IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by Waka Kotahi NZ Transport Agency (Waka Kotahi) to Manawatū-Whanganui Regional Council and Greater Wellington Regional Council for resource consents to enable the construction, operation and maintenance of new state highway, shared use path and associated infrastructure, between Taylors Road (to the north of Ōtaki) and Stage Highway 1 north of Levin.

SECTION 87F REPORT OF PETER FREDERICK KINLEY – HYDROLOGY AND FLOODING

MANAWATŪ-WHANGANUI REGIONAL COUNCIL AND GREATER WELLINGTON REGIONAL COUNCIL

28 April 2023

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A. OUTLINE OF REPORT

1. This report, required by section 87F of the Resource Management Act 1991 ("**RMA**"), addresses hydrology and flooding effects arising from resource consent applications lodged with the Manawatū-Whanganui Regional Council ("**Horizons**") and Greater Wellington Regional Council ("**GWRC**") for the Ōtaki to North of Levin Highway Project (the "**O2NL Project**").

2. The resource consents applied for, by Waka Kotahi NZ Transport Agency ("**Waka Kotahi**"), are required to authorise the construction, operation and maintenance of new state highway, shared use path and associated infrastructure, between Taylors Road (to the north of Ōtaki) and State Highway 1 north of Levin.

3. In addition, Waka Kotahi separately lodged Notices of Requirement ("**NoRs**") relating to the Ō2NL Project with Horowhenua District Council and Kāpiti Coast District Council (the "**District Councils**"), respectively. Matters relating to the NoRs are outside the scope of this report, and are being addressed by technical advisors for the District Councils.

4. In preparing this report, I have discussed the application and technical reporting with Mr John McArthur, who is reporting on hydrology and flooding for the District Councils.

5. While this report is pursuant to section 87F of the RMA, I have in accordance with section 42A(1A) and (1B) attempted to minimise the repetition of information included in the application and where I have considered it appropriate, adopt that information.

B. QUALIFICATIONS / EXPERIENCE

6. My name is Peter Frederick Kinley. I am an Associate and the New Zealand Water Leader at Arup New Zealand Limited ("**Arup**"). I have been in that position since February 2020. Prior to my role at Arup, I had been working as a technical director and/or advisor, in the area of hydrology and flooding since 2007.

7. My role at Arup involves providing technical direction for unusual and complex matters, technical support and direction for the wider water

team, overseeing tenders/new work, client liaison, and team management and development.

8. I hold a Bachelor of Engineering in Civil Engineering from the University of Auckland. I am a member of Water New Zealand.

9. I have worked on a number of projects which are relevant to the current brief/Ō2NL Project. These are set out in **Appendix A.**

10. I am familiar with the site and surrounding area. I visited the site along with other Horizons and GWRC experts on 24 and 25 August 2022. I also visited the site on 16 September 2019 as part of an initial meeting to assess the flood risk for the area to the north and east of Levin, as a part of a separate brief for Horizons.

C. CODE OF CONDUCT

11. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. I confirm that I have stated the reasons for my opinions I express in this report, and considered all the material facts that I am aware of that might alter or detract from those opinions.

12. Statements expressed in this report are made within the scope of my expertise, except where I rely on the technical advice which I have referred to in paragraph 19 of this report.

13. I have all the information necessary to assess the application within the scope of my expertise and am not aware of any gaps in the information or my knowledge.

D. EXECUTIVE SUMMARY

14. Having reviewed the resource consent application, I am in general agreement with Waka Kotahi's approach to hydrological modelling, the general approach to hydraulic modelling, including the approach of undertaking a comparison of baseline and "with-road" scenarios, and the selection of climate change scenarios to estimate the impact of climate change.

15. However, I have a number of concerns with the technical assessments underpinning the conclusions in the application regarding effects relating to hydrology and flooding. In my opinion:

(a) Waka Kotahi's conclusion that the Ō2NL Project will have effects that are less than minor is not supported by the technical assessments (hydrology and flooding) lodged with the application.

(b) The hydrology and flooding assessments prepared for the applications show the design solution will have adverse effects. The magnitude of these effects is such that I cannot reach the view they are less than minor. I consider the criteria/threshold to determine whether a change in flood level is "less than minor" is too high. Further, there is insufficient information within the application to be confident of the existence of a design solution that will adequately address adverse effects on the environment.

(c) Waka Kotahi's reporting focusses on changes in depth as the primary potential effect of the Ō2NL Project. Consideration of the effects of the works on velocity, area of flooding, duration of flooding, scour, flood hazard (the product of velocity and depth) and of the flooding at buildings is insufficiently detailed to provide confidence around the magnitude and acceptability of effects.

(d) The absence of an assessment of the 0.5% AEP storm event, with an allowance for the effects of climate change, means that the effects of the works that Horizons seeks to understand in the Manawatu-Whanganui One Plan ("**One Plan**") are not quantified.

(e) The selection of the 10% AEP storm event as the smallest storm event used in the assessment means that any effects that may occur frequently and be recognisable and understood by affected parties, for example a 50% AEP storm event or a 20% AEP storm event, are not known.

(f) The threshold values used by Waka Kotahi to describe whether an effect is significant are inconsistent with current practice.

(g) The absence of a complete assessment of freeboard means that it is not possible to confirm whether the proposed design is compliant with Waka Kotahi's requirements.

(h) The approach used to assess the effects of the proposed scour protection is high level and as a consequence the effects of the works on flood levels are not quantified.

(i) The assessment of the effects of the works on the flooding of buildings is incomplete.

(j) The assessment of the effects of the works on the duration of flooding and flood hazard is cursory.

16. Overall, the assertion within the application that the proposed works will have a less than minor effect on hydrology and flooding is based on an incomplete analysis. On this basis, I have a low level of confidence in the conclusions reached by Waka Kotahi, and I am of the opinion that the flooding impacts of the proposed design are likely to be more than minor.

17. On receipt of the information identified within my report, however, there is the potential for the issues I have raised to be worked through in expert conferencing and other discussions between the technical experts.

E. SCOPE OF REPORT

18. This report addresses hydrology and flooding effects of the Ō2NL Project. Specifically, I consider the following:

(a) Selection of the largest storm event;

(b) Selection of the suite of storm events used to identify effects;

(c) Selection of threshold values used to identify effects;

(d) Review of whether the design meets those thresholds;

(e) Assessment of freeboard;

(f) Approach to assessing the effects of scour protection;

(g) Assessment of the effects of the works on flooding of buildings;

(h) Assessment of debris arrestors; and

(i) Scope of peer review.

19. In preparing my report I have considered the following information:

(a) *Technical Assessment F: Flooding and Hydrology* ("**Technical Assessment F**");

(b) Waka Kotahi's responses to Horizons and GWRC's s 92 requests dated 23 December 2022;

(c) *Ōtaki to North of Levin: Baseline Flood Assessment Report* dated August 2022 (the "**Baseline Flood Report"**), which is included as Appendix F.1 of Technical Assessment F;

(d) *Ōtaki to North of Levin: With-Scheme Flood Assessment Report* dated August 2022 (the "**With-Scheme Report**"), which is included as Appendix F.2 of Technical Assessment F;

(e) *Role as hydrology peer reviewer*, a memorandum dated 20 October 2022 (the "**Peer Review Memorandum**"), which is included as Appendix F.3 of Technical Assessment F;

(f) Nicholas John Keenan *Appendix 4.2: Stormwater Management Design* (17 October 2022) of *Design and Construction Report rev 0.9* (28 October 2022);

(g) *Bridge Manual SP/M/022, Third edition, Amendment 4* (the "**Bridge Manual**"), published by Waka Kotahi and dated effective from May 2022;

(h) *Stormwater Modelling Specifications, Version 4.0*, published by Auckland Council and dated November 2011; and

(i) *AM STA 6200 Flood Mapping Projects Specification*, published by Melbourne Water and dated July 2020.

20. In preparing my report, I have considered the planning framework within the One Plan and Greater Wellington Regional Policy Statement / Natural Resources Plan (appeals version) ("**Natural Resources Plan**").[1] While Mr St Clair will address the planning matters arising from application of these policies to the Ō2NL Project, this framework (and policy direction) is relevant when considering the extent of modelling, and investigation, undertaken by Waka Kotahi.

