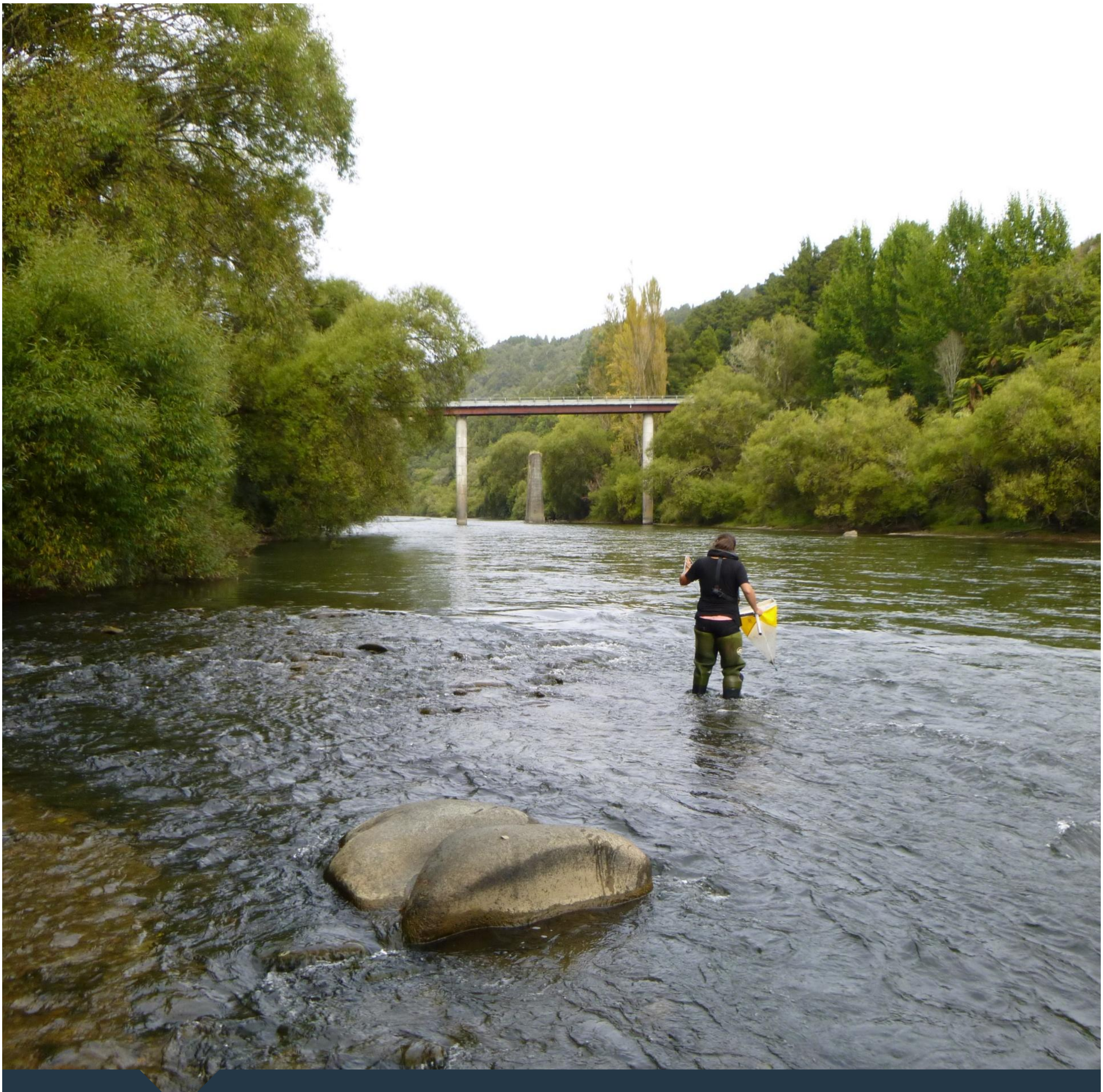

Flow-habitat reassessment of selected reaches of upper Manawatū tributaries and the Rangitīkei River to support the Horizons Regional Council One Plan update

October 2025

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REGIONAL COUNCIL

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Robin Holmes, Karen Shearer

Prepared for Horizons Regional Council

Glossary

Term	Definition
7DMALF	Seven-day mean annual low flow – the mean of an annual series of flow minima after having applied a 7-day running mean to a river flow time-series.
Core allocation	The maximum amount of water available to be abstracted from a specified water management area or sub-area. In the Horizons region, the core allocation limit does not include supplementary allocation (additional allocation available during flows higher than the median flow) or permitted activities.
Default limits	Water resource use limits to be applied in situations where minimum flow and allocation limits have not been derived for a specific waterbody or part of a waterbody based on local-scale ecological, hydrological, cultural or economic assessments.
Environmental flow regime	River flows that will result in a river flow regime that is able to support instream values.
Flow-critical value	The instream value present in a river that is the most flow-demanding within that river, and therefore the most vulnerable to flow reduction through abstraction. Typical flow-critical instream values include torrentfish, bluegill bully, adult trout and trout spawning habitat.
IFIM	Instream Flow Incremental Methodology – a framework for assessing flow–habitat relationships for instream values.
Instream values	Environmental values of streams / rivers, including ecological status or health, cultural values, fishery values and aesthetic values. Instream values may be identified by the local authority, iwi, or national legislation via the National Policy Statement for Freshwater Management 2020.
Minimum flow	Water abstractions must be restricted during times of low flow such that flow is not artificially drawn below the minimum flow. Under the current One Plan, non-essential associated water abstractions must generally cease when river flow is below the minimum flow.
Naturalised flow	An estimation of river flow that would have been observed under the present land cover but in the absence of abstractions or diversions of either groundwater or surface water.
NPS-FM 2020	National Policy Statement for Freshwater Management 2020 (MfE 2024).
Total allocation	The sum of all instantaneous allowable rates of abstraction that are associated with a catchment or management zone.

Contents

Executive summary

In support of the process to update the Horizons Regional Council One Plan, this report re-evaluates flow–habitat modelling studies at three Instream Flow Incremental Methodology (IFIM) river reaches in the upper Manawatū tributaries (in the Tamaki River and Ōruakeretaki Stream), and three IFIM reaches in the mid–lower Rangitīkei River. This updated assessment was undertaken to:

1. Ensure all relevant / critical freshwater invertebrate and fish species and instream values are accounted for
2. Apply the most recent and appropriate habitat suitability curves (which best represent current regional instream values)
3. Incorporate up-to-date flow statistics
4. Interpret flow–habitat modelling results using current best practice ecological risk-based frameworks.

For each IFIM reach, habitat modelling results are expressed in habitat retention tables that show the percentage of habitat quantity / quality retained (expressed as area-weighted suitability [AWS] index scores) for instream values under various abstraction scenarios relative to key naturalised flow statistics: the 7-day mean annual low flow (7DMALF) and the summer median flow. In total, four abstraction scenarios were modelled:

1. The naturalised flow – river flows with no abstraction occurring
2. Status quo – flows with the current level of abstraction in place (i.e. actual measured flows)
3. Realistic maximum abstraction – all allowable water under the One Plan is allocated with some assumptions to reflect a realistic level of use by landowners
4. Maximum allowable abstraction – full use under the One Plan minimum flow and allocation limits.

Results

Tamaki River
In the Tamaki River, the current status quo level of abstraction maintains habitat quality / quantity for most species, with only minor percentage reductions relative to naturalised flows. However, across both reaches modelled, under the maximum abstraction scenarios, trout quality / quantity declines by approximately 15–25% (depending on life history stage). This equates to a 'moderate' to 'strong' risk of negative ecological effects. Under the same abstraction scenarios, the quality / quantity of torrentfish habitat declines by 21–30% in the lower river, near State Highway 2 (SH2), and by 30–50% for the upper Water Supply Weir (WSW) reach. This suggests the potential for a 'strong' to 'very strong' risk of negative effects if this species is present in the river.

The effects of abstraction are more pronounced in the upper WSW reach relative to the SH2 reach, potentially because the abstraction for municipal supply in this reach constitutes a greater proportion of the total flow. Habitat quantity / quality for most macroinvertebrates, food-producing habitat and the native dwarf galaxias fish is largely unaffected in both reaches and across all modelled abstraction scenarios.

Ōruakeretaki Stream
The current level of water abstraction (i.e. the status quo scenario) has little impact on habitat quality / quantity for any species / instream value modelled in the Ōruakeretaki Stream. However, under the maximum use scenarios,

habitat quality / quantity for flow-sensitive species shows marked declines: torrentfish (-40%), juvenile lamprey (-40%), kōaro (-16%), and salmonids (-13–21%, depending on life history stage), indicating 'very strong' to 'moderate' ecological risks. Habitat for the macroinvertebrates, *Zelandoperla* (-29%) and *Aoteapsyche* (-16%) also show 'strong' to 'moderate' declines in habitat quantity / quality. Habitat for dwarf galaxias and the mayfly *Deleatidium* show only minor reductions across all abstraction scenarios.

Rangitīkei River

In the Rangitīkei River, abstraction effects on habitat quality / quantity are minimal for all species and instream values modelled, under all scenarios. There are only small (i.e. 'less than minor') reductions (≤ 9%) in sensitive macroinvertebrate habitat under maximum allocation and use scenarios. This suggests that the flow rules in the operative One Plan are protective of aquatic habitat in the Rangitīkei River. However, our results are assessed against a naturalised flow scenario that does not account for any effects of the Tongariro Power Scheme diversion, and so focused on quantifying the potential effects of abstraction under the control of the One Plan.

Conclusions and recommendations

In the Rangitīkei River, habitat for all modelled species is well protected by the flow rules set within the One Plan. Across all three rivers assessed, the current status quo level of abstraction generally maintains habitat quality and quantity for most modelled species and instream values, including species with high cultural and conservation significance (such as longfin eels and dwarf galaxiids). However, in the Tamaki River and Ōruakeretaki Stream, under the maximum allocation scenarios, there is a 'moderate' to 'very strong' risk of negative effects on habitat for some flow-sensitive instream values such as torrentfish, juvenile lamprey and adult trout.

A 'moderate' risk of negative effects on habitat values, as indicated by flow–habitat modelling (i.e. AWS reductions of < 20% relative to naturalised flows), could be considered acceptable in a flow-setting context under the objectives of the One Plan. However, 'strong' or 'very strong' risks (i.e. > 20% AWS reductions) may not be consistent with local or national policy directives to maintain (or enhance) specific instream values and overall instream health.

Habitat for torrentfish in particular is reduced substantially under maximum allocation scenarios in the upper Manawatū tributaries. However, before these modelling results are considered with reference to flow-allocation policy, we recommend that the Tamaki River and Ōruakeretaki Stream, and perhaps other upper Manawatū tributaries, are assessed for their potential to support viable torrentfish and lamprey populations. Torrentfish seem to be relatively rare in the upper Manawatū tributaries, as are lamprey. If habitat for these species is not considered important in these tributaries, because they are unlikely to occur there naturally or occur at very low densities, then trout are the next most flow-sensitive instream value. Under a 'realistic level of abstraction', the current flow allocation rules of the One Plan generally afford a moderate level of protection in both tributaries for brown and rainbow trout habitat, across their various life history stages. However, in the WSW reach there is potential for a 'strong' risk of negative effects on adult brown trout and trout spawning habitat.

1. Introduction

In 2023, Horizons Regional Council commissioned a panel of environmental flow experts to:

1. Assess the council's current surface water allocation framework against the requirements of the National Policy Statement for Freshwater Management 2020 (MfE 2024) (hereafter NPS-FM 2020)
2. Outline priority work requirements to ensure the current water allocation framework is fit for purpose to inform an update of the regional One Plan (Horizons Regional Council 2014; Appendix 1).

One priority recommendation made by the panel was to revisit existing studies where the Instream Incremental Flow Methodology (IFIM) had been applied to inform the setting of minimum flows and allocation limits. Most of the IFIM investigations to support the existing One Plan were undertaken around 20 years ago (e.g. Hay and Hayes 2004, 2007). Since that time, there have been advances in the way the flow–habitat modelling component of the IFIM process is undertaken, and how results are interpreted. In addition, hydrological data collected in the subsequent 20 years can now be incorporated into the updated flow–habitat modelling to substantially increase the accuracy of model predictions. Re-evaluating the existing IFIM studies in key rivers within the Horizons region ensures that up-to-date flow statistics and flow management science can be used to inform the process of a future update to the One Plan.

1.1 Report aims

This report re-evaluates six IFIM studies across the catchments of the upper Manawatū and Rangitīkei Rivers. The purpose of revisiting the existing IFIM studies in Horizons major catchments is to improve the reliability of environmental flow limits set to protect freshwater habitat by:

1. Ensuring all relevant / critical freshwater invertebrate and fish species and instream values are accounted for
2. Applying the most recent and appropriate habitat suitability curves (which best represent current regional instream values)
3. Incorporating updated flow statistics
4. Interpreting results using current best practice ecological risk-based frameworks.

At the time of writing, the Government is in the process of revising the NPS-FM 2020. While this report has considered the requirements of the NPS-FM 2020 for guidance when interpreting flow modelling results, the underpinning habitat modelling results are presented in such a way as to inform flow setting in light of directions provided by any future freshwater policy / legislation updates.

To aid interpretation, we first provide some context around flow–ecology relationships and flow–habitat modelling, before providing our results and interpretation.

1.2 Key aspects of a river flow regime with respect to ecology

A river flow regime has a range of key hydraulic features, which play various roles in determining ecological structure and function, as well as river form. Viewed simply, typical 'summer low flows' represent the most stressful conditions for most river fauna on an annual basis (i.e. the smallest amount of available habitat, highest temperatures and lowest dissolved oxygen levels). In most waterbodies, the lowest flows in summer set the minimum available habitat, or 'carrying capacity', for fish (as well as some macroinvertebrates) that take more than a year to complete their life cycle. 'Mid-range flows' (between summer low flows and the median flow) are important for the productivity of a river. This is because these flows occur most of the time (over the course of a year) and provide habitat for benthic periphyton and macroinvertebrates – which in turn provide food for fish and river birds.

Small floods or 'freshes' trigger important ecological processes, such as fish migration, and also remove or 'reset' the benthic periphyton community by removing it from the surface of the streambed. Large flood flows determine sediment transport dynamics and channel form, among other processes (MfE 1998; Booker et al. 2022; Stoffels et al. 2024). Typical summer low flows are usually characterised by the mean annual low flow (MALF) or the 7-day MALF (7DMALF). River size is often characterised by the mean or median flow (Booker et al. 2022). Typically, water abstraction demand is highest in summer, when it has the greatest potential to alter summer low flows through to the median flow. For this reason, in the absence of large mainstem dams, flows between the 7DMALF and median are the most important flows to manage within a regional plan. See Appendix 2 for a graphic summary of key hydrological features and linked ecological structure and function. Consequently, in this report, we focus our modelling effort on flows around this range.

2. Overview of Instream Incremental Flow Methodology and the current study methodology

The main outcomes of the IFIM modelling process are predictions about how the quantity and / or quality of aquatic species habitat (or in some cases physical aquatic values, such as spawning habitat) change as a function of flow (Jowett et al. 2008). Outputs can be summarised as graphs and tables showing the relationship between flow and area-weighted suitability (AWS[1]) and the Combined (habitat) Suitability Index (CSI). AWS is an index of both the quantity and quality of available habitat for a species or instream value. CSI indicates the average quality of habitat. The species / instream value 'habitat curves', which underpin the model outputs, are based on the quantitative (correlative) relationship between species / instream value occurrence and selected aspects of habitat, including depth, velocity, substrate composition and sometimes (hiding) cover.

The analyses presented in this report are based on flow–habitat modelling for one- and two-dimensional reach-scale hydraulic models as a component of the instream IFIM process. Using the System for Environmental Flow Analysis (SEFA) software program (Jowett et al. 2015), hydraulic–habitat versus flow modelling was undertaken using the RHYHABSIM hydraulic models previously calibrated for IFIM reaches in the headwater tributaries of the Manawatū River and the mid–lower reaches of the Rangitīkei River. Flow–habitat responses were modelled using existing habitat suitability criteria (HSC), which were considered appropriate for the suite of biota present mostly from the SEFA HSC library. The set of freshwater instream values modelled were determined through consultation with Horizons staff, a review of technical reports associated with the development of the One Plan, and a desktop assessment of the native fish communities in the relevant catchments using the New Zealand Freshwater Fish Database (NZFFD). The HSC used are listed in Appendices 3 and 4; in some cases, more than one habitat curve was used for the same species.

The IFIM process has received criticism for some applications and has some inherent limitations and assumptions that are important to consider when interpreting results. Despite this, however, flow–habitat modelling is still one of the most useful tools for determining potential effects of different environmental flow scenarios on instream life, provided results are interpreted with respect to its limitations. For a short narrative description of the key assumptions and limitations inherent within the IFIM process, see Appendix 5.

To account for key hydrological features, we have modelled habitat quality / quantity at a range of instantaneous flows that include flow statistics that typically represent critical stress points for biota. Habitat for fish (and fish-related values) were modelled and assessed against the naturalised 7DMALF, which represents a flow rate that is likely to be limiting for fish communities on an annual basis. Habitat for benthic macroinvertebrates and 'food-producing'[2] habitat was assessed relative to the naturalised summer median flow (December–February inclusive). The summer median flow represents flows that are

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1 AWS is synonymous with the acronym WUA (weighted usable area), used in some hydraulic–habitat modelling reporting.

2 Waters' (1976) general invertebrate habitat suitability criteria – based on a review of studies that measured depths, velocities and substrate in habitats supporting benthic invertebrate production (mainly riffles and runs) in moderate-sized trout rivers in the United States.

particularly important for the production of macroinvertebrates that feed fish and river birds, given that macroinvertebrate populations usually recover relatively rapidly (in the order of months) from flow-limiting events and thus can use these ‘mid-range’ flows for growth and reproduction.

3. Interpreting results of modelled flow 'scenarios'

The main output in this report are tables where AWS habitat values are calculated as a percentage of the AWS habitat value retained relative to the 'naturalised' 7DMALF flow and naturalised summer median flow (i.e. the modelled 7DMALF and summer median flows, with no water abstraction in place). In this manner, the tables can be interpreted as displaying the percentage of habitat retained for each flow increment (e.g. 0.01 m/s) under the different flow abstraction scenarios *relative* to the amount and quality of habitat that naturally occurs during a typical natural low or summer median flow. A value of less than 100% indicates a reduction in habitat quantity / quality as flows reduce, and a value greater than 100% indicates that reduced flows improve habitat (as can be the case for some biota that prefer shallow water with low velocities). For example, under the 'status quo' abstraction regime, if the AWS retention value for 'Species X' is 90% relative to the naturalised 7DMALF, this equates to a 10% loss in habitat quality / quantity as a direct result of abstraction. It is important to note that this does not necessarily mean that the abundance or biomass of Species X will also be reduced by 10%, because abundance may be limited by factors that are unrelated to habitat quality or quantity. For instance, regular large floods could be limiting the abundance of Species X to the extent that they can never 'fill up' all the available high-quality habitat. With this in mind, AWS should be considered as an index of the *potential* habitat quantity / quality in a river at a given flow.

For all reaches, flows under four 'abstraction scenarios' were modelled by Traverse Environmental. These flow scenarios were then used to calculate key flow statistics (e.g. 7DMALF, median flow and summer median flow) to benchmark the flow–habitat modelling results:

1. **Naturalised flow:** River flows without abstraction. This scenario does not account for hydrological changes caused by land use (e.g. drainage schemes or exotic forestry).
2. **Status quo abstraction:** The current measured river flow record, which includes existing levels of actual abstraction.
3. **Realistic abstraction under maximum allocation**: An estimate of abstraction levels assuming all allocatable water is allocated, but with constraints applied to reflect actual water use patterns.
4. **Maximum allowable abstraction**: Assumes all water available under the One Plan is allocated and used to its full extent.

Together, these scenarios represent the potential range (or 'envelope') of water use allowable under the One Plan. A more detailed description of the scenario modelling methods is provided in Appendix 6 and in Keenan (2024, 2025). For the Tamaki reach, an additional abstraction scenario was modelled to account for the effects of a municipal water supply take.

3.1 Interpreting habitat retention model outputs using an ecological risk-based framework

To aid interpretation of the habitat retention results, a traffic light-coded ecological risk framework has been developed to help decision-makers determine appropriate environmental flows regimes within regional plans (Table 1) (Holmes 2024). The framework is aligned with recently developed methods for setting 'default' minimum flow and allocation limits used by other regional councils, including Otago Regional Council and Greater Wellington Regional Council. The risk-based approach is modified from Beca (2008) and Richter et al. (2012), and was endorsed more recently within an Aotearoa New Zealand context by Hayes et al. (2021).

In a resource management context, the bands presented in Table 1 can be used to assess the risk of 'more than minor' effects from habitat alteration, as determined by flow–habitat modelling (e.g. expressed as habitat retention values relative to naturalised flows). Alternatively, if flow modelling results are not available, they can be used to assess the risk as determined by the degree of hydraulic alteration as indicated by key flow statistics (Holmes 2024).

