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24th September 2020

Report Prepared for Greater Wellington Regional Council

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Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment

24th September 2020

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EXECUTIVE SUMMARY

Background

Greater Wellington Regional Council (GWRC) are working with the Whaitua Te Whanganui-a-Tara Committee to develop a Whaitua Implementation Programme (WIP) that describes how the community want to manage their water now and for future generations through a range of integrated tools, policies and strategies[1]. The WIP will likely include:

- Specific objectives for water quality and quantity outcomes related to ecosystem and human health;
- Timeframes and priorities for achieving the objectives; and
- Water quality and quantity limits and other methods to help ensure objectives are met.

A key component of the whaitua process is scenario testing, whereby the environmental, societal, cultural and economic effects of a range of different management options are assessed in order to inform the Whaitua Committee of their costs and benefits. The intent is to inform good decision-making on objectives, limits, methods and timeframes. Three scenarios have been designed to represent a range of possible future management efforts. Climate change has been assumed consistently across all three scenarios so that assessments predict the net effect of climate change and management compared to the current state. The scenario details are described at the back of this Executive Summary. The three scenarios include:

- Business as usual (BAU) – Represents the current regulatory and management approach;
- Improved – Includes a significant step up in effort across several aspects of both urban and rural land and water management; and
- Sensitive – Includes a further step up in effort to fully incorporate numerous water sensitive urban design and rural land and water management methods.

The task of assessing just the environmental effects of these scenarios has been divided into three parts, with assessment of each part assigned to a suitably qualified expert panel. One of these is the 'water quality and ecology' assessment that is the focus of this report. The two other parts are the 'river flows and allocation' and 'coastal water quality and ecology' assessments, which will each be reported separately to this report.

It is intended that the findings from all three of these environmental assessments will be subsequently amalgamated, along with assessments of the social, cultural and economic implications of scenarios, in order to fully inform Whaitua Committee and Council decision-making.

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[1] The WIP will help GWRC to implement the National Policy Statement for Freshwater Management (NPS-FM 2017) which requires regional councils to establish, amongst other things, objectives for a specified set of water quality measures (called attributes) and to set limits on resource use to ensure those objectives are met.

Purpose

The purpose of this Executive Summary is to summarise the main findings of the 'water quality and ecology' assessment report. The purpose of the full report is to:

- Describe the process undertaken by the Freshwater Quality and Ecology Expert Panel (hereafter 'the panel') to assess water quality and ecology under climate change and three management scenarios;
- Document the outputs from the expert panel's assessment;
- Describe the methods used to 'downscale' the expert panel's assessments to allow estimates of future environmental state at localised scales; and
- Compare water quality and ecology effects under climate change and across management scenarios.

Methods

While the methods are described in detail in the full report, four aspects are important for understanding the results and key messages in this Executive Summary:

1. The assessments have used a range of measured environmental data, predictive models built either specifically for this project or for other Whaitua in the region or other regions, local expert science knowledge and a considerable base of science literature. Predicting the effects of future land and water scenarios is complicated due to the interacting effects of multiple stressors, uncertain environmental response relationships and the need to make uncertain assumptions about future change. An expert panel approach has been used to integrate, debate and test the available information and to reach expert consensus on future predictions.

2. Predictions are made of the effects of scenarios on water quality and ecology measures called 'attributes', including some that are nationally compulsory[2] and others that are commonly used for this purpose and for which data and predictive tools are available (see Table 1 to Table 4). An 'A/B/C/D' system is used to describe different levels of 'state' for each attribute where A is 'Excellent', B is 'Good', C is 'Fair' and D is 'Poor', following the system provided for this purpose in the NPS-FM (2017)[3]. Improvement or degradation under each scenario can then be described in terms of a small, moderate or large change, where a 'small' change is one that is detectable but does not shift the state level (e.g., C stays as C), a 'moderate' change

[2] The NPS-FM (2017) includes a list of compulsory attributes to be used in objective and limit setting and provides for other attributes to also be used at regional councils' discretion.

[3] While each attribute state can be simply described in ABC terms there are technical tables documenting the numeric measurement thresholds that define the boundary of each state (i.e., the A/B, B/C and C/D numeric thresholds).

is one that causes a shift in state (e.g., from C to B state), and a 'large' change causes a two-state shift (e.g., from C to A state) (see Table 5).

3. The expert panel made predictions of state for all attributes under each scenario, and for each of six pre-determined spatial units termed Expert Panel Assessment Units (EPAU)[4] (see Figure 1). The panel outputs were subsequently used to further 'downscale' the assessment to predict state at sub-catchments and at GWRC State of Environment (SoE) monitoring sites.

4. Uncertainty is inevitable when predicting effects of future change in complex systems. There is no method to remove uncertainty. The expert panel approach has been transparent about uncertainty by explicitly assessing and then documenting the relative level of confidence (on a scale of 0 to 3) associated with each of their state predictions. See the full report for detail of that assessment.

Summary of results

A summary of predicted change compared to current state is shown for each of the three scenarios in Table 6. The colour system in Table 6 indicates whether a scenario is predicted to maintain current state (yellow), improve to varying degrees (deepening shades of green), or degrade to varying degrees (deepening shades of orange).

The obvious first thing to observe from Table 6 is that there is general improvement across the scenarios from left (BAU scenario) to right (Sensitive scenario) as would be expected. However, the degree of improvement varies by attribute and location. Key messages for each scenario are described in the following sub-sections.

Business as Usual (BAU) Scenario

Most attributes in most sub-catchments were predicted either unlikely to change from their current attribute state or to get worse, despite the better management measures under the BAU scenario than have occurred historically. A key reason for some attributes getting worse is the negative effects of climate change. Attributes that got worse in some parts of the Whaitua due to climate change include:

- Flow – Lower minimum flows and increased flood intensities (to varying degree across the Whaitua);
- Sediment – Increased risk of sediment loss from both bank and slope erosion (slope wash and slips);
- Periphyton - Increased risk due to reduced summer low flows, although offset in part by flood increases;
- Macroinvertebrates – Impacted by increased temperature, periphyton, sediment and flood disturbance of habitat;

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[4] The expert panel made separate assessments for each of six EPAUs that were delineated based on catchment boundaries and land-use. These were, Headwater urban; Hutt [River] main stem; Mangaroa/Pakuratahi Valleys; Mixed rural; Groundwater fed urban and Surface water fed urban (see Figure 1).

- Ecosystem health – Increased risk from combination of above factors; and
- Overall suitability for recreation – Impacted by reduced summer flows, sediment and periphyton risk

In most parts of the Whaitua the negative effects from climate change listed were predicted to be detectable but not large enough to cause a moderate degradation or a whole attribute state change (see light orange cells in Table 6). The exceptions were for ecosystem health in the Groundwater fed urban (Unit 5) and Surface water fed urban (Unit 6) EPAUs where the negative climate change effects combined with further urban development were predicted to result in a moderate degradation in ecosystem health (see darker orange cells in Table 6).

The common stormwater contaminants, copper (Cu) and zinc (Zn), were predicted to worsen due to an increase in impervious surface cover arising from further urban development to house an increasing population. The urban design measures under BAU scenario are insufficient to mitigate these effects of urban development. As a result, Cu concentrations at the SoE monitoring site on the Kaiwharawhara Stream will likely shift from the C state to the D state, while Zn concentrations are expected to shift from the B state to the C state. A one attribute state degradation is also likely for Cu and Zn in the following sub-catchments:

- East Harbour;
- Hutt Valley West Urban;
- Kaiwharawhara Stream; and
- Owhiro Stream .

Very few attributes improved under the BAU scenario, and only slightly in particular locations in the Mangaroa and Pakuratahi EPAU (see Table 6). The slight improvements were for dissolved reactive phosphorus (DRP), sediment input, *Escherichia coli* (*E. coli*) and overall suitability for recreation and were the result of the assumed stock exclusion and riparian planting in these catchments. These improvements were predicted to be detectable but not sufficient to improve a whole attribute state (see light green cells in Table 6).

Improved Scenario

The Improved scenario brings better urban management (e.g., better stormwater treatment, reduced leakage from the wastewater network, fewer wastewater overflows, better roof materials and more rainwater storage tanks on dwellings), and better rural management (e.g., more extensive stock exclusion, riparian planting and retirement of the steepest erosion-prone land into native woody vegetation). In general, these measures are predicted to more than offset the negative effects of climate change predicted under the BAU scenario above (see more green cells for the Improved scenario in Table 6). Key predicted environmental improvements include:

- Zn concentrations improve by one attribute state in the Hutt River Valley floor and Waiwhetu Stream sub-catchments due to stormwater capture and treatment and the replacement of 50% of existing roofs constructed from materials containing zinc. The SoE monitoring site on the Waiwhetu Stream shifts from D state to C state.

- Extensive stock exclusion and greater riparian planting than under BAU scenario in the Mangaroa Valleys and Pakuratahi Grassland sub-catchments result in a one attribute state improvement in DRP concentrations. This means most river reaches in the Pakuratahi Grassland sub-catchment will be in A or B attribute state (currently B or C state) while most reaches in the Mangaroa Valley sub-catchment will be in the B or C state (currently C or D state).

- The benefits of retirement, stock exclusion and riparian planting also bring significant improvements for sediment, periphyton, macroinvertebrates and ecosystem health compared to the BAU scenario in almost all other sub-catchments assessed (see change in colour from generally orange to yellow or light green for these attributes in Table 6). While these improvements do not bring a whole attribute state improvement compared to current, they are significantly better compared to BAU because they offset many of the negative changes predicted to arise from climate change.

- The removal of dry weather wastewater contamination results in a two attribute state improvement in *E. coli* concentrations (and, consequently, suitability for recreation) in all sub-catchments in the Groundwater fed urban (Unit 5) and Surface water fed urban (Unit 6) EPAUs. As a result, all river reaches and SoE sites will likely be in the 'swimmable' attribute states (A, B or C). This is a significant improvement as in most of those sub-catchments less than 15% of reaches are predicted to be currently swimmable.

- Reduced wastewater contamination in urban areas combined with stock exclusion and riparian planting results in a one attribute state improvement in *E. coli* concentrations (and thus also suitability for recreation) in the sub-catchments in the Headwater urban, Hutt mainstem and Mangaroa/Pakuratahi Valleys EPAUs. Between 57% and 100% of river reaches in these sub-catchments will likely be in the swimmable attribute states (up from between 18% to 74% currently), except in the Karori Stream – Urban sub-catchment where 88% of reaches will remain unswimmable.

Sensitive Scenario

The Sensitive scenario brings a further step up in urban management (e.g., water sensitive urban design and stormwater treatment, further reduced wastewater overflows, more rainwater storage tanks on dwellings), and better rural management (e.g., even greater stock exclusion and wider riparian planting buffers, retirement of both moderate and steep erosion-prone land into native woody vegetation). These measures are predicted to produce further environmental improvements than those for the Improved scenario above (see more darker green cells for the Sensitive scenario in Table 6). Key predicted environmental improvements include:

- Cu concentrations improve by two attribute states in the Hutt River Valley Floor and Waiwhetu Stream sub-catchments in response to stormwater capture and treatment (see dark green cells in Table 6). The SoE site on the Waiwhetu Stream shifts from the C state to the A state.

- Stormwater capture and treatment combined with the replacement of all roofs containing Zn result in a two attribute state improvement in Zn concentrations in sub-catchments in the Groundwater fed urban (Unit 5) EPAU and a one attribute state improvement in the Surface water fed urban (Unit 6) EPAU and the Karori Stream – Urban and Wainuiomata River – Urban sub-catchments. The SoE sites on the Karori and Waiwhetu streams will likely shift from the D attribute state to the B state, while the site in the Kaiwharawhara Stream will likely shift from the B state to the A state.

- Dissolved inorganic nitrogen (DIN) concentrations in the Mangaroa Valley and Pakuratahi Grassland sub-catchments improve one attribute state as a result of extensive stock exclusion and riparian planting (see mid-green cells in Table 6). This shift is likely to result in 85% of river reaches in the Mangaroa Valley sub-catchment and 91% of reaches in the Pakuratahi Grassland being in the A state (up from 38% and 77% respectively).

- DRP concentrations improve an attribute state in all sub-catchments in the Headwater urban, Mangaroa/Pakuratahi Valleys and Mixed rural catchments (see mid-green cells in Table 6). Most SoE sites and river reaches in these sub-catchments will be in the B or C attribute state (currently C or D)

- *E. coli* concentrations in the Headwater urban (Unit 1), Groundwater fed urban (Unit 5), and Surface water fed urban (Unit6) catchments are expected to change by the same number of attribute states as under the Improved scenario. While management of *E.coli* sources is better than under the Improved scenario it does not cause a further lift in attribute state.

- A two-attribute state improvement in *E. coli* concentrations is expected in the Hutt mainstem and Mangaroa/Pakuratahi Valleys catchments due to more extensive riparian planting than under the Improved scenario. The proportion of swimmable river reaches (in the A, B or C state) will likely increase from 18% to 76% in the Mangaroa Valleys sub-catchment and from between 42% and 75% to 100% in the Te Awa Kairangi mainstem and Pakuratahi Grassland sub-catchments.

- Extensive land retirement in the Mixed rural (Unit 4) catchments produces a one attribute state improvement in *E. coli* concentrations. The proportion of swimmable reaches increases by between 27% to 83% depending on the sub-catchment, with total proportion of swimmable reaches ranging from 27% to 94% (up from 0% to 56%).

- Reduced nutrient concentrations (due to land retirement and riparian planting) and increased shading (due to more riparian planting) is expected to decrease periphyton biomass by one attribute state in the sub-catchments in the Mangaroa/Pakuratahi

Valleys (Unit 3) catchments. As a result, 85% of river reaches in the Mangaroa Valley sub-catchment are expected to be in the B state (up from 10%), and 97% of reaches in the Pakuratahi Grassland sub-catchment will likely be in the A or B states (up from 58%).

- Stock exclusion, riparian planting, land retirement and reduced metal concentrations in urban sub-catchments are expected to result in a two-attribute state improvement in the Macroinvertebrate Community Index (MCI) in the Mangaroa Valleys sub-catchment (see dark green cell in Table 6). A one attribute state improvement in the MCI attribute is also expected in sub-catchments in the Mixed rural (Unit 4) and Groundwater fed urban (Unit5) EPAU, and the Wainuiomata River – Urban/Rural, Karori Stream – Urban and Pakuratahi Grassland sub-catchments. All these improvements in the MCI attribute are reflected in significant improvements in ecosystem health (see mid-green cells for all catchments under the Sensitive scenario in Table 6). The MCI attribute improvements result in:
    - Most river reaches (85%) and the SoE site in the Mangaroa Valley sub-catchment shift from the B or C state to the A state;
    - The proportion of reaches in the Pakuratahi Grassland sub-catchment in the A state increase from 52% to 85% ;
    - At least 70% of river reaches in all sub-catchments in the Mixed rural EPAU, except Ohariu Stream, shift from the B state to the A state;
    - At least 70% of river reaches in the Ohariu Stream, Waiwhetu Stream and Hutt River Valley Floor sub-catchments being in the A or B state (up from 31% to 48%);
    - The proportion of reaches in the Karori Stream – Urban sub-catchment in the A or B state increasing from 25% to 100%; and
    - 100% of reaches in the urban and rural Wainuiomata River sub-catchments being in the A or B attribute state (up from 67% and 81% respectively).

- Finally, the significant improvements detailed above, both for *E. coli* and for other factors such as riparian enhancement and amenity improvement, in combination significantly improve suitability for recreation (see dark green cells in Table 6).

High level messages

High level messages for resource management, at whole of Whaitua scale, include:

- Climate change is expected to bring several negative effects for water quality and ecology (e.g., caused by adverse effects of reduced minimum flows and increased flood intensities) that are not offset by BAU scenario management approaches. Under BAU and with an increasing population to be housed, water quality, ecological health and suitability for recreation will generally get worse. (See in Table 6 that there are generally yellow and orange cells under the BAU scenario).

- Better than BAU scenario management effort is generally necessary just to 'hold ground' against climate change and maintain current levels of water quality and ecological health. (See in Table 6 that most of the orange cells under the BAU scenario are improved to at least yellow or light green under the Improved scenario).

- The Improved scenario achieves some improvement on current state for some attributes (e.g., nitrate (NO_3-N) and ammonia (NH_4-N) toxicity, nutrients (DIN and DRP), sediment, *E. coli*, periphyton, invertebrates, ecosystem health and suitability for recreation, and in a few places for copper and zinc), but the improvements are generally small (except for *E. coli* and suitability for recreation discussed next) despite the greater management effort than under BAU. This result is at least partly because the benefits of the Improved scenario measures are masked in some places by the negative effects of climate change and an increasing population needing to be housed. The situation is certainly worse without the Improved measures as can be seen by comparison with the BAU scenario results.

- While the swimmable standard is not achieved everywhere all the time, the Improved scenario does achieve significant and moderate improvements on current state for *E. coli* and overall suitability for recreation respectively (Table 6). This is primarily due to improvements in wastewater network leakage and reduced wastewater overflows in urban areas, and greater stock exclusion, riparian buffers and retirement of steep erosion-prone land in rural areas.