F. BACKGROUND

21. My involvement in the Ō2NL Project began in April 2022, and I have been continuously involved since then. Along with review of the resource consent application, and Assessment of Environmental Effects ("**AEE**"), I have also reviewed draft reports from Waka Kotahi, and liaised with their experts to identify and resolve issues, including through the Section 92 request for information, on 9 December 2022, and Waka Kotahi's response, of 23 December 2022 (the "**Section 92 Response**").

22. I have used Annual Exceedance Probability ("**AEP**") and Exceedances per Year ("**EY**") as the metrics for storm event size throughout my evidence. This is consistent with the Australian Rainfall and Runoff Guidelines, which I consider to be best practice for describing storm event size. The use of AEP is also consistent with the One Plan and the Natural Resources Plan, which use AEP as the primary metric for storm event size.

G. REVIEW OF APPLICATION

23. There are a number of areas of agreement that I have identified in my review of the hydrology and flooding assessments for the Ō2NL Project. These include:

    (a) The hydrological modelling, including the delineation of catchments, the assessment of rainfall, the conversion of rainfall to runoff and flow in the upstream catchments using HEC-HMS

[1] One Plan Objective 9-1, One Plan Policies 9-1, 9-3 and 9-5, and One Plan Rule 16-3; Natural Resources Plan Policy P25, P26, P27, P28, P117, Natural Resources Plan "Uses of beds of lakes and rivers general conditions", Natural Resources Plan Rule R126, R128, and R147.

software, and the method used to identify critical storm durations for the catchments.

(b) The selection of hydraulic model extents and the use of HEC-RAS software to model flood flows.

(c) The approach of modelling the baseline scenario and a "with-road" scenario, and comparing them to identify effects.

(d) The selection of Representative Concentration Pathways ("**RCPs**") to estimate the impacts of climate change. RCP6.0 has been used for the Serviceability Limit State event, which is the event in which the works will remain operational and undamaged, and RCP8.5 has been used for the Ultimate Limit State event, which is the largest event the works are designed for.

24. However, as set out at paragraph 18, I have identified nine issues in Waka Kotahi's hydrology and flooding assessments for the Ō2NL Project. I address these below.

Selection of the largest storm event

25. In my opinion, the flooding assessment should consider the largest flood event being the 0.5% AEP flood event with an appropriate allowance for the effects of climate change (the "**0.5% AEP + CC flood event**"). This assessment is necessary in order to satisfy the One Plan requirements. The approach is also aligned with the Australian Rainfall and Runoff Guidelines, which I have referred to above.[2]

26. The 0.5% AEP +CC flood event would have larger flows and water levels than the largest event used by Waka Kotahi in their flooding and hydrology assessment.

[2] The Australian Rainfall and Runoff Guidelines classify a 1% AEP flood event as "Rare", though on the cusp of "Very Rare", whereas 0.5% AEP flood events are "Very Rare". (ARR2019 Book 1, Chapter 2, Table 1.2.1). ARR2019 also notes that if the 1% AEP event is used without climate change, then the 0.5% AEP and 0.2% AEP flood events should be used to assess the impacts of climate change.

Selection of the suite of storm events

27. Aside from the largest flood event size, adverse effects can occur in a range of different flood sizes, and I consider it to be good practice to consider a suite of smaller flood events when undertaking flood assessments for the purposes of assessing effects.

28. For example:

    (a) On Ara Tūhono Stage 2, the Warkworth to Wellsford Road of National Significance, the flood assessment considered the 0.5EY, 10% AEP, 5% AEP and 1% AEP flood events, with appropriate allowances for climate change.

    (b) The MRPV projects included assessments of the 20% AEP, 10% AEP, 5% AEP, 2% AEP and 1% AEP flood events, and the 1% AEP plus climate change event.

29. The smallest event used by Waka Kotahi in the assessment of effects is the 10% AEP flood event. In my opinion, Waka Kotahi should have also considered an event or events smaller than the 10% AEP flood event, and an event or events between the 10% and 1% AEP + CC flood events.

30. The assessment of effects shows the 10% AEP flood event will cause increases in water levels outside the designation at a level that I consider to be significant. For example, Figure F.14 of Technical Assessment F shows that increases in peak water levels in the 10% AEP flood event of at least 50mm occur approximately 500m downstream of the designation boundary, and increases of more than 200mm occur approximately 200m downstream of the designation boundary. I have reproduced Figure F.14 of Technical Assessment F below and marked the three areas where flood increases are shown to occur outside the designation boundary with thick black lines.

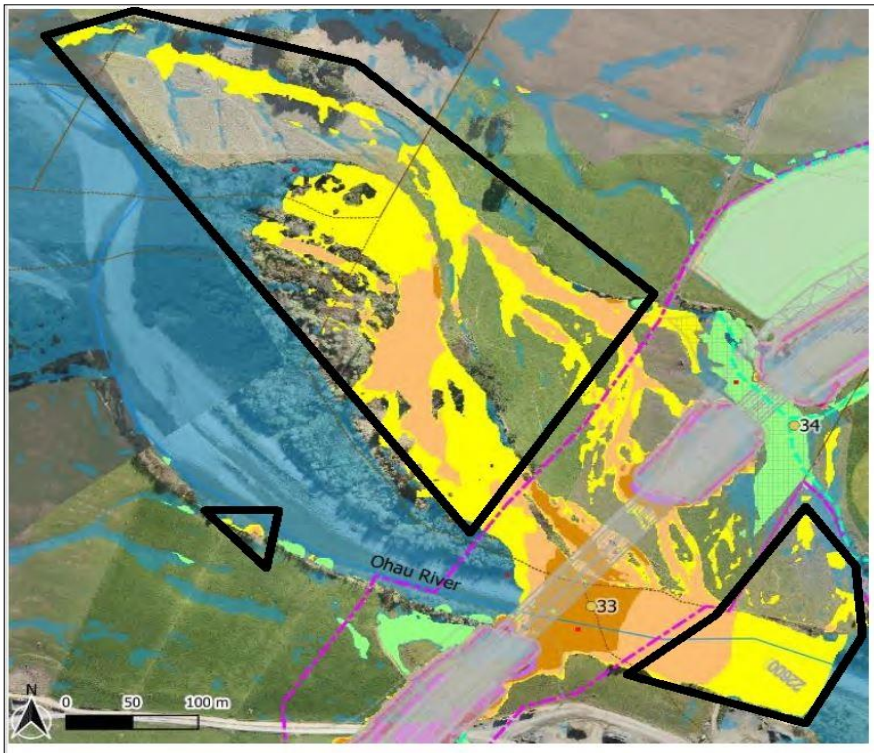

Figure F.14: Peak water level differences Ohau River and floodplain in a 1:10 AEP flood event

Figure 1: Example of reported increases in flooding outside the designation boundary

31. I compared the information provided in Figure F.14 of Technical Assessment F to the information in Figure F.13, which is for the same location and the 1% AEP +CC flood event. Figure F.13 shows that while increases in water level still occur downstream of the designation boundary, their extent is greater in the smaller 10% AEP flood event than in the 1% AEP +CC flood event. On this basis I disagree with Waka Kotahi's assertion at paragraph 36 of Technical Assessment F that *"The effects of the Ō2NL Project on smaller and more frequent events than 1:10 AEP will be much less than the above events…"*.

32. I consider that it is likely that there will also be significant effects in flood events that are smaller than the 10% AEP flood event, and these effects have not been identified.

33. In my opinion, Waka Kotahi have not demonstrated that the Ō2NL Project will not cause adverse effects on the environment in the event of a flood, because they have not identified the smallest event that causes effects.

Selection of the threshold used to identify effects

34. Waka Kotahi provides a table that describes the criteria used to determine whether a change in flood level is "less than minor" at Table F.4 of their report.[3] The table classifies changes to water level by location with respect to the designation, by the AEP of the flood event, and by change in water level or depth (the "**threshold depth**").

