IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents and notices of requirement in relation to the Ōtaki to North of Levin Project
BY	**WAKA KOTAHI NZ TRANSPORT AGENCY** Applicant

ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

TECHNICAL ASSESSMENT K: FRESHWATER ECOLOGY

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. The Ōtaki to north of Levin Highway Project ("**Ō2NL Project**" or "**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.

2. This technical report assesses the actual and potential effects of the Project on freshwater ecology. It has been prepared to support the notices of requirement ("**NoRs"**) for designations and application for resource consents for the Ō2NL Project.

Methodology and existing state of freshwater environment

3. The proposed Ō2NL Project route traverses five water catchments (see Volume III Stormwater drawing set 310203848-01-300-C2000 – C2003). From north to south, these are the Koputaroa (a sub-catchment of the Manawatū River), Punahau/Lake Horowhenua, Ohau, Waikawa, and Waitohu. Forty-eight waterways that intersect with the Ō2NL Project have been identified (four ponds, 25 permanently flowing streams/rivers, and 19 ephemeral watercourses/overland flow paths). No intermittent streams have been identified.

4. Field surveys and site visits to all accessible sites were undertaken between March and November 2021. At the 21 permanent streams where access was available, surveys involved assessments of stream function and habitat condition using the Stream Ecological Valuation (**"SEV"**) methodology, collection of macroinvertebrate samples, and collection of environmental DNA ("**eDNA**") samples to determine which fish species were present. Ephemeral sites were documented via site notes and photography. Surveys and site visits were undertaken at the site of impact (where the proposed designation intersects with the waterway).

5. The ecological surveys indicated that the majority of sites were degraded by agricultural and/or horticultural land use. Based on flow permanence, SEV scores, habitat characteristics, macroinvertebrate community assemblages, and fish species present, the overall ecological values were:

   (a) "High" – two sites (Ohau River and Waikawa River).

(b) “Moderate” – ten sites (Stream 39, Stream 39.1, Kuku Stream, Stream 29, Stream 27.1, Stream 19, Stream 17, Stream 18, Manakau Stream, and Waiauti Stream)

(c) “Low” – all other permanently flowing streams.

(d) “Negligible” – ephemeral waterways.

Assessment of effects

6. The actual and potential effects of the Ō2NL Project on freshwater ecology were assessed separately for the construction phase (generally short-term effects) and operational phase (generally long-term effects).

7. The construction phase effects identified were:

(a) Freshwater habitat disturbance – the unavoidable disturbance of freshwater habitats during the construction of culverts and diversions that may injure and kill stream biota.

(b) Fish migration disturbance – disruption to the natural movements of fish resulting from the use of temporary diversions during construction.

(c) Release and deposition of fine sediments – the discharge of fine sediments from construction sites to adjacent waterways where it may cause adverse effects on stream biota by smothering of the streambed.

(d) Water contamination – the contamination of waterways and connected wetlands by machinery (e.g., oils, greases, fuel, hydraulic fluids) and construction materials (e.g., concrete, concrete wastewater, grouts, mortars).

(e) Water abstraction – the abstraction of water for construction purposes has the potential to have adverse effects on freshwater habitats and biota.

8. The operational phase effects identified were:

(a) Reduction in free movement of aquatic fauna – the permanent alteration of natural migration and movement pathways via the installation of culverts.

(b) Stormwater discharges – the discharge of stormwater from the Ō2NL Project to adjacent waterways where it may have adverse effects due to the contaminants (e.g., metals, hydrocarbons, fine sediments) it contains and via alteration to existing hydrology.

(c) Freshwater habitat loss and modification – the permanent loss and modification of freshwater habitat via installation of culverts and stream reclamation. There will be approximately 3,224 m of existing permanent stream channel length lost over the project

(d) Light pollution – the installation of artificial lighting in locations where it may have adverse effects on freshwater ecology.

Effects management and overall level of effects

9. Various effects management actions are proposed to avoid, remedy, mitigate or offset the adverse effects on freshwater ecology identified above. The management actions, and assessment of overall levels of effect applying the Ecological Impact Assessment Guidelines (**"EcIAG"**) matrix, are summarised below.

Construction effects

10. Freshwater habitat disturbance effects during the construction phase will be minimised by the capture and relocation of fish and large macroinvertebrates (kōura, kākahi) from impacted stream reaches. With this action, the overall effect will be "Low" for the Ohau River and "Very Low" for all other sites.

11. Fish migration disturbance effects during construction will be avoided by either avoiding works during migration periods of fish species known to exist in the water course / at the site or by ensuring fish passage is possible through any temporary diversion pipes or open channels. With these actions, the overall effect will be "Low" for Stream 2 (near chainage 34,050) and "Very Low" for all other waterways.

12. The effects of release and subsequent deposition of fine sediments during construction will be minimised by the implementation of an erosion and sediment control plan ("**ESCP**") (and associated site-specific erosion and sediment control plans) detailing the various methods and procedures to limit the discharge of runoff laden with fine sediments to adjacent waterways. Because of the differing sensitivities of receiving environments

to fine sediment deposition, and the high likelihood that there will be at least some discharges of turbid water from the construction zone to adjacent waterways, the overall effects taking into account the implementation of the management plans vary among waterways. Effects are, as follows:

(a) "Moderate" for Stream 17 (chainage 29,500) and Stream 19 (chainage 28,850);

(b) "Low" or "Very Low" for the remaining waterways.

13. Water contamination from machinery and construction materials during the construction phase will be avoided by:

(a) appropriate vehicle and fuel management;

(b) ensuring all work areas using wet concrete are isolated from flowing waters;

(c) ensuring all grouts or mortars are fully cured prior to contact with flowing water.

With these actions, the overall effect will be "Low" to "Very Low" for all waterways.

14. Adverse effects of water abstraction for construction purposes will be minimised or avoided by:

(a) constructing storage ponds which will be replenished at low instantaneous abstraction rates;

(b) only taking water from existing available allocations and use minimum flow levels defined in the relevant Regional Plan for each watercourse as the flow level at which any abstraction must cease;

(c) ensuring all intakes have 2-3 mm screens to avoid fish from entering pumps.

15. With these actions, the overall effect will be "Low" for all waterways where abstraction is proposed.

Operational effects

16. The reduction in the free movement of aquatic fauna by installation of permanent culverts will be avoided at the major streams with the use of bridges. All culverts in permanent streams will be designed to provide fish passage using the “stream simulation” designs as standard. Ephemeral streams with permanent habitats upstream (that is farm dams and ponds) may use a flexible baffle design to facilitate fish passage at times when there is surface water flowing. This equates to:

    (a) A “no effect” situation for bridge sites (Ohau River, Waikawa Stream, Manakau Stream, Waiauti Stream).

    (b) A “Net Gain” for Stream 2 (new culvert under existing SH1 near chainage 34,050), Stream 20 (approximate chainage 28,575), and Stream 23 (approximate chainage 28,050), where a new culvert will increase connectivity due to existing barriers being removed, and for Kuku Stream where an existing farm culvert is being removed. This equates to a “positive effects” situation.

    (c) A “Very Low” level of effect for all other waterways.

17. The operational effects of stormwater discharges will be minimised by capturing all road runoff for conveyance through a stormwater treatment train incorporating swales and retention ponds/wetlands. This will result in any runoff to adjacent waterways being treated to remove as many contaminants as possible. This design means the overall effect is a “Net Gain”, “Low” or “Very Low” level for all waterways.

18. The permanent loss and modification of freshwater habitat as a result of culvert installation and stream reclamation is an unavoidable effect of road construction. At some locations, stream diversions will reduce the overall length of open stream that is lost. Offsetting is proposed to address residual effects that are not able to be managed at the site of impact. This is to be achieved with riparian fencing and revegetation at other locations in the affected catchments. The quanta of offsetting is determined using the environmental compensation ratio derived from SEV scores.

19. The overall effect magnitude of freshwater habitat loss and modification is “Very High” in the absence of any effects management. When offsetting to achieve no-net-loss, including the construction of diversion channels, is taken into account the magnitude of effect is reduced from “Very High” to

"Negligible" and potentially "Positive". This equates to either a "Very Low" to "Net Gain" overall level of effect in EcIAG terms. In practice, due to the practicalities of stream fencing (i.e., completing fencing to meet existing fence lines) a greater area is likely to be fenced and planted than strictly required by SEV Environmental Compensation Ratio (**"ECR"**) calculations. This will result in a net-gain situation.

20. The adverse effects of artificial lighting on freshwater ecology are largely avoided by the Ō2NL Project by only installing lighting at conflict points (being intersections where traffic enters/exits). This has meant that only four waterway sites are in close proximity to artificial lighting. These are all small streams, where riparian planting will create a closed canopy that will shade the stream surface from artificial light at night. Additionally, these streams are dominated by non-insect taxa that do not have flying adult stages, meaning that their macroinvertebrate assemblage is not overly sensitive to artificial light at night. For the four affected streams (Stream 39, Stream 39.1, Stream 1, and Stream 3) the overall level of effect of artificial lighting is "Very Low". For all other stream sites there is "No Effect".

21. To summarise, the Ō2NL Project will have adverse effects on freshwater habitats. These adverse effects have been appropriately avoided, minimised, remedied, mitigated or offset.

INTRODUCTION

22. My full name is Alexander Bryan Wilfried James. I am a Senior Freshwater Ecologist at EOS Ecology. I am the author of this technical assessment.

23. I have been providing freshwater ecology advice relating to the Ō2NL Project to Waka Kotahi NZ Transport Agency ("**Waka Kotahi**") since December 2020.

24. My involvement to date in the Ō2NL Project includes:

    (a) Designing and undertaking a field survey programme to collect information on the existing state of waterways intersected by the Ō2NL Project.

    (b) Providing advice on fish passage requirements at waterway crossings along the Ō2NL Project.

    (c) Producing a freshwater ecology assessment of environmental effects to support a consent application to allow test pits to be excavated in close proximity to some waterways as part of geotechnical investigations.

    (d) Input into development of the Cultural and Environmental Design Framework ("**CEDF**").

    (e) Attending various community meetings in 2021 and consultation and engagement exercises in May 2022 to provide Project updates on ecological matters.

    (f) Attending ecology workshops and attending a site visit with Project partners Muaūpoko and Ngāti Ruakawa ki te Tonga and also with stakeholders Horizons, the Department of Conservation ("**DOC**"), and Forest and Bird.

    (g) Attending hui with Project partners Muaūpoko and Ngāti Ruakawa ki te Tonga to discuss freshwater ecology.

    (h) Input into the assessment of natural character.

    (i) Initial site visits and discussions with landowners of potential stream offsetting locations.

    (j) Preparation of this technical assessment of the Ō2NL Project's effects on freshwater ecology.

Qualifications and experience

25. I am a Senior Freshwater Ecology Scientist at EOS Ecology, where I have worked for 13 years. My role entails undertaking freshwater ecology research and consultancy work for various clients including large multidisciplinary consultancies, local councils, regional councils, government departments and agencies, and private individuals.

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

    (a) I hold a PhD in freshwater ecology and a Bachelor of Science (Hons) in ecology, both from Massey University.

    (b) I also hold a Bachelor of Science (majoring in ecology, geology, and biology) from Victoria University of Wellington.

    (c) In the 13 years I have worked at EOS Ecology I have undertaken various freshwater ecology assessments of environmental effects for various infrastructure projects, including roads (e.g., Christchurch's West Belfast Bypass and Northern Corridor) and flood protection infrastructure (for example, Pinehaven Stream Improvement Project). I have also reviewed numerous consent applications on behalf of regional councils that have involved disturbance of freshwater habitats.

    (d) Prior to my role at EOS Ecology, I was a self-employed freshwater ecologist from 2007 to 2009, where I undertook one of the first assessments of fish passage barriers in the Manawatū-Whanganui Region.

27. I am a member of relevant associations including:

    (a) New Zealand Freshwater Sciences Society ("**NZFSS**") since 2002; and

    (b) Engineering New Zealand/Water NZ Rivers Group since 2018.

Code of conduct

28. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not

omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

29. Waka Kotahi is giving NoRs for designations to Horowhenua District Council ("**HDC**") and Kapiti Coast District Council ("**KCDC**") and is applying for the necessary resource consents from Horizons and the Greater Wellington Regional Council ("**GWRC**") for the Ō2NL Project. The Ō2NL Project is part of the New Zealand Upgrade Programme ("**NZUP**") and has the purpose to *"improve safety and access, support economic growth, provide greater route resilience, and better access to walking and cycling facilities"*

30. This technical report is one of a suite of technical reports prepared for the Ō2NL Project and assesses the actual and potential environmental effects of the Ō2NL Project on freshwater ecology.

31. Over the course of the assessment phase I have attended various meetings and workshops and other activities that have helped shape the Ō2NL Project including:

    (a) Four ecological workshops that included representatives of the Project's Iwi Partners and key stakeholders. The ecological response package required to mitigate, offset and/or compensate for the adverse effects of the Ō2NL Project on freshwater ecology were described at these workshops, including the stream offsetting sites that were being explored. Workshop participants did not raise any particular issues regarding the location of potential stream offsetting sites.

    (b) Two natural character workshops focussing on the assessment of natural character to assist the Natural Character Assessment detailed by **Mr Gavin Lister**.

    (c) Three meetings and a site visit on 8 September 2022 with Logan Brown, the Freshwater and Partnerships Manager from Horizons, who is the reviewer of the freshwater ecological technical assessment on behalf of Horizons and GWRC.

    (d) Having the Project's Iwi Partner representatives assist with site-specific survey fieldwork.

(e) Site visit with the Project's Iwi Partners from Muaūpoko Tribal Authority and Ngāti Ruakawa ki te Tonga; and also with representatives from the Department of Conservation, Horizons and GWRC.

32. To provide background and context, this assessment should be read in conjunction with the following expert technical assessments and plans that have been developed to support the Ō2NL Project:

(a) Volume III: Drawings and Plans

(b) The CEDF, prepared in collaboration with iwi Partners **(**Appendix Three of Volume II of the application), which has the overarching purpose to "***integrate*** *the design elements of the Ō2NL project in response to* ***context*** *through te ao māori and agreed* ***principles*** *and design* ***outcomes*** *that flow from this. With mātaurangi māori and te mana o te wai placed at the centre of the design framework, the wero (challenge) for the project, in achieving its objectives, is to look for all opportunities to 'do no harm' and to let the whenua and the awa be its natural self*."

(c) The Design and Construct Report ("**DCR**"), prepared by **Mr Jamie Povall** (Appendix Four, Volume II).

(d) The Erosion and Sediment Control Report and Plan (included in the DCR Appendix Four, Volume II), prepared by **Mr Gregor McLean.**

(e) The Stormwater Management Design report (included in the DCR Appendix Four, Volume II), prepared by **Mr Nick Keenan**.

(f) Technical Assessment D: Visual, Natural Character and Landscape Effects by **Mr Gavin Lister.**

(g) Technical Assessment F: Hydrology and Flooding by **Mr Andrew Craig.**

(h) Technical Assessment G: Hydrogeology and Groundwater by **Dr Jack McConchie**.

(i) Technical Assessment H: Water Quality by **Mr Keith Hamill** and **Mrs Kristy Harrison**

(j) Technical Assessment J: Terrestrial Ecology by **Dr Nick Goldwater.**

(k) The Cultural Impact Assessments (Volume V) from the Project iwi Partners.

ASSUMPTIONS AND EXCLUSIONS IN THIS ASSESSMENT

33. My assessment is limited to the freshwater ecological effects and actions to address adverse effects resulting from the Ō2NL Project.

34. It is assumed the project description and associated plans and drawings (Volume III) accurately depict the Project intent and scale.

35. This assessment is for the Ō2NL Project and covers all construction activities, including potential enabling works that are described in Volume II and its Appendix Four (Design and Construction Report) that may be required prior to the main construction programme beginning.

36. I provided input into the assessment of natural character values and effects. Natural character matters, including my input into the assessment, are addressed in Technical Assessment D (and not repeated in this assessment).

PROJECT DESCRIPTION

37. The Ōtaki to north of Levin Highway Project ("**Ō2NL Project**" or "**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. The Ō2NL Project includes the following key features:

    (a) a grade separated diamond interchange at Tararua Road, providing access into Levin;

    (b) two dual lane roundabouts located where Ō2NL crosses SH57 and where it connects with the current SH1 at Heatherlea East Road, north of Levin;

    (c) four lane bridges over the Waiauti, Waikawa and Kuku Streams, the Ohau River and the North Island Main Trunk ("**NIMT**") rail line north of Levin;

    (d) a half interchange with southbound ramps near Taylors Road and the new Peka Peka to Ōtaki expressway to provide access from the current SH1 for traffic heading south from Manakau or heading north from Wellington, as well as providing an alternate access to Ōtaki.

(e) local road underpasses at South Manakau Road and Sorensons Road to retain local connections;

(f) local road overpasses to provide continued local road connectivity at Manakau Heights Drive, North Manakau Road, Kuku East Road, Muhunoa East Road, Tararua Road (as part of the interchange), and Queen Street East;

(g) new local roads at Kuku East Road and Manakau Heights Road to provide access to properties located to the east of the Ō2NL Project;

(h) local road reconnections connecting:

  (i) McLeavey Road to Arapaepae South Road on the west side of the Ō2NL Project;

  (ii) Arapaepae South Road, Kimberley Road and Tararua Road on the east side of the Ō2NL Project;

  (iii) Waihou Road to McDonald Road to Arapaepae Road/SH57;

  (iv) Koputaroa Road to Heatherlea East Road and providing access to the new northern roundabout;

(i) the relocation of, and improvement of, the Tararua Road and current SH1 intersection, including the introduction of traffic signals and a crossing of the NIMT;

(j) road lighting at conflict points, that is, where traffic can enter or exit the highway;

(k) median and edge barriers that are typically wire rope safety barriers with alternative barrier types used in some locations, such as bridges that require rigid barriers or for the reduction of road traffic noise;

(l) stormwater treatment wetlands and ponds, stormwater swales, drains and sediment traps;

(m) culverts to reconnect streams crossed by the Ō2NL Project and stream diversions to recreate and reconnect streams;

(n) a separated (typically) three metre wide SUP, for walking and cycling along the entire length of the new highway (but deviating away from being alongside the Ō2NL Project around Pukehou (near Ōtaki)) that will link into shared path facilities that are part of the PP2Ō expressway (and further afield to the Mackays to Peka expressway SUP);

(o) spoil sites at various locations along the length of the Project; and

(p) five sites for the supply of bulk fill /earth material located near Waikawa Stream, the Ohau River and south of Heatherlea East Road.

38. Project elements that are particularly relevant to this assessment include the following:

(a) The design, construction, and operation of culverts, bridges, and diversion channels.

(b) The design, construction, and operation of stormwater treatment and detention infrastructure, including the water quality of stormwater discharges.

(c) Earthworks cut and fill locations, spoil disposal sites, and erosion and sediment control methodologies/infrastructure.

(d) Lighting design.

METHODOLOGY

Determining the State of the Existing Environment

39. A suite of existing and Project-specific ecological survey data was utilised to describe the existing state of the freshwater environment.

Existing Catchment-wide Information

40. To gain an overall appreciation of catchment condition, water quality and ecological information collected by GWRC and Horizons' state of the environment (**"SOE"**) monitoring programmes was obtained from the Land, Air, Water Aotearoa (**"LAWA"**) website,[1] Additionally, fish records were obtained from the New Zealand Freshwater Fish Database (**"NZFFD"**),[2] supplemented by some eDNA sampling undertaken by Horizons in the lower Koputaroa (January 2021), Ohau at Gladstone Reserve (March 2021), and Waikawa at North Manakau Rd (March 2021).

[1] https://www.lawa.org.nz/
[2] Crow S (2017). New Zealand Freshwater Fish Database. Version 1.2. The National Institute of Water and Atmospheric Research (NIWA). Occurrence Dataset https://doi.org/10.15468/ms5iqu

Stream Classification

41. All streams (with the exception of four sites with no access) and many flow paths within the proposed Ō2NL Project area were visited and classified as either ephemeral, intermittent, or permanent. The Horizons One Plan adopts the RMA definition of river – "continually or intermittently flowing body of freshwater" – meaning that intermittent streams (those that flow for part of the year) and permanently flowing streams are treated the same when assessing effects. In contrast, ephemeral streams and overland flow paths that only flow for short periods following significant rainfall are not considered to be "rivers" from a Resource Management Act ("**RMA**") perspective. Likewise, the GWRC Proposed Natural Resources Plan (**"PNRP"**) (Appeals version) specifically excludes ephemeral watercourses from their definition of "surface water body", which includes "any river, lake, natural wetland, estuary outside of the coastal marine area, or water race, and their bed."

42. From an ecological perspective, permanently flowing and intermittently flowing streams provide habitat for aquatic biota and are key components of the wider ecological landscape. Ephemeral streams contain surface water for such short periods that they do not provide habitat for aquatic biota, are often filled with terrestrial vegetation, and their main function from a freshwater ecology perspective is to convey water from the landscape to downstream intermittent and/or permanent freshwater environments, including wetlands. They do, however, provide pathways for shortfin tuna/eels (*Anguilla australis*) to colonise more permanent bodies of water (such as artificial ponds and farm dams) when they are flowing.

43. The One Plan does not include a definition or methodology that allows a reliable and consistent distinction to be made between ephemeral and intermittent streams/flow paths. Likewise, the GWRC PNRP (Appeals version) while providing definitions of "ephemeral watercourses" and "surface water bodies", does not specifically define intermittent streams. To fill this gap, the stream-type definitions of the Auckland Unitary Plan Operative in Part (**"AUPOP"**) were used to classify streams as ephemeral, intermittent, or permanent and also aid in determining artificial channels from natural channels (Appendix K1).[3]

[3] The AUPOP approach was also taken by Te Ahu a Tūranga project.

Watercourse Nomenclature

44. The names of a high proportion of watercourses traversed by the proposed designation are not known (or they are unnamed). All proposed locations where the road crosses watercourses (culverts and bridges) were numbered in a south to north direction and for consistency these have been used as the stream naming convention. Note that this numbering scheme also includes locations that are indistinct overland flow paths where no watercourse is evident. For the larger named waterways, we have used their recognised names (for example, Waiauti Stream, Manakau Stream, Waikawa Stream, Kuku Stream, Ohau River).

Site Investigations and application of SEV methodology

45. Site visits have been undertaken to all watercourses at the location of the proposed designation, where access to private property was obtained. For each watercourse the type, channel form, and flow permanence has been determined. “Type” is simply a determination of whether it was a flowing water (stream/river) or still water habitat (pond/lake) and classified as either “pond”, “stream” or “river”. “Channel form” was determined as either:[4]

(a) “Artificial” are those watercourses that meet the definition of “artificial watercourse” as defined in Appendix K1.

(b) “Modified” are those channels that have been straightened, deepened or otherwise altered from their natural state, often to facilitate drainage for conversion of wetland to pasture. The term is also applied to those ponds that have been created through the construction of embankments (i.e., railway, driveways) or dams across what formerly would have been permanent, intermittent, or ephemeral stream channels.

(c) “Natural” are those channels that appear to retain their natural flow path and have avoided significant straightening, deepening, and/or channel modification.

46. No sites that meet the definition of “intermittent stream” are located within the proposed designation. One site (Stream 11), which was predominantly permanently flowing, contained a short section that appeared intermittent, however, this site was treated as a permanent stream.

[4] Flow permanence was determined with the aid of the AUPOP definitions (see Appendix K1) with watercourses identified as either permanent or ephemeral

47. Ephemeral watercourses were documented via site walkovers and photography. At permanently flowing sites, habitat characteristics were measured using the SEV methodology.[5] The SEV is a method for quantifying stream value based on the performance of key ecological functions. It was developed to quantify the ecological value of streams in a consistent manner to inform resource management decisions.[6] The methodology consists of the 14 most important ecosystem functions as identified by an expert panel which fall into four broad categories:

(a) Hydraulic – covers flow regime and connectivity (floodplain, groundwater, species migrations).

(b) Biogeochemical – covers water chemistry, organic matter input and retention, and decontamination of pollutants.

(c) Habitat provision – covers habitats for aquatic fauna and fish spawning habitat.

(d) Biodiversity – covers fish and macroinvertebrate fauna and state of riparian vegetation.

48. SEV assesses the performance of each function relative to reference (pristine) conditions and provides a scheme to compile data and then interpret and report the results as a numeric scoring system on a scale of 0 to 1, with 1 being the theoretical pristine stream. The nearer the score to 0, the more the stream deviates from reference conditions.

49. Specifically, SEV includes the measurement of various habitat parameters at ten cross sections including:

(a) stream bed substrate composition and size;

(b) the presence of organic material (e.g., leaf litter, periphyton, moss, macrophytes, roots); and,

(c) water depths, estimation of maximum water velocities, and channel shading.

50. At a reach scale, SEV measurements include:

---

[5] Storey, R.G., Neale, M.W., Rowe, D.K., Collier, K.J., Hatton, C., Joy, M.K., Maxted, J.R., Moore, S., Parkyn, S.M., Phillips, N. and Quinn, J.M. (2011) Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.
[6] Ibid.

(a) the degree of channel modification;

(b) the presence of piped inflows and fish barriers;

(c) floodplain connectivity;

(d) the presence and type of any channel linings;

(e) estimation of oxygen reducing processes;

(f) riparian vegetation composition;

(g) stream channel-riparian zone connectivity;

(h) estimation of riparian zone filtering ability;

(i) intactness of riparian zone;

(j) the extent and quality of galaxiid spawning habitat; and,

(k) an estimate of physical habitat quality (incorporating measures of aquatic habitat diversity and abundance, hydrologic heterogeneity, channel shade, and riparian vegetation integrity).

51. In addition to those parameters prescribed by the SEV methodology, other parameters measured included channel width (both wetted width and bankfull width) at each of the ten cross sections, and spot measures of water temperature, pH, and conductivity. Numerous photos of each site were also taken, including underwater photos where conditions allowed.

52. I utilised a version of the SEV calculator spreadsheet that had been modified for use in the Horizons region for Te Ahu a Turanga Project, by the addition of local reference data for the following variables:

(a) Vfish – a version of Fish-Index of Biotic Integrity (IBI) developed specifically for the Horizons region was used.[7]

(b) Vsurf – substrate composition and organic material category data supplied by Horizons was added.

[7] Joy, M & Henderson, I. 2015. A fish index of biotic integrity (IBI) for Horizons Regional Council. Report and user guide for use with the Horizons Fish IBI excel macro. Report by Mike Joy and excel macros by Ian Henderson. Ecology Group, Massey University, Palmerston North.

(c) Vphyshab – physical habitat quality (aquatic habitat diversity, aquatic habitat abundance, hydrologic heterogeneity, channel shade, riparian vegetation integrity) data supplied by Horizons was added.

(d) Vept and Vinvert – aquatic macroinvertebrate data supplied by Horizons was added.

53. At all permanently flowing stream sites where SEV was undertaken, the freshwater macroinvertebrate community was sampled via collection of three composite kick net samples following Protocol C1 (hard-bottomed, semi-quantitative) or Protocol C2 (soft-bottomed, semi-quantitative).[8] Macroinvertebrate samples were processed at a laboratory following a full count with subsampling methodology, which is the same as the "Protocol P3 - Full count with subsampling option" of Stark *et al.* (2001)[9] after the modifications required by the National Environmental Monitoring Standards (**"NEMS"**) – Macroinvertebrates[10] have been applied.

54. Macroinvertebrate community data was summarised using the following metrics:

(a) Taxa richness: The number of different taxa identified in each sample. Taxa is generally a term for taxonomic groups, and in this case refers to the lowest level of classification that was obtained during the study. Taxa richness is a useful community metric related to habitat diversity, with sites with more diverse habitats often having greater richness. However, there are numerous aquatic invertebrate taxa that prefer or tolerate degraded instream conditions such that taxa richness on its own should not be used to infer stream health.

(b) EPT-richness and %EPT-abundance: EPT refers to three "Orders" of invertebrates that are generally regarded as 'cleanwater' taxa. These Orders are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); forming the acronym EPT. These taxa are relatively intolerant of organic enrichment or other pollutants and habitat degradation. EPT taxa are generally more diverse and abundant in less polluted/degraded stream systems. The exceptions to this are the hydroptilid caddisflies (e.g. Trichoptera: Hydroptilidae: *Oxyethira,*

[8] Stark, J.D., Boothroyd, I.K.G., Harding, J.S., Maxted, J.R. & Scarsbrook, M.R. 2001. Protocols for sampling macroinvertebrates in wadeable streams. Ministry for the Environment, Wellington. 65 p.
[9] Ibid.
[10] National Environmental Monitoring Standards (NEMS) – Macroinvertebrates: Collection and processing of macroinvertebrate samples from rivers and streams. Version 0.0.1 Draft, November 2020.

Paroxyethira), which are algal piercers and often found in high numbers in nutrient-enriched waters with high algal content.

(c) Macroinvertebrate Community Index ("**MCI**"): In the mid-1980s the MCI was developed as an index of community integrity for use in stony riffles in New Zealand streams and rivers and can be used to determine the level of organic enrichment for these types of streams (Stark, 1985).[11] Although developed to assess nutrient enrichment, the MCI will respond to any disturbance that alters macroinvertebrate community composition (Boothroyd & Stark, 2000),[12] and as such is used widely to evaluate the general health of waterways in New Zealand. A variant for use in streams with a streambed of sand/silt/mud (i.e. soft-bottomed) was developed by Stark & Maxted (2007)[13] and is referred to as the MCI-sb. Both the hard-bottomed (MCI-hb) and soft-bottomed (MCI-sb) versions calculate an overall score for each sample, which is based on pollution-tolerance values for each invertebrate taxon that range from 1 (very pollution tolerant) to 10 (pollution-sensitive). MCI-hb and MCI-sb are calculated using presence/absence data and a quantitative version has been developed that incorporates abundance data and so gives a more accurate result by differentiating rare taxa from abundant taxa (QMCI-hb, QMCI-sb). MCI and QMCI are attributes included in the National Policy Statement for Freshwater Management 2020 (**"NPS-FM"**), with a "national bottom line" of 4.5 for QMCI and 90 for MCI. The NPS-FM (2020) uses the following bands and descriptions:

(i) QMCI ≥6.5; MCI ≥130; A band; "Macroinvertebrate community, indicative of pristine conditions with almost no organic pollution or nutrient enrichment."

(ii) QMCI ≥5.5 and <6.5; MCI ≥110 and <130; B band; "Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution/nutrient enrichment."

(iii) QMCI ≥4.5 and <5.5; MCI ≥90 and <110; C band; "Macroinvertebrate community indicative of moderate organic

[11] Stark, J.D. 1985. A macroinvertebrate community index of water quality for stony streams. Taranaki Catchment Commission, Wellington. Water & Soil Miscellaneous Publication No. 87. 53 p.
[12] Boothroyd, I. & Stark, J.D. 2000. Use of invertebrates in monitoring. In: Winterbourn, M.J. & Collier, K.J. (ed). *New Zealand Stream Invertebrates: Ecology and Implications for Management*. New Zealand Limnological Society, Christchurch. Pp. 344-373.
[13] Stark, J.D. & Maxted, J.R. 2007a. A biotic index for New Zealand's soft-bottomed streams. *New Zealand Journal of Marine and Freshwater Research* 41: 43-61.

pollution or nutrient enrichment. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment."

(iv) QMCI <4.5; MCI <90; D band; "Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment."

(d) Average Score Per Metric (**"ASPM"**): The ASPM is an aggregated metric developed by Collier (2008)[14] that generates a score between 0 and 1 based on averaging normalised values of %EPT-abundance, EPT-richness, and MCI. This metric is an attribute included in the NPS-FM (2020) with a score of 0.3 being the "national bottom line" and the following bands and descriptions:[15]

(i) ≥0.6, A band, "Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions."

(ii) <0.6 and ≥0.4, B band, "Macroinvertebrate communities have mild-to-moderate loss of ecological integrity."

(iii) <0.4 and ≥0.3, C band, "Macroinvertebrate communities have moderate-to-severe loss of ecological integrity."

(iv) <0.3, D band, "Macroinvertebrate communities have severe loss of ecological integrity."

55. Freshwater fish were originally intended to be surveyed via electrofishing, trapping (fyke nets and/or Gee minnow traps), or spotlighting. However, due to delays in obtaining access to survey sites on private land, fieldwork was required to be undertaken in the autumn and winter, which is outside the recommended period for fish surveys (1 October to 30 April).[16] Fish are generally less active due to lower water temperatures (e.g., eels may remain inactive once water temperatures fall below 11-12 °C),[17] meaning survey

---

[14] Collier, K. (2008). Average score per metric: An alternative metric aggregation method for assessing wadeable stream health. *New Zealand Journal of Marine and Freshwater Research*, 42:4, 367-378, DOI: 10.1080/00288330809509965.
[15] See Table 14 of the NPS-FM (2020).
[16] Joy, M., David, B. & Lake, M. 2013. New Zealand freshwater fish sampling protocols: Part 1- Wadeable rivers & streams. Palmerston North, New Zealand, Massey University. Pp. 64.
[17] Graynoth, E. & Taylor, M.J. 2000. Influence of different rations and water temperatures on the growth rates of shortfinned eels and longfinned eels. *Journal of Fish Biology* 57(3): 681–699.

data collected at such times are more likely to underrepresent the range of fish species present at a site.

56. The characteristics of streams requiring fish survey varied widely, from larger gravel bed streams (Waikawa Stream, Ohau River) to very small, soft bottomed streams. Some of the smaller streams were of a size that meant standard fish sampling methodologies such as electrofishing and trapping were not realistic due to thick macrophyte growth and shallow water depths. To enable a unified and consistent fish survey methodology across all sites, eDNA sampling was utilised.

57. eDNA is a technique that involves filtering a volume of water in the field, with the preserved filter material being sent to a laboratory where the DNA present on the filter is extracted. DNA fragments are then compared to a reference database of DNA sequences that allow identification of numerous animal species, including all freshwater fish known from New Zealand.

58. eDNA samples reflect the fish assemblage of a greater spatial area than standard fish sampling methodologies as DNA fragments are transported from some distance upstream. Numerous studies have found eDNA generally detects greater freshwater fish species diversity than “conventional” fish sampling methods.[18] It is, however, important to collect replicate samples at the site level to increase the likelihood of detecting rare or uncommon species. Currently, it is recommended to collect six replicate samples per site.