- The Sensitive scenario produces improvements beyond those predicted for the Improved scenario, particularly for Zn, Cu, sediment, DRP, invertebrates and ecosystem health, and especially so for *E. coli* and overall suitability for contract recreation. For *E. coli* the Sensitive scenario achieves a two-attribute state improvement in many catchments (see dark green cells in Table 6) resulting in more waterways achieving the swimmable standard more of the time than under the Improved scenario. However, even under the Sensitive scenario a swimmable standard is not achieved everywhere all the time, illustrating just how challenging this is to achieve.

- None of the scenarios completely overcame the negative effects of climate change on flow. This is primarily because none of the scenarios included any assumed changes to current flow regime rules (e.g., minimum flows or allocations), which are being considered in the separate 'river flows and allocation' assessment report. However, some improvement can be seen for flow in the Sensitive scenario due to the flood attenuating benefits of water sensitive urban design and stormwater treatment.

- There were also no benefits assessed for the fish Index of Biotic Integrity (IBI) under any scenario (see all yellow cells in Table 6). This result is due to the assessment criteria being based on fish diversity and requiring the introduction or loss of a species to conclude a change in diversity. The expert panel did not consider that any of the scenario assumptions were likely to produce a gain or loss of species from a catchment and so the result was no change for all scenarios. However, there are of course numerous management actions not assumed in the scenarios that could benefit fish communities such as removing barriers to fish passage and improving in-stream habitat and riparian cover. In addition, the improvements predicted for ecosystem health generally under the Improved and Sensitive scenarios in Table 6 would also be expected to be positive for native fish communities and population carrying capacity even if they would not necessarily result in a new species introduction to catchments.

Table 1. Description of the Tier 1 attributes assessed by the panel.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider
Dissolved metals	The concentrations of copper and zinc. When assessing the effects of any predicted changes toxicity should be considered.	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on dissolved metal, nitrogen and phosphorus concentration; and • Modelling data from the Porirua Whaitua process applied to representative catchments.	• Copper • Zinc	Toxicity effects
Nitrogen 1	The concentrations of nitrate and ammonia. When assessing the effects of any predicted changes only toxicity should be considered.		• Ammonia • Nitrate	
Nitrogen 2	The concentration of dissolved inorganic nitrogen. When considering the effects of any predicted changes periphyton, macrophyte and cyanobacteria growth should be taken into account.		Dissolved inorganic nitrogen	• Periphyton growth • Macrophyte growth • Cyanobacteria growth
Phosphorus	The concentration of dissolved reactive phosphorus. When considering the effects of any predicted changes periphyton, macrophyte and cyanobacteria growth should be taken into account.		Dissolved reactive phosphorus	• Periphyton growth • Macrophyte growth
Fine sediment input	The amount of sediment entering the river network. When assessing the effects of any predicted changes, likely changes in sediment cover and suspended sediment concentrations should be considered.	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on sediment input. • Modelling data from the Porirua Whaitua process (suspended sediment only) applied to representative catchments.	Sediment load	• Sediment in suspension and the likely direct effects on flora and fauna • Visual clarity and the likely effects on amenity, aesthetics and recreation • Sediment deposited on the bed and the likely direct and indirect effects on flora and fauna

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider
Faecal contamination	The level of faecal contamination throughout the river network.	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on *E. coli* concentrations; and • Modelling data from the Porirua Whaitua process applied to representative catchments.	*E.coli*	Human health risks and resulting suitability for recreation
Flow	The entire hydrological regime including, mean flow, variability and flood frequency.	Downscaled climate change projections provided by Greater Wellington Regional Council	• Mean annual low flow • Mean annual Flood • Q5-Q95	All aspects of habitat, plant growth and water quality

Table 2. Description of the Tier 2 attributes assessed by the panel.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider	Tier 1 attributes to consider

Plant growth	All aspects of plant growth including cyanobacteria. Effects should be considered in terms of ecological health, aesthetic value and human health risks.	The panel's understanding of how the changes Tier 1 attributes will impact plant growth.	• Periphyton cover and biomass
			• Macrophyte cover
			• Cyanobacteria cover
				• Periphyton
				  ○ Habitat value both for fish and invertebrates
				  ○ Aesthetics
				• Macrophytes
				  ○ Habitat value both for fish and invertebrates
				  ○ Aesthetics
				  ○ The ongoing effects of continued drain management
				• Cyanobacteria
				  ○ Habitat
				  ○ Aesthetics
				  ○ Human health risks
					• Nitrogen 2
					• Phosphorus
					• Sediment
					• Flow

Table 3. Description of the Tier 3 attributes assessed by the panel.

<table>
<tr><th>Attribute</th><th>Narrative</th><th>Predicted changes in attribute provided by:</th><th>Parameters to consider</th><th>Effects to consider</th><th>Tier 1 attributes to consider</th><th>Tier 2 attributes to consider</th><th>Tier 3 attributes to consider</th></tr>
<tr><td>Invertebrate community health</td><td>Changes in invertebrate community composition in response to Tier 1 and Tier 2 attributes</td><td>The panel's understanding of how the changes Tier 1 and 2 attributes will impact invertebrate communities.</td><td>MCI</td><td>• Effects on other trophic levels both above and below
• Ecosystem health</td><td>• Nitrogen 1
• Dissolved metals
• Sediment
• Flow</td><td rowspan="2">Plant growth</td><td>N/A</td></tr>
<tr><td>Fish diversity</td><td>Changes in fish diversity at the local, regional, and national scale in response to Tier 1 and Tier 2 attributes. The effects of this should be considered in terms of the likely effects on the fish abundance, the species present, and the distribution of these species regionally and nationally.</td><td>The panel's understanding of how the changes Tier 1 and 2 attributes will impact fish communities, the threat classification of different species, and the distribution of threatened species in the Whaitua.</td><td>Fish diversity at the local scale</td><td>• Fish diversity at the regional scale (extreme e.g., complete loss of connectivity with the sea in an area with a homogenous fish community composed solely of long-fin eels will have more of an impact on regional fish diversity than in an area with a homogenous fish community composed solely of common bully, despite the local scale effects being the same)
• Fish diversity at the national scale (e.g., the loss of a small population of shortjaw kokopu will have a greater impact on national biodiversity than the loss of a small population of long-fin eels)
• Ecosystem health
• Effects on lower trophic levels</td><td>• Dissolved metals
• Nitrogen 1
• Sediment
• Flow</td><td>Invertebrate community health</td></tr>
</table>

Table 4. Description of the Tier 4 attributes assessed by the panel.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Tier 1 attributes to consider	Tier 2 attributes to consider	Tier 3 attributes to consider
Ecosystem health	The suitability of a waterway to sustain healthy ecosystems, including a diversity and abundance of species and ecological processes.	The panel's understanding of how the changes in Tier 1, Tier 2 and Tier 3 attributes will impact rivers and streams in terms of the ecosystem health value	All parameters describing water quality, water quantity, physical habitat, aquatic biota and instream processes (including those not explicitly provided as lower order attributes) and how they interact.	• Dissolved metals (copper and zinc) • Nitrogen 1 • Nitrogen 2 • Phosphorus • Sediment input • Flow	Plant growth	• Macroinvertebrate community health • Fish diversity
Overall suitability for recreation	The suitability of a river for recreation both in terms of health risk for contact recreation and aesthetic value for all forms of recreation	The panel's understanding of how the changes Tier 1 and 2 attributes will impact key rivers and streams in terms of the human health risk and amenity/aesthetic value	• Human health risks • Aesthetic and amenity value	• Faecal contamination • Sediment input • Flow	Plant growth	N/A

Table 5. Criteria for assessing "change" under scenarios, compared to current state.

Change	Narrative
-3 (large -)	A significant degradation in concentration/state. A two attribute state decline likely (where applicable).
-2 (moderate -)	A noticeable degradation in concentration/state. A one attribute state decline likely (where applicable).
-1 (small -)	A detectable degradation in concentration/state. However, a decline in attribute state is unlikely (where applicable).
0 (no/negligible)	Changes in concentration/state non-existent or unlikely to be detectable.
1 (small +)	A detectable improvement in concentration/state. However, an improvement in attribute state is unlikely (where applicable).
2 (moderate +)	A noticeable improvement in concentration/state. A one attribute state improvement likely (where applicable).
3 (significant +)	A significant improvement in concentration/state. A two attribute state improvement likely (where applicable).

Colour coding indicates whether a scenario is predicted to maintain current state (yellow), improve to varying degrees (deepening shades of green), or degrade (deepening shades of orange)

Table 6. Summary assessment of predicted change compared to current state for each of the three scenarios.

The colour system indicates whether a scenario is predicted to maintain current state (yellow), improve to varying degrees (deepening shades of green), or degrade to varying degrees (deepening shades of orange). Note that this table presents the same results as Table 11 in the full report but rearranged and with the colour system applied.

Scenarios – Business as Usual

EPAU	Sub-catchment	Cu	Zn	NO_3-N	NH_4-N	DIN	DRP	Sediment input	Faecal cont. (E.	Flow	Periphyton	Invertebrates	Fish (IBI)	Ecosystem health	Suitability for rec.
1	Karori S. – Rur.	-1	-1	0	0	0	0	-1	0	-2	0	-1	0	-1	-1
1	Karori S. – Urb.	-2	-2	0	0	0	0	-1	0	-2	0	-1	0	-1	-1
1	Wainuiomata R. – Rur.	-1	-1	0	0	0	0	-1	0	-2	-1	-1	0	-1	-1
1	Wainuiomata R. – Urb.	-2	-2	0	0	0	0	-1	0	-2	-1	-1	0	-1	-1
2	Te Awa Kairangi lower mainstem	-1	-1	0	0	0	0	0	0	-1	-1	-1	0	-1	-1
3	Mangaroa Valleys	0	0	0	0	0	1	1	1	-2	-1	0	0	0	1
3	Pakuratahi Grass	0	0	0	0	0	1	1	1	-2	-1	0	0	0	1
4	Hutt Valley West. Hills	0	0	0	0	0	0	-1	0	-2	-1	-1	0	-1	-1
4	Korokoro S.	0	0	0	0	0	0	-1	0	-2	-1	-1	0	-1	-1
4	Makara Coast	0	0	0	0	0	-1	-1	0	-2	0	-1	0	-1	-1
4	Makara S.	0	0	0	0	0	-1	-1	0	-2	0	-1	0	-1	-1
4	Ohariu S.	0	0	0	0	0	-1	-1	0	-2	0	-1	0	-1	-1
4	South Karori	0	0	0	0	0	-1	-1	0	-2	0	-1	0	-1	-1
5	Hutt R. Val. floor	-1	-1	0	0	0	0	-1	0	-2	-1	-1	0	-2	0
5	Waiwhetu S.	-1	-1	0	0	0	0	-1	0	-2	-1	-1	0	-2	0
6	East Harb.	-2	-2	0	0	0	0	-1	0	-2	-1	-1	0	-2	-1
6	Hutt Val. W. Urb.	-2	-2	0	0	0	0	-1	0	-2	-1	-1	0	-2	-1
6	Kaiwharawhara S.	-2	-2	0	0	0	0	-1	0	-2	0	-1	0	-2	-1
6	North-West Har.	0	0	0	0	0	0	-1	0	-2	0	-1	0	-2	-1
6	Owhiro S.	-2	-2	0	0	0	0	-1	0	-2	0	-1	0	-2	-1

Scenarios – Improved

EPAU	Sub-catchment	Cu	Zn	NO_3-N	NH_4-N	DIN	DRP	Sediment input	Faecal cont. (E.	Flow	Periphyton	Invertebrates	Fish (IBI)	Ecosystem health	Suitability for rec.
1	Karori S. – Rur.	0	1	1	1	1	1	1	2	-2	0	1	0	1	2
1	Karori S. – Urb.	0	2	1	1	1	1	1	2	-2	0	1	0	1	2
1	Wainuiomata R. – Rur.	0	1	1	1	1	1	1	2	-2	0	1	0	1	2
1	Wainuiomata R. – Urb.	0	2	1	1	1	1	1	2	-2	0	1	0	1	2
2	Te Awa Kairangi lower mainstem	1	1	1	1	1	1	1	2	-1	0	0	0	0	2
3	Mangaroa Valleys	0	0	1	0	1	2	2	2	-2	1	1	0	2	2
3	Pakuratahi Grass	1	1	1	0	1	2	2	2	-2	1	1	0	2	2
4	Hutt Valley West. Hills	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
4	Korokoro S.	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
4	Makara Coast	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
4	Makara S.	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
4	Ohariu S.	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
4	South Karori	0	0	1	0	1	1	1	1	-2	1	1	0	1	1
5	Hutt R. Val. floor	1	2	1	1	1	1	0	3	-2	0	1	0	1	2
5	Waiwhetu S.	1	2	1	1	1	1	0	3	-2	0	1	0	1	2
6	East Harb.	-1	1	1	1	1	1	0	3	-2	0	1	0	1	2
6	Hutt Val. W. Urb.	-1	1	1	1	1	1	0	3	-2	0	1	0	1	2
6	Kaiwharawhara S.	-1	1	1	1	1	1	0	3	-2	0	1	0	1	2
6	North-West Har.	0	1	1	1	1	1	0	3	-2	0	1	0	1	2
6	Owhiro S.	-1	1	1	1	1	1	0	3	-2	0	1	0	1	2

Scenarios – Sensitive

EPAU	Sub-catchment	Cu	Zn	NO_3-N	NH_4-N	DIN	DRP	Sediment input	Faecal cont. (E.	Flow	Periphyton	Invertebrates	Fish (IBI)	Ecosystem health	Suitability for rec.
1	Karori S. – Rur.	0	1	1	1	1	2	2	2	-2	1	1	0	2	3
1	Karori S. – Urb.	0	3	1	1	1	2	2	2	-2	1	2	0	2	3
1	Wainuiomata R. – Rur.	0	1	1	1	1	2	2	2	-2	1	2	0	2	3
1	Wainuiomata R. – Urb.	0	3	1	1	1	2	2	2	-2	1	2	0	2	3
2	Te Awa Kairangi lower mainstem	1	1	1	1	1	1	1	3	-1	0	0	0	0	3
3	Mangaroa Valleys	0	0	1	0	2	2	2	3	-1	2	3	0	2	3
3	Pakuratahi Grass	1	1	1	0	2	2	2	3	-1	2	2	0	2	3
4	Hutt Valley West. Hills	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
4	Korokoro S.	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
4	Makara Coast	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
4	Makara S.	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
4	Ohariu S.	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
4	South Karori	0	0	1	0	1	2	2	2	-1	1	2	0	2	2
5	Hutt R. Val. floor	3	3	1	1	1	1	1	3	0	1	2	0	2	3
5	Waiwhetu S.	3	3	1	1	1	1	1	3	0	1	2	0	2	3
6	East Harb.	1	2	1	1	1	1	1	3	0	1	1	0	2	3
6	Hutt Val. W. Urb.	1	2	1	1	1	1	1	3	0	1	1	0	2	3
6	Kaiwharawhara S.	1	2	1	1	1	1	1	3	0	1	1	0	2	3
6	North-West Har.	1	2	1	1	1	1	1	3	0	1	1	0	2	3
6	Owhiro S.	1	2	1	1	1	1	1	3	0	1	1	0	2	3

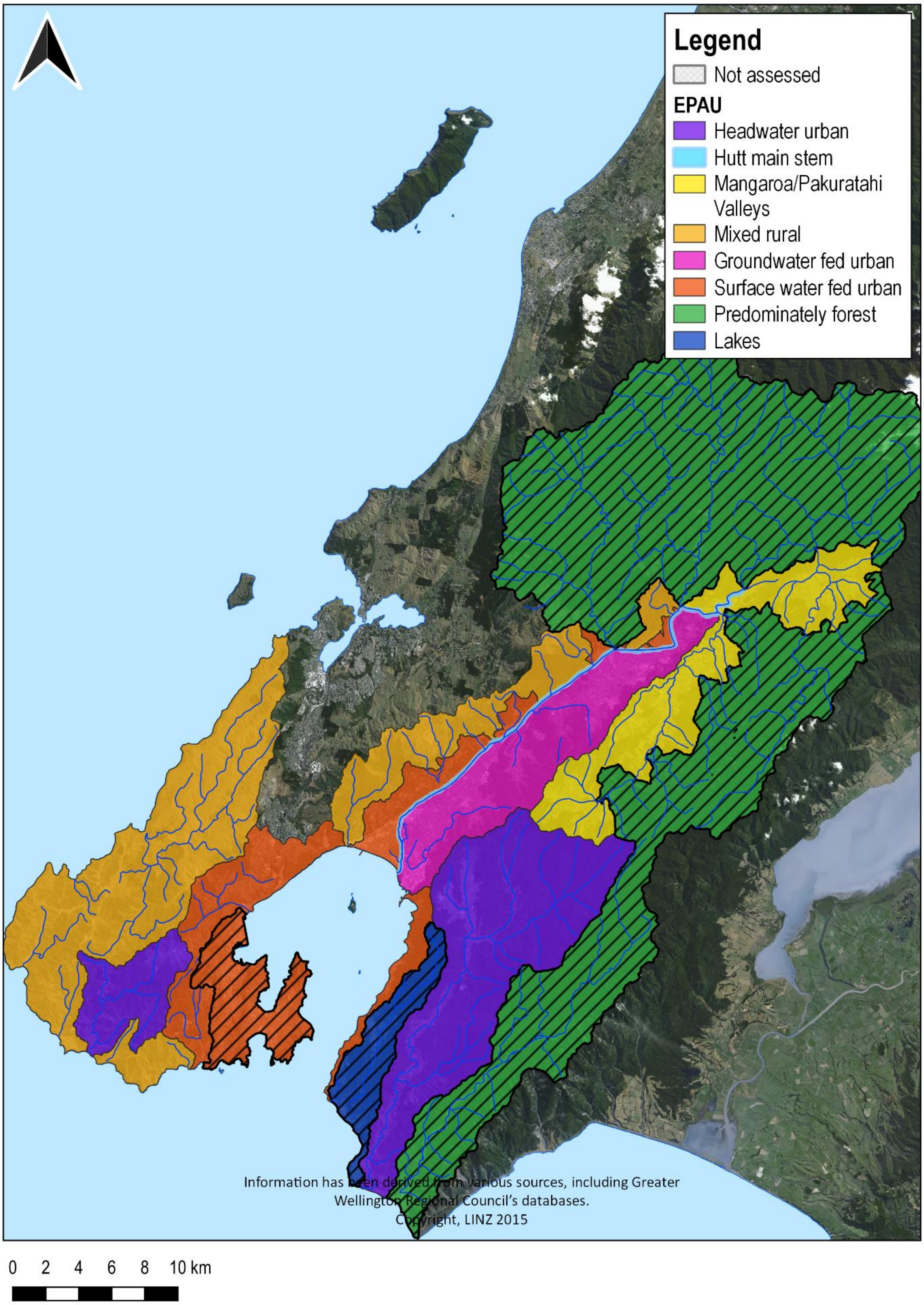

Figure 1. Map of the EPAUs, including the areas not considered in the panel's assessment.