35. The application looks at effects within the designation and outside the designation.

36. Within the designation, Waka Kotahi has proposed two categories for changes in flood level. These are "upstream of bridges" and "upstream of culverts". As Waka Kotahi will have control over the land within the designation, it is their responsibility to manage flood effects within the designation. Therefore, I have only considered whether the values are appropriate where the land is accessible by the public. An example of this is where the works cross an existing public road on a bridge, which will occur where the new road crosses South Manakau Road.

37. Waka Kotahi has then proposed two categories for changes in flood level at the designation boundary. These are "Upstream at proposed designation, provided no buildings impacted (confirmed by model)" and "Downstream at proposed designation".

38. The threshold values for "Upstream at proposed designation, provided no buildings impacted (confirmed by model)" are <0.2m for the 10% AEP flood event and <0.5m for the 1% AEP + CC flood event. The threshold values for "Downstream at proposed designation" are <0.2m for both the 10% AEP flood event and the 1% AEP + CC flood event. In my experience, the threshold values relied on by Waka Kotahi are too high.

39. In two of the categories, Waka Kotahi has included reference to a distance beyond the designation that a threshold value could apply to. These are "Upstream 50m beyond proposed designation, provided no buildings impacted (confirmed by model)" and "Downstream 100m beyond proposed designation". However, when flooding effects are

[3] Technical assessment F, paragraph 117.

contained within the designation boundary, the flooding effects outside the designation will be either neutral or positive. For this reason, I do not consider it necessary to have identified/relied on the two categories described above.

40. I consider that flooding effects should be contained within the designation. Increases in flood depth can directly result in adverse effects including increased risk to human life, increased areas of flooding which decrease the utility of the land and provide greater levels of restriction on its development, increased risk to the well-being of animals and stock, and increased likelihood, frequency and extent of damage to pasture and crops.

41. Also, I note that Policy 9-3(b) of the One Plan requires that the infrastructure will not cause any adverse effect on the environment in the event of a flood or another type of natural hazard. I consider that the most certain means of demonstrating this requirement is met, in the absence of a final design, is to set the threshold depth value to zero, i.e., no increase to flood levels. I note Mr McArthur has proposed a threshold depth of ≤ 0.01m which, in his view, reflects the computational accuracy expected in the type of model used for the Ō2NL Project. I would also agree with this approach.

42. I have reviewed the threshold depth information and compared it to threshold depths used on similar projects in New Zealand and Australia. I found that threshold depths for the purpose of assessing whether an effect is minor vary depending on the particular circumstances, but are typically much lower than the thresholds used in Technical Assessment F. Examples of threshold depth values I reviewed include:

    (a) The Christchurch Northern Corridor required no increase in flood levels outside the designation.

    (b) Pekapeka to Ōtaki, which reported increases in water levels of up to 0.07m. This is 0.13m less than the smallest limit proposed for Ōtaki to North of Levin.

(c) Transmission Gully recommended changes to water level should be managed within the designation, which equates to a zero threshold for change in water level.

(d) MRPV had a stated requirement of zero change and in practice this was implemented as a change of no more than 0.01m. This is 0.19m less than the lowest limit proposed for Ōtaki to North of Levin.

43. In work I undertook on the Pinehaven catchment in Upper Hutt between 2015 and 2020 I also became familiar with the practical application of GWRC's threshold depths. While the nature of the works was different, with the project's purpose to deliver stream capacity improvements, the threshold applied for reporting effects was zero. This zero threshold is lower than the threshold values referred to in Technical Assessment F. All increases in water level were reported and additional justification was provided to demonstrate the effects were minor. There has been no additional justification provided in this case.

44. I consider that the majority of the terrain traversed by Te Ahu a Turanga – Manawatū Gorge Replacement Road is sufficiently different to the terrain traversed by the Ō2NL Project to mean that comparisons between the two projects have limited value when considering flooding effects.

45. I consider that the depth thresholds proposed for the Ō2NL Project are too high. My approach is supported by review of depth thresholds utilised on other projects. Given the threshold depths relied on to assess effects are too high, I cannot support the statement in the application that the effects of the project will be less than minor.

Review of whether the design meets the proposed thresholds

46. As noted above, and further explained below, Waka Kotahi demonstrates within the hydrology/flooding assessments supporting the application that the design does not comply with the proposed threshold depths (i.e., there will be increases in water levels above the identified thresholds). I provide examples of this in **Appendix B**.

47. I have set out above my view that the threshold depths relied on to assess flooding effects outside the designation are too high. Further, even if adopting those threshold depths, I cannot be confident of the existence of a design solution that would not give rise to adverse effects. This is because the geographical extent and magnitude of the increases in water levels above the identified thresholds is large.

48. The plans of flooding provided in Waka Kotahi's report are mostly at a large scale, which makes the independent examination of specific locations impossible.

49. Waka Kotahi has provided detailed maps in some selected locations. Based on the information provided by Waka Kotahi, I have identified seven instances on six separate figures provided with the application where the design may not or does not comply with the proposed requirements. These are as follows:

    (a) Figure F.13 shows an increase in flood levels of 0.05m to 0.1m more than 100m downstream of the Ōhau River bridge, which is more than Waka Kotahi's proposed threshold of <0.05m downstream 100m beyond the proposed designation.

    (b) Figure F.14 shows an increase in flood levels of 0.2m to 0.5m and significant areas where the increase is 0.1m to 0.2m or 0.05m to 0.1m up to several hundred metres downstream of the Ōhau River bridge, which is more than Waka Kotahi's proposed threshold of <0.05m downstream 100m beyond the proposed designation.

    (c) Figure F.19 shows increases in flood levels of up to 1 to 1.5m at the designation boundary on the upstream side in the 1% AEP + CC flood event, which is more than Waka Kotahi's proposed threshold of <0.5m at the designation boundary.

    (d) Figure F.23 shows an increase in flood levels of 0.1m to 0.2m downstream of the designation boundary, which may not meet Waka Kotahi's proposed threshold of <0.2m downstream at the proposed designation boundary.

(e) Figure F.23 also shows an increase in flood levels of 0.5m to 1m at the designation boundary on the upstream side in the 1% AEP + CC flood event, which is more than Waka Kotahi's proposed threshold of <0.5m at the designation boundary.

(f) Figure F.24 shows a possible area where an increase in flood levels of 0.1m to 0.2m occurs in the 10% AEP flood event, which may not meet Waka Kotahi's proposed threshold of <0.2m at the upstream designation boundary.

(g) Figure F.31 shows an extensive area with increased flood levels of 0.05m to 0.1m more than 100m downstream of the proposed designation boundary in the 10% AEP flood event in the Manakau Stream, which is more than Waka Kotahi's proposed threshold of <0.05m at downstream 100m beyond the designation boundary.

50. Given these apparent exceedances, the large scale nature of the "change in flood levels" maps provided by Waka Kotahi do not adequately demonstrate that the proposed highway (as critical infrastructure) will not have an adverse effect on the environment in the event of a flood. Further, the large scale mapping does not allow for identification of all the locations where effects occur.

The assessment of freeboard

51. An assessment of freeboard is necessary to demonstrate that the critical infrastructure will not be adversely affected by floodwaters.

52. Table 2.4 of the current Bridge Manual sets out Waka Kotahi's requirements for the provision of freeboard. It sets out the freeboard requirements for bridges and for culverts. These include minimum freeboard allowances of:

(a) 0.6m to the underside of the deck of bridges in normal circumstances,

(b) 1.2m to the underside of the deck of bridges where there is a possibility that large trees may be carried down the waterway, and

(c) 0.5m to the road surface for all culverts.

53. In my opinion, compliance of the design with the current Bridge Manual would demonstrate that the critical infrastructure will not be adversely affected by floodwaters.

54. Waka Kotahi refers [4]to the provision of at least 0.6m of freeboard at the Ōhau River bridge and the Waikawa Stream bridge. Based on visits to the site and checks of aerial photography, I consider that there is a reasonable possibility that large trees may be carried down the Ōhau River and the Waikawa Stream. In that case, it is my view, that the appropriate freeboard requirement is 1.2m.