59. Six replicate eDNA samples were collected from each of the 23 sites (19 permanent watercourses that were accessible and four ponds). For two sites in the Koputaroa Stream catchments (Stream 39 and 39.1) SEV and macroinvertebrate sampling was completed, however, access was revoked prior to eDNA sampling being possible, due to a change in land ownership.

60. It is generally considered that the rate of eDNA detection is diminished over the winter months. In the case of fish in New Zealand, there is the potential that this may occur because fish are generally less active during winter. However, the site with the greatest number of fish species detected (Ohau River with 11 species) also had one of the lowest water temperatures recorded (9.9 ºC). Hence, the eDNA results have provided an excellent

[18] Doi *et al.* (2021). Estimation of biodiversity metrics by environmental DNA metabarcoding compared with visual and capture surveys of river fish communities. *Freshwater Biology* DOI: 10.1111/fwb.13714; Hallam *et al.* (2021). Biodiversity assessment across a dynamic riverine system: A comparison of eDNA metabarcoding versus traditional fish surveying methods. *Freshwater Biology* 3:1247-1266. DOI: 10.1002/edn3.241

indication of fish presence data across the range of stream types and sizes intersected by the proposed designation. As such, it is not intended to undertake any further fish sampling from river and stream habitats, as this would be highly unlikely to change conclusions regarding ecological value or the effects management actions required.

61. Given that there are some uncertainties around the detection of brown mudfish in still water environments (i.e., wetland ponds), "conventional" surveys were undertaken at two pond sites near the northern extent of the proposed designation (Stream 42 and Stream 42.3) during December 2021. These ponds are directly in the path of the proposed roadway. These surveys included:

(a) Stream 42 – The setting of five large fine-mesh fyke nets and 30 Gee minnow traps (**"GMTs"**) in the main larger raupō-wetland pond, and one fyke net and six GMTs in a smaller pond just downstream. All traps were baited with seafood-flavoured dry cat food. The fykes and GMTs were set on 2 December and retrieved on 3 December. The traps were dispersed around each pond, targeting habitats with cover that brown mudfish would utilise (e.g., raupō, woody debris).

(b) Stream 42.3 – The setting of six large fine-mesh fyke nets and 36 GMTs, all baited with seafood-flavoured dry cat food, around the pond targeting habitats with cover that brown mudfish would utilise (e.g., overhanging vegetation, woody debris). The fykes and GMTs were set on 16 December and retrieved on 17 December.

62. Based on eDNA results, the fish index of biotic integrity (**"F-IBI"**) was calculated using a MS Excel calculation file developed especially for the Horizons region.[19] The F-IBI compares the survey data fish assemblage against what would be expected given the particular site's altitude and distance from the coast. It does not however, take into account catchment or site-specific factors that may influence fish assemblages such as migration barriers (natural or artificial). The F-IBI generates a site score between 0 (no fish) and a theoretical maximum of 100. Based on the distribution of scores from 1619 sites in the Horizons region, the suggested integrity class thresholds and attributes of Joy & Henderson are:[20]

[19] Joy, M & Henderson, I. 2015. A fish index of biotic integrity (IBI) for Horizons Regional Council. Report and user guide for use with the Horizons Fish IBI excel macro. Report by Mike Joy and excel macros by Ian Henderson. Ecology group, Massey University, Palmerston North.
[20] Ibid.

(a) Score: 68-100; “Excellent”; “*Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 80th percentile of Horizons sites”*

(b) Score: 58-67; “Good”; “*Site is above the 60th percentile of all Horizons sites, species richness is slightly less than best for the region*”

(c) Score: 46-57; “Moderate”; “*Site is above the 40th percentile of Horizons sites but species richness and habitat or migratory access reduced, some signs of stress*”

(d) Score: 36-45; “Poor”; “*Site is less than average for Horizons region IBI scores, less than the 40th percentile, thus species richness and or habitat are severely impacted*”

(e) Score: 1-35; “Very poor”: “*Site is below the 20th percentile meaning site is impacted or migratory access almost non-existent*”

(f) Score: 0; “No native fish”; “*Site is grossly impacted or access non-existent*”

Determining the Ecological Value and Magnitude of Effects

63. Freshwater ecological values and the magnitude of effects on these values have been assessed using the Environment Institute of Australia and New Zealand (“**EIANZ**”) Ecological Impact Assessment Guidelines (“**EcIAG**”).[21] The aim of EcIAG is to provide a consistent and robust approach to ecological impact assessment in New Zealand and it is widely used by ecologists.

64. The EcIAG is a stepwise process:

(a) **Step 1 – Determine ecological value of waterways in the proposed Ō2NL Project Area.** Given the numerous individual waterways that intersect with the proposed designation, each site has been assigned a value. EcIAG provides guidance for evaluation of ecological value based on four “matters” – representativeness, rarity/distinctiveness, diversity and pattern, and ecological context. These “matters” are more suited for application to terrestrial habitats (e.g., forests, vegetation assemblages, and wetlands that have distinct boundaries), rather than waterways, the

[21] Roper-Lindsay, J., Fuller, S., Hooson, S., Sanders, M., & Ussher, G. 2018. *Ecological Impact Assessment (EcIA) EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems* (2nd ed, Environmental Institute of Australia and New Zealand Inc, Melbourne, 2018). Available at: https://www.eianz.org/document/item/4447.

condition and values of which are strongly influenced by the land use and catchment upstream of any particular survey site. The EcIAG actually states, "*Although a wide range of metrics and measures are used in the assessment of freshwaters there is no unifying set of attributes used to assign value or significance.*"

Consequently, a method used by Te Ahu a Turanga freshwater ecology assessment and elsewhere (e.g., the RiverLink Project) has been adopted. This is a values assessment based on the EcIAG that uses a suite of widely accepted metrics to determine ecological value (e.g., macroinvertebrate community indices, fish community metrics, SEV scores, degree of channel modification, riparian vegetation condition) to assign a five-point scale value to a site (Very High, High, Moderate, Low, Negligible). Descriptions and criteria have been updated, including adding reference to NPS-FM (2020) attribute bands for MCI, QMCI, and ASPM. Table K22 in Appendix K3 outlines this ecological values assessment scheme.

(b) **Step 2 – Determine magnitude of ecological effect of the various activities resulting from the construction and operation of the Ō2NL Project in the <u>absence</u> of any effects management actions** (e.g., stream reclamation without any fish relocation actions). The magnitude is a measure of change/alteration from the existing baseline state. Table 8 of the EcIAG provides descriptive criteria to determine magnitude of effect (see Table K23 in Appendix K3). Assessing magnitude of effect takes into account:

- (i) Level of confidence that effects will occur in the way anticipated;
- (ii) Spatial scale/extent of the effect;
- (iii) Duration of the effect (see Table K25 in Appendix K3);
- (iv) Reversibility (is the potential effect reversable?);
- (v) Timing of the effect in relation to ecological cycles and patterns (e.g. fish migration).

(c) **Step 3 – Determine the magnitude of ecological effect of the various activities resulting from the construction and operation of the Ō2NL Project <u>after</u> any effect management actions have been applied** (e.g., stream reclamation with a fish salvage and relocation action).

(d) **Step 4 – Determine the overall level of effect based on the ecological value and magnitude of effect based on the matrix approach shown Table 9 of the EcIAG** (see Table K24 in Appendix K3). This matrix describes the overall level of effect on a six-point scale: Net Gain, Very Low, Low, Moderate, High, and Very High. Where the effects cannot be reduced to an acceptable level, further avoidance, remedy, or mitigation may be required on site and if that is not possible or practical, offsetting or compensation elsewhere.

Offsetting and Compensation Methodology

65. Where avoidance, remedy, or mitigation of the adverse effects of an activity at the site of impact is insufficient (or impossible) to reduce those adverse effects to an appropriate level, offsetting may be required.

66. As defined in the EcIAG, biodiversity offsets are measures taken to counterbalance any residual adverse impacts after implementation of the avoidance-remedy-mitigate hierarchy.

67. Maysek *et al.* (2018),[22] the latest document addressing biodiversity offsetting in a New Zealand RMA context, sets out 11 principles that underpin good biodiversity offsetting practice and differentiate it from compensation (which is not designed to demonstrate no-net-loss):

(a) Limits to offsetting: Many biodiversity values are not able to be offset, and if they are impacted then they will be permanently lost.

(b) No-net-loss and preferably a net-gain: The goal of a biodiversity offset is a measurable outcome that can reasonably be expected to result in no-net-loss, and preferably a net-gain in biodiversity.

(c) Landscape context: The design of a biodiversity offset should consider the landscape context of both the impact site and the offset site, taking into account interactions between species, habitats, and ecosystems, spatial connections, and system functionality.

(d) Additionality: A biodiversity offset must achieve gains in biodiversity above and beyond gains that would have occurred anyway in the absence of the offset.

[22] Maysek, F., Ussher, G., Kessels, G., Christensen, M., and Brown, M. (2018). Biodiversity offsetting under the Resource Management Act – A guidance document.

(e) Permanence: The biodiversity benefits at an offset site should be managed to secure outcomes that last at least as long as the impacts and preferably in perpetuity.

(f) Ecological equivalence: The degree to which the biodiversity gain attributable to an offset is balanced with the biodiversity losses due to development across type, space, and time; and therefore, whether the exchange achieves no-net-loss.

(g) Adherence to the mitigation hierarchy: A biodiversity offset is a commitment to redress significant residual adverse impacts. In an RMA context, offsets should only be contemplated after steps to avoid, remedy, or mitigate adverse effects have sequentially been exhausted, and thus applies only to residual biodiversity impacts.

(h) Stakeholder participation: The effective participation of stakeholders should be ensured in decision making about biodiversity offsets, including their evaluation, selection, design, implementation, and monitoring.

(i) Transparency: The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner.

(j) Science and traditional knowledge: The design and implementation of a biodiversity offset should be a documented process informed by science, including an appropriate consideration of traditional knowledge.

(k) Equity: A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risks and rewards associated with a project and offset in a fair and balanced way, respecting legal and customary arrangements.

SEV and ECRs

68. The SEV methodology has been implemented to collect habitat data in anticipation of utilising it to generate ECRs. ECRs then inform biodiversity offsetting calculations to address the residual effects of stream loss and modification, that invariably occur during large roading projects.

69. SEV and the ECRs generated have been applied widely in New Zealand, including in the Te Ahu a Turanga Project, to inform offsetting decision making. It provides a quantum of streambed area that is required to be rehabilitated/enhanced to achieve a “no net loss” outcome. It does not address all the principles of offsetting , however, it is considered that its output is a robust starting point in determining an ecological response package that is suitable to landowners, stakeholders, project partners and can be practically achieved in the real world. Consideration of how far past this “starting point” the Project needs to go is discussed later in this report.

70. As described in Storey et al. (2011),[23] the steps in the calculation of the ECR are:[24]

(a) Step 1: Establish the ‘current’ SEV values for the site that will be impacted and for the proposed environmental compensation / offset site (“**SEVm-C**”).

(b) Step 2: Determine the ‘potential’ SEV values for both the impact (“**SEVi-P**”) and environmental compensation / offset (“**SEVm-P**”) sites by recalculating the variables using ‘predicted’ function scores assuming ‘best-practice’ remediation works have been carried out at both sites. Predictions are the best scores possible if the sites were to be restored as far as practical from present with current best-practice. Best-practice here will include permanent fencing of riparian zones to prevent stock access and revegetation of fenced areas with appropriate native species. Ultimately this will provide a level of canopy cover over the stream, permanently shading the stream channel as well as providing leaf litter and woody inputs.

(c) Step 3: Determine the SEV value at the impact site (“**SEVi-I**”) again using predicted function scores but now assuming that the proposed development works (e.g., piping, filling) have been carried out.

(d) Step 4: Using the above described values the ECR = [(SEVi-P – SEVi-I)/(SEVm-P – SEVm-C)] x 1.5. This value will be the amount you have to multiply the area of the stream you are impacting by to determine how much area of stream needs to be restored. The 1.5 multiplier is a

[23] Storey, R.G., Neale, M.W., Rowe, D.K., Collier, K.J., Hatton, C., Joy, M.K., Maxted, J.R., Moore, S., Parkyn, S.M., Phillips, N. and Quinn, J.M. (2011) Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

[24] Note: do not include biotic functions (IFI and FFI) in these calculations because of the difficulty of predicting these outcomes).

standard value applied to the formula to account for the predictable time lag in establishment of enhancement features (e.g., the time for riparian vegetation to establish and perform the desired functions).

71. Proposed offsetting sites were selected as per the process outlined in paragraph 76. To generate SEV scores for the proposed offsetting sites, 100 m long representative reaches in these streams were surveyed in March 2022. For some offset sites, which were directly upstream or downstream of the proposed designation, the SEV scores of the impact sites were representative of the current condition of the proposed offset sites in that stream.

Accounting for the impact of the Stock Exclusion Regulations

72. The Resource Management (Stock Exclusion) Regulations 2020 ("**Stock Exclusion Regulations**") mandate that certain stock (beef cattle, dairy cattle, dairy support cattle, deer or pigs):

(a) be excluded from lakes and rivers over 1 m wide; and

(b) must not be allowed closer than 3 m to the edge of the bed of a lake or river.

73. Conditions for stock crossing lakes and rivers apply from 1 July 2023 or 1 July 2025 (or from 2020 for new pastoral systems), depending on the stock type, and land type.

74. Many potential stream offsetting sites will therefore be subject to some level of stock exclusion within the next few years as a result of the Stock Exclusion Regulations. This presents a challenge to the Ō2NL Project to effectively integrate biodiversity offsetting with these regulations, such that the biodiversity offsetting additionality principle is met. To properly account for the influence of the Stock Exclusion Regulations, in terms of additionality of the offsetting proposed for the Ō2NL Project, the following principles have been applied:

(a) The Stock Exclusion Regulations do not apply to sheep, or to streams less than one metre wide. Therefore, the full benefit of fencing and planting on sheep farms, and fencing and planting of all streams less than one metre wide, will be claimed for SEV calculations. If a farm has mixed stock (for example, sheep and beef cattle), where some stock are included in the Stock Exclusion Regulations, and others are not, the default will be that the Stock Exclusion Regulations do apply;[25]

(b) The Stock Exclusion Regulations require stock exclusion but do not require any form of revegetation or vegetation management. For properties subject to the Stock Exclusion Regulations, if no riparian planting is planned by the landowner, the full benefit of riparian planting will be claimed for SEV calculations. Benefits attributable solely to fencing will not be claimed. At likely offsetting sites this will be achieved by adjusting the existing SEV parameters that would be expected to change if the minimum Stock Exclusion Regulation requirements were applied (that is, a fenced 3 m buffer with no planting), as described in paragraph 75 below;

(c) The Stock Exclusion Regulations require a 3 m setback from the edge of lake and river beds. For properties subject to the Stock Exclusion Regulations, the full benefit of any additional setback width beyond 3 m will be claimed for SEV calculations. A full list of the SEV parameters that were altered to determine the predicted SEV of likely offset sites is described in paragraph 77 below; and

(d) The Stock Exclusion Regulations only apply to beef cattle and deer on land where:

  (i) the land is identified as “low slope” on a map provided by Ministry for the Environment; or

  (ii) the stock are not intensively grazed.

  For other situations where the relevant stock is beef cattle or deer, the Ō2NL Project will claim the full benefit of fencing as well as planting for SEV calculations.

75. In practice, this has meant that when stream offset sites were identified that were subject to the Stock Exclusion Regulations, SEV values for the current state of the site (SEVm-C) assumed the site would be fenced from stock even in the absence of the Ō2NL Project. This involved an adjustment of the following SEV parameters, resulting in a small increase in the current SEV value of the sites that currently were unfenced with full stock access:

[25] The definition of “wide river” will be used to determine the 1 m threshold (i.e., a river with a bed that is wider than 1 m anywhere in a land parcel.

(a) Vrough, which is an assessment of riparian vegetation in the 20 m wide riparian zone, was assumed to be of “mainly long grass” in a 3 m wide fenced buffer on either side of the stream.

(b) Vripfilt, which is an assessment of the ability of the riparian zone to filter surface water runoff, was deemed to be “high filtering activity” on account of the dense grass in the fenced buffer.

(c) Vphyshab, which measures various physical habitat characteristics on a 0-20 scale, there were minor increases in “channel shade” and “riparian vegetation integrity” as a result of the fenced buffer.

Selection of potential offsetting sites and generation of predicted SEV values

76. The selection of potential stream offsetting sites was an iterative process that included:

(a) Development and circulation of an “Ecological response package” principles and process document, which was shared with councils and stakeholders on 26 July 2021.

(b) Circulation of email to iwi partners on 21 September 2021 requesting information on any potential terrestrial, wetland, and stream offset sites, that should be considered.

(c) Creation of long list of potential stream sites.

(d) Presentation of possible offset sites at the third ecology workshop on 21 February 2022, including request from those present for information on any other potential sites they may be aware of.

(e) Compiling short list of potential steam sites and contacting landowners in February 2022. Site visits and initial discussions with landowners occurred in February and May 2022. Initial offset site SEV fieldwork was carried out in March 2022 to record existing condition of sites (where sites were sufficiently different or distant from baseline SEV survey sites).

(f) Securing an agreement in principle from land owners as to which stream sections on their site can be fenced off and planted up by Waka Kotahi, on the understanding that these planted areas will not be removed and afforded legal protection to secure this outcome. Waka Kotahi is managing the “agreement in principle” process. I have visited the sites and landowners so can confirm there is the opportunity to achieve a "net gain" outcome.

(g) Ultimately landowners will need to enter a legal agreement with Waka Kotahi providing access for the planting and fence work to occur and which protects the planting from removal in the future. Waka Kotahi will obtain legal agreements once resource consents have been granted.

77. To determine the predicted SEV score of likely offsetting sites (SEVm-P), the following SEV parameters were adjusted from their existing states (SEVm-C), taking into account landowner requirements:

(a) Vsurf, which measures stream substrate composition and organic matter cover, was adjusted to include more wood and leaf litter as increased tall, woody, riparian vegetation would result in increased inputs of such organic matter to the stream.

(b) Vmacro, which measures the cover of macrophytes (aquatic plants), was decreased for sites where they were currently present, as increased channel shading from riparian vegetation would be expected to reduce macrophyte growth.

(c) Vshade, which measures channel shade, was increased to "high" for those sites where a 20 m wide planted riparian zone was likely, and "moderate" for those sites where a lesser width planted zone was likely.

(d) Vrough, which is an assessment of riparian vegetation in the 20 m wide riparian zone, was assigned the "mature indigenous vegetation" category, while lesser planted widths were assigned the "low diversity regenerating bush" category in recognition that narrower vegetated buffers are less likely to achieve climax forest than wider planted buffers.

(e) Vripfilt, which is an assessment of the ability of the riparian zone to filter surface water runoff, was increased to "very high filtering activity" at sites were a 20 m buffer is likely.

(f) Vripar, which is an assessment of the proportion of the 20 m wide riparian zone covered in trees or bushes, was raised to 1 (that is, 100 % cover) for sites were a 20 m buffer is likely and graduated downward based on the likely vegetated buffer width of the site.

(g) Vgalqual, which is an assessment of the quality of the stream reach to support galaxiidae fish spawning, was increased to “medium” on account of increased shading of the stream bed for those sites that had scored “low” primarily as a result of a lack of shade.

(h) Vphyshab, which measures various physical habitat characteristics on a 0-20 scale, there were increases in “channel shade” and “riparian vegetation integrity” resulting from the planting of native vegetation. For those sites with a 20 m planted buffer, “channel shade” was assigned a score of 16 and “riparian vegetation integrity” a score of 18. For those sites with a lesser width buffer, “channel shade” was assigned a score of 12 and “riparian vegetation integrity” a score of 12. Note the minimum acceptable riparian width was set at 3 m, to align with the minimum fencing requirements of the Stock Exclusion Regulations.

Accounting for the values associated with culverts and stream diversions

78. The Ō2NL Project concept design involves installation of 1,276 m of culverts in permanently flowing streams (this length includes allowances for culvert aprons). While piping existing streams has overall negative impacts on freshwater ecology, it is acknowledged that culverts do provide some habitat in which freshwater fauna can exist. For example:

(a) A fish relocation from an approximately 250 m long pipe in Karori, Wellington found resident longfin tuna, banded kōkopu, and kōaro and many aquatic macroinvertebrates living within this pipe (author’s pers. obs.); and

(b) a study of buried urban streams in Wellington found tuna (longfin and shortfin) to be present at five of the six survey sites.[26] Further, 31 aquatic macroinvertebrate taxa were found across the six buried stream sites.

79. Therefore, it is reasonable to expect the culverts installed by the Ō2NL Project in permanent streams will provide some level of habitat for freshwater fauna, that needs to be accounted for in SEV ECR calculations. SEV was never designed for use in culverts, so it would not be valid to try to generate an impact score for each proposed culvert. For consistency, we have opted to assign culverts a SEV score of 0.23. This is the same as the value used in the Mt Messenger Project and Te Ahu a Turanga: Manawatū

[26] James, A. 2020. Freshwater Ecology of piped streams in Wellington: pilot study final report. EOS Ecology Report No. GRE01-17087-02. Prepared for GWRC. 45 p.

Tararua Highway Project for culverts with a gradient of <6% (Ō2NL Project permanent stream concept design culvert gradients are within the 0.5-4.3% range). An SEV of 0.23 is indicative of very poor stream functioning if it were to be measured in an open channel, hence I consider it appropriate as it reflects the heavily modified stream habitat inside a culvert.

80. The Ō2NL Project concept design involves construction of approximately 1,711 m of diversion channels. While the creation of these is a necessary part of the Project to maintain existing drainage patterns, such diversions provide opportunities to enhance stream habitat conditions relative to the existing state, and hence need to be accounted for in SEV ECR calculations. The approach recommended by Dr Martin Neale in his review of the Mt Messenger stream biodiversity offsetting package has been adopted.[27] This involves using an ECR of 1.5 for diversion channels and including remediation of diversion channels as part of the offset. Therefore, all diversion channels will be designed to include suitable instream habitat features (e.g., pools, runs, riffles as appropriate depending on length and gradient constraints) with permanent fencing and riparian vegetation planting. In practice this ECR value will result in diversion channels specifically designed to maximise their ecological potential plus rehabilitation of other existing stream reaches elsewhere via fencing and riparian planting of a sufficient area to achieve the 1.5 value. As the diversion channels to be created are directly connected to the existing streams, it is anticipated they will be quickly colonised by aquatic fauna and flora from undisturbed habitats upstream and downstream.

Statutory Considerations

81. Below is a brief summary of statutory considerations relevant to this assessment. A full assessment of the RMA statutory framework within which designations and resource consents are sought is provided in Volume II of the Assessment of Environmental Effects ("**AEE**").

Horizons One Plan

82. The majority of the proposed designation is within the Waikawa, Ohau, Punahau/Lake Horowhenua, and Koputaroa catchments, which are within the Horizons region, and therefore covered by the One Plan.

---

[27] Hamill, K. 2018. Supplementary state of evidence of Keith David Hamill (freshwater ecology) on behalf of the NZ Transport Agency. 17 July 2018.

83. Table K26 in Appendix K4 of this report details the One Plan Schedule A water management zones and applicable Schedule B values (zone-wide and site/reach specific) for each freshwater ecology survey site in the Waikawa, Ohau, Punahau/Lake Horowhenua, and Koputaroa catchments.

84. The following sites have site/reach specific Schedule B values of ecological and water quality relevance:

    (a) Ohau River – Site of Significance-Aquatic ("**SOS-A**"), Trout Fishery ("**TF**"), Domestic Food Supply ("**DFS**").

    (b) Waikawa Stream –SOS-A, Site of Significance-Riparian ("**SOS-R**"), DFS.

    (c) Kuku Stream, Stream 31, Stream 29, Stream 25, Stream 18, Stream 17, Manakau Stream, Waiauti Stream –DFS.

85. The Waikawa and Punahau/Lake Horowhenua (and neighbouring Papaitonga) catchments are also listed as "Target Catchment (Water Management Sub-zone)" where management of existing intensive farming land must be specifically controlled.

GWRC Proposed Natural Resources Plan

86. The southern portion of the Ō2NL Project is within the Waitohu catchment, which is within the GWRC region, and therefore covered by the PNRP.

87. Table K27 in Appendix K4 of this report details the PNRP Schedule A, F1, and I values of the freshwater ecology survey sites in the Waitohu catchment.

88. The Waitohu catchment has the following PNRP values (note that values apply catchment wide and those sites on Table K27 that are not indicated as having any values do not appear on the waterways layer used by GWRC's GIS maps):

    (a) Schedule F1 – rivers and lakes with significant indigenous biodiversity.

    (b) Schedule F1 – threatened or at risk fish habitat.

    (c) Schedule F1 – migratory fish habitat.

NPS-FM

89. The NPS-FM gives effect to Te Mana o Te Wai.[28] Its objective is to *"ensure that natural and physical resources are managed in a way that prioritises:*

(a) first, the health and well-being of water bodies and freshwater ecosystems;

(b) second, the health needs of people (such as drinking water);

(c) third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future."

90. Key NPS-FM policies of relevance to the effects of the Ō2NL Project on freshwater ecology include:

(a) Policy 7: The loss of river extent and values is avoided to the extent practicable.

(b) Policy 9: The habitats of indigenous freshwater species are protected.

91. More specifically, the NPS-FM policy position is that the loss of river extent and values should be avoided except where there is a *'functional need*' for the activity in that location, and the effects of the activity are managed through the application of the effects management hierarchy.[29]

92. This assessment sets out in detail the application of the effects management hierarchy to the loss of extent or values of the waterways affected by the Ō2NL Project.

93. Appendix 2A of the NPS-FM also sets value categories for various water quality and ecological attributes requiring limits on resource use. These include national bottom-line values. Of particular relevance to this assessment are the macroinvertebrate attributes.

94. The NPS-FM requires regional councils to actively address fish passage and to include the following wording (or words to the same effect) in their regional plan(s): "*The passage of fish is maintained, or is improved, by instream structures, except where it is desirable to prevent the passage of some fish species in order to protect desired fish species, their life stages, or their habitats.*"

[28] The NPSFM explains Te Mana o Te Wai is a fundamental concept at 1.3.
[29] NPS-FM, clause 3.24.

Resource Management (National Environmental Standards for Freshwater) Regulations 2020 ("NES-FW")

95. The NES-FW came into effect on 3 September 2020 and includes provisions to deal with the effect on the passage of fish resulting from the placement, use, alteration, extension, or reconstruction of culverts, weirs, flap gates, dams, and fords in, on, over, or under the bed of any river or connected area.

96. Of particular relevance to the Ō2NL Project is Regulation 70, which lists the permitted activity conditions for culverts, and also Regulations 62, 63 and 69, which indicate the information about culverts that must be provided to regional councils.

EXISTING ENVIRONMENT

Introduction

97. The Ō2NL Project traverses five separate catchments. In a north to south direction, these are the Koputaroa Stream (a tributary of the Manawatū River), Punahau/Lake Horowhenua, Ohau River, Waikawa Stream, and Waitohu Stream catchments. The Waitohu Stream catchment is within the GWRC region, while all other catchments are within the Horizons region.

98. There is no existing surface water connection between the proposed designation and the Punahau/Lake Horowhenua catchment, with all flows being groundwater. These connections are covered in Technical Assessment G (Hydrogeology and Groundwater).

Regional Council State of the Environment Information

99. Ecology and/or water quality state of the environment (SOE) monitoring information is available for 20 individual sites across the five catchments. Table K1 and Figure K1 provides details regarding the 20 monitoring sites and the location of the sites respectively.

Table K1 Regional council state of the environment monitoring sites within the catchments affected by the proposed designation*.

Regional Council	Catchment	Site Name	Available Data
GWRC	Waitohu	Mangapouri Stream at Bennetts Rd	Ecology, Water quality
		Waitohu Stream at Norfolk Crescent	Ecology, Water quality
Horizons	Waikawa	Waikawa at North Manakau Road	Ecology, Water quality
		Manakau at SH1 Bridge	Ecology, Water quality

		Waikawa at Huritini	Ecology, Water quality
		Waikawa at u/s Manakau Confluence	Ecology, Water quality
	Ohau	Ohau at u/s Makahika Confluence	Ecology, Water quality
		Ohau at State Highway Bridge	Ecology, Water quality
		Ohau at Haines Property	Ecology, Water quality
		Ohau at Gladstone Reserve	Ecology, Water quality
		Makorokio at Tirohanga Station	Ecology, Water quality
		Makaretu above Ohau Confluence	Ecology, Water quality
		Makahika above Ohau Confluence	Ecology, Water quality
		Kuku at N. Johnstone Farm Bridge	Ecology, Water quality
	Punahau/Lake Horowhenua	Patiki Stream at Kawiu Road	Ecology, Water quality
		L Horowhenua Inflow at Lindsay Road	Water quality
		Arawhata at Hokio Beach Road	Ecology, Water quality
		Hokio at Lake Horowhenua	Ecology, Water quality
	Koputaroa (Manawatū sub-catchment)	Koputaroa at Tavistock Road	Ecology, Water quality

*SOE data collected by Greater Wellington Regional Council (GWRC) and Manawatū-Wanganui Regional Council (Horizons). The site names and data available were derived from Land, Air, Water, Aotearoa (LAWA; https://www.lawa.org.nz/)

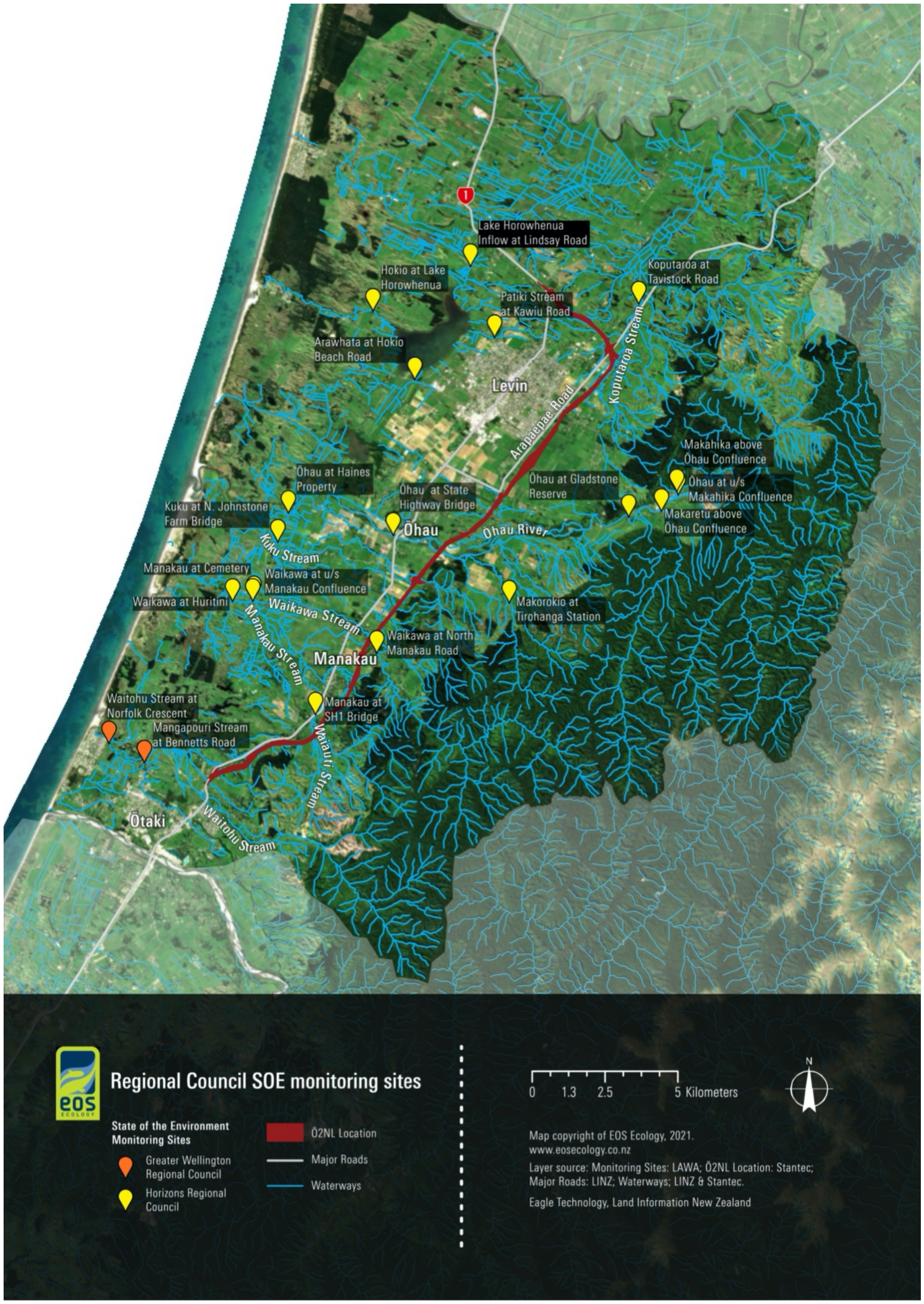


Figure K1 Regional Council state of the environment monitoring sites in the Koputaroa, Punahau/Lake Horowhenua, Ohau, Waikawa, and Waitohu catchments.

100. A plan of all catchments crossed by the Ō2NL Project is included in Volume III: Stormwater drawing set 310203848-01-300-C2000 – C2003.

101. The Waitohu Stream has its headwaters in the foothills of the Tararua Ranges and drains an area of 54 km^2. GWRC monitors the ecology and water quality of two sites, both in the lower catchment downstream of the proposed designation (refer to Table K1 and Figure K1). Table K2 illustrates low MCI scores and high *E. coli* concentrations, which are indicative of the negative impacts of agriculture and urban development. It is highly likely conditions are better further up the catchment, especially upstream of agricultural land use.