In a typical river, flow alterations that result in more than a 10% change can be interpreted as having a 'moderate' risk of 'more than minor' ecological effects. If a river has very high instream values, then a 10% change threshold, or a 'very low risk of negative or "more than minor" effects', might be considered by community and decision-makers as an appropriate benchmark. When interpreting hydrological alteration or habitat retention values against the risk framework in Table 1, it is important to bear in mind that the 'risk' of an effect should not be considered the same as an 'actual' effect. These are guidelines to consider when balancing potential ecological effects against abstraction demands.

Table 1. Interpretation bands for alteration of key hydraulic statistics (e.g. minimum flow, median flow or flood frequency) and / or percentage species (or value) habitat retention in relation to the naturalised 7-day MALF, as determined by the flow–habitat modelling component of the IFIM process. See Holmes (2024).

Hydrological alteration *or* reduction in habitat retention relative to naturalised 7-day MALF	**Descriptors of risk of change**	**Interpretation of ecological effect**
< 10%	Small risk	Very low risk of negative or 'more than minor' effects. Minimum flows and allocation limits restricted to this level of alteration are considered highly conservative (precautionary) with respect to ecological protection.
10–20%	Moderate	Moderate risk of negative or 'more than minor' effects. Minimum flows and allocation limits restricted to this level of alteration are considered moderately conservative with respect to ecological protection.
21–30%	High	Strong risk of negative effect; high likelihood of measurable changes in ecosystem structure and function (i.e. effects are likely to be 'more than minor'). Minimum flows and allocation limits set to this level of alteration are not conservative with respect to ecological protection.
> 30%	Very high	Very strong risk of a significant negative effect. Minimum flows and allocation limits set to this level of alteration could be considered difficult to justify in the context of the NPS-FM 2020.

4. Freshwater values in the Manawatū tributaries and the Rangitīkei River

In choosing the fish species and values to be assessed in this report, we considered:

- fisheries and conservation value
- sensitivity to flow change,
- representation of the wider fish community
- likelihood of being in the river segment of interest
- availability of HSC.

Brown and rainbow trout were included because of their fishery value, and in many rivers in Aotearoa New Zealand they are the fish species most sensitive to flow variability. Generally speaking, environmental flow limits set to protect these species will also be sufficient for the protection of native species, hence the focus on these species in the Hay and Hayes (2007) report undertaken to support the implementation of the One Plan. Torrentfish were included in our current assessment as in most rivers they are the native species with the highest flow requirements. Eel, bully and galaxiid species were included so that the influence of the current environmental flow limits could be assessed relative to a wider range of native fish that have either a high cultural or conservation status, or are generally commonly found in the rivers.

In addition to modelling fish values, we also chose to model several macroinvertebrate species that represent a range of sensitivities to flow reduction. While common macroinvertebrates may not be highly valued in their own right, they play a crucial role in aquatic food webs. Therefore, habitat for macroinvertebrates – and the associated 'food-producing' habitat curves – serve as important indicators of how overall stream health might be affected by changes in flow.

4.1 Instream values in the upper Manawatū River tributaries

Within the upper Manawatū catchment tributaries, including the Tamaki River and Ōruakeretaki Stream, 20 native and introduced fish species are likely to be present (Table 2). In the upper Manawatū tributaries, the fish communities are typically characterised by the following species: longfin and shortfin eels, non-migratory bullies (including Cran's and upland bullies), brown and rainbow trout, and dwarf galaxiids. The Tamaki catchment supports a regionally significant trout fishery and a significant population of native dwarf galaxias, which has a threat status of At Risk: Declining (McArthur and Lambie 2007a, 2007b). Anecdotally, the Tamaki River has one of the highest densities of dwarf galaxias in the North Island (Death et al. 2005). Protection of flow levels for these instream values is also likely to provide adequate flow rates / levels for species that prefer slow currents and / or shallow water, such as upland bully.

Among native species, torrentfish usually have the highest flow requirements. In many rivers their habitat quality / quantity declines with reducing flow in a similar manner to adult trout habitat. However, only a few torrentfish have ever been recorded upstream of the Manawatū Gorge, suggesting that less weight should be placed on consideration of their flow–habitat requirements when setting environmental flow limits in the upper catchment. The reasons for the low torrentfish abundances in the upper Manawatū are unclear. Torrentfish are common in the lower Manawatū catchment and the gorge is unlikely to be an impassable barrier for this species. Death et al. (2005) suggest that poor water quality may play a role in their relatively low numbers. If this is true, torrentfish habitat should be considered when setting environmental flows to enable their return to the upper catchment should water quality improve. Therefore, we have included torrentfish habitat in the flow–habitat modelling habitat retention tables to enable consideration of the habitat requirements for the most flow-demanding native species that could *potentially* inhabit these rivers.

There is little ecological information about the Ōruakeretaki Stream other than it is considered to be a trout spawning stream that contributes recruits to the trout population in the Manawatū River (Horizons 2014). It is also considered to have a robust population of dwarf galaxias (McArthur and Lambie 2007a). This means that it should be managed according to the same flow-critical instream values as the Tamaki River for trout, trout spawning and dwarf galaxias habitat.

Table 2. Department of Conservation threat classifications (Dunn et al. 2018) and regional threat classifications (Hickey et al. 2025) of native and introduced freshwater fish species likely to be found in the upper Manawatū River and its major tributaries. Fish included in the habitat retention analyses (Section 5.1) are shaded grey. The list excludes estuarine and marine wandering species such as yellow-eyed mullet, as well as crustaceans and molluscs.

Common name	Scientific name	National threat classification	Regional threat classification
Shortfin eel	*Anguilla australis*	Not Threatened	Not Threatened
Longfin eel	*Anguilla dieffenbachii*	At Risk: Declining	At Risk – Regionally Declining
Torrentfish	*Cheimarrichthys fosteri*	At Risk: Declining	Threatened – Regionally Vulnerable
Giant kōkopu	*Galaxias argenteus*	At Risk: Declining	Threatened – Regionally Critical
Kōaro	*Galaxias brevipinnis*	At Risk: Declining	Threatened – Regionally Vulnerable
Dwarf galaxias	*Galaxias divergens*	At Risk: Declining	Threatened – Regionally Vulnerable
Banded kōkopu	*Galaxias fasciatus*	Not Threatened	Threatened – Regionally Vulnerable
Īnanga	*Galaxias maculatus*	At Risk: Declining	At Risk – Regionally Declining
Shortjaw kōkopu	*Galaxias postvectis*	Nationally Vulnerable	Threatened – Regionally Endangered
Lamprey	*Geotria australis*	Nationally Vulnerable	Threatened – Regionally Endangered
Cran's bully	*Gobiomorphus basalis*	Not Threatened	Not listed
Upland bully	*Gobiomorphus breviceps*	Not Threatened	Not listed
Common bully	*Gobiomorphus cotidianus*	Not Threatened	Not Threatened
Giant bully	*Gobiomorphus gobioides*	At Risk: Naturally Uncommon	Threatened – Regionally Endangered
Dinah's bully	*Gobiomorphus dinae*	Unknown as only recently described *	At Risk – Naturally Uncommon
Redfin bully	*Gobiomorphus huttoni*	Not Threatened	Regionally Not Threatened
Kaharore bully	*Gobiomorphus mataraerore*	Not Threatened	At Risk – Naturally Uncommon
Brown mudfish	*Neochanna apoda*	At Risk: Declining	Threatened – Regionally Vulnerable
Rainbow trout	*Oncorhynchus mykiss*	Introduced and Naturalised	Introduced and Naturalised
Brown trout	*Salmo trutta*	Introduced and Naturalised	Introduced and Naturalised

* Thacker et al. (2023).

4.2 Rangitīkei River

There are 20 species of freshwater fish and large crustaceans and molluscs (including native crayfish / kōura) recorded within the wider Rangitīkei River catchment. Within the upper catchment and tributaries, 13 native and introduced fish with high fishery values are likely to be present (Table 3). Trout and torrentfish are the most flow-sensitive species present, making their habitat requirements appropriate flow-critical instream values to guide water allocation decisions.

Table 3. . Department of Conservation threat classifications (Dunn et al. 2018) and regional threat classifications (Hickey et al 2025) of native and introduced freshwater fish species likely to be found in the Rangitīkei River and its major tributaries. Information was accessed from the New Zealand Freshwater Fish Database (NZFFD). Fish included in the habitat retention analyses (Section 5.2) are shaded grey. Aside from smelt, the list excludes estuarine and marine wandering species such as yellow-eyed mullet, along with crustaceans and molluscs. Smelt have been included as they were part of the Hay and Hayes (2004) assessment and could potentially be influenced by environmental flow change – at least in the lowermost study reach of the Rangitīkei River (i.e. Hampton).

Common name	Scientific name	National threat classification	Regional threat classification
Shortfin eel	*Anguilla australis*	Not Threatened	Not Threatened
Longfin eel	*Anguilla dieffenbachii*	At Risk: Declining	At Risk – Regionally Declining
Torrentfish	*Cheimarrichthys fosteri*	At Risk: Declining	Threatened – Regionally Vulnerable
Giant kōkopu *	*Galaxias argenteus*	At Risk: Declining	Threatened – Regionally Vulnerable
Kōaro	*Galaxias brevipinnis*	At Risk: Declining	Threatened – Regionally Vulnerable
Īnanga	*Galaxias maculatus*	At Risk: Declining	At Risk – Regionally Declining
Cran's bully	*Gobiomorphus basalis*	Not Threatened	Not listed
Upland bully	*Gobiomorphus breviceps*	Not Threatened	Not listed
Common bully	*Gobiomorphus cotidianus*	Not Threatened	Not Threatened
Giant bully	*Gobiomorphus gobioides*	At Risk: Naturally Uncommon	Threatened – Regionally Endangered
Redfin bully	*Gobiomorphus huttoni*	Not Threatened	Regionally Not Threatened
Common smelt	*Retropinna retropinna*	Not Threatened	At Risk – Regionally Declining
Rainbow trout	*Oncorhynchus mykiss*	Introduced and Naturalised	Introduced and Naturalised
Brown trout	*Salmo trutta*	Introduced and Naturalised	Introduced and Naturalised

* Only one specimen has been recorded in the NZFFD, in a tributary of the Rangitīkei River (i.e. the specimen was not found in the mainstem where the IFIM reaches are located). However, giant kōkopu are diadromous, i.e. they migrate between freshwater and saltwater environments to complete their life cycle.

5. Flow modelling re-evaluation results

The habitat retention tables presented below, covering all the different reaches assessed, are grouped into macroinvertebrates and food-producing habitat assessed against the naturalised summer median flow, and native fish values and salmonids assessed against the naturalised 7DMALF. The results for each set of tables are discussed in context with the ecological risk framework provided in Table 1. Graphical outputs for the AWS–flow relationships are presented in Appendix 7.

5.1 Upper Manawatū IFIM reaches

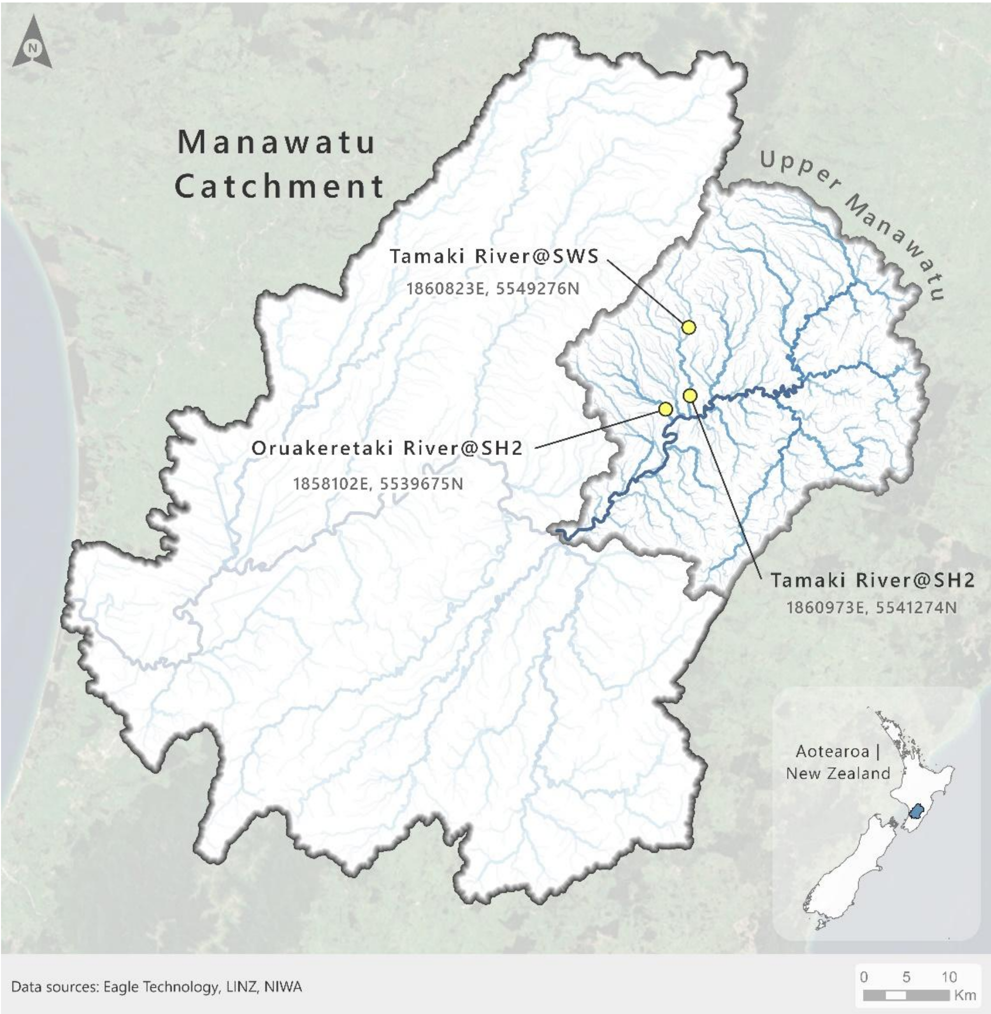


Figure 1. The upper Manawatū catchment, showing the locations of IFIM survey reaches being assessed in this report (coordinates: NZTM).

Tamaki River at State Highway 2 (SH2)

Retention of physical habitat properties

Table 4 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under the status quo scenario, there is practically no change in physical habitat features relative to flows at the naturalised 7DMALF. Under more abstractive scenarios, including Scenario 1b (with essential water takes included, which are additional to abstraction for irrigation), there is a moderate reduction in depth and riffle area (with the range of 12% and 15%, respectively) (Table 4).

Table 4. Tamaki River at SH2 retention values for physical habitat features relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	0.100	68	59	91	221	70	71
	0.110	70	61	91	211	70	76
	0.120	71	62	91	207	71	77
	0.130	73	64	90	198	73	80
	0.140	74	65	88	197	75	78
	0.150	76	66	87	197	79	73
	0.160	77	67	86	188	82	74
	0.170	80	67	84	184	81	77
	0.180	82	67	82	179	89	69
	0.190	85	68	79	163	91	76
	0.200	89	67	78	147	95	80
	0.210	90	69	79	141	102	75
	0.220	91	69	80	143	101	74
	0.230	92	71	81	136	104	74
	0.240	92	72	82	131	107	74
	0.250	93	73	83	128	107	76
	0.260	94	74	84	124	107	77
	0.270	94	75	85	126	105	79
	0.280	95	77	85	127	103	81
	0.290	95	78	87	120	105	82
	0.300	96	79	87	118	109	79
	0.310	96	80	87	118	109	78
	0.320	97	82	88	119	110	77
	0.330	97	82	89	116	109	79
	0.340	98	84	90	114	110	79
	0.350	98	85	90	115	106	83
	0.360	98	87	91	112	106	85
Scenario 1b - with essential take	0.366	98	88	92	113	106	85
	0.370	98	88	92	113	103	88
Scenario 1a - full utilisation	0.372	98	88	92	113	103	88
	0.380	98	89	93	114	103	88
Scenario 2 - realistic utilisation	0.382	98	89	93	114	103	88
	0.390	99	91	94	115	100	92
Measured (status quo) 7DMALF	0.397	99	91	94	115	99	93
	0.400	99	91	94	114	99	93
	0.410	99	93	95	100	103	96
	0.420	99	93	96	102	104	94
	0.430	99	95	97	103	105	92
	0.440	99	96	98	101	100	100
	0.450	100	97	98	102	100	99
	0.460	100	99	99	102	100	99
	0.470	100	99	100	101	100	100
Naturalised 7DMALF	0.475	100	100	100	100	100	100

Habitat retention for species and values

Table 5 shows AWS retention values for macroinvertebrates and food-producing habitat relative to the summer median flows. Under the status quo scenario, there is a 'moderate' reduction in habitat quantity / quality for the fast-current-loving *Zelandoperla* stonefly, but practically no change in AWS for food-producing habitat and other macroinvertebrates species. Under the estimated realistic water use scenario, *Zelandoperla* and *Aoteapsyche* habitat quality / quantity is moderately reduced. However, *Deleatidium* and food-producing habitat are practically unaffected by any of the abstraction scenarios relative to naturalised flows (Table 5).

Under the status quo scenario, with the exception of torrentfish, habitat retention for all native species remains in, or near to, the 'small' ecological risk category. For torrentfish, habitat quality / quantity is reduced by 30% under the status quo scenario relative to naturalised flows, indicating a 'high' risk of negative effects. Under more intensive abstraction scenarios, torrentfish habitat quality / quantity is reduced by up to 42% (under Scenario 1b) (high risk of negative effects), and there are moderate habitat reductions for other flow-sensitive values such as kōaro and juvenile longfin eel habitat (by 18% and 14%, respectively) (Table 6).

Under the status quo level of abstraction, habitat at the 7DMALF for brown and rainbow trout across all life history stages is reduced by about 15% relative to naturalised flows, indicating there is a 'moderate' risk of negative ecological effects. Under the most intensive abstraction scenario (Scenario 1b), habitat for all salmonid life history stages is reduced by 17–19% relative to naturalised flows, and therefore remains in the 'moderate' risk of negative effects bracket (Table 7).