55. I note that Waka Kotahi has not provided an assessment of freeboard allowances for any culverts. Waka Kotahi has also not provided an assessment of freeboard provisions for any bridges, except the Ōhau and Waikawa bridges.

56. As such, I consider that Waka Kotahi has not demonstrated that the critical infrastructure will not be adversely affected by debris carried by floodwaters.

The approach to assessing the effects of scour protection

57. Section 2.3.6 of the Bridge Manual requires that scour protection works ensure the security of the bridge up to the Ultimate Limit State ("**ULS**") event, which it defined as "The state beyond which the strength or ductility capacity of the structure is exceeded, or when it cannot maintain equilibrium and becomes unstable."

58. The Ō2NL Project has been determined by Waka Kotahi to have an Importance Level of 3+. This requires the scour protection works to ensure security of the bridge in a 0.067% AEP flood event. However, some of the proposed bridges appear to be likely to have a construction cost exceeding $18.0 million (as of December 2021)[5] and if so, the works may fall into the higher IL4 category. This would require the scour

[4] Technical Report F, paragraph 86(b).
[5] Bridge Manual v3.4 Table 2.1 (Page 2-4).

protection works to ensure the security of the bridge in a 0.04% AEP flood event.

59. In general, scour protection works by reinforcing the waterway with natural substrates of rocks and boulders. These can have the effect of slowing the flow down which, in turn, can increase water levels. These increases are at their maximum at the location of the scour protection, and taper off to zero upstream and downstream of the scour protection.

60. Waka Kotahi's technical assessments contain contradictory statements on scour protection. The With-Scheme Report states that where the design drawings indicated scour protection, the surface roughness was changed to 0.055.[6] Then it also goes on to state that scour protection details have not been modelled explicitly.[7] I have been unable to establish which of these approaches has been used.

61. The selection of the surface roughness value of 0.055 referred to in the With Scheme Report[8] is not supported by analysis. The usual process is iterative, and involves identifying areas that are prone to scour through an assessment of changes in velocity in the ULS flood event, calculating the size of the rocks and boulders required to provide the scour protection and their associated surface roughness value, updating the surface roughness in the model, re-running the ULS flood event and checking for additional areas where scour protection is necessary, until it is shown that no additional areas of scour protection are necessary.

62. Neither approach – whether it be not explicitly modelling scour protection measures or using of a surface roughness value of 0.055 to model scour protection - adequately identifies whether the critical infrastructure will be adversely affected by floodwaters and will cause adverse effects on the environment in the event of a flood. I am mindful of the fact that scour protection works can cause adverse effects on the environment such as increases in flood levels, and for this reason, I consider it necessary to model their effect as part of the application. In my opinion, any other

6 In paragraph two of section 2.3.1.
7 In the first sentence of the third paragraph of section 2.8.
8 At section 2.3.1, paragraph 2.

approach would need to be considered arbitrary because it is not supported by technical analysis.

The assessment of the effects of the works on flooding of buildings

63. Waka Kotahi states,[9] that "Any existing building in an area potentially affected by the Ō2NL Project was given careful analysis".

64. There is no discussion of flooding of buildings in the Baseline Flood Report that would have established the number of buildings currently at risk of flooding or the severity of the current flooding. There is also no discussion of the flooding of buildings or changes to the number of buildings flooded or the severity of the flooding in the With-Scheme Report.

65. Waka Kotahi summarises the findings of the analysis primarily with two phrases in their report. These are:[10]

> No buildings outside the proposed designations are impacted by the modelled increase in flood levels for the 1:100 AEP [sic] with climate change RCP 6.0 to 2130.

And

> There are…no existing buildings with **discernible increases** in flood risk.

66. The report does not provide an explanation of what Waka Kotahi considers to be a "discernible increase" or what change in flood level at a building is considered to have more than "no impact". The statements are not supported by technical analysis.

67. Waka Kotahi has shown that the works will cause increases in flood levels beyond the designation. Information on the location of buildings in relation to the increased flooding has not been provided, nor has a table of buildings and water levels for the Baseline and "with-road" scenarios. Both of these approaches are commonly used to provide information of the effects of developments on flood levels at buildings.

9 At paragraph 115 (a) of the evidence.
10 Technical assessment F, paragraphs 201 and 203.

68. In the absence of this kind of information I cannot agree with Waka Kotahi's statement that "No buildings outside the proposed designations are impacted…" and "There are…no buildings with discernible increases in flood risk". I do not consider there to be any supporting assessment provided for these statements.

69. A request from Horizons and GWRC for clarification through the request for information under section 92 of the RMA did not yield any further information.[11]

70. Accordingly, I consider that Technical Assessment F does not contain sufficient information on the effects of the proposed works on flood levels at buildings.

The assessment of debris arrestors

71. Waka Kotahi have proposed the use of debris arrestors to reduce the risk of debris damaging critical infrastructure. I consider this to be appropriate.

72. However, Waka Kotahi has not provided specific information on important aspects of the debris arrestors, such as where they will be installed and how they will function.

73. This information is considered important as debris arrestors (while useful mitigation) have the potential to increase upstream water levels, especially during large floods, and they may also create changes in the distribution of flows within the channel.

74. Waka Kotahi states that monitoring and maintenance plans will be developed in the detailed design phase, and that this will include regimes to clear debris arrestors. In the With-Scheme Report, Waka Kotahi confirms that debris arrestors were not modelled.[12]

75. In my opinion, when combined with the likelihood of effects on flooding that debris arrestors can create, the use of debris arrestors requires

[11] Waka Kotahi's response to Horizons and GWRC's s 92 requests (December 2022), paragraph 78.
[12] Section 3.3.

modelling work to be undertaken with an allowance for the effects of the debris arrestors on flooding.

76. I consider that Technical Assessment F does not contain sufficient information on the effects of debris arrestors to demonstrate that the effects are able to be managed so as to not cause adverse effects, including to neighbouring properties.

The peer review

77. The scope of the peer review is limited. It does not address any of the issues I have raised in my section 87F report.

H. SUBMISSIONS

78. On review, flooding is raised as a concern in multiple submissions. I comment on each submission with substantial concerns about flooding below.

79. The submission of N and S Whyte (submission #3) raises concerns about the drainage at 22-24 Koputaroa Road. Waka Kotahi's reporting shows pre-existing flooding at this location in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be no change to the flooding with the works in place.

80. The submission of G Williams (submission #10) raises concerns that flooding may be worsened where the Ō2NL expressway crosses a bridge over South Manakau Road. Waka Kotahi's reporting appears to show existing flood levels are increased at this location in the 1% AEP + CC flood event and the 10% AEP flood event. I consider that increases in flood levels on South Manakau Road and within the proposed designation will potentially cause an adverse effect.

81. The submission of A and J McCallum (submission #11) raises concerns about flooding at 213a Muhunoa Road. Waka Kotahi's reporting shows pre-existing flooding at this location in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be reductions in flood levels with the works in place. While the submitters have requested that the flooding issues are completely resolved, this is not required as

a consequence of the Ō2NL Project. The reduction in flooding is a positive effect.

82. The submission of L Miles (submission #20) raises concerns about flooding in the lower Manakau village. Waka Kotahi's reporting shows pre-existing flooding at this location in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be no change to the flooding with the works in place. I consider that the works are unlikely to have any impact on flooding in this location because it is several hundred metres away from the Ō2NL expressway.

83. The submission of G Anderson (submission #22) raises concerns about drainage at 413 Arapaepae South Road. Waka Kotahi's reporting shows pre-existing flooding at this location in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be no change to the flooding with the works in place. I have been unable to verify these concerns because the mapping provided by Waka Kotahi is too coarse for this particular property. However, the maps show the property adjacent to the proposed designation, and the mapping appears to show increases in water levels up to the designation boundary but with no increase beyond the designation.

84. The submission of Te Whatu Ora – Public Health Services Midcentral (submission #45) raises concerns about the fencing of ponds and pest management relating to mosquitoes. In my view, neither matter is directly relevant to flooding and hydrology.

