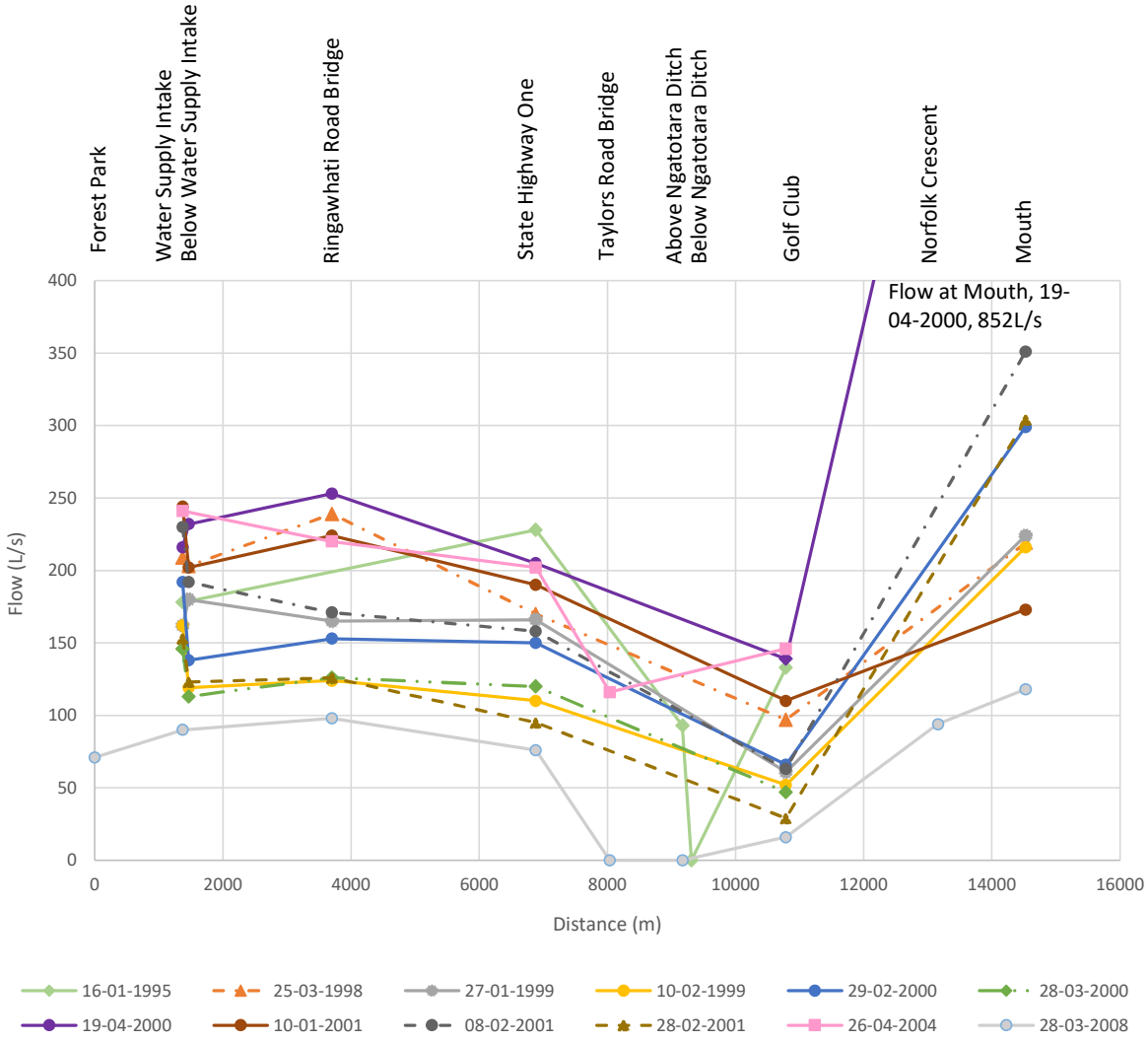

Figure 4: Data from the series of concurrent gaugings, excluding the 'extreme' value recorded at 'The Mouth' on 19 April 2000 to improve resolution at lower flows.