Description of scenarios assessed by the Freshwater Quality and Ecology Expert Panel

Current state

- Current estimated areas of residential and numbers of dwellings based on areas of Urban grass and parks, and residential roads, paved and roofs within residential zoned areas. Dwelling numbers are estimated based on 15 dwellings per hectare (ha).
- Average current 'residential form' varies for each sub-catchment but is within the range of around 40-50% urban grassland and parks, 15-18% roads, 10-24% paved, 19-23% roofs.
- Retired pasture includes Fernland, Forest –Harvested, Gorse and/or Broom, Manuka and/or Kanuka, Matagouri or Grey Scrub, Mixed Exotic Shrubland, Sub Alpine Shrubland, Tall Tussock Grassland.
- No current exclusion in grassland areas.

BAU scenario

- There is no storm water capture or treatment assumed in the BAU scenario.
- Wastewater network condition does not change, and additional dwellings and population does not increase the wastewater overflows.
- Numbers of additional dwellings are from the overall supply of realisable residential capacity from the Wellington City Council, Hutt City Council and Upper Hutt City Council housing and business development capacity assessments. These projections aim to represent the realisable new dwellings to accommodate residential population growth over the 30 years from 2017-2047.
- The resulting areas for development are calculated based on an assumed density of 15 additional dwellings/ha for standalone and 7.5 additional dwellings/ha (ha) for terraced housing (giving a total density of 20 dwellings/ha).
- Assumed new development form for dwellings within existing residential zones is 43% urban grassland and parks, 15% roads, 17% paved, 25% roofs. For greenfield development zones it is 36% urban grassland and parks, 20% roads, 14% paved, 30% roofs. These follow the assumed residential forms adopted through Jacobs scenario modelling in TAoP Whaitua.
- Standalone houses and greenfield development are replacing forest and pasture covers, while terrace style housing replaces urban grass and parks and residential impervious covers.
- Additional livestock exclusion of all REC streams in identified 'Category 1 or 2' areas of the proposed Natural Resources Plan (pNRP)
- No current exclusion in grassland areas so the pNRP requirements provide additional exclusion on 100% of stream length within those zones.

Improved scenario

- Numbers of additional dwellings, development form and land cover replacement for are the same as for BAU.
- A mixture of site and catchment scale stormwater retention devices are fitted to catch and treat runoff from impervious surfaces of residential developments. These treatment trains result in reductions in contaminate yields and flow from impervious surfaces in these areas of approximately:
  - Suspended sediment, 80%
  - Total and dissolved zinc, 70%
  - Total and dissolved copper, 70%
  - Total nitrogen, 40%
  - Total phosphorus, 50%
  - *E. coli*, 90%
  - Total flow, 6%. The hydrology case study catchments also illustrated that flow characteristics such as the frequency of 'channel forming flows' and cumulative frequency distribution shifted towards pre-development state.
- Retro-fit of rain tanks to 10% existing residential roofs reduced total flow from these by 1%.
- 50% of runoff from commercial and industrial paved surfaces and major roads receives media filter treatment. These result in weighted reductions for these surfaces of around:
  - Suspended sediment, 40%.
  - Total and dissolved zinc and copper, 20%.
  - Total nitrogen and phosphorus, 20%.
  - *E. coli*, no change.
- 50% of commercial and industrial roofs and existing residential roofs are replaced/treated with low zinc yielding materials. These reduce zinc yields from these surfaces by nearly 50% .
- Wastewater network condition is significantly improved to remove dry weather leaks and overflows are removed in all but the four largest rainfalls each year.
- Additional livestock exclusion is undertaken on all REC order 2 or greater streams with grassland land cover and catchment slope less than 10 degrees. All areas of exclusion receive riparian planting following the GWRC planting guidance. These result in weighted reduction factors for runoff from pastoral lands with exclusion and planting of:
  - Total and dissolved phosphorus, 50%;
  - *E. coli*, 44%; and
  - Streambank erosion component of suspended sediment, 80%.
- Space/pole planting of Land Use Capability (LUC) class 6e land with grassland land cover. The scenario assumes the poles have reached maturity and act to reduce the hillslope erosion component of sediment load and reduce particulate phosphorus by 28%.

- Retirement of LUC class 7e and 8e land with grassland land cover. The scenario assumes this reverts to native cover and adopts the relevant contaminant and flow generation characteristics. Streams within these areas are assumed to receive livestock exclusion through the retirement.

Water sensitive scenario

- Numbers of additional dwellings and land cover replacement for are the same as for BAU. However, the development form changes to have less paved surfaces and greater urban grassland and parks.
- A mixture of site and catchment scale stormwater retention devices are fitted to catch and treat runoff from greater areas of impervious surfaces of residential developments. These made small change to the contaminant load reduction factors in the Improved scenario, but greater use and size of rain tanks reduces total flow by around 37%. The hydrology case study catchments also illustrate that flow characteristics such as the frequency of 'channel forming flows' and cumulative frequency distribution will shift further towards a pre-development state.
- Retro-fit of rain tanks to 50% existing residential roofs reduce total flow from these by 30%.
- 100% of runoff from commercial and industrial paved surfaces and major roads receives different types of runoff treatment. These result in weighted reductions for these surfaces of around:
    - Suspended sediment, 75-90%;
    - Total and dissolved zinc and copper, 50-80%;
    - Total nitrogen and phosphorus, 40-60%; and
    - *E. coli*, 90%.
- 100% of commercial and industrial roofs and existing residential roofs are replaced/treated with low zinc yielding materials. These reduce zinc yields from these surfaces by 97%.
- Wastewater network condition is significantly improved to remove dry weather leaks and overflows are removed in all but the two largest rainfalls each year.
- Additional livestock exclusion is undertaken on all REC order 2 or greater streams with grassland land cover and catchment slope less than 15 degrees. All areas of exclusion receive full riparian planting following the GW planting guidance. The reduction factors are the same as the Improved scenario.
- Retirement of LUC classes 6e, 7e and 8e land with grassland land cover. The scenario assumes this reverts to native cover and adopts the relevant contaminant and flow generation characteristics. Streams within these areas are assumed to receive livestock exclusion through the retirement.

Assumed riparian management under the different scenarios

The panel assumed the following riparian management is undertaken in streams where stock exclusion is required:

- Under BAU the expert panel assumed that stock exclusion entailed a simple one metre fencing setback with no riparian planting;
- Under Improved the expert panel assumed a five-metre setback with riparian planting carried in accordance with existing guidance documents from Greater Wellington Regional Council[5] (see Figure 2 for the type of riparian planting assumed); and
- Under Sensitive the expert panel assumed a 10-metre setback with riparian planting carried in accordance with existing guidance (see Figure 2 for the type of riparian planting assumed).

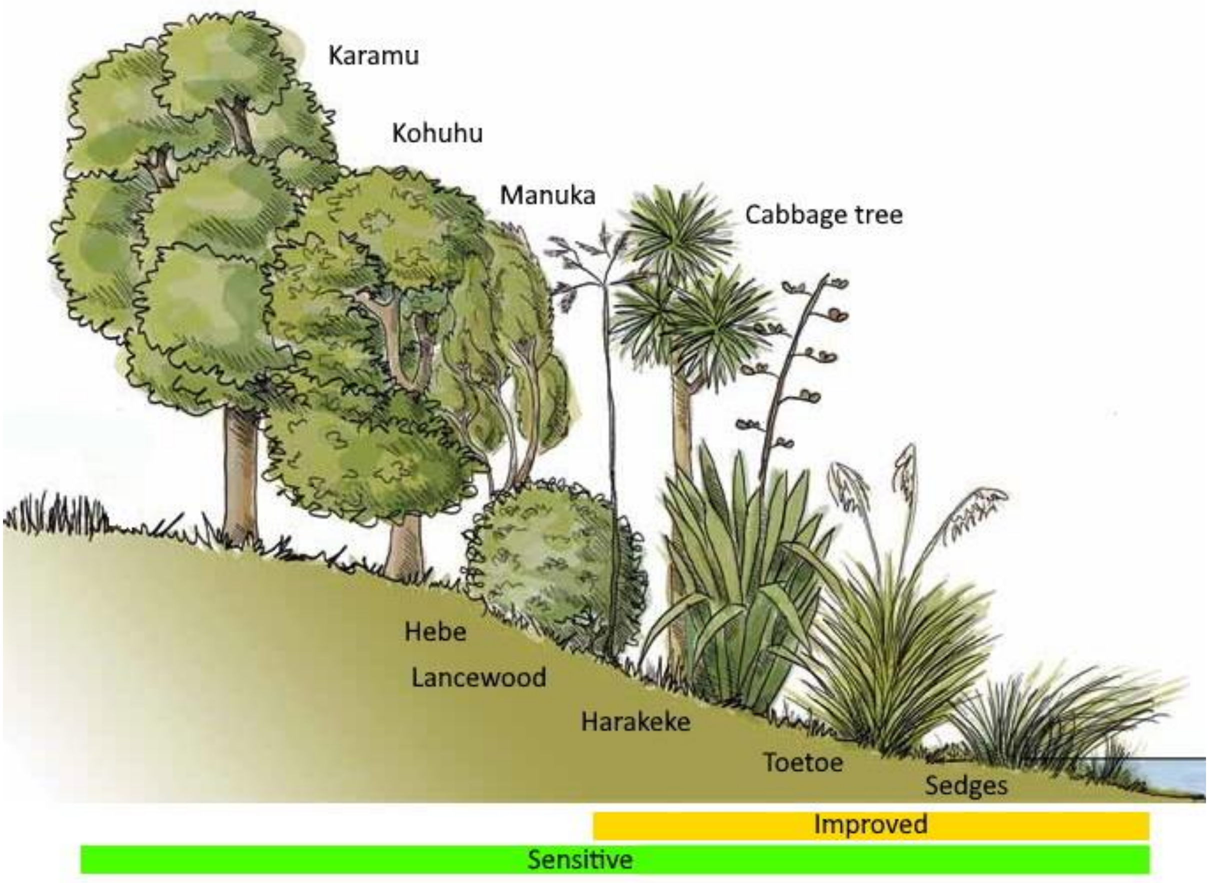

Figure 2: Assumed level of riparian planting under the Improved and Sensitive scenarios.

[5] Greater Wellington Regional Council, 2009: Mind the Stream – A guide to looking after streams in the Wellington Region. Wellington. http://www.gw.govt.nz/assets/council-publications/Mind%20the%20stream%20booklet%20Full.pdf

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1. Introduction

1.1. Context

The National Policy Statement for Freshwater Management 2014 (NPS-FM 2014) requires regional councils to establish objectives for a specified set of water quality measures (attributes) and set limits on resource use to ensure those objectives are met. To implement the NPS-FM 2014, Greater Wellington Regional Council (GWRC) are working with the Whaitua Te Whanganui-a-Tara Committee to develop a Whaitua Implementation Programme (WIP) that describes the ways in which the people from that catchment want to manage their water now and for future generations through a range of integrated tools, policies and strategies. The WIP will likely include:

- Specific Whaitua or catchment objectives for water quality and quantity outcomes related to ecosystem health and human health for recreation, including setting timeframes and priorities for achieving Whaitua or catchment objectives; and
- Water quality limits and targets, including nutrient load and contaminant limits, that will ensure objectives and targets are met.

A key component on the whaitua process is scenario testing, whereby the environmental, societal, cultural and economic effects of a range of different management options are assessed in order to inform the Whaitua Committee of their costs and benefits. Past whaitua processes have relied almost exclusively on large models to test the effects of different scenarios on water quality and ecology. However, for the Whaitua Te Whanganui-a-Tara process GWRC have decided to use a less model intensive approach, whereby smaller models are used whenever possible, with the bulk of the assessment made by three expert panels. These panels cover river flows and allocation, freshwater quality and ecology and coastal water quality and ecology, and feed into one another.

1.2. Aim and Scope

The purpose of this report is to:

- Describe process undertaken by the Freshwater quality and Ecology Expert Panel (hereafter referred to as ‘the panel’ or the ‘expert panel’) to assess how water quality and ecology in Whaitua Te Whanganui-a-Tara may change under the following scenarios:
    - Business as usual;
    - Improved; and
    - Sensitive
- Set out the methods used to ‘downscale’ the expert panel’s assessments to a sub-catchment scale and translate their outputs into estimates of future ‘attribute state’ at a reach and site scale;
- Present the expert panels outputs; and

- Compare water quality and ecology in Whaitua Te Whanganui-a-Tara under the different scenarios with current state based on the results of the downscaling of the expert panels outputs.

1.3. Structure of the Report

This report is comprised of five sections:

- In Section 2, the expert panel approach is described in detail;
- In Section 3, the methods used to translate the expert panels assessments in to sub-catchment scale estimates of the future state of water quality and ecology under the different scenarios are described;
- In Section 4, the expert panels outputs are presented;
- In Section 5, predicted water quality and ecology under the scenarios are compared to current state.

2. Methods 1 – Expert panel approach

2.1. Purpose of the expert panel:

The purpose of the expert panel was to assess the likely consequences of different management regimes on surface water quality and ecology in the Whaitua Te Whanganui-a-Tara, in order to inform the Whaitua Committee during the objective and limit setting process (the Terms of Reference for the expert panel are provided in Appendix A)

2.2. Objectives:

The specific objectives of the expert panel process were:

- To assess the current bio-physical state of surface water quality and ecology within the Whaitua for sites with little monitoring information.
- Using a science technical library, which included reports, monitoring data and some modelling information, evaluate scenarios that may influence indicators of water quality and ecosystem health. The following scenarios were considered:
  - Business as Usual (BAU) –Assumed all the natural resources plan (NRP) rules are operative and being undertaken at 100% compliance;
  - Improved –Applied increasing levels of mitigations to the rural/urban environment, greater than BAU; and
  - Water Sensitive Design (Sensitive) –Applied high levels of mitigations to rural/urban environment, significantly more than BAU.

  More details on scenarios are provided in Section 2.9.
- To produce a panel summary for each scenario that details the potential magnitude of change for a number of key attributes across six Expert Panel Assessment Units (EPAUs), the effects of those changes and the panel's confidence in their assessment.

2.3. Expert panel road map

The road map followed during the expert panel process is described below.

Phase 1 **Develop the scenario assessment methodology**

- **The technical attributes the panel will assess is decided.**
- **The spatial units for which the panel will make their assessments are agreed upon.**
- **An assessment methodology is developed and finalised based on feedback from the panel.**
- **The process for contributing to a "science technical library" which the panel will work from is agreed upon by its members.**

Phase 2 **Develop an understanding of current state**

- **The panel is provided with Greater Wellington's "science technical library", which will contain information on the state of the rivers and streams in the Whaitua. Key sources of information will likely include:**
  - **Technical reports;**
  - **National modelling outputs;**
  - **Whaitua specific modelling data; and**
  - **Geospatial data on land-use, infrastructure and riparian management.**

Phase 3 **Scenario assessments**

- **What the changes in land-use, infrastructure and water allocation expected under each scenario will look like "on the ground" are defined.**
- **The likely changes in technical attributes under each scenario are assessed by each individual panel member based on the information in the science technical library and expert knowledge.**
- **Differing opinions are discussed and consensus reached where possible.**
- **A final panel assessment is produced.**

Phase 4 **Reporting**

- **The final panel assessments are documented in a technical report.**
- **Panel outputs are translated into shape files that can be overlaid on existing model/state data to assign predicted future attribute states at the reach/site scale.**

2.4. Role descriptions

The various roles within the expert panel were as follows

Chair:

- Person: Ms. Penny Fairbrother
- Role:
  - Facilitated and chaired scenario assessment workshops; and
  - Ensured the Expert Panel Terms of Reference were always met.