102. The Waikawa Stream has its headwaters in the foothills of the Tararua Ranges, has a major tributary (Manakau Stream) and drains an area of 29.4 km^2 upstream of the proposed designation. Table K1 and Figure K1 show that Horizons monitors ecology at five sites and water quality at three sites in the catchment. As presented in Table K2, the upstream-most monitoring site (Waikawa at North Manakau Road), which is only approximately 1 km upstream of the proposed designation, had high MCI and %EPT values, high water clarity, and low *E. coli* and nutrient concentrations, indicating high water quality and good instream habitat conditions. Table K2 also shows that habitat conditions generally degrade in a downstream direction as indicated by reductions in the MCI and %EPT metrics at the 'Waikawa at u/s [upstream] of Manakau confluence' and 'Waikawa at Huritini' monitoring sites.

103. The Ohau River has a 120.5 km^2 catchment upstream of the proposed designation, the largest of all the waterways to be crossed by the Ō2NL Project. The Project also crosses the Kuku Stream, which is a tributary of the Ohau River, and has a catchment area of 7.5 km^2 catchment upstream of the proposed designation. Table K1 and Figure K1 show that Horizons monitors ecology at eight sites and water quality at two sites in the catchment. Table K2 shows that at the upstream-most monitoring site on the Ohau River (Ohau at Gladstone Reserve), which is upstream of the proposed designation and near where the river exits the hill country, the water quality is high and macroinvertebrate metrics indicative of high instream habitat condition. Table K2 also shows that at the downstream monitoring site (Ohau at Haines Property), which is near the coast, higher *E. coli* concentrations, reduced water clarity and invertebrate metrics (MCI, %EPT) all indicate an overall decline in ecological health as it flows across

the plains. Table K1 and Figure K1 illustrate that ecological monitoring of three Ohau River tributaries in the mid to upper catchment (Makorokio Stream, Makaretu Stream, Makahika Stream) appear to have good instream conditions based on the high invertebrate metrics (MCI, %EPT) observed there. In contrast, the lowland Kuku Stream site has invertebrate metrics indicative of degraded conditions.

104. The Punahau/Lake Horowhenua Stream catchment does not receive any direct surface water inputs from west of the Levin urban area, including the proposed designation area; hence all of Horizons' four monitoring sites are to the east of the town. The water quality of the sites generally reflects the well-known, degraded state of the Lake and surrounds. Table K1 and Figure K1 show that there are very high total organic nitrogen ("**TON**") concentrations at the Patiki Stream and Arawhata Stream monitoring sites, and low invertebrate metrics (MCI, %EPT) at all four sites.

105. Table K1 and Figure K1 show that the Koputaroa Stream is a tributary of the Manawatū River, with the single monitoring site in the sub-catchment having water quality and invertebrate metrics (MCI, %EPT) generally indicative of degraded conditions. In particular, the high median for *E. coli* would imply much of the stream is unfenced from stock.

Table K2 Selected data from regional council state of the environment monitoring sites in the Waitohu, Waikawa, Ohau, Punahau/Lake Horowhenua, and Koputaroa catchments*.

Site Name (Catchment)	MCI	QMCI	ASPM	%EPT Rich-ness	*E. coli* (n/100 ml)	Black disc clarity (m)	Turb-idity (NTU)	TON (g/m^3)	NH_3-N (g/m^3)	DRP (g/m^3)
Mangapouri Stream at Bennetts Rd (Waitohu)	81.6 (D)	No data	No data	13.3	1700 (E)	0.88	6.8	1.57	0.05 (B)	0.034 (D)
Waitohu Stream at Norfolk Crescent (Waitohu)	92.2 (D)	No data	No data	23	930 (E)	1.01	5.2	0.37	0.028 (A)	0.016 (C)
Waikawa at North Manakau Road (Waikawa)	128 (B)	7.53 (A)	0.673 (A)	63	39 (A)	3.05	0.83	0.09	0.005 (A)	0.011 (C)
Manakau at SH1 Bridge (Waikawa)	97 (C)	4.38 (D)	0.327 (C)	38	460 (E)	1.05	4.67	0.27	0.01 (A)	0.011 (C)
Waikawa at u/s Manakau Confluence (Waikawa)**	114 (B)	6.54 (A)	0.491 (B)	59	145	4.03	0.67	0.060	0.005	0.012

Waikawa at Huritini (Waikawa)	104 (C)	4.67 (C)	0.411 (B)	43	340 (E)	1.10	4.64	0.98	0.025 (A)	0.015 (C)
Ohau at u/s Makahika Confluence (Ohau)	140 (A)	7.80 (A)	0.657 (A)	65	25	No data	No data	0.03	0.005 (A)	0.009 (B)
Ohau at Gladstone Reserve (Ohau)	133 (A)	7.51 (A)	0.625 (A)	61	34 (A)	3.86	0.75	0.06	0.005 (B)	0.008 (B)
Ohau at State Highway Bridge (Ohau)	113.3 (B)	5.50 (B)	0.489 (B)	50	62 (A)	No data	No data	0.205	0.005 (A)	0.007 (B)
Ohau at Haines Property (Ohau)	101.9 (C)	4.85 (C)	0.347 (C)	37	80.5 (B)	2.60 (B)	1.19	0.29	0.005 (B)	0.007 (B)
Makorokio at Tirohanga Station (Ohau)**	127.5 (B)	7.6	0.54	58.8	125	No data	1.57	0.064	0.005	0.02
Makaretu above Ohau Confluence (Ohau)**	127.8 (B)	7.93	0.69	64.6	22.5	No data	0.5	0.044	0.005	0.01
Makahika above Ohau Confluence (Ohau)**	120.3 (B)	5.53	0.47	55	66	No data	0.79	0.077	0.005	0.008
Kuku at N. Johnstone Farm Bridge (Ohau)	83.5 (D)	4.16 (D)	0.175 (D)	17	505	No data	No data	0.81	0.0115 (B)	0.011 (C)
Patiki Stream at Kawiu Road (Punahau/Lake Horowhenua)	81 (D)	4.31 (D)	0.190 (D)	20	295	0.47	4.83	5.985	0.03	0.0325
L Horowhenua Inflow at Lindsay Road (Punahau/Lake Horowhenua)	No data	No data	No data	No data	180	0.28	15.2	1.83	0.47	0.0275
Arawhata at Hokio Beach Road (Punahau/Lake Horowhenua)	63.5 (D)	3.53 (D)	0.107 (D)	0	445	0.79	3.895	10.35	0.03	0.024
Hokio at Lake Horowhenua (Punahau/Lake Horowhenua)	68 (D)	4.29 (D)	0.113 (D)	0	72	0.35	11.55	0.505	0.02	0.0105
Koputaroa at Tavistock Road (Koputaroa (Manawatū sub-catchment))	92 (C)	4.08 (D)	0.299 (C)	35	1400 (E)	0.45	5.52	2.23	0.02 (B)	0.018 (C)

* The values are five-year medians as shown on LAWA website in February 2022 and applicable quality bands from the NPM-FM (2020) are shown in parentheses. See the LAWA website for interpretation of these quality bands.[30] MCI = macroinvertebrate community index; TON=total oxidised nitrogen; NH_3-N=ammoniacal nitrogen; DRP=dissolved reactive phosphorus.

**Sites with water quality data not available on LAWA and supplied by Horizons.

[30] https://www.lawa.org.nz

New Zealand Freshwater Fish Database, Horizons eDNA, and One Plan data

106. The NZFFD provides a good indication of the range of fish species known from each of the catchments traversed by the proposed designation. The fish species known from each of the relevant catchments is presented in Table K3. Note the Koputaroa Stream would have a far greater number of species indicated if all those known from the greater Manawatū River catchment were shown.

107. A core assemblage of commonly found, widespread fish species are found in all five of the catchments, including shortfin tuna/eel, longfin tuna/eel (*Anguilla dieffenbachii*), upland bully (*Gobiomorphus breviceps*), common bully (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*), and banded kōkopu (*Galaxias fasciatus*).

108. The majority of fish species known from the catchments traversed by the proposed designation require free passage to the ocean to complete their lifecycles, hence could be adversely affected by any instream structures that impede their upstream (or downstream) movement.

109. According to the national freshwater fish threat classification of Dunn *et al.* (2018),[31] seven fish species known from at least one of the catchments traversed by the proposed designation are considered to be 'At Risk – Declining' (longfin tuna/eel, bluegill bully (*Gobiomorphus hubbsi*), inanga, giant kōkopu (*Galaxias argenteus*), kōaro (*Galaxias brevipinnis*), brown mudfish (*Neochanna apoda*), torrentfish (*Cheimarrichthys fosteri*)), while two are considered 'Threatened – Nationally Vulnerable' (shortjaw kōkopu (*Galaxias postvectis*), pirahau/lamprey (*Geotria australis*).

110. According to the regional threat classifications of McArthur *et al.* (2007)[32] four fish species known from at least one of the catchments traversed by the proposed designation are considered to be "regionally rare" (redfin bully, bluegill bully, banded kōkopu, kōaro) and four are considered to be "regionally threatened" (giant kōkopu, shortjaw kōkopu, brown mudfish, pirahau/ lamprey).

[31] Dunn, N.R., Allibone, R.M., Closs, G.P., Crow, S.K., David, B.O., Goodman, J.M., Griffiths, M. Jack, D.C., Ling, N., Waters, J.M. & Rolfe, J.R. 2018. Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24*. Department of Conservation, Wellington. 11 p.
[32] McArthur, K., Clark, M., & McGehan, J. 2007. Sites of significance for aquatic biodiversity in the Manawatu-Wanganui Region: Technical report to support policy development. Report No. 2007/EXT/794. Horizons Regional Council. 96 pp.

111. Brown trout (*Salmo trutta*) are the only exotic fish known from the Waikawa catchment, while brown and rainbow trout (*Oncorhynchus mykiss*) are present in the Waitohu and Ohau catchments. Koi carp (*Cyprinus carpio*) and perch (*Perca fluviatilis*) have been found within Punahau/Lake Horowhenua, while goldfish (*Carassius auratus*) are known from four of the five catchments. The invasive mosquitofish (*Gambusia affinis*) has recently been detected in the lower Koputaroa catchment by Horizons via eDNA sampling.

112. Brown mudfish are known from wetlands in the Koputaroa, Punahau/Lake Horowhenua, and Waitohu catchments.

113. Detailed information regarding fish species known from each of the catchments traversed by the proposed designation based on the NZFFD entries and Horizons eDNA sampling is contained in Table K3.

114. Schedule B of the One Plan includes the "Sites of Significance – Aquatic (SOS-A) Value. These were originally determined based on the presence of certain fish species (kōaro, dwarf *Galaxias*, shortjaw kōkopu, redfin bully, bluegill bully, banded kōkopu, lamprey, brown mudfish, giant kōkopu) or whio. In practical terms, these sites are either sections of streams or distinct points as defined in Table B.3, Schedule B of the One Plan. Two SOS-A reaches are crossed by Ō2NL Project area, the Ohau River (redfin bully, lamprey, and shortjaw kōkopu) and the Waikawa Stream (redfin bully and shortjaw kōkopu). All these fish species were also detected via site specific eDNA sampling as, were additional fish species that would contribute to the One Plan's SOS-A classification (Ohau River: kōaro, banded kōkopu; Waikawa Stream: kōaro, lamprey). The SOS-A information for these sites in terms of determining ecological values, was captured by the site-specific eDNA sampling.

115. At the site scale, only one SOS-A site was within a catchment crossed by Ō2NL. These were brown mudfish in the Perawhiti Wetland, a wetland adjacent the Koputaroa Stream. This site is kilometres downstream of the Ō2NL Project area and directly adjacent a proposed Ō2NL wetland offset site (see Technical Assessment J – Terrestrial Ecology).

Table K3 Fish species known from each of the catchments traversed by the Ō2NL Project based on New Zealand Freshwater Fish Database (NZFFD) entries and Horizons eDNA sampling*.

Fish Species	Koputaroa	Punahau/Lake Horowhenua	Ohau	Waikawa	Waitohu
Shortfin tuna/eel (NT) *Anguilla australis*	✓	✓	✓	✓	✓
Longfin tuna/eel (AR-D) *Anguilla dieffenbachii*	✓	✓	✓	✓	✓
Giant bully (AR-NU) *Gobiomorphus gobioides*		✓			
Upland bully (NT) *Gobiomorphus breviceps*	✓	✓	✓	✓	✓
Crans bully (NT) *Gobiomorphus basilis*			✓		
Redfin bully (NT; regionally rare) *Gobiomorphus huttoni*		✓	✓	✓	✓
Bluegill bully (AR-D; regionally rare) *Gobiomorphus hubbsi*			✓		
Common bully (NT) *Gobiomorphus cotidianus*	✓	✓	✓	✓	✓
Inanga (AR-D) *Galaxias maculatus*	✓	✓	✓	✓	✓
Banded kōkopu (NT; regionally rare) *Galaxias fasciatus*	✓	✓	✓	✓	✓
Giant kōkopu (AR-D; regionally threatened) *Galaxias argenteus*		✓		✓	✓
Shortjaw kōkopu (T-NV; regionally threatened) *Galaxias postvectis*			✓	✓	✓
Kōaro (AR-D; regionally rare) *Galaxias brevipinnis*			✓	✓	✓
Brown mudfish (AR-D; regionally threatened) *Neochanna apoda*	✓	✓			✓
Torrentfish (AR-D) *Cheimarrichthys fosteri*		✓	✓	✓	✓
Common smelt (NT) *Retropinna retropinna*		✓	✓	✓	✓
Grey mullet (NT) *Mugil cephalus*		✓			
Pirahau/lamprey (T-NV; regionally threatened) *Geotria australis*			✓	✓^	✓
Brown trout (IN) *Salmo trutta*			✓	✓	✓
Rainbow trout (IN) *Oncorhynchus mykiss*			✓		✓
Koi carp (IN) *Cyprinus carpio*		✓			
Goldfish (IN) *Carassius auratus*	✓^	✓	✓^		✓
Perch (IN) *Perca fluviatilis*		✓			✓
Mosquitofish (IN) *Gambusia affinis*	✓^				

*The national threat classification of Dunn *et al.* (2018)[33] are shown for each species in parentheses (NT=Not Threatened; AR-D=At Risk-Declining; AR-NU = At Risk-Naturally Uncommon; T-NV=Threatened-Nationally Vulnerable; IN=Introduced and Naturalised). The regional threat classifications are shown for those species for which categories were assigned by McArthur *et al.* (2007).[34]

Grey shading denotes those species that are diadromous, meaning they require free access to the ocean to complete their lifecycles.
^Additional records from Horizons eDNA sampling in early 2021.

[33] Dunn *et al.* (2018).

[34] McArthur *et al.* (2007)

Site-Specific Surveys

116. Figure K2 and Figure K3 show the locations of 48 waterways that intersect with the proposed designation (four ponds, 25 permanently flowing streams/rivers, and 19 ephemeral watercourses/overland flow paths). Table K4 summarises watercourse types, channel form, flow permanence, and the locations of site-specific SEV, macroinvertebrate, and fish surveys (eDNA sampling). Representative images of all sites visited are shown in Appendix 2.

117. Table K5 summarises wetted widths, water depths, and thalweg water velocities from the 21 permanently flowing stream sites where SEV was undertaken. The majority of streams were small, with 15 sites having a mean wetted width of less than 2 m and 16 sites having mean water depths less than 20 cm. The widest waterways were the Ohau River and Waikawa Stream. Thalweg water velocities were generally very low, with the highest values measured in the gravel bed Ohau River, Kuku Stream, and Waikawa Stream.

118. Table K6 summarises macrophyte cover and bed substrate sizes from the 21 permanently flowing stream sites where SEV was undertaken. The macrophytes observed were generally emergent and bankside species (i.e., watercress, water celery, semi-aquatic grasses) and were present to some extent at 18 sites. Slow flowing, silt/mud bottomed streams tended to have the highest coverage of macrophytes, although this was influenced at some sites by stock access. The bed substrate consisted of almost entirely silt at eight sites, while another six sites had a mix of silt and harder substrates. All the larger, fast flowing streams (Ohau River, Kuku Stream, Waikawa Stream, Manakau Stream, Waiauti Stream) had predominantly hard, stony bed substrates.

119. SEV scores are summarised in Table K7. The more modified streams, which have often been straightened and deepened to facilitate drainage (e.g. Streams 1, 10, 17, 31, 39, 40, 43), tended to have lower scores (in the 0.26-0.38 range) than those that retain a more natural flow path and channel form (e.g., Ohau River, Kuku Stream, Stream 27.1, Waikawa Stream, Manakau Stream, Waiauti Stream) and have scores in the 0.51-0.72 range. Stream 11 was a special case of a very small, soft bottomed stream, with around half the site length being within a patch of well-developed native revegetation, hence it scored relatively highly compared

to other similar sized streams in the SEV survey. It is likely SEV scores from adjacent sections of Stream 11 would have been lower. The Waikawa Stream had the highest overall SEV score of all sites surveyed at 0.72, while the lowest of 0.26 was at Stream 31.

Figure K2 Waterway sites along the Ō2NL Project area, north of Ohau.

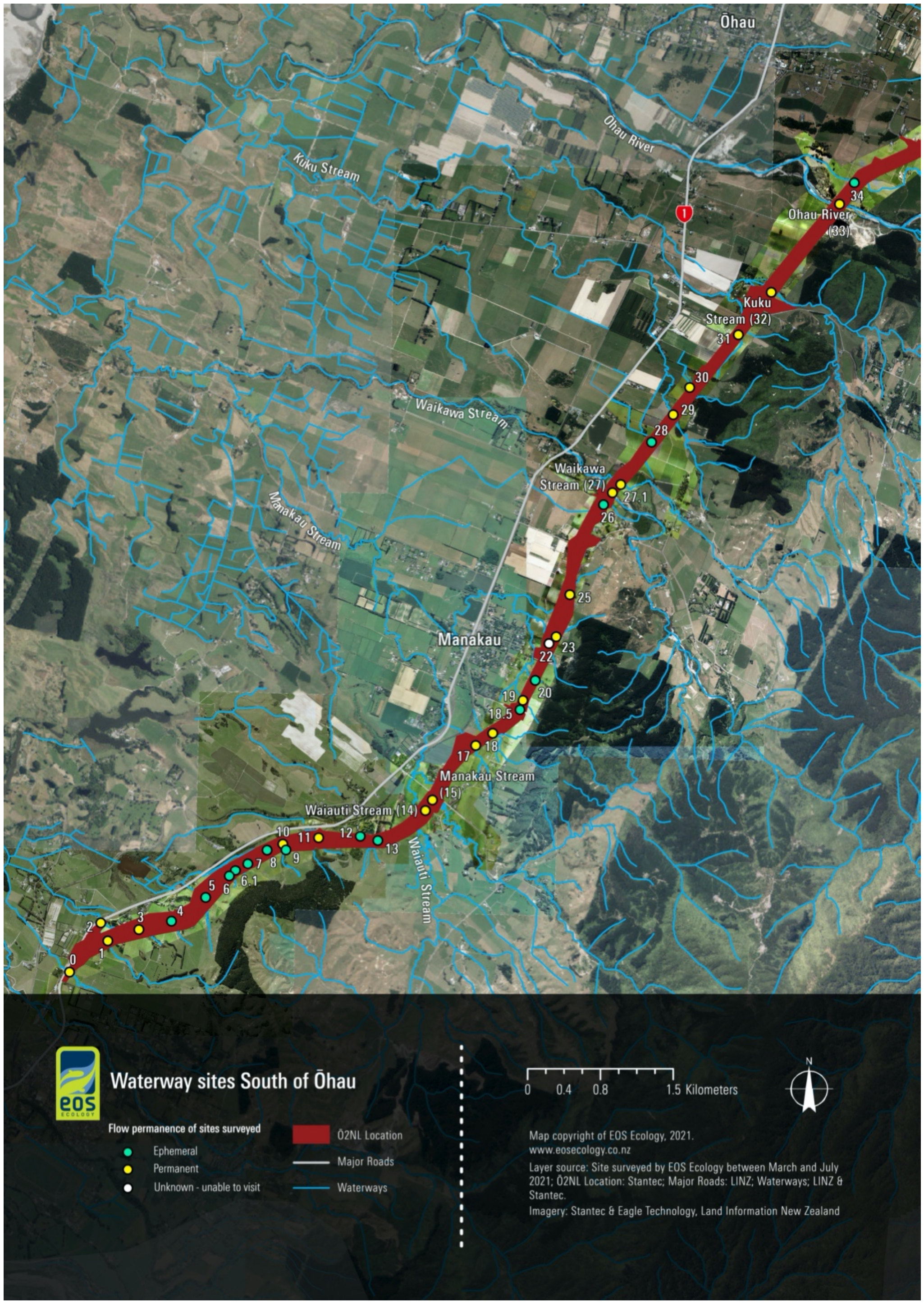


Figure K3 Waterway sites along the Ō2NL Project area, south of Ohau. Note Stream 22 has been deemed to be a permanent stream for the purposes of assigning ecological value and offsetting.

Table K4 Details of watercourses visited for the Ō2NL Project site-specific survey*.

Catchment	Stream Name/Code	Type & Channel Form	Permanence	Assess-ment Date	SEV	Macro-invertebrates	eDNA
Koputaroa	42.3^	Pond – modified	Periodically dries**	24/6/2021	✕	✕	✓
	42.2^	Pond – modified	Permanent	24/6/2021	✕	✕	✓
	42^	Pond – modified	Permanent	29/4/2021	✕	✕	✓
	43	Stream - modified	Permanent	19/5/2021	✓	✓	✓
	41^	Pond – modified	Permanent	12/5/2021	✕	✓	✓
	40	Stream – modified	Permanent	19/5/2021	✓	✓	✓
	39 (Waitaiki Stream)	Stream – modified	Permanent	12/3/2021	✓	✓	No access
	39.2	Stream – artificial	Ephemeral	12/3/2021	✕	✕	✕
	39.1 (Waitaiki Stream)	Stream – modified	Permanent	12/3/2021	✓	✓	No access
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	Stream – modified	Ephemeral	29/4/2021	✕	✕	✕
Ohau	35.4	Stream – artificial	Ephemeral	29/4/2021	✕	✕	✕
	35.1	Stream – artificial	Ephemeral	11/5/2021	✕	✕	✕
	34.5	Stream – modified	Ephemeral	29/4/2021	✕	✕	✕
	34	Stream – modified	Ephemeral	19/5/2021	✕	✕	✕
	Ohau River (33)	River – natural	Permanent	28/5/2021	✓	✓	✓
	Kuku Stream (32)	Stream – modified	Permanent	20/5/2021	✓	✓	✓
	31	Stream – modified	Permanent	1/7/2021	✓	✓	✓
	30	Stream – modified	Permanent	28/5/2021	✓	✓	✓
	29 (Waikokopu Stream)	Stream – modified	Permanent	12/11/2021	✓	✓	✓
	28	Stream – artificial	Ephemeral	16/4/2021	✕	✕	✕
Waikawa	27.1	Stream – natural	Permanent	28/5/2021	✓	✓	✓
	Waikawa Stream (27)	Stream – natural	Permanent	21/5/2021	✓	✓	✓
	26	Stream – artificial	Ephemeral	21/5/2021	✕	✕	✕
	25	Stream – modified	Permanent		No access		
	23	Stream – modified	Permanent	2/7/2021	✓	✓	✓
	22	Stream – modified	Permanent		No access		

*Details include type (pond, stream, river), channel form (artificial, modified, natural), and permanence (permanent, ephemeral). Also indicated are the ecological surveys undertaken to date. SEV = stream ecological valuation; eDNA = environmental DNA sampling. Recognised names in common use are used in preference to code numbers for major watercourses. For some streams, historic names that are not in common use are shown in parentheses.

Sites shaded grey meet the RMA definition of "river".
^Included in the wetland assessment in Technical Assessment J (Terrestrial Ecology).
**Based on Google Earth imagery, this pond appears to hold water for extended periods of time, but varies greatly in area and sometimes may be entirely dry.

Table K4 continued….

Catchment	Stream Name/Code	Type & Channel Form	Permanence	Assess-ment Date	SEV	Macro-invertebrates	eDNA
Waikawa	20	Stream – modified	Ephemeral	11/5/2021	✕	✕	✕
	19	Stream – natural	Permanent	16/4/2021	✓	✓	✓
	18.5	Stream – artificial	Ephemeral	16/4/2021	✕	✕	✕
	18	Stream – natural	Permanent	7/4/2021	✓	✓	✓
	17	Stream – modified	Permanent	7/4/2021	✓	✓	✓
	Manakau Stream (15)	Stream – natural	Permanent	12/4/2021	✓	✓	✓
	Waiauti Stream (14)	Stream – natural	Permanent	14/4/2021	✓	✓	✓
	13	Stream – natural	Ephemeral	14/4/2021	✕	✕	✕
	12	Stream – natural	Ephemeral	14/4/2021	✕	✕	✕
Waitohu	11	Stream – natural	Permanent	4/6/2021	✓	✓	✓
	10	Stream – modified	Permanent	9/4/2021	✓	✓	✓
	9	Stream – modified	Ephemeral	9/4/2021	✕	✕	✕
	8	Stream – natural	Ephemeral	26/3/2021	✕	✕	✕
	7	Stream – modified	Ephemeral	26/3/2021	✕	✕	✕
	6.1	Stream – natural	Ephemeral	26/3/2021	✕	✕	✕
	6	Stream – modified	Ephemeral	26/3/2021	✕	✕	✕
	5	Stream – modified	Ephemeral	9/4/2021	✕	✕	✕
	4	Stream – modified	Ephemeral	11/5/2021	✕	✕	✕
	3	Stream – modified	Permanent	27/5/2021	✓	✓	✓
	2+	Stream – modified	Permanent	12/4/2021	✕	✕	✕
	1	Stream – modified	Permanent	12/4/2021	✓	✓	✓
	0 (Greenwoods Stream)	Stream - natural	Permanent		No access		

+Stream 2 results from confluence of Stream 1 and 3 just upstream of the existing SH1, and did not undergo ecological survey as this data is captured by the full surveys of Stream 1 and 3.

Sites shaded grey meet the RMA definition of "river"

Table K5 Summary of wetted width, water depth, and water velocity for permanently flowing sites in the Ō2NL Project that underwent SEV survey*.

Catchment	Stream Name/Code	Wetted Width (m)	Water Depth (cm)	Thalweg Water Velocity (m/s)
Koputaroa	43	1.21(0.5-3)	5(1-45)	0.07(0.01-0.15)
	40	1.01(0.5-2.4)	7(2-17)	0.02(0.01-0.06)
	39 (Waitaiki Stream)	1.89(1.46-2.27)	34(2-59)	0.01
	39.1 (Waitaiki Stream)	1.4(0.68-2.5)	18(1-46)	0.21(0.01-0.48)
Ohau	Ohau River (33)	29.89(12-36.7)	37(1-1.01)	1.1(0.5-2)
	Kuku Stream (32)	1.88(0.95-2.5)	15(2-33)	0.72(0.44-1.17)
	31	2.01(1.4-3.3)	9(1-26)	0.01
	30	0.58(0.3-1.4)	3(1-10)	0.01
	29 (Waikokopu Stream)	0.92(0.6-1.35)	10(1-49)	0.14(0.01-0.3)
Waikawa	27.1	1.3(0.8-1.9)	11(2-25)	0.1(0.01-0.2)
	Waikawa Stream (27)	10.79(4.2-18.1)	24(1-63)	0.9(0.5-1.33)
	25 – no access			
	23	0.55(0.4-0.75)	5(1-19)	0.17(0.01-0.33)
	22 – no access			
	19	0.44(0.25-0.9)	9(1-17)	0.01
	18	1.01(0.5-2.1)	11(1-34)	0.01
	17	0.98(0.3-1.7)	13(2-6)	0.01
	Manakau Stream (15)	3.11(1.9-6)	21(4-75)	0.38(0.01-0.83)
	Waiauti Stream (14)	2.32(1.3-3.7)	31(3-99)	0.22(0.01-0.5)
Waitohu	11	0.65(0.3-1.4)	2(1-25)	0.02(0.01-0.1)
	10	0.66(0.45-1.2)	7(1-25)	0.01
	3	2.56(0.65-5.4)	13(1-58)	0.01
	1	1.04(0.5-1.6)	16(1-38)	0.01
	0 (Greenwoods Stream) – no access			

* For wetted width (10 measurements per site), water depth (50 measurements per site), and thalweg water velocity (10 measurements per site), averages are shown with the range indicated in parentheses. For water velocity, many sites had very slow water velocities that could not be accurately measured due to shallow water depths and/or thick macrophyte growth. Such cross-sections were assigned a value of 0.01 m/s.

Table K6 Summary of macrophyte cover as measured across a 1 m band at each transect (10 measurements per site) and stream bed substrate size (100 measurements per site) for permanently flowing sites in the Ō2NL Project area that underwent SEV survey.

Catchment	Stream Name/Code	Macrophyte cover (%)		Substrate Size
		Surface reaching, emergent, & bankside	Submerged	
Koputaroa	43	70(30-95)	0.5(0-5)	Silt / Sand (<2 mm): 99% Wood - Small (<50 mm): 1%
	40	79(10-100)	2(0-10)	Silt / Sand (<2 mm): 100%
	39 (Waitaiki Stream)	98(80-100)	0	Silt / Sand (<2 mm): 65% Small gravel (2-8 mm): 2% Small medium gravel (8-16 mm): 9% Medium large gravel (16-32 mm): 7% Large gravel (32-64 mm): 13% Small cobble (64-128 mm): 1% Large cobble (128-256 mm): 1% Wood - Medium (50-100 mm): 1% Wood - Small (<50 mm): 1%
	39.1 (Waitaiki Stream)	58(5-100)	0	Silt / Sand (<2 mm): 65% Small gravel (2-8 mm): 1% Small medium gravel (8-16 mm): 6% Medium large gravel (16-32 mm): 12% Large gravel (32-64 mm): 8% Small cobble (64-128 mm): 3% Large cobble (128-256 mm): 3% Boulders (>256 mm): 1% Wood - Small (<50 mm): 1%
Ohau	Ohau River (33)	0	0	Silt / Sand (<2 mm): 4% Small gravel (2-8 mm): 1% Small medium gravel (8-16 mm): 5% Medium large gravel (16-32 mm): 13% Large gravel (32-64 mm): 24% Small cobble (64-128 mm): 27% Large cobble (128-256 mm): 18% Boulders (>256 mm): 8%
	Kuku Stream (32)	9(0-20)	0.5(0-5)	Silt / Sand (<2 mm): 12% Small gravel (2-8 mm): 4% Small medium gravel (8-16 mm): 7% Medium large gravel (16-32 mm): 43% Large gravel (32-64 mm): 26% Small cobble (64-128 mm): 7% Boulders (>256 mm): 1%
	31	63(5-100)	0	Silt / Sand (<2 mm): 100%
	30	41(10-100)	0.1(0-1)	Silt / Sand (<2 mm): 99% Wood - Medium (50-100 mm): 1%
	29 (Waikokopu Stream)	22(0-100)	0	Silt / Sand (<2 mm): 22% Small gravel (2-8 mm): 11% Small medium gravel (8-16 mm): 21% Medium large gravel (16-32 mm): 26% Large gravel (32-64 mm): 8% Small cobble (64-128 mm): 1% Bedrock: 9% Wood - Small (<50 mm): 2%
Waikawa	27.1	28(10-90)	0	Silt / Sand (<2 mm): 17% Small gravel (2-8 mm): 10% Small medium gravel (8-16 mm): 23% Medium large gravel (16-32 mm): 31% Large gravel (32-64 mm): 17% Small cobble (64-128 mm): 1% Wood - Small (<50 mm): 1%
	Waikawa Stream (27)	0	0	Silt / Sand (<2 mm): 1% Small medium gravel (8-16 mm): 6% Medium large gravel (16-32 mm): 11% Large gravel (32-64 mm): 34% Small cobble (64-128 mm): 25%

Catchment	Stream Name/Code	Macrophyte cover (%)		Substrate Size
		Surface reaching, emergent, & bankside	Submerged	
				Large cobble (128-256 mm): 17% Boulders (>256 mm): 4% Wood - Medium (50-100 mm): 1% Wood - Large (>100 mm): 1%
Waikawa	25 – no access			
	23	0	0	Silt / Sand (<2 mm): 28% Small gravel (2-8 mm): 11% Small medium gravel (8-16 mm): 19% Medium large gravel (16-32 mm): 16% Small cobble (64-128 mm): 2% Bedrock: 21% Wood - Small (<50 mm): 3%
	22 – no access			
	19	92(80-100)	0	Silt / Sand (<2 mm): 72% Small gravel (2-8 mm): 10% Small medium gravel (8-16 mm): 9% Medium large gravel (16-32 mm): 2% Wood - Large (>100 mm): 7%
	18	47(0-100)	0	Silt / Sand (<2 mm): 54% Small gravel (2-8 mm): 8% Small medium gravel (8-16 mm): 23% Medium large gravel (16-32 mm): 10% Large gravel (32-64 mm): 4% Wood - Small (<50 mm): 1%
	17	75(0-100)	0	Silt / Sand (<2 mm): 58% Small gravel (2-8 mm): 2% Small medium gravel (8-16 mm): 14% Medium large gravel (16-32 mm): 9% Large gravel (32-64 mm): 7% Small cobble (64-128 mm): 6% Large cobble (128-256 mm): 2% Bedrock: 2%
	Manakau Stream (15)	2(0-5)	0	Silt / Sand (<2 mm): 1% Small medium gravel (8-16 mm): 9% Medium large gravel (16-32 mm): 25% Large gravel (32-64 mm): 39% Small cobble (64-128 mm): 20% Large cobble (128-256 mm): 3% Boulders (>256 mm): 2% Wood - Medium (50-100 mm): 1%
	Waiauti Stream (14)	16(0-40)	4(0-30)	Silt / Sand (<2 mm): 18% Small gravel (2-8 mm): 4% Small medium gravel (8-16 mm): 15% Medium large gravel (16-32 mm): 36% Large gravel (32-64 mm): 18% Small cobble (64-128 mm): 3% Bedrock: 6%
Waitohu	11	26(0-100)	0	Silt / Sand (<2 mm): 92% Wood - Small (<50 mm): 8%
	10	59(0-100)	0	Silt / Sand (<2 mm): 96% Small medium gravel (8-16 mm): 1% Large gravel (32-64 mm): 3%
	3	93(40-100)	0	Silt / Sand (<2 mm): 100%
	1	71(20-100)	0	Silt / Sand (<2 mm): 100%
	0 (Greenwoods Stream) – no access			

Table K7 Summary of SEV scores for permanently flowing watercourses in the Ō2NL Project area.