It should be noted that these figures differ from those provided in an internal GWRC report produced by Laura Keenan *Mean annual low flow statistics for rivers and streams in the Wellington region* in two respects:

- The data are plotted relative to their actual distance downstream of the most upstream site. Keenan (nd) plotted the data as if it was 'categorical' and therefore the rates of actual gains and losses in flow are misrepresented; and
- Some of the data available currently from GWRC's hydrometric archive is different to that used by Keenan (nd). It is assumed that the current data are the more accurate.

Notwithstanding the above, it is apparent that:

- There are significant differences in both the location and volume of losses and gains in flow down Waitohu Stream. Each gauging run indicates a different pattern of behaviour;

- Flow between the Waitohu at Water Supply Intake and SH1, however, is essentially constant, at least within the generally accepted accuracy of open channel flow measurements i.e., ±8%. Consequently, flows measured upstream at the Water Supply Intake are likely to be indicative of those at SH1 and therefore the likely point of abstraction of any water used to support the construction of the Ō2NL Project;
- The minimum flow (140L/s) is sufficient to sustain channel flow downstream of SH1 i.e., at the minimum flow continuity of flow is maintained throughout the entire length of Waitohu Stream. It should be noted that the data from the concurrent gaugings of 16 January 1995 have been excluded when identifying conditions when Waitohu Stream 'goes dry'. This is because the relative flows upstream and downstream of Ngatotara Ditch appear anomalous. Given the distance between the gaugings is probably only a few 10s of metres, it is unlikely that the river loses 93L/s over this reach. This is the only occasion when this apparent behaviour was observed. The increase in flow to 133L/s at the Golf Club suggests that zero flow downstream of Ngatotara Ditch is an error in the data in the hydrological archive (Table 2);
- Although there are limited data, it appears that flow in Waitohu Stream at the Water Supply Intake must drop to at least 100L/s for a sustained period before flow in the river downstream of Taylors Road ceases, before commencing again further downstream;
- Since the Ō2NL Project proposes to stop abstracting at the current minimum flow (140L/s) and flow downstream does not cease until a flow of less than 100L/s persists, the proposed abstraction will have no effect on periods of no flow, their occurrence, frequency, or duration. These will remain controlled by natural climatic and fluvial processes;
- A flow of 140L/s at the Water Supply Intake would appear to ensure continuity of flow and a flow at the Golf Course of 60-70L/s. Assuming the entire 14L/s sought by the Ō2NL Project at the minimum flow reduced this flow, which is considered unlikely given the interaction between surface water and groundwater over this reach, this would reduce flow at the Golf Course by between 20-23%. Any potential effects of this are suggested to be extremely small. Since flows have reduced to significantly less than this naturally in the past, stream biota would have adjusted to these conditions.
- Consequently, any effects of the abstraction proposed by the Ō2NL Project will be '*less than minor*' as argued in the resource consent application.

Periods of low flow

As discussed, the key hydrological metrics for abstraction from Waitohu Stream are the minimum flow (140L/s) and the flow threshold that, when sustained for a period, is associated with surface flow ceasing in a reach downstream of Taylors Road (100L/s). It should be noted that while the abstraction of water can affect flows above 140L/s, since all abstractions must cease when the flow drops below this level, the dynamics of flow between 140L/s and 100L/s (and below this threshold) are entirely natural. They are controlled by climate and fluvial processes.

Figure 5 shows the periods when flow in Waitohu Stream dropped below these two thresholds since 1994 and these are summarised in Table 3. It is apparent that the mean daily flow drops below 140L/s most years, although how often and for how long is highly variable. As expected, the mean daily flow drops below 100L/s

considerably less often and only three times since 1995. During the 'driest year on record' (2003) flow was below 100L/s for 43 days. Most recently, in 2020, flow was below this threshold for five days.