Technical Lead:

- Person: Dr Michael Greer
- Role:
  - Developed the expert panel process;
  - Led preliminary workshops on the expert panel process and current state;
  - Ensured that the panel's information requirements were fulfilled through a science technical library;
  - Ensured the panel completed key technical tasks on time;
  - Individually assessed the effects of three scenarios on key water quality and ecology attributes prior to scenario assessment workshops;

   - Attended and contributed to scenario assessment workshops where an overall assessment of the water quality and ecological effects of the three scenarios were put together based on the individual assessments of the panel members;
   - Synthesised an overall panel assessment from the outputs of its members; and
   - Documented the expert panel process and outputs in a technical report.

2.5. Panel members

- People:
   - Dr Olivier Ausseil
   - Dr Joanne Clapcott
   - Mr Stu Farrant
   - Dr Michael Greer
   - Dr Mark Heath
   - Mr Ned Norton
- Role:
   - Attended preliminary workshops on the expert panel process and current state;
   - Contributed to a science technical library;
   - Individually assessed the effects of three scenarios on key water quality and ecology attributes prior to scenario assessment workshops; and
   - Attended and contributed to scenario assessment workshops where an overall assessment of the water quality and ecology effects of the three scenarios were put together based on the individual assessments of the panel members.

2.6. Development of the panel's shared understanding

2.6.1. The science technical library

The primary tool used by the panel when making their assessments was a science technical library put together by GWRC and contributed to by the panel. This library included but was not limited to:

- Technical reports on current state;
- Relevant national modelling data to help describe current state;
- Maps of key values in the Whaitua (e.g., inanga spawning, trout fishing areas etc.);
- Maps of current land-use, riparian management and infrastructure;
- Whaitua specific modelling data (relevant for both current state and scenario assessments);
- Maps of future land-use, riparian management and infrastructure under the different scenarios;
- A dossier of peer reviewed literature on the effects of the scenario assumptions; and
- The results of other expert panel processing being conducted (e.g., Hutt, Wainuiomata and Orongorongo rivers flow panel).

2.6.2. Procurement of specialist advice

Where the panel felt they did not have sufficient expertise to comment on a certain topic, they had the option to request that GWRC commission an expert outside the panel to provide specialist advice that would then be added to the science technical library.

2.6.3. Scenario definition

So that all members had a shared understanding of what the scenario assumptions meant for land-use, infrastructure and water allocation, GWRC provided the panel with a detailed assessment of how and where each of these factors will change under each scenario. This included but was not limited to:

- Maps and statistics of residential development under current state and the scenarios;
- Maps of the extent of stock exclusion under current state and the scenarios;
- Details about the condition of wastewater and stormwater infrastructure under current state and the scenarios;
- Details about the location of wastewater overflows under current state and the scenarios; and
- Details about the location of stormwater mitigations under current state and the scenarios.

2.7. Assessment units

The Whaitua was split into the following eight EPAUs based on catchment boundaries and land-use (Figure 1):

- EPAU 1 – Headwater urban
- EPAU 2 – Hutt [River] mainstem
- EPAU 3 – Mangaroa/Pakuratahi Valleys
- EPAU 4 – Mixed rural
- EPAU 5 – Groundwater fed urban
- EPAU 6 – Surface water fed urban
- EPAU 7 – Lakes
- EPAU 8 – Predominately forest

The panel made separate assessments for each EPAU, except Lakes (EPAU 7) and Predominately forest (EPAU 8), which were not assessed at all. For each EPAU the panel's assessment was limited to areas not in indigenous forest and did not include any piped streams.

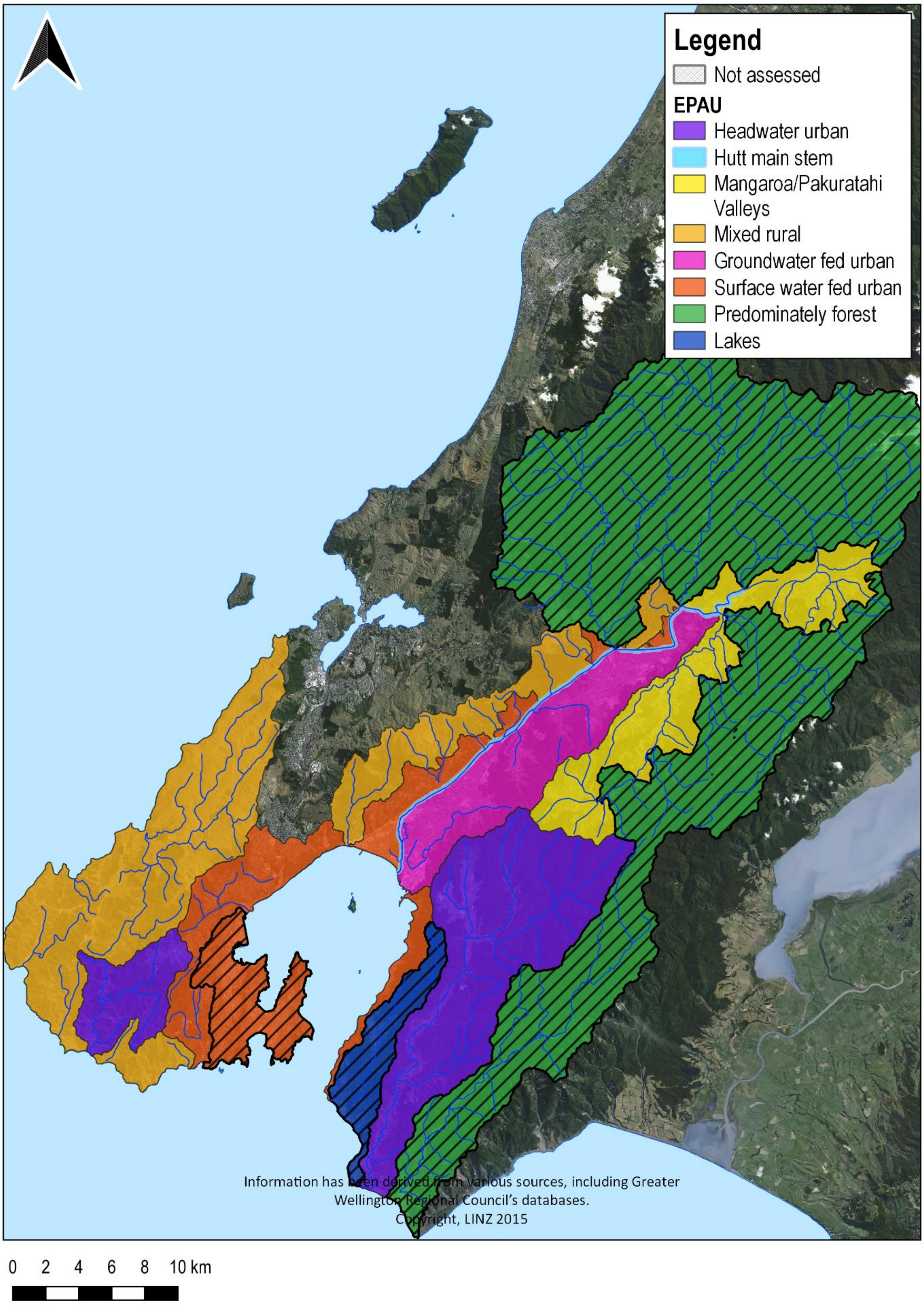

Figure 1: Map of the EPAUs, including the areas which were not considered in the panel's assessments.

2.8. Attributes

The attributes that the panel assessed were split into tiers based on how directly they are affected by changes in land-use, infrastructure and water allocation and their influence on other attributes. This ensured that attributes were not assessed before others that have a direct influence over them. The attribute tiers and the specific attributes are described below and set out in detail in Table 1 to Table 4:

- Tier 1 attributes – Attributes that are directly affected by a change in land-use, infrastructure and water allocation (Table 1).
- Tier 2 attributes – Water quality and habitat parameters that are indirectly affected by a change in land-use, infrastructure and water allocation (i.e., changes are the result of changes in Tier 1 attributes) (Table 2).
- Tier 3 attributes – Attributes that quantify the response of higher trophic levels to Tier 1 and 2 changes (Table 3).
- Tier 4 attributes – Attributes that quantify the response of values to Tier 2, 3 and 4 changes (Table 4).

The attribute state frameworks for those attributes that have them are provided in Appendix B

Table 1: Description of the Tier 1 attributes assessed by the expert panel.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider
Dissolved metals	The concentrations of copper and zinc. When assessing the effects of any predicted changes toxicity should be considered	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on dissolved metal, nitrogen and phosphorus concentrations; and • Modelling data from the Porirua Whaitua process applied to representative catchments.	• Copper • Zinc	Toxicity effects
Nitrogen 1	The concentrations of nitrate and ammonia. When assessing the effects of any predicted changes only toxicity should be considered		• Ammonia • Nitrate	
Nitrogen 2	The concentration of dissolved inorganic nitrogen. When considering the effects of any predicted changes periphyton, macrophyte and cyanobacteria growth should be taken into account		Dissolved inorganic nitrogen	• Periphyton growth • Macrophyte growth • Cyanobacteria growth
Phosphorus	The concentration of dissolved reactive phosphorus. When considering the effects of any predicted changes periphyton, macrophyte and cyanobacteria growth should be taken into account		Dissolved reactive phosphorus	• Periphyton growth • Macrophyte growth
Fine sediment input	The amount of sediment entering the river network. When assessing the effects of any predicted changes, likely changes in sediment cover and suspended sediment concentrations should be considered	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on sediment input • Modelling data from the Porirua Whaitua process (suspended sediment only) applied to representative catchments	Sediment load	• Sediment in suspension and the likely direct effects on flora and fauna • Visual clarity and the likely effects on amenity, aesthetics and recreation • Sediment deposited on the bed and the likely direct and indirect effects on flora and fauna

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider
Faecal contamination	The level of faecal contamination throughout the river network	• The panel's understanding of the effect of riparian management, land-use, infrastructure and water allocation change on *E. coli* concentrations; and • Modelling data from the Porirua Whaitua process applied to representative catchments.	*E.coli*	Human health risks and resulting suitability for recreation
Flow	The entire hydrological regime including, mean flow, variability and flood frequency	Downscaled climate change projections provided by Greater Wellington Regional Council	• Mean annual low flow • Mean annual Flood • Q5-Q95	All aspects of habitat, plant growth and water quality

Table 2: Description of the Tier 2 attributes assessed by the expert panel.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Effects to consider	Tier 1 attributes to consider

Plant growth	All aspects of plant growth including cyanobacteria. Effects should be considered in terms of ecological health, aesthetic value and human health risks	The panel's understanding of how the changes Tier 1 attributes will impact plant growth	• Periphyton cover and biomass
			• Macrophyte cover
			• Cyanobacteria cover
				• Periphyton
				  ○ Habitat value both for fish and invertebrates
				  ○ Aesthetics
				• Macrophytes
				  ○ Habitat value both for fish and invertebrates
				  ○ Aesthetics
				  ○ The ongoing effects of continued drain management
				• Cyanobacteria
				  ○ Habitat
				  ○ Aesthetics
				  ○ Human health risks
					• Nitrogen 2
					• Phosphorus
					• Sediment
					• Flow

Table 3: Description of the Tier 3 attributes assessed by the expert panel.

<table>
<tr><th>Attribute</th><th>Narrative</th><th>Predicted changes in attribute provided by:</th><th>Parameters to consider</th><th>Effects to consider</th><th>Tier 1 attributes to consider</th><th>Tier 2 attributes to consider</th><th>Tier 3 attributes to consider</th></tr>
<tr><td>Invertebrate community health</td><td>Changes in invertebrate community composition in response to Tier 1 and Tier 2 attributes</td><td>The panel's understanding of how the changes Tier 1 and 2 attributes will impact invertebrate communities</td><td>MCI</td><td>• Effects on other trophic levels both above and below
• Ecosystem health</td><td>• Nitrogen 1
• Dissolved metals
• Sediment
• Flow</td><td rowspan="2">Plant growth</td><td>N/A</td></tr>
<tr><td>Fish diversity</td><td>Changes in fish diversity at the local, regional, and national scale in response to Tier 1 and Tier 2 attributes. The effects of this should be considered in terms of the likely effects on the fish abundance, the species present, and the distribution of these species regionally and nationally.</td><td>The panel's understanding of how the changes Tier 1 and 2 attributes will impact fish communities, the threat classification of different species and the distribution of threatened species in the Whaitua</td><td>Fish diversity at the local scale</td><td>• Fish diversity at the regional scale (extreme e.g., complete loss of connectivity with the sea in an area with a homogenous fish community composed solely of long-fin eels will have more of an impact on regional fish diversity than in an area with a homogenous fish community composed solely of common bully, despite the local scale effects being the same)
• Fish diversity at the national scale (e.g., the loss of a small population of shortjaw kokopu will have a greater impact on national biodiversity than the loss of a small population of long-fin eels)
• Ecosystem health
• Effects on lower trophic levels</td><td>• Dissolved metals
• Nitrogen 1
• Sediment
• Flow</td><td>Invertebrate community health</td></tr>
</table>

Table 4: Description of the Tier 4 attributes assessed by the expert panel. As this is the highest tier of attributes, the panel did not consider the effects of a change in these attributes.

Attribute	Narrative	Predicted changes in attribute provided by:	Parameters to consider	Tier 1 attributes to consider	Tier 2 attributes to consider	Tier 3 attributes to consider
Ecosystem health	The suitability of a waterway to sustain healthy ecosystems, including a diversity and abundance of species and ecological processes	The panel's understanding of how the changes in Tier 1, Tier 2 and Tier 3 attributes will impact rivers and streams in terms of the ecosystem health value	All parameters describing water quality, water quantity, physical habitat, aquatic biota and instream processes (including those not explicitly provided as lower order attributes) and how they interact.	• Dissolved metals (copper and zinc) • Nitrogen 1 • Nitrogen 2 • Phosphorus • Sediment input • Flow	Plant growth	• Macroinvertebrate community health • Fish diversity
Overall suitability for recreation	The suitability of a river for recreation both in terms of health risk for contact recreation and aesthetic value for all forms of recreation	The panel's understanding of how the changes Tier 1 and 2 attributes will impact key rivers and streams in terms of the human health risk and amenity/aesthetic value	• Human health risks • Aesthetic and amenity value	• Faecal contamination • Sediment input • Flow		N/A

2.9. Scenarios assessed

2.9.1. Scenario descriptions provided to the expert panel

The ‘performance assumptions’ that were adopted to represent the scenario changes are briefly described through the points below.

Current state

- Current estimated areas of residential and numbers of dwellings based on areas of Urban grass and parks, and residential roads, paved and roofs within residential zoned areas. Dwelling numbers are estimated based on 15 dwellings per hectare (ha).
- Average current ‘residential form’ varies for each sub-catchment but is within the range of around 40-50% urban grassland and parks, 15-18% roads, 10-24% paved, 19-23% roofs.
- Retired pasture includes Fernland, Forest –Harvested, Gorse and/or Broom, Manuka and/or Kanuka, Matagouri or Grey Scrub, Mixed Exotic Shrubland, Sub Alpine Shrubland, Tall Tussock Grassland.
- No current exclusion in grassland areas.

BAU scenario

- There is no storm water capture or treatment assumed in the BAU scenario.
- Wastewater network condition does not change, and additional dwellings and population does not increase the wastewater overflows.
- Numbers of additional dwellings are from the overall supply of realisable residential capacity from the Wellington City Council, Hutt City Council and Upper Hutt City Council housing and business development capacity assessments. These projections aim to represent the realisable new dwellings to accommodate residential population growth over the 30 years from 2017-2047.
- The resulting areas for development are calculated based on an assumed density of 15 additional dwellings/ha for standalone and 7.5 additional dwellings/ha (ha) for terraced housing (giving a total density of 20 dwellings/ha).
- Assumed new development form for dwellings within existing residential zones is 43% urban grassland and parks, 15% roads, 17% paved, 25% roofs. For greenfield development zones it is 36% urban grassland and parks, 20% roads, 14% paved, 30% roofs. These follow the assumed residential forms adopted through Jacobs scenario modelling in TAoP Whaitua.
- Standalone houses and greenfield development are replacing forest and pasture covers, while terrace style housing replaces urban grass and parks and residential impervious covers.
- Additional livestock exclusion of all REC streams in identified ‘Category 1 or 2’ areas of the proposed Natural Resources Plan (pNRP)
- No current exclusion in grassland areas so the pNRP requirements provide additional exclusion on 100% of stream length within those zones.