Table 5. Tamaki River at SH2 percentage area-weighted suitability (AWS) retention values for benthic invertebrates relative to the naturalised summer median flow (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning caddis)	Hydrobiosidae (free-living caddis)	O. feredayi (cased caddis)
	0.850	88	93	65	74	158	100
	0.860	89	94	66	76	158	100
	0.870	90	94	68	77	159	100
	0.880	90	94	69	78	159	100
	0.890	91	95	70	79	159	100
	0.900	91	95	71	80	160	100
	0.910	92	95	73	81	160	100
	0.920	92	95	74	82	160	100
	0.930	93	96	76	83	161	100
	0.940	93	96	77	84	161	100
Scenario 1b - with essential take	0.942	94	96	77	84	94	100
Scenario 1a - full utilisation	0.946	94	96	78	85	95	100
	0.950	94	96	79	85	161	100
	0.960	95	97	80	86	161	100
Scenario 2 - realistic utilisation	0.965	95	97	81	87	95	100
	0.970	95	97	81	88	162	100
	0.980	95	97	83	89	162	100
	0.990	96	97	84	90	162	100
Measured (status-quo) Summer Median	0.998	96	98	86	91	96	100
	1.000	96	98	86	91	162	100
	1.010	97	98	87	92	163	100
	1.020	97	98	89	93	163	100
	1.030	98	99	91	94	163	100
	1.040	98	99	92	95	163	100
	1.050	99	99	94	96	164	100
	1.060	99	99	96	97	164	100
	1.070	99	100	97	98	164	100
	1.080	100	100	99	99	164	100
Naturalised Summer Median	1.086	100	100	100	100	100	100

Table 6. Tamaki River at SH2 percentage area-weighted suitability (AWS) retention values for native fish relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Dwarf galaxias	Torrentfish	Kōaro	Juvenile lamprey Jellyman & Glova (2002)	Banded kōkopu (adult)	Longfin eel <300mm	Longfin eel >300mm
	0.100	69	56	55	37	0	21	81	260	32	44
	0.110	70	58	57	39	1	24	81	244	34	47
	0.120	71	60	59	41	2	26	81	229	36	49
	0.130	73	61	61	43	3	29	81	217	39	51
	0.140	74	63	63	45	4	31	81	207	41	53
	0.150	76	64	65	47	5	33	81	198	43	55
	0.160	77	65	67	49	7	35	81	190	45	57
	0.170	79	66	69	52	8	37	81	182	47	59
	0.180	80	68	71	54	10	40	81	177	50	61
	0.190	81	69	73	56	11	42	81	172	52	63
	0.200	82	71	75	58	13	44	81	167	54	65
	0.210	83	72	77	59	15	47	81	161	56	66
	0.220	84	73	79	61	17	50	81	155	58	68
	0.230	85	75	81	63	19	52	81	150	60	70
	0.240	86	76	83	64	21	55	84	146	62	72
	0.250	88	78	84	66	23	57	84	142	64	73
	0.260	89	79	86	68	26	60	84	139	66	75
	0.270	90	80	87	70	28	62	86	136	67	77
	0.280	91	81	89	72	31	64	86	133	69	78
	0.290	92	83	90	74	34	67	86	129	71	80
	0.300	93	84	91	76	36	69	88	126	73	81
	0.310	94	85	93	78	39	71	88	123	75	83
	0.320	95	86	94	79	42	73	91	121	77	84
	0.330	96	87	95	81	46	75	91	119	79	86
	0.340	97	88	96	83	49	77	91	117	81	87
	0.350	98	90	97	85	52	79	93	116	83	88
	0.360	98	91	98	86	56	81	93	113	85	89
Scenario 1b - with essential take	0.366	99	92	98	87	58	82	93	113	86	90
	0.370	99	92	98	88	59	82	95	112	87	90
Scenario 1a - full utilisation	0.372	99	92	98	88	60	83	95	112	87	90
	0.380	100	93	99	89	63	84	95	111	89	91
Scenario 2 - realistic utilisation	0.382	100	94	99	90	64	85	95	111	89	92
	0.390	100	94	99	91	66	86	95	110	90	92
Measured (status quo) 7DMALF	0.397	100	95	99	92	69	87	98	110	91	93
	0.400	100	96	99	92	70	88	98	109	92	93
	0.410	101	97	100	94	74	89	95	104	93	94
	0.420	101	97	100	95	78	91	95	104	95	95
	0.430	101	98	100	96	82	93	95	102	96	96
	0.440	101	99	100	97	86	94	98	102	97	97
	0.450	100	99	100	98	90	96	98	101	98	98
	0.460	100	100	100	99	94	98	98	101	99	99
	0.470	100	100	100	100	98	99	98	101	100	100
Naturalised 7DMALF	0.475	100	100	100	100	100	100	100	100	100	100

Table 7. Tamaki River at SH2 percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout	Juvenile Brown and Rainbow trout	Brown trout adult	Brown trout spawning habitat	Juvenile Brown trout	Juvenile Rainbow trout feeding	Adult Rainbow trout feeding
		Wilding (2012)	Wilding (2012)	Hayes and Jowett (1994)	Shirvell and Dungey (1983)	Bovee (pers. comm)	Thomas and Bovee (1993)	Thomas and Bovee (1993)
	0.100	33	36	24	15	35	36	26
	0.110	35	38	25	19	37	38	28
	0.120	37	39	27	23	39	40	30
	0.130	39	41	29	26	41	42	32
	0.140	41	43	30	30	43	43	34
	0.150	43	45	32	33	45	45	36
	0.160	44	46	34	36	47	47	38
	0.170	47	48	36	39	49	49	40
	0.180	48	50	38	42	50	51	42
	0.190	50	52	40	45	52	52	44
	0.200	52	53	43	48	54	54	46
	0.210	54	55	45	50	56	56	48
	0.220	56	57	47	52	58	58	50
	0.230	58	59	49	54	60	60	52
	0.240	60	60	52	57	62	61	54
	0.250	61	62	54	59	64	63	56
	0.260	63	64	57	61	65	65	59
	0.270	65	66	59	63	67	67	60
	0.280	67	67	61	66	69	68	63
	0.290	69	69	64	68	71	70	64
	0.300	70	71	66	70	72	72	67
	0.310	72	72	69	72	74	73	68
	0.320	74	74	71	74	76	75	71
	0.330	76	76	73	76	77	77	73
	0.340	78	77	75	78	79	78	75
	0.350	79	79	77	80	81	80	77
	0.360	81	81	80	82	82	82	78
Scenario 1b - with essential take	0.366	82	82	80	83	83	83	80
	0.370	83	83	81	84	84	83	81
Scenario 1a - full utilisation	0.372	83	83	82	85	84	84	81
	0.380	84	84	84	86	86	85	82
Scenario 2 - realistic utilisation	0.382	85	85	84	86	86	85	83
	0.390	86	86	85	88	87	87	84
Measured (status quo) 7DMALF	0.397	87	87	86	89	88	88	86
	0.400	88	88	87	90	89	88	86
	0.410	89	89	89	91	90	90	88
	0.420	91	91	91	93	92	91	90
	0.430	93	93	93	95	93	93	92
	0.440	94	94	94	96	95	95	94
	0.450	96	96	96	97	96	96	96
	0.460	97	98	98	98	98	98	0
	0.470	99	99	99	100	99	99	0
Naturalised 7DMALF	0.475	100	100	100	100	100	100	100

Tamaki River at Water Supply Weir (WSW)

Of note in the following habitat retention tables (Tables 8–11), the status quo (measured flows) scenarios have a lower 7DMALF and summer median flow than Scenario 1a (full utilisation). We contacted Traverse Environmental (the organisation that undertook the scenario modelling) to check this and were assured that it is a true result. This suggests that there is potential for abstraction occurring above currently consented levels in the catchment, which may be worth further investigation. For the purposes of interpreting the habitat retention tables in this report, we have focused on the status quo scenario and Scenario 1b to indicate the range of potential abstraction effects.

Retention of physical habitat properties

Table 8 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under the status quo scenarios ,there is less than a 10% change in any physical habitat parameter relative to flows at the naturalised 7DMALF. Under more abstractive scenarios, including Scenario 1b (with essential water takes included), there is a moderate reduction in riffle area (between 13% and 19%, depending on the scenario (Table 8).

Table 8. Tamaki River at WSW retention values for physical habitat features relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	0	12	23	0	445	0	0
	0.01	39	49	27	318	49	11
	0.02	47	54	37	235	66	49
	0.03	51	58	44	225	65	62
	0.04	58	60	48	228	64	61
	0.05	64	61	51	224	59	74
	0.06	68	63	55	213	64	75
	0.07	71	67	60	190	63	98
	0.08	74	69	64	186	65	98
	0.09	77	70	66	184	68	93
	0.100	80	72	68	170	75	91
	0.110	82	74	70	170	78	84
	0.120	83	76	72	170	80	79
	0.130	85	77	74	167	82	77
	0.140	86	79	76	157	84	83
	0.150	87	81	78	149	87	82
	0.160	89	82	79	139	91	84
	0.170	90	83	81	138	93	81
	0.180	91	84	83	138	92	82
	0.190	92	86	84	135	92	84
	0.200	93	88	86	136	93	83
Scenario 1b - with essential take	0.210	94	89	87	139	92	81
	0.220	95	90	88	136	93	83
Measured (status quo) 7DMALF	0.230	96	91	90	131	94	83
	0.240	97	93	91	134	92	87
Scenario 1a - full utilisation	0.241	97	93	91	134	92	87
	0.250	98	94	93	129	92	90
	0.260	98	96	95	107	99	96
	0.270	99	97	96	105	102	92
	0.280	99	98	98	109	100	93
	0.290	100	100	100	105	98	100
Naturalised 7DMALF	0.293	100	100	100	100	100	100

Habitat retention for species and values

Table 9 shows AWS retention values for macroinvertebrates and food-producing habitat relative to the summer median flows. Under the status quo scenario, there is a high level of reduction in habitat quantity / quality for the fast-current-loving *Zelandoperla* stonefly (a reduction of 21%) and a moderate level of reduction for *Aoteapsyche*. There is practically no change in AWS for food-producing habitat and other macroinvertebrates species. The more intensive abstraction scenarios have essentially the same effect as the status quo scenario on macroinvertebrate and food-producing habitat (Table 9).

With the exception of torrentfish and juvenile lamprey habitat, native fish habitat at the 7DMALF for the species modelled is largely protected under the status quo level of abstraction. Depending on the scenario, torrentfish habitat quality / quantity is reduced by 34–51%, indicating a 'high' to 'very high' risk of negative effects. Likewise, juvenile lamprey habitat is reduced by 27–45 %. Habitat for longfin eels is reduced to an extent where there is a 'moderate' risk of ecological effects, while habitat for all other native fish species is within the 'small' risk threshold (Table 10).

Under the status quo level of abstraction, habitat at the 7DMALF for brown and rainbow trout across all life history stages is reduced by about 10% relative to naturalised flows. This level of reduction can be considered on the cusp of a 'small' to 'moderate' risk of ecological effects. Under the most intensive abstraction scenario (i.e. Scenario 1b), habitat for all salmonid life history stages is reduced by 15–25% relative to naturalised flows, meaning there is a 'moderate' to 'high' risk of negative ecological effects at flows around the 7DMALF (Table 11).

Table 9. Tamaki River at WSW percentage area-weighted suitability (AWS) retention values for benthic invertebrates relative to the naturalised summer median flow (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning caddis)	Hydrobiosidae (free-living caddis)	O. feredayi (cased caddis)
	0.450	82	90	54	69	92	97
	0.460	84	91	56	71	93	97
	0.470	85	92	58	73	93	97
	0.480	86	93	61	75	94	98
	0.490	88	93	63	77	95	98
	0.500	89	94	68	78	95	98
	0.510	90	95	70	80	96	98
	0.520	91	95	73	82	96	99
Scenario 1b - with essential take	0.525	92	96	75	83	96	99
Scenario 1a - full utilisation	0.526	92	96	75	83	96	99
	0.530	92	96	76	84	97	99
Measured (status-quo) Summer Median	0.538	93	96	79	86	97	99
	0.540	93	96	79	86	97	99
	0.550	94	97	82	88	98	99
	0.560	95	98	86	90	98	99
	0.570	96	98	89	93	98	99
	0.580	97	99	92	95	99	100
	0.590	98	99	96	97	99	100
	0.600	99	100	99	99	100	100
Naturalised Summer Median	0.606	100	100	100	100	100	100

Table 10. Tamaki River at WSW percentage area-weighted suitability (AWS) retention values for native fish relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Dwarf galaxias	Torrentfish	Kōaro	Juvenile lamprey Jellyman & Glova (2002)	Banded kōkopu (adult)	Longfin eel <300mm	Longfin eel >300mm
	0	6	4	6	4	0	0	27	144	1	41
	0.01	33	17	29	20	0	5	32	314	9	46
	0.02	46	27	38	29	0	9	32	313	16	48
	0.03	55	37	44	34	1	13	32	286	22	49
	0.04	61	45	49	38	3	17	32	261	27	51
	0.05	65	52	54	41	5	21	32	243	31	53
	0.06	69	57	59	45	6	25	32	226	35	54
	0.07	72	61	63	48	7	29	32	206	38	56
	0.08	76	63	67	52	9	33	32	189	42	58
	0.09	79	66	71	56	10	36	36	174	45	60
	0.100	83	68	75	60	12	40	36	159	50	62
	0.110	85	71	78	64	14	44	36	148	54	64
	0.120	88	73	82	68	16	47	36	139	58	66
	0.130	91	76	84	72	19	51	36	132	62	68
	0.140	93	79	87	75	22	54	41	126	66	70
	0.150	95	82	89	77	25	57	41	121	70	72
	0.160	97	85	90	80	28	61	41	117	74	75
	0.170	99	87	92	82	32	64	41	113	77	77
	0.180	100	90	93	84	35	67	45	111	80	79
	0.190	101	92	94	86	39	70	50	108	82	81
	0.200	101	94	95	87	44	73	55	107	85	83
Scenario 1b - with essential take	0.210	102	95	96	89	49	76	55	106	87	85
	0.220	102	97	97	90	54	79	64	105	89	87
Measured (status quo) 7DMALF	0.230	102	98	98	91	59	83	68	104	91	88
	0.240	101	99	98	93	65	86	73	104	93	90
Scenario 1a - full utilisation	0.241	101	99	98	93	66	86	73	104	93	91
	0.250	101	100	99	94	71	89	77	101	94	92
	0.260	101	100	99	96	78	91	82	98	96	94
	0.270	101	100	100	97	84	94	86	98	97	96
	0.280	100	100	100	98	91	97	91	99	98	97
	0.290	100	100	100	100	98	99	100	99	100	99
Naturalised 7DMALF	0.293	100	100	100	100	100	100	100	100	100	100

Table 11. Tamaki River at WSW percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Tamaki River at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout Wilding (2012)	Juvenile Brown and Rainbow trout Wilding (2012)	Brown trout adult Hayes and Jowett (1994)	Brown trout spawning habitat Shirvell and Dungey (1983)	Juvenile Brown trout Bovee (pers. comm)	Juvenile Rainbow trout feeding Thomas and Bovee (1993)	Adult Rainbow trout feeding Thomas and Bovee (1993)
	0	12	9	19	0	8	11	5
	0.01	21	16	23	1	17	18	12
	0.02	26	20	25	2	21	22	16
	0.03	30	24	28	4	26	26	20
	0.04	33	27	30	5	30	29	24
	0.05	37	31	32	8	33	32	27
	0.06	40	34	34	11	37	35	31
	0.07	44	37	36	15	40	38	35
	0.08	47	40	38	19	44	42	38
	0.09	50	43	40	24	47	45	42
	0.100	53	46	43	28	50	48	45
	0.110	56	49	45	32	54	51	48
	0.120	59	52	47	36	57	54	51
	0.130	62	55	49	39	60	56	54
	0.140	64	58	53	43	62	59	58
	0.150	67	60	55	46	65	62	61
	0.160	69	63	57	50	68	65	64
	0.170	73	66	60	54	71	68	66
	0.180	75	69	62	59	73	71	69
	0.190	78	72	66	63	76	73	72
	0.200	80	75	70	67	78	77	75
Scenario 1b - with essential take	0.210	82	78	72	71	81	79	78
	0.220	84	80	75	76	83	82	81
Measured (status quo) 7DMALF	0.230	87	83	79	80	86	85	83
	0.240	89	86	81	83	88	87	86
Scenario 1a - full utilisation	0.241	89	86	83	84	88	88	87
	0.250	91	89	85	87	90	90	89
	0.260	93	91	89	91	93	92	91
	0.270	96	94	92	94	95	95	94
	0.280	98	97	94	97	97	97	97
	0.290	100	99	98	99	99	99	99
Naturalised 7DMALF	0.293	100	100	100	100	100	100	100

Ōruakeretaki Stream

Retention of physical habitat properties

Table 12 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under the status quo abstraction scenarios, there is almost no change in average width, depth and velocity relative to the naturalised 7DMALF. Under more abstractive scenarios, there is a moderate reduction in widths, depths and velocities. For example, under the maximum use scenario (Scenario 1a), there is a 12%, 17% and 16% reduction in wetted width, depth and velocity, respectively, relative to the naturalised 7DMALF (Table 12).

Table 12. Ōruakeretaki Stream retention values for physical habitat features relative to the naturalised 7-day MALF (Ōruakeretaki Stream at SH2 flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	0.000	18	21	0	403	0	0
	0.010	54	39	36	239	42	72
	0.020	60	46	43	220	52	72
	0.030	66	49	49	181	72	75
	0.040	69	54	54	169	79	75
	0.050	72	58	58	164	81	75
	0.060	74	61	62	156	79	85
	0.070	77	63	64	155	82	82
	0.080	78	65	65	148	89	78
	0.090	80	68	67	140	90	83
	0.100	81	70	70	139	90	82
	0.110	82	73	73	137	89	85
	0.120	83	75	75	126	93	89
	0.130	84	76	77	123	94	90
	0.140	85	78	79	114	99	90
	0.150	86	80	81	117	99	89
	0.160	87	82	82	110	101	91
Scenario 1a - full utilisation	0.166	88	83	84	106	103	91
	0.170	88	83	84	104	106	88
	0.180	89	85	86	99	109	88
	0.190	91	85	84	102	110	85
	0.200	93	87	85	104	109	83
	0.210	94	88	86	100	113	81
	0.220	94	89	88	97	112	85
	0.230	95	91	89	97	112	86
Scenario 2 - realistic utilisation	0.233	96	91	89	96	111	86
	0.240	96	92	91	94	110	89
	0.250	97	93	92	93	109	92
	0.260	97	94	94	96	107	93
	0.270	98	96	95	96	105	96
	0.280	98	96	96	98	105	95
Measured (status quo) 7DMALF	0.287	99	98	97	99	103	97
	0.290	99	98	97	99	101	99
	0.300	100	99	99	99	100	100
Naturalised 7DMALF	0.309	100	100	100	100	100	100

Habitat retention for species and values

Table 13 shows AWS retention values for macroinvertebrates and food-producing habitat relative to the summer median flows. Under the status quo scenario, there is little change, or a very slight reduction, for food-producing habitat and macroinvertebrates species. Under the estimated realistic utilisation of maximum allocated abstraction, *Aoteapsyche* and *Zelandoperla* habitat is reduced by 16% and 29% , respectively, relative to naturalised 7DMALF, indicating a 'moderate' to 'high' risk of negative effects . *Deleatidium* habitat is only slightly reduced by any of the abstraction scenarios relative to naturalised flows. Food-producing habitat is reduced to the extent that there is a 'moderate' risk of negative effects under the maximum abstraction scenario (Table 13).

Native fish habitat at the 7DMALF for the species modelled is largely protected under the status quo level of abstraction. Under the more intensive, realistic abstraction scenario, torrentfish, kōaro and juvenile lamprey habitat retention is reduced by 40%, 16% and 40%, respectively, relative to naturalised 7DMALF. This indicates a 'moderate' to 'very high' risk of negative effects (Table 14).

Under the status quo level of abstraction, habitat at the 7DMALF for brown and rainbow trout across all life history stages shows almost no change. Under maximum realistic abstraction scenarios, habitat for all salmonid life history stages is reduced by 13–21% relative to naturalised flows, suggesting there would be a 'moderate' level of ecological risk of negative effects at flows around the 7DMALF if all available water was allocated (Table 15). Full water utilisation would result in a substantial loss of habitat quantity / quality, with reductions of around 35–45% across both species and all life history stages. This would indicate a 'very high' risk of ecological effects for trout.

Table 13. Ōruakeretaki Stream percentage area-weighted suitability (AWS) retention values for benthic invertebrates relative to the naturalised summer median flow (Ōruakeretaki Stream at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning)	Hydrobiosidae (free-living	O. feredayi
	0.390	73	81	33	56	85	91
	0.400	75	82	35	58	86	92
	0.410	76	83	37	60	87	92
	0.420	77	84	39	61	87	92
	0.430	79	84	41	63	88	93
	0.440	80	85	42	64	89	93
	0.450	81	86	44	66	89	94
	0.460	82	87	46	67	90	94
	0.470	83	87	49	69	90	94
	0.480	84	88	51	71	91	95
	0.490	85	89	53	72	91	95
	0.500	86	89	56	74	92	95
	0.510	87	90	58	76	92	96
Scenario 1a - full utilisation	0.514	88	90	58	76	92	96
	0.520	88	91	60	77	93	96
	0.530	89	91	62	79	93	96
	0.540	90	92	65	80	94	96
	0.550	91	93	67	82	94	97
	0.560	92	93	69	83	95	97
Scenario 2 - realistic utilisation	0.567	92	94	71	84	95	97
	0.570	93	94	72	85	96	98
	0.580	93	95	74	86	96	98
	0.590	94	95	76	88	96	98
	0.600	95	96	79	89	97	98
	0.610	96	96	82	91	97	99
	0.620	96	97	85	92	98	99
	0.630	97	98	88	94	98	99
	0.640	98	98	91	95	99	99
	0.650	99	99	93	97	99	100
Measured (status-quo) Summer Median	0.653	99	99	94	97	99	100
	0.660	99	99	96	98	99	100
	0.670	100	100	99	100	100	100
Naturalised Summmer Median	0.672	100	100	100	100	100	100

Table 14. Ōruakeretaki Stream percentage area-weighted suitability (AWS) retention values for native fish relative to the naturalised 7-day MALF (Ōruakeretaki Stream at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Dwarf Galaxias	Torrentfish	Kōaro	Juvenile lamprey Jellyman & Glova (2002)	Banded kōkopu (adult)	Longfin eel <300mm	Longfin eel >300mm
	0.000	13	7	12	8	0	0	60	215	2	25
	0.010	46	22	39	24	0	5	60	392	9	26
	0.020	63	37	51	35	0	10	60	409	18	27
	0.030	74	49	60	42	0	15	60	401	28	29
	0.040	82	60	66	48	1	20	60	392	36	31
	0.050	86	69	71	52	1	25	60	364	44	33
	0.060	90	76	75	55	2	29	60	327	50	36
	0.070	93	81	78	58	3	34	60	292	56	39
	0.080	95	86	81	60	5	38	60	267	60	41
	0.090	96	90	83	63	6	42	60	247	64	44
	0.100	97	93	85	65	8	45	60	230	67	46
	0.110	98	95	87	68	10	49	60	212	70	49
	0.120	99	96	88	70	13	52	60	197	73	51
	0.130	100	97	90	72	16	56	60	182	75	54
	0.140	100	97	91	74	19	59	60	169	77	56
	0.150	100	98	93	77	22	62	60	156	80	59
	0.160	101	98	94	79	26	65	60	143	82	62
Scenario 1a - full utilisation	0.166	101	99	94	80	28	66	60	136	83	63
	0.170	101	99	95	81	30	68	60	131	84	64
	0.180	101	99	95	83	34	70	60	125	86	67
	0.190	101	100	96	84	39	73	60	122	88	70
	0.200	101	100	97	85	43	76	60	121	89	73
	0.210	101	100	97	87	48	78	60	119	91	76
	0.220	101	101	98	88	53	81	60	118	92	78
	0.230	100	101	98	89	59	83	60	116	93	81
Scenario 2 - realistic utilisation	0.233	100	101	99	90	60	84	60	115	93	82
	0.240	100	101	99	91	64	86	60	114	94	84
	0.250	100	101	99	92	70	88	60	112	95	86
	0.260	100	101	100	94	75	90	60	109	96	88
	0.270	100	101	100	95	80	92	60	107	97	90
	0.280	100	100	100	97	85	94	60	105	98	93
Measured (status quo) 7DMALF	0.287	100	100	100	97	89	96	100	103	98	95
	0.290	100	100	100	98	91	96	100	103	98	95
	0.300	100	100	100	99	96	98	100	101	99	98
Naturalised 7DMALF	0.309	100	100	100	100	100	100	100	100	100	100