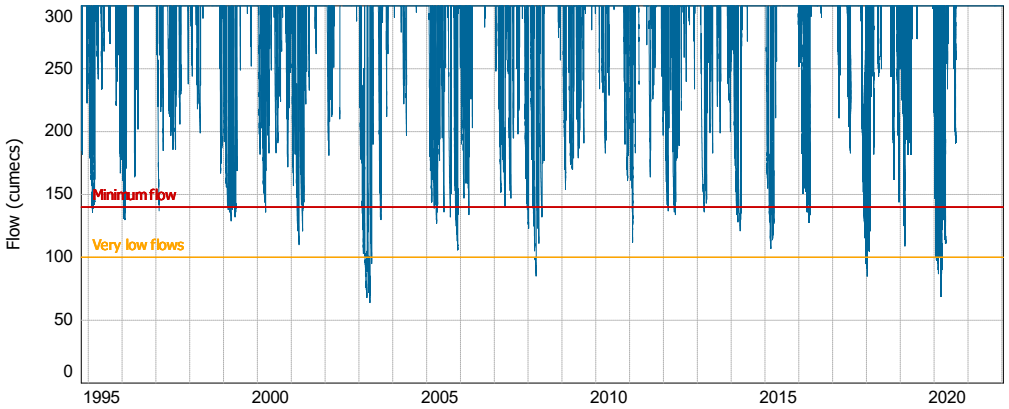

Figure 5: Waitohu Stream at Water Supply Intake flow record below 300L/s with minimum flow threshold of 140L/s (red line) and very low flow threshold of 100 L/s (orange line).

Table 3: Number of days per year that the mean daily flow dropped below 140L/s and 100L/s in Waitohu Stream at the Water Supply Intake.

Year	Flow below min flow (140 L/s)	Flow below 100 L/s
1995	1	-
1996	-	-
1997	-	-
1998	-	-
1999	16	-
2000	1	-
2001	21	-
2002	-	-
2003	80	43
2004	-	-
2005	34	-
2006	3	-
2007	1	-
2008	47	11
2009	-	-
2010	-	-
2011	3	-
2012	4	-
2013	6	-
2014	27	-
2015	31	-
2016	4	-
2017	11	-
2018	9	-
2019	8	-
2020	28	5

Details of the changes in flow that occurred naturally, solely from climate and fluvial processes, over these three periods of sustained low flow are shown in Figure 6 through Figure 8.

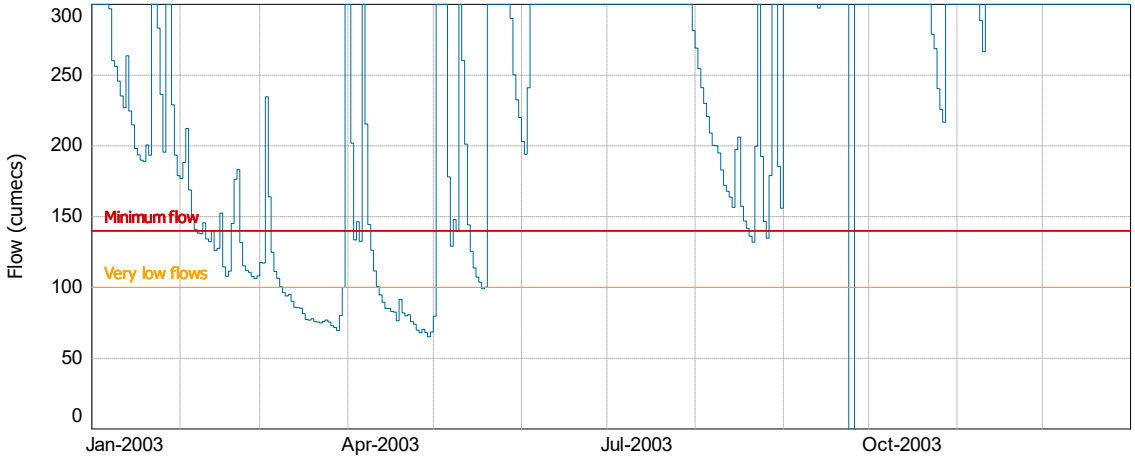

Figure 6: Flow in Waitohu Stream at the Water Supply Intake below 300L/s over 2003 with minimum flow threshold of 140L/s (red line) and very low flow threshold of 100L/s (orange line).