Improved scenario

- Numbers of additional dwellings, development form and land cover replacement for are the same as for BAU.
- A mixture of site and catchment scale stormwater retention devices are fitted to catch and treat runoff from impervious surfaces of residential developments. These treatment trains result in reductions in contaminate yields and flow from impervious surfaces in these areas of approximately:
    - Suspended sediment, 80%
    - Total and dissolved zinc, 70%
    - Total and dissolved copper, 70%
    - Total nitrogen, 40%
    - Total phosphorus, 50%
    - *E. coli*, 90%
    - Total flow, 6%. The hydrology case study catchments also illustrated that flow characteristics such as the frequency of 'channel forming flows' and cumulative frequency distribution shifted towards pre-development state.
- Retro-fit of rain tanks to 10% existing residential roofs reduced total flow from these by 1%.
- 50% of runoff from commercial and industrial paved surfaces and major roads receives media filter treatment. These result in weighted reductions for these surfaces of around:
    - Suspended sediment, 40%.
    - Total and dissolved zinc and copper, 20%.
    - Total nitrogen and phosphorus, 20%.
    - *E. coli*, no change.
- 50% of commercial and industrial roofs and existing residential roofs are replaced/treated with low zinc yielding materials. These reduce zinc yields from these surfaces by nearly 50% .
- Wastewater network condition is significantly improved to remove dry weather leaks and overflows are removed in all but the four largest rainfalls each year.
- Additional livestock exclusion is undertaken on all REC order 2 or greater streams with grassland land cover and catchment slope less than 10 degrees. All areas of exclusion receive riparian planting following the GWRC planting guidance. These result in weighted reduction factors for runoff from pastoral lands with exclusion and planting of:
    - Total and dissolved phosphorus, 50%;
    - *E. coli*, 44%; and
    - Streambank erosion component of suspended sediment, 80%.
- Space/pole planting of Land Use Capability (LUC) class 6e land with grassland land cover. The scenario assumes the poles have reached maturity and act to reduce the hillslope erosion component of sediment load and reduce particulate phosphorus by 28%.

- Retirement of LUC class 7e and 8e land with grassland land cover. The scenario assumes this reverts to native cover and adopts the relevant contaminant and flow generation characteristics. Streams within these areas are assumed to receive livestock exclusion through the retirement.

Water sensitive scenario

- Numbers of additional dwellings and land cover replacement for are the same as for BAU. However, the development form changes to have less paved surfaces and greater urban grassland and parks.
- A mixture of site and catchment scale stormwater retention devices are fitted to catch and treat runoff from greater areas of impervious surfaces of residential developments. These made small change to the contaminant load reduction factors in the Improved scenario, but greater use and size of rain tanks reduces total flow by around 37%. The hydrology case study catchments also illustrate that flow characteristics such as the frequency of 'channel forming flows' and cumulative frequency distribution will shift further towards a pre-development state.
- Retro-fit of rain tanks to 50% existing residential roofs reduce total flow from these by 30%.
- 100% of runoff from commercial and industrial paved surfaces and major roads receives different types of runoff treatment. These result in weighted reductions for these surfaces of around:
    - Suspended sediment, 75-90%;
    - Total and dissolved zinc and copper, 50-80%;
    - Total nitrogen and phosphorus, 40-60%; and
    - *E. coli*, 90%.
- 100% of commercial and industrial roofs and existing residential roofs are replaced/treated with low zinc yielding materials. These reduce zinc yields from these surfaces by 97%.
- Wastewater network condition is significantly improved to remove dry weather leaks and overflows are removed in all but the two largest rainfalls each year.
- Additional livestock exclusion is undertaken on all REC order 2 or greater streams with grassland land cover and catchment slope less than 15 degrees. All areas of exclusion receive full riparian planting following the GW planting guidance. The reduction factors are the same as the Improved scenario.
- Retirement of LUC classes 6e, 7e and 8e land with grassland land cover. The scenario assumes this reverts to native cover and adopts the relevant contaminant and flow generation characteristics. Streams within these areas are assumed to receive livestock exclusion through the retirement.

2.9.2. Assumed riparian management under the different scenarios

The panel assumed the following riparian management is undertaken in streams where stock exclusion is required:

- Under BAU the expert panel assumed that stock exclusion entailed a simple one metre fencing setback with no riparian planting;
- Under Improved the expert panel assumed a five-metre setback with riparian planting carried in accordance with existing guidance documents from Greater Wellington Regional Council[6] (see Figure 2 for the type of riparian planting assumed); and
- Under Sensitive the expert panel assumed a 10-metre setback with riparian planting carried in accordance with existing guidance (see Figure 2 for the type of riparian planting assumed)

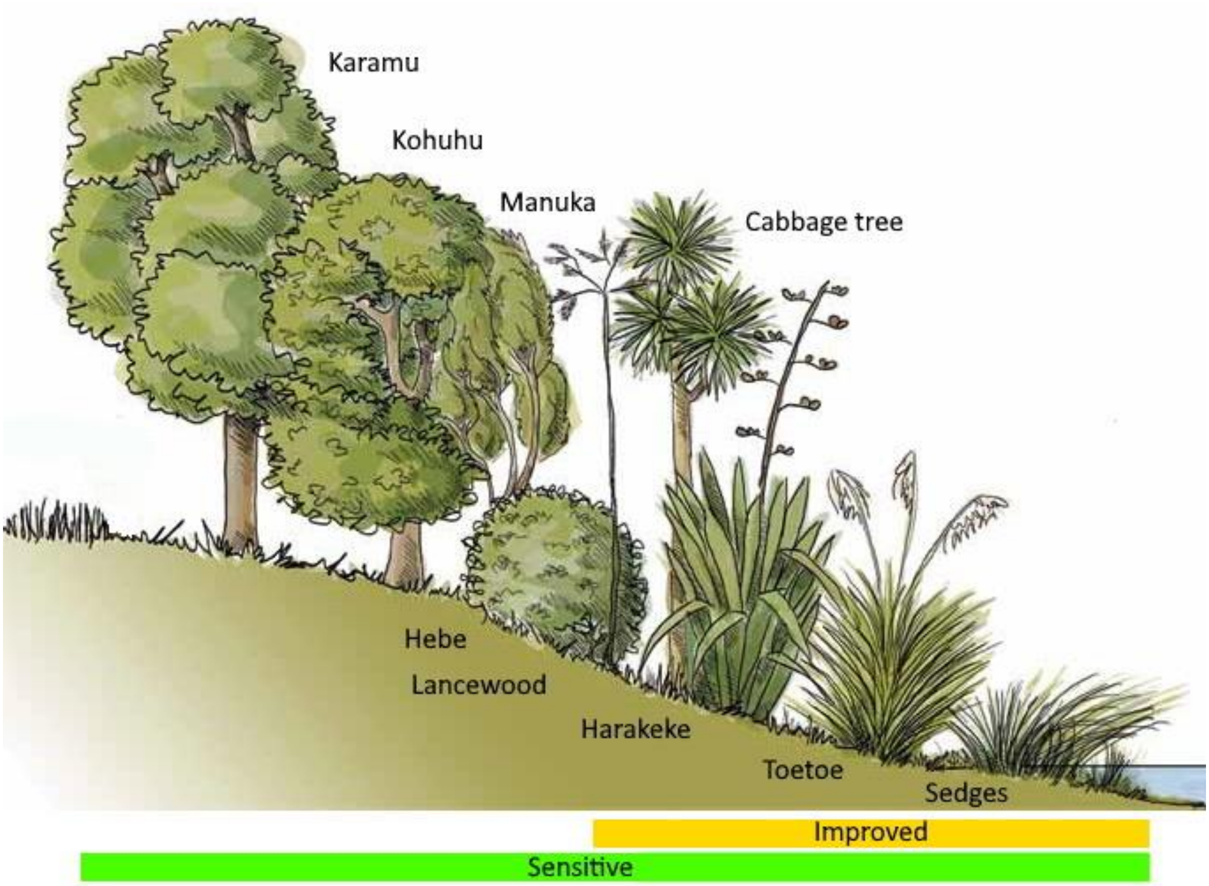

Figure 2: Assumed level of riparian planting under the Improved and Sensitive scenarios.

[6] Greater Wellington Regional Council, 2009: Mind the Stream – A guide to looking after streams in the Wellington Region. Wellington. http://www.gw.govt.nz/assets/council-publications/Mind%20the%20stream%20booklet%20Full.pdf

2.10. Assessment methodology

2.10.1. Individual assessments

For each scenario, all panel members made a qualitative/semi-quantitative assessment of the likely change of each attribute in each EPAU by filling out the template presented in Table 5.

Table 5: Assessment table template.

Attribute			
Change	**Effect**	**Confidence**	**Justification**
☐ **-3 (large -)**	☐ **-3 (strong -)**	☐ **0 (not assessed)**	**Change:** **Effect:** **Confidence:**
☐ **-2 (moderate -)**	☐ **-2 (moderate -)**	☐ **1 (low)**	
☐ **-1 (small -)**	☐ **-1 (weak -)**	☐ **2 (moderate)**	
☐ **0 (no/negligible)**	☐ **0 (no/negligible)**	☐ **3 (high)**	
☐ **+1 (small +)**	☐ **+1 (weak +)**		
☐ **+2 (moderate +)**	☐ **+2 (moderate +)**		
☐ **+3 (large +)**	☐ **+3 (strong +)**		

The assessment template required the panel to consider three factors:

- Change – How much an attribute will improve or degrade by under the scenario;
- Effect – The influence that this change will likely have on other attributes; and
- Confidence – The level of certainty the panel member has with their assessment of their "change" assessment.

The assessment criteria considered by the panel for each of these factors are set out in Table 6.

Table 6: Individual assessment criteria for Change, Effect and Confidence

Change	Narrative
-3 (large -)	A significant degradation in concentration/state. A two attribute state decline likely (where applicable).
-2 (moderate -)	A noticeable degradation in concentration/state. A one attribute state decline likely (where applicable).
-1 (small -)	A detectable degradation in concentration/state. However, a decline in attribute state is unlikely (where applicable).
0 (no/negligible)	Changes in concentration/state non-existent or unlikely to be detectable.
+1 (small +)	A detectable improvement in concentration/state. However, an improvement in attribute state is unlikely (where applicable).
+2 (moderate +)	A noticeable improvement in concentration/state. A one attribute state improvement likely (where applicable).
+3 (large +)	A significant improvement in concentration/state. A two attribute state improvement likely (where applicable).
Effect	**Narrative**
-3 (strong -)	Changes in attribute are likely to result in a significant degradation of one or more higher-order attributes.
-2 (moderate -)	Changes in attribute are likely to result in a noticeable degradation of one or more higher-order attributes.
-1 (weak -)	Changes in attribute are likely to result in a small but detectable degradation of one or more higher-order attributes.
0 (no/negligible)	Changes in attribute unlikely to have a detectable effect on higher-order attributes.
+1 (weak +)	Changes in attribute are likely to result in a small but detectable improvement for one or more higher-order attributes.
+2 (moderate +)	Changes in attribute are likely to result in a noticeable improvement for one or more higher-order attributes.
+3 (strong +)	Changes in attribute are likely to result in a significant improvement for one or more higher-order attributes.
Confidence	**Reasons**
0 (not assessed)	• Not assessed as outside of scope or area of expertise.
1 (low)	• Data on current state of attribute not available for most of assessment unit and/or data exist but are of poor quality or conflicting. • Limited research available on the response of attributes to the changes applied in the scenario. • Relationships between attribute and key drivers not well understood or predictable (e.g., deposited sediment and sediment load).
2 (moderate)	• Data on current state of attribute available but have some limitations (i.e., poor spatial resolution) or basic modelling data available. • Effects of scenario changes on attributes partially transferable from proxy catchments or other research. • Relationships between attribute and key drivers well documented but not predictable (e.g., invertebrates).
3 (high)	• Data on current state of attribute available for much of the assessment unit or high-resolution modelling data available. • Effects of scenario changes on attributes reliably transferable from proxy catchments or other research. • Relationships between attribute and key drivers well understood and predictable (e.g., metal toxicity).

Each individual's assessments needed to be based on the panel's shared understanding of current state, the scenario assumptions and the relevant scientific literature, as well as their own knowledge. Accordingly, these assessments were justified through a narrative citing relevant documents in the science technical library (an example is provided in Table 7).

Table 7: Example of an assessment table written by a panel member that has been modified to remove references to specific catchments.

Phosphorus			
Change	**Effect**	**Confidence**	**Justification**
☐ -3 (large -)	☐ -3 (strong -)	☐ 0 (not assessed)	<u>Change:</u> Based on the review conducted by Parkyn (2004), it is likely that a 5m riparian margin planted using good practice will decrease DRP loads carried in overland flow. Under this scenario it is assumed that a 5m buffer will achieve a 50% reduction in total and dissolved P load in run-off (in targeted reaches only), but this is likely high given that studies cited by Parkyn reported a 55% reduction in dissolved P with a 10m buffer. Furthermore, stock exclusion will reduce bank erosion in targeted reaches, and by association sediment bound P. Extensive riparian management is expected under this scenario which will reduce DRP concentrations, and between 2.2% and 14% of both majors catchments are expected to be retired or space planted which will further reduce DRP. Proxy catchment modelling data suggests an attribute state change is possible under this scenario (-25% median and -43% 95th %ile), and in my opinion this is transferable given the similarities in retirement with the proxy catchment, the far greater stock exclusion, and the fact a two attribute state increase is not likely even with a 40% reduction (based on results presented in "Modelling of nitrogen DRP and Periphyton reductions using Proxy catchment results")) <u>Effect:</u> Based on the Snelder et al (2019) nutrient criteria modelling, a > 40% reduction in DRP would be needed for most sites to shift one attribute state for periphyton growth (C to B). This is unlikely as that level of change was not even observed in the Horokiri proxy catchment under the sensitive scenario. Thus, I have noted a small effect. However, phosphorus is just one factor influencing periphyton growth and, in interaction with other factors (notably DIN and shade), moderate or significant improvements in periphyton growth may occur in this EPAU. <u>Confidence:</u> The amount of rural mitigation predicted under this scenario means that an improvement in DRP concentrations is almost certain. However, it seems unlikely that an attribute state change will occur through most of the EPAU given the ~40% reduction needed to go from the top of C state to the top of the B. However, state data are available for two sites and national scale models. Proxy catchment modelling data are also transferable.
☐ -2 (moderate -)	☐ -2 (moderate -)	☐ 1 (low)	
☐ -1 (small -)	☐ -1 (weak -)	☒ 2 (moderate)	
☐ 0 (no/negligible)	☐ 0 (no/negligible)		
☐ +1 (small +)	☒ +1 (weak +)		
☒ +2 (moderate +)	☐ +2 (moderate +)		
☐ +3 (large +)	☐ +3 (strong +)	☐ 3 (high)	

2.10.2. Group assessments

Once all panel members had completed their individual assessments a series of workshops were ran, during which the panel developed their group assessments. In these workshops the effects of each scenario on each attribute were considered one EPAU at a time through the following process:

1. Each member briefly presented their individual assessment to the group;

2. Upon hearing the whole panel's assessments, members were given the opportunity to update their individual assessments based on what had been said by others in the group;
3. The technical lead then provided a summary of the group's overall assessment based on notes taken during each panel members assessment;
4. A brief discussion was held among the panel about the overall assessment, and changes made based on this discussion. Points of disagreement between panel members were noted in the final overall assessment and reflected in the confidence scoring.

2.10.3. Final output

After each workshop, the technical lead compiled all of the overall attribute assessments for each assessment unit and used them to fill out the template presented in Table 8. These final outputs included detailed notes, such as:

- Exactly where then panel's change score applied in the EPAU, and the level of change expected in other areas; and
- Any differences in the response of individual water quality parameters within an attribute. For example, for dissolved metals notes were made if the expected change in copper concentrations were different than those expected for zinc.

All panel members were given an opportunity to review and request changes to the final assessments before providing final sign off for their release

Table 8: Final assessment table to be populated for each assessment unit under each scenario.

Tier	Attribute	Change	Effect	Confidence	Narrative
1	**Dissolved metals**				**Change:** **Effect:** **Confidence:**
	Nitrogen 1				**Change:** **Effect:** **Confidence:**
	Nitrogen 2				**Change:** **Effect:** **Confidence:**
	Phosphorus				**Change:** **Effect:** **Confidence:**
	Sediment input				**Change:** **Effect:** **Confidence:**
	Faecal contamination				**Change:** **Effect:** **Confidence:**
	Flow				**Change:** **Effect:** **Confidence:**
2	**Plant growth**				**Change:** **Effect:** **Confidence:**
3	**Macroinvertebrate community health**				**Change:** **Effect:** **Confidence:**
	Fish diversity				**Change:**

					Effect: **Confidence** **:**
4	**Ecosystem health**				**Change:** **Effect:** **Confidence** **:**
	Overall suitability for recreation				**Change:** **Effect:** **Confidence** **:**

3. Methods 2 – Analysis of future state under the scenarios

3.1. Purpose

The expert panel assessed how a range of attributes are likely to change under the different scenarios, but they did not define what state each attribute would be in after that change. Accordingly, the purpose of the 'downscaling' exercise described in this section of the report was to overlay the expert panels assessments on top of existing current state data to assess the likely future state of water quality and ecology under each scenario at the sub-catchment scale.