Catchment	Stream Name/Code	Function Mean scores				Overall mean SEV score
		Hydraulic	Biogeo-chemical	Habitat Provision	Biodiversity	
Koputaroa	43	0.32	0.29	0.19	0.22	**0.27**
	40	0.44	0.42	0.21	0.08	**0.32**
	39 (Waitaiki Stream)	0.48	0.26	0.27	0.19	**0.31***
	39.1 (Waitaiki Stream)	0.48	0.26	0.25	0.21	**0.31***
Ohau	Ohau River (33)	0.61	0.60	0.57	0.63	**0.61**
	Kuku Stream (32)	0.62	0.54	0.33	0.56	**0.54**
	31	0.32	0.26	0.23	0.21	**0.26**
	30	0.73	0.40	0.20	0.29	**0.44**
	29 (Waikokopu Stream)	0.56	0.53	0.32	0.40	**0.47**
Waikawa	27.1	0.61	0.51	0.32	0.50	**0.51**
	Waikawa Stream (27)	0.89	0.64	0.67	0.68	**0.72**
	25 – no access	Likely similar to the nearby Stream 23^				
	23	0.38	0.53	0.30	0.18	**0.38**
	22 – no access	Possibly similar to the nearby Stream 23^				
	19	0.43	0.41	0.44	0.36	**0.41**
	18	0.60	0.45	0.27	0.48	**0.47**
	17	0.48	0.42	0.24	0.29	**0.38**
	Manakau Stream (15)	0.71	0.61	0.40	0.60	**0.60**
	Waiauti Stream (14)	0.59	0.55	0.31	0.45	**0.51**
Waitohu	11	0.53	0.66	0.48	0.26	**0.51**
	10	0.32	0.36	0.23	0.32	**0.32**
	3	0.63	0.32	0.21	0.29	**0.38**
	1	0.48	0.35	0.25	0.32	**0.37**
	0 (Greenwoods Stream) – no access	Possibly similar to Stream 1^				

*The fish component of the SEV score is based on site observations and assumptions rather than eDNA due to a lack of site access.
^ For those sites where we could not obtain access, text has been added to indicate which sites SEV scores they are most likely to align with.

Macroinvertebrates

120. Freshwater macroinvertebrate community indices are summarised in Table K8. The majority of sites (12 out of 20) had MCI, QMCI, EPT, and ASPM values indicative of degraded conditions. For MCI, QMCI, and ASPM, those 12 sites score a D grade and are, therefore, below the national bottom lines outlined in the NPS-FM (2020). For MCI/QMCI this is a "*Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic*

pollution/nutrient enrichment.". For ASPM, a D grade means "*Macroinvertebrate communities have severe loss of ecological integrity*."

121. The only sites with any of their MCI, QMCI, or ASPM scores above the NPS-FM (2020) bottom line were the Ohau River, Kuku Stream, Stream 30, Stream 27.1, Waikawa Stream, Stream 23, Stream 19, Manakau Stream, Waiauti Steam, and Stream 11 (refer to Table K8). Of all the sites surveyed the two standouts in terms of freshwater macroinvertebrate communities where the Ohau River and Waikawa Stream, which had A grade scores for MCI, QMCI, and ASPM (with the exception of B grade for MCI in Ohau River) and also very high numbers of EPT taxa and %EPT. For MCI/QMCI an A grade is a "*Macroinvertebrate community, indicative of pristine conditions with almost no organic pollution or nutrient enrichment.*", and for ASPM indicates "*Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions.*".

122. The use of eDNA allowed the identification of many macroinvertebrates to the species level, beyond that which is generally possible with standard sampling and laboratory processing methods. Of the 182 invertebrate taxa identified to species level via eDNA, 33 had a published threat classification in Grainger *et al.* (2018).[35] Of these 31 were listed as "Not threatened", while two species were listed as "Naturally uncommon". These were the dusk dragonfly (*Antipodochlora braueri*) and a mayfly (*Zephlebia pirongia*). *A. braueri* was detected in Stream 27.1 and Kuku Stream. *Z. pirongia* was detected in Waiauti Stream, Manakau Stream, Kuku Stream, Ohau River, Stream 27.1, and Stream 2. However, it is likely the *Z. pirongia* are actually *Z. dentata* (which are "Not threatened"), based on known misidentifications of specimens from Canterbury Museum that have been used to derive DNA sequences (Dr Steve Pohe, pers. comm.).

Kōura and Kākahi

123. Kōura (*Paranephrops planifrons*) and kākahi (*Echyridella menziesii*) were out of scope of the standard animal eDNA assays used at the time. They do get detected but generally only at high abundances.[36] In the time since the eDNA samples were processed by Wilderlab, they have developed a new

[35] Grainger, N.; Harding, J.; Drinan, T.; Collier, K.; Smith, B.; Death, R.; Makan, T.; Rolfe, J. 2018. Conservation status of New Zealand freshwater invertebrates, 2018. New Zealand Threat Classification Series 28. Department of Conservation, Wellington. 25 p.
[36] Wilderlab. 2021. Guide to interpreting eDNA results. Version 1.2.2 . 30 May 2021.

reliable primer for detecting kākahi. In August 2022, all eDNA samples collected for the Ō2NL Project were rerun with this new kākahi test.

124. Kōura were detected via eDNA in Stream 1, Stream 19, Stream 29, and Stream 30, and found in a benthic macroinvertebrate sample from Stream 27.1. There are NZFFD records of kōura in all the catchments crossed by the proposed designation (Koputaroa, Punahau/Lake Horowhenua, Ohau, Waikawa, and Waitohu). Further, kōura are regularly mentioned among the cultural values for waterways throughout the Horowhenua including Hokio Stream, Punahau/Lake Horowhenua, the Kuku Stream tributary of the Ohau River, and Waikawa Stream.[37] Based on their ability to persist in a wide range of habitats from lakes and ponds to large gravel bed rivers and small soft-bottomed streams, they are potentially present at all survey sites with permanent surface water.

125. Kākahi were not detected via eDNA nor observation of alive or dead shells at any survey sites, despite SEV fieldwork requiring detailed observations of the survey reaches to be made. There are no kākahi records from the NZFFD for any of the catchments crossed by the Ō2NL Project (Koputaroa, Punahau/Lake Horowhenua, Ohau, Waikawa, and Waitohu). However, they are regularly mentioned among the cultural values for waterways throughout the Horowhenua including Koputaroa Stream, Lake Horowhenua, the Kuku Stream tributary of the Ohau River, and Waikawa River.[38] There is always the potential they will be found within the proposed designation.

Fish

126. Table K9 shows that fish were detected at all sites sampled for fish with the exception of a pond that periodically dries or at least shrinks to a very small size (Stream 42.3) and a very small, modified stream in the Koputaroa Stream catchment (Stream 40). Shortfin tuna/eel were the most widespread species, being detected at all sites where there were fish, and were the only fish species present at seven sites. The Ohau River (11 species) and Waikawa Stream (nine species) had the greatest fish species richness, followed by Kuku Stream (seven species), Manakau Stream (seven species), Stream 27.1 (six species), and Waiauti Stream (five species).

[37] Smith, H. 2017. Porirua ki Manawatū inquiry inland waterways cultural perspectives technical report. Te Rangitāwhia Whakatupu Mātauranga Ltd. 303 p.
[38] Smith (2017).

127. Table K9 highlights that conventional fish sampling (fyke nets and Gee minnow traps) aimed at detecting brown mudfish at two ponds sites (Stream 42 and Stream 42.3) found:

(a) Only shortfin tuna/eel (44 individuals) at Stream 42, which had already been detected previously via eDNA;

(b) A single shortfin tuna/eel at Stream 42.3.

128. According to the national freshwater fish threat classification of Dunn *et al.* (2018),[39] fish species with an At Risk - Declining threat classification were present at ten sites, while two species with a Threatened - Nationally Vulnerable threat classification (shortjaw kōkopu and pirahau/lamprey) were detected in the Ohau River and Waikawa Stream.

129. According to the regional threat classifications of McArthur *et al.* (2007)[40] fish species with a Regionally Rare classification were known from eleven sites. Three Regionally Rare species were present in the Ohau River and Kuku Stream (redfin bully, banded kōkopu, kōaro). Regionally Threatened species were found at three sites (shortjaw kōkopu and pirahau/lamprey in the Ohau River and Waikawa Stream, and giant kōkopu in Manakau Stream).

130. In terms of sports fish, brown trout were detected in the Ohau River, Waikawa Stream, Stream 27.1, Manakau Stream, and Waiauti Stream. Rainbow trout were detected only in the Ohau River.

131. Detailed information regarding fish species found at each survey site is contained in Table K9.

[39] Dunn *et al.* (2018).
[40] McArthur *et al.* (2007)

Table K8 Summary of freshwater macroinvertebrate community metrics for permanently flowing sites in the Ō2NL Project area that underwent SEV surveys*.

Catchment	Stream Name/Code	Mean MCI^	Mean QMCI^	Mean Taxa Richness (Range)	Mean EPT Taxa Richness (Range)	Mean %EPT Individuals (Range)	Mean ASPM^
Koputaroa	43	68.8(D)	2.4(D)	17 (15-19)	0.7 (0-1)	0.6 (0-1.3)	0.12(D)
	40	84.8(D)	4.1(D)	12 (11-14)	0	0	0.14(D)
	39 (Waitaiki Stream)	59.4(D)	2.0(D)	14 (12-16)	0	0	0.10(D)
	39.1 (Waitaiki Stream)	62.8(D)	3.0(D)	13 (9-15)	0	0	0.10(D)
Ohau	Ohau River (33)	129.7(B)	7.5(A)	22 (16-26)	13.7 (12-15)	83.7 (81-87.6)	0.65(A)
	Kuku Stream (32)	112.1(B)	5.5(B)	26 (25-28)	12 (10-13)	26.1 (14.6-43.2)	0.41(B)
	31	73.4(D)	3.2(D)	18 (12-23)	0.7 (0-1)	0.4 (0-0.9)	0.13(D)
	30	86.2(D)	3.5(D)	12 (11-14)	0.3 (0-1)	0.1 (0-0.4)	0.15(D)
	29 (Waikokopu Stream)	88 (D)	4.2 (D)	20 (12-24)	4	4.5 (3.1-6.8)	0.21(D)
Waikawa	27.1	107.8(C)	4.8(C)	17 (13-21)	8 (5-11)	14.7 (0.9-23)	0.32(C)
	Waikawa Stream (27)	134.8 (A)	7.6(A)	27 (25-28)	16.3 (16-17)	76.4 (68.8-89.3)	0.67(A)
	25 – no access	Likely similar to the nearby Stream 23					
	23	97.3(C)	4.4(D)	14 (11-17)	2.3 (2-3)	1.7 (0.3-2.6)	0.19(D)
	22 – no access	Possibly similar to the nearby Stream 23					
	19	80.4(D)	2.8(D)	14 (11-14)	1 (0-2)	0.1 (0-0.3)	0.14(D)
	18	70.9(D)	2.6(D)	21 (18-27)	2 (0-5)	0.4 (0-1.3)	0.14(D)
	17	63.1(D)	2.0(D)	17 (17-18)	0	0	0.11(D)
	Manakau Stream (15)	109.8 (C)	5.2(C)	27 (26-29)	12 (12-12)	18.8 (12.3-24.8)	0.38(C)
	Waiauti Stream (14)	98 (C)	4.7(C)	23 (18-26)	8.3 (8-9)	8.1 (5.1-12.4)	0.29(D)
Waitohu	11	96.4(C)	3.6(D)	15 (10-22)	0.7 (0-1)	0.6 (0-1.1)	0.17(D)
	10	66.1(D)	2.3(D)	15 (11-18)	0.3 (0-1)	0.1 (0-0.3)	0.11(D)
	3	69.8(D)	2.9(D)	18 (16-20)	0.3 (0-1)	0.1 (0-0.2)	0.12(D)
	1	66.8(D)	3.1(D)	15 (12-19)	0.3 (0-1)	0.2 (0-0.6)	0.12(D)
	0 (Greenwoods Stream) – no access	Possibly similar to Stream 1					

* For MCI, QMCI, and ASPM the NPS-FM (2020) attribute band, the value falls within are shown in parentheses. National bottom lines are MCI=90, QMCI=4.5, and ASPM=0.3. For those sites where we could not obtain access, text has been added to indicate which sites macroinvertebrate metrics they are most likely to align with.
^For those sites with a >50% sand/silt stream bed the soft-bottomed MCI, QMCI, and ASPM values are shown.

Table K9 Summary of fish presence based on eDNA sampling at permanently flowing stream sites and ponds in the Ō2NL Project area*.

Catchment	Stream Name/Code	Fish present (mean no. DNA segments in samples from six replicate samples)	Confirmed species richness	Fish Index of Biotic Integrity
Koputaroa	42.3	No fish detected via eDNA One shortfin tuna/eel captured by mudfish survey	1	24 (Very Poor)
	42.2 Main pond	Shortfin tuna/eel (349.5) NT Goldfish (2602.3) IN	2	24 (Very Poor)
	42.2 Other ponds	Shortfin tuna/eel (1017.7) NT Goldfish (146) IN	2	24 (Very Poor)
	43	Shortfin tuna/eel (53.2) NT	1	24 (Very Poor)
	42	Shortfin tuna/eel (1290.3) NT Bullies (10.7) Cyprinids (7) IN	3	28 (Very Poor)
	41	Shortfin tuna/eel (2355.7) NT	1	24 (Very Poor)
	40	No fish detected	0	0
	39 (Waitaiki Stream)	eDNA not collected – assumed to have similar fish assemblage as 39.1		46 (Moderate)^
	39.1 (Waitaiki Stream)	eDNA not collected – Upland bully (NT) and inanga (AR-D) observed, shortfin tuna/eel (NT) assumed to be present		46 (Moderate)^
Ohau	Ohau River (33)	Shortfin tuna/eel (10.3) NT Longfin tuna/eel (243.3) AR-D Upland or Crans bully (585.3) Upland bully (279.2) NT Redfin bully (97.7) NT/RR Banded kōkopu (13.5) NT/RR Kōaro (10.5) AR-D/RR Shortjaw kōkopu (2) T-NV/RT Torrentfish (119.7) AR-D Lamprey/pirahau (15.2) T-NV/RT Brown trout (156) IN Rainbow trout (6.2) IN	11	92 (Excellent)
	Kuku Stream (32)	Shortfin tuna/eel (103.7) NT Longfin tuna/eel (1139.3) AR-D Upland or Crans bully (272.2) Upland bully (835.2) NT Redfin bully (13.7) NT/RR Giant bully (4.7) AR-NU Banded kōkopu (821.8) NT/RR Kōaro (4.3) AR-D/RR	7	78 (Excellent)
	31	Shortfin tuna/eel (410.2) NT	1	24 (Very Poor)
	30	Shortfin tuna/eel (209.3) NT	1	24 (Very Poor)
	29 (Waikokopu Stream)	Shortfin tuna/eel (2432) NT Banded kōkopu (750.5) NT/RR Inanga (17.2) AR-D Longfin tuna/eel (2.3) AR-D	4	76 (Excellent)

*The national threat classification Dunn *et al.* (2018)[41] of each species is shown as: T-NV = Threatened-Nationally Vulnerable; AR-D = At Risk-Declining; AR-NU = At Risk-Naturally Uncommon; NT=Not Threatened; IN=Introduced and Naturalised. The regional threat classifications are shown for those species for which categories were assigned by McArthur *et al.* (2007):[42] RR = Regionally Rare; RT = Regionally Threatened. The Fish Index of Biotic Integrity (F-IBI) was derived using the Index of Biological Integrity – Horizons Region Excel calculator of Joy & Henderson (2015).[43]
^F-IBI derived from observations during SEV and macroinvertebrate fieldwork and assumed presence of shortfin tuna/eel as no eDNA sampling has occurred at these sites due to a lack of property access.

[41] Dunn *et al.* (2018)
[42] McArthur *et al.* (2007)
[43] Joy, M & Henderson, I. 2015. A fish index of biotic integrity (IBI) for Horizons Regional Council. Report and user guide for use with the Horizons Fish IBI excel macro. Report by Mike Joy and excel macros by Ian Henderson. Ecology group, Massey University, Palmerston North.

Catchment	Stream Name/Code	Fish present (mean no. DNA segments in samples from six replicate samples)	Confirmed species richness	Fish Index of Biotic Integrity
Waikawa	27.1	Shortfin tuna/eel (27.2) NT Longfin tuna/eel (841.3) AR-D Upland or Crans bully (1832.2) Upland bully (1453) NT Banded kōkopu (3) NT/RR Inanga (25.5) AR-D Brown trout (3.8) IN	6	82 (Excellent)
	Waikawa Stream (27)	Shortfin tuna/eel (50.5) NT Longfin tuna/eel (1466.5) AR-D Upland or Crans bully (507.2) Upland bully (331) NT Redfin bully (584.7) NT/RR Giant or shortjaw kōkopu (116.7) Shortjaw kōkopu (146.8) T-NV/RT Kōaro (369) AR-D/RR Torrentfish (83.3) AR-D Lamprey/pirahau (37) T-NV/RT Brown trout (615.5) IN	9	84 (Excellent)
	25 – no access			
	23	Shortfin tuna/eel (256.2) NT	1	24 (Very Poor)
	22 – no access			
	19	Shortfin tuna/eel (2009.3) NT Longfin tuna/eel (112.7) AR-D Banded kōkopu (507.7) NT/RR	3	62 (Good)
	18	Shortfin tuna/eel (267.2) NT Banded kōkopu (69.5) NT/RR Inanga (15.2) AR-D	3	62 (Good)
	17	Shortfin tuna/eel (495.3) NT Longfin tuna/eel (12.2) AR-D Japanese smelt (22)**	2	52 (Moderate)
	Manakau Stream (15)	Shortfin tuna/eel (62.5) NT Longfin tuna/eel (684.7) AR-D Upland or Crans bully (2534.3) Upland bully (835.2) NT Banded kōkopu (38.8) NT/RR Giant or shortjaw kōkopu (3.3) Giant kōkopu (25.5) AR-D/RT Inanga (2.3) AR-D Brown trout (7) IN	7	82 (Excellent)
	Waiauti Stream (14)	Shortfin tuna/eel (18.2) NT Longfin tuna/eel (159.8) AR-D Upland or Crans bully (500.3) Upland bully (876.5) NT Banded kōkopu (1.2) NT/RR Brown trout (22) IN	5	70 (Excellent)
Waitohu	11	Shortfin tuna/eel (746.8) NT	1	24(Very Poor)
	10	Shortfin tuna/eel (508.8) NT Banded kōkopu (171.3) NT/RR	2	52 (Moderate)
	3	Shortfin tuna/eel (269.7) NT	1	24 (Very Poor)
	1	Shortfin tuna/eel (212.7) NT Banded kōkopu (15.2) NT/RR	2	52 (Moderate)
	0 (Greenwoods Stream) – no access			

**Japanese smelt (*Hypomesus nipponensis*) is not known from New Zealand and this detection is potentially the result of fish food used in ornamental ponds upstream of the Stream 17 site.

Ecological Values Assessment

132. Table K10 summarises the ecological value of each waterway site based on the criteria in Table K22 in Appendix K3. This assessment only considers freshwater ecological values, and some sites may have higher terrestrial and wetland ecological or cultural values.

133. Ephemeral sites were deemed to have very low overall freshwater ecological value on account of such waterways providing surface water habitat sporadically and only for short periods of time. However, it is recognised that some ephemeral waterways which have constructed farm dams or ornamental ponds upstream of the proposed designation, sporadically provide for passage of shortfin tuna/eel. Further, ephemeral waterways are also important hydrologically as they generally convey water during significant rain events to permanent waterways and wetlands downstream.

134. The assessed ponds were all deemed to have very low or low freshwater ecological value. They are all constructed or induced features being either the result of embankments (railway: Stream 42.3; driveway: Stream 42) or dams (ornamental: Stream 42.2; farm: Stream 41). As they are all effectively stream channels that have been modified via embankments, they have been referred to as “streams” here.

135. The Stream 42.3 pond was rated as having low freshwater ecological value based on historical imagery that indicates it periodically dries or at least shrinks to a very small size. It is unknown how long it holds surface water or how any surface water may expand or contract seasonally. However, the fyke net and Gee minnow trap survey in December 2021 captured a single eel, while eDNA did not detect any fish, which indicates it likely had very low fish abundance. The other three ponds (Stream 42.2, Stream 42, and Stream 41) were all permanent ponds with ephemeral channels directly downstream. The Stream 42.2 site is actually a series of ornamental ponds down a small gully. Shortfin tuna/eel were present in these ponds, indicating ephemeral stream sections do not preclude this species from reaching isolated permanent water bodies.

136. There is also another pond created by a farm dam impacted by the proposed designation at Stream 3. This has been considered in the overall assessment of the Stream 3 site, and thus deemed to be of low value.

137. The majority of permanent waterways were assessed as having low freshwater ecological value, which is generally the result of modification and degradation by agriculture, meaning they have been greatly altered from their natural state. These waterways typically have very small catchment areas upstream of the proposed designation.

138. Ten sites were deemed to have moderate freshwater ecological value, with four of these being gravel bed catchments with larger catchments upstream of the proposed designation (Kuku Stream, Waiauti Stream, Manakau Stream, and Stream 27.1, which is a tributary of the Waikawa Stream). The other six were smaller streams (Streams 39, 39.1, 29, 19, 18, and 17), which were elevated to a moderate value on account of providing habitat to "At Risk – Declining" fish species (inanga and/or longfin tuna/eel).

139. The waterways with the highest ecological value were the Ohau River and Waikawa Stream, which were both assessed as having high freshwater ecological value, largely on account of their high fish species richness, macroinvertebrate community composed of a high proportion of pollution-sensitive taxa, and overall habitat condition.

Table K10 Summary of ecological values based on assessing site specific survey information and observations of ephemeral sites against the values criteria outlined in Table K22 of Appendix 3.

Catchment	Stream Name/Code	Type & Channel Form	Permanence	Freshwater Ecological Value
Koputaroa	42.3	Pond – modified	Periodically dries*	Low
	42.2	Pond – modified	Permanent	Low
	42	Pond – modified	Permanent	Low
	43	Stream - modified	Permanent	Low
	41	Pond – modified	Permanent	Low
	40	Stream – modified	Permanent	Low
	39 (Waitaiki Stream)	Stream – modified	Permanent	Moderate
	39.2	Stream – artificial	Ephemeral	Negligible
	39.1 (Waitaiki Stream)	Stream – modified	Permanent	Moderate
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	Stream – modified	Ephemeral	Negligible
Ohau	35.4	Stream – artificial	Ephemeral	Negligible
	35.1	Stream – artificial	Ephemeral	Negligible
	34.5	Stream – modified	Ephemeral	Negligible
	34	Stream – modified	Ephemeral	Negligible
	Ohau River (33)	River – natural	Permanent	High
	Kuku Stream (32)	Stream – modified	Permanent	Moderate
	31	Stream – modified	Permanent	Low

Catchment	Stream Name/Code	Type & Channel Form	Permanence	Freshwater Ecological Value
	30	Stream – modified	Permanent	Low
	29 (Waikokopu Stream)	Stream – modified	Permanent	Moderate
	28	Stream – artificial	Ephemeral	Negligible
Waikawa	27.1	Stream – natural	Permanent	Moderate
	Waikawa Stream (27)	Stream – natural	Permanent	High
	26	Stream – artificial	Ephemeral	Negligible
Waikawa	25	Stream – modified	Permanent	No access – likely Low
	23	Stream – modified	Permanent	Low
	22	Stream – modified	Permanent	No access – likely Low
	20	Stream – modified	Ephemeral	Negligible
	19	Stream – natural	Permanent	Moderate
	18.5	Stream – artificial	Ephemeral	Negligible
	18	Stream – natural	Permanent	Moderate
	17	Stream – modified	Permanent	Moderate
	Manakau Stream (15)	Stream – natural	Permanent	Moderate
	Waiauti Stream (14)	Stream – natural	Permanent	Moderate
	13	Stream – natural	Ephemeral	Negligible
	12	Stream – natural	Ephemeral	Negligible
Waitohu	11	Stream – natural	Permanent	Low
	10	Stream – modified	Permanent	Low
	9	Stream – modified	Ephemeral	Negligible
	8	Stream – natural	Ephemeral	Negligible
	7	Stream – modified	Ephemeral	Negligible
	6.1	Stream – natural	Ephemeral	Negligible
	6	Stream – modified	Ephemeral	Negligible
	5	Stream – modified	Ephemeral	Negligible
	4	Stream – modified	Ephemeral	Negligible
	3	Stream – modified	Permanent	Low
	2	Stream – modified	Permanent	Low
	1	Stream – modified	Permanent	Low
	0 (Greenwoods Stream)	Stream - natural	Permanent	No access – likely Low

*Based on Google Earth imagery, this pond appears to hold water for extended periods of time, but varies greatly in area and sometimes may be entirely dry.

PROJECT SHAPING AND AVOIDING AND MINIMISING EFFECTS

140. A wide range of project shaping measures have been pursued in order to avoid and minimise the potential adverse effects of the O2NL Project on aquatic ecology values.

141. All crossings of the main gravel bed waterways (Ohau River, Kuku Stream, Waikawa Stream, Manakau Stream, Waiauti Stream), which are generally the highest value streams, are bridges meaning there will be no potential adverse effects on the passage of fish and flying adult aquatic insects.

Including bridges over these waterways in the Project design is an appropriate response, and a primary way in which adverse effects on the ecological values of these waterways have been largely avoided.

142. Several adjustments to the design have been proposed to avoid or minimise adverse effects on freshwater ecology and to enhance existing values:

(a) The pond at Stream 42.3 location (approx. chainage 10,600; low ecological value): This pond has formed behind the railway embankment and functions as an open water habitat that varies greatly in area over time and appears to be dry at times. Technical Assessment J (Terrestrial Ecology) highlights its use by native water bird species. A fish survey with fyke nets and Gee minnow traps found a single shortfin eel. To minimise the adverse impacts of the Ō2NL Project on waterbodies, the portion of this pond that lies outside the construction footprint will be retained. This has been confirmed by the design team.

(b) The series of ponds at Stream 42.2 location (approx. chainage 10,700-10,900; low ecological value) should be avoided during construction and enhanced through fencing and revegetation to maintain their value as shortfin tuna/eel habitat. They are currently just outside the proposed construction footprint and their retention has been confirmed by the design team. Based on eDNA sampling, these ponds have goldfish and shortfin tuna/eel present.

(c) The pond at the Stream 41 location (approx. chainage 12,050; low ecological value) should be avoided during construction and enhanced through removal of stock access and revegetation of riparian zone to maintain its value as shortfin tuna/eel habitat. Based on eDNA sampling, shortfin tuna/eel are present. The retention of this pond has been confirmed by the design team with the construction footprint adjusted accordingly.

(d) At several sites where diversion channels are being constructed, there is the potential to maximise their length through meandering, which will act to minimise open channel loss within the proposed designation:

(i) Stream 39.1 (approx. chainage 13,200-13,300) should be meandered through the paddock to the west of its current location following what appears to have been its original flow path. Upland bully and inanga have been observed and shortfin tuna/eel are assumed to be present in this stream. This design is now shown on the plans (Volume III) and the proposed designation boundary has been amended to incorporate the meandering diversion.

(ii) Stream 31 (approx. chainage 24,300). The design team has confirmed this fits within the proposed designation, works with the topography of the site. This meander has been added to the plans found in Volume III.

(iii) Stream 29 (approx. chainage 25,400). The design team has considered if this would actually be reinstating the stream's former course, which appears to have been modified in 2017-2018, and have added this meander into the plans (Volume III).

(iv) Stream 25 (approx. chainage 27,500-27,700). Meandering was proposed upstream and downstream of the culvert. The design team has confirmed the topography upstream of the culvert is not suitable, but added some minor lengthening of the diversion channel there. Greater meandering has been added to the diversion channel downstream of the culvert.

(v) Stream 18 (approx. chainage 29,300). The requested meander at this location is not able to be progressed due to challenging terrain meaning significant earthworks and rock armouring would be required to achieve a relatively small increase in diversion channel length.

(vi) Waiauti Stream (approx. chainage 30,400-30,500). There is also the potential to recreate an oxbow wetland habitat at this location. Increased meandering of diversion channels have been confirmed at this location.

(vii) Stream 9 and 10 (approx. chainage 31,850-32,075). Some meandering has been added to the design at this location, and gradients would suggest this diversion channel has the potential to be a long, wetland type habitat.

(viii) Stream 1 (approx. chainage 34,000-34,100). There is also the potential to create wetland habitat in this area. The design team agree there is a lot of scope for diversion channel meandering and wetland creation at this location, although this will have to avoid the fill batters of the roundabout at this location. The exact extent of meandering here will require detailed design work.

(e) It would have been ideal if the Waikawa Stream bridge was extended northward to avoid the need for culverting Stream 27.1, however, this would have effectively doubled the span of the bridge, approximately doubling the $13 million base cost estimate of this bridge. Given avoidance of a stream crossing here was not possible, a culvert solution for Stream 27.1 was selected. This uses best practice mitigation in the form of the stream simulation design, hence is an acceptable alternative.

(f) An early large culvert solution for the Waiauti Stream crossing has been revised to be a bridge, which has resulted in a reduction in channel length loss and improved fish and macroinvertebrate passage outcomes.

(g) At various locations along the alignment, design adjustments have been made (and will continue to be made during the design process) to avoid and minimise impacts on water courses. Examples include:

(i) Adjustment of stormwater pond and SUP footprint to avoid adjacent watercourse (Stream 40) at chainage 12,500;

(ii) Adjustment of stormwater pond footprint to avoid adjacent watercourse (Stream 17) at chainage 29,500;

(iii) The use of vertical abutments adjacent to Manakau Stream at chainage 30,100 to avoid encroachment on the stream channel; and,

(iv) An overall reduction in length of stream reclamation and culverts, resulting from changes to the vertical alignment of the Project (relative to Pukehou and north of Levin).

ASSESSMENT OF EFFECTS

143. The assessment of effects on freshwater ecology was undertaken following the methodology described in the EcIAG as fully described in the methodology section of this report. In summary, this methodology involves:

(a) Using the ecological information obtained during the site-specific surveys and site visits to assign an ecological value to each site on a five-point scale (Very High, High, Moderate, Low, Negligible) (see Table K22 in Appendix K3).

(b) Determine the various effects of the Ō2NL Project on freshwater ecology during the construction and operational phases.

(c) Assign a magnitude for each identified effect on a six-point scale (Very High, High, Moderate, Low, Negligible, positive) using the criteria indicated in the EcIAG (see Table K23 in Appendix K3) before any effect management actions are taken. This magnitude is determined on a site-by-site basis as individual site characteristics can have a significant bearing on effect magnitude (e.g., ephemeral vs. permanent waterways, soft-bottomed vs hard-bottomed waterways).

(d) Determine the level of effect before any effects management actions are taken using the ecological value – magnitude of effect matrix approach of the EcIAG (see Table K24 of Appendix K3), which has a six-point scale (Very High, High, Moderate, Low, Very Low, Net gain).

(e) Determine all the various effects management actions that are able to be taken to minimise adverse effects.

(f) Reapply the magnitude for each identified effect using the criteria indicated in the EcIAG (see Table K23 in Appendix K3) after any avoidance, mitigation, or remedial actions are taken.

(g) Determine the level of effect after any effects management are taken by reapplying the ecological value – magnitude of effect matrix approach of the EcIAG (see Table K24 of Appendix K3).

(h) Determine whether the adverse effects can be adequately managed via avoidance, mitigation, or remedy at the site of impact and if not, determine the quanta of required offsetting to achieve a "no net loss" and preferably a "net gain" outcome via the SEV ECR methodology.

(i) Development of an offsetting process to identify suitable stream offsetting sites, while aligning with the biodiversity offsetting principles as closely as possible.

144. For the Ō2NL Project, I have identified the following (before mitigation) potential and actual adverse effects during the construction phase (to occur over an approximate five year period):

(a) Freshwater habitat disturbance – the unavoidable, actual adverse effect of disturbance to existing freshwater habitats as a result of culvert installation and stream reclamation.

(b) Fish migration disturbance – the potential adverse effect of impeding the free passage of fish during the construction phase via the use of temporary waterway diversion pipes and channels.

(c) Release and deposition of fine sediments – the potential adverse effect of construction zone runoff transporting fine sediments to adjacent waterways, where they may reduce water clarity and increase deposited fine sediment concentrations; and have negatively impacting aquatic biota.

(d) Water contamination – the potential adverse effect of water contamination from construction machinery (fuels, oils, greases) and materials (concrete, grouts, mortars).

(e) Reduced flows – the potential adverse effects of abstracting water for construction purposes, such as reduced water depths and water velocities, increased sediment deposition, and reduced habitat area.

145. I have identified the following (before mitigation and/or offsetting) potential and actual adverse effects during the operational phase:

(a) Reduction in free movement of aquatic fauna through the proposed designation – the potential adverse effect of impeding the free movement and migrations of aquatic biota through the installation of culverts.

(b) Stormwater discharges – the potential adverse effects of stormwater runoff from the operational Ō2NL Project via alteration of water quality and water quantity.

(c) Freshwater habitat loss and modification – the actual, unavoidable adverse effect of permanent habitat loss resulting from the culverting, diversion, and reclamation of waterways.

(d) Light pollution – the actual, unavoidable adverse effect of introducing artificial light to the landscape for safety reasons.

146. The above-mentioned construction and operational phase effects are assessed in more detail in the following sections.

Magnitude of Effects

147. As described in the methodology section of this report, the magnitude of potential effects was determined using the criteria of the EcIAG (see Table K23 in Appendix K3). Table K11 summarises the overall magnitude of effect of proposed activities relating to the construction and operation of Ō2NL, from a whole project perspective.

148. A more detailed assessment of each effect on a site-by-site or grouping of similar sites/activities basis is then provided in the following sections.

Table K11 A summary of the magnitude of effects from proposed activities related to the construction and operation of the Ō2NL Project.