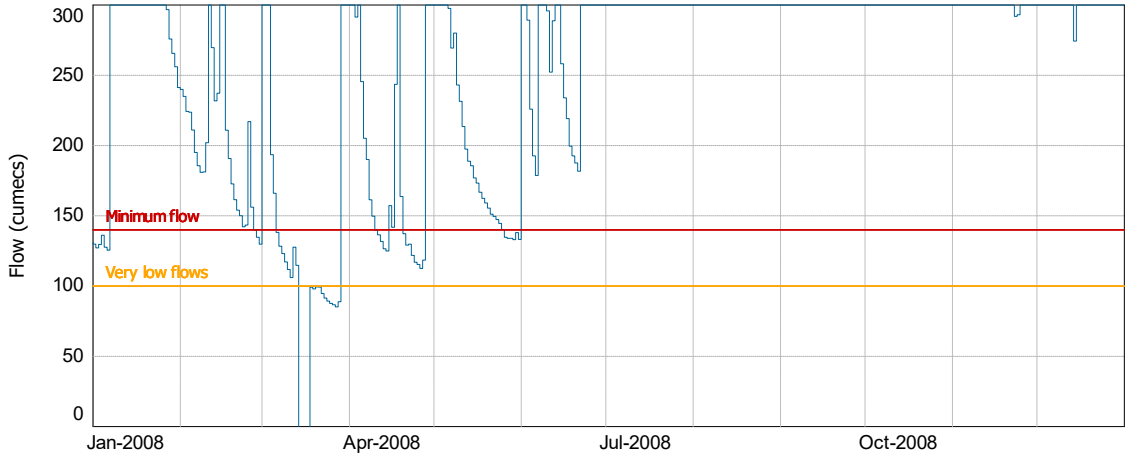

Figure 7: Waitohu Stream at Water Supply Intake flow record below 300L/s over 2008 with minimum flow threshold of 140L/s (red line) and very low flow threshold of 100L/s (orange line).

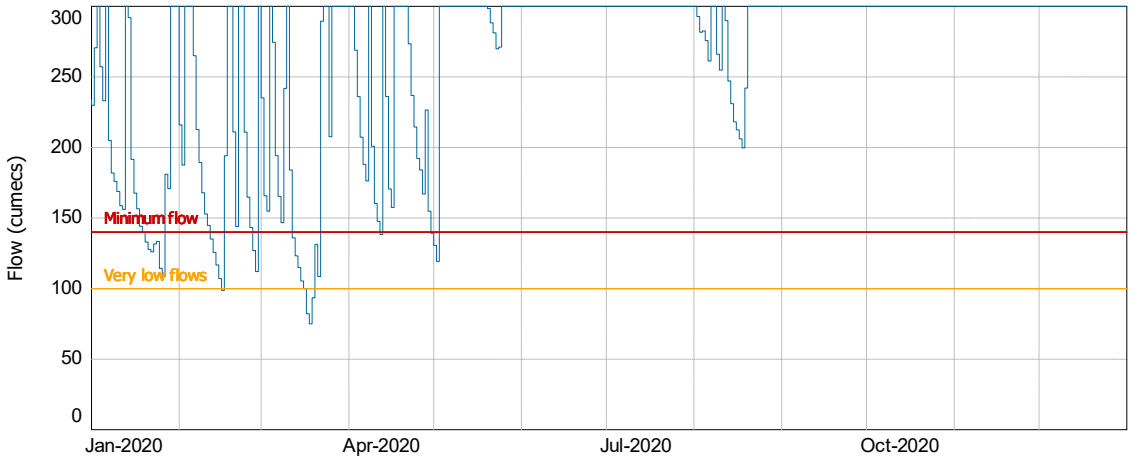

Figure 8: Waitohu Stream at Water Supply Intake flow record below 300L/s over 2020 with minimum flow threshold of 140L/s (red line) and very low flow threshold of 100L/s (orange line).