3.2. Objectives

The specific objectives of this process were :

- To 'downscale' the expert panels 'Change' assessments from the EPAU scale to the sub-catchment scale based on any the inter-catchment differences noted in the panels final outputs and any noted differences between water quality parameters within an attribute (e.g., nitrate nitrogen (NO_3-N) and ammoniacal nitrogen (NH_4-N) for the Nitrogen 1 attribute).
- For those water quality/ecology parameters with an existing A to D/E attribute state framework:
  - To translate the panels downscaled 'Change' score into an expected change in attribute state for each sub-catchment under each scenario; and
  - To calculate the future attribute state at each GWRC Rivers State of the Environment (RSoE) monitoring site and River Environment Classification[7] (REC) reach under each scenario based on the expected change in attribute state and modelled or measured current state.
- Present the downscaled expert panels 'Change' assessments for those attributes without an attribute state framework

3.3. Parameters assessed

For this exercise the expert panel attributes described in Table 1 to Table 4 were split into the specific water quality and ecology parameters set out in Table 9.

[7] The REC is a database of catchment spatial attributes, summarised for every segment in New Zealand's network of rivers

Table 9: Specific parameters assessed within each expert panel attribute

The abbreviation used for each parameter in this report and the source of the attribute state framework used (if applicable). A detailed description of each attribute state framework is provided in Appendix B.

Expert panel attribute	Parameters assessed	Abbreviation	Attribute state framework source if applicable
Dissolved metals	**Copper**	**Cu**	**GWRC**
	Zinc	**Zn**	
Nitrogen 1	**Nitrate-nitrogen**	**NO_3-N**	**NPS-FM 2014**
	Total ammoniacal-nitrogen	**NH_4-N**	
Nitrogen 2	**Dissolved inorganic nitrogen**	**DIN**	**2019 proposed amendments to the NPS-FM**
Phosphorus	**Dissolved reactive phosphorus**	**DRP**	
Sediment input	**N/A**		
Faecal contamination	**Escherichia coli**	**E. coli**	**NPS-FM 2014 (as amended 2017)**
Flow	**N/A**		
Plant growth	**Periphyton biomass**		**NPS-FM 2014**
Invertebrate community health	**Macroinvertebrate community index**	**MCI**	**GWRC**
Fish diversity	**Index of Biotic Integrity**	**IBI**	**2019 proposed amendments to the NPS-FM**
Ecosystem health	**N/A**		
Overall suitability for recreation			

3.4. Sub-catchments

The sub-catchments that the expert panel outputs were downscaled to were decided by GWRC and are presented in Figure 3 and Table 10. Several sub-catchments were excluded from the expert panel's assessments, and these are also noted in Table 10.

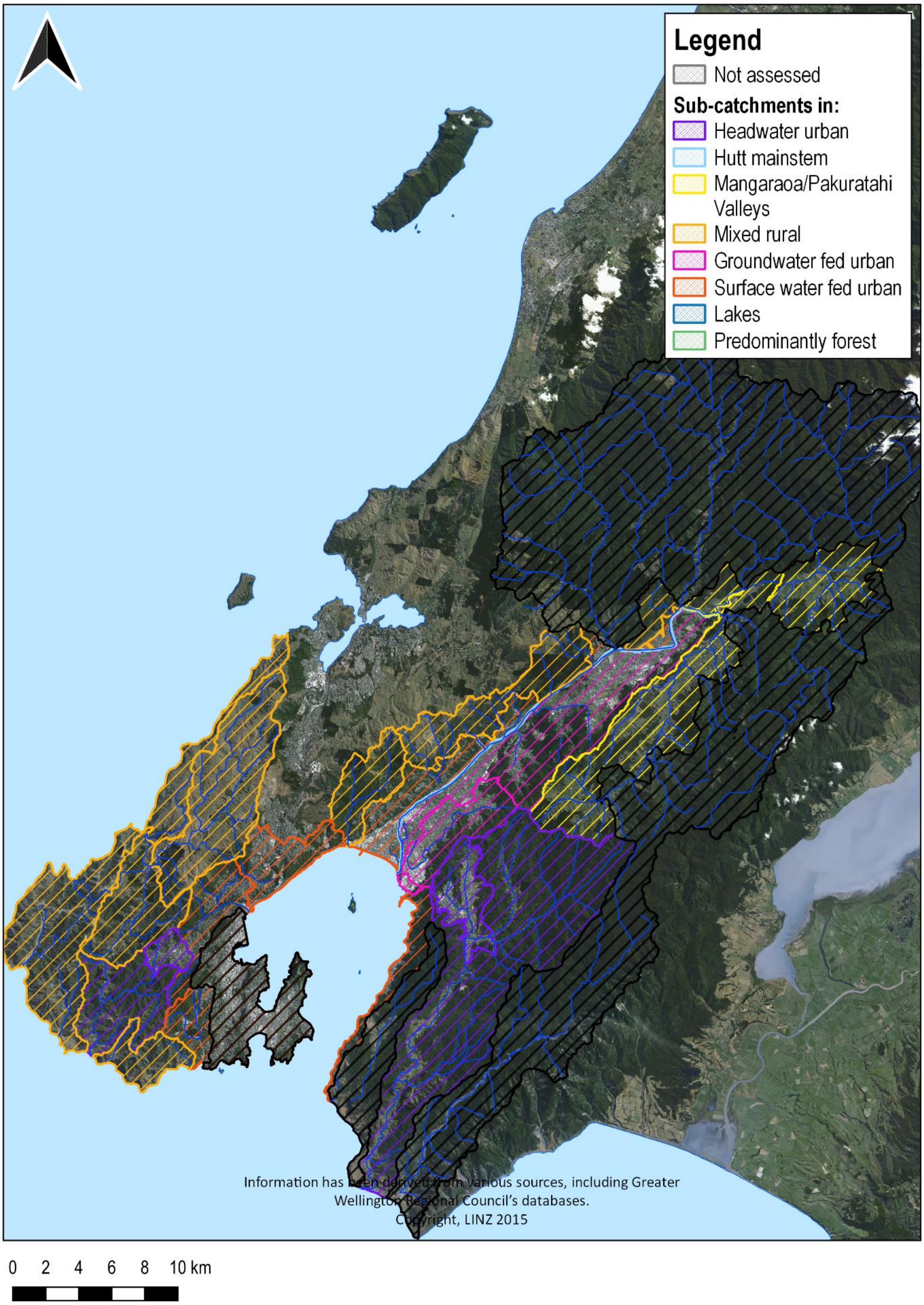

Figure 3: Map of the sub-catchments that the expert panel assessments were downscaled to, including those that were not considered in the panel's assessments.

Table 10: The sub-catchments that the expert panel assessments were downscaled to.

<table>
<tr><th>EPAU</th><th>Sub-catchment</th><th>Assessed by panel (Y/N)</th><th>Reason for not assessing</th></tr>
<tr><td rowspan="4">Headwater urban</td><td>Karori Stream – Rural</td><td rowspan="7">Y</td><td rowspan="7">N/A</td></tr>
<tr><td>Karori Stream – Urban</td></tr>
<tr><td>Wainuiomata River – Rural</td></tr>
<tr><td>Wainuiomata River – Urban</td></tr>
<tr><td>Hutt mainstem</td><td>Te Awa Kairangi lower mainstem</td></tr>
<tr><td rowspan="3">Mangaroa/Pakuratahi Valleys</td><td>Mangaroa Valleys</td></tr>
<tr><td>Pakuratahi Grass</td></tr>
<tr><td>Te Marua</td><td>N</td><td>Influences the Hutt mainstem more than the major surface water bodies in the EPAU.</td></tr>
<tr><td rowspan="6">Mixed rural</td><td>Hutt Valley Western Hills</td><td rowspan="13">Y</td><td rowspan="13">N/A</td></tr>
<tr><td>Korokoro Stream</td></tr>
<tr><td>Makara Coast</td></tr>
<tr><td>Makara Stream</td></tr>
<tr><td>Ohariu Stream</td></tr>
<tr><td>South Karori</td></tr>
<tr><td rowspan="2">Groundwater fed urban</td><td>Hutt River Valley floor</td></tr>
<tr><td>Waiwhetu Stream</td></tr>
<tr><td rowspan="6">Surface water fed urban</td><td>East Harbour</td></tr>
<tr><td>Hutt Valley West Urban</td></tr>
<tr><td>North-West Harbour</td></tr>
<tr><td>Owhiro Stream</td></tr>
<tr><td>Kaiwharawhara Stream</td></tr>
<tr><td>Wellington</td><td>N</td><td>Vast majority of stream reaches are piped and therefore not rivers under RMA.</td></tr>
<tr><td rowspan="2">Lakes</td><td>Gollan's Stream</td><td rowspan="8">N</td><td rowspan="8">It was decided not to assess these EPAUs when developing the expert panel approach due to their receiving environment (Lakes) or land cover (Predominantly forest)</td></tr>
<tr><td>Lake Kohangapiripiri</td></tr>
<tr><td rowspan="6">Predominantly forest</td><td>Akatarawa</td></tr>
<tr><td>Mangaroa Hills</td></tr>
<tr><td>Orongorongo</td></tr>
<tr><td>Pakuratahi Native</td></tr>
<tr><td>Upper Hutt</td></tr>
<tr><td>Whakatikei River</td></tr>
</table>

3.5. Downscaling of expert panel assessments to the sub-catchment scale

The process of downscaling the expert panel outputs to the sub-catchment scale was conducted by two of the panel's members (Dr Greer and Dr Heath), who reviewed all of the notes in the panel's final outputs to:

- Identify the EPAU scale change score for each attribute under each scenario;
- Identify instances where the EPAU scale change score did not apply to a given parameter within an expert panel attribute. For example, where the notes showed that for the Dissolved metals expert panel attribute the expected change in Cu concentrations was different than that expected for Zn; and
- Identify instances where the EPAU scale change score did not apply to a given sub-catchment within an EPAU. For example, where the notes showed that the Dissolved metals change score was dependent on the amount of new impervious surface cover in the sub-catchment.

The results of this downscaling exercise are provided in Table 11.

Note: The process described above did not change the expert panels assessments in anyway as Dr Greer and Dr Heath made their assessment based purely on the notes made in the panel's final assessments and the land-cover/stock exclusion data included in the science technical library.

Table 11: Downscaled expert panel change assessments for key parameters

EPAU	Sub-catchment	Cu			Zn			NO_3-N			NH_4-N			DIN			DRP			Sed. input			*E. coli*			Flow			Peri. biomass			MCI			IBI			Eco. health			Suitability for rec.		
		BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.
1	Karori S. – Rur.	-1	0	0	-1	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+2	-1	+1	+2	0	+2	+2	-2	-2	-2	0	0	+1	-1	+1	+1	0	0	0	-1	+1	+2	-1	+2	+3
	Karori S. – Urb.	-2	0	0	-2	+2	+3	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+2	-1	+1	+2	0	+2	+2	-2	-2	-2	0	0	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+2	+3
	Wainuiomata R. – Rur.	-1	0	0	-1	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+2	-1	+1	+2	0	+2	+2	-2	-2	-2	-1	0	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+2	+3
	Wainuiomata R. – Urb.	-2	0	0	-2	+2	+3	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+2	-1	+1	+2	0	+2	+2	-2	-2	-2	-1	0	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+2	+3
2	Te Awa Kairangi lower mainstem	-1	+1	+1	-1	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	0	+2	+3	-1	-1	-1	-1	0	0	-1	0	0	0	0	0	-1	0	0	-1	+2	+3
3	Mangaroa Valleys	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+2	+1	+2	+2	+1	+2	+2	+1	+2	+3	-2	-2	-1	-1	+1	+2	0	+1	+3	0	0	0	0	+2	+2	+1	+2	+3
	Pakuratahi Grass	0	+1	+1	0	+1	+1	0	+1	+1	0	0	0	0	+1	+2	+1	+2	+2	+1	+2	+2	+1	+2	+3	-2	-2	-1	-1	+1	+2	0	+1	+2	0	0	0	0	+2	+2	+1	+2	+3
4	Hutt Valley West. Hills	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	0	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	-1	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
	Korokoro S.	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	0	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	-1	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
	Makara Coast	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	-1	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	0	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
	Makara S.	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	-1	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	0	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
	Ohariu S.	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	-1	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	0	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
	South Karori	0	0	0	0	0	0	0	+1	+1	0	0	0	0	+1	+1	-1	+1	+2	-1	+1	+2	0	+1	+2	-2	-2	-1	0	+1	+1	-1	+1	+2	0	0	0	-1	+1	+2	-1	+1	+2
5	Hutt R. Val. floor	-1	+1	+3	-1	+2	+3	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	-1	0	+1	-1	+1	+2	0	0	0	-2	+1	+2	0	+2	+3
	Waiwhetu S.	-1	+1	+3	-1	+2	+3	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	-1	0	+1	-1	+1	+2	0	0	0	-2	+1	+2	0	+2	+3
6	East Harb.	-2	-1	+1	-2	+1	+2	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	-1	0	+1	-1	+1	+1	0	0	0	-2	+1	+2	-1	+2	+3
	Hutt Val. W. Urb.	-2	-1	+1	-2	+1	+2	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	-1	0	+1	-1	+1	+1	0	0	0	-2	+1	+2	-1	+2	+3
	Kaiwharawhara S.	-2	-1	+1	-2	+1	+2	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	0	0	+1	-1	+1	+1	0	0	0	-2	+1	+2	-1	+2	+3
	North-West Har.	0	0	+1	0	+1	+2	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	0	0	+1	-1	+1	+1	0	0	0	-2	+1	+2	-1	+2	+3
	Owhiro S.	-2	-1	+1	-2	+1	+2	0	+1	+1	0	+1	+1	0	+1	+1	0	+1	+1	-1	0	+1	0	+3	+3	-2	-2	0	0	0	+1	-1	+1	+1	0	0	0	-2	+1	+2	-1	+2	+3

3.6. Using downscaled expert panel outputs to predict future state under different scenarios

3.6.1. Defining current state

In order to use the downscaled expert panel outputs to predict the future state of key parameters it was necessary to define current state for use as a baseline. This involved calculating the current attribute states for those parameters for which there is an attribute state framework at each:

- GWRC RSoE monitoring site based on monitoring data (The locations of the RSoE sites in Whaitua Te Whanganui-a-Tare are provided in Table 12 and Figure 4).
- REC reach based on empirical water quality and ecology models[8].

Table 12: GWRC RSoE sites in Whaitua Te Whanganui-a-Tara.

EPAU	Sub-catchment	Site	East	North	Metals	Periphyton
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	1744222	5427016	Yes	No
	Wainuiomata R. – Rur.	Wainuiomata R. @ Manuka Tr.	1768301	5430792	No	No
		Wainuiomata R. D/S of White Br.	1757315	5415739	No	Yes
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	1761038	5437628	Yes	Yes
		Hutt R.@ Manor Park	1766679	5442285	Yes	No
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	Mangaroa River @ Te Marua	1778726	5448590	No	Yes
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	1784607	5451677	No	No
4 – Mixed rural	Makara Stream	Makara S. @ Kennels	1743530	5433635	No	No
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	1760977	5434510	Yes	No
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	1749069	5431077	Yes	Yes
8 – Predominantly forest	Akatarawa	Akatarawa R. @ Hutt Conf.	1776183	5449184	No	No
	Upper Hutt	Hutt R. @ Te Marua	1780071	5450158	No	Yes
	Whakatikei River	Whakatikei R. @ Riverstone	1772256	5446748	No	No

Note – While the monitoring site in the Wainuiomata River at Manuka Track is within a sub-catchment assessed by the Expert Panel, their assessments do not apply as the entire upstream catchment is in indigenous forest (see Section 2.7). As such, downscaled expert panel outputs have not been applied to data from this site.

[8] Reach scale IBI attribute states were calculated from measured data and are only available for those reaches that have been fished.