Table 15. Ōruakeretaki Stream percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Ōruakeretaki Stream at SH2 flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7 day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.1 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout Wilding (2012)	Juvenile Brown and Rainbow trout Wilding (2012)	Brown trout adult Hayes and Jowett (1994)	Brown trout spawning habitat Shirvell and Dungey (1983)	Juvenile Brown trout Bovee (pers. comm)	Juvenile Rainbow trout feeding Thomas and Bovee (1993)	Adult Rainbow trout feeding Thomas and Bovee (1993)
	0.000	26	8	37	0	7	10	12
	0.010	34	16	40	0	16	17	19
	0.020	39	20	41	0	21	21	23
	0.030	42	24	43	1	25	24	27
	0.040	45	28	46	4	29	27	30
	0.050	48	31	47	8	32	30	33
	0.060	51	34	49	11	35	32	36
	0.070	54	37	50	16	39	35	40
	0.080	55	40	53	21	42	38	43
	0.090	58	42	54	26	45	40	46
	0.100	61	45	56	32	48	43	49
	0.110	63	48	57	37	50	46	51
	0.120	65	50	59	42	53	49	54
	0.130	67	53	62	47	56	52	57
	0.140	69	55	63	52	59	55	60
	0.150	71	58	65	57	61	58	62
	0.160	73	60	66	61	64	61	65
Scenario 1a - full utilisation	0.166	74	62	68	64	66	62	67
	0.170	75	63	69	65	67	63	68
	0.180	77	65	71	69	69	66	71
	0.190	79	68	72	72	72	69	73
	0.200	81	70	75	75	74	72	76
	0.210	83	73	76	77	77	75	78
	0.220	85	75	79	80	79	77	80
	0.230	86	78	81	82	82	80	83
Scenario 2 - realistic utilisation	0.233	87	79	81	83	83	81	83
	0.240	88	81	82	85	84	83	85
	0.250	90	83	85	88	87	85	87
	0.260	92	86	87	90	89	88	90
	0.270	94	89	90	92	91	90	92
	0.280	95	92	91	94	93	93	94
Measured (status quo) 7DMALF	0.287	96	94	94	96	95	95	96
	0.290	97	94	94	96	96	95	96
	0.300	99	97	97	98	98	98	98
Naturalised 7DMALF	0.309	100	100	100	100	100	100	100

5.2 Mid–lower Rangitīkei River IFIM reaches

Figure 2. The mid–lower Rangitīkei catchment, showing the locations of IFIM survey reaches being assessed in this report (coordinates: NZTM).

Otara reach

Retention of physical habitat properties

Table 16 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under all abstraction scenarios, there is practically no change in any physical habitat features relative to the naturalised 7DMALF (Table 16).

Table 16. Otara IFIM reach retention values for physical habitat features relative to the naturalised 7-day MALF (Rangitīkei River at Mangaweka flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	4.00	65	73	71	153	39	106
	4.20	66	73	72	154	39	105
	4.40	67	74	73	151	40	108
	4.60	68	75	74	149	40	110
	4.80	69	75	76	148	40	110
	5.00	69	76	77	146	42	112
	5.20	71	77	76	147	43	109
	5.40	72	77	77	147	43	109
	5.60	73	78	78	145	42	111
	5.80	74	78	79	143	44	113
	6.00	74	79	80	143	45	111
	6.20	75	80	80	144	44	111
	6.40	76	81	81	142	45	112
	6.60	76	81	82	143	46	111
	6.80	77	82	83	142	46	111
	7.00	78	82	83	141	46	112
	7.20	79	83	84	141	46	111
	7.40	79	84	84	142	46	111
	7.60	80	84	85	137	52	110
	7.80	81	85	85	138	52	109
	8.00	82	85	86	136	56	107
	8.20	83	86	86	135	57	107
	8.40	84	87	87	135	57	107
	8.60	85	87	88	135	57	108
	8.80	86	88	88	134	58	107
	9.00	88	88	88	132	61	107
	9.20	90	89	88	131	59	109
	9.40	91	89	89	132	60	107
	9.60	92	90	89	129	63	108
	9.80	93	90	90	128	63	109
	10.00	93	91	91	126	65	108
	10.20	94	91	91	124	68	108
	10.40	95	92	92	123	69	107
	10.60	95	92	92	121	72	107
	10.80	96	93	93	120	74	106
	11.00	97	94	93	121	75	104
	11.20	97	94	94	119	76	105
	11.40	98	95	95	119	77	104
	11.60	98	95	95	117	79	103
	11.80	98	96	96	118	79	103
	12.00	99	96	96	111	85	104
	12.20	99	97	97	109	88	103
	12.40	99	97	98	105	93	103
	12.60	99	98	98	103	95	103
Scenario 1 - full utilisation	12.76	99	98	99	102	98	101
	12.80	99	99	99	102	98	101
	12.90	100	99	99	102	98	101
Scenario 2 - realistic utilisation	12.98	100	99	99	102	98	101
	13.00	100	99	99	102	98	101
	13.20	100	100	100	101	99	100
Measured (status quo) 7DMALF	13.26	100	100	100	100	100	100
	13.30	100	100	100	100	100	100
Naturalised 7DMALF	13.33	100	100	100	100	100	100

Habitat retention for species and values

Tables 17–20 show that, under all modelled abstraction scenarios (from status quo through to maximum utilisation), AWS retention values for macroinvertebrates (and food-producing habitat), native fish and salmonids are practically unchanged relative to the naturalised flows.

Table 17. Otara IFIM reach percentage area-weighted suitability (AWS) retention values for invertebrates relative to the naturalised summer median flow (Rangitīkei River at Mangaweka flow recorder). Habitat retention is calculated as the percentage change of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning caddis)	Hydrobiosidae (free-living caddis)	O. feredayi (cased caddis)
	18.00	106	103	86	102	100	101
	18.20	106	103	87	102	100	101
	18.40	106	103	87	103	100	101
	18.60	106	103	88	103	100	101
	18.80	106	103	88	103	100	101
	19.00	106	103	89	103	100	101
	19.20	106	103	89	103	100	101
	19.40	106	103	90	103	100	101
	19.60	105	103	90	103	100	101
	19.80	105	103	91	103	100	101
	20.00	105	103	92	103	100	101
	20.20	105	102	92	102	100	101
	20.40	105	102	93	102	100	101
	20.60	105	102	93	102	100	101
	20.80	104	102	94	102	100	101
	21.00	104	102	94	102	100	101
	21.20	104	102	95	102	101	101
	21.40	104	102	95	102	101	101
	21.60	103	102	95	102	101	101
	21.80	103	102	96	102	101	101
	22.00	103	102	96	102	100	101
	22.20	103	101	97	102	100	101
	22.40	102	101	97	101	100	101
	22.60	102	101	98	101	100	101
	22.80	102	101	98	101	100	101
	23.00	102	101	98	101	100	101
	23.20	102	101	99	101	100	100
	23.40	101	101	99	101	100	100
	23.60	101	101	99	101	100	100
Scenario 1 - full utilisation	23.71	101	100	99	101	100	100
	23.80	101	100	99	100	100	100
	24.00	101	100	100	100	100	100
Scenario 2 - realistic utilisation	24.04	100	100	100	100	100	100
	24.10	100	100	100	100	100	100
	24.20	100	100	100	100	100	100
Measured (status-quo) Summer Median	24.25	100	100	100	100	100	100
	24.30	100	100	100	100	100	100
Naturalised Summer Median	24.35	100	100	100	100	100	100

Table 18. Otara IFIM reach percentage area-weighted suitability (AWS) retention values for native fish (excluding eels) relative to the naturalised 7-day MALF (Rangitīkei River at Mangaweka flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Redfin bully	Torrentfish	Īnanga feeding Jowett (2002)	Kōaro	Smelt
	4.00	77	107	74	89	49	110	82	202
	4.20	78	107	76	89	50	108	85	198
	4.40	78	106	77	90	52	106	87	193
	4.60	77	104	77	89	54	105	91	188
	4.80	76	102	77	88	56	103	94	183
	5.00	75	101	77	88	58	102	96	178
	5.20	75	100	76	88	59	100	98	173
	5.40	74	98	76	88	61	99	100	168
	5.60	73	96	76	88	64	98	101	164
	5.80	72	95	76	88	66	98	103	160
	6.00	72	93	76	88	68	97	104	157
	6.20	71	92	76	88	70	97	105	153
	6.40	71	91	76	87	73	96	106	150
	6.60	71	91	76	86	75	96	106	148
	6.80	71	90	75	85	77	95	106	145
	7.00	70	90	75	85	79	94	106	143
	7.20	70	89	75	84	81	94	107	141
	7.40	70	88	75	83	83	93	106	139
	7.60	70	87	75	83	84	93	106	138
	7.80	70	87	75	83	86	92	106	136
	8.00	70	86	76	82	87	92	106	134
	8.20	70	86	77	82	89	91	106	132
	8.40	70	86	77	82	90	91	105	131
	8.60	70	85	78	82	91	91	106	129
	8.80	71	85	79	82	92	91	105	127
	9.00	72	85	80	83	93	91	105	126
	9.20	72	85	80	82	95	91	105	124
	9.40	73	85	81	83	95	91	105	123
	9.60	74	85	83	84	96	92	105	122
	9.80	75	86	84	86	96	92	104	120
	10.00	77	86	86	87	97	92	104	119
	10.20	78	87	87	89	98	92	104	118
	10.40	79	87	89	90	98	93	104	116
	10.60	81	88	90	91	99	93	103	115
	10.80	83	88	91	93	99	93	103	114
	11.00	84	89	93	94	99	94	103	112
	11.20	86	90	94	95	100	94	103	111
	11.40	87	90	95	96	100	94	102	110
	11.60	89	91	97	97	100	95	102	109
	11.80	91	91	98	98	100	95	102	107
	12.00	93	91	98	99	100	96	101	106
	12.20	95	92	99	100	100	96	101	105
	12.40	96	93	100	101	100	97	101	104
	12.60	98	95	100	101	100	98	101	103
Scenario 1 - full utilisation	12.76	99	96	101	100	100	98	101	103
	12.80	99	96	101	100	100	98	101	102
	12.90	100	97	100	100	100	99	100	102
Scenario 2 - realistic utilisation	12.98	100	98	100	100	100	99	100	102
	13.00	100	98	100	100	100	99	100	101
	13.20	100	99	100	100	100	100	100	101
Measured (status quo) 7DMALF	13.26	100	100	100	100	100	100	100	100
	13.30	100	100	100	100	100	100	100	100
Naturalised 7DMALF	13.33	100	100	100	100	100	100	100	100

Table 19. Otara IFIM reach percentage area-weighted suitability (AWS) retention values for eels relative to the naturalised 7-day MALF (Rangitīkei River at Mangaweka flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7 day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. The source used for the eel habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Longfin eel <300mm	Longfin eel >300mm	Shortfin eel <300mm	Shortfin eel >300mm
	4.00	72	148	115	148
	4.20	75	148	116	147
	4.40	77	149	116	145
	4.60	80	149	116	144
	4.80	82	149	116	142
	5.00	84	148	116	141
	5.20	85	147	115	139
	5.40	86	146	115	137
	5.60	87	145	115	135
	5.80	88	144	114	133
	6.00	88	142	113	131
	6.20	89	141	113	129
	6.40	89	140	112	127
	6.60	90	139	112	125
	6.80	90	137	111	123
	7.00	90	136	110	121
	7.20	90	135	110	120
	7.40	89	133	109	118
	7.60	89	132	108	116
	7.80	89	130	107	114
	8.00	89	129	107	112
	8.20	89	128	106	111
	8.40	89	126	105	110
	8.60	89	125	104	108
	8.80	89	123	103	107
	9.00	89	122	103	106
	9.20	89	121	101	105
	9.40	89	119	101	104
	9.60	89	118	101	103
	9.80	89	117	100	102
	10.00	89	115	100	101
	10.20	89	114	100	101
	10.40	89	112	100	100
	10.60	90	111	100	100
	10.80	90	110	100	99
	11.00	90	109	100	99
	11.20	90	108	100	99
	11.40	91	107	100	99
	11.60	91	106	100	99
	11.80	92	105	100	99
	12.00	93	104	100	99
	12.20	94	103	100	99
	12.40	95	103	100	99
	12.60	97	102	100	99
Scenario 1 - full utilisation	12.76	98	101	100	99
	12.80	98	101	100	99
	12.90	98	101	100	99
Scenario 2 - realistic utilisation	12.98	99	101	100	99
	13.00	99	101	100	99
	13.20	100	100	100	100
Measured (status quo) 7DMALF	13.26	100	100	100	100
	13.30	100	100	100	100
Naturalised 7DMALF	13.33	100	100	100	100

Table 20. Otara IFIM reach percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Rangitīkei River at Mangaweka flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout Wilding (2012)	Juvenile Brown and Rainbow trout Wilding (2012)	Brown trout adult Hayes and Jowett (1994)	Brown trout spawning habitat Shirvell and Dungey (1983)	Juvenile Brown trout Bovee (pers. comm)	Juvenile Rainbow trout feeding Thomas and Bovee (1993)	Adult Rainbow trout feeding Thomas and Bovee (1993)
	4.00	48	65	71	113	77	79	49
	4.20	49	66	74	112	78	80	51
	4.40	50	68	76	112	80	81	52
	4.60	51	69	79	112	81	82	54
	4.80	53	70	81	112	82	83	56
	5.00	54	71	84	112	83	84	57
	5.20	55	72	86	112	84	84	59
	5.40	56	73	87	113	85	85	60
	5.60	57	74	89	113	86	86	62
	5.80	59	75	90	114	87	86	63
	6.00	60	76	92	114	87	87	64
	6.20	61	77	93	114	88	87	66
	6.40	62	77	94	112	89	88	67
	6.60	64	78	96	111	90	88	69
	6.80	65	79	97	110	90	89	70
	7.00	66	80	98	109	91	89	71
	7.20	67	81	99	108	92	90	73
	7.40	68	81	100	107	92	90	74
	7.60	69	82	101	106	93	90	75
	7.80	71	83	102	104	93	91	76
	8.00	72	83	103	103	94	91	77
	8.20	73	84	103	101	94	92	78
	8.40	74	85	104	100	95	92	79
	8.60	75	85	105	101	95	92	81
	8.80	76	86	105	100	95	93	82
	9.00	78	87	106	99	96	93	83
	9.20	79	88	106	97	96	94	84
	9.40	80	88	106	96	97	94	85
	9.60	81	89	106	96	97	94	86
	9.80	82	90	106	95	97	95	86
	10.00	83	90	106	95	97	95	87
	10.20	84	91	106	94	98	95	88
	10.40	85	92	106	94	98	96	89
	10.60	86	92	106	94	98	96	90
	10.80	87	93	105	94	98	96	91
	11.00	88	94	105	93	99	96	92
	11.20	89	94	105	94	99	97	93
	11.40	91	95	104	94	99	97	93
	11.60	92	95	104	94	99	97	94
	11.80	93	96	103	94	99	98	95
	12.00	94	97	103	94	99	98	96
	12.20	95	97	102	95	99	98	96
	12.40	96	98	102	95	100	99	97
	12.60	97	98	102	96	100	99	98
Scenario 1 - full utilisation	12.76	97	99	101	96	100	99	98
	12.80	97	99	101	96	100	99	98
	12.90	98	99	101	97	100	99	99
Scenario 2 - realistic utilisation	12.98	98	99	101	97	100	100	99
	13.00	98	99	101	97	100	100	99
	13.20	99	100	100	99	100	100	100
Measured (status quo) 7DMALF	13.26	100	100	100	99	100	100	100
	13.30	100	100	100	100	100	100	100
Naturalised 7DMALF	13.33	100	100	100	100	100	100	100

Onepuhi reach

The Onepuhi IFIM reach is located at the end of the Onepuhi Road.

Retention of physical habitat properties

Table 21 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under all abstraction scenarios ,there is practically no change in average width, depth and velocity relative to the naturalised 7DMALF. However, under the realistic and maximum allocation scenarios, there is a 27% reduction in riffle area relative to the naturalised 7DMALF. This is likely due to a slight reduction in flows, causing a small, shallow side braid to lose flow (Table 21).

Table 21. Onepuhi IFIM reach retention values for physical habitat features relative to the naturalised 7-day MALF (Rangitīkei River at Onepuhi flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	4.00	83	68	52	267	39	59
	4.20	84	69	53	265	40	58
	4.40	85	70	54	262	42	56
	4.60	85	71	56	262	42	56
	4.80	86	72	57	262	42	55
	5.00	86	73	58	255	44	59
	5.20	87	73	59	249	46	61
	5.40	87	74	60	245	48	60
	5.60	88	75	61	245	48	62
	5.80	88	76	62	238	50	64
	6.00	88	76	64	237	50	64
	6.20	89	77	65	236	50	66
	6.40	89	78	66	229	53	66
	6.60	89	79	67	229	53	68
	6.80	89	79	68	228	53	68
	7.00	90	80	69	225	54	69
	7.20	90	81	70	222	55	69
	7.40	90	82	71	219	56	71
	7.60	90	82	72	214	58	72
	7.80	90	83	73	215	58	72
	8.00	91	84	74	212	59	72
	8.20	91	84	75	212	59	73
	8.40	91	85	76	211	59	75
	8.60	91	85	77	206	61	72
	8.80	91	86	78	201	64	73
	9.00	92	87	79	201	63	73
	9.20	92	87	79	194	66	74
	9.40	92	88	80	188	68	75
	9.60	92	88	81	181	72	74
	9.80	92	89	82	175	74	77
	10.00	93	89	83	173	75	75
	10.20	93	90	84	172	75	76
	10.40	93	90	84	169	76	76
	10.60	94	91	85	162	80	75
	10.80	94	91	86	155	83	74
	11.00	94	92	86	154	83	75
	11.20	95	92	87	148	86	74
	11.40	95	93	88	146	86	76
	11.60	96	93	88	139	90	75
	11.80	96	93	89	135	91	75
	12.00	96	94	90	135	91	75
	12.20	97	94	90	133	92	76
	12.40	97	95	91	132	93	75
	12.60	97	95	92	130	93	75
	12.80	98	96	92	126	95	75
	13.00	98	96	93	126	96	74
	13.20	98	96	94	126	96	74
	13.40	98	97	94	126	96	73
Scenario 1 - full utilisation	13.57	99	97	95	124	97	73
	13.60	99	97	95	124	97	73
	13.80	99	98	95	125	96	73
	14.00	99	98	96	125	96	73
	14.20	99	99	97	123	97	74
Scenario 2 - realistic utilisation	14.37	100	99	97	122	98	73
	14.40	100	99	97	122	98	73
	14.60	100	99	99	102	99	101
Measured (status quo) 7DMALF	14.67	100	100	99	102	99	102
	14.70	100	100	99	102	99	102
	14.80	100	100	100	100	100	101
Naturalised 7DMALF	14.90	100	100	100	100	100	100

Habitat retention for species and values

Tables 22–25 show that AWS retention values for macroinvertebrates (and food-producing habitat), native fish and salmonids are all almost unaffected relative to the naturalised flows under any of the modelled scenarios, from status quo through to maximum utilisation.