85. The submission of K and S Prouse (submission #49) raises concerns about flooding at 1024 Queen Street East. Waka Kotahi's reporting shows pre-existing flooding at this location, which is adjacent to the designation, in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be increases in flood levels in both events. I have had difficulty in identifying the quantum of the increases in flood levels because the mapping provided by Waka Kotahi is too coarse. However, it appears from the maps that the increase on this property and outside the designation boundary is more than 0.5m in the 1% AEP + CC flood event and more than 0.1m in the 10% AEP flood

event. I consider that the works will create a significant adverse effect at this location.

86. The submission of R McLeay (submission #52) is concerned about the size of the largest event used to assess the effects of the works on flooding. Mr McLeay suggests a larger storm should have been considered. The submission does not acknowledge that the work undertaken by Waka Kotahi has included the effects of climate change. Mr St Clair addresses the planning requirements that are relevant to the selection of the largest storm event used to assess the effects of the works on flooding.

87. The submission of E and C Chalmers (submission #60) raises concerns about flooding at 366 Arapaepae South Road. Waka Kotahi's reporting shows pre-existing flooding at this location in the 1% AEP + CC flood event and the 10% AEP flood event. It indicates that there will be no change to the flooding with the works in place. I consider that there are no flooding or hydrology issues arising from this submission.

88. The submission of KiwiRail Holdings Limited (submission #73) discusses the need to size culverts to avoid adverse effects on KiwiRail assets. Mr Brown addresses culverts in his report. The KiwiRail submission does not raise any specific concerns, with issues addressed during Waka Kotahi's reporting and the concerns raised in my evidence.

89. The submission of S Austin (submission #79) raises concerns about flooding at Kimberley Reserve. Waka Kotahi's reporting does not extend to this area, and it is well away from the works. I consider that there are no flooding or hydrology issues arising from this submission.

I. FURTHER INFORMATION

90. In my view, further and more detailed information is required to show that the proposed works will not have adverse effects on the environment in the event of a flood. I anticipate that these outstanding matters/information can then be the subject of conferencing and further discussion between the technical experts for the parties.

91. This information would include, as a minimum:

(a) Maps at an appropriate scale that show:

(i) Flood Extents for the largest flood event modelled, the smallest flood event modelled and an intermediate flood event, for the baseline scenario and the "with-road" scenario (two sets of maps; the extents for the three events can be overlayed).

(ii) Flood Level Difference between the baseline scenario and the "with-road" scenario for the largest flood event modelled, the smallest flood event modelled and an intermediate flood event (three sets of maps).

(iii) Flood Velocity for the largest flood event modelled, the smallest flood event modelled and an intermediate flood event, for the baseline scenario and the "with-road" scenario (six sets of maps; the three events cannot be overlayed).

(iv) Flood Velocity Difference between the baseline scenario and the "with-road" scenario for the largest flood event modelled, the smallest flood event modelled and an intermediate flood event (three sets of maps).

(v) Categorised Flood Hazard, which is the product of depth and velocity, for the largest flood event modelled and the smallest flood event modelled, for the baseline scenario and the "with-road" scenario (four sets of maps). Flood Hazard can be categorised in accordance with the Australian Rainfall and Runoff Guidelines, Book 6, Chapter 7, or a suitable alternative.

(vi) Flood Hazard Category Difference between the baseline scenario and the "with-road" scenario for the largest flood event modelled and the smallest flood event modelled (two sets of maps).

(vii) Flood Affected Parcels and Flood Affected Buildings for the largest flood event modelled in the "with-road"

scenario (one set of maps). I consider a Flood Affects Parcel to be a parcel of land that is covered, either partially or entirely, with flood water at least 0.05m deep. I consider a Flood Affected Building to be a building (as defined in the Building Act 2004) whose footprint partially or entirely overlaps the floodplain where the flood water is at least 0.05m deep.

(b) Tables that show:

(i) Maximum flood depths on each Flood Affected Parcel for all events modelled, in the baseline and "with-road" scenarios.

(ii) Maximum flood levels at each Flood Affected Building for all events modelled, in the baseline and "with-road" scenarios.

(iii) Maximum velocities on each Flood Affected Parcel for all events modelled, in the baseline and "with-road" scenarios.

(iv) The quantum of freeboard achieved at all bridges and culverts for all the events modelled.

92. I consider an appropriate scale for the maps to be one that covers the full length of the route in its entirety, the full extent of the designation either side of the main alignment and, in areas where increases in flood effects extend beyond the designation boundary, to at least 50m further than the increased flood effects. I note that the maps of stormwater drainage included in Appendix III of the application are at 1:2,000 scale at A3 paper size with portrait orientation. To be helpful it is my view that if the maps I refer to in paragraph 91(a) were produced at 1:2,500 scale at A3 paper size with landscape orientation these map sets would likely to be at an appropriate scale.

93. I understand that Mr McArthur for the District Councils has recommended the provision of additional mapping in his section 198D report. I agree with these recommendations.

94. I am available to discuss any of the above information requirements with the technical advisors for Waka Kotahi if that would be helpful going forward.

J. CONDITIONS

95. I have reviewed the conditions proposed by Waka Kotahi and recommended amendments to conditions RBS1 and RWB1 to address issues I have raised above. These changes are set out in the condition set provided with Mr St Clair's s 87F report.

96. I also consider that additional conditions are required, including:

    (a) A condition to require a range of flood events to be used to demonstrate the conditions are met. The number of events should be at least five, and these could either be defined in the condition or the condition could be written to require the technical experts at Horizons, GWRC, the District Councils and Waka Kotahi to agree on the events. The condition should be included in the RBS series of conditions.

    (b) A condition to require that earthworks associated with the construction of the formation of the expressway do not cause adverse effects on flooding. Currently the conditions are specific to bridges and culverts.

Peter Kinley

28 April 2023

APPENDIX A:

Relevant Work Experience

(a) The Boundary Creek Bank Remediation, as a technical expert through evidence and joint expert conferencing. Subsequently I supported the delivery of the remedial work ordered by the Court as the Technical Director for Sydney Water Corporation.

(b) The Auckland Council Flood Response and Recovery, on behalf of Auckland Council.

(c) Auckland Light Rail Notice of Requirements Phase, as the Technical Director on behalf of the Auckland Light Rail company overseeing the Flooding and Hydrology impacts assessment for the full route.

(d) Ara Tūhono Stage 2, the Warkworth to Wellsford Road of National Significance, as the Technical Leader for Flooding and Hydrology for the design consultant at the Notice of Requirements phase.

(e) Ara Tūhono Stage 1, Puhoi to Warkworth Road of National Significance, as Waka Kotahi's Principal's Technical Advisor for the Flooding and Hydrology work at the Detailed Design phase. The role involved review of the design undertaken by Waka Kotahi's design consultant.

(f) Auckland Northern Corridor Improvements, as the Technical Leader and Lead Modeller for Flooding and Hydrology for the design consultant at the Detailed Design phase.

(g) Christchurch Northern Corridor as a Technical Advisor on Flooding and Hydrology for the design consultant at the Construction phase.

(h) Waikato Expressway – Huntly Bypass as the Technical Leader for Flooding and Hydrology for the design consultant at the Design phase.

(i) The flooding risk assessment for the New Dunedin Hospital as the Technical Leader for the design consultant at the Feasibility and Consenting phase, advising the Southern District Health Board.

(j) Transmission Gully, as the Flood Risk Assessment and Hydraulic Structures Design Lead for the design consultant at the Feasibility phase.

(k) State Highway 20 – Hillsborough Road to Maioro Street section, as the Technical Reviewer on behalf of Auckland City Council at the Design phase.

(l) Flooding and Hydrology impact assessments at Bridge Inn Road, Sunbury Road, Craigieburn Road, Pound Road West, Childs Road and Fitzsimmons Lane in the Greater Melbourne area, as the Principal's Technical Advisor for Major Roads Projects Victoria ("**MRPV**").

(m) Hydrology, flooding and water utilities assessments at the Clayton Campus, as the Technical Advisor to Monash University for the Suburban Rail Link Project in Melbourne.

(n) Flood impact assessments arising from proposed developments, as the Technical Leader advising Kapiti Coast District Council.

(o) Development of catchment level flood maps for four catchments in Wellington and Porirua, as the Technical Leader advising Wellington Water.