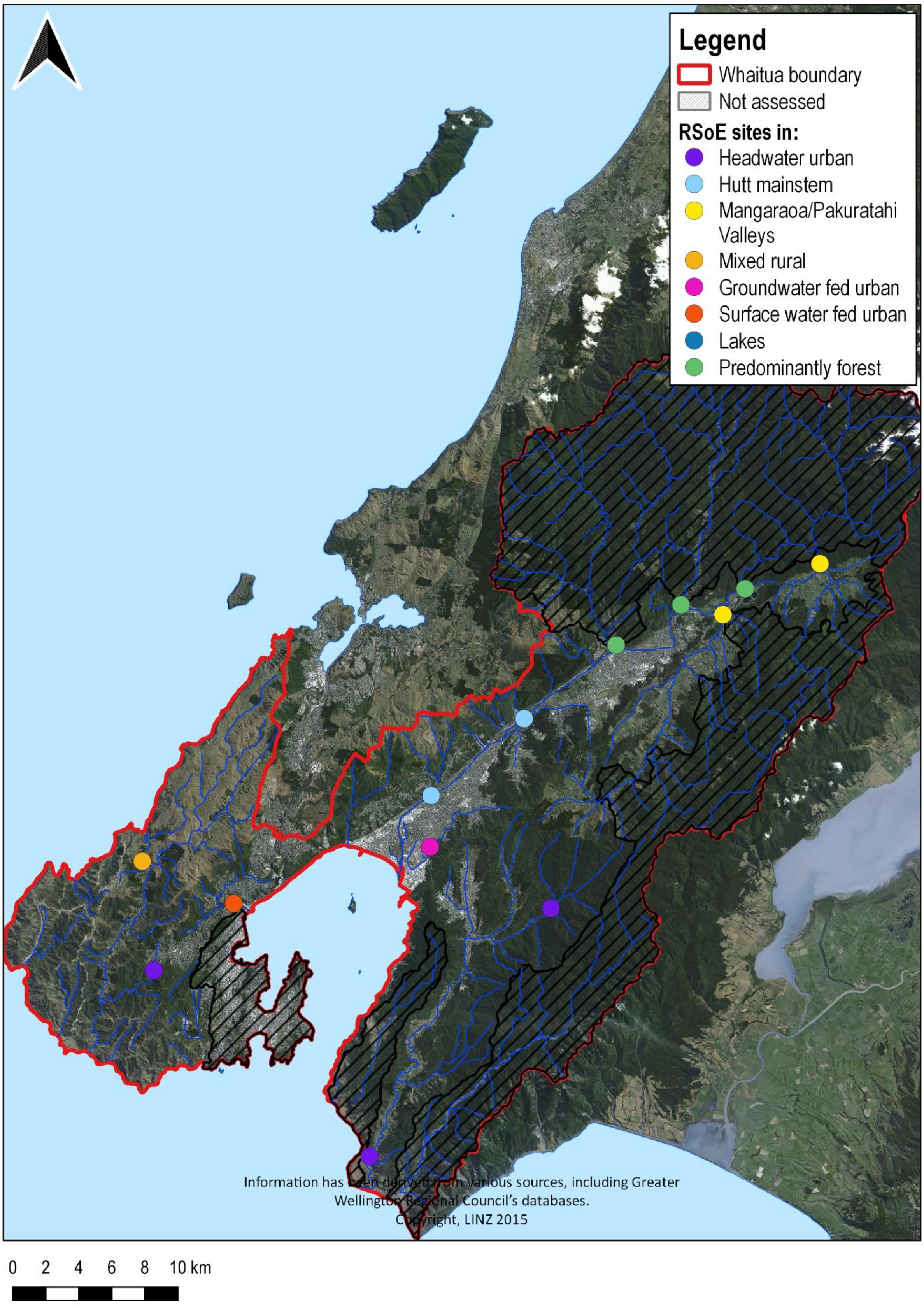

Figure 4: Map of RSoE sites in each EPAU, including those that were not considered in the panels assessments.

Table 12 describes the various sources of data used for this assessment and the baseline year at which attribute state was calculated.

Table 13: The source and baseline year for site and reach-scale current state data.

Parameters	Site data		Reach scale data	
	Year	**Source**	**Year**	**Source**
Cu	**2020**	**GWRC RSoE**	**N/A**	
Zn				
NO_3-N			**2013**	**Larned *et al.* (2017)**
NH_4-N				
DIN				
DRP				
E. coli			**2015**	**Snelder *et al.* (2016)**
MCI			**2013**	**Clapcott & Goodwin (2014)**
IBI	**N/A**		**2018**	**MfE (2019)**

3.6.2. Calculating future attribute state

The future attribute state for each parameter listed in Table 12 was calculated by using the lookup table presented in Table 14. This lookup table was developed by modifying the downscaled expert panel outputs presented in Table 11 to reflect the attribute state change shifts indicated by the expert panel change scores (see Table 6 for how the expert panels scores relate to shifts in attribute state).

This look up table was then used to calculate the future attribute state of each parameter at each REC reach and RSoE site by:

- Creating two spreadsheets containing the sub-catchment name and current attribute state for each parameter at each REC reach and each RSoE monitoring site;
- Transforming the current attribute states in those spreadsheets to numbers between one and five, with one reflecting the A state and five representing the E state;
- Using the VLOOKUP and basic mathematical functions in excel to calculate future attribute state at each reach/site under the different scenarios based on current state, sub-catchment name (lookup value) and the relevant adjustment factor set out in the lookup table (Table 14); and
- Re-alphabetising the attribute states.

3.6.3. Note on the use of reach scale empirical models

The national and regional empirical models relied on in this report (Table 13) are useful tools for assessing the distribution of attribute states within a catchment. However, their performance reduces as spatial resolution increases, and they should not be relied on as an absolute measure of attribute state at a given reach.

3.7. Presentation of results

3.7.1. Statistical

The results of the analysis described in Section 3.6 are presented in this report in the following ways:

- For parameters with an attribute state framework:
  - The current and future attribute state of each parameter at the RSoE monitoring sites within the Whaitua have been tabulated; and
  - The percentage of REC reaches in each sub-catchment in each attribute state have been graphed using stacked column charts (summary tables are also provided in Supplement 2).
- For parameters without an attribute state framework the downscaled expert panel scores for each sub-catchment and GWRC RSoE monitoring site have been tabulated.

3.7.2. Cartographical

The downscaled expert panel outputs have been converted into a mappable format by joining the excel spreadsheets described in Section 3.6.2 files to existing shape files of the REC and RSoE monitoring sites using the Join function in QGIS v3.10.3. This was done so that the current and future (under different scenarios) attribute states of different rivers and streams can be viewed as either points (RSOE sites) or lines (REC reaches) on a Web map.

Note: While the maps described above are not presented in this report, they have been provided to GWRC for upload to the Whaitua Story Map.

Table 14: Look up table used to calculate future attribute states. A '+' means an improvement in attribute state (e.g., B to A) while a '-' represented shift in the opposite direction.

EPAU	Sub-catchment	Number of attribute state changes																													
		Cu			Zn			NO_3-N			NH_4-N			DIN			DRP			*E. coli*			Peri. biomass			MCI			IBI		
		BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.	BAU	Imp.	Sens.
1	Karori S. – Rur.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	0	0	0	0	0	0	0	0
	Karori S. – Urb.	-1	0	0	-1	+1	+2	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	0	0	0	0	+1	0	0	0
	Wainuiomata R. – Rur.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	0	0	0	0	+1	0	0	0
	Wainuiomata R. – Urb.	-1	0	0	-1	+1	+2	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	0	0	0	0	+1	0	0	0
2	Te Awa Kairangi lower mainstem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+2	0	0	0	0	0	0	0	0	0
3	Mangaroa Valleys	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	+1	+2	0	0	+1	0	0	+2	0	0	0
	Pakuratahi Grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	+1	+2	0	0	+1	0	0	+1	0	0	0
4	Hutt Valley West. Hills	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
	Korokoro S.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
	Makara Coast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
	Makara S.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
	Ohariu S.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
	South Karori	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	0	0	0
5	Hutt R. Val. floor	0	0	+2	0	+1	+2	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	+1	0	0	0
	Waiwhetu S.	0	0	+2	0	+1	+2	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	+1	0	0	0
6	East Harb.	-1	0	0	-1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	0	0	0	0
	Hutt Val. W. Urb.	-1	0	0	-1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	0	0	0	0
	Kaiwharawhara S.	-1	0	0	-1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	0	0	0	0
	North-West Har.	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	0	0	0	0
	Owhiro S.	-1	0	0	-1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+2	0	0	0	0	0	0	0	0	0

4. Expert panel results

The final expert output group assessments described in Section 2.10.3 are provided as a supplement to this report (Supplement 1).

5. Downscaled expert panel results

5.1. By parameter

5.1.1. Copper

At elevated concentrations, dissolved metals, including copper (Cu), can be toxic to aquatic fauna and flora. What is more, these contaminants may accumulate in bed sediments and the flesh of exposed animals, meaning that toxicity effects can build up over time. Metal toxicity is dependent on a number of factors, including water temperature, pH, dissolved organic matter and hardness. Species sensitivity to such contaminants also depends on the life-stage of exposure (juvenile versus adult), the ability to regulate body-burdens, as well as the duration and frequency of exposure (e.g., pulse disturbance of first flush stormwater discharges).

Reach scale national or regional models of dissolved Cu concentrations do not currently exist. Accordingly, future concentrations and attribute states under the different scenarios can only be assessed at a subset of the GWRC RSoE monitoring sites (Table 15). However, the expected change in Cu attribute state in each sub-catchment is provided in Table 16 for context.

Measured Cu concentrations at the RSoE monitoring sites in the Kaiwharawhara Stream and Waiwhetu Stream sub-catchments are currently in the C attribute state (Table 15). Concentrations at the site in the Karori Stream – Urban sub-catchment are in the D state and both sites in the Te Awa Kairangi mainstem sub-catchment are in the A state (Table 15).

Table 15: Predicted Cu attribute state (GWRC) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb	Karori S. @ Mountain Bike Pk	D	D	D	D
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	C	C	C	A
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	C	D	C	C

The results of the expert panel (Supplement 1) and downscaling processes indicate that the distribution of Cu attributes states across RSoE sites is unlikely to change under the different scenarios in most-sub-catchments. However, in some urban sub-catchments a one attribute state degradation is likely under the BAU scenario, and a two attribute state improvement is possible in some areas under the Sensitive scenario. Cu concentrations are likely to change in the following ways under each scenario:

- With the exception of the North-West Harbour sub-catchment, Cu concentrations are expected to increase in all urbanised sub-catchments under the BAU scenario due to an increase in impervious surface cover. However, an attribute state change is only predicted for sub-catchments in the Surface water fed urban EPAU (excluding North-West Harbour) and the urban sub-catchments in the Headwater urban EPAU (Table 16) as:
    - Concentrations are likely to already be in the D state in the sub-catchments in the Groundwater fed urban EPAU;
    - Dissolved Cu in the Headwater urban EPAU will be quickly diluted when it flows out of the urban areas of Karori and Wainuiomata; and
    - Increases in impervious surface cover in the Te Awa Kairangi mainstem sub-catchment are very small compared to total catchment size.
- Cu concentrations are not expected to change from current in any of the rural sub-catchments or the North-West Harbour sub-catchment under BAU as impervious surface cover will not increase (Table 16).
- Under the Improved scenario, Cu concentrations are not expected to change in the Mangaroa Valley and North-West Harbour sub-catchments, or in any of the sub-catchments in the Mixed rural or Headwater urban EPAUs (This also applies under the Sensitive scenario). Furthermore, as the effects of increased impervious surface area will be partially offset by the benefits of stormwater capture and treatment under this scenario, an attribute state change is not expected in any of the urban sub-catchments, despite expectations that Cu concentrations will (Table 16):
    - Increase by a small amount in the Kaiwharawhara Stream, Hutt Valley West Urban and Owhiro Stream catchments (Supplement 1); and
    - Decrease a small amount in the Waiwhetu Stream, Hutt River Valley floor and Pakuratahi Grassland (due to treatment of rub-off from SH2) sub-catchments (Supplement 1).
- It is predicted that the stormwater capture and treatment assumed under the Sensitive scenario will result in a two attribute state improvement in Cu concentrations in the sub-catchments in the Groundwater fed urban EPAU and the urban areas of the Headwater urban EPAU(Table 16). In contrast, while a small improvement is likely in all sub-catchments in the Surface water fed urban EPAU and the Pakuratahi Grassland sub-catchment, an attribute state change is not expected there (Supplement 1).

Based on the assessment presented above, the likely changes in Cu attribute state at the RSoE monitoring sites are a shift from the C to D state in the Kaiwharawhara Stream sub-catchment under BAU and a shift from the C state to the A state in the Waiwhetu Stream sub-catchment under Sensitive (Table 15)

Table 16: Predicted change in Cu attribute state by sub-catchment and scenario. A '+' means an improvement in attribute state (e.g., B to A) while a '-' represented shift in the opposite direction.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	0	0	0
	Karori S. – Urb.	-1	0	0
	Wainuiomata R. – Rur.	0	0	0
	Wainuiomata R. – Urb.	-1	0	0
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	0	0	0
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	0	0	0
	Pakuratahi Grass	0	0	0
4 – Mixed rural	Hutt Valley Western Hills	0	0	0
	Korokoro S.	0	0	0
	Makara Coast	0	0	0
	Makara S.	0	0	0
	Ohariu S.	0	0	0
	South Karori	0	0	0
5 – Groundwater fed urban	Hutt River Valley floor	0	0	+2
	Waiwhetu S.	0	0	+2
6 – Surface water fed urban	East Harbour	-1	0	0
	Hutt Valley West Urban.	-1	0	0
	Kaiwharawhara S.	-1	0	0
	North-West Harbour	0	0	0
	Owhiro S.	-1	0	0

5.1.2. Zinc

As with Cu, elevated zinc (Zn) concentrations can be toxic to aquatic fauna and flora, with toxicity being dependent on the species being impacted and external factors such as water temperature, pH, dissolved organic matter and hardness.

Modelled dissolved Zn concentrations are not available. Thus, future attribute states under the different scenarios can only be assessed at a sub-set of RSoE monitoring sites (Table 17). Nevertheless, the expected changes in Zn attribute state in each sub-catchment are provided in Table 18 for context.

Measured Zn concentrations at the GWRC monitoring sites in the Karori Stream and Waiwhetu Stream sub-catchments are in attribute state D (Table 17). Concentrations in the Kaiwharawhara Stream sub-catchment are in the B state, while both sites in the Te Awa Kairangi mainstem sub-catchment are in the A state (Table 17).

Table 17: Predicted Zn attribute state (GWRC) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urban	Karori S. @ Mountain Bike Pk	D	D	C	B
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	D	D	C	B
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	B	C	B	A

Based on the expert panel outputs, the distribution of Zn attributes states is not expected to change under the different scenarios in most-sub-catchments. Nevertheless, an attribute state degradation is expected in some urban sub-catchments under the BAU scenario, and one and two state improvements are expected under the Improved and Sensitive scenarios respectively. Zn concentrations are likely to change in the following ways under each scenario:

- The assumed increase in impervious surface cover under BAU is likely to increase Zn concentrations in all urban sub-catchments, except North-West Harbour. However, an attribute state change is only expected in sub-catchments in the Surface water fed urban EPAU and urban parts of the Headwater Urban EPAU (Table 18) for the same reasons described for Cu (see Section 5.1.1). Zn concentrations are not expected to change from current in any of the rural sub-catchments or the North-West Harbour sub-catchment under BAU, as impervious surface cover is not expected to increase there (Table 18).
- Under the Improved scenario the effects of increased impervious surface cover are assumed to be at least partially offset by the benefits of stormwater capture and treatment and the replacement of existing roofs containing zinc. However, the only sub-catchments where an attribute state change is expected are the Waiwhetu Stream, Hutt River Valley floor, Karori Stream – Urban and Wainuiomata River – Urban (Table 18).
- Under Sensitive the assumed stormwater capture and treatment combined with the replacement of all existing zinc roofs is expected to result in a two attribute state improvement in all sub-catchments in the Groundwater fed urban EPAU and the urban sub-catchments in the Headwater urban EPAU. A one attribute state improvement is also expected in all sub-catchments in the Surface water fed urban EPAU (Table 18).

Based on the assessment presented above, Zn attribute state at the RSoE site in the Kaiwharawhara Stream sub-catchment is predicted to shift from B to C state under BAU but will improve to the A state under Sensitive. Additionally, the monitoring sites in the Waiwhetu and Karori Stream – Urban sub-catchments are expected to improve to the C state under the Improved scenario and the B state under the Sensitive scenario (Table 17).

Table 18: Predicted change in Zn attribute state by sub-catchment and scenario. A '+' means an improvement in attribute state (e.g., B to A) while a '-' represented shift in the opposite direction.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	0	0	0
	Karori S. – Urb.	-1	+1	+2
	Wainuiomata R. – Rur.	0	0	0
	Wainuiomata R. – Urb.	-1	+1	+2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	0	0	0
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	0	0	0
	Pakuratahi Grass	0	0	0
4 – Mixed rural	Hutt Valley Western Hills	0	0	0
	Korokoro S.	0	0	0
	Makara Coast	0	0	0
	Makara S.	0	0	0
	Ohariu S.	0	0	0
	South Karori	0	0	0
5 – Groundwater fed urban	Hutt River Valley floor	0	+1	+2
	Waiwhetu S.	0	+1	+2
6 – Surface water fed urban	East Harbour	-1	0	+1
	Hutt Valley West Urban.	-1	0	+1
	Kaiwharawhara S.	-1	0	+1
	North-West Harbour	0	0	+1
	Owhiro S.	-1	0	+1

5.1.3. Nitrate

Nitrate (NO_3-N) is toxic to invertebrates and fish in high concentrations, as it interferes with oxygen transport in the blood, and consequently, metabolic function. In humans this effect is known as methemoglobinemia and is often referred to as blue baby syndrome due to the cyanosis (blue skin colouration) commonly observed in affected children. Susceptibility to NO_3-N toxicity varies between species and even different life stages of a particular species.

Of the sub-catchments covered by the expert panels assessments, only Hutt River Valley Floor, Mangaroa Valleys and Pakuratahi River Grassland are predicted to contain a small number (≤3%) of REC reaches where modelled NO_3-N concentrations are in the B state (Figure 5 and Figure 6). All other reaches in those sub-catchments, and the rest of the Whaitua are predicted to be in attribute state A (Figure 5 and Figure 6). Measured NO_3-N concentrations at most RSoE sites are also in the A attribute state, with only the sites in the Kaiwharawhara Stream and Karori Stream sub-catchments in the B state (Table 19).