Table 22. Onepuhi IFIM reach percentage area-weighted suitability (AWS) retention values for invertebrates relative to the naturalised summer median flow (Rangitīkei River at Onepuhi flow recorder). Habitat retention is calculated as the percentage change of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning caddis)	Hydrobiosidae (free-living caddis)	O. feredayi (cased caddis)
	18.00	102	112	78	91	100	106
	18.20	102	112	78	91	100	106
	18.40	102	111	79	92	100	106
	18.60	102	111	80	92	100	106
	18.80	103	111	81	93	100	105
	19.00	103	110	81	93	100	105
	19.20	103	110	82	93	100	105
	19.40	103	110	83	94	100	105
	19.60	103	109	83	94	100	105
	19.80	103	109	84	94	100	105
	20.00	103	109	84	95	100	105
	20.20	103	108	85	95	100	104
	20.40	103	108	86	95	100	104
	20.60	103	108	86	96	100	104
	20.80	103	107	87	96	100	104
	21.00	103	107	88	96	100	104
	21.20	103	107	88	97	100	104
	21.40	103	106	89	97	100	103
	21.60	103	106	89	97	100	103
	21.80	103	106	90	97	100	103
	22.00	102	105	91	98	100	103
	22.20	102	105	91	98	100	103
	22.40	102	105	92	98	100	103
	22.60	102	104	92	98	100	102
	22.80	102	104	93	98	100	102
	23.00	102	104	93	98	100	102
	23.20	102	103	94	99	100	102
	23.40	102	103	95	99	100	102
	23.60	102	103	95	99	100	102
	23.80	101	102	96	99	100	101
Scenario 1 - full utilisation	23.90	101	102	96	99	100	101
	24.00	101	102	96	99	100	101
	24.20	101	102	97	99	100	101
	24.40	101	102	97	99	100	101
	24.60	101	101	98	100	100	101
Scenario 2 - realistic utilisation	24.77	101	101	98	100	100	101
	24.80	101	101	98	100	100	101
	25.00	100	101	99	100	100	100
	25.20	100	100	99	100	100	100
Measured (status-quo) Summer Median	25.27	100	100	99	100	100	100
	25.30	100	100	99	100	100	100
	25.40	100	100	100	100	100	100
Naturalised Summer Median	25.54	100	100	100	100	100	100

Table 23. Onepuhi IFIM reach percentage area-weighted suitability (AWS) retention values for native fish (excluding eels) relative to the naturalised 7-day MALF (Rangitīkei River at Onepuhi flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Redfin bully	Torrentfish	Īnanga feeding	Kōaro	Smelt
							Jowett (2002)		
	4.00	203	226	164	182	66	453	131	231
	4.20	196	222	162	179	68	428	131	230
	4.40	191	217	160	175	70	403	132	229
	4.60	186	213	158	172	72	379	133	227
	4.80	181	208	156	169	74	359	133	225
	5.00	178	205	155	166	76	341	134	223
	5.20	176	202	153	164	79	328	135	220
	5.40	173	199	151	162	81	315	135	217
	5.60	171	196	148	161	84	303	136	214
	5.80	169	193	146	160	86	291	136	210
	6.00	166	191	144	158	89	281	137	207
	6.20	164	189	142	156	91	269	137	203
	6.40	163	187	139	155	93	260	137	200
	6.60	161	184	137	153	95	251	137	196
	6.80	159	182	134	151	97	243	137	193
	7.00	157	180	132	149	98	236	137	189
	7.20	155	178	130	147	100	229	137	186
	7.40	152	176	127	145	101	223	136	182
	7.60	150	173	125	142	103	218	136	179
	7.80	147	171	123	140	104	214	135	175
	8.00	144	168	121	137	105	211	134	172
	8.20	142	166	119	135	106	207	133	168
	8.40	139	163	117	133	107	203	133	165
	8.60	137	160	115	130	108	199	132	161
	8.80	134	157	113	128	109	195	130	158
	9.00	132	154	111	126	109	192	129	155
	9.20	129	151	110	124	110	188	128	152
	9.40	127	148	108	122	110	184	127	150
	9.60	124	146	107	120	110	180	125	147
	9.80	122	143	106	118	111	176	124	145
	10.00	120	140	104	116	111	172	123	142
	10.20	118	137	103	114	111	168	122	140
	10.40	116	135	102	113	111	164	120	138
	10.60	114	132	101	111	111	161	119	136
	10.80	113	130	100	110	111	158	118	134
	11.00	111	128	99	109	111	155	116	132
	11.20	110	126	99	107	111	153	115	130
	11.40	108	123	98	106	111	150	114	128
	11.60	107	121	98	106	110	148	113	126
	11.80	106	119	98	105	110	146	111	125
	12.00	105	117	98	104	110	144	110	123
	12.20	104	116	98	103	109	142	109	121
	12.40	103	114	98	103	109	140	108	119
	12.60	103	112	98	102	108	139	107	118
	12.80	103	111	98	102	108	138	106	116
	13.00	103	109	98	102	107	137	105	114
	13.20	102	108	98	101	107	135	104	113
	13.40	102	106	99	101	106	134	103	111
Scenario 1 - full utilisation	13.57	102	105	99	100	105	133	103	110
	13.60	102	105	99	100	105	133	102	110
	13.80	102	104	99	100	105	132	102	108
	14.00	102	103	99	99	104	131	101	106
	14.20	102	103	99	99	103	130	100	105
Scenario 2 - realistic utilisation	14.37	102	102	99	98	102	129	99	104
	14.40	102	102	99	98	102	129	99	104
	14.60	100	101	100	101	101	102	101	102
Measured (status quo) 7DMALF	14.67	100	101	100	100	101	102	101	102
	14.70	100	101	100	100	101	102	101	101
	14.80	100	100	100	100	100	101	100	101
Naturalised 7DMALF	14.90	100	100	100	100	100	100	100	100

Table 24. Onepuhi IFIM reach percentage area-weighted suitability (AWS) retention values for eels relative to the naturalised 7-day MALF (Rangitīkei River at Onepuhi flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. The source used for the eel habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Longfin eel <300mm	Longfin eel >300mm	Shortfin eel <300mm	Shortfin eel >300mm
	4.00	115	157	171	259
	4.20	114	159	170	260
	4.40	114	162	169	261
	4.60	114	164	168	260
	4.80	114	166	167	260
	5.00	114	168	166	259
	5.20	115	169	165	258
	5.40	115	170	164	256
	5.60	115	171	163	254
	5.80	115	172	162	252
	6.00	115	172	161	249
	6.20	115	172	160	245
	6.40	115	172	158	242
	6.60	115	172	157	238
	6.80	114	171	155	234
	7.00	114	171	154	230
	7.20	114	170	152	226
	7.40	114	169	150	221
	7.60	113	168	149	217
	7.80	113	166	147	213
	8.00	113	165	145	208
	8.20	112	163	144	204
	8.40	112	161	142	200
	8.60	111	159	140	196
	8.80	111	158	138	192
	9.00	110	156	136	187
	9.20	109	154	135	183
	9.40	109	152	133	179
	9.60	108	150	131	175
	9.80	108	148	129	171
	10.00	107	146	128	168
	10.20	106	144	126	164
	10.40	106	142	124	160
	10.60	105	140	123	157
	10.80	105	138	121	153
	11.00	104	136	120	150
	11.20	103	134	118	147
	11.40	103	132	117	143
	11.60	102	130	116	140
	11.80	101	128	115	137
	12.00	101	126	113	134
	12.20	100	124	112	131
	12.40	100	122	111	129
	12.60	99	120	110	126
	12.80	99	118	109	124
	13.00	98	117	108	121
	13.20	98	115	107	119
	13.40	98	113	106	116
Scenario 1 - full utilisation	13.57	98	111	105	115
	13.60	98	111	105	114
	13.80	98	109	104	112
	14.00	97	108	103	110
	14.20	97	106	102	108
Scenario 2 - realistic utilisation	14.37	97	105	102	106
	14.40	97	104	102	106
	14.60	100	102	101	103
Measured (status quo) 7DMALF	14.67	100	102	101	102
	14.70	100	102	101	102
	14.80	100	101	100	101
Naturalised 7DMALF	14.90	100	100	100	100

Table 25. Onepuhi IFIM reach percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Rangitīkei River at Onepuhi flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout Wilding (2012)	Juvenile Brown and Rainbow trout Wilding (2012)	Brown trout adult Hayes and Jowett (1994)	Brown trout spawning habitat Shirvell and Dungey (1983)	Juvenile Brown trout Bovee (pers. comm)	Juvenile Rainbow trout feeding Thomas and Bovee (1993)	Adult Rainbow trout feeding Thomas and Bovee (1993)
	4.00	41	79	46	179	78	91	41
	4.20	42	80	48	183	80	93	43
	4.40	44	82	50	184	82	95	45
	4.60	45	83	52	185	83	96	46
	4.80	46	84	54	185	85	98	48
	5.00	48	86	57	184	86	99	50
	5.20	49	87	59	183	88	101	51
	5.40	50	88	61	182	89	102	53
	5.60	52	89	63	180	90	103	54
	5.80	53	90	65	177	91	104	56
	6.00	54	91	67	175	92	105	57
	6.20	56	91	68	172	93	105	59
	6.40	57	92	70	169	94	106	60
	6.60	58	93	72	165	95	107	62
	6.80	59	93	74	163	96	107	63
	7.00	61	94	75	160	97	108	65
	7.20	62	94	77	158	98	108	66
	7.40	63	95	78	155	98	109	68
	7.60	64	95	80	153	99	109	69
	7.80	66	96	81	151	100	109	70
	8.00	67	96	82	149	100	109	72
	8.20	68	97	84	147	101	109	73
	8.40	69	97	85	146	101	109	74
	8.60	70	97	86	144	102	109	75
	8.80	71	98	87	143	102	109	77
	9.00	72	98	88	142	102	109	78
	9.20	73	98	89	140	103	109	79
	9.40	74	98	90	139	103	109	80
	9.60	75	99	91	137	103	109	81
	9.80	77	99	92	135	103	109	82
	10.00	78	99	93	134	104	109	83
	10.20	79	99	94	132	104	109	84
	10.40	80	99	94	130	104	109	85
	10.60	81	99	95	127	104	109	86
	10.80	82	99	96	125	104	108	87
	11.00	83	99	96	123	104	108	88
	11.20	84	100	97	121	104	108	89
	11.40	85	100	98	119	104	108	89
	11.60	86	100	98	117	104	107	90
	11.80	86	100	98	115	104	107	91
	12.00	87	100	99	113	104	107	92
	12.20	88	100	99	111	104	106	92
	12.40	89	100	99	109	104	106	93
	12.60	90	100	100	107	103	105	94
	12.80	91	100	100	105	103	105	94
	13.00	92	100	100	104	103	104	95
	13.20	93	100	100	103	103	104	95
	13.40	94	100	100	101	102	104	96
Scenario 1 - full utilisation	13.57	94	100	100	100	102	103	96
	13.60	95	100	100	100	102	103	96
	13.80	95	100	100	99	102	103	97
	14.00	96	100	100	98	101	102	97
	14.20	97	100	100	97	101	102	98
Scenario 2 - realistic utilisation	14.37	98	100	100	97	101	101	98
	14.40	98	100	100	97	101	101	98
	14.60	99	100	100	101	101	101	99
Measured (status quo) 7DMALF	14.67	99	100	100	101	100	101	100
	14.70	99	100	100	101	100	101	100
	14.80	100	100	100	100	100	100	100
Naturalised 7DMALF	14.90	100	100	100	100	100	100	100

Hampton reach

Retention of physical habitat properties

Table 26 shows the retention values of various reach-scale physical habitat properties and features, including the basic meso-habitat components of a stream (riffle, runs and pools). Under all abstraction scenarios, there is practically no change in average width, depth and velocity relative to the naturalised 7DMALF. Under the maximum allocation scenario, there is an 11% reduction in average cross-sectional velocity (Table 26).

Table 26. Hampton IFIM reach retention values for physical habitat features relative to the naturalised 7-day MALF (Rangitīkei River at McKelvies flow recorder). Habitat retention is calculated as the percentage change of habitat feature predicted for a flow relative to the occurrence of that habitat feature at the naturalised 7-day MALF. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)
	4.00	81	84	49	133	77	28
	4.20	82	84	50	132	79	28
	4.40	83	85	52	133	75	34
	4.60	83	85	53	132	76	35
	4.80	84	85	55	131	77	34
	5.00	84	86	56	132	75	40
	5.20	85	86	57	132	75	37
	5.40	85	86	58	131	72	49
	5.60	86	87	60	130	73	52
	5.80	86	87	61	130	72	55
	6.00	87	88	62	130	69	65
	6.20	87	88	63	127	72	66
	6.40	87	88	64	128	72	65
	6.60	88	89	65	129	70	65
	6.80	88	89	67	128	71	64
	7.00	89	89	68	127	72	67
	7.20	89	90	69	126	74	67
	7.40	89	90	70	125	74	72
	7.60	90	90	71	125	74	68
	7.80	90	91	72	124	74	73
	8.00	90	91	73	118	81	79
	8.20	91	91	73	116	81	84
	8.40	91	91	74	114	85	85
	8.60	91	92	75	112	88	84
	8.80	92	92	76	111	89	84
	9.00	92	92	77	107	92	90
	9.20	92	93	78	107	93	89
	9.40	92	93	79	107	93	89
	9.60	93	93	80	107	94	88
	9.80	93	93	81	108	92	90
	10.00	93	94	81	108	91	92
	10.20	94	94	82	109	90	93
	10.40	94	94	83	108	91	93
	10.60	94	94	84	108	90	93
	10.80	94	95	85	109	90	93
	11.00	95	95	85	109	90	92
	11.20	95	95	86	109	90	91
	11.40	95	96	87	108	91	91
	11.60	95	96	88	108	92	91
	11.80	96	96	89	107	93	90
Scenario 1 - full utilisation	11.81	96	96	89	107	93	90
	11.90	96	96	89	107	93	91
	12.00	96	96	90	107	92	95
	12.20	96	97	90	107	91	97
	12.40	97	97	91	108	90	97
	12.60	97	97	92	107	91	97
	12.80	97	97	92	106	93	96
	13.00	97	98	93	105	94	96
	13.20	98	98	94	105	95	96
	13.40	98	98	94	105	94	97
	13.60	98	98	95	105	94	96
	13.80	99	99	96	105	94	97
Scenario 2 - realistic utilisation	13.81	99	99	96	105	93	99
	13.90	99	99	96	104	94	99
	14.00	99	99	96	105	94	98
	14.20	99	99	97	103	96	99
	14.40	99	99	98	102	98	99
Measured (status quo) 7DMALF	14.56	100	99	98	101	99	101
	14.60	100	100	99	101	99	101
	14.80	100	100	99	101	99	100
	15.00	100	100	100	100	100	100
Naturalised 7DMALF	15.03	100	100	100	100	100	100

Habitat retention for species and values

Tables 27–30 show that AWS retention values for macroinvertebrates (and food-producing habitat), native fish and salmonids are all almost unaffected relative to the naturalised flows under any of the modelled scenarios, from status quo through to maximum utilisation.

Table 27. Hampton IFIM reach percentage area-weighted suitability (AWS) retention values for invertebrates relative to the naturalised summer median flow (Rangitīkei River at McKelvies flow recorder). Habitat retention is calculated as the percentage change of habitat predicted for a flow relative to the habitat predicted for the naturalised summer median flow. Percentage habitat feature retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. Summer median flows for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the invertebrate habitat suitability criteria is Jowett et al. (1991).

	Flow (m^3/s)	Food producing (Waters 1976)	Deleatidium (mayfly)	Zelandoperla (stonefly)	Aoteapsyche (net-spinning caddis)	Hydrobiosidae (free-living caddis)	O. feredayi (cased caddis)
	18.00	109	104	74	95	98	104
	18.20	109	104	75	95	98	104
	18.40	109	104	75	96	99	104
	18.60	109	104	76	96	99	104
	18.80	109	104	76	96	99	104
	19.00	109	103	77	97	99	104
	19.20	109	103	78	97	99	104
	19.40	109	103	78	97	99	103
	19.60	108	103	79	97	99	103
	19.80	108	103	80	98	99	103
	20.00	108	103	80	98	99	103
	20.20	108	103	81	98	99	103
	20.40	108	103	82	98	99	103
	20.60	108	103	83	99	99	103
	20.80	108	103	83	99	99	103
	21.00	107	103	84	99	99	102
	21.20	107	103	85	99	99	102
	21.40	107	103	85	99	99	102
	21.60	107	103	86	100	99	102
	21.80	107	103	87	100	99	102
	22.00	106	102	87	100	99	102
	22.20	106	102	88	100	99	102
	22.40	106	102	88	100	99	102
	22.60	106	102	89	100	99	102
	22.80	105	102	90	100	99	102
Scenario 1 - full utilisation	23.00	105	102	90	100	99	101
	23.20	105	102	91	100	99	101
	23.40	104	102	92	101	99	101
	23.60	104	102	92	101	100	101
	23.80	104	102	93	101	100	101
	24.00	104	102	93	101	100	101
	24.20	103	101	94	101	100	101
	24.40	103	101	95	101	100	101
	24.60	103	101	95	101	100	101
Scenario 2 - realistic utilisation	24.78	102	101	96	100	100	101
	24.80	102	101	96	100	100	101
	25.00	102	101	96	100	100	101
	25.20	102	101	97	100	100	101
	25.40	102	101	98	100	100	100
	25.60	101	101	98	100	100	100
Measured (status-quo) Summer Median	25.70	101	100	98	100	100	100
	25.80	101	100	99	100	100	100
	26.00	101	100	99	100	100	100
	26.20	100	100	100	100	100	100
Naturalised Summer Median	26.30	100	100	100	100	100	100

Table 28. Hampton IFIM reach percentage area-weighted suitability (AWS) retention values for native fish (excluding eels) relative to the naturalised 7-day MALF (Rangitīkei River at McKelvies flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. Unless specified, the source used for the native fish habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Crans bully	Common bully	Upland bully	Redfin bully	Torrentfish	Īnanga feeding Jowett (2002)	Kōaro	Smelt
	4.00	148	138	145	131	61	306	88	164
	4.20	148	138	146	131	63	294	89	164
	4.40	148	138	146	132	64	283	91	164
	4.60	147	138	147	133	66	272	93	164
	4.80	147	137	147	134	67	262	94	164
	5.00	147	137	147	134	69	253	95	163
	5.20	147	136	148	134	70	245	97	163
	5.40	147	135	148	135	72	237	98	163
	5.60	146	135	148	135	74	230	99	163
	5.80	146	134	148	135	75	224	100	163
	6.00	145	133	148	135	77	217	101	162
	6.20	145	132	148	135	79	212	102	161
	6.40	144	131	147	135	81	206	103	160
	6.60	143	131	146	135	82	201	103	160
	6.80	142	130	145	134	84	195	104	158
	7.00	140	129	144	134	85	190	105	157
	7.20	139	127	143	133	87	185	105	156
	7.40	137	126	142	132	89	180	106	155
	7.60	136	125	141	131	90	175	106	153
	7.80	135	123	139	130	92	170	106	151
	8.00	134	122	138	128	93	165	107	150
	8.20	133	121	137	127	95	160	107	148
	8.40	132	119	135	126	96	156	107	146
	8.60	131	118	134	124	97	152	108	144
	8.80	131	117	132	123	99	148	108	142
	9.00	130	117	130	122	100	145	108	141
	9.20	129	116	129	120	101	141	108	139
	9.40	128	115	127	119	101	138	108	137
	9.60	127	115	125	118	102	135	108	135
	9.80	126	114	124	117	103	133	108	133
	10.00	125	113	122	115	103	130	108	132
	10.20	124	113	121	115	104	128	108	130
	10.40	123	112	120	114	104	126	108	128
	10.60	121	111	118	113	104	124	108	127
	10.80	120	110	117	112	105	122	108	125
	11.00	119	109	116	111	105	120	108	124
	11.20	118	108	115	110	105	118	108	122
	11.40	117	108	114	109	105	116	108	121
	11.60	116	107	113	108	105	115	108	120
	11.80	115	106	111	107	105	113	108	118
Scenario 1 - full utilisation	11.81	115	106	111	107	105	113	108	118
	11.90	114	106	111	107	104	113	108	118
	12.00	114	106	110	107	104	112	107	117
	12.20	112	106	109	106	104	111	107	116
	12.40	111	105	109	106	104	110	107	114
	12.60	110	105	108	105	104	109	106	113
	12.80	109	104	107	105	104	108	106	112
	13.00	108	104	106	104	103	107	106	110
	13.20	107	103	105	104	103	106	105	109
	13.40	106	103	104	103	103	105	105	108
	13.60	105	102	103	103	103	104	104	107
	13.80	104	102	103	102	102	104	103	106
Scenario 2 - realistic utilisation	13.81	104	102	103	102	102	104	103	106
	13.90	104	102	103	102	102	103	103	105
	14.00	103	102	102	102	102	103	103	105
	14.20	103	101	102	102	102	102	102	104
	14.40	102	101	102	102	101	102	102	103
Measured (status quo) 7DMALF	14.56	101	101	101	101	101	101	101	102
	14.60	101	101	101	101	101	101	101	102
	14.80	101	100	101	101	100	101	101	101
	15.00	100	100	100	100	100	100	100	100
Naturalised 7DMALF	15.03	100	100	100	100	100	100	100	100

Table 29. Hampton IFIM reach percentage area-weighted suitability (AWS) retention values for eels relative to the naturalised 7-day MALF (Rangitīkei River at McKelvies flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column. The source used for the eel habitat suitability criteria is Jowett and Richardson (2008).