Activity/Effect	Magnitude WITHOUT effects management	Reasoning	Effects Management Actions	Magnitude WITH effects management applied
Construction Phase Effects				
Freshwater habitat disturbance Level of confidence: High, a predictable and unavoidable effect, but magnitude dependant on site specific characteristics Spatial scale: Limited to Ō2NL Project Area Duration: Construction phase Reversibility: No Timing: Has potential to impact fish spawning, depending on time of year and fish species present.	High to Negligible	Disturbance of the existing stream channel is unavoidable at all sites that involve channel diversion and/or installation of culvert pipes. At most such locations the existing channel will be filled in and permanently lost. This will have a permanent mortality or injury effect on fauna present in such impacted stream sections. Differs among sites depending on flow permanence and presence of threatened fish species.	Fish salvage will be undertaken prior to dewatering and/or filling in of any existing channels. A fish (and kōura and kākahi) salvage plan will be produced as part of the Ecological Management Plan (“**EMP**”) to enable a consistent methodology across the numerous sites in the proposed designation. Special consideration will need to be given to the methods used in small, soft-bottomed streams where standard trapping and electrofishing methods are likely inefficient at capturing fish. A “muck-out” type method may need to be employed where the stream bed is scooped out and fish (mostly tuna/eels) recovered from the spoil.	Low to Negligible – but unavoidable mortality of aquatic fauna and flora that cannot be effectively salvaged (i.e., macroinvertebrates)
Fish migration disturbance Level of confidence: Moderate, depends on timing of works, and fish species present. Spatial scale: Potential to affect catchments upstream of Ō2NL Project Area Duration: Potential longer-term effect as presence of barrier during one or more juvenile fish upstream migration cycle could alter population structure due to missing cohort(s). Reversibility: Yes Timing: Level of effect depends on time of year and fish species present.	Moderate to Negligible	If construction methodologies involve the use of temporary diversion pipes or channels, there is the potential that fish migrations may be adversely affected. Effect could be permanent if barrier caused recruitment failure for one or more years. Differs among sites depending on flow permanence and fish assemblage.	Avoid where practical, any instream works or diversion at key migration times of the fish species known to be present at a site. Ensure all temporary diversion pipes and channels are fish passable.	Moderate to Negligible

Activity/Effect	Magnitude WITHOUT effects management	Reasoning	Effects Management Actions	Magnitude WITH effects management applied
Release and subsequent deposition of fine sediments Level of confidence: High Spatial scale: Potential to affect habitats downstream of Ō2NL Project Area Duration: Construction phase and period after completion depending on time for any sediment to be washed/dispersed from streambed. Reversibility: Yes Timing: Potential to impact fish migration and spawning, depending on fish present.	High to Low	Large scale earthworks are unavoidable with roading projects of this scale and all earthworks have an inherent risk of creating sediment laden runoff that may enter adjacent waterways. The Ō2NL Project will build approximately 24 km of new highway that crosses numerous waterways, from ephemeral systems to larger gravel bed systems such as the Ohau River and Waikawa Stream. The deposition of this sediment on the streambed (at rates and with quantities of smaller particles greater than the natural state) is a major stressor on waterway ecosystems through altering physical habitat (clogging interstitial spaces in the stream bed used as refugia by fish and invertebrates), altering food resources (e.g., smothering algae), and degrading sites used for egg laying by many aquatic species. Differs among sites depending on flow permanence and existing bed substrate composition.	Development of a detailed Erosion and Sediment Control Plan. Minimising the area of bare earth exposed at any one time by using a staged approach to construction. Wherever possible, undertake culvert and diversion channel construction offline from flowing water.	High to Low
Water contamination Level of confidence: Contamination from machinery – moderate – the small size of most of the affected waterways mean machinery will not be required to work directly in flowing water at most crossing sites. Contamination from construction materials – high – concrete, grouts, and mortars being used extensively in close proximity to waterways.	High	Construction machinery has the potential to release contaminants into the environment (fuel, oil, grease, hydraulic fluids). Even small contaminant releases can have adverse effects via injury or mortality of stream biota. Small streams with little flow volume are particularly vulnerable due to lack of dilution and flushing flow. Bridge and culvert construction will involve the use of concrete, mortars, and grouts in close proximity of waterways and have the potential to adversely affect aquatic life via	A high level of vehicle maintenance, refuelling away from waterways, using appropriately bunded fuel storage tanks, and ensuring spill kits are in close proximity to all machinery. Isolate from flowing water all sites where wet concrete is being poured. Ensure any mortars and grouts are appropriate for use in aquatic environments and are completely cured before contact with water.	Low

Activity/Effect	Magnitude WITHOUT effects management	Reasoning	Effects Management Actions	Magnitude WITH effects management applied
Spatial scale: Potential to affect habitats downstream of Ō2NL Project Area Duration: Construction phase Reversibility: Yes Timing: Potential to impact fish migration and spawning, depending on fish present.		rapid changes in pH and discharge of ammonia and other toxic chemicals.		
Water abstraction Level of confidence: High Spatial scale: Potential to affect habitats downstream of Ō2NL Project Area Duration: Construction phase Reversibility: Yes Timing: Potential to adversely affect freshwater habitats due to reduced flows and mortality of fish that enter the intake.	High	High volume of abstraction can alter freshwater habitat and water chemistry to the detriment of some taxa. Fish can enter unscreened intakes and be killed by pump mechanism.	Use of storage ponds. Low instantaneous abstraction rates to replenish storage ponds. Using existing unallocated water that was determined via regional planning processes. Cessation of abstraction at minimum flows that were established to protect ecological values during the regional planning process. Screens on all intakes to avoid fish from entering pipes.	Low
Operational Effects				
Reduction in free movement of aquatic fauna through the proposed designation (fish and flying adult aquatic insects) Level of confidence: Moderate Spatial scale: Potential to affect habitats upstream of Ō2NL Project Area Duration: Permanent Reversibility: Yes Timing: Potential to impact fish migration	High to Negligible depending on site specific character-istics	The majority of New Zealand's native and endemic fish fauna require free access to/from the ocean to complete their lifecycle. Any barriers to such migration can have adverse effects on fish populations and potentially render otherwise suitable habitats inaccessible. Many aquatic insects have a flying adult life stage (e.g., mayflies, caddisflies, stoneflies, beetles, dobsonflies). Such flying adults are important for dispersal within and between catchments. Stream crossings have the potential to adversely affect upstream-	Bridges are proposed for all the major fish migration pathways (Ohau River, Kuku Stream, Waikawa Stream, Manakau Stream, Waiauti Stream). All culverts in permanent streams are designed following the stream simulation methodology, such that fish passage will be retained. Additionally, several culverts in ephemeral waterways will have fish friendly designs to allow fish (mostly shortfin tuna/eel) to continue accessing constructed ponds and dams upstream of the proposed designation.	Positive to Low adverse

Activity/Effect	Magnitude WITHOUT effects management	Reasoning	Effects Management Actions	Magnitude WITH effects management applied
		downstream dispersal. The magnitude of effect at a crossing site will depend on the composition of the macroinvertebrate and fish community and the length/area of high quality habitats upstream of the proposed designation.	Potential "Net gain" at three locations due to new culverts replacing old culverts that are likely partial fish barriers (two sites) and reconnecting a small permanently flowing stream to downstream channels (one site). Riparian revegetation immediately upstream and downstream of culvert.	
Stormwater discharges (quality and quantity). Level of confidence: High Spatial scale: Potential to affect habitats downstream of Ō2NL Project Area Duration: Permanent Reversibility: No Timing: Potential to impact fish migration	High	Stormwater from roads generally contains numerous contaminants such as metals (e.g., Cu, Zn), hydrocarbons, and fine sediments. Such contaminants can have adverse effects on biota, especially in streams that have a high proportion of pollution sensitive species. The construction of lateral drainage channels, and treatment/detention ponds/wetland can alter the existing flow regime of waterways. This has the potential to have adverse effects through decreasing (less habitat) or increasing (increase channel erosion) flow.	The stormwater design philosophy is to use a treatment train approach to treat and detain stormwater using swales and large constructed ponds and wetlands. For smaller rain events, infiltration will be the main disposal method. The existing SH1 has no stormwater treatment, hence the redirection of a large proportion of traffic to Ō2NL will result in an overall improvement in water quality in the receiving watercourses.	Low adverse to Positive
Freshwater habitat loss and modification Level of confidence: High – unavoidable effect of road construction Spatial scale: Restricted to Ō2NL Project Area Duration: Permanent Reversibility: No	Very High	Permanent loss of open channel freshwater habitat resulting from culverting and reclamation. There will be approximately 3108 m of existing permanent stream channel length lost over the project comprising: (i) 1424 m of "moderate" ecological value channel; (ii) 1256 m of "low" ecological value channel; and,	Creation of diversion channels within the proposed designation to minimise overall channel loss. Design diversion channels to maximise their ecological potential (e.g., creating deeper pool habitat, dense riparian planting) and length (meander where possible). Reduce length of culverts as much as practicable, noting desirability to also shorten stream length loss. Fish friendly, stream simulation culvert design as a default. Offsetting via stream rehabilitation outside the designation in the Waiauti Stream, Manakau Stream, and Kuku Stream.	Very High – but offset outside designation to achieve a no net loss situation (discussed later in this report).

Activity/Effect	Magnitude WITHOUT effects management	Reasoning	Effects Management Actions	Magnitude WITH effects management applied
		(iii) 428 m of channel that is likely to be "low" ecological value, but is unsurveyed due to access issues. The minimum length of new open, permanently flowing diversion channels to be created is 1592 m. Results in overall reduction in open stream habitat length in the proposed designation of 1516 m.		
Light pollution Level of confidence: High – unavoidable effect of road construction Spatial scale: Restricted to Ō2NL Project Area where lighting is required. Duration: Permanent Reversibility: No	Moderate	Artificial lighting is required for safety reasons at points along the proposed designation Artificial light at night can confuse and alter the natural behaviours of various biota including insects, birds, fish, reptiles, and amphibians. Differs among sites depending on flow permanence and proximity to proposed areas with artificial lighting.	Artificial lighting will only be installed at conflict points (where traffic enters/exits the proposed state highway). Use LED luminaires that direct light to where it is needed and avoid spillage into wider landscape. Riparian planting of affected waterways to shade from artificial lighting at night.	Low

Construction Effects

Freshwater habitat disturbance

149. Disturbance of the existing stream habitat at locations where culverts are being installed and open diversion channels created is an unavoidable consequence of construction. The existing open channel will be reclaimed (filled in) leading to the potential loss of all biota present in the affected stream sections at that time. Table K12 summarises freshwater habitat disturbance effects on a site-by-site basis.

150. To minimise the loss of aquatic biota, fish capture and relocation will be undertaken in all stream sections (including online ponds/dams) holding surface water at the time of works. An Ecological Management Plan ("**EMP**") will be prepared in advance of construction and will include a fish (including kākahi and kōura) salvage plan to enable a consistent methodology across the numerous sites within the proposed designation. This plan will include details on procedures should exotic pest species be captured (e.g., mosquitofish, perch, rudd) and also if exotic amphibians are found (e.g., bell frog tadpoles). The EMP is proposed in conditions at Appendix Seven to Volume II.

151. With mitigation via fish capture and relocation where surface water is present, the adverse effects for all but one site have been deemed to be of a "Very Low" level based on the ecological value-magnitude matrix approach of the EcIAG (see Table K24 in Appendix K3).

152. For the Ohau River and Waikawa Stream, where there is the potential of habitat disturbance when creating a dry area in which to install a bridge pier, the overall level of adverse effects have been assessed as "Low" based on the ecological value-magnitude matrix approach of the EcIAG (see Table K24 in Appendix K3). This "Low" assessment is based on appropriate mitigation being undertaken at this site if necessary, specifically the relocation of fish if any channel diversions are required to create a dry work platform.

153. There will still be the unavoidable loss of flora and fauna that cannot be practically relocated (e.g., macroinvertebrates other than kōura and kākahi) from the affected sections of stream.

Table K12 Site-by-site consideration of freshwater habitat disturbance effects during the construction phase of the Ō2NL Project.
Here the EcIAG matrix (see Table K24 in Appendix K3) is applied to each site's ecological value and site-specific effect magnitude to determine the overall level of adverse effect at that waterway location.

Catchment	Stream Name/Code	Habitat Disturbance Activity	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
Koputaroa	42.3	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Reclamation of ephemeral pond with no fish present. Associated culvert does not involve existing channel.
	42.2	Culvert install	Low	Negligible	Very Low	Negligible	Very Low	Associated culvert does not involve existing channel and pond will not be disturbed.
	42	Culvert install Reclamation	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken from the pond at this site.
	43	None	Low	None	No effect	None	No effect	Channel will not be disturbed – no culvert, diversion, or reclamation required.
	41	Culvert install	Low	Negligible	Very Low	Negligible	Very Low	Pond will be retained and associated culvert is in an ephemeral channel.
	40	Culvert install	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	39 (Waitaiki Stream)	Culvert install	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.
	39.2	Culvert install Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral, artificial channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	39.1 (Waitaiki Stream)	Culvert install Reclamation Diversion	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
Ohau	35.4	Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.

Catchment	Stream Name/Code	Habitat Disturbance Activity	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
	35.1	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	34.5	Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral flow path. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	34	Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	Ohau River (33)	Bridge	High	High	Very High	Low	Low	Bridge site. Potential division of flow to allow pier to be built in the dry. If so, then fish relocation would be undertaken. No reclamation or diversion of existing channel.
	Kuku Stream (32)	Bridge	Moderate	Moderate	Moderate	Negligible	Very Low	Bridge site. No reclamation or diversion of existing channel.
	31	Culvert install Reclamation Diversion	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	30	Culvert install Reclamation	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	29 (Waikokopu Stream)	Culvert install Reclamation	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.
	28	Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral, artificial channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
Waikawa	27.1	Culvert install Reclamation	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.
	Waikawa Stream (27)	Bridge	High	High	Very High	Low	Low	Bridge site. Potential division of flow to allow pier to be built in the dry. If so, then fish relocation would be undertaken. Otherwise it is possible that no reclamation or diversion of

Catchment	Stream Name/Code	Habitat Disturbance Activity	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
								existing channel is necessary in which case the overall level of effect would reduce to negligible.
	26	Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	25	Culvert install Reclamation Diversion	No access – likely Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	23	Culvert install Reclamation	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	22	Culvert install Reclamation Diversion	No access – likely Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
Waikawa	20	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	19	Culvert install Reclamation	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.
	18.5	Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	18	Culvert install Reclamation Diversion	Moderate	Moderate	Low	Low	Low	Fish relocation will be undertaken.
	17	Culvert install Reclamation	Moderate	Moderate	Low	Low	Low	Fish relocation will be undertaken.
	Manakau Stream (15)	Bridge Reclamation Diversion	Moderate	Moderate	Moderate	Low	Low	Fish relocation will be undertaken.

Catchment	Stream Name/Code	Habitat Disturbance Activity	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
	Waiauti Stream (14)	Bridge Reclamation Diversion	Moderate	Moderate	Low	Low	Low	Fish relocation will be undertaken.
	13	Culvert install Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	12	Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
Waitohu	11	Culvert install	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	10	Culvert install Reclamation Diversion	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	9	Culvert install Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	8	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	7	Culvert install Reclamation Diversion	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	6.1	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	6	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.

Catchment	Stream Name/Code	Habitat Disturbance Activity	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
	5	Culvert install Reclamation	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	4	Culvert install	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral flow path, no defined channel. Undertake works when no water present to minimise risk of sediments being transported to downstream permanent freshwater habitats.
	3	Culvert install Reclamation Diversion	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	2+	Culvert install	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	1	Culvert install Reclamation Diversion	Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.
	0 (Greenwoods Stream)	Culvert install Reclamation	No access – likely Low	Moderate	Low	Low	Very Low	Fish relocation will be undertaken.

Fish migration disturbance

154. During construction, temporary diversions may be required at some stream crossing locations to enable culvert installation and diversion channel earthworks to be undertaken in dry conditions. Such diversions, be they lined temporary channels or pipes, have the potential to impede the free movement of migratory fish, often by creating velocity barriers. Table K13 summarises potential fish migration disturbance effects during the construction phase on a site by site basis, based on the current indicative concept design. The need for temporary diversion at a site has been determined by reviewing the alignment of proposed culverts and diversion channels relative to the existing channel. However, this could change during detailed design. Whatever the case, all temporary diversions need to allow for fish passage. This is now relatively standard practice for large construction projects and can be readily assumed to be able to be achieved in the context of known site conditions.

155. Given the scale and extent of the Ō2NL Project, it is highly likely such temporary diversion structures will need to be in place for extended periods of time (i.e., months rather than days/weeks) and will unavoidably need to be in place during peak fish migration periods.

156. Where fish passage through temporary diversion structures is desirable, diversion pipes or temporary channels will need to incorporate features to enable fish to pass (e.g., baffles, buried invert).

157. The Ohau River and Waikawa Stream bridge design include a single pier in the active river channel (see Volume III "Ohau River Bridge (CH22600) GA Plan and Long Section" and "Waikawa Stream Bridge (CH26500) GA Plan and Long Section"). Based on the current design, these are the only bridges with a pier in the active river channel. Depending on the location of the main flowing channel at the time of construction (it moves freely across the channel), diversion may be required, however, this would simply be moving the main flow path within the existing bed, rather than creating a temporary diversion channel. Hence there would be no adverse effect on fish migration.

158. By ensuring any temporary waterway diversions required by the Ō2NL Project allow for fish passage wherever there is available fish habitat upstream, the adverse effects for all but one site (discussed in the next paragraph) have been deemed to be of a "Very Low" level based on the

ecological value-magnitude matrix approach of the EcIAG (see Table K24 in Appendix 3).

Table K13 Site-by-site consideration of fish migration disturbance effects during the construction phase of the Ō2NL Project

Here the EcIAG matrix (see Table K24 in Appendix K3) is applied to each site's ecological value and site-specific effect magnitude to determine the overall level of adverse effect at that waterway location.

Catchment	Stream Name/Code	Temporary Diversion Required	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning & Mitigation Requirements
Koputaroa	42.3	No	Negligible	Negligible	Very Low	Negligible	Very Low	No channel to divert. No freshwater habitat upstream of culvert.
	42.2	No	Low	Negligible	Very Low	Negligible	Very Low	No channel to divert. No freshwater habitat upstream of culvert.
	42	Possibly	Low	Negligible	Very Low	Negligible	Very Low	No freshwater habitat upstream of culvert.
	43	No	Low	None	No effect	None	No effect	Channel will not be disturbed.
	41	Possibly	Low	Low	Very Low	Negligible	Very Low	Ephemeral channel being piped downstream of permanent pond with shortfin tuna/eel present. Any temporary diversion should allow for fish passage.
	40	No	Low	Moderate	Low	Negligible	Very Low	Culvert and diversion should be built offline from existing channel.
	39 (Waitaiki Stream)	No	Moderate	Moderate	Moderate	Negligible	Very Low	Culvert and diversion should be built offline from existing channel.
	39.2	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	39.1 (Waitaiki Stream)	No	Moderate	Negligible	Very Low	Negligible	Very Low	Permanent diversion would be built offline.
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
Ohau	35.4	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	35.1	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	34.5	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral flow path.

Catchment	Stream Name/Code	Temporary Diversion Required	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning & Mitigation Requirements
	34	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	Ohau River (33)	No	High	Low	Low	Negligible	Very Low	Bridge site with pier in active channel. Any diversion of flow around pier site would maintain fish passage.
	Kuku Stream (32)	No	Moderate	Moderate	Moderate	Negligible	Very Low	Bridge site. Scour protection installation may require a temporary diversion. Any temporary diversion must allow for fish passage.
	31	No	Low	Moderate	Low	Negligible	Very Low	Culvert and diversion should be built offline from existing channel.
	30	Possibly	Low	Moderate	Low	Low	Very Low	Culvert should be built offline from existing channel. Any temporary diversion must allow for fish passage.
	29 (Waikokopu Stream)	Possibly	Moderate	Moderate	Moderate	Negligible	Very Low	Any temporary diversion must allow for fish passage.
	28	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
Waikawa	27.1	No	Moderate	Moderate	Moderate	Low	Low	Culvert should be built offline from existing channel. Any temporary diversion must allow for fish passage.
	Waikawa Stream (27)	No	High	Negligible	Very Low	Negligible	Very Low	Bridge site. Channel retains form during construction. Any diversion of flow around pier site would maintain fish passage.
	26	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	25	Possibly	No access – likely Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	23	Possibly	Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	22	No	No access – likely Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	20	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.

Catchment	Stream Name/Code	Temporary Diversion Required	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning & Mitigation Requirements
	19	Possibly	Moderate	Moderate	Moderate	Low	Low	Any temporary diversion must allow for fish passage.
	18.5	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	18	Possibly	Moderate	Moderate	Low	Low	Low	Any temporary diversion must allow for fish passage.
	17	Possibly	Moderate	Moderate	Moderate	Low	Low	Any temporary diversion must allow for fish passage.
	Manakau Stream (15)	Possibly	Moderate	Moderate	Moderate	Low	Low	Any temporary diversion must allow for fish passage.
	Waiauti Stream (14)	Possibly	Moderate	Moderate	Moderate	Low	Low	Any temporary diversion must allow for fish passage.
	13	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	12	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
Waitohu	11	Possibly	Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage. Ephemeral upstream of culvert site, but farm dam present that likely has shortfin tuna/eel.
	10	Possibly	Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	9	Possibly	Negligible	Low	Very Low	Negligible	Very Low	Any temporary diversion must allow for fish passage. Ephemeral but farm dam upstream of culvert site that likely has shortfin tuna/eel.
	8	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	7	Possibly	Negligible	Negligible	Very Low	Negligible	Very Low	Any temporary diversion must allow for fish passage. Ephemeral but farm dam upstream of culvert site that likely has shortfin tuna/eel.
	6.1	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	6	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	5	No	Negligible	Negligible	Very Low	Negligible	Very Low	Any temporary diversion must allow for fish passage. Ephemeral but farm dam upstream of culvert site that likely has shortfin tuna/eel.

Catchment	Stream Name/Code	Temporary Diversion Required	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning & Mitigation Requirements
	4	No	Negligible	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	3	Possibly	Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	2	Possibly	Low	Moderate	Low	Moderate	Low	Any temporary diversion must allow for fish passage.
	1	Possibly	Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage.
	0 (Greenwoods Stream)	Possibly	No access – likely Low	Moderate	Low	Low	Very Low	Any temporary diversion must allow for fish passage. Note this site has already been impacted by culvert installation associated with the Peka to Ōtaki Highway Project.

Release and subsequent deposition of fine sediments

159. Given the scale and extent of the Ō2NL Project, a large volume of earthworks is required. The estimated volumes of cut and fill are described in the Design and Construct Report ("**DCR**") provided as Appendix Four in Volume II of this application. Earthworks will typically involve the following activities:

(a) topsoil stripping and stockpiling;

(b) ground improvements;

(c) bulk excavation to cut to fill and borrow to fill;

(d) placement of engineered fill;

(e) placement of landscape fill, or spoil, using excess materials;

(f) temporary stockpiling of cut material for potential reuse in pavement construction; and

(g) replacement of topsoil and grass on cut and fill batters.

160. Such disturbance unavoidably exposes bare earth, which may then be mobilised via wind and rain and enter adjacent waterways. Suspended sediment can have a range of impacts on aquatic ecosystems including alteration of water chemistry, increasing turbidity, increasing invertebrate drift and altering community structure (Ryan, 1991).[44] Turbidity levels as low as 5 nephelometric turbidity units (NTU) can decrease primary production (photosynthesis) by 3–13% (Ryan, 1991). High turbidity can affect the amenity value of naturally clear waterways leading to public perceptions that the water is "dirty".

161. Several studies in the late 1990s – early 2000s investigated the sublethal effects of turbidity on New Zealand native fish. In general, many common New Zealand native fish species are relatively tolerant of elevated turbidity for short periods (Boubée *et al*., 1997;[45] Richardson *et al*., 2001;[46] Rowe & Dean, 1998).[47]. A further investigation into the lethal effects of suspended

[44] Ryan, P.A. 1991. Environmental effects of sediment on New Zealand streams: a review. *New Zealand Journal of Marine and Freshwater Research* 25: 207-221.
[45] Boubée J., Dean, T., West, D., & Barrier, R. 1997. Avoidance of suspended sediment by the juvenile migratory stage of six New Zealand native fish species. *New Zealand Journal of Marine and Freshwater Research* 31: 61-69.
[46] Richardson, J., Rowe, D.K. & Smith, J.P. 2001. Effects of turbidity on the migration of juvenile banded kokopu (*Galaxias fasciatus*) in a natural stream. *New Zealand Journal of Marine and Freshwater Research* 35: 191–196.
[47] Rowe, D. K. & Dean, T. 1998. Effects of turbidity on the feeding ability of the juvenile migrant stage of six New Zealand freshwater fish species. *New Zealand Journal of Marine and Freshwater Research* 32: 21-29.

sediment found the survival of five insect larvae (the mayflies *Deleatidium* and *Zephlebia*, the caddisflies *Polyplectropus* and *Triplectides*, and the damselfly *Xanthocnemis*), kōura, banded kokopu, and redfinned bullies to be not significantly different at turbidities up to c. 20,000 NTU compared to control groups in clear water under laboratory conditions (Rowe *et al*., 2002).[48]

162. While many aquatic biota are relatively tolerant of at least short-term increases in suspended sediment, the deposition of this sediment on the streambed (at rates and with quantities of smaller particles greater than the natural state) is a major stressor on waterway ecosystems. Such deposition can alter physical habitat (clogging interstitial spaces in the stream bed used as refugia by fish and invertebrates), alter food resources (e.g., smothering algae), and degrade sites used for egg laying by many aquatic species. Hence sediment effects the diversity and composition of algae, macrophytes, fish, and aquatic invertebrates (Clapcott *et al*., 2011).[49]

163. Sensitivity of a stream to elevated fine sediment deposition is influenced by the existing state of a waterway. Modified, soft-bottomed streams or those hard-bottomed streams that already have unnatural levels of fine sediment on their beds, are generally dominated by aquatic fauna that are tolerant of or prefer such conditions. More pristine hard-bottomed streams with minimal fine sediment coverage generally have a high proportion of aquatic fauna that are intolerant to elevated levels of fine sediment. Therefore, the potential adverse effects of fine sediment deposition will vary among the streams intersected by the Ō2NL Project. However, as waterways are an interconnected network across the landscape that actively transport sediments from the source to the ocean, excessive fine sediments entering a relatively "insensitive" site have the potential to have adverse effects on connected habitats as they are transported downstream over time.

164. Table K14 provides a site-by-site assessment of the potential impacts of the elevated levels of sediment mobilisation during the construction phase of

[48] Rowe, D.K., Suren, A.M., Martin, M., Smith, J.P., Smith, B. & Williams, E. 2002. Lethal turbidity levels for common freshwater fish and invertebrates in Auckland streams. Auckland Regional Council Technical Publication Number 337. 37 p.

[49] Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. & Death, R.G. 2011. Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

the Ō2NL Project. The relative sensitivity of each site has been determined based on the existing state of the stream bed and faunal composition:

(a) Nil: A nil effect has been determined for most ephemeral sites given they lack any freshwater habitat for most of the time;

(b) Low: Most modified, soft-bottomed, streams as they are typically dominated by a fauna tolerant of sedimentation.

(c) Moderate: Streams that appear to have unnatural loadings of fine sediment and would likely be predominantly hard-bottomed in the absence of elevated fine sediment inputs.

(d) High: Hard-bottomed streams with zones of high-quality, swift flowing habitat, but also having obvious signs of elevated fine sediment inputs (e.g., actively eroding/slumping banks) and depositional zones with thick fine sediments.

(e) Very high: Streams with very low to no fine sediment cover evident, and a high proportion of aquatic taxa that are intolerant of elevated fine sediment deposition.

165. The approach to erosion and sediment control ("**ESC**") proposed by **Mr Gregor McLean** is described in the DCR (Appendix Four to Volume II). This outlines the various procedures and methodologies that will be employed to minimise the likelihood of fine sediments entering adjacent waterways.

166. Given the five-year construction period, it is highly likely that there will be at least one rainfall event that exceeds the design parameters of any stormwater treatment infrastructure and which may result in sediment laden discharges entering adjacent waterways. Additionally, from past experience on similar projects it is generally impossible to undertake a project of this scale, that includes numerous flow diversions and culvert installations, without some increased rate of sediment release to adjacent waterways despite all the various methodologies and controls in place. Based on the catchment modelling approach of Technical Assessment H (Water Quality) which incorporated the USLE modelling included in the erosion and sediment control report (Attachment Four to the DCR (Volume II)), the magnitude of effect of construction period sediment has been determined to be:

(a) ”High” for modelled catchment D (Stream 11);

(b) "Moderate” (“partial change”) for modelled catchments B, C, G, I, and P (which includes Streams 1, 3, 10, 17, 19, 22, 23, 25, 42.3 (pond), 42.2 (pond), 42 (pond), 43, and 41); and

(c) “Low” (“discernible change”) for modelled catchments A, E, F, H, J, K, L, M, and O (which includes Streams 0, 18, 27.1, 29, 30, 31, 40, 39. 39.1 and the Ohau River, Kuku Stream, Waikawa Stream, Waiauti Stream, Manakau Stream).

167. A low magnitude of effect (rather than very low) has been assigned to ephemeral waterways in recognition of their connectivity to downstream permanent freshwater habitats and ability to transport fine sediment to those habitats during extended rainfall events.

168. The level of adverse effects of construction phase sedimentation <u>after effects management actions have been applied</u> has been assessed as:

(a) “Moderate” for Stream 17 and Stream 19;

(b) “Low” or “Very Low” for the remaining waterways.

169. These levels of effect apply only <u>during</u> the construction phase (an estimated five-year period) and assume ESC controls operate as intended such that there are not any major fine sediment release events during the construction period that result in a large slug of fine sediment entering a waterway (e.g., treatment devices fail to meet expected discharge standards, structural failure of treatment devices, or unanticipated events such as slips). If there was a significant discharge of sediment during the construction phase, the effects could endure beyond the completion of construction. It is difficult to postulate how long this could be, but given the relative regularity of high flow events in the area, it is expected that any deposited sediments would be dispersed in the short term and hence be a temporary effect based on timescales in Table K25 of Appendix K3. Additionally, the staged approach of construction will mean the duration that any given area of unstabilised exposed earth will be far less than five years.

170. The two waterways where the construction phase sedimentation level of effect has been assessed as moderate (Stream 17 and Stream 19), have been designated as having low sensitivity to increased sedimentation. Both

are small, modified channels with degraded instream habitat that were deemed to be of “moderate” ecological value on account of the presence of the “At Risk – declining” longfin eel.

171. As shown in Table K14, despite many individual stream sites crossed by the proposed designation having low sensitivity to increased fine sediment deposition, many such sites are directly connected to downstream habitats. Some of these habitats may be more sensitive to elevated fine sediment (e.g., Streams 29, 30, and 31 (low sensitivity) are all tributaries of the Kuku Stream (high sensitivity)). Therefore, irrespective of a site’s sensitivity to fine sediment, it is crucial that all practical efforts are made to minimise fine sediment entering waterways in the entire proposed designation. The standards for ESC devices are outlined in the proposed consent conditions provided as Appendix Six of Volume II in the Ō2NL consent application. This is also the case for ephemeral channels and flow paths, that have the ability to transport fine sediments to downstream permanent habitats during larger rain events.

172. The monitoring and maintenance requirements of erosion and sediment control infrastructure are described in erosion and sediment control report (Design and Construct Report (Appendix Four to Volume II)).

173. The monitoring of fine sediments (suspended and deposited) before, during construction and post-construction in key representative waterways should be included as part of an aquatic ecology monitoring programme that is detailed in the EMP. Suspended fine sediment monitoring has already begun and will continue (see Technical Assessment H - Water Quality). Pre-construction, baseline monitoring of deposited sediment on a monthly basis, should begin as soon as possible to capture potential site variability over as long a period as possible before construction begins. The initiation and duration of post-construction monitoring should be related to stabilisation of cut and fill surfaces. The timing of monitoring in any one stream would be related to completion of earthworks in that construction zone/catchment, and therefore will not necessarily be related to the overall completion of the Ō2NL Project.

Table K14 Site-by-site consideration of sediment release and deposition during the construction phase of the Ō2NL Project.

Here the EcIAG matrix (see Table K24 in Appendix K3) is applied to each site's ecological value and site-specific effect magnitude to determine the overall level of adverse effect at that waterway location.