Conclusions

The above analysis allows the following conclusions:

- As discussed in the Resource Consent application, the proposed abstraction of construction water from Waitohu Stream is consistent with the requirements of the relevant Regional Plan and policies.
- The flow recorder for Waitohu Stream at the Water Supply Intake provides a reliable estimate of the flow in the vicinity of SH1 and therefore the location of the proposed abstraction. Any difference in flow between the two locations is within the margin of uncertainty (±8%) of open channel flow measurements, and likely significantly less than this.
- During prolonged periods of low flow, likely flow less than 100L/s at the Water Supply Intake, surface flow in Waitohu Stream can cease over the reach between Taylors Road and the Golf Course. Flow both upstream of Taylors Road and downstream of the Golf Course is continuous.
- The characteristics of any flow recession below the minimum flow are natural and affected solely by the climate, hydrology, and characteristics of the channel. Since periods of sustained low flow, and no flow, have occurred in the past, the instream biota will have adapted to these occasional but infrequent conditions.
- Since it is proposed to cease abstraction of construction water below the minimum flow (140L/s), the abstraction will have no effect on the frequency or duration of periods of low flow, and specifically periods when surface flow ceases in Waitohu Stream.
- Abstraction of 14L/s at the minimum flow has the potential to reduce flows downstream at the Golf Course by between 20-23%, however, flow will be sustained throughout the reach downstream of SH1.

This analysis therefore confirms the conclusion in the resource consent application that any effects of the proposed abstraction of construction water from Waitohu Stream will be '*less than minor'.*

I would be happy to discuss this memorandum and its conclusions if that would be useful in resolving any residual issues or concerns you may have regarding the proposed abstraction of water from Waitohu Stream to support the construction of the Ō2NL Project.

APPENDIX C

Memorandum

To:	Michaela Stout, Scientist - Allocation	**At:**	Horizons Regional Council
Copy:	Greg Lee & Caitlin Kelly	**At:**	Ō2NL Project Team, Waka Kotahi
From:	Dr John (Jack) McConchie	**At:**	SLR Consulting NZ Limited
Date:	31 January 2023	**Ref:**	720.30017.00000 O2NL Koputaroa Water Abstraction FINAL.docx
Subject:	Clarification of proposed abstraction of construction water		

Background

To support the construction of the Ō2NL Project, a resource consent has been lodged with Horizons Regional Council to abstract water from several streams. The abstraction proposed is consistent with:

- The Core Allocation available;
- The minimum flow listed in the One Plan; and
- A Supplementary Allocation of up to 10% of the flow when it is above the median.

In addition to the above, and to further mitigate any potential 'less than minor' adverse environmental effects, abstraction would also be constrained by:

- Only abstracting for the duration of construction of the Ō2NL Project i.e., estimated at five years;
- Total abstraction across several sites used to support construction of the Ō2NL Project cannot exceed a maximum of 3,950m^3 a day;
- Total abstraction across sites used to support construction of the Ō2NL Project cannot exceed an average of 2,160m^3 a day; and
- Wherever possible, water abstracted from a particular stream would be used to support construction of the Ō2NL Project within that catchment. That is, as far as practicable there will be no inter-basin transfer of water. This will reduce the duration, and volume of water, that may need to be abstracted from a stream.

Following lodgement of the resource consent application for the Ō2NL Project, Horizons requested further information regarding some aspects of the proposed abstraction of water to support construction. A response to the further information request was provided on 23 December 2023 confirming and clarifying the effects of the resource consent applications lodged.