	Flow (m^3/s)	Longfin eel <300mm	Longfin eel >300mm	Shortfin eel <300mm	Shortfin eel >300mm
	4.00	107	139	121	160
	4.20	109	140	121	158
	4.40	110	140	122	156
	4.60	111	140	122	154
	4.80	112	139	122	152
	5.00	113	139	122	150
	5.20	114	139	122	149
	5.40	114	138	122	147
	5.60	115	138	122	145
	5.80	116	137	123	144
	6.00	116	137	123	142
	6.20	117	136	123	141
	6.40	117	136	122	139
	6.60	117	135	122	138
	6.80	118	134	122	136
	7.00	118	133	121	135
	7.20	118	133	121	134
	7.40	118	132	120	132
	7.60	117	131	120	131
	7.80	117	130	119	130
	8.00	117	130	119	128
	8.20	116	129	118	127
	8.40	116	128	117	125
	8.60	116	127	117	124
	8.80	115	126	116	123
	9.00	115	125	115	121
	9.20	115	124	115	120
	9.40	114	123	114	119
	9.60	114	123	114	117
	9.80	113	122	113	116
	10.00	112	121	113	115
	10.20	112	120	112	114
	10.40	111	119	112	113
	10.60	110	118	111	111
	10.80	110	117	110	110
	11.00	109	116	110	109
	11.20	109	115	109	108
	11.40	108	114	109	108
	11.60	108	113	108	107
	11.80	107	112	108	106
Scenario 1 - full utilisation	11.81	107	112	108	106
	11.90	107	112	107	106
	12.00	107	112	107	105
	12.20	107	111	107	105
	12.40	106	110	106	104
	12.60	106	109	106	103
	12.80	105	108	105	103
	13.00	105	107	105	103
	13.20	104	106	104	102
	13.40	104	106	104	102
	13.60	103	105	103	102
	13.80	103	104	103	101
Scenario 2 - realistic utilisation	13.81	103	104	103	101
	13.90	102	104	103	101
	14.00	102	104	102	101
	14.20	102	103	102	101
	14.40	101	102	102	101
Measured (status quo) 7DMALF	14.56	101	102	101	101
	14.60	101	101	101	100
	14.80	101	101	101	100
	15.00	100	100	100	100
Naturalised 7DMALF	15.03	100	100	100	100

Table 30. Hampton IFIM reach percentage area-weighted suitability (AWS) retention values for trout relative to the naturalised 7-day MALF (Rangitīkei River at McKelvies flow recorder). Habitat retention is calculated as the percentage of habitat predicted for a flow relative to the habitat predicted for the naturalised 7-day MALF. Percentage habitat retention is colour-coded as follows: 90–100% blue, 80–89.9% green, 70–79.9% yellow, < 70% light red. 7-day MALFs for the naturalised, status quo and One Plan Schedule 3 limits scenarios (see Appendix A6.2 for a full explanation of scenarios) are underlined in the first column.

	Flow (m^3/s)	Adult Brown and Rainbow trout	Juvenile Brown and Rainbow trout	Brown trout adult	Brown trout spawning habitat	Juvenile Brown trout	Juvenile Rainbow trout feeding	Adult Rainbow trout feeding
		Wilding (2012)	Wilding (2012)	Hayes and Jowett (1994)	Shirvell and Dungey (1983)	Bovee (pers. comm)	Thomas and Bovee (1993)	Thomas and Bovee (1993)
	4.20	63	79	79	121	91	106	59
	4.40	64	79	80	122	92	106	61
	4.60	66	80	82	123	93	106	63
	4.80	67	81	83	124	94	107	64
	5.00	68	81	84	124	94	107	66
	5.20	69	82	86	124	95	107	67
	5.40	70	83	87	125	96	107	69
	5.60	71	83	88	125	96	107	70
	5.80	72	84	90	126	97	108	72
	6.00	73	84	91	127	97	108	73
	6.20	73	85	92	127	97	108	74
	6.40	74	86	93	128	98	108	75
	6.60	75	86	95	129	98	108	77
	6.80	76	87	96	129	98	108	78
	7.00	77	87	97	130	99	108	79
	7.20	78	88	98	130	99	108	80
	7.40	79	88	100	130	99	108	81
	7.60	79	89	101	128	99	108	82
	7.80	80	89	102	127	99	108	83
	8.00	81	90	103	125	100	108	84
	8.20	82	90	104	122	100	107	85
	8.40	82	90	105	120	100	107	86
	8.60	83	91	106	118	100	107	87
	8.80	84	91	107	116	100	107	87
	9.00	84	92	108	115	100	107	88
	9.20	85	92	109	113	100	107	89
	9.40	86	93	109	112	100	107	90
	9.60	86	93	110	111	100	106	90
	9.80	87	93	110	110	101	106	91
	10.00	88	94	110	109	101	106	92
	10.20	88	94	110	108	101	106	92
	10.40	89	94	110	107	101	106	93
	10.60	89	95	110	106	101	105	94
	10.80	90	95	110	105	101	105	94
	11.00	91	96	110	104	101	105	95
	11.20	91	96	110	103	101	105	95
	11.40	92	96	109	103	101	105	96
	11.60	92	96	109	102	101	104	96
	11.80	93	97	109	102	101	104	96
Scenario 1 - full utilisation	11.81	93	97	109	102	101	104	96
	11.90	93	97	109	102	101	104	97
	12.00	93	97	108	102	101	104	97
	12.20	94	97	108	102	101	104	97
	12.40	94	98	108	101	101	103	97
	12.60	95	98	107	102	101	103	98
	12.80	95	98	107	102	101	103	98
	13.00	96	98	106	102	101	102	98
	13.20	96	98	106	102	101	102	99
	13.40	97	99	105	101	101	102	99
	13.60	97	99	104	101	100	102	99
	13.80	97	99	104	101	100	101	99
Scenario 2 - realistic utilisation	13.81	98	99	104	101	100	101	99
	13.90	98	99	103	101	100	101	99
	14.00	98	99	103	101	100	101	99
	14.20	98	99	102	101	100	101	100
	14.40	99	100	102	100	100	101	100
Measured (status quo) 7DMALF	14.56	99	100	101	100	100	101	100
	14.60	99	100	101	100	100	100	100
	14.80	100	100	101	100	100	100	100
	15.00	100	100	100	100	100	100	100
Naturalised 7DMALF	15.03	100	100	100	100	100	100	100

6. Caveats to flow modelling analysis

The Rangitīkei River contributes to the Tongariro Power Scheme (TPS) via water diversion from the Moawhango River. The Moawhango River enters the Rangitīkei River in its mid-reaches, above the three IFIM study reaches. The naturalised flow record provided for this report does *not* account for the water that is diverted from the Moawhango River to the TPS. The analysis presented here isolates the potential effects of land-use abstraction from potential hydropower diversion effects.

The original IFIM surveys in the Rangitīkei reaches were undertaken in 1994 (Environmental Services Ltd 2004). Hay and Hayes re-evaluated the 1994 data in 2004 (Hay and Hayes 2004). This report also uses the original IFIM survey information. This means there is an underlying assumption that the IFIM reaches being re-analysed in this report, 30 years later, are still characteristic of the habitat in the wider river segments of interest. The main geomorphological processes that can influence the character of the reaches over time are changes to the sediment supply and floodplain (e.g. through bank erosion). We visually assessed aerial photographs taken in 1994 at the time the IFIM reaches were surveyed, and in 2021 of the Rangitīkei River around Bulls bridge (located between the Onepuhi and Hampton study reaches) and the Hampton IFIM study reach, to assess whether the 1994 reaches were still representative of the river habit 30 years later. We concluded that the river around Bulls bridge had changed relatively little over time. However, at the Hampton reach, a significant bend had been removed and the land reclaimed. Therefore, the results we present in this report for the Hampton reach will not be representative of the fish community at that reach. Nevertheless, we suggest that the reach, as it was in 1994, is still broadly representative of habitat today at a river segment scale (approximately 10 km being largely a single channel).

A similar assessment could not be undertaken for the Manawatū River IFIM reaches (Tamaki River and Ōruakeretaki Stream) as there were no historical aerial photos for these sites. However, substantial changes to channel form, to the extent that the IFIM reaches are no longer characteristic of the wider river segments, are less likely in small single-channel rivers and streams.

7. Summary

7.1 Upper Manawatū tributaries

Tamaki River

For both IFIM reaches in the Tamaki River, flow–habitat modelling suggests that habitat quality / quantity for most macroinvertebrate species and native fish is protected at current (status quo) abstraction levels. For the key values of food-producing habitat and dwarf galaxiid habitat, there were only small reductions in habitat quality / quantity that are likely to result in 'less than minor' habitat changes relative to naturalised flows. The exceptions include a moderate level of habitat reduction for most trout life history stages at the WSW reach (around a 15% reduction) and around a 35% reduction in habitat for torrentfish, relative to naturalised low flows (7DMALF) at both the WSW and SH2 reaches. For torrentfish, this indicates a 'very high' risk of negative effects. Furthermore, there are also high to moderate levels of reduction in habitat quantity / quality for the fast-current-loving *Zelandoperla* stonefly and *Aoteapsyche* macroinvertebrates, relative to summer median flows.

Reductions in the quality / quantity of trout habitat at the SH2 reach remains within the 'moderate' ecological risk band for all species and life history stages, under all abstraction scenarios. At both reaches under the maximum use scenario, excluding municipal supply take, salmonid habitat quality / quantity is reduced by around 15–20%, depending on life history stage – within the likely 'moderate' risk of ecological effects band. At the WSW reach under the most intensive abstraction scenario (Scenario 1b), habitat across salmonid life history stages is reduced by around 25% relative to naturalised flows, meaning there is a 'high' risk of negative ecological effects at flows around the 7DMALF.

At both reaches, torrentfish habitat is reduced by around 30–50% under the fully allocated scenarios, suggesting strong to very strong negative effects on torrentfish habitat quality / quantity. In general, stronger potential negative habitat reduction effects occurred at the upstream WSW reach, possibly because the abstraction for municipal supply constitutes a greater proportion of the flow at this site. Likewise, at the WSW reach under maximum abstraction, juvenile lamprey habitat is reduced by 27–45% depending on the scenario. Habitat for longfin eels is reduced to an extent where there is a 'moderate' risk of ecological effects under full abstraction. Habitat for dwarf galaxias and all other native fish species, food-producing habitat, *Deleatidium* and most other macroinvertebrate species remain largely unaffected under all abstraction scenario investigated.

Given the potential for strong negative effects on torrentfish and lamprey, the presence or potential for viable populations of these fish in the catchment should be confirmed to determine whether habitat quality for these species should be accounted for when assessing flow policy-setting changes. Given there are sporadic records for these species in the upper Manawatū, it seems likely that they will be present in the catchment, albeit in low numbers. Determining whether low numbers of torrentfish and lamprey should drive flow management is an important question for Horizons and the communities the council represents.

Overall, while current abstraction levels maintain an acceptable level of habitat for most species, higher abstraction – allowable under the current One Plan rules – would lead to a 'moderate' to 'high' risk of declines in habitat quantity and quality for trout, and potentially a 'very high' risk of negative effects on torrentfish. A 'moderate' risk of negative effects on trout habitat (i.e. less than or near to a 20% reduction during summer low flows) under the 'realistic' maximum abstraction scenario could be considered acceptable within a resource management context, as occurs at the SH2 reach. However, there is a moderate to strong risk of negative effects on adult brown trout and trout spawning habitat at the WSW reach under maximum abstraction scenarios. This should be factored into decisions on water allocation levels in the upper catchment because this stream is considered a regionally significant trout fishery and spawning area.

Ōruakeretaki Stream

Under the current status quo level of abstraction, most macroinvertebrate, native fish and salmonid habitats remain largely unaffected relative to naturalised flows, with only slight reductions in quantity and quality. Under maximum realistic abstraction, *Zelandoperla* and *Aoteapsyche* habitats decline by 28% (likely strong negative effects) and 15% (moderate negative effects), respectively, and food-producing habitat also shows a moderate level of reduction relative to median flows. Meanwhile, habitat for *Deleatidium* (an important prey item for most river invertebrate predators) remains largely unaffected.

Relative to naturalised low flows, the realistic maximum level of abstraction scenario reduces habitat for torrentfish by 40%, for kōaro by 16%, and for juvenile lamprey by 40%. This would suggest a 'moderate' to 'very high' risk of negative ecological effects in the case of torrentfish and juvenile lamprey. Under the same scenario, salmonid habitat quality / quantity declines by 13–21% across all species and life stages, indicating a 'moderate' risk of negative ecological effects. Dwarf galaxias habitat shows little reduction under the realistic maximum level of abstraction scenario (an estimated 10% reduction relative to naturalised 7DMALF).

Overall, current abstraction levels maintain habitat quality and quantity for most species. However, a realistic level of increased water use, if the catchment were to be fully allocated under the current rule settings, could significantly impact some flow-sensitive taxa. That said, as with the Tamaki River, the presence or potential for viable populations of torrentfish and juvenile lamprey in the catchment should be confirmed to determine whether habitat quality for these species should drive any flow policy-setting changes. If habitat for these species is not considered important, trout are the next most flow-sensitive instream value in the catchment. Should the river become fully allocated, the modelled realistic level of abstraction suggests there is a 'moderate' risk for negative effects on trout habitat across life history stages.

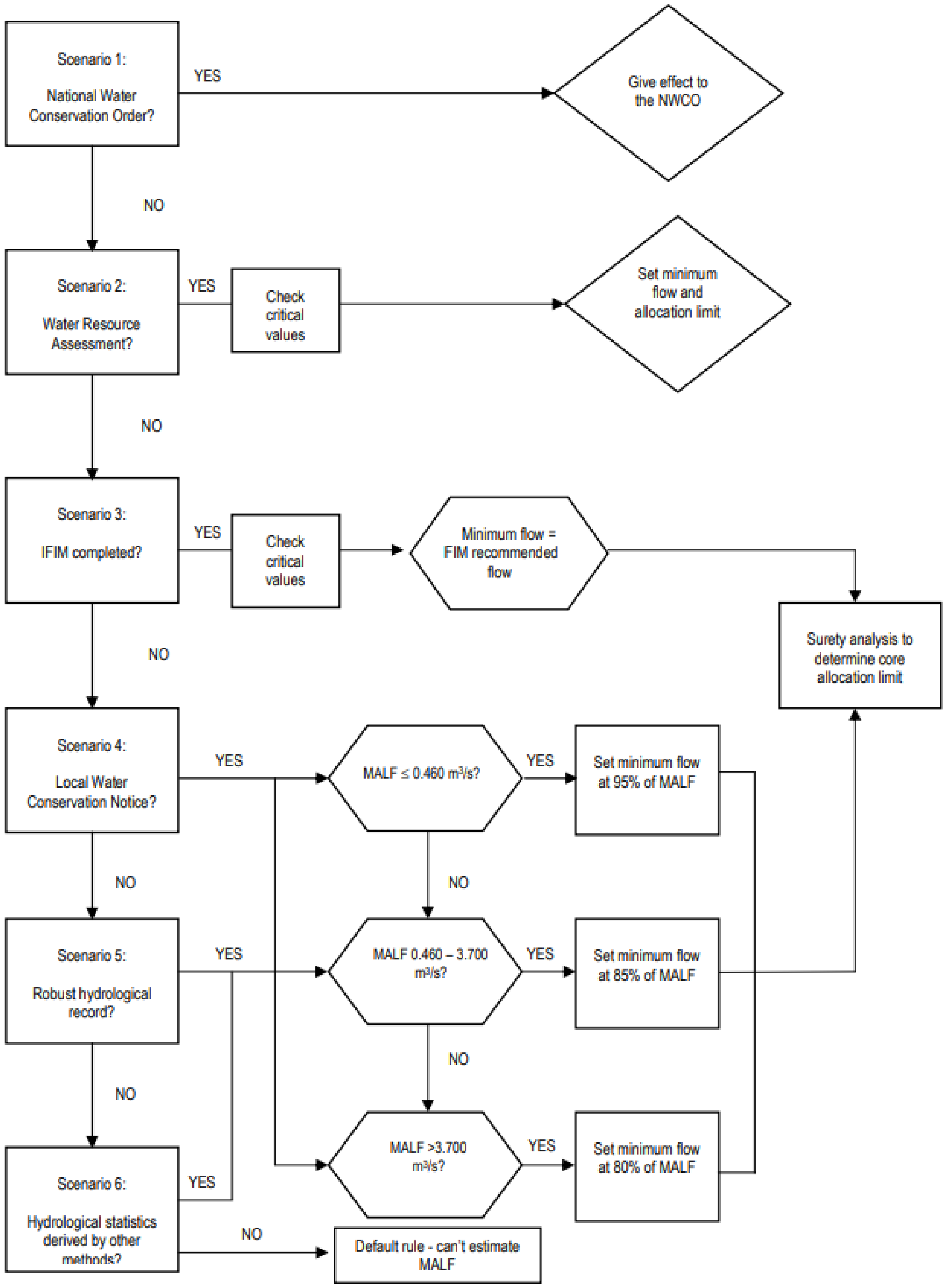
7.2 Rangitīkei River reaches

In the Rangitīkei River, across the Otara, Onepuhi and Hampton reaches and under all abstraction scenarios, habitat for all species modelled is offered a high level of protection relative to naturalised flows under the current One Plan abstraction rules. The greatest modelled effect was a 9% reduction of *Zelandoperla* habitat quality / quantity relative to median flows under the maximum use scenario. In any case, the mainstem of the middle reaches of the Rangitīkei River is probably not suitable for this highly flow-sensitive species, which prefers shaded headwater tributaries.

This assessment comes with the major caveat that the effects of the TPS diversion are not accounted for in this analysis. However, whatever those effects might be, the updated flow modelling suggests that abstraction for land use-related reasons under the current One Plan rules will not be causing any notable additional reductions in habitat quality or quantity for key aquatic values in the mid- to lower reaches of the Rangitīkei River.

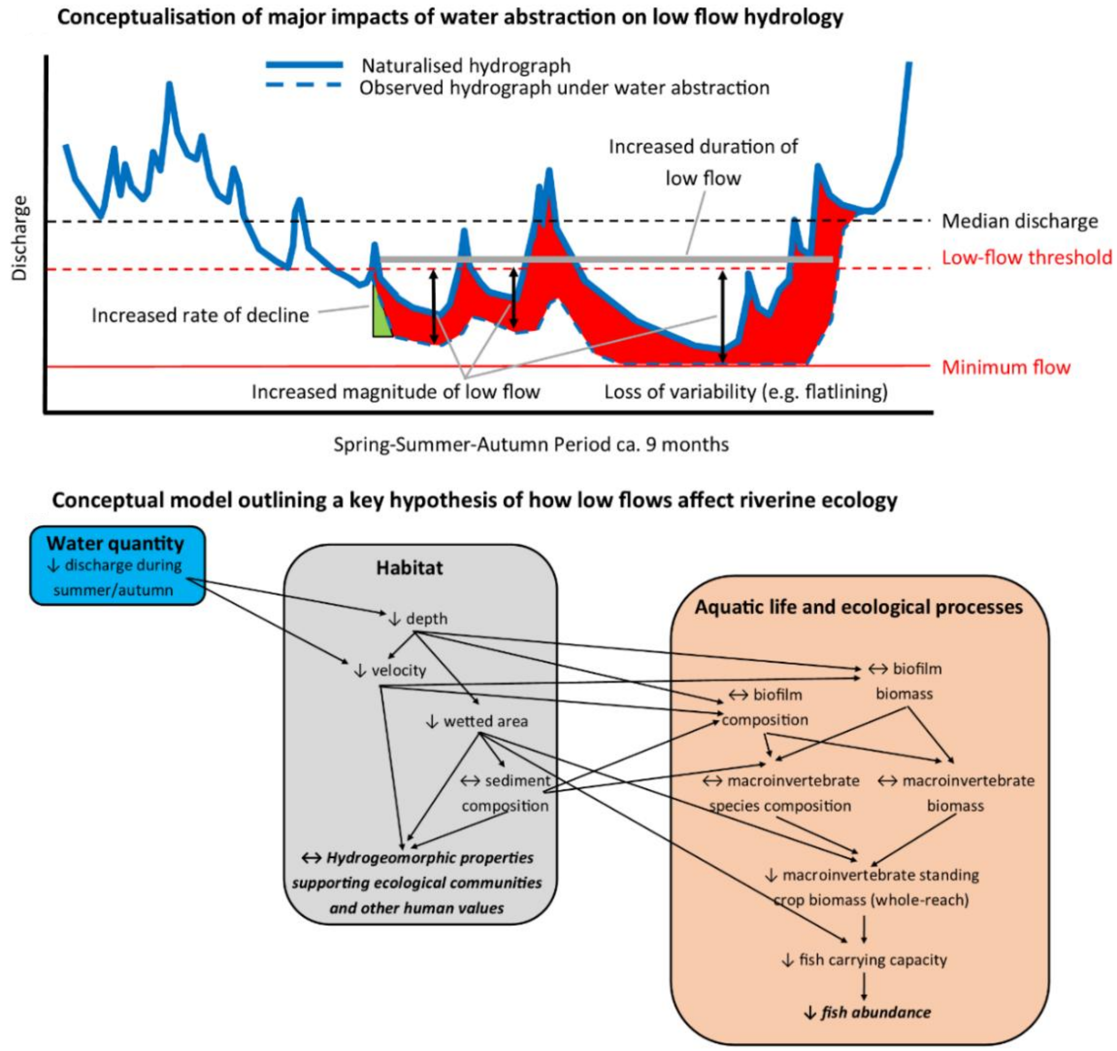
8. Appendices

Appendix 1. Decision support system from Hurndell (2009) outlining the One Plan approach to setting minimum flows and allocation limits



Appendix 2. Summary of key hydrological features and linked ecological structure and function

Figure A2.1 below, adapted from Stoffels et al. (2024), summarises the typical effects of surface and hydraulically linked groundwater abstraction on a hypothetical summer hydrograph of a standard rain-fed river. The figure also outlines how linked ecological structure and functions can be affected by abstraction. Since surface water abstraction primarily impacts the magnitude and duration of low-flow conditions, it is important that default water allocation rules are primarily targeted at minimising these impacts.