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
Koputaroa	42.3	Soft	Soft	Low	Negligible	Moderate	Very Low	Moderate	Very Low	Induced ephemeral pond. Limited connectivity to downstream freshwater habitats. Will be mostly infilled during construction.
	42.2	Soft	Soft	Low	Low	Moderate	Low	Moderate	Low	Constructed ornamental pond. Limited connectivity to downstream freshwater habitats.
	42	Soft	Soft	Low	Low	Moderate	Low	Moderate	Low	Induced permanent pond. Limited connectivity to downstream freshwater habitats. Will be completely infilled during construction.
	43	Soft	Soft	Low	Low	Moderate	Low	Moderate	Low	Modified soft-bottomed stream with no sensitive taxa.
	41	Soft	Soft	Low	Low	Moderate	Low	Moderate	Low	Constructed farm dam
	40	Soft	Soft	Low	Low	Moderate	Low	Low	Very Low	Modified soft-bottomed stream with no sensitive taxa.
	39 (Waitaiki Stream)	Mostly Soft	Hard	Moderate	Moderate	Moderate	Moderate	Low	Low	Assumed to be gravel bed with unnatural loading of fine sediment. Direct connection to Koputaroa Stream not far downstream.
	39.2	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel with no clear connection to

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
										downstream freshwater habitats.
	39.1 (Waitaiki Stream)	Mostly Soft	Hard	Moderate	Moderate	Moderate	Moderate	Low	Low	Assumed to be gravel bed with unnatural loading of fine sediment. Direct connection to Koputaroa Stream not far downstream.
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	Soft	?	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel with no clear connection to downstream freshwater habitats.
Ohau	35.4	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel.
	35.1	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel.
	34.5	Soft	Soft	Low	Negligible	Low	Very Low	Low	Very Low	Ephemeral overland flow path with no defined channel. Degraded wetland downstream.
	34	Soft	Hard	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	Ohau River (33)	Hard	Hard	Very High	High	High	Very High	Low	Low	High quality instream habitat with very little deposited sediment. Many macroinvertebrate taxa intolerant of deposited fine sediments present.
	Kuku Stream (32)	Hard	Hard	High	Moderate	High	Moderate	Low	Low	High quality instream habitat, but subject to fine sediment inputs from active bank erosion. Obvious depositional zones with high deposited sediment cover, but relative clean stony habitat in zones of faster

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
										flow. Still retains many macroinvertebrate taxa intolerant of deposited fine sediments.
	31	Soft	Hard	Low	Low	Moderate	Low	Low	Very Low	Modified soft-bottomed stream with no sensitive taxa. Connects to Kuku Stream.
	30	Soft	Hard	Low	Low	Moderate	Low	Low	Very Low	Modified soft-bottomed stream with no sensitive taxa. Connects to Kuku Stream.
	29 (Waikokopu Stream)	Hard	Hard	Moderate	Moderate	Moderate	Moderate	Low	Low	Likely a stony stream with high fine sediment load. Recent channel straightening has occurred. Connects to Kuku Stream.
	28	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel.
Waikawa	27.1	Hard	Hard	High	Moderate	High	Moderate	Low	Low	High quality instream habitat, but subject to fine sediment inputs from active bank erosion and upper agricultural catchment. Obvious depositional zones with high deposited sediment cover, but relative clean stony habitat in zones of faster flow. Joins Waikawa Stream not far downstream.
	Waikawa Stream (27)	Hard	Hard	Very High	High	High	Very High	Low	Low	High quality instream habitat with very little deposited sediment. Many macroinvertebrate taxa

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
										intolerant of deposited fine sediments present.
	26	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel.
	25	Mostly Hard - assumed	Hard	Moderate - assumed	No access – likely Low	Moderate	Low	Moderate	Low	Site not surveyed, however, likely to be similar to Stream 23.
	23	Mostly Hard	Hard	Moderate	Low	Moderate	Low	Moderate	Low	Small gravel bed stream with actively eroding banks contributing to sediment load. Dominated by sediment tolerant species.
	22	?? Likely Soft	Hard	Low - assumed	No access – likely Low	Moderate	Low	Moderate	Low	Site not surveyed.
	20	Soft	Hard	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	19	Soft	Hard	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Modified soft-bottomed stream with no sensitive taxa.
	18.5	Soft	NA	Nil	Negligible	Low	Very Low	Low	Very Low	Artificial ephemeral channel.
	18	Mostly Soft	Hard	Low	Moderate	Moderate	Moderate	Low	Low	Assumed to be gravel bed with unnatural loading of fine sediment. Dominated by sediment tolerant species.
	17	Mostly Soft	Hard	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Modified soft-bottomed stream with no sensitive taxa.
	Manakau Stream (15)	Hard	Hard	High	Moderate	High	Moderate	Low	Low	High quality instream habitat, but subject to fine sediment inputs from active bank erosion and agricultural land use.

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
										Obvious depositional zones with high deposited sediment cover, but relative clean stony habitat in zones of faster flow. Still retains many macroinvertebrate taxa intolerant of deposited fine sediments.
	Waiauti Stream (14)	Hard	Hard	High	Moderate	High	Moderate	Low	Low	High quality instream habitat, but subject to fine sediment inputs from active bank erosion and agricultural land use. Obvious depositional zones with high deposited sediment cover, but relative clean stony habitat in zones of faster flow. Still retains many macroinvertebrate taxa intolerant of deposited fine sediments.
	13	Soft	Soft	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	12	Soft	Soft	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral overland flow path with no defined channel.
Waitohu	11	Soft	Soft	Low	Low	Moderate	Low	High	Low	Modified soft-bottomed stream with no sensitive taxa.
	10	Soft	Soft – likely former swamp	Low	Low	Moderate	Low	Moderate	Low	Modified soft-bottomed stream with no sensitive taxa.
	9	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.

Catchment	Stream Name/Code	Existing stream bed substrate	Likely natural state stream bed substrate	Relative Sensitivity to Increased Sedimentation	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Level of Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Level of Effect AFTER effects management applied	Reasoning
	8	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	7	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	6.1	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	6	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	5	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral channel.
	4	Soft	Soft – likely former swamp	Nil	Negligible	Low	Very Low	Low	Very Low	Ephemeral overland flow path with no defined channel.
	3	Soft	Soft – likely former swamp	Low	Low	Moderate	Low	Moderate	Low	Modified soft-bottomed stream with no sensitive taxa.
	2	Soft	Soft – likely former swamp	Low	Low	Moderate	Low	Moderate	Low	Modified soft-bottomed stream with no sensitive taxa.
	1	Soft	Soft – likely former swamp	Low	Low	Moderate	Low	Moderate	Low	Modified soft-bottomed stream with no sensitive taxa.
	0 (Greenwoods Stream)	Hard - assumed	Hard	Moderate - assumed	No access – likely Low	Moderate	Low	Low	Very Low	Site not surveyed. Assume a hard-bottomed stream with unnatural loading of fine sediments.

Water contamination from construction activities

174. Contamination of adjacent waterways with substances other than fine sediment can occur in two general ways during the construction phase:

(a) Machinery – In particular fuel, oil, grease and hydraulic fluids either directly from machinery mishaps or accidental spillage (e.g., during refuelling).

(b) Construction materials – Construction of the Ō2NL Project involves the installation of concrete structures in close proximity to numerous waterways. Many of the concrete structures will more than likely be precast although bridge piers will require pouring of wet concrete. In conjunction with all the concrete drainage infrastructure structures, it is highly likely mortars and grouts will be required where necessary.

175. Concrete wash water and uncured cement-related products can harm aquatic life primarily though causing rapid pH shifts and the discharge of ammonia. Ammonia can block oxygen transfer from the gills to the blood and can cause immediate and long-term damage to the gills of fish (Ogbonna & Chinomso, 2010).[50] The careless use of such products can result in significant fish kill events, such as that observed by EOS Ecology in Akaroa where the grout used in a culvert repair killed hundreds of fish (McMurtrie, 2014).[51]

176. The potential adverse effect of water contamination during the construction phase in the absence of any effects management was determined to be of a "High" magnitude based on the EcIAG definitions (see Table K23 in Appendix K3). This is because of the high probability of causing mortality (fish kills in particular) to aquatic biota. In terms of level of effect, based on the matrix approach of the EcIAG this would equate to:

(a) A "Very High" level of effect for those sites with "High" ecological value (i.e., Ohau River and Waikawa Stream);

(b) A "Moderate" level of effect for those sites with "Moderate" ecological value (i.e., Stream 39, Stream 39.1, Stream 29, Kuku Stream, Stream

---

[50] Ogbonna, J. F. & Chinomso, A. A. 2010. Determination of the concentration of ammonia that could have lethal effects on fish ponds. ARPN Journal of Engineering and Applied Sciences 5 (2): 1-5.

[51] McMurtrie, S. 2014. Memorandum report: Assessment of the ecological impact of culvert repair work at Rue Noyer culvert on Walnut Creek. EOS Ecology Report No. CHR01-14027-01. EOS Ecology, Christchurch. 53 p incl. appendices.

27.1, Stream 19, Stream 18, Stream 17, Manakau Stream, Waiauti Stream);

(c) A "Low" level of effect for those sites with "Low" ecological value (i.e., all other permanent waterways); and

(d) A "Very Low" level of effect for those sites with "Negligible" ecological value (the ephemeral waterways).

177. In practice the contamination of adjacent waterways can be prevented via the following avoidance actions that will be detailed in the Construction Environmental Management Plan ("**CEMP**"):

(a) Ensuring a high level of vehicle maintenance and cleanliness;

(b) Avoiding machinery from tracking/driving in flowing water;

(c) Ensuring all refuelling is undertaken well away from waterways;

(d) Ensuring all fuels and other construction liquids are stored in appropriately bunded locations;

(e) Ensuring spill kits are in close proximity to all machinery and staff are trained in how to use them properly in the environments to be encountered in the Ō2NL Project;

(f) Isolating work areas from flowing water by creating temporary diversions or undertaking construction offline, particularly in relation to those areas that require the pouring of wet concrete and/or usage of mortars and grouts;

(g) Ensuring all mortars and grouts used in culverts are suitable for use in such situations, and they are fully cured according to manufacturer's instructions prior to contact with flowing water.

178. With the above avoidance actions adequately implemented, the magnitude of effect can be reduced to "Low" based on the EcIAG definitions (see Table K23 in Appendix K3). Technical Assessment H (Water Quality) also concludes a "Low" magnitude of effect for "concrete/hazardous substances" for all catchments after avoidance/mitigation. For sites with moderate or high ecological value (i.e., Stream 39, Stream 39.1, Ohau River, Kuku Stream, Waikawa Stream, Stream 29, Stream 27.1, Stream 19, Stream 18, Stream 17, Manakau Stream, Waiauti Stream), this would equate to a "Low"

level of effect. For all the other sites, which have low or negligible ecological value, this would equate to a “Very Low” level of effect.

Abstraction of water for construction purposes

179. The Project requires water during construction for various activities including dust suppression and moisture conditioning during earthworks and pavement construction. A construction water abstraction strategy is included as part of the DCR (Appendix Four to Volume II) and includes details of proposed abstraction rates and storage capacity. In short, storage ponds will be constructed and replenished via pumped water abstraction from the Koputaroa Stream, Ohau River, Waikawa Stream, Manakau Stream, Waiauti Stream, and Waitohu Stream. The proposed water abstraction and storage pond locations are shown on the accommodation works plans (drawing number 310203848-01-500-C1000 to C1017).

180. Water abstraction can have adverse ecological impacts, if abstraction rates cause changes in aquatic habitat. Decreased stream discharge resulting from water abstraction can cause decreased water velocity, water depth, and wetted channel width; increased sedimentation of the stream bed; and changes in thermal regime and water chemistry[52]. Such habitat effects can lead to changes in algal, macroinvertebrate, and fish communities as taxa that prefer such conditions may increase at the expense of other taxa. Fish and macroinvertebrate mortality can also occur if animals are sucked into water abstraction intakes.

181. The Project proposes to only take water from existing available allocations and use minimum flow levels defined in the relevant Regional Plan for each watercourse as the flow level at which any abstraction must cease. Therefore any abstraction will be within the environmental limits that were derived during regional planning processes, and are therefore considered to be of a level that will not cause any significant adverse effects on freshwater ecology.

182. The proposed instantaneous rates of abstraction are set low as to provide trickle replenishment of storage ponds (see Table 4.4 of the DCR (Appendix Four to Volume II)). At any time no more than 10% of the flow will be abstracted and abstraction rates will be scaled depending on the actual flow at the time. Therefore proposed abstraction rates are a relatively small

[52] Dewson, Z.S., James, A.B.W., & Death, R.G. 2007. A review of the consequences of decreased flow for instream habitat and macroinvertebrates. Journal of the North American Benthological Society 26: 401-415.

proportion of the flow at any time, even as water courses approach their minimum flow level.

183. All water intake points will have screens to avoid fish being sucked into the pipes and passing through pumps. As per the Ministry for the Environment's "National works in waterways guideline"[53] all intakes will be screened with 2-3 mm mesh.

184. In terms of assessing effects, of the water courses subject to water abstraction, the Ohau River, Waikawa Stream, Manakau Stream, and Waiauti Stream were surveyed during the Ō2NL existing environment investigations very near to the proposed abstraction sites. The Waitohu Stream and Koputaroa Stream abstraction sites were not surveyed as they were not directly affected by Ō2NL, hence ecological values have not been previously derived for those exact sites. For the Waitohu Stream, we have used the ecological value assigned during the Peka to Ōtaki (PP2Ō) consent investigations by NIWA[54]. For the Koputaroa Stream, expert judgement informed by the fish community known from the catchment, HRC biomonitoring results from the Tavistock Rd site, and values of other similar streams along the Ō2NL route were used to assign ecological value. The water abstraction sites have the following overall ecological values:

(a) High (Ohau River, Waikawa Stream, and Waitohu Stream);

(b) Moderate (Koputaroa Stream, Manakau Stream, and Waiauti Stream).

185. The magnitude of effect of water abstraction, when taking into account the effects management that will be applied (as described above in paragraphs 179-182), was deemed to be "low" based on the EcIAG definitions (see Table K23 in Appendix K3).

186. Based on the ecological value-magnitude matrix approach of the EcIAG (see Table K24 in Appendix K3) the level of effect of water abstraction on all water abstraction sites is deemed to be "Low".

Operational Effects

Reduction in free movement of aquatic fauna

---

[53] Ministry for the Environment. 2021. *National works in waterways guideline*. Prepared for the Ministry for the Environment by Boffa Miskell Limited. Wellington: Ministry for the Environment.
[54] Larned, S., Wech, J., & Suren A. 2013. Peka Peka to North Ōtaki Expressway: aquatic ecology. Prepared for Opus. NIWA Client Report No. CHC2012-100.

187. Of the 12 native or endemic fish species detected during the freshwater ecology survey, only one (upland bully) does not require free access between freshwater habitats and the ocean to complete their lifecycles. Therefore, instream barriers that impede fish passage can have serious implications on fish distributions and render otherwise suitable habitats inaccessible to fish.

188. Culverts can also prevent the upstream-downstream movement of flighted adult aquatic insects, potentially limiting dispersal and influencing population dynamics. It has been shown that culverts appear to prevent the movement of some New Zealand caddisflies while the more open structure of bridges had no such effect (Blakely *et al*., 2006).[55] Such an adverse effect would be greater in those higher ecological value streams which have a greater proportion of macroinvertebrate taxa with flying adult stages (e.g., mayflies, stoneflies, caddisflies).

189. As detailed in Table K15, the Ō2NL Project includes the installation of culverts in permanently flowing and ephemeral waterways along its length. Such culverts have the potential to impede the free passage of fish and flying adult aquatic insects. Therefore, in the absence of any effects management (i.e., culverts not providing any fish passage) the magnitude of this effect was determined to be "High".

190. The culvert details shown in Table K15 are based on the most recent concept design which show that designing culverts to provide fish passage is possible. The concept design culvert dimensions are shown in Volume III "Catchment Culvert Schedule", drawing no. 310203848-01-300-C3000. During detailed design it is likely there will be changes to the dimensions of some culverts. Once culvert lengths are confirmed during the detailed design stage, SEV ECR calculations will need to be checked and likely recalculated at some locations to ensure the stream offsetting programme will achieve "no net loss". It is not anticipated that any future changes to culvert dimensions will alter the overall level of effect at any location. Any major change to culvert design at a location (e.g., change from "stream simulation" to a less preferable solution) would require a consent variation so any change of effect could be properly considered.

[55] Blakely, T.J., Harding, J.S., McIntosh, A.R. & Winterbourn, M.J. 2006. Barriers to the recovery of aquatic insect communities in urban streams. Freshwater Biology 51: 1634–1645.

191. Bridges, which allow the existing stream bed to remain essentially intact, and generally have much greater headspace than culverts, are the ideal solution for road crossings from a freshwater ecology perspective. Adverse effects on the free movement of aquatic fauna have been avoided by the proposed installation of bridges at all the larger gravel bed waterways with relatively large catchment areas upstream of the Ō2NL Project (Ohau River, Waikawa Stream, Kuku Stream, Waiauti Stream, Manakau Stream).

192. Table K16 summarises a site-by-site assessment of the effect of the installation of culverts and bridges on the free movement of aquatic biota. Based on the ecological value-magnitude matrix approach of the EcIAG (see Table K24 in Appendix K3) the effect of culvert installation in permanent flowing streams in the absence of any effects management would be "Low". While for some environmental effects a "Low" rating may mean further effects management is not required, this is clearly not the case for fish passage in permanent streams as it would be ecologically irresponsible to not ensure biota have continued free access to habitats upstream of the Ō2NL Project where doing so is practicable.

193. On 1 June 2021, a culvert design philosophy detailing fish passage and interpretation guidance for NES-FW Regulation 70 was provided to regional councils (Appendix K5). For permanent stream crossings that are culverted, the default position is to follow the "stream simulation" design outlined in the New Zealand Fish Passage Guidelines for Structures up to 4 m (**"NZFPG"**) (NIWA/DOC, 2018[56] This design seeks to create a near-natural stream bed through the culvert so there is a seamless transition between upstream and downstream habitats in terms of channel morphology, water depths, and water velocities. Figure K4 illustrates a typical culvert design to ensure fish passage. The intent is to, where practicable, meet the permitted activity requirements of the NES-FW Regulation 70 criteria.

[56] NIWA/DOC. 2018. New Zealand fish passage guidelines – for structures up to 4 metres. NIWA Client Report: 2018019NH.226 p. [https://www.niwa.co.nz/freshwater-and-estuaries/research-projects/new-zealand-fish-passageguidelines]

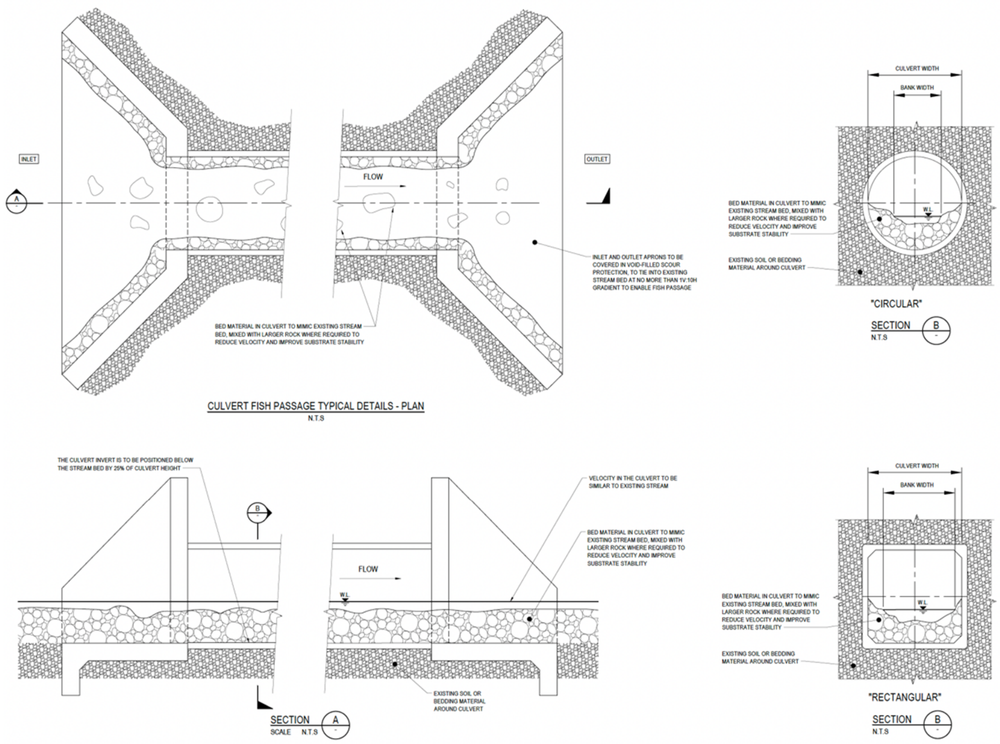


Figure K4 Typical culvert design details to ensure fish passage from Volume III plan 310203848-01-300-C9300.

194. In addition to the “stream simulation” culvert design, it will be important to ensure the riparian zone upstream and downstream of all culverts is planted with vegetation, that will ideally eventually form a closed canopy over the affected streams. This will act to shade the streams and soften the interface between the culverts and surrounding environment, such that the stress of passing from a totally dark culvert environment to an open channel will be minimised for the fish and invertebrates passing through culverts. At a minimum, this planting will extend for the length of the stream that is within the proposed designation.

195. As shown in Table K16, for permanent stream crossings, this has resulted in an overall level of effect being reduced to a “Very Low”. Three sites have been assessed as receiving a “Net Gain” as a result of a new culvert being installed:

(a) Stream 23 currently has a perched culvert, which would be at least a partial fish barrier, within the proposed designation which will be effectively replaced by the new culvert.

(b) Stream 20 within the proposed designation appears to have been artificially made ephemeral via the digging of a sump into which a small permanently flowing stream discharges. The culvert here has the potential to increase the surface water connectivity of this stream to downstream habitats.

(c) Stream 2’s existing culvert under SH1 is to be replaced with a larger capacity pipe, which will likely improve fish passage into the Stream 1 and 3 catchments.

196. Fish passage will also be provided for in some ephemeral channels where there are permanent freshwater habitats upstream of the; these being constructed farm dams where fish (predominantly shortfin tuna/eel) are known or highly likely to be present.

197. The EMP will include procedures to measure of culvert parameters post-construction to ensure they meet the NES-FW Regulation 70 criteria. It is also intended to assess all completed / constructed culverts using the Fish Passage Assessment Tool (“**FPAT**”), which will add their details to a publicly-searchable online database (see https://niwa.co.nz/freshwater/management-tools/fish-passage-assessment-tool).

Table K15 Basic details of permanently flowing stream crossings along the proposed designation.

Stream Code	Ecological Survey or Site Visit	Centreline Chainage (m)	Name / Comments	Shape	Fish passage required
Bridges					
14	✓	30350	Waiauti	Bridge	Yes
15	✓	30190	Manakau	Bridge	Yes
27	✓	26440	Waikawa	Bridge	Yes
32	✓	23808	Kuku	Bridge	Yes
33	✓	22658	Ohau	Bridge	Yes
34	✓	22420	Ohau flood relief	Bridge	No
Culverts (only permanent stream culverts and those ephemeral flow path culverts that require fish passage are shown)					
0	✕	34575	Greenwoods	Arch	Yes
1	✓	34050	New culvert 1	Rectangular	Yes
2	✓	34050 offline	New culvert 2	Rectangular	Yes
3	✓	33700	New culvert 3	Rectangular	Yes
5	✓	32950	New culvert 5	Rectangular	Yes
7	✓	32345	New culvert 7	Rectangular	Yes
8 (also conveys Stream 10)	✓	32085	New culvert 8	Rectangular	Yes
11	✓	31565	New culvert 11	Circular	Yes
17	✓	29515	New culvert 17	Rectangular	Yes
18	✓	29315	New culvert 18	Rectangular	Yes
19	✓	28830	New culvert 19	Rectangular	Yes

Stream Code	Ecological Survey or Site Visit	Centreline Chainage (m)	Name / Comments	Shape	Fish passage required
20	✓	28565	New culvert 20	Circular	Yes
22	✕	28205	New culvert 22	Rectangular	Yes
23	✓	28060	New culvert 23	Rectangular	Yes
25	✕	27645	New culvert 25	Rectangular	Yes
27.1	✓	26300	New culvert 27.1	Rectangular	Yes
29	✓	25430	New culvert 29	Rectangular	Yes
30	✓	25125	New culvert 30	Rectangular	Yes
31	✓	24280	New culvert 31	Rectangular	Yes
39	✓	12880	New culvert 39	Rectangular	Yes
40	✓	12690	New culvert 40	Rectangular	Yes
41	✓	12075	New culvert 41	Rectangular	Yes

* Adapted from the Volume III "Catchment Culvert Schedule", drawing no. 310203848-01-300-C3000.

Table K16 Site-by-site assessment of fish passage effects on permanently flowing stream crossings along the proposed designation. The EcIAG matrix (see Table K24 in Appendix K3) is applied to each site's ecological value and site-specific effect magnitude to determine the overall level of adverse effects at that waterway location.

Catchment	Stream Name/Code	Freshwater Ecological Value	Fish Passage Required	Fish Passage Solution	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Effect AFTER effects management applied	Reasoning
Koputaroa	42.3	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Induced ephemeral pond. Limited connectivity to downstream freshwater habitats. Will be mostly infilled during construction. No freshwater habitat upstream of proposed culvert.
	42.2	Low	No	Nil	Negligible	Very Low	Negligible	Very Low	Constructed ornamental pond. Limited connectivity to downstream freshwater habitats. No freshwater habitat upstream of proposed culvert.
	42	Low	No	Nil	Negligible	Very Low	Negligible	Very Low	Induced permanent pond. Limited connectivity to downstream freshwater habitats. Will be completely infilled during construction. No freshwater habitat upstream of proposed culvert.
	43	Low	Yes	Nil	Negligible	No effect	No culvert	No effect	No alteration to existing channel.
	41	Low	Yes	Stream simulation	High	Low	Low	Very Low	Culvert in ephemeral channel downstream of permanent freshwater habitat (constructed farm dam) with shortfin tuna/eel present.
	40	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	39 (Waitaiki Stream)	Moderate	Yes	Stream simulation	High	Moderate	Low	Low	Stream simulation culvert to be installed.
	39.2	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Artificial ephemeral channel with no clear connection to downstream freshwater habitats.
	39.1 (Waitaiki Stream)	Moderate	Yes	Diversion	No culvert	No effect	No culvert	No effect	A diversion at this site avoids the need for a culvert.

Catchment	Stream Name/Code	Freshwater Ecological Value	Fish Passage Required	Fish Passage Solution	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Effect AFTER effects management applied	Reasoning
Punahau/Lake Horowhenua	37 (Waimarie Stream)	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral channel with no clear connection to downstream freshwater habitats.
Ohau	35.4	Negligible	No	Nil	No culvert	No effect	No culvert	No effect	Ephemeral channel with flows diverted avoiding need for culvert.
	35.1	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Artificial ephemeral channel. No freshwater habitat upstream of proposed culvert.
	34.5	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral overland flow path with no defined channel. Degraded wetland downstream. No freshwater habitat upstream of proposed culvert.
	34	Negligible	No	Bridge	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. However, an Ohau River flood relief bridge is proposed.
	Ohau River (33)	High	Yes	Bridge	Negligible	Very Low	Negligible	Very Low	Bridge avoids fish passage impacts and will allow ample headspace for flying aquatic insect passage.
	Kuku Stream (32)	Moderate	Yes	Bridge	Negligible	Very Low	Positive	Net Gain	Bridge avoids fish passage impacts and will allow ample headspace for flying aquatic insect passage. An existing undersized farm crossing culvert will be removed.
	31	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	30	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	29 (Waikokopu Stream)	Moderate	Yes	Stream simulation	High	Moderate	Low	Low	Stream simulation culvert to be installed.
	28	Negligible	No	Diversion	No culvert	No effect	No culvert	No effect	Artificial ephemeral channel. A diversion at this site avoids the need for a culvert.

Catchment	Stream Name/Code	Freshwater Ecological Value	Fish Passage Required	Fish Passage Solution	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Effect AFTER effects management applied	Reasoning
Waikawa	27.1	Moderate	Yes	Stream simulation	High	Moderate	Low	Very Low	Stream simulation culvert to be installed.
	Waikawa Stream (27)	High	Yes	Bridge	Negligible	Very Low	Negligible	Very Low	Bridge avoids fish passage impacts and will allow ample headspace for flying aquatic insect passage.
	26	Negligible	No	Nil	No culvert	No effect	No culvert	No effect	Artificial ephemeral channel.
	25	No access – likely Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	23	Low	Yes	Stream simulation	High	Low	Positive	Net Gain	Replaces an existing perched culvert that is at least a partial barrier to fish passage.
	22	No access – likely Low	??	Stream simulation	High	Low	Low	Very Low	Site not surveyed but getting an embedded culvert.
	20	Negligible	Yes	Stream simulation	High	Low	Positive	Net Gain	Directly upstream of the ephemeral channel being lost, a small permanent stream was observed that disappears into a sump at the property boundary. The proposed culvert here will potentially improve connectivity and fish passage to the catchment upstream of the Ō2NL Project.
	19	Moderate	Yes	Stream simulation	High	Moderate	Low	Low	Stream simulation culvert to be installed.
	18.5	Negligible	No	Nil	No culvert	No effect	No culvert	No effect	Artificial ephemeral channel.
	18	Moderate	Yes	Stream simulation	High	Moderate	Low	Low	Stream simulation culvert to be installed.
	17	Moderate	Yes	Stream simulation	High	Moderate	Low	Low	Stream simulation culvert to be installed.
	Manakau Stream (15)	Moderate	Yes	Bridge	Negligible	Very Low	Negligible	Very Low	Bridge avoids fish passage impacts and will allow ample headspace for flying aquatic insect passage.

Catchment	Stream Name/Code	Freshwater Ecological Value	Fish Passage Required	Fish Passage Solution	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Effect AFTER effects management applied	Reasoning
	Waiauti Stream (14)	Moderate	Yes	Bridge	Negligible	Very Low	Negligible	Very Low	Bridge avoids fish passage impacts and will allow ample headspace for flying aquatic insect passage.
	13	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral channel.
	12	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral overland flow path with no defined channel.
Waitohu	11	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	10	Low	Yes	Diversion	No culvert	No effect	No culvert	No effect	Diversion to Stream 9 culvert.
	9	Negligible	Yes	Stream simulation	High	Very Low	Low	Very Low	Stream simulation culvert to be installed.
	8	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. No freshwater habitat upstream of proposed culvert.
	7	Negligible	Yes	Stream simulation	High	Very Low	Low	Very Low	Culvert in ephemeral channel downstream of permanent freshwater habitat (constructed farm dam) with shortfin tuna/eel potentially present.
	6.1	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. No freshwater habitat upstream of proposed culvert.
	6	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral channel. No freshwater habitat upstream of proposed culvert.
	5	Negligible	Yes	Stream simulation	High	Very Low	Low	Very Low	Culvert in ephemeral channel downstream of permanent freshwater habitat (constructed farm dam) with shortfin tuna/eel potentially present.
	4	Negligible	No	Nil	Negligible	Very Low	Negligible	Very Low	Ephemeral overland flow path with no defined channel. No freshwater habitat upstream of proposed culvert.
	3	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.

Catchment	Stream Name/Code	Freshwater Ecological Value	Fish Passage Required	Fish Passage Solution	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied	Overall Effect AFTER effects management applied	Reasoning
	2	Low	Yes	??	High	Low	Positive	Net Gain	Replacement culvert under existing SH1 with a more fish friendly solution.
	1	Low	Yes	Stream simulation	High	Low	Low	Very Low	Stream simulation culvert to be installed.
	0 (Greenwoods Stream)	No access – likely Low	Yes	Stream simulation	High	Low	Low	Very Low	Site not surveyed. Extension of new Peka Peka to Ōtaki culvert that is already in place.

Stormwater discharge effects on water quality and quantity

198. The stormwater management concept design is described in detail in the Stormwater Management Design report by Nick Keenan, included as an attachment to the DCR (Volume II, Appendix Four).

199. All stormwater originating from the road surface will be captured and treated prior to any discharge to the receiving environment. Constructed wetlands and wetland swales, which also have a detention function, will be constructed at locations close to the discharge locations.

200. Technical Assessment H (Water Quality) details the likely impacts of the Ō2NL Project on water quality of the receiving environment. It states:

> *"Overall, the Ō2NL Project will result in a net reduction in road related contaminants (TSS, Zn, Cu and TPH) entering waterways of all the major catchments (i.e. Waitohu, Manakau, Waikawa, Kuku, Ohau, Koputaroa) crossed by the route. This is because traffic will be shifted from the current SH1 and SH57 (which have no formal stormwater treatment), to the new road (which will have extensive stormwater treatment). Catchments B, L and P may have an increase in contaminant load of TPH, in part due to the small length of SH1 draining to the catchment relative to a larger length of the new road. The risk of adverse ecological effects is low for all catchments and contaminants, because the modelled concentration of contaminants in the stormwater discharges after treatment are within guideline values either at the point of discharge or after reasonable mixing."*

201. In the absence of any effects management, stormwater discharge would be expected to have a permanent, “High” magnitude of effect based on the EcIAG definitions (see Table K23 in Appendix K3). This would result from the ongoing discharges of road-derived contaminants (e.g., metals, hydrocarbons) to downstream waterways and connected wetlands. Some contaminants (e.g., zinc and copper) would likely increase in waterway sediments over time. Such contaminants are relatively low in waterways draining agricultural and native vegetation landscapes compared to those waterways that receive a large proportion of their runoff from roads and urban areas. In terms of level of effect in the absence of any effects management, based on the matrix approach of the EcIAG this would equate to:

(a) A “Very High” level of effect for those sites with “High” ecological value (i.e., Ohau River and Waikawa Stream);

(b) A “Moderate” level of effect for those sites with “Moderate” ecological value (i.e., Stream 39, Stream 39.1, Stream 29, Kuku Stream, Stream 27.1, Stream 19, Stream 18, Stream 17, Manakau Stream, Waiauti Stream);

(c) A “Low” level of effect for those sites with “Low” ecological value (i.e., all other permanent waterways); and

(d) A “Very Low” level of effect for those sites with “Negligible” ecological value (the ephemeral waterways).

202. Given the comprehensive stormwater capture, conveyance, and treatment system planned for the Ō2NL Project, it is expected a high level of treatment will be achieved. Based on the catchment modelling approach of Technical Assessment H (Water Quality), the magnitude of effect with such a stormwater treatment system in place, has been determined to be:

(a) Negligible for modelled catchments:

(i) P (includes Streams 42.3 (pond), 42.2 (pond), 42 (pond), 43, and 41);

(ii) O (includes Streams 40, 39, and 39.1);

(iii) M (Ohau River); J (Stream 27.1 and Waikawa Stream);

(iv) I (includes Streams 19, 20, 22, 23, and 25);

(v) F (Manakau Stream);

(vi) E (Waiauti Stream); and,

(vii) B (includes Streams 4, 3, and 1).

(b) Low for modelled catchments:

(i) L (Kuku Stream and Stream 31).

(c) Positive for modelled catchments:

(i) K (includes Streams 29 and 30);

(ii) H (Stream 18);

(iii) G (Stream 17);

(iv) D (Stream 11);

(v) C (includes Streams 10, 9, 8, 7, 6.1, 6, and 5); and,

(vi) A (Stream 0).

203. In terms of the overall level of effect based on the EcIAG matrix (see Table K24 in Appendix K3), this would equate to:

(a) A “Net Gain” for Streams 30, 29, 18, 17, 11, 10, and 0;

(b) A “Low” level of effect for Kuku Stream; and

(c) A “Very low” level of effect for all other sites not listed above.