During a site visit, including members of the Project Team and Michaela Stout (Horizons), it appeared that further clarification of several matters would be useful. Michaela and I discussed these matters by telephone on 24 January 2023. This memorandum now summarises the results of our discussion and provides some clarification of what is proposed relating to how abstraction from Koputaroa Stream could be managed.

Ohau River – situation regarding the Core Allocation

Michaela provided some clarification regarding the Core Allocation available from the Ohau catchment.

Over the past year, Horizons have been evaluating the current allocation of water from the Ohau River and how this relates to the Core Allocation provided in the One Plan. A review of abstractions from the Ohau River is ongoing. Given the potential hydraulic interaction between surface water and groundwater, Horizons consider that the Core Allocation from the Ohau River is likely to be fully allocated. This needs to be formally confirmed. Furthermore, there are additional consents (for both surface water and groundwater) ahead of consideration of any application to support the Ō2NL Project.

Koputaroa Stream

Having inspected the potential site for the proposed abstraction of water to support the construction of the Ō2NL Project i.e., Koputaroa Stream at McDonald Road, there was some discussion as to how the abstraction would be managed. This memorandum therefore provides a suggested strategy for managing the abstraction so that any effects on the environment can be considered *'less than minor'*.

The effects of abstraction from the Koputaroa Stream can be assessed by analysing the flow series from the Koputaroa at Tavistock Road recorder. This recorder is located approximately 5km north-east of Levin, and 6.5km upstream of Koputaroa Stream's confluence with the Manawatū River. This site and flow record were maintained by Horizons from 1974-1996, after which the site was decommissioned (Figure 1). The gauging site and flow recorder have been subsequently reinstated to support the development of the Ō2NL Project, although the recent record is relatively short (Figure 2). The site is maintained by NIWA on behalf of the Ō2NL Project. Summary statistics and range of metrics derived from the full flow series now available is provided in Table 1.

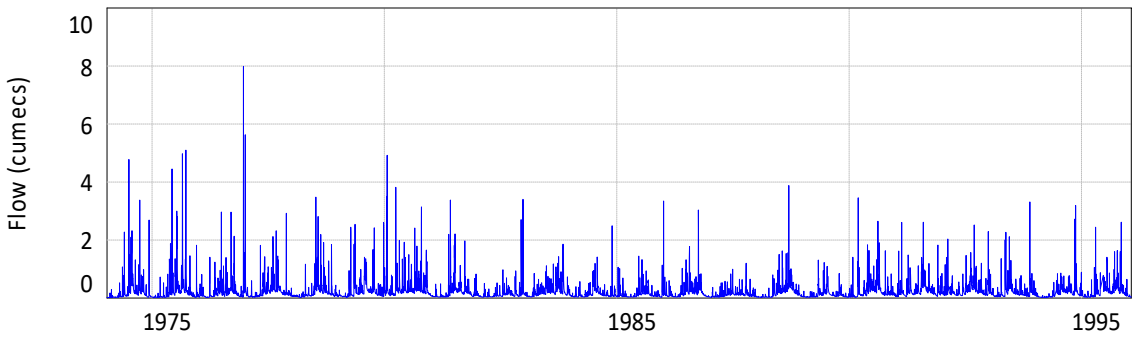

Figure 1: Koputaroa at Tavistock Road mean daily flow series (1974-1996).