Appendix 3. Habitat suitability criteria (HSC) used in the Manawatū River environmental flows assessment undertaken by Hay and Hayes (2007) and in this report

Name	HSC criteria Hay and Hayes (2005)	HSC criteria This report
Benthic invertebrates		
Food-producing	Waters (1976)	Waters (1976)
Deleatidium (mayfly)	Not assessed	Jowett et al. (1991)
Zelanoperla (stonefly)	Not assessed	Jowett et al. (1991)
Aoteapsyche (net-spinning caddis)	Not assessed	Jowett et al. (1991)
Hydrobiosidae (free-living caddis)	Not assessed	Jowett et al. (1991)
Olinga feredayi (horny-cased caddis)	Not assessed	Jowett et al. (1991)
Native fish		
Cran's bully	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Common bully	Not assessed	Jowett and Richardson (2008)
Upland bully	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Dwarf galaxias	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Torrentfish	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Īnanga feeding	Jowett (2002)	Jowett (2002)
Kōaro	Not assessed	Jowett and Richardson (2008)
Longfin eel < 300 mm	Jellyman et al. (2003)*	Not assessed
Longfin eel > 300 mm	Jellyman et al. (2003)*	Not assessed
Longfin eel < 300 mm	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Longfin eel > 300 mm	Not assessed	Jowett and Richardson (2008)
Shortfin eel < 300 mm	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Shortfin eel > 300 mm	Not assessed	Jowett and Richardson (2008)
Introduced fish		
Adult brown and rainbow trout	Not assessed	Wilding (2012)
Juvenile brown and rainbow trout	Not assessed	Wilding (2012)
Brown trout juvenile	Hayes et al. (2018: 'Bovee [1995]')	Hayes et al. (2018; 'Bovee, pers. comm.')
Brown trout fry to 15 cm (0.1–0.4 m depth)	Raleigh et al. (1986)**	Not assessed
Brown trout 15–25cm^2	Raleigh et al. (1986)***	Not assessed

Name	HSC criteria Hay and Hayes (2005)	HSC criteria This report
Brown trout yearling	Roussel et al. (1999)*	Not assessed
Brown trout adult	Hayes and Jowett (1994)	Hayes and Jowett (1994)
Brown trout adult	Hayes et al. (2018: 'Bovee [1995]')	Hayes et al. (2018; 'Bovee, pers. comm.')
Brown trout spawning	Shirvell and Dungey (1983)	Shirvell and Dungey (1983)

* HSC superseded as new criteria became available or criteria were updated.

** This HSC was reported in Hay and Hayes (2005) as 'Brown trout 15–25cm' but it is more commonly reported as 'Brown trout yearling'. It is likely Hay and Hayes (2005) modified the name of the Raleigh et al. (1986) HSC to avoid confusion with the Roussel et al. (1999) 'Brown trout yearling' HSC.

*** HSCs no longer considered suitable for this assessment – appendix 2 in Hayes and Jowett (2021) provides a review of currently available trout HSCs and their appropriateness in an Aotearoa New Zealand setting.

Appendix 4. Habitat suitability criteria (HSC) used in the Rangitīkei River environmental flows assessment undertaken by Hay and Hayes (2004) and in this report

Name	HSC criteria Hay and Hayes (2004)	HSC criteria This report
Benthic invertebrates		
Food-producing	Waters (1976)	Waters (1976)
Deleatidium (mayfly)	Not assessed	Jowett et al. (1991)
Zelanoperla (stonefly)	Not assessed	Jowett et al. (1991)
Aoteapsyche (net-spinning caddis)	Not assessed	Jowett et al. (1991)
Hydrobiosidae (free-living caddis)	Not assessed	Jowett et al. (1991)
Olinga feredayi (horny-cased caddis)	Not assessed	Jowett et al. (1991)
Native fish		
Cran's bully	Not assessed	Jowett and Richardson (2008)
Common bully	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Upland bully	Not assessed	Jowett and Richardson (2008)
Redfin bully	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Torrentfish	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Īnanga feeding	Jowett (2002)	Jowett (2002)
Kōaro	Not assessed	Jowett and Richardson (2008)
Smelt*	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Longfin eel < 300 mm	Jellyman et al. (2003)**	Not assessed
Longfin eel > 300 mm	Jellyman et al. (2003)**	Not assessed
Longfin eel < 300 mm	Not assessed	Jowett and Richardson (2008)
Longfin eel > 300 mm	Not assessed	Jowett and Richardson (2008)
Shortfin eel < 300 mm	Jowett and Richardson (1995)	Jowett and Richardson (2008)
Shortfin eel > 300 mm	Not assessed	Jowett and Richardson (2008)
Introduced fish		
Adult brown and rainbow trout	Not assessed	Wilding (2012)
Juvenile brown and rainbow trout	Not assessed	Wilding (2012)
Brown trout adult	Hayes and Jowett (1994)	Hayes and Jowett (1994)
Brown trout spawning	Shirvell and Dungey (1983)	Shirvell and Dungey (1983)
Brown trout juvenile	Hayes et al. (2018: 'Bovee [1995]')	Hayes et al. (2018; 'Bovee, pers. comm.')

Name	HSC criteria Hay and Hayes (2004)	HSC criteria This report
Juvenile Rainbow trout feeding	Not assessed	Thomas and Bovee (1993)
Adult Rainbow trout feeding	Not assessed	Thomas and Bovee (1993)
Brown trout adult	Hayes et al. (2018: 'Bovee [1995]')	Not assessed
Rainbow trout adult	Raleigh et al. (1986)***	Not assessed

* The assessment of smelt is most likely relevant only to the lowermost Rangitīkei reach (i.e. the Hampton reach).

** HSC superseded as new criteria became available or criteria were updated.

*** HSCs no longer considered suitable for this assessment – appendix 2 in Hayes and Jowett (2021) provides a review of currently available trout HSCs and their appropriateness in an Aotearoa New Zealand setting.

Appendix 5. Inherent assumptions of flow–habitat modelling

The species / value 'habitat curves', which underpin the model outputs, are based on the relationship between species / value occurrence and selected aspects of habitat, including depth, velocity, substrate composition and, sometimes, (hiding) cover. Habitat curves are often applied to rivers that were not used for the development of the models; therefore, the process often assumes that habitat preferences of a species in one river are relevant to a different river. Furthermore, many aspects of a species' life history are not factored into model outputs. To illustrate this, fish habitat suitability predictions for a given location and flow do not account for the potential importance of other aspects of a flow regime that might be crucial for population viability. For example, in a river with natural fish passage barriers, small floods or 'freshes' may be necessary for fish migration; likewise, mid-range flows that may not provide optimum habitat quality or quantity may be important for food production.

Another fundamental assumption is that area-weighted suitability (AWS) is positively related to species abundance (or instream value occurrence / quality). AWS can be considered an indication of the necessary, but not sufficient, habitat conditions for species occurrence. In other words, good habitat quality for 'Species X' does not necessarily mean that that habitat will be occupied by Species X. This is because there are many other factors – which are not related to reach and patch-scale habitat quality – that can control population abundance for a given species. For example, regular (natural) large floods or extremely high summer temperatures may depress a fish population to the point where the fish cannot occupy all the optimum habitat within the river.

Appendix 6. Flow scenarios and statistics assessed for the IFIM re-evaluation

A6.1 Manawatū River catchment (Keenan 2024)

For the Manawatū River catchment, the following flows and flow scenarios were assessed for the current IFIM evaluation:

- **Naturalised flow**: An estimation of river flow that would have been observed under the present land cover but in the absence of abstractions or diversions of either groundwater or surface water.
- **Measured flow (status quo):** Flows as they currently are, i.e. with all abstraction in place.
- **Scenario 1a (One Plan Schedule 3 limits – full utilisation):** Flows assuming full utilisation of the One Plan Schedule 3 allocation limits, with the allocation reducing to zeros in accordance with the Schedule 3 minimum flows.
- **Scenario 1b (One Plan Schedule 3 limits – with essential take):** Flows assuming full utilisation of the One Plan Schedule 3 allocation limits, with the essential take for the Dannevirke municipal water supply continuing below the minimum flow in accordance with the current consent condition (applies to the Tamaki River only).
- **Scenario 2 (One Plan Schedule 3 limits – realistic utilisation):** Flows assuming the Schedule 3 limits are fully allocated but the consents realistically used. For the Tamaki River, the monthly utilisation factor is applied to the allocation limit minus the water supply abstraction, i.e. the water supply is assumed to fully exercise the current consented allocation and the remaining allocation is reduced according to the monthly variable utilisation. For the Ōruakeretaki Stream, a 'variable' utilisation factor is applied to the allocation limit based on past maximum average monthly allocation use. The factor ranges from 2.2% (June / July) to 78% (January).

Tables A6.1 and A6.2 provide the flow statistics and scenarios assessed for the Tamaki River, and Table A6.3 provides the flow statistics and scenarios assessed for the Ōruakeretaki Stream.

Table A6.1. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Tamaki River at Stephensons based on the flow record period 2005/06 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	1.086	0.475
Measured (status quo)	0.998	0.397
Scenario 1a	0.946	0.372
Scenario 1b	0.942	0.366
Scenario 2	0.965	0.382

Table A6.2. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Tamaki River at Water Supply Weir based on the flow record period 2000/01 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	0.606	0.293
Measured (status quo)	0.538	0.230
Scenario 1a	0.526	0.241
Scenario 1b	0.525	0.210

Table A6.3. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Ōruakeretaki Stream at SH2 based on the flow record period 2007/08 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	0.672	0.309
Measured (status quo)	0.653	0.287
Scenario 1a	0.514	0.166
Scenario 2	0.567	0.233

A6.2 Rangitīkei River catchment (Keenan 2025)

For the Rangitīkei River catchment, the following flows and flow scenarios were assessed for the current IFIM evaluation:

- **Naturalised flow:** An estimation of river flow that would have been observed under the present land cover but in the absence of abstractions or diversions of either groundwater or surface water.
- **Measured flow (status quo):** Flows as they currently are, i.e. with all abstraction in place.
- **Scenario 1 (One Plan Schedule 3 limits – full utilisation):** Flows assuming full utilisation of the One Plan Schedule 3 allocation limits, with the allocation reducing to zeros in accordance with the Schedule 3 minimum flows.
- **Scenario 2 (One Plan Schedule 3 limits – realistic utilisation):** Flows assuming the Schedule 3 limits are fully allocated but the consents realistically used. A 'variable' utilisation factor is applied to the allocation limit based on past maximum monthly (modelled abstraction for the Rangitīkei catchment during the period 2014–24) allocation use. The factor ranges from 13% (July and August) to 49% (February).

Tables A6.4–A6.6 provide the flow statistics and scenarios assessed for the three Rangitīkei River IFIM reaches.

Table A6.4. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Rangitīkei River at Mangaweka (Otara IFIM reach) based on the flow record period 2004/05 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	24.35	13.33
Measured (status quo)	24.25	13.26
Scenario 1	23.71	12.76
Scenario 2	24.04	12.98

Table A6.5. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Rangitīkei River at Onepuhi (Onepuhi IFIM reach) based on the flow record period 2004/05 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	25.54	14.90
Measured (status quo)	25.27	14.67
Scenario 1	23.90	13.57
Scenario 2	24.77	14.37

Table A6.6. Flow scenarios and estimated summer median and 7-day mean annual low flow statistics for the Rangitīkei River at McKelvies (Hampton IFIM reach) based on the flow record period 2004/05 to 2023/24.

Flow scenario	Summer median flow (Dec–Mar) (m^3/s)	7-day mean annual low flow (m^3/s)
Naturalised	26.30	15.03
Measured (status quo)	25.70	14.56
Scenario 1	23.00	11.81
Scenario 2	24.78	13.81

Appendix 7. Area-weighted suitability (AWS) versus flow curves for selected invertebrates (food-producing) and fish species with high fishery and / or conservation value

A7.1 Manawatū River

Note: Food-producing curves have been reproduced in both sets of curves below as they represent the food base for fish (native and introduced).

Tamaki River at SH2

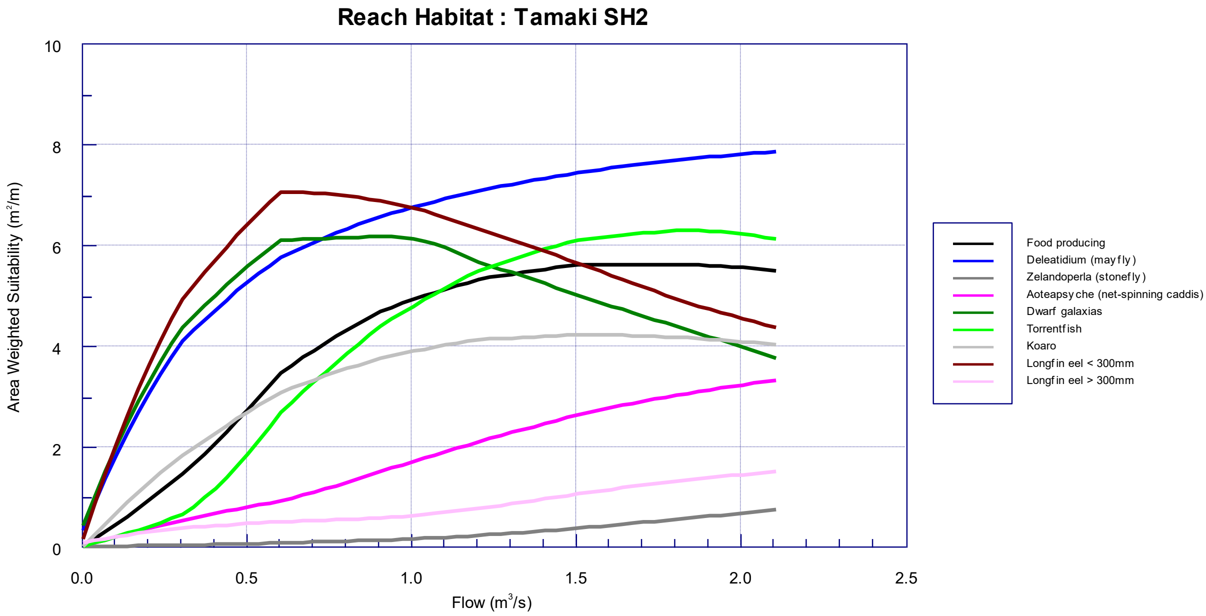


Figure A7.1. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Tamaki River at SH2.

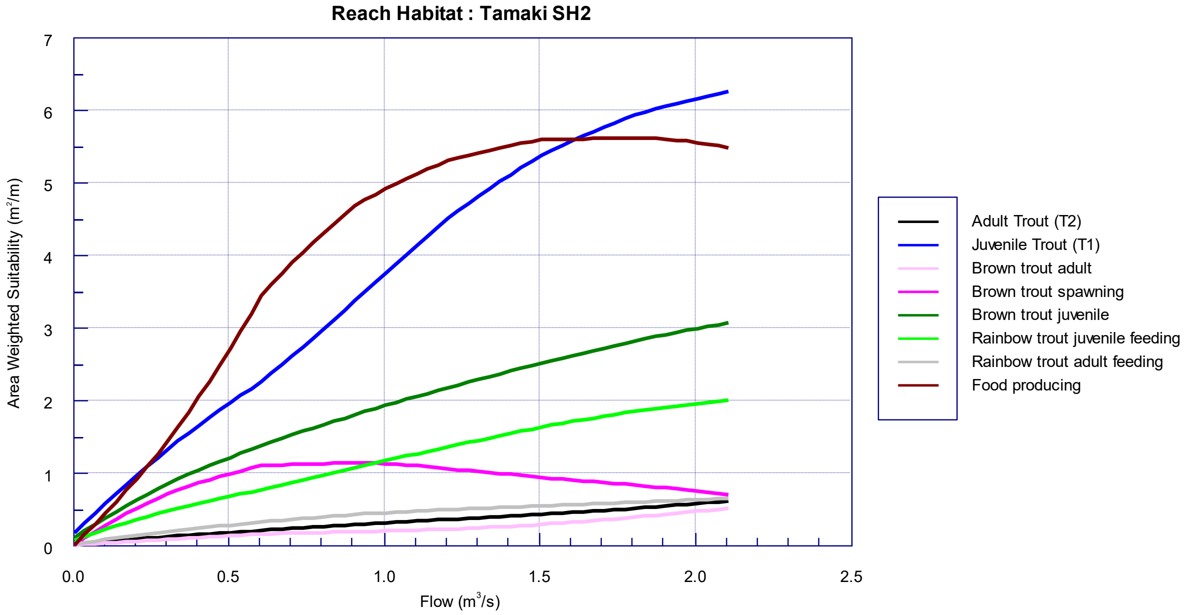


Figure A7.2. Area-weighted suitability versus flow plot for trout in the Tamaki River at SH2. The invertebrate food-producing curves have been reproduced in this figure as this curve represents the food base for fish (native and introduced).

Tamaki River at Water Supply Weir (WSW)

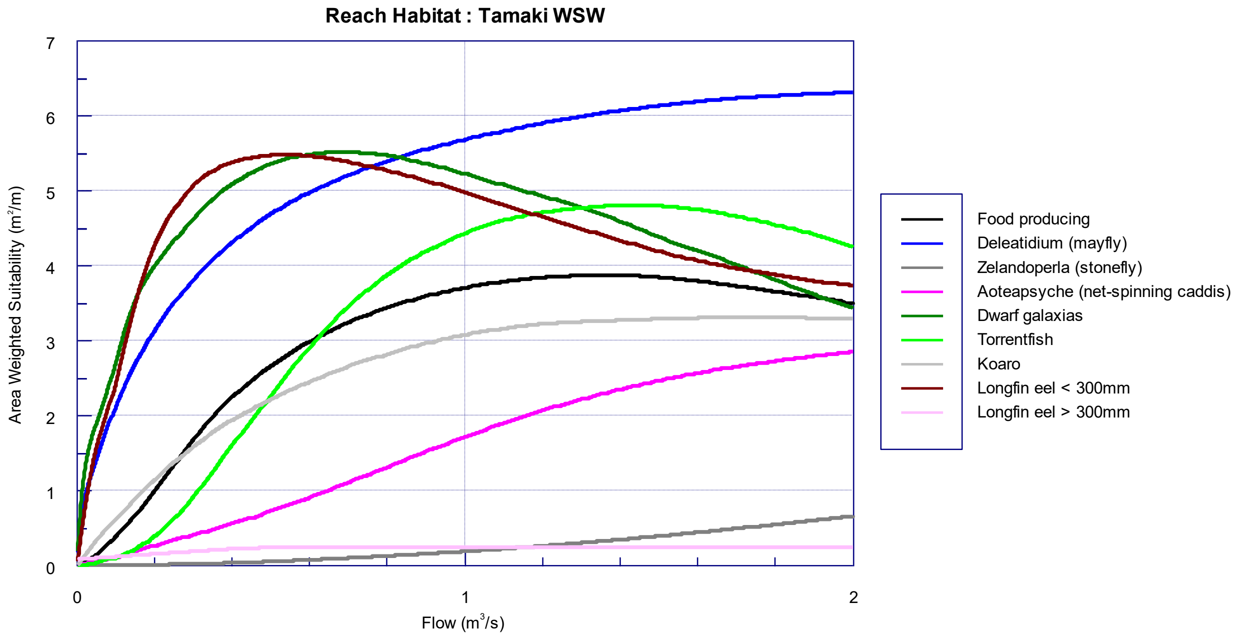


Figure A7.3. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Tamaki River at WSW.