204. Alteration of hydrology from the Ō2NL Project is likely to be of a “Low” or “Very Low” level of effect for all streams as a result of:

(a) Allowing passage of flows under the highway and discharge within the same catchment wherever practical and to follow the existing landform;

(b) Managing peak discharge from the main alignment to be equal to, or less than, existing flow rates;

(c) Managing flood risk upstream of the main alignment by allowing for sufficient flow area under the carriageway; and

(d) Protecting stream beds and banks from scour and erosion.

Freshwater habitat loss and modification

205. The Ō2NL Project involves the unavoidable, permanent loss and modification of existing stream habitats via culvert installation and stream reclamation. Stream loss details of permanently flowing waterways are shown in Table K17. The loss of open water bodies (i.e., Stream 42.3 and Stream 42) are covered in the wetland loss calculations of Technical Assessment J (Terrestrial Ecology) and not accounted for here.

206. The Ō2NL Project will generate spoil that will require disposal. Spoil disposal site locations were subject to a multi-criteria assessment (MCA) process to manage and minimise effects, which is documented in Volume II of the application. Selected spoil sites are all at least 20 metres from

waterways, hence there will be no direct adverse effects on freshwater habitats, provided adequate erosion and sediment controls are utilised.

207. Material supply sites have been identified, to provide suitable bulk earth fill for construction of road and bridge embankments. The selection of these sites were subject to an assessment process to manage and minimise effects, which is documented in Volume II of the application. None of the proposed material supply sites have a direct adverse impact on a permanent stream (that is, directly disturb any existing stream channel). There are, however, some locations where material supply sites do come close of permanent streams or ponds:

(a) “Site 34A Koputaroa” is within 20 m of a pond created by a farm dam (Stream 41) and associated upstream wetland.

(b) “Site 19 North (East) of Waikawa Stream” (chainage 26100) and “Site 19 North (West) of Waikawa Stream” (chainage 26250) each come within 20 m of Stream 27.1.

208. The adverse effects of material supply sites on any adjacent waterways will be avoided and minimised by utilising appropriate erosion and sediment controls. Further, the rehabilitation of the material supply sites will involve revegetation and where conditions allow, creation of wetland habitats as described in Volume II of the application.

209. The Project also includes the construction of stormwater treatment facilities which will have discharge outlets to nearby waterways. These will include outlet structures that include erosion protection features that may have adverse effects on existing stream channels (see drawing 310203848-01-300-C9600). The exact designs will not be determined until the detailed design phase, which will take into account the site-specific characteristics of each outlet location and determine how best to integrate this with the existing stream channel. At some locations it may be feasible to mitigate or remedy any adverse effects by enhancing the physical habitat of modified and degraded channels (e.g., creating stable, deeper pool habitats), while other sites may require offsetting. Any such sites requiring offset will be picked up in the stream offsetting recalculation/review that is to occur once detailed design is confirmed.

210. Calculations based on the concept design GIS information indicate that for permanently flowing streams:

(a) A total of 3,108 m of existing permanent stream length will be lost;

(b) A total of 1,261 m of culverts will be installed; and

(c) A total of at least 1,592 m of permanently flowing open diversion channel will be constructed within the designation.

211. For the permanent culverting and reclamation of stream channels, the magnitude of effect involves “total loss” and “very major alteration” and is deemed to be “Very High” based on the EcIAG definitions (see Table K23 in Appendix K3). In the absence of any effects management actions, this equates to either a “Moderate” or “High” overall level of effect based on the EcIAG matrix (see Table K24 in Appendix K3).

212. The permanent loss of open stream habitat through culverting and reclamation cannot be mitigated or remedied at the site of impact as that location is either filled in or enclosed in a culvert. However, the construction of diversion channels at some locations will act to minimise the loss of open stream habitat. The residual adverse effects need to be addressed via offsetting or compensation.

213. The appropriate offsetting quanta to ensure no net loss was determined using ECR’s derived from the SEV scores of impact sites and rehabilitation/restoration sites. Culvert and diversion channels have also been included in these calculations.

214. A generic design of the proposed diversion channels is shown in Figure K5 and some indicative images from another project in Figure K6. In practice, diversion channels will be designed to seamlessly integrate with the stream channel morphology of the existing channel to which they connect upstream and downstream. All diversion channels will be designed to maximise their ecological potential and provide habitats for key local species such as shortfin tuna. Within the constraints of channel gradient and length, diversion channels will be designed to have high habitat variability and where possible include deep pools, stable woody debris as fish and invertebrate habitat, faster flowing sections (runs and riffles), and larger emergent boulders to facilitate oviposition by some macroinvertebrate species. At some lower gradient locations, it may be more appropriate to create linear wetland-type environments. All diversion channels will have permanent fencing where required to exclude stock and have riparian margins planted with appropriate vegetation. Indicative riparian planting

widths are shown on Table K17 and also depicted on the planting concept plans. At some sites the diversion channel riparian planting is integrated and continuous with plantings at adjacent offsetting sites (that are centred on the existing stream channel) and landscape plantings.

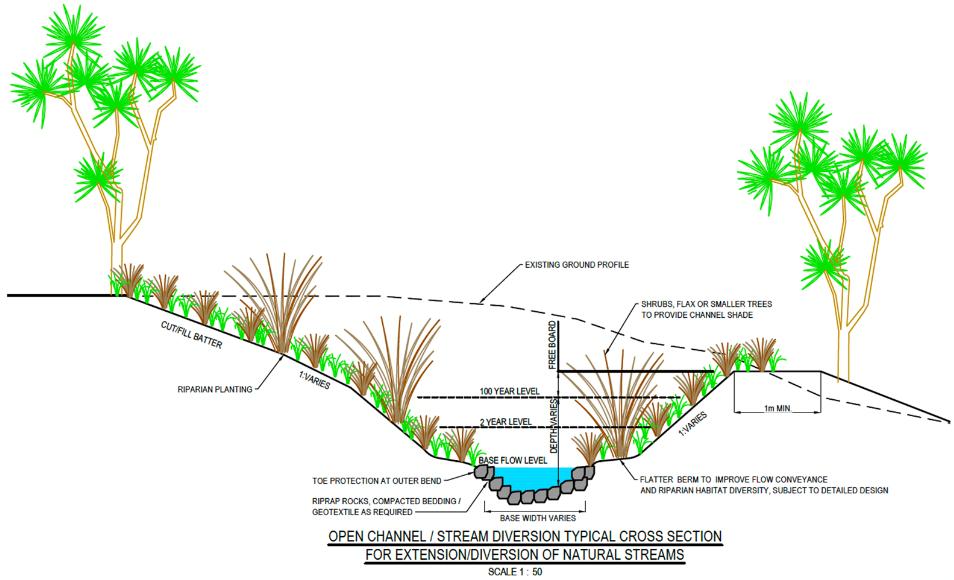


Figure K5 Indicative constructed stream diversion channel cross section from drawing 310203848-01-300-C9100.

A. Huntly Bypass diversion shortly after livening in 2016. Photo taken by Keith Hamill, River Lake.	B. Huntly Bypass diversion in 2019, approximately 3 years after construction. Photo taken by Keith Hamill, River Lake.

Figure K6 Examples of permanent stream diversion channels created during highway construction projects.

215. The selection of potential stream offsetting sites was an iterative process and is detailed in paragraph 76.

216. The main proposed freshwater ecology offsetting activity will involve stream rehabilitation/restoration via fencing and riparian planting of degraded agricultural streams within the catchments impacted by the Ō2NL Project, supplemented by constructing diversion channels in a manner that maximises their ecological potential. Proposed performance standards for riparian plantings are shown in the proposed conditions in Appendix Six of the application.

217. The proposed locations of stream biodiversity offsetting are concentrated in the following areas (subject to landowner agreements):

(a) Waiauti Stream, Waiauti Stream tributaries, and Manakau Stream (see Planting Concept Plan Sheet 15; drawing number 310203848-01-700-C1014). This offsetting site includes several landowners, including properties already owned by Waka Kotahi. This location was chosen as the streams are generally unfenced with full stock access and would benefit greatly from stock exclusion and riparian revegetation. Additionally, by starting with the Waka Kotahi property as a core area we have been able to extend the offsetting site upstream and downstream of Ō2NL, to encompass several "lifestyle" properties and a larger farmed property. Initial discussions with landowners has indicated they are generally pleased to be part of a larger stream fencing and revegetation project.

(b) Kuku Stream within designation (see Planting Concept Plan Sheet 10-11; drawing number 310203848-01-700-C1009 and C1010). This offsetting site is directly upstream and downstream of the Ō2NL Kuku Stream bridge site on land that will be acquired by Waka Kotahi for the project. The Kuku Stream is a small gravel bed river that will benefit greatly from fencing and revegetation.

(c) Stream 27.1 and tributaries (Waikawa Stream catchment; see Planting Concept Plan Sheet 12; drawing number 310203848-01-700-C1011). This offsetting includes a section of Stream 27.1 directly upstream of the Ō2NL designation boundary that is continuous with other riparian plantings, plus sections of tributary streams further upstream. All sites are on property owned by the Martin family.

(d) Kuku Stream downstream of the existing SH1 through several private properties, including one location where riparian planting will be directly adjacent am existing forest remnant (see Planting Concept Plan Sheet 11; drawing number 310203848-01-700-C1010).

218. Due to the Stock Exclusion Regulations and varying land uses, offset site SEV scores (SEVm-C (current) and SEVm-P (potential)) were generated individually for each property as described in paragraphs 75 and 77 and detailed in Table K28 in Appendix K6.

219. The proposed stream biodiversity offsetting response has been assessed as meeting the eleven biodiversity offsetting principles of the "Biodiversity offsetting under the RMA" guidance document:[57]

(a) Limits to offsetting: While there is some permanent loss of overall stream length, this can be offset by the fencing and revegetation of agricultural streams. Compared to many other habitats that are considered irreplaceable (e.g., old growth forest, many wetland types) and hence cannot be effectively offset, streams are dynamic habitats that are regularly subject to flood disturbance and channel migration (i.e., the sinuous Waiauti Stream and Manakau Stream naturally lose stream length when meanders are cut off by channel erosion). As such their fauna and flora are adapted to cope with regular disturbance and are generally quick to colonise disturbed or new habitats such as permanent diversion channels. Therefore compared to, for example, an old growth forest that takes centuries to develop or a wetland that relies on very particular hydrological characteristics, stream habitats are not irreplaceable.

(b) No-net-loss and preferably a net-gain: The use of the SEV ECR methodology has ensured no-net-loss, while in practice due to the practicalities of stream fencing (i.e., completing fencing to meet existing fence lines) a greater area is likely to be fenced and planted than strictly required by SEV ECR calculations. This will result in a net-gain situation.

(c) Landscape context: The stream biodiversity offsets have been concentrated to achieve fencing and revegetation of long, continuous sections of stream. All offset sites were located within catchments directly affected by the Ō2NL Project. In the Waiauti Stream, the offsetting reaches directly adjoin the diversion channels that will be created. A few long, continuous sections of riparian fencing and planting are likely to have greater ecological benefits than if the same effort was spread over numerous, smaller sites.

(d) Additionality: The current and potential SEV scores used to generate ECRs have specifically taken into account the Stock Exclusion Regulations to ensure this principle is met. Therefore, gains that 'would have occurred anyway' are not counted towards the offset.

[57] Maysek *et al.* (2018).

(e) Permanence: Appropriate legal protections will be attached to all fenced and planted areas. These will ensure that future landowners are bound to the agreements reached with current landowners.

(f) Ecological equivalence: The habitat being improved (small streams) is ecologically equivalent to the habitat being adversely impacted.

(g) Adherence to the mitigation hierarchy: Stream biodiversity offsets are only being applied for unavoidable, residual effects that exist after consideration of avoidance, remedy, and mitigation actions.

(h) Stakeholder participation: Through ecology and project workshops, stakeholders and partners have been given the opportunity to participate in the stream offsetting process. Comments from stakeholders and project partners have been supportive of the proposed stream offsetting at these workshops. In particular, the offsetting in the Waiauti Stream and Manakau Stream have been noted as being in the Waikawa Stream catchments, which is a Horizons priority catchment. The Project's iwi partners have been generally supportive of the proposed stream rehabilitation.

(i) Transparency: Offsetting has been discussed at community workshops, and the public will have the ability to comment further as the Project progresses through the statutory approval process. Further, the extent of stream offsetting required has been determined by an accepted and clear methodology (SEV ECRs), the outputs of which were provided to stakeholders and project partners.

(j) Science and traditional knowledge: The stream offsetting process is driven by the scientific-basis of the SEV methodology. The Project's iwi partners have contributed to the process and the proposed offsetting package, via input at ecology workshops. The rehabilitation of streams is of particular interest to our Iwi Partners. Additionally, offsetting is proposed on Maori-owned freehold land along the Kuku Stream.

(k) Equity: The stream biodiversity offsetting includes sites situated in two of the main catchments crossed by the proposed designation (Ohau and Waikawa). Agreements between Waka Kotahi and private landowners will need to address equity related to responsibilities around long-term maintenance of offsetting sites. Waka Kotahi will undertake the fencing and planting, and then maintain for an establishment period of a minimum of 5 years or until 80% canopy cover is achieved as per the performance standards for riparian plantings shown in the proposed consent conditions in Appendix Six of the application. After this establishment period, landowners will take over management and maintenance of planted areas.

220. When offsetting to achieve no-net-loss (including the construction of diversion channels) is taken into account, the magnitude of effect is reduced from “Very High” to “Negligible” and potentially “Positive”. This equates to either a “Very Low” to “Net Gain” overall level of effect based on the EcIAG matrix (see Table K18 included in this report and Table K24 in Appendix K3). The confirmed area of stream habitat to offset via fencing and riparian planting based on the current concept design and proposed offsetting sites of the Ō2NL Project is 17,380 m^2. The strict area of stream habitat requiring offsetting before correcting for the channel widths differences between impact and offset sites as calculated with SEV ECR’s was 9,419 m^2. A further 2,179 m^2 of stream habitat will be created within permanent stream diversions. Hence, the proposed stream offsetting will achieve a "net gain" in stream functioning.

221. All proposed offsetting details outlined in Table K17 are based on the current concept design. It is highly likely key design elements that affect offsetting calculations such as culvert length, diversion channel length, and the extent of stream loss will change during the detailed design phase. As such all stream offsetting calculations will be reconfirmed and altered as necessary once the final design is confirmed. At the time of lodgement some offsetting sites are yet to be confirmed and SEV yet to be undertaken from representative sections. Hence Table K17 provides the best estimate of offset location details at the time of lodgement. Based on the length and area of stream habitat suitable for offsetting in the catchments affected by Ō2NL, I am confident there is sufficient stream available to offset the final design.

Table K17 Indicative concept design site-by-site assessment of freshwater habitat loss and modification by culvert installation and channel reclamation in permanent stream sites along the proposed designation, environmental compensation ratios (ECRs), and proposed offset measures. The proposed offset measures will be reconfirmed and altered as necessary once the final design is confirmed.

Only those waterways that meet the RMA definition of "river" are included here.

Catchment	Stream Code/Name (Ecological Value)	Total channel loss linear length (m): area (m^2)	Diversion channel linear length (m): area (m^2)	Diversion channel ECR	Culvert linear length (m): area (m^2)	Culvert ECR	Residual effects area (m^2)	Residual effects ECR	Proposed offset measures
Koputaroa	43 (Low)	0	NA	NA	NA	NA	NA	NA	NA
	40 (Low)	150:151.5	98: 98.98	1.5	70: 70.7	1.74	0	NA	98 m long (99 m^2 area) diversion channel in Stream 40 with approximately 7 to 12 m wide riparian planting; 171 m long (321 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a 20 m width.
	39/Waitaiki Stream (Moderate)	85: 160.74	19: 35.93	1.5	71: 134.26	1.68	0	NA	19 m long (36 m^2 area) diversion channel in Stream 39 with approximately 10 m wide riparian planting; 130 m long (244 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a 20 m width.
	39.1/Waitaiki Stream (Moderate)	258: 364	228: 321.7	1.5	NA	NA	42.3	4.5	228 m long (322 m^2 area) diversion channel in Stream 39.1 with approximately 10 to 20 m wide riparian planting; 249 m long (578 m^2 area) stream rehabilitation via fencing and riparian planting in Waiauti Stream to a 20 m width.
Ohau	33/Ohau River (High)	0	NA	NA	NA	NA	0	NA	None
	32/Kuku Stream (Moderate)	0	NA	NA	NA	NA	0	NA	None
	31 (Low)	194: 398.7	101: 207.56	1.5	74: 152.07	2.52	39	5	101 m long (208 m^2 area) diversion channel in Stream 31 with approximately 7 to 20 m wide riparian planting; 187 m long (581 m^2 area) stream rehabilitation via fencing and riparian planting in Waiauti Stream and Manakau Stream to a width of 5 to 20 m.
	30 (Low)	82: 47.2	NA	NA	75: 43.2	3.18	4	5.7	279 m long (499 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream and tributary of Waiauti Stream to a width of 5 to 20 m.

Catchment	Stream Code/Name (Ecological Value)	Total channel loss linear length (m): area (m^2)	Diversion channel linear length (m): area (m^2)	Diversion channel ECR	Culvert linear length (m): area (m^2)	Culvert ECR	Residual effects area (m^2)	Residual effects ECR	Proposed offset measures
	29/Waikokopu Stream (Moderate)	162: 149	104: 95.7	1.5	71: 65.32	2.1	0	NA	104 m long (96 m^2 area) diversion channel in Stream 29 with approximately 20 m wide riparian planting; 201 m long (378 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a width of 5 to 20 m.
Waikawa	27.1 (Moderate)	123: 159.3	17: 22.02	1.5	82: 106.19	2.46	31.1	10.67	17 m long (22 m^2 area) diversion channel in Stream 27.1 with approximately 20 m wide riparian planting; 466 m long (989 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to 20 m width and Waiauti Stream to a width of 3 to 10 m.
	27/Waikawa Stream (High)	0	NA	NA	NA	NA	NA	NA	None
	25 (No access – likely Low)	207:207	186: 186	1.5	74: 74	2.34	0	NA	186 m long (186 m^2 area) diversion channel in Stream 25 with approximately 3 to 20 m wide riparian planting; 266 m long (500 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a width of 5 to 20 m.
	23 (Low)	92: 50.8	NA	NA	77: 42.5	2.34	8.3	3.72	180 m long (339 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a width of 5 to 20 m. 56 m long (174 m^2 area) stream rehabilitation via fencing and riparian planting to a width of 5 to 20 m in Manakau Stream.
	22 (No access – likely Low)	109: 54.5	26: 13	1.5	78: 39	2.34	2.5	5.17	26 m long (13 m^2 area) diversion channel in Stream 22 with approximately 7 to 20 m wide riparian planting; 196 m long (368 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to 5 to 20 m width; 26 m long (26 m^2 area) in Waiauti Stream tributaries to a width of 3 to 20 m.
	19 (Moderate)	94: 41.4	4: 1.76	1.5	76: 33.44	2.7	6.2	5.67	4 m long (1.8 m^2 area) diversion channel in Stream 19 with approximately 10 m wide riparian planting; 207 m long (390 m^2 area) stream rehabilitation via fencing and riparian planting in Kuku Stream to 5 to 20 m width; 79 m long (184 m^2 area) in Waiauti Stream to a width of 20 m.
	18 (Moderate)	125: 126.3	40: 40.4	1.5	81: 81.81	3.58	4	5.5	40 m long (40.4 m^2 area) diversion channel in Stream 18 with approximately 5 to 20 m wide riparian planting; 332 m

Catchment	Stream Code/Name (Ecological Value)	Total channel loss linear length (m): area (m²)	Diversion channel linear length (m): area (m²)	Diversion channel ECR	Culvert linear length (m): area (m²)	Culvert ECR	Residual effects area (m²)	Residual effects ECR	Proposed offset measures
									long (771 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream to a width of 8 to 20 m.
	17 (Moderate)	95: 93	16: 15.7	1.5	74: 72.45	6.33	4.9	5.08	16 m long (15.7 m² area) diversion channel in Stream 17 with approximately 10 to 20 m wide riparian planting; 502 m long (1,165 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream to a width of 8 to 20 m.
	15/Manakau Stream (Moderate)	127: 395	58: 180.4	1.5	NA	NA	214.6	6.32	58 m long (180.4 m² area) diversion channel in Manakau Stream with approximately 10 m wide riparian planting although much of this diversion is under the Ō2NL bridge and is which is continuous with stream offset planting; 465 m long (1445 m² area) stream rehabilitation via fencing and riparian planting in Manakau Stream to a width of 5 to 20 m.
	14/Waiauti Stream (Moderate)	355: 823.6	230: 533.6	1.5	NA	NA	359.6	4.08	230 m long (533.6 m² area) diversion channel in Waiauti Stream with approximately 5 to 20 m wide riparian planting which is continuous with stream offset planting; 747 m long (2308 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream and Manakau Stream to a width of 5 to 20 m.
Waitohu	11 (Low)	68: 44.1	NA	NA	67: 43.42	10.93	0.6	15.86	748 m long (969 m² area) stream rehabilitation via fencing and riparian planting in Stream 27.1 to a width of 3 to 5 m.
	10 (Low)	255: 168.3	270: 178.2	1.5	55: 36.29	3.17	2	4.58	270 m long (178.2 m² area) diversion channel in Stream 10 with approximately 4 to 20 m wide riparian planting; 309 m long (717 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream to a width of 20 m.
	3 (Low)	77: 197.1	NA	NA	62: 158.96	2.64	0	4.02	305 m long (573 m² area) stream rehabilitation via fencing and riparian planting in Kuku Stream to a width of 5 to 20 m.
	2 (Low)	36: 92.2	30: 76.8	1.5	64: 164.84	NA – replacement of existing culvert	15.4	5.03	30 m long (77 m² area) diversion channel in Stream 2 with approximately 5 to 20 m wide riparian planting; 91 m long (115 m² area) stream rehabilitation via fencing and riparian

Catchment	Stream Code/Name (Ecological Value)	Total channel loss linear length (m): area (m²)	Diversion channel linear length (m): area (m²)	Diversion channel ECR	Culvert linear length (m): area (m²)	Culvert ECR	Residual effects area (m²)	Residual effects ECR	Proposed offset measures
									planting in Waiauti Stream tributaries to a width of 3 to 20 m.
	1 (Low)	302: 314.1	165: 171.6	1.5	61: 62.95	2.5	79.5	4.42	165 m long (172 m² area) diversion channel in Stream 1 with approximately 5 to 20 m wide riparian planting; 572 m long (1326 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream to a width of 20 m.
	0/Greenwoods Stream (No access – likely Low)	112: 112	NA	NA	49: 48.85	3.21	63.1	3.98	408 m long (475 m² area) stream rehabilitation via fencing and riparian planting in Waiauti Stream tributaries to a width of 3 to 20 m.

Table K18 Site-by-site assessment of freshwater habitat loss and modification by culvert installation and channel reclamation in permanent stream sites along the proposed designation.

Catchment	Stream Name/Code	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied including offsetting	Overall Effect AFTER effects management applied
Koputaroa	43	Low	No loss	No effect	NA	No effect
	40	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	39 (Waitaiki Stream)	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	39.1 (Waitaiki Stream)	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
Ohau	Ohau River (33)	High	No loss	No effect	NA	No effect
	Kuku Stream (32)	Moderate	No loss	No effect	NA	No effect
	31	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	30	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	29 (Waikokopu Stream)	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
Waikawa	27.1	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	Waikawa Stream (27)	High	No loss	No effect	NA	No effect
	25	No access – likely Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	23	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	22	No access – likely Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	19	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	18	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	17	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	Manakau Stream (15)	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
	Waiauti Stream (14)	Moderate	Very High	High	Negligible to Positive	Very Low to Net Gain
Waitohu	11	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain

Catchment	Stream Name/Code	Freshwater Ecological Value	Effect Magnitude in ABSENCE of effects management	Overall Effect in ABSENCE of effects management	Effect Magnitude AFTER effects management applied including offsetting	Overall Effect AFTER effects management applied
	10	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	3	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	2	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	1	Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain
	0 (Greenwoods Stream)	No access – likely Low	Very High	Moderate	Negligible to Positive	Very Low to Net Gain

Light Pollution

222. Artificial lighting can confuse various biota including birds, insects, fish, reptiles and frogs. A Royal Commission on environmental pollution concluded that "*Given the effects of light on living organisms, it is plausible, and even probable, that introduction of artificial light into the natural light regime will disturb the normal routines of many plants and animals.*" (The Royal Commission on Environmental Pollution, 2009).[58]

223. For night flying insects (including winged adult aquatic insects) such lights can have a synergistic effect with the asphalt road surface to create what appears to be a waterway (Longcore & Rich, 2004;[59] Horvath *et al*., 2009).[60] Mayflies, caddisflies, stoneflies, and other aquatic insects have been observed treating asphalt surfaces as waterways and in some instances actually laying eggs on road surfaces (Horvath *et al*., 2009). This can have serious implications for some species when such behaviour decreases population viability as reproductive success is diminished.

224. The Ō2NL Project avoids significant ecological light pollution as road lighting will:

(a) be installed only at conflict points (i.e., where traffic can enter or exit the highway); and

(b) meet the Waka Kotahi M30 Specification for Road Lighting and AS/NZS 1158 and light spill mitigation will be consistent with this specification.

225. There are four conflict points where lighting will be installed:

(a) A roundabout at the northern end linking to the existing SH1 and Heatherlea East Road (chainage 10300). There are no stream sites near this location.

(b) A roundabout linking Ō2NL to SH57 (chainage 13100). Stream 39 and 39.1 are within approximately 200 m of the centre of this roundabout, so have the potential to be impacted by increased artificial lighting in the area.

---

[58] The Royal Commission on Environmental Pollution 2009. Artificial light in the environment. Pp. 48.
[59] Longcore, T. & Rich, C. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2(4): 191–198.
[60] Horvath, G., Kriska, G., Malik, P., Robertson, B. & G, H. 2009. Polarized light pollution: a new kind of ecological photo pollution. Frontiers in Ecology and the Environment 7(6): 317–325.

(c) An interchange at Tararua Rd (chainage 18200). There are no stream sites near this location.

(d) An interchange near the southern end linking to the existing SH1 (chainage 34100). This is very close to Stream 1 and Stream 3.

226. The four streams in relatively close proximity to new Ō2NL Project artificial lighting have all been deemed to be either "Low" (Stream 1, Stream 3) or "Moderate" (Stream 39, Stream 39.1) ecological value. They have aquatic macroinvertebrate communities dominated by non-insect taxa that do not have flying adult stages (for example, snails, crustaceans) so will not be overly disturbed by the lighting. However, this artificial light at night could impact the natural behaviour of nocturnal fish such as eel/tuna. In the absence of any effects management, a "Moderate" magnitude of effect based on the EcIAG definitions (see Table K23 in Appendix K3) is likely. For the "Low" ecological value streams, this would equate to a "Low" overall level of effect based on the EcIAG matrix. For the "Moderate" ecological value streams, this would equate to a "Moderate" overall level of effect based on the EcIAG matrix (see Table K24 in Appendix K3).

227. The streams with "High" or "Moderate" ecological value, some of which have a very high proportions of aquatic macroinvertebrates with a flying adult stage, are all far away from any locations that are to be artificially lit by the Ō2NL Project. They will thus, retain their current darkness (with the exception of vehicular lights).

228. Aspects of the Ō2NL Project design will mitigate the adverse light pollution effects via:

(a) The riparian planting of all streams in the immediate vicinity of the road, including the four streams in close proximity to artificial lighting. Once a closed canopy is achieved, very little light will reach the stream surface.

(b) Adhering to the Waka Kotahi M30 Specification for Road Lighting and AS/NZS 1158, which has strict specifications for minimising light spill into the surrounding environment.

229. Other factors that should be considered to further reduce adverse effects of light include:

(a) Avoidance of lights that emit a broad spectrum of light with a high UV component (Bruce-White & Shardlow, 2011).[61]

(b) It is preferable to use lighting that produce light at one wavelength, but emit no UV (e.g., narrow spectrum LEDs) (Bruce-White & Shardlow, 2011).

230. With appropriate mitigation, the adverse effects of artificial lighting installed by the Ō2NL Project, will be reduced to a "Low" magnitude of effect, and an overall "Low" and "Very Low" level of effect for those four stream sites in close proximity to said lighting. There will be no effect on all other stream sites.

POTENTIAL EFFECTS OF TOLLING ON THE Ō2NL PROJECT

231. The effect of tolling on traffic volumes on each section of Ō2NL are detailed in the traffic assessment (Technical Assessment A). Changes in the relative volumes of traffic using Ō2NL and the current SH1 have the potential to alter the surface water quality effects assessment (Technical Assessment H). A greater volume of traffic continuing to use the existing SH1 to avoid tolls once Ō2NL is operational, would reduce the overall treatment of stormwater-borne contaminants from traffic along the route.

232. The surface water quality assessment (Technical Assessment H – Water Quality) has assessed the effect of tolling by running the contaminant load model (CLM) with revised traffic volumes based on a tolled scenario. That assessment has concluded: "*Overall, the tolled scenario of the Ō2NL Project will result in a net reduction in road related contaminants (TSS, Zn, Cu and TPH) entering waterways of all the major catchments (i.e. Waitohu, Manakau, Waikawa, Ohau, Koputaroa) crossed by the route. Catchment P may have an increase in contaminant load of TPH, but the risk of adverse ecological effects from changes in stormwater quality is low for all catchments and contaminants.*"

233. Based on the conclusions regarding tolling from the surface water quality assessment (Technical Assessment H – Water Quality), I conclude that tolling on Ō2NL would have no measurable adverse effect on freshwater ecology.

[61] Bruce-White, C. & Shardlow, M. 2011. A review of the impact of artificial light on invertebrates. Buglife – The Invertebrate Conservation Trust. 33 p.

SUMMARY OF EFFECTS AND CONCLUSION

234. To summarise, the Ō2NL Project will have adverse effects on freshwater habitats. These adverse effects have been appropriately avoided, minimised, remedied, mitigated, or offset.

235. Table K19 provides a summary of:

(a) The effect management actions for each construction-phase and operational-phase effect; and

(b) The overall level of effect assuming the effects management actions are applied.

Table K19 An overall summary of effects ratings and effects management actions relating to the impacts of the Ō2NL Project on freshwater ecology.

Activity/Effect	Effects Management Actions	Overall Effect AFTER effects management applied
Construction Phase Effects		
Freshwater habitat disturbance (actual, unavoidable, temporary adverse effect)	• Fish (including kōura and kākahi) salvage and relocation to be undertaken at all sites with surface water as per methods and protocols outlined in the EMP.	Stream 39, Stream 39.1, Stream 29, Stream 27.1, Stream 19, Stream 18, Stream 17, Ohau River, Manakau Stream, Waiauti Stream: Low All other sites: Very Low
Fish migration disturbance (potential, avoidable, temporary adverse effect)	• Avoid where practical, any instream works or diversion at key migration times of the fish species known to be present at a site. The EMP will include site-specific guidance based on fish known to be present. • Ensure fish passage is possible through all temporary diversion pipes and open channels.	Stream 27.1, Stream 19, Stream 18, Stream 17, Manakau Stream, Waiauti Stream 2: Low All other sites: Very Low
Release and subsequent deposition of fine sediments (actual, avoidable, temporary adverse effect)	• Implementation of an ESCP tailored to the soil types and topography of the Ō2NL Project area. • Wherever possible undertaking works in streams and wetlands offline (i.e., in the dry). • Include baseline, construction phase, and post-construction deposited fine sediment monitoring as part of an aquatic ecology monitoring programme (to be outlined in an EMP – refer conditions Appendix Seven to Volume II).	Stream 17 and Stream 19: Moderate (but temporary and reversible) All other sites: Low or Very Low
Water contamination (actual, avoidable, temporary adverse effect)	• Ensure a high level of vehicle maintenance and cleanliness; • Avoid, where practical, machinery from tracking/driving in flowing water; • Ensure all refuelling is undertaken well away from waterways; • Ensure all fuels and other construction liquids are stored in appropriately bunded locations; • Ensure spill kits are in close proximity to all machinery and staff are trained in how to use them properly in the environments to be encountered in the Ō2NL Project; • Isolate from flowing water, all works areas that will require the pouring of wet concrete and/or usage of mortars and grouts by either undertaking construction offline or the use of temporary diversions; • Ensure all mortars and grouts used in culverts are suitable for use in such situations, and they are fully cured according to manufacturer's instructions prior to contact with flowing water.	Stream 39, Stream 39.1, Ohau River , Kuku Stream, Stream 29, Stream 27.1, Stream 19, Stream 18, Stream 17, Waikawa Stream, Waiauti Stream, and Manakau Stream: Low All other sites: Very Low

Activity/Effect	Effects Management Actions	Overall Effect AFTER effects management applied
Water abstraction	• Construct storage ponds and replenish at low instantaneous abstraction rates. • Only take water from existing available allocations and use minimum flow levels defined in the relevant Regional Plan for each watercourse as the flow level at which any abstraction must cease. • All intakes to have 2-3 mm screens to avoid fish from entering pumps.	
Operational Effects		
Reduction in free movement of aquatic fauna through the Ō2NL highway (fish and flying adult aquatic insects) **(actual, avoidable, permanent adverse effect)**	• Bridges are proposed for all the major fish migration pathways and streams with high proportion of macroinvertebrates with flying adult stages (Ohau River, Kuku Stream, Waikawa Stream, Manakau Stream, Waiauti Stream). • All culverts in permanent streams are designed following the stream simulation methodology, such that fish passage will be retained. • Several culverts in ephemeral waterways will incorporate fish passage features to allow fish (mostly shortfin tuna/eel) to continue accessing constructed ponds and dams upstream of the Ō2NL Project Area. • Post-construction fish passage assessment and monitoring to be included in the EMP (refer conditions Appendix Seven to Volume II).	Bridge sites: No effect Stream 2, Stream 20, Stream 23, Kuku Stream: Net Gain All other sites: Low to Very Low
Stormwater discharges (quality and quantity) **(actual, avoidable, permanent adverse effect)**	• All stormwater from the road surface will be captured and discharged either via infiltration (smaller rain events) or conveyed to constructed ponds and wetlands (large rain events). Hence contaminants will be minimised via a high level of treatment prior to any discharge to surface waterways.	Stream 30, Stream 29, Stream 18, Stream 11, Stream 0: Net Gain All other sites: Low to Very Low
Freshwater habitat loss and modification (actual, unavoidable, permanent adverse effect)	• Minimise via reducing length of culverts as much as practical and using fish friendly, stream simulation culvert design as a default. • Offset residual adverse effects through creation of diversion channels within the Ō2NL Project Area to minimise overall channel loss, stream rehabilitation/enhancement via fencing and riparian planting in the Waiauti Stream, Manakau Stream, Kuku Stream, and Stream 27.1 (a tributary of Waikawa Stream).	No Net Loss to Net Gain once offsetting and diversion channel creation taken into account.
Light pollution **(actual, avoidable, permanent adverse effect)**	• Artificial lighting of the landscape by the Ō2NL Project is largely avoided by only installing lighting at conflict points (where traffic enters/exits Ō2NL). Only four stream sites are in close proximity to such locations. • Streams will undergo riparian planting, which once established will shade stream surface from artificial light at night. • Lighting design will follow the Waka Kotahi M30 Specification for Road Lighting and AS/NZS 1158, which has strict specifications for minimising light spill into the surrounding environment.	Stream 39, Stream 39.1: Low Stream 1, Stream 3: Very Low All other sites: No effect

236. A key aspect of ensuring the freshwater ecology effects management actions are adequately implemented will be the preparation of, and implementation of, an EMP that details:

(a) Fish salvage protocols and methodologies;

(b) Site-specific guidance of fish migration times;

(c) An aquatic ecology monitoring programme that collects fine sediment (suspended and deposited) and macroinvertebrate community data before, during, and after construction; and

(d) Post-construction measurement and monitoring of fish passage parameters at culverts.