(p) Peer reviewer of the updated hydrological method developed for Wellington Water.

(q) Technical Leader and Expert Witness for the flooding and hydrology aspects of the Pinehaven Catchment Improvements, advising Wellington Water, Upper Hutt City Council and GWRC.

(r) Technical Leader for the flood risk assessments of Reids Line Floodway, the Mangaone Stream and East of Levin, advising Horizons.

(s) Technical Leader for the flood risk assessment of the lower Waimea River, advising Tasman District Council.

(t) Technical Leader for flood risk assessments of approximately 50 catchments across greater Auckland.

(u) Technical Leader for flood risk assessments at Maurice Road, Westfield Yards, Matata, Te Puke and Otira Tunnel, advising KiwiRail.

APPENDIX B

Examples of locations where the design exceeds proposed change threshold values

The figures below are from Waka Kotahi's Technical Assessment F. In all figures the general locations of areas where the proposed change threshold values are exceeded are shown with thick black lines.

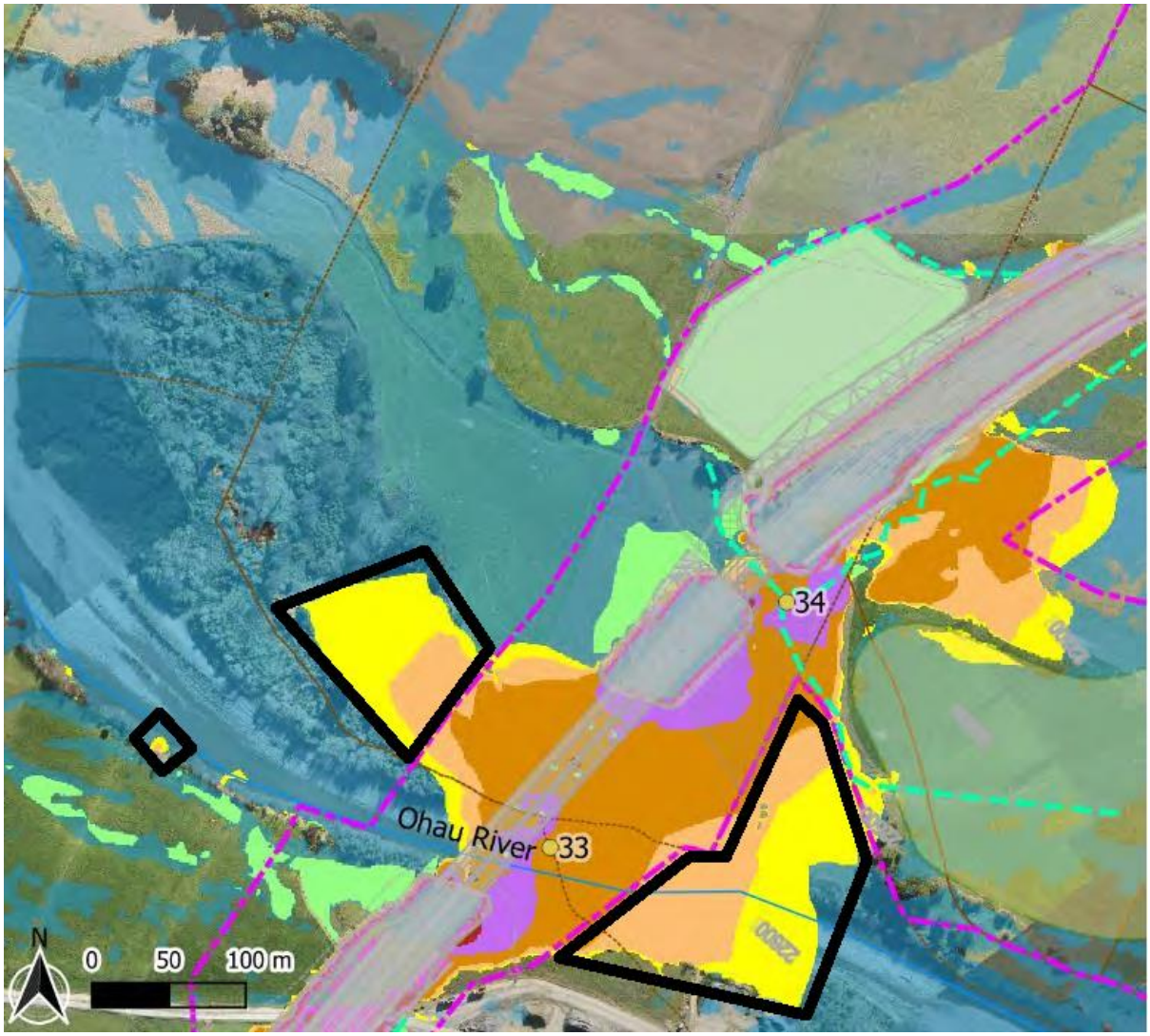

Figure 2: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.13