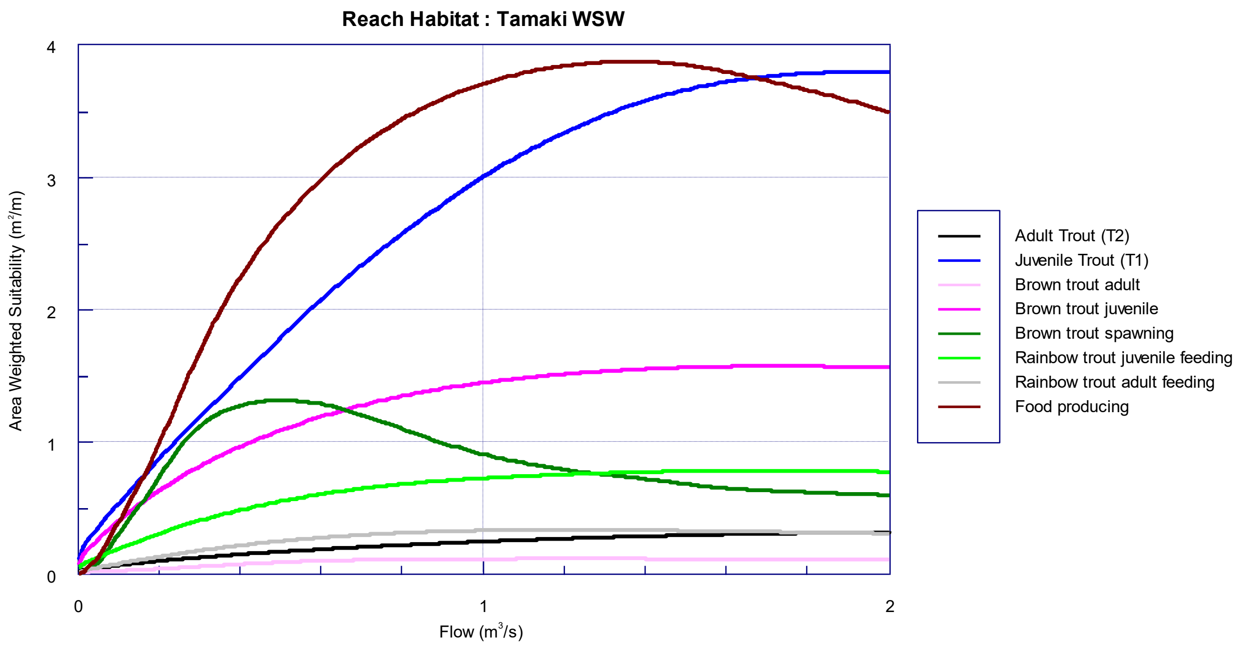


Figure A7.4. Area-weighted suitability versus flow plot for trout in the Tamaki River at WSW.

Ōruakeretaki Stream

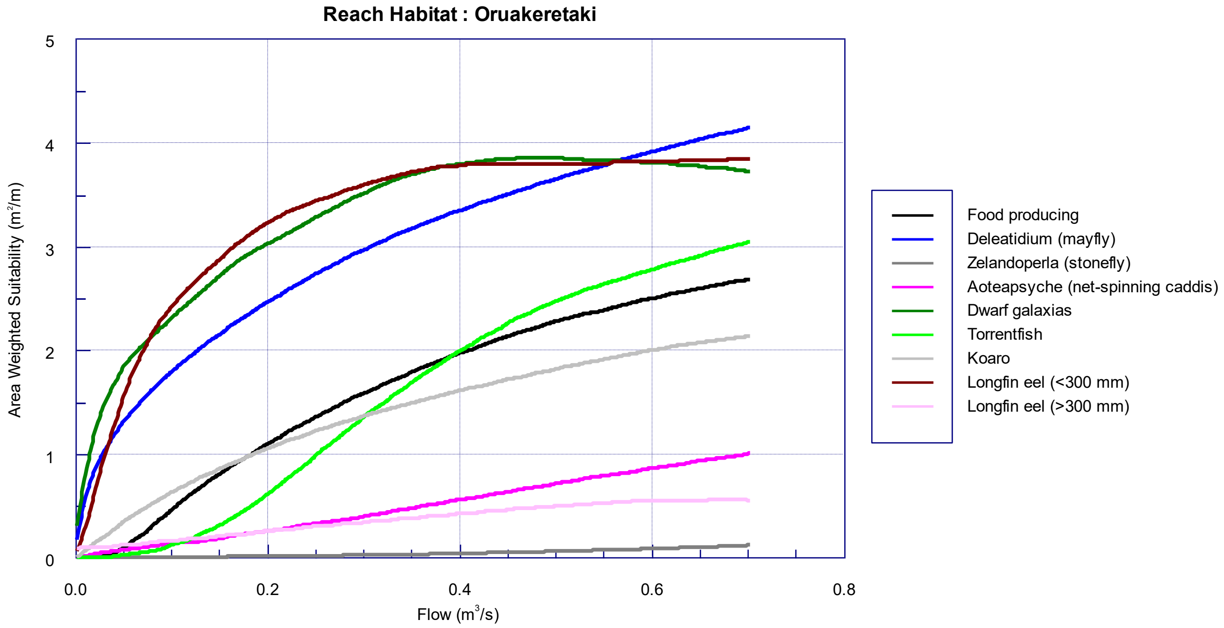


Figure A7.5. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Ōruakeretaki Stream.

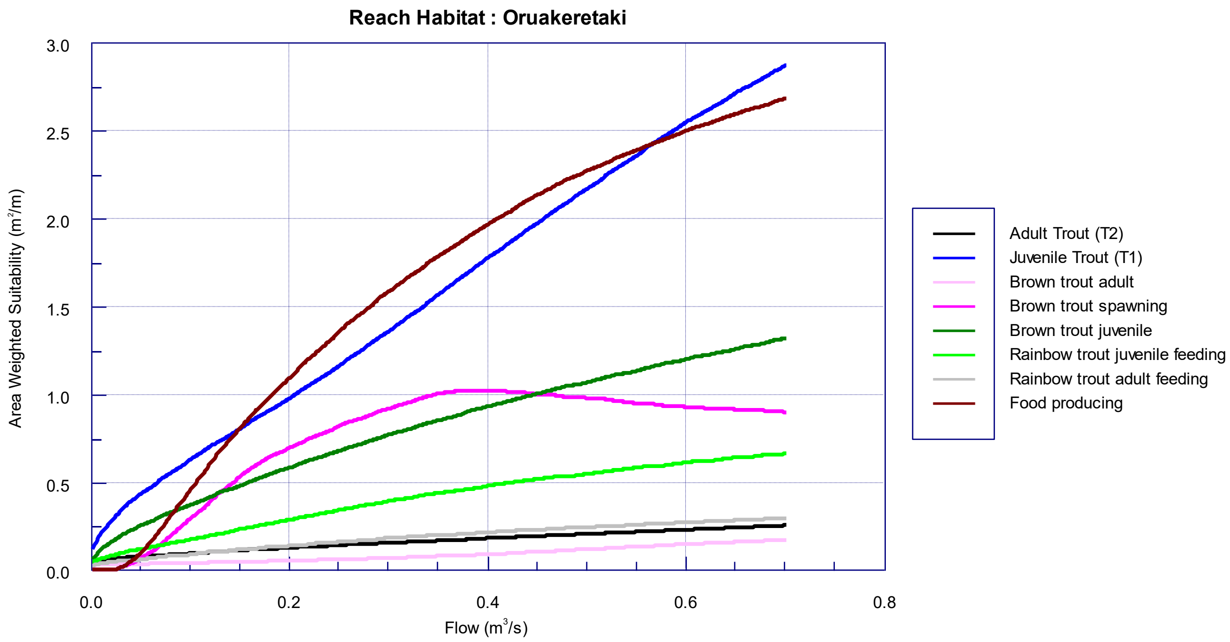


Figure A7.6. Area-weighted suitability versus flow plot for trout in the Ōruakeretaki Stream. The invertebrate food-producing curves have been reproduced in this figure as this curve represents the food base for fish (native and introduced).

A7.2 Rangitīkei River

Note: Food-producing curves have been reproduced in both sets of curves below as they represent the food base for fish (native and introduced).

Otara reach

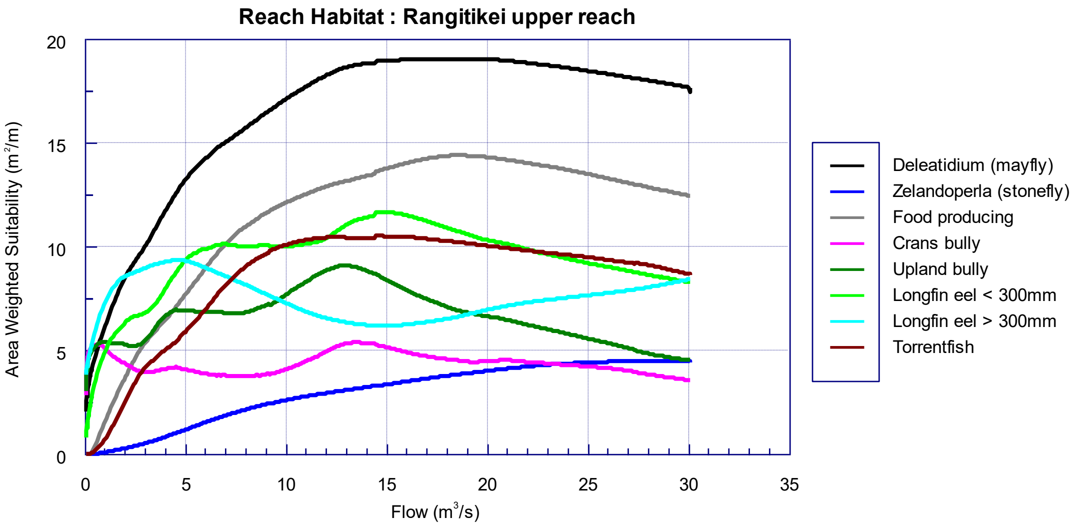


Figure A7.7. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Otara reach (upper Rangitīkei River).

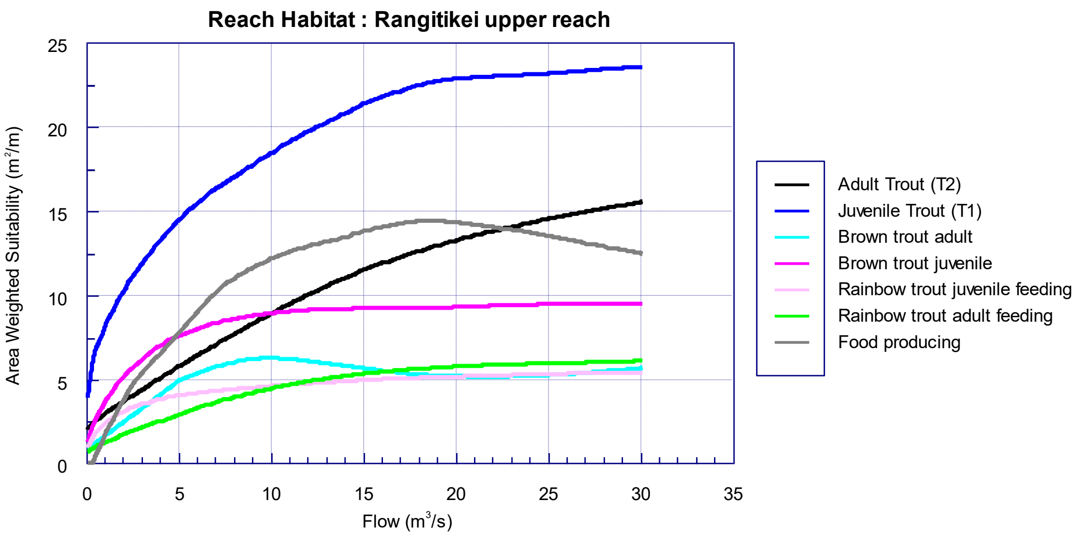


Figure A7.8. Area-weighted suitability versus flow plot for trout in the Otara reach (upper Rangitīkei River). The invertebrate food-producing curves have been reproduced in this figure as this curve represents the food base for fish (native and introduced).

Onepuhi reach

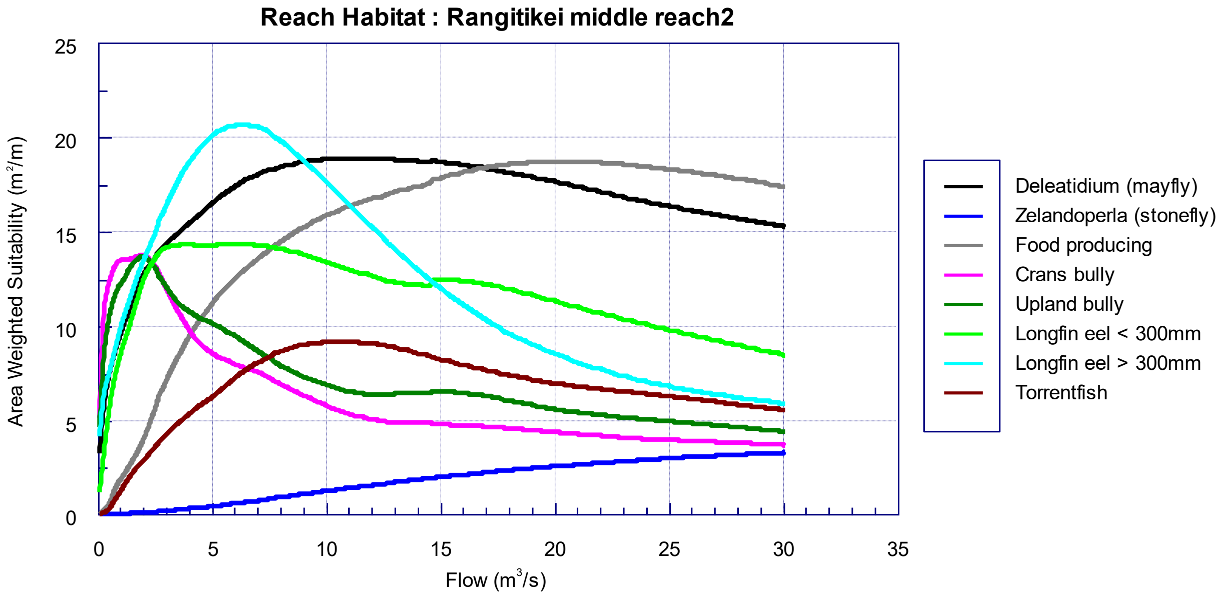


Figure A7.9. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Onepuhi reach (middle Rangitīkei River).

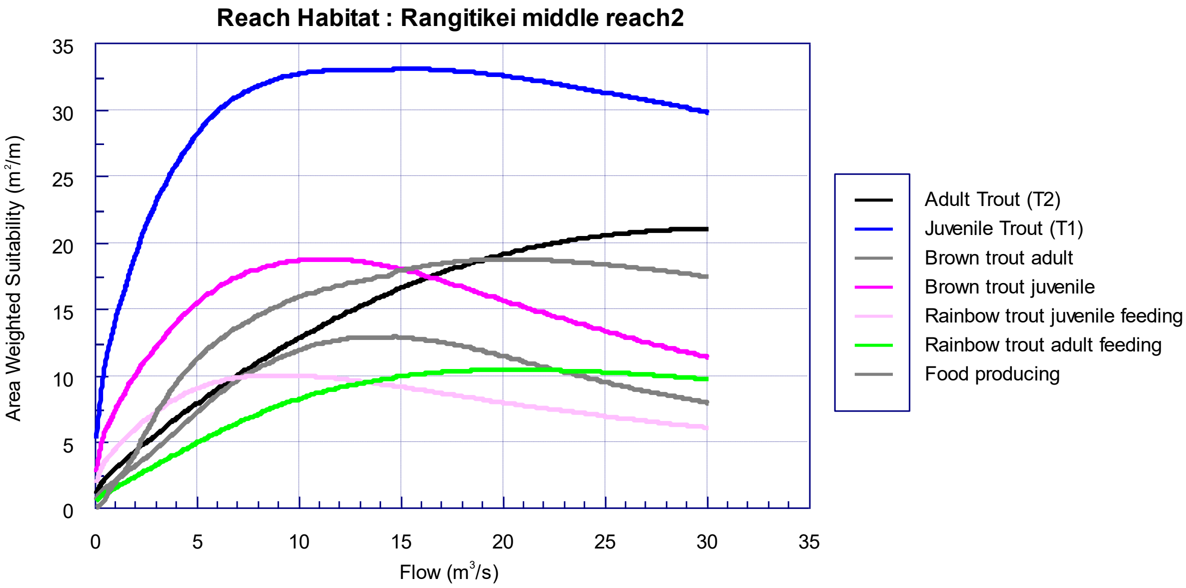


Figure A7.10. Area-weighted suitability versus flow plot for trout in the Onepuhi reach (middle Rangitīkei River). The invertebrate food-producing curves have been reproduced in this figure as this curve represents the food base for fish (native and introduced).

Hampton reach

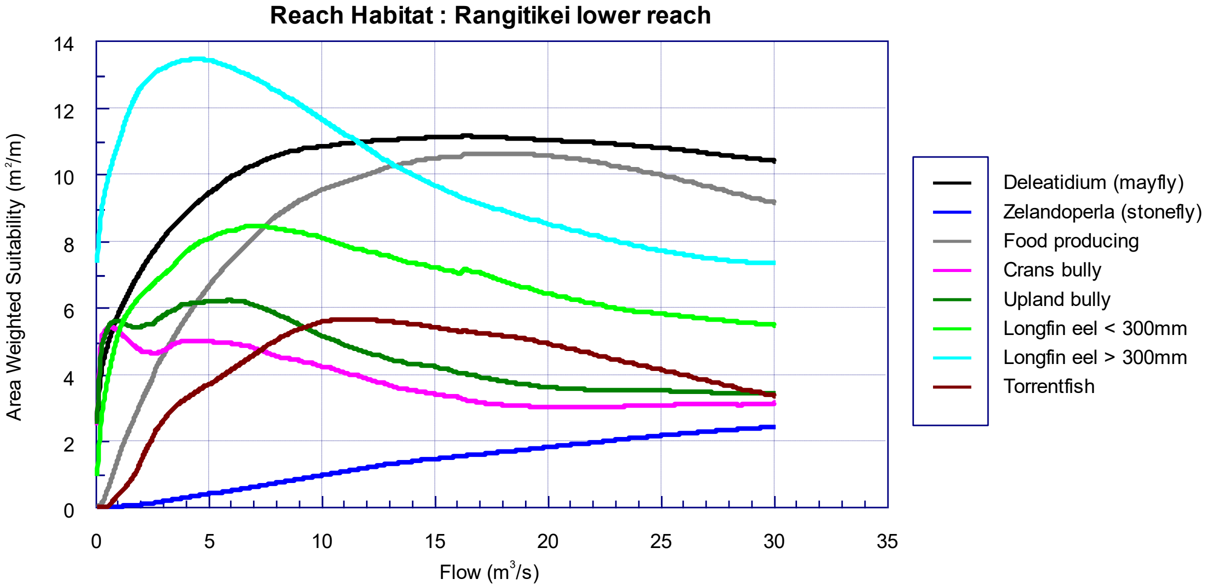


Figure A7.11. Area-weighted suitability versus flow plot for selected invertebrates and native fish in the Hampton reach (lower Rangitīkei River).

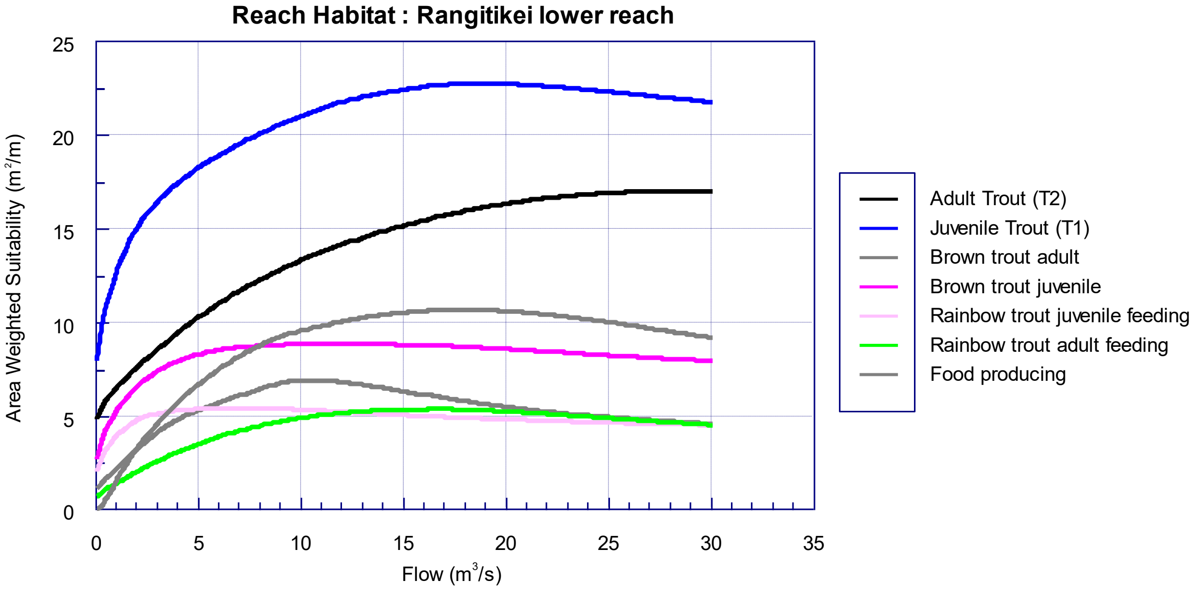


Figure A7.12. Area-weighted suitability versus flow plot for trout in the Hampton reach (lower Rangitīkei River). The invertebrate food-producing curves have been reproduced in this figure as this curve represents the food base for fish (native and introduced).

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