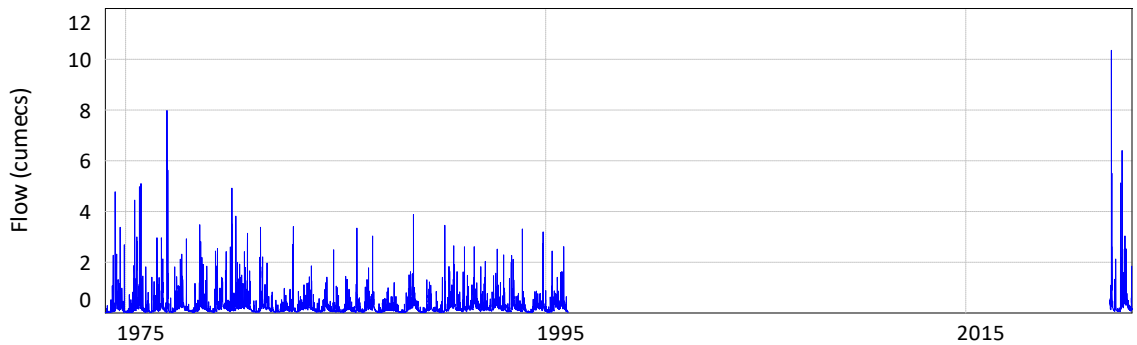

Figure 2: Koputaroa at Tavistock Road extended mean daily flow series.

Table 1: Summary statistics of flows recorded in Koputaroa Stream (m^3/s to 2dp).

Site	Min	Max	Mean	Std Dev	L.Q.*	Median	U.Q.**	MALF
Koputaroa @ Tavistock Road	0.012	10.35	0.25	0.37	0.07	0.15	0.29	0.04

* ***L.Q. is the Lower Quartile flow i.e., the flow that is exceeded 75% of the time***
** ***U.Q. is the Upper Quartile flow i.e., the flow that is exceeded 25% of the time***

Likely because there was no flow recorder on the Koputaroa Stream at the time of the One Plan, abstraction of water in this catchment is managed currently with reference to the minimum flow in the Manawatū River, measured at Teachers' College.

Proposal

The resource consent application seeks to abstract:

- Up to 231m^3 per day from the existing Core Allocation (351m^3 per day) when flow is above the minimum flow; and
- A Supplementary Allocation of up to 10% of any flow above the median.

Potential abstraction location

The Project corridor, and therefore any potential abstraction of construction water, is likely to be a significant distance upstream of the flow recorder. For example, the catchment area upstream of McDonald Road, a possible source of abstraction, is only about 40% of that upstream of Tavistock Road. Since flows, particularly low flows, in a stream are largely a function of catchment area, flows in Koputaroa Stream near McDonald Road are likely to be only about 40% of those recorded downstream at Tavistock Road. It is likely, however, that this approach is slightly conservative as the specific yield upstream of McDonald Road is likely to be higher than at Tavistock Road. This is because that portion of the catchment is closer to the hills, which receive greater rainfall because of orographic enhancement.

The reduced flows at McDonald Road, relative to those downstream at Tavistock Road, when combined with management based on the minimum flow in the Manawatū River is problematic when trying to minimise potential environmental effects. This is particularly the case during periods of low flow in Koputaroa Stream.

Management of abstraction

Since the rate of abstraction and its potential effects are directly related to flow in Koputaroa Stream, it is suggested that this should be the metric used in the management of any abstraction. This requires using a flow measured directly within the catchment and a 'catchment specific' minimum flow.

Using the same methodology as applied when developing the minimum flows in the One Plan (i.e., 80% of the 1-day MALF), the minimum flow for Koputaroa Stream at Tavistock Road would be ~32L/s. Abstracting a maximum of 10% of this would be 3.2L/s. However, when flow is scaled upstream to McDonald Road, the minimum flow would be only 13L/s. Therefore, the abstraction of 3.2L/s from this reach would be 25% of the flow and not only 10%.

To avoid the potential 'over-abstraction' of water at McDonald Road, the rate of abstraction at the minimum flow must also be reduced in the same proportion as total flow i.e., 40%. This would allow the abstraction of only 1.3L/s at McDonald Road at the minimum flow. At flows greater than the minimum, abstraction could increase *pro rata* i.e., up to 4% of the flow recorded at Tavistock Road.

The same scaling approach could be applied to locations other than McDonald Road if that was necessary.

I would be happy to discuss this further or provide any additional clarification that you might require.