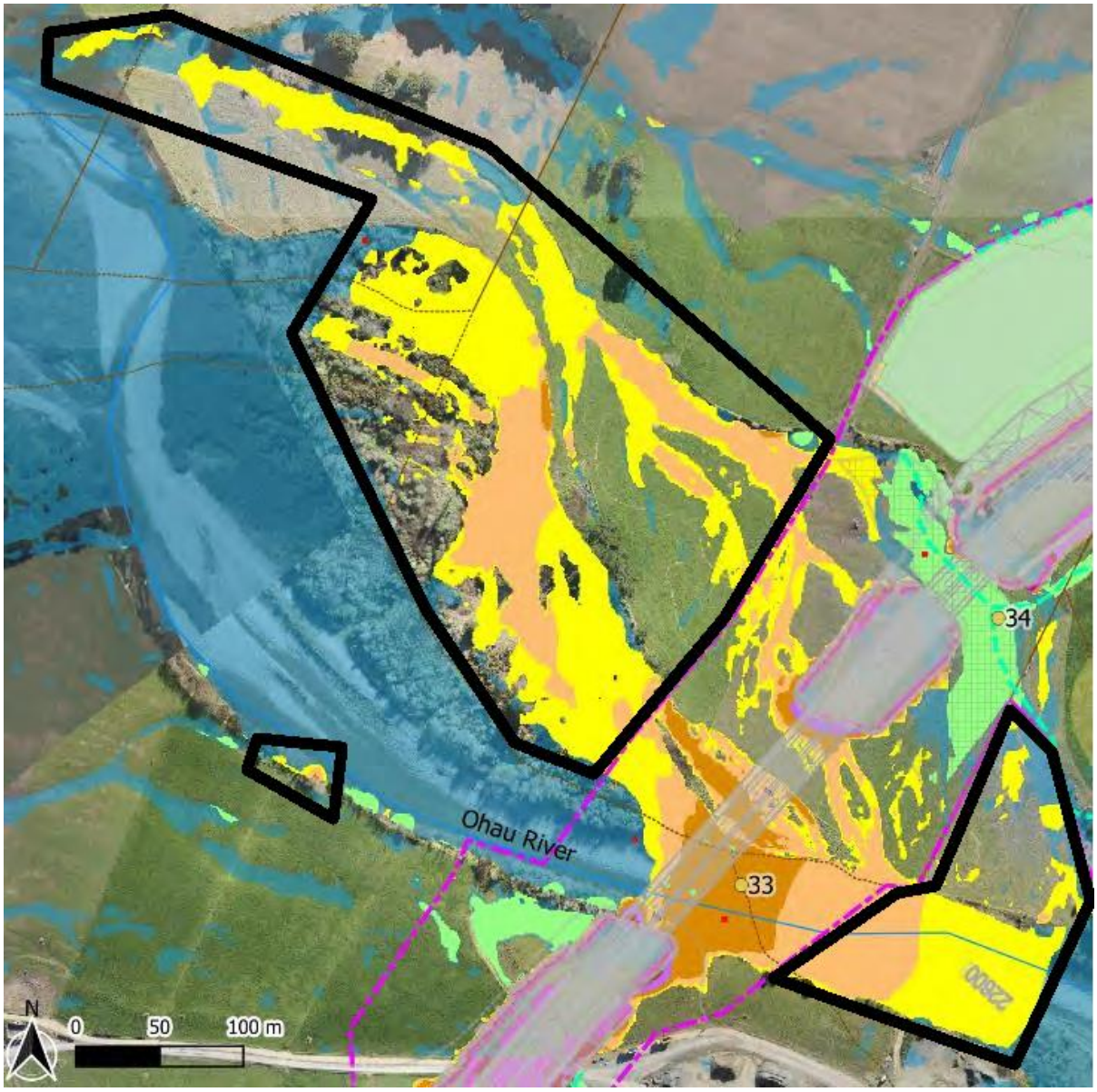

Figure 3: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.14

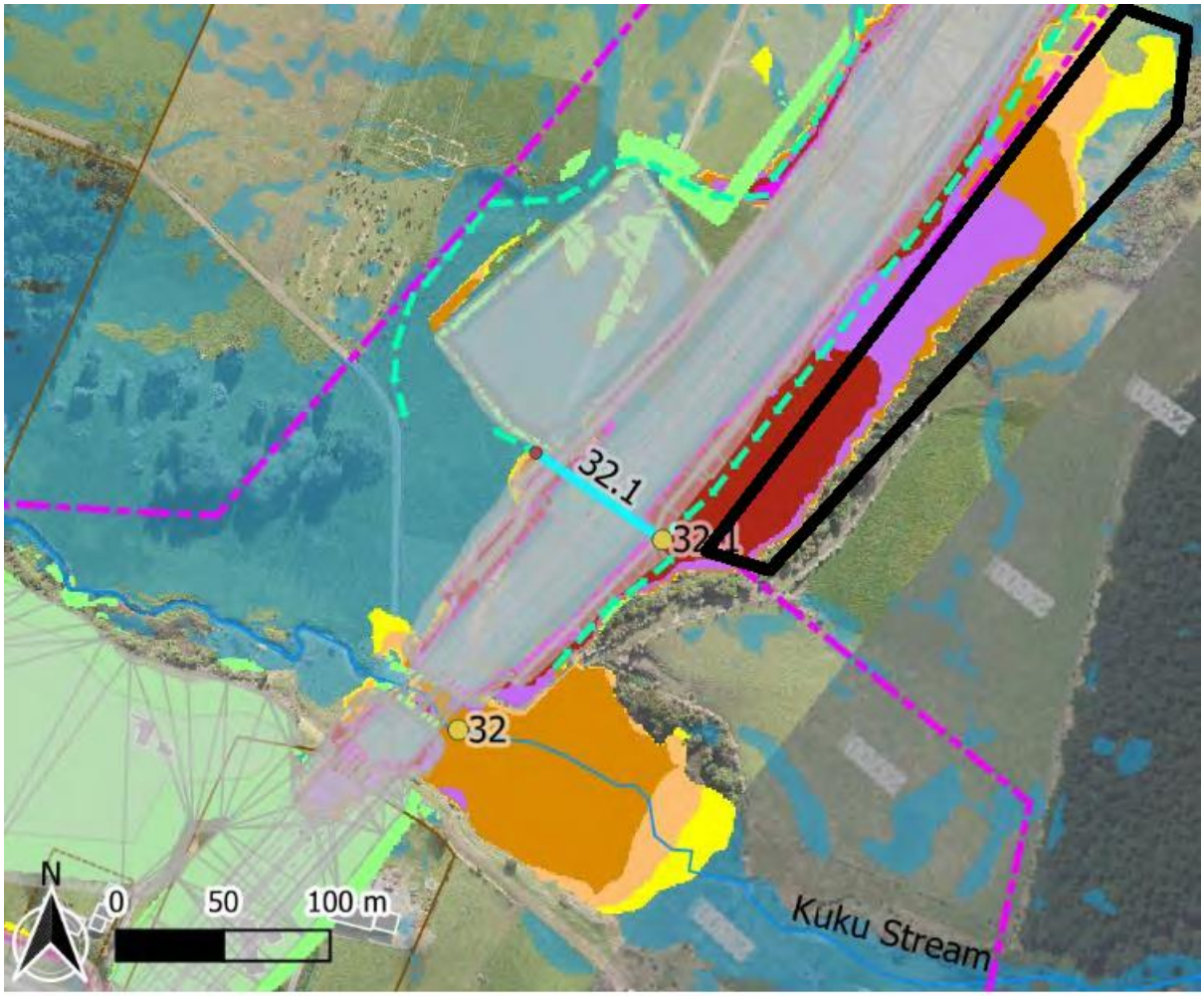

Figure 4: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.19

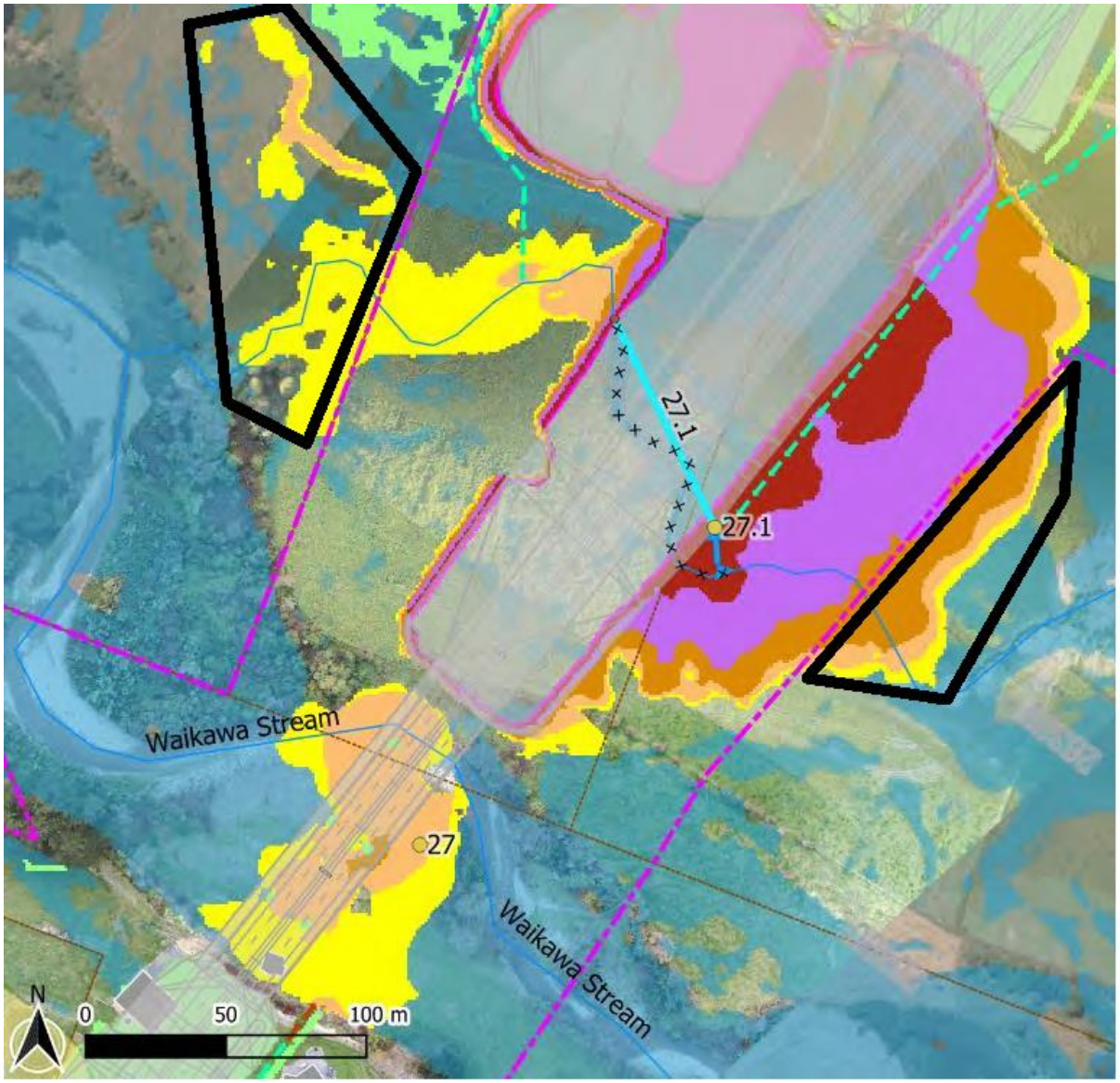

Figure 5: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.23

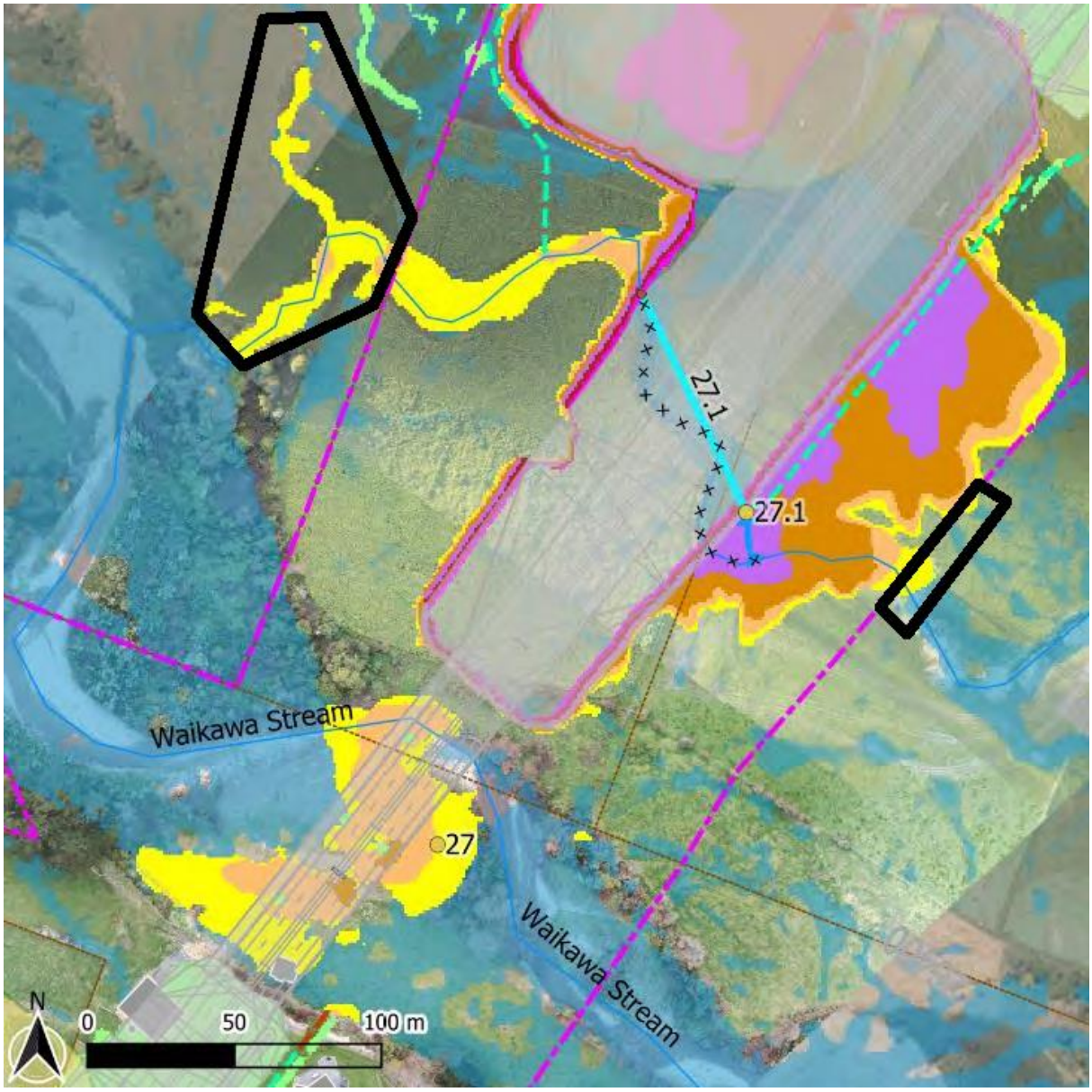

Figure 6: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.24

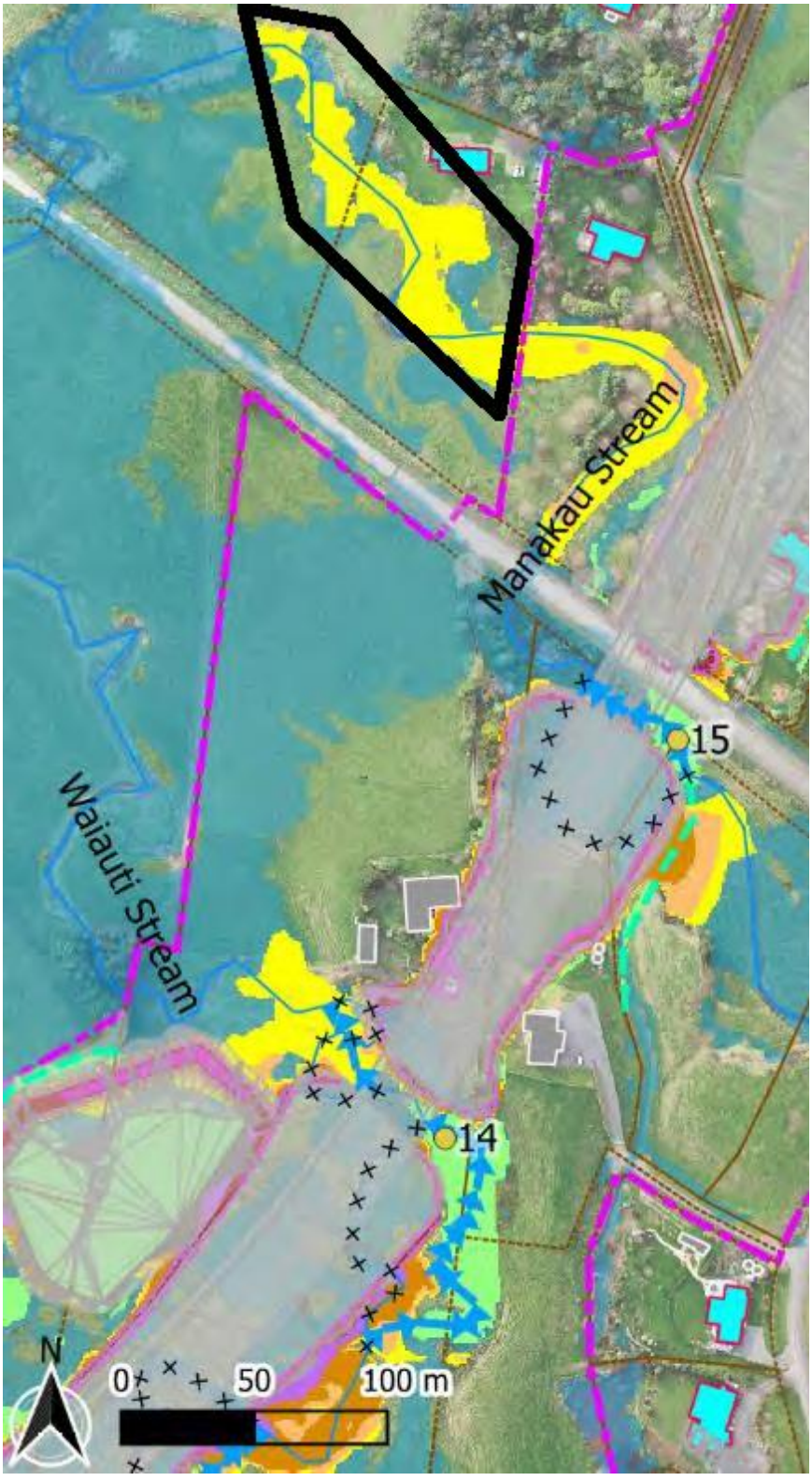

Figure 7: Increases in flooding outside the designation boundary shown in Waka Kotahi's Technical Assessment F Figure F.31