237. On this basis it is concluded that the actual and potential adverse effects of the Ō2NL Project on freshwater ecology as assessed by the EcIAG have been either avoided, mitigated, or offset (to achieve "No Net Loss" or "Net Gain") to an acceptable level via the effects management actions described in this assessment.

Dr Alex James

11 October 2022

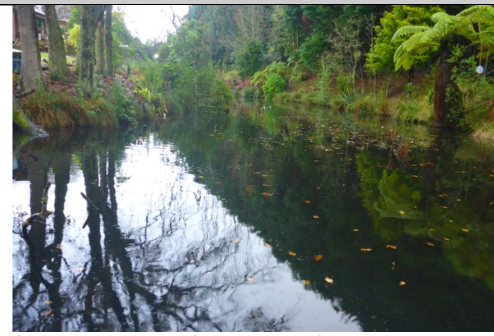
APPENDIX K1: WATERWAY DEFINITIONS APPLIED TO THE Ō2NL PROJECT

Table K20 Stream-type classification and definition from the Auckland Unitary Plan (Operative in part).

Stream-type Classification	**Auckland Unitary Plan Operative in Part definition**
River or stream	A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).
Permanent river or stream	The continually flowing reaches of any river or stream.
Intermittent stream	Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria: a) it has natural pools; b) it has a well-defined channel, such that the bed and banks can be distinguished; c) it contains surface water more than 48 hours after a rain event which results in stream flow; d) rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel; e) organic debris resulting from flood can be seen on the floodplain; or f) there is evidence of substrate sorting process, including scour and deposition.
Ephemeral stream	Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.
Artificial watercourse	Constructed watercourses that contain no natural portions from their confluence with a river or stream to their headwaters. Includes: • canals that supply water to electricity power generation plants; • farm drainage canals; • irrigation canals; and • water supply races. Excludes: • naturally occurring watercourses.

APPENDIX K2: SITE PHOTOS

Table K21 Representative photos of site visited during the Ō2NL freshwater ecology survey between March and November 2021.

Koputaroa catchment	
 Stream 42.3 - pond (24 June 2021)	 Stream 42.2 - pond (18 June 2021)
 Stream 42 - pond (29 April 2021)	 Stream 43 (19 May 2021)
 Stream 41 - pond (12 May 2021)	 Stream 40 (19 May 2021)
 Stream 39 (Waitaiki Stream) (12 March 2021)	 Stream 39.1 (Waitaiki Stream) (12 March 2021)

Koputaroa catchment	Punahau/Lake Horowhenua **catchment**
 Stream 39.2 (12 March 2021)	 Stream 37 (Waimarie Stream) (29 April 2021)
Ohau catchment	
 Stream 35.4 (29 April 2021)	 Stream 35.1 (11 May 2021)
 Stream 34.5 (29 April 2021)	 Stream 34 (19 May 2021)
 Ohau River (28 May 2021)	 Kuku Stream (20 May 2021)

Ohau catchment	
 Stream 31 (1 July 2021)	 Stream 30 (28 April 2021)
 Stream 29 (12 November 2021)	 Stream 28 (16 April 2021)
Waikawa catchment	
 Stream 27.1 (28 April 2021)	 Waikawa Stream (21 May 2021)
 Stream 26 (21 May 2021)	Stream 25 (no access)

Waikawa catchment	
 Stream 23 (2 July 2021)	Stream 22 (no access)
 Stream 20 (11 May 2021)	 Stream 19 (16 April 2021)
 Stream 18.5 (16 April 2021)	 Stream 18 (7 April 2021)
 Stream 17 (7 April 2021)	 Manakau Stream (12 April 2021)

Waikawa catchment


Waiauti Stream (14 April 2021)


Stream 13 (14 April 2021)


Stream 12 (14 April 2021)

Waitohu catchment


Stream 11 (4 June 2021)


Stream 10 (9 April 2021)


Stream 9 (9 April 2021)


Stream 8 (26 March 2021)

Waitohu catchment	
 Stream 7 (26 March 2021)	 Stream 6.1 (26 March 2021)
 Stream 6 (9 April 2021)	 Stream 5 (9 April 2021)
 Stream 4 (11 May 2021)	 Stream 3 (9 April 2021)
 Stream 2 culvert beneath SH1 (12 April 2021)	 Stream 1 (26 March 2021)

Waitohu catchment	
 Stream 0 – directly downstream of Taylors Road (8 September 2022) (no access to Ō2NL site)	

APPENDIX K3: ECOLOGICAL IMPACT ASSESSMENT METHODOLOGY TABLES

Table K22 Ecological impact assessment categories and criteria. Adapted and updated from that used for Te Ahu a Turanga by Justine Quinn.[62]

Value	Description	Characteristics
Very High	A pristine waterway that would be representative of conditions close to its pre-human condition (i.e., a reference condition). No anthropogenic contaminant inputs. Flora and fauna effectively unchanged from pre-human condition. E.g., waterway with 100% native forest catchment.	Benthic invertebrate community: • Contains many taxa that are sensitive to organic enrichment and settled sediments. • Typically with no single dominant species or group of species. • MCI, QMCI, ASPM scores in NPS-FM (2020) A band (MCI ≥130, QMCI ≥6.5, ASPM ≥0.6). • EPT richness and proportion of overall benthic invertebrate community typically high. SEV scores high, typically >0.8. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat natural and unmodified.
High	A waterway that has been modified through loss of natural riparian vegetation, catchment land use change, to the extent it is no longer pristine or could considered to be in reference condition. However, many natural, pre-human qualities are retained. E.g., A mixed native forest-agricultural catchment.	Benthic invertebrate community: • Contains many taxa that are sensitive to organic enrichment and settled sediments. • Typically with no single dominant species or group of species. • MCI, QMCI, ASPM scores in NPS-FM (2020) A (MCI ≥130; QMCI ≥6.5; ASPM ≥0.6) or B Bands (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4). • EPT richness and proportion of overall benthic invertebrate community typically moderate to high. SEV scores moderate to high, typically 0.6-0.8. Fish communities typically diverse and abundant. The presence of an "At Risk – Declining" or "Threatened" fish or invertebrate species may elevate an otherwise moderate value site to be high. Riparian vegetation may have a well-established closed canopy in smaller streams. No pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat largely unmodified.
Moderate	A waterway that retains components of its natural state, but has been modified through a loss of riparian vegetation and land use change. E.g., A predominantly agricultural catchment.	Benthic invertebrate community: • Dominated by taxa that are not sensitive to organic enrichment and settled sediments. • Typically with dominant species or group of species (especially snails, amphipods, worms, chironomid midge larvae). • MCI, QMCI, ASPM scores sometimes in NPS-FM (2020) in B Band (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4) but generally in C Band

[62] Te Ahu a Turanga: Technical Assessment F – Freshwater ecology (nzta.govt.nz)

		(MCI ≥90 and <110; QMCI ≥4.5 and <5.5; ASPM <0.4 and ≥0.3) • EPT richness and proportion of overall benthic invertebrate community typically low. SEV scores moderate, typically 0.4-0.6. Fish communities typically moderate diversity with lower species richness than high or very high value sites. The presence of an “At Risk – Declining” or “Threatened” fish or invertebrate species may elevate an otherwise low value site to be moderate. Pest or invasive fish species (excluding trout and salmon) may be present. Stream channel and morphology typically modified (e.g., channelised) Stream banks may be modified or managed and may be highly engineered and/or evidence of significant erosion. Riparian vegetation often lacking and stock may have access to channel. Habitat modified.
Low	Waterway is highly modified and may have been deepened, straightened or created for wetland drainage purposes. Virtually no aspects of its natural state remain. E.g., modified channel in agricultural or urban landscape.	Benthic invertebrate community: • Dominated by taxa that are not sensitive to organic enrichment and settled sediments. • Typically with dominant species or group of species (especially snails, amphipods, worms, chironomid midge larvae). • MCI, QMCI, ASPM scores generally below NPS-FM (2020) bottom-line (D band) (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4) but generally in C Band (MCI <90; QMCI <4.5; ASPM <0.3) • EPT richness and proportion of overall benthic invertebrate community typically low or zero. SEV scores low, typically less than 0.4. Fish communities typically low diversity and less than that of moderate value sites. Shortfin tuna/eel often dominant or the only species present. Pest or invasive fish (excluding trout and salmon) species often present. Stream channel and morphology typically modified (e.g., channelised). Stream banks often highly modified or managed and maybe highly engineered and/or evidence of significant erosion. Riparian vegetation typically without a well-established closed canopy. Habitat highly modified.
Negligible	Waterway is ephemeral and only has surface water for a short period following significant rainfall. Terrestrial vegetation often fills the channel. Typically no aquatic fauna or flora present.	No aquatic invertebrates present. No fish present, although can provide migration pathways for fish (especially tuna/eel) to upstream permanent habitats (e.g., dams, lakes, ponds). In some instances, can also provide temporary foraging habitat for fish (especially tuna/eel). Do not met RMA definition of “river”.

Table K23 Criteria for describing magnitude of effect (from Table 8 of EcIAG).[63]

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally change and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

Table K24 Matrix for determining the level of effects based on ecological value of site to be disturbed and magnitude of the effects of the proposed activity. Adapted from Table 10 of EcIAG.

		Ecological Value				
		Very high	**High**	**Moderate**	**Low**	**Negligible**
Magnitude	**Very high**	Very high	Very high	High	Moderate	Low
	High	Very high	Very high	Moderate	Low	Very low
	Moderate	High	High	Moderate	Low	Very low
	Low	Moderate	Low	Low	Very low	Very low
	Negligible	Low	Very low	Very low	Very low	Very low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

Table K25 Timescales for duration of effects from Table 9 of EcIAG.

Permanent	• Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long term	• Where there is likely to be substantial improvement after a 25-year period (e.g., the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary	• Long term (15-25 years or longer – see above) • Medium term (5-15 years) • Short term (up to 5 years) • Construction phase (days or months)

[63] Roper-Lindsay, J., Fuller, S., Hooson, S., Sanders, M., & Ussher, G. 2018. *Ecological Impact Assessment (EcIA) EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems* (2nd ed, Environmental Institute of Australia and New Zealand Inc, Melbourne, 2018). Available at: https://www.eianz.org/document/item/4447.

APPENDIX K4: REGIONAL PLAN SCHEDULE VALUES

Table K26 Horizons One Plan Schedule A (water management zones) and Schedule B (zone-wide & site/reach specific) Values for each Ō2NL Project freshwater ecology site surveyed or visited in the Koputaroa, Punahau/Lake Horowhenua, Ohau, and Waikawa catchments. LSC=life-supporting capacity (LM=lowland mixed; HM=hill mixed); CR=contact recreation; Mau=Mauri; IA=industrial abstraction; I=irrigation; SW=stock water; CAP=capacity to assimilate pollution; NS=natural state; SOS-A=site of significance-aquatic; SOS-R=site of significance-riparian; TF=trout fishery; TS=trout spawning; WS=water supply; DFS=domestic food supply; and FC/D=flood control and drainage.

Catchment	Stream Name/Code	One Plan Schedule A Water Management Sub-zone	Zone-wide Values							Site/Reach-specific Values							
			LSC	CR	Mau	IA	I	SW	CAP	NS	SOS-A	SOS-R	TF	TS	WS	DFS	FC/D
Koputaroa	42.3	Mana_13e	LM	✓	✓	✓	✓	✓	✓								
	42.2	Mana_13e	LM	✓	✓	✓	✓	✓	✓								
	42	Mana_13e	LM	✓	✓	✓	✓	✓	✓								
	43	Mana_13e	LM	✓	✓	✓	✓	✓	✓								✓
	41	Mana_13e	LM	✓	✓	✓	✓	✓	✓								
	40	Mana_13e	LM	✓	✓	✓	✓	✓	✓								✓
	39 (Waitaiki Stream)	Mana_13e	LM	✓	✓	✓	✓	✓	✓								✓
	39.2	Mana_13e	LM	✓	✓	✓	✓	✓	✓								
	39.1 (Waitaiki Stream)	Mana_13e	LM	✓	✓	✓	✓	✓	✓								✓
Punahau/ Lake Horowhenua	37 (Waimarie Stream)	Hoki_1a	LM	✓	✓	✓	✓	✓	✓								
Ohau	35.4	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								

	35.1	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								✓
	34.5	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								
	34	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								
	Ohau River (33)	Ohau_1b	HM	✓	✓	✓	✓	✓	✓		✓		✓			✓	✓
	Kuku Stream (32)	Ohau_1b	HM	✓	✓	✓	✓	✓	✓							✓	✓
	31	Ohau_1b	HM	✓	✓	✓	✓	✓	✓							✓	
	30	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								
	29 (Waikokopu Stream)	Ohau_1b	HM	✓	✓	✓	✓	✓	✓							✓	
	28	Ohau_1b	HM	✓	✓	✓	✓	✓	✓								
Waikawa	27.1	West_9a	HM	✓	✓	✓	✓	✓	✓							✓	
	Waikawa Stream (27)	West_9a	HM	✓	✓	✓	✓	✓	✓		✓	✓				✓	✓
	26	West_9b	HM	✓	✓	✓	✓	✓	✓								
	25	West_9b	HM	✓	✓	✓	✓	✓	✓							✓	
	23	West_9b	HM	✓	✓	✓	✓	✓	✓								
	22	West_9b	HM	✓	✓	✓	✓	✓	✓								
	20	West_9b	HM	✓	✓	✓	✓	✓	✓								
	19	West_9b	HM	✓	✓	✓	✓	✓	✓								
	18.5	West_9b	HM	✓	✓	✓	✓	✓	✓								
	18	West_9b	HM	✓	✓	✓	✓	✓	✓							✓	
	17	West_9b	HM	✓	✓	✓	✓	✓	✓							✓	

	Manakau Stream (15)	West_9b	HM	✓	✓	✓	✓	✓	✓							✓	
	Waiauti Stream (14)	West_9b	HM	✓	✓	✓	✓	✓	✓							✓	✓
	13	West_9b	HM	✓	✓	✓	✓	✓	✓								
	12	West_9b	HM	✓	✓	✓	✓	✓	✓								

Table K27 GWRC Proposed Natural Resources Plan – Schedule A, F1, and I Values for each Ō2NL Project freshwater ecology site surveyed or visited in the Waitohu catchment.

Catchment	Stream Name/Code	Natural Resources Plan - Schedule Values					
		Schedule A – Outstanding waterbodies	Schedule F1 – rivers & lakes with significant indigenous ecosystems	Schedule F1 - high macroinvertebrate community health	Schedule F1 - threatened or at risk fish habitat	Schedule F1 - migratory fish habitat	Schedule I – important trout fishery rivers and spawning waters
Waitohu	11						
	10		✓		✓	✓	
	9						
	8						
	7						
	6.1						
	6						
	5		✓		✓	✓	
	4						
	3		✓		✓	✓	
	2+		✓		✓	✓	
	1		✓		✓	✓	
	0 (Greenwoods Stream)		✓		✓	✓	

APPENDIX K5: CULVERT DESIGN PHILOSOPHY MEMO SENT TO REGIONAL COUNCILS ON 1 JUNE 2021

To:	Horizons Regional Councils and Greater Wellington Regional Council	From:	Andrew Craig, Stantec Alex James, EOS Ecology Nick Goldwater, Wildlands
		Date:	May 25, 2021

Ō2NL proposed culvert design philosophy incorporating fish passage and Freshwater NES Regulation 70 interpretation

1. INTENTION AND OVERVIEW

The Resource Management National Environmental Standards for Freshwater Regulations 2020 (Freshwater NES) regulates activities that pose risks to the health of freshwater and freshwater ecosystems. Having only come into effect from September 2020, there is limited precedence on the interpretation of some clauses, including Permitted Activity Regulation 70 which relates specifically to fish passage.

The intention of this document is to present our interpretation of Freshwater NES Regulation 70 and how we are using this to inform field data collection and ongoing hydraulic design calculations to inform our assessment of the effects of new culverts on the environment, specifically taking into consideration Regulation 70 of the Freshwater NES. This memo is provided to the Regional Councils so that they can advise if the proposed approach is acceptable.

The emphasis for this document is on hydrological and freshwater considerations and does not cover the design philosophy across all disciplines, e.g. structural and geotechnical.

In the sections that follow, we will first present the high-level design philosophy and then additional considerations on field data collection and design, followed by our interpretation of Freshwater NES Regulation 70 for discussion and confirmation.

Importantly, we note that some hydraulic performance metrics set in Freshwater NES Regulation 70 may be difficult to provide quantitative evidence in some instances. These metrics appear to correlate with and derive from parts of the recent New Zealand Fish Passage Guidelines for structures up to 4 metres high (NIWA/DOC 2018). The same guidance references the preferred hierarchy of options as Bridges, followed by Stream Simulation Design and then Hydraulic Design.

2. DESIGN PHILOSOPHY

The design philosophy is informed by the Cultural and Environmental Design Framework project values of treading lightly on the landscape and leaving a positive legacy. This includes the concept of re-stitching the streams to maintain the health and natural function of affected streams and maintaining or enhancing fish passage.

These values are used as part of the interpretation and application of various sets of guidance (referenced below). Key elements of the design philosophy will include the following, as far as reasonably practicable:

- Partner with Iwi to integrate cultural values into all aspects of the design.
- Plan for an intended durable asset lifespan of at least 100 years.
- Existing watercourses should be allowed to pass underneath the highway whilst maintaining the existing natural drainage patterns of the contributing catchment, i.e. to not concentrate several watercourses into one discharge point. Existing flood prone areas should not be exacerbated or new flooding issues created. It is worth noting early that given the large footprint of the highway some change is to be expected, and some mitigation through creation of enhanced storage may be required.
- Fish passage will be assumed as required for all watercourse crossings and will only be withdrawn if identified and evidenced by site-specific ecological assessment as not being required/ desirable. The site-specific assessment will include consideration of possible future removal of current obstructions to fish passage in a watercourse. In other words, provision of fish passage will be provided (if practicable) even if no evidence is found for current fish passage if the potential reasonably exists for this to change in future. Fish passage will be designed /provided based on Stream Simulation where feasible, by minimising alteration to existing stream slope, with generous width and bank/channel margins and avoiding excessive turbulence or vertical drops even at low flows. Depending on slopes, substrate stability and peak velocities, lined inlet and outlet aprons may comprise rock rip rap that is partly buried to avoid highly turbulent flow, and transitions of bed and channel margins to upstream and downstream should be gradual.
- Preference should be given to open channel rather than piped systems to reduce habitat loss. Culvert lengths should be kept as short as reasonably possible whilst balancing the requirements for optimal fish and sediment passage, the imperative to retain / keep open channel and provision of habitat diversity.
- Maintain or enhance natural processes including the passage of natural substrate within and downstream of the structure, to reduce whole of life maintenance requirements whilst not increasing risks that could be associated with blockage. Consideration should be given to safe maintenance options, such as to inspect and if required clear blockages (notably after major floods or landslide debris flows). Debris arrestors will also be considered, based on reasonably anticipated catchment debris loads potential blockage risks, and the impacts of exceedance overland flow paths (as relevant).
- Existing and new stream beds and banks should be protected from any residual erosion and scour effects that may be caused by the Project, which may include localised rock rip rap for scour protection and/or additional planting to stabilise banks. This will include consideration of possible upstream and downstream effects. Additional resilience measures may be required to limit damage in exceedance events, both around structures and possible overland flow paths.
- Consider the safety, cost and environmental impacts of construction, including whether to build culverts on the existing watercourse alignment (which will usually involve moving the watercourse before culvert construction can begin) or offline (which may be safer to construct, allow better foundations and shorter construction timeframes).
- Once the bore area and width have been informed by the above requirements, the culvert shape (e.g. circular, arch or rectangular) and material choices will be informed by geotechnical and constructability considerations, capital and whole life cost / value engineering. Some

aspects will require reasonable confidence for DBC and consent, while other elements will only be finalized during detailed design.

3. KEY DOCUMENTS REFERENCED

- Resource Management National Environmental Standards for Freshwater Regulations 2020 (Ministry for the Environment, 2020)
- New Zealand Fish Passage Guidelines for structures up to 4m (NIWA/DOC, 2018)
- Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (US Department of Agriculture, 2008, as referenced by NIWA/DOC 2018)
- NZTA P46 Stormwater Specification (NZTA, 2016)
- NZTA SP/M/022 Bridge Manual (3rd edition, NZTA, 2018)
- Austroads AGBT Hydraulic Design of Waterway Structures (Austroads, 2019)
- Adapting to Climate Change in New Zealand (Ministry for the Environment, 2018)
- HIRDS High Intensity Rainfall Design System version 4 (NIWA, 2018)
- Bridge Scour (B Melville and S Coleman, 2000)

4. KEY DESIGN SCENARIOS

For design purposes, the new state highway classification (under the NZTA One Network Road Classification) has been selected as “IL3+ National (High Volume)”. The associated design scenarios are:

- 1:25 AEP with climate change (RCP6.0 2130) for SLS1 (no damage to significant infrastructure)
- 1:100 AEP with climate change (RCP6.0 2130) for SLS2 (expressway operationally functional)
- 1:1500 AEP with climate change (RCP8.5 2130) for ULS resilience case (damage limitation, avoiding collapse)
- Q95% exceedance flow where required for ‘low flow fish passage design’
- Q20% exceedance flow where required for ‘high flow fish passage design’

5. NOTE REGARDING BRIDGES

- Bridges are the preferred crossing solution to avoid or minimise impacts on fish and natural sediment processes.
- The Freshwater NES Regulation 70 applies to culverts rather than bridges. The effects of bridges on fish passage are likely to be no more than minor (subject to site-specific design and AEE), and hence the nature of the evidence required to support this will be different to culverts.
- Large bridges are automatically designed for Stream Simulation, including bank/channel margin within the structure and minimising impacts within the stream. Bridges will be hydraulically shorter than culverts, and have less effects on flow regime and daylight. Bridge soffits will be set using freeboard (at least 0.6m) above the SLS2 design flood level (1:100 AEP flood event including climate change RCP6.0 to 2130), and land access requirements if greater.
- Two major bridges on the Ō2NL route, namely the Ōhau and Waikawa, are likely to be multi-span structures to allow these rivers some space to migrate laterally within their most active river corridor. These structures are

large with bridge abutments and scour protection works expected to be set back from the current water's edge.
- The Kuku Stream crossing is expected to be a single span over the watercourse, in the order of 15m span, without realignment of the watercourse.
- The Manakau Stream crossing is expected to be a single shared-span bridge, with the river alignment adjusted slightly to be tighter alongside South Manakau Road. The tighter river alignment will likely require scour protection and some training works upstream and downstream.
- The Waiauti Stream crossing occurs on the location of a major meander and a design option to cross this stream is under development, and will need to at least take into consideration ecological, cultural and landscape values.

6. CULVERTS (INCLUDING MAJOR CULVERTS)

- All culverts (including 'major culverts' above 3.4m^2 as defined in the Bridge Manual) will be subject to a design process in line with the design philosophy above, which includes provision of fish passage.
- Vertical culvert alignments (i.e. bed elevation and gradient) are chosen as close to the existing natural river bed elevation and gradient as possible, to meet existing upstream and downstream channel inverts, while balancing the preference to minimise habitat loss, in addition to constructability considerations.
- Due to the moderate gradients on most of the watercourses (typically in the 1% to 6% range in the vicinity of the proposed highway), there are likely to be upstream ponding impacts that could extend in the order of 100m upstream of the culvert inlet in the design flood (1:100 AEP flood event with climate change). These effects need to be considered and factored into the culvert design process.
- Stream Simulation design considerations encourage an increase in culvert width where feasible to achieve a channel margin. Further details are provided below on the approach and data that will inform or evidence the assessment.

7. PROPOSED FIELD DATA COLLECTION AND APPLICATION RELEVANT TO FRESHWATER NES REGULATION 70

The preceding section has explained that in some instances it may not be required or desirable to provide fish passage. The design of these culverts will not necessarily aim to meet the requirements of Regulation 70 of the NES (although they may do so by default) and consents and NES approvals will be sought on the basis of hydraulic and morphology basis only. However, where fish passage is required / proposed then the aim will be to meet all of the criteria in Regulation 70 of the NES Freshwater and to provide an assessment taking into consideration those criteria (see following section).

Where fish passage is required / proposed then at each of those proposed culvert or watercourse crossing, 10 transects will be taken in the reach under the anticipated Ō2NL footprint. These transects will measure channel (as practicable) width (wetted and bankfull), bankfull height, water depths, and thalweg water velocity (in some instances bankfull width and height is difficult or impossible to determine, and for many ephemeral streams there is limited / no defined channel). If riffles are present additional measurements of depths and velocity will be made in this habitat. Substrate distribution will be estimated, including D84 as a benchmark grain size for substrate mobility analysis. Photographs will be taken to support the estimation of representative Manning's 'n' roughness values.

The design team will assign Manning's 'n' roughness to the existing reach based on the site photographs (provided above by the Project Ecologist), and derive slope based on DEM (upstream and downstream invert at tie-in locations to existing bed, and existing path length between these two points).

8. REGULATION 70 NES FRESHWATER INTERPRETATION

The table below provides our proposed approach to assessing the effects of the proposed culverts relative to the provisions on Regulation 70 of the NES Freshwater. For the consent application, this information will be summarised for each culvert location (including those where fish passage is not proposed / required), including whether each criterion is met by the proposed solution.

Freshwater NES Regulation 70 Criteria	Proposed approach to assessment
(a) the culvert must provide for the same passage of fish upstream and downstream as would exist without the culvert, except as required to carry out the works to place, alter, extend, or reconstruct the culvert; and	If a culvert meets all of criteria (b)-(f), it will be deemed to meet this criterion. If one or more of criteria (b)-(f) are not met, then consent is needed as a discretionary activity with an assessment of the effects of the proposed work on the environment provided. This assessment will address the criteria described below.
(b) the culvert must be laid parallel to the slope of the bed of the river or connected area; and	The existing average watercourse slope will by established by measuring and tabulating existing thalweg elevations at the upstream tie-in and downstream tie-in respectively (start and end of proposed works including channel preparations), and the existing watercourse length between these points. The proposed culvert slope will be tabulated and considered to meet this criterion if within 5% of the existing average slope. The suitability of existing thalweg elevations and slopes based on LiDAR ground model (used for consent stage) should be verified during detailed design.
(c) the mean cross-sectional water velocity in the culvert must be no greater than that in all immediately adjoining river reaches; and	The mean velocity is difficult to measure both for existing and for proposed situations. Mean velocity is a function of slope, roughness, and hydraulic radius (area to wetted perimeter ratio at mean flow), allowing these parameters to be used together as a proxy for mean velocity. The mean flow is a relatively low in-bank flow, so the mean width will be taken as the average wetted width from the 10 transects taken by site ecologist (provided the stream flow was not in flood, and will be replaced with average bed width if channel was dry). This velocity criterion will be considered met if the proposed culvert bed width is greater than or equal to the existing average transect wetted width, the culvert slope criterion (b) is met, and design roughness is greater than or equal to the existing average roughness. These parameters will be tabulated for existing and proposed cases. Whilst roughness at low flows can be subjective and difficult to estimate

	accurately, transparency will be achieved by correlating site photos to "Roughness Characteristics of New Zealand Rivers" (NIWA, 1998).
(d) the culvert's width where it intersects with the bed of the river or connected area (**s**) and the width of the bed at that location (**w**), both measured in metres, must compare as follows: (i) where w ≤ 3, s ≥ 1.3 × w: (ii) where w > 3, s ≥ (1.2 × w) + 0.6; and	The width of the existing bed (**w**) is taken as the average existing bed or wetted width measured on site from the 10 transects. The culvert width (**s**) where it meets bed material (i.e. just above existing stable bankfull height) should meet criteria (i) or (ii) as applicable.
(e) the culvert must be open-bottomed or its invert must be placed so that at least 25% of the culvert's diameter is below the level of the bed; and	This information will be provided in tabulated form.
(f) the bed substrate must be present over the full length of the culvert and stable at the flow rate at or below which the water flows for 80% of the time; and	A typical prelim design will be provided for a circular and a rectangular culvert. The table of culverts will confirm where embedment and substrate are present in the proposed design. In terms of substrate material, this criterion will be assumed met based on the typical design which will state use of substrate material from the existing channel bed (augmented if required for construction sequencing with similar particle size distribution and/or containing some larger rock sizes to help maintain substrate stability in the culvert due to the lack of vegetation). The verification that the existing material and/or supplementary substrate material are stable at q20% exceedance will be performed during detailed design.
(g) the culvert provides for continuity of geomorphic processes (such as the movement of sediment and debris)	If a culvert meets all of criteria (b)-(f), it will be deemed to meet this criterion. If one or more of criteria (b)-(f) are not met, then an assessment of the effect of non-continuity of geomorphic processes on fish passage will be provided, and the effect of the loss of habitat included in the overall assessment of streams. This will consider the relationship of those geomorphic processes to fish passage in that particular instance.

For the purposes of the assessment it will be assumed that conditions of consent will be imposed that will require information be provided as per the requirements of Regulations 63(3), 68 (where applicable) and 69 of the NES Freshwater.

APPENDIX K6: OFFSETTING SITE DETAILS

Table K28 Stream biodiversity offsetting reach details.

Stream name	Offsetting site landowner	The Property Group reference no.	Location	Stream	Restoration length and area available	Stock exclusion regulations apply	Current SEV (SEVm-C)	Potential SEV (SEVm-P)
Waiauti	Staples – Waka Kotahi to purchase	63	Waitohu Valley Rd (Staples upstream block)	Waiauti Stream	837 m (1,942 m^2)	Yes	0.5	0.68
				Waiauti Stream tributaries	230 m (230 m^2)	Yes	0.46	0.64
	Rutherford	81	534 Waitohu Valley Rd	Waiauti Stream	189 m (438 m^2)	Yes	0.5	0.61
				Waiauti Stream tributary	172 m (172 m^2)	Yes	0.5	0.64
	Pilet	68	Waitohu Valley Rd	Waiauti Stream	314 m (728 m^2)	Yes	0.5	0.59
				Waiauti Stream tributary	432 m (546 m^2)	Yes	0.5	0.7
	Gray	79	50 Mountain View Drive	Waiauti Stream	131 m (304 m^2)	Yes	0.5	0.59
	Cording	78	44A Mountain View Drive	Waiauti Stream	262 m (608 m^2)	No	0.5	0.59
	Parkes	76	30 Mountain View Drive	Waiauti Stream	41 (95 m^2)	No	0.53	0.68
	Waka Kotahi	62	36 South Manakau Rd	Waiauti Stream	414 m (960 m^2)	Yes	0.5	0.68
	Staples – Waka Kotahi to purchase	63	10 South Manakau Rd (Staples downstream block)	Waiauti Stream	518 m (1,202 m^2)	Yes	0.5	0.68
Manakau	Pilet	68	South Manakau Rd (upstream of driveway bush remnant)	Manakau Stream	304 m (945 m^2)	Yes	0.55	0.7
			South Manakau Rd (downstream of driveway bush remnant)		554 (1,723 m^2)	Yes	0.55	0.8

Stream name	Offsetting site landowner	The Property Group reference no.	Location	Stream	Restoration length and area available	Stock exclusion regulations apply	Current SEV (SEVm-C)	Potential SEV (SEVm-P)
	Waka Kotahi	64 & 65	14 & 14A Mountain View Drive	Manakau Stream	316 m (983 m^2)	Yes	0.55	0.8
	Waka Kotahi	62	36 South Manakau Rd	Manakau Stream	57 m (177 m^2)	No	0.56	0.78
	Waka Kotahi		South Manakau Rd	Manakau Stream	151 m (470 m^2)	No	0.56	0.78
Kuku (within Ō2NL designation)	Honore – Waka Kotahi to purchase	46	93-111 Kuku East Rd (upstream of Ō2NL Kuku Stream bridge)	Kuku Stream	275 m (517 m^2)	Yes	0.49	0.74
			93-111 Kuku East Rd (downstream of Ō2NL Kuku Stream bridge)	Kuku Stream	242 m (455 m^2)	Yes	0.49	0.74
Stream 27.1	Martin family		Just upstream of Ō2NL designation	Stream 27.1	278 m (361 m^2)	Yes	0.47	0.54
			Martins Rd	Stream 27.1	586 m (1,119 m^2)	Yes	0.47	0.54
			Martins Rd	Stream 27.1 tributary	590 m (295 m^2)	Yes	0.4	0.47
Kuku (downstream of existing SH1)	Various – too be confirmed		State Highway 1; Kuku Beach Rd	Kuku Stream	1,728 m (3,249 m^2)	Yes	0.49	0.74