Table 19: Predicted NO_3-N attribute state (NPS-FM 2014) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urban	Karori S. @ Mountain Bike Pk	B	B	B	B
	Wainuiomata R. – Rural	Wainuiomata R. D/S of White Br.	A	A	A	A
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	A	A	A	A
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	A	A	A	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	A	A	A	A
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	A	A	A	A
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	B	B	B	B

Based on the expert panel outputs (Supplement 1), the distribution of NO_3-N attributes states across REC reaches and RSoE sites are not expected to change in any sub-catchment under BAU, Improved or Sensitive as:

- Nitrogen loads from diffuse and point source nitrogen discharges will be unchanged under BAU, and NO_3-N concentrations will continue to reflect current state under that scenario.
- While small but detectable reduction in NO_3-N concentrations are expected in all sub-catchments under the Improved and Sensitive scenarios due to the urban and rural mitigations, this is not predicted to result in an attribute state shift as the vast majority of reaches are already in the A state.

Accordingly, under BAU, Improved and Sensitive all REC reaches and sites are expected to remain in the A attribute state, except a small number of reaches in the Hutt River Valley Floor, Mangaroa Valleys and Pakuratahi River Grassland sub-catchments (Figure 5, Figure 6 and Supplement 2) and the RSoE monitoring sites in the Kaiwharawhara Stream and Karori Stream sub-catchments, which will be in the B state (Table 19).

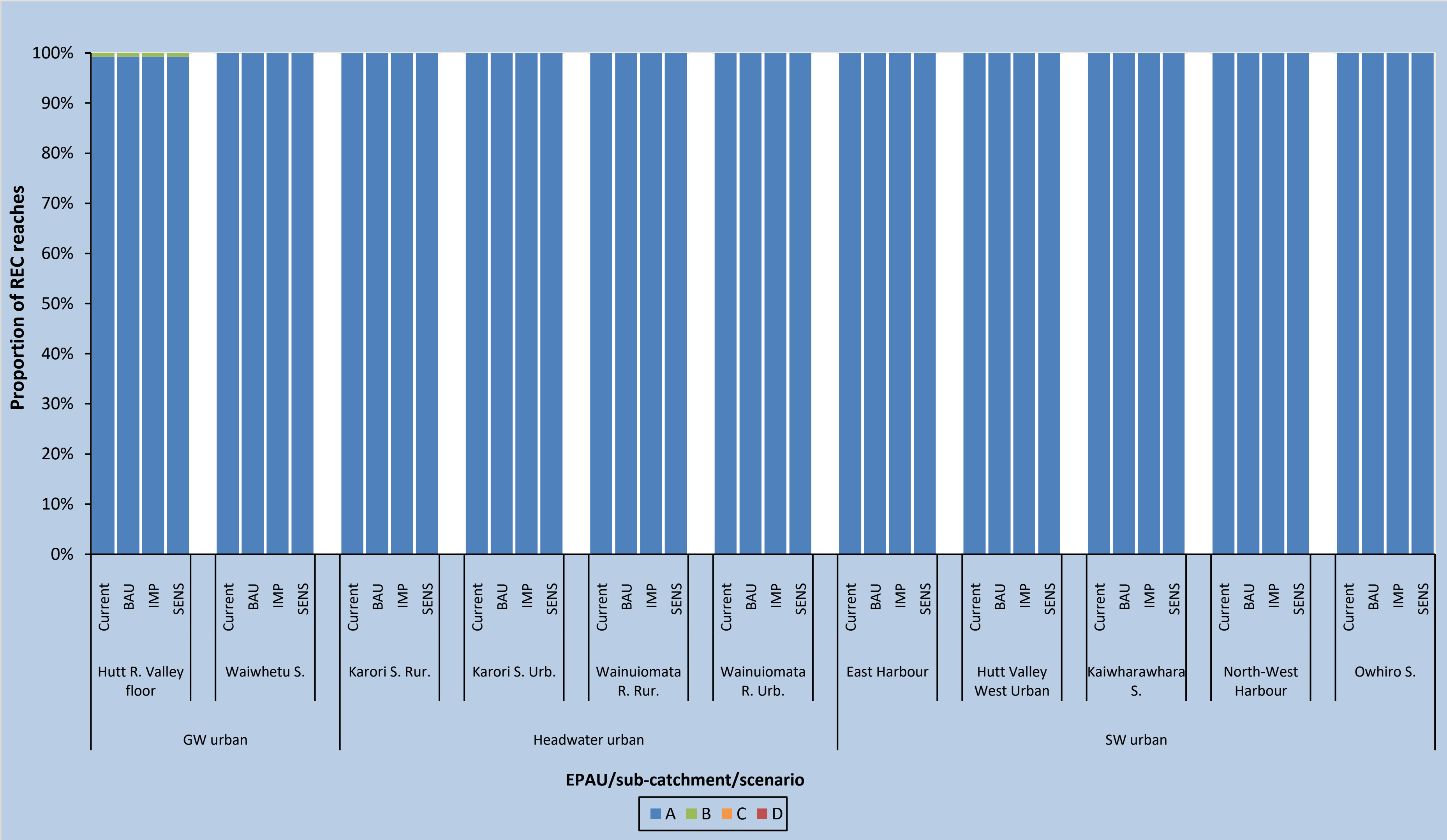

Figure 5: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted NO_3-N concentrations in the NPS-FM 2014 A, B, C and D NO_3-N attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

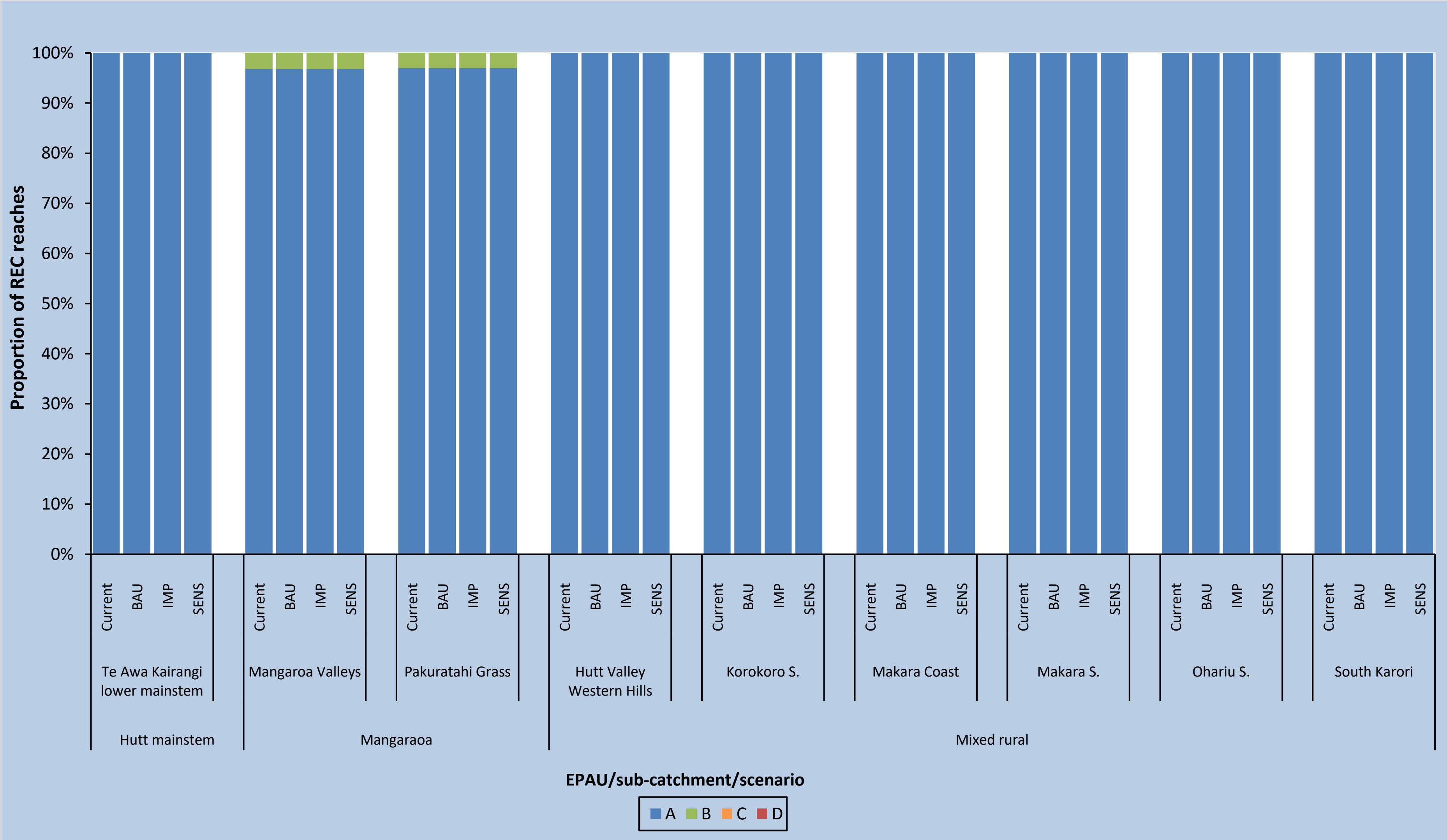

Figure 6: The percentage of REC reaches within each assessed sub-catchment in EPAU 3, 3 and 4 with predicted NO_3-N concentrations in the NPS-FM 2014 A, B, C and D NO_3-N attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

5.1.4. Ammonia

Ammonia (NH_4-N) toxicity occurs when accumulations inside the body interfere with metabolic processes and increase body pH. When exposed to extreme concentrations fish go into convulsions followed by coma, and death. As with NO_3-N , susceptibility to NH_4-N toxicity is species and life stage dependent.

Apart from a small proportion (≤16%) of the Hutt River Valley Floor, Waiwhetu Stream, Mangaroa Valleys and Pakuratahi River Grassland sub-catchments that are predicted to be in B attribute state, all REC reaches in the Whaitua are predicted to be in the A attribute state for NH_4-N under the NPS-FM 2014 (Figure 7 and Figure 8). Furthermore, measured NH_4-N concentrations at most RSoE monitoring sites are also in the A attribute state, with only sites in the Kaiwharawhara Stream and Waiwhetu Stream sub-catchments in the B state (Table 20).

Table 20: Predicted NH_4-N attribute state (NPS-FM 2014) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	A	A	A	A
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	A	A	A	A
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	A	A	A	A
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	A	A	A	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	A	A	A	A
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	B	B	B	B
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	B	B	B	B

The expert panels outputs presented in Supplement 1 suggest that a change in NH_4-N attribute state is unlikely in all sub-catchments under all scenarios as:

- NH_4-N concentrations will be unaffected by the BAU scenario assumptions and will continue to reflect current state under that scenario;
- NH_4-N in all urban sub-catchments (i.e., those in the Headwater urban, Groundwater fed urban and Surface water fed urban EPAUs) will decrease under the Improved and Sensitive scenarios due to a reduction in wastewater contamination. However, this is not expected to result in a shift in attribute state as most of the reaches within those sub-catchments are already in the A state; and
- NH_4-N concentrations will not change in any of the rural sub-catchments (i.e., those in the Mixed rural or Mangaroa/Pakuratahi Valley EPAUs) under Improved or Sensitive as they are not impacted by NH_4-N sources that will be eliminated or minimised under these scenarios.

Based on the assessment presented above the vast majority of REC reaches (Figure 7 and Figure 8) and RSoE sites (Table 20) in all sub-catchments are expected to remain in the A state for NH_4-N under the BAU, Improved and Sensitive scenarios. The exceptions being the monitoring sites on the Kaiwharawhara and Waiwhetu Streams and a small proportion of reaches in the Hutt River Valley Floor, Waiwhetu Stream, Mangaroa Valleys and Pakuratahi River Grassland sub-catchments, which will remain in the B state (Figure 7, Figure 8 and Supplement 2).

5.1.5. Dissolved inorganic nitrogen

Dissolved inorganic nitrogen (DIN) is composed of NO_3-N, nitrite nitrogen (NO_2-N), and NH_4-N, and is the component of nitrogen that is readily available for plant uptake. As concentrations of DIN increase so too does the risk of nuisance periphyton growths in hill-fed systems and, to a lesser extent, nuisance macrophyte growths in spring-fed systems.

Currently the vast majority of REC reaches in all sub-catchments (≥82%) are predicted to be either the A or B attribute state for DIN (under the 2019 proposed changes to the NPS-FM), and only three sub-catchments, Hutt River Valley floor, Mangaroa Valleys and Pakuratahi River Grassland, are predicted to contain reaches in the D state (Figure 9 and Figure 10). Most RSoE monitoring sites are also in the A or B attribute state. However, the sites in the Waiwhetu and Makara Stream sub-catchment are in the C state and the sites in the Karori Stream – Urban and Kaiwharawhara Stream sub-catchments are in the D state (Table 21).

Table 21: Predicted DIN attribute state (2019 proposed NPS-FM) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	D	D	D	D
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	A	A	A	A
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa River @ Te Marua	B	B	B	A
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	A	A	A	A
4 – Mixed rural	Makara Stream	Makara S. @ Kennels	C	C	C	C
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	C	C	C	C
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	D	D	D	D

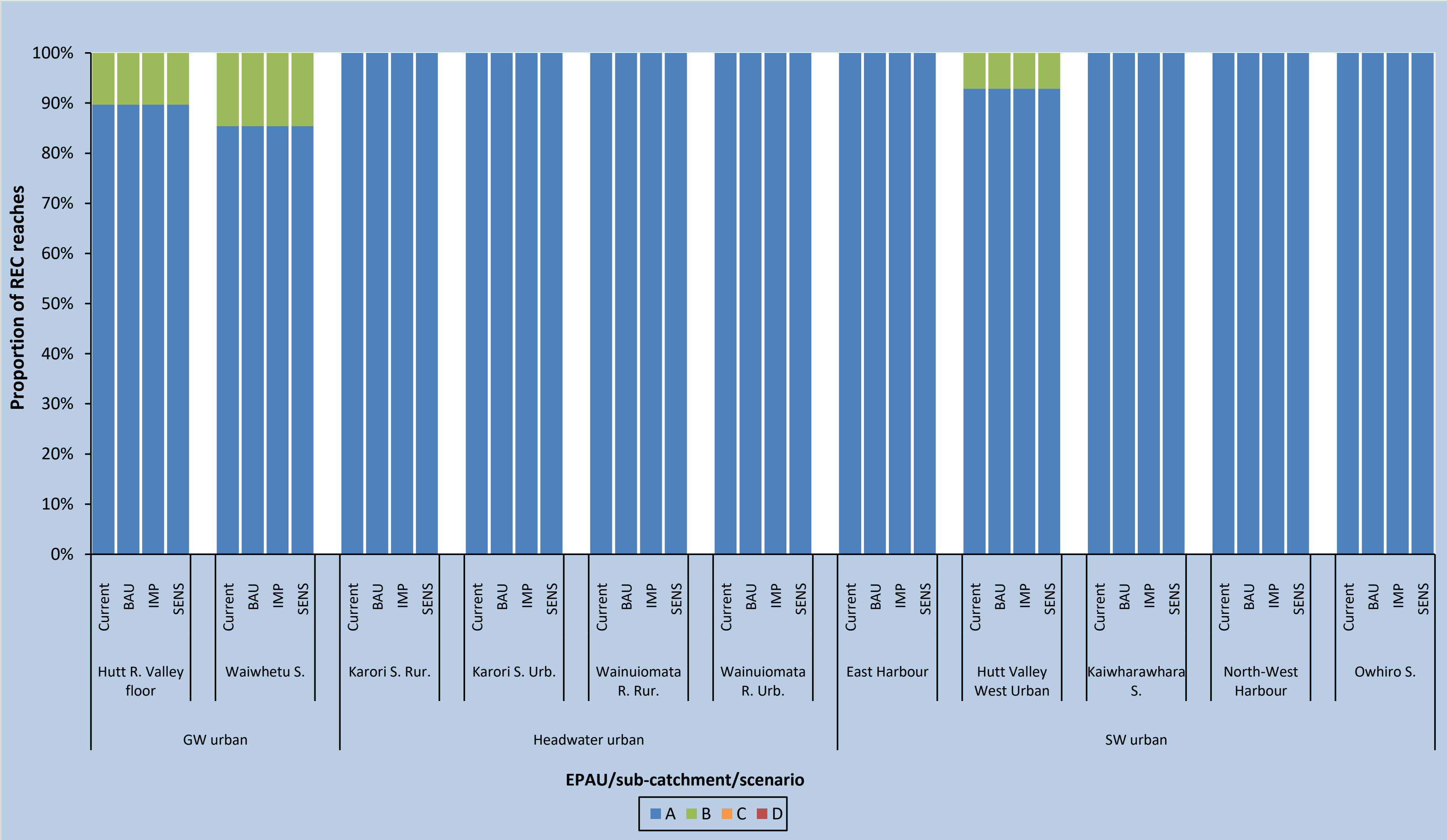

Figure 7: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted NH_4-N concentrations in the NPS-FM 2014 A, B, C and D NH_4-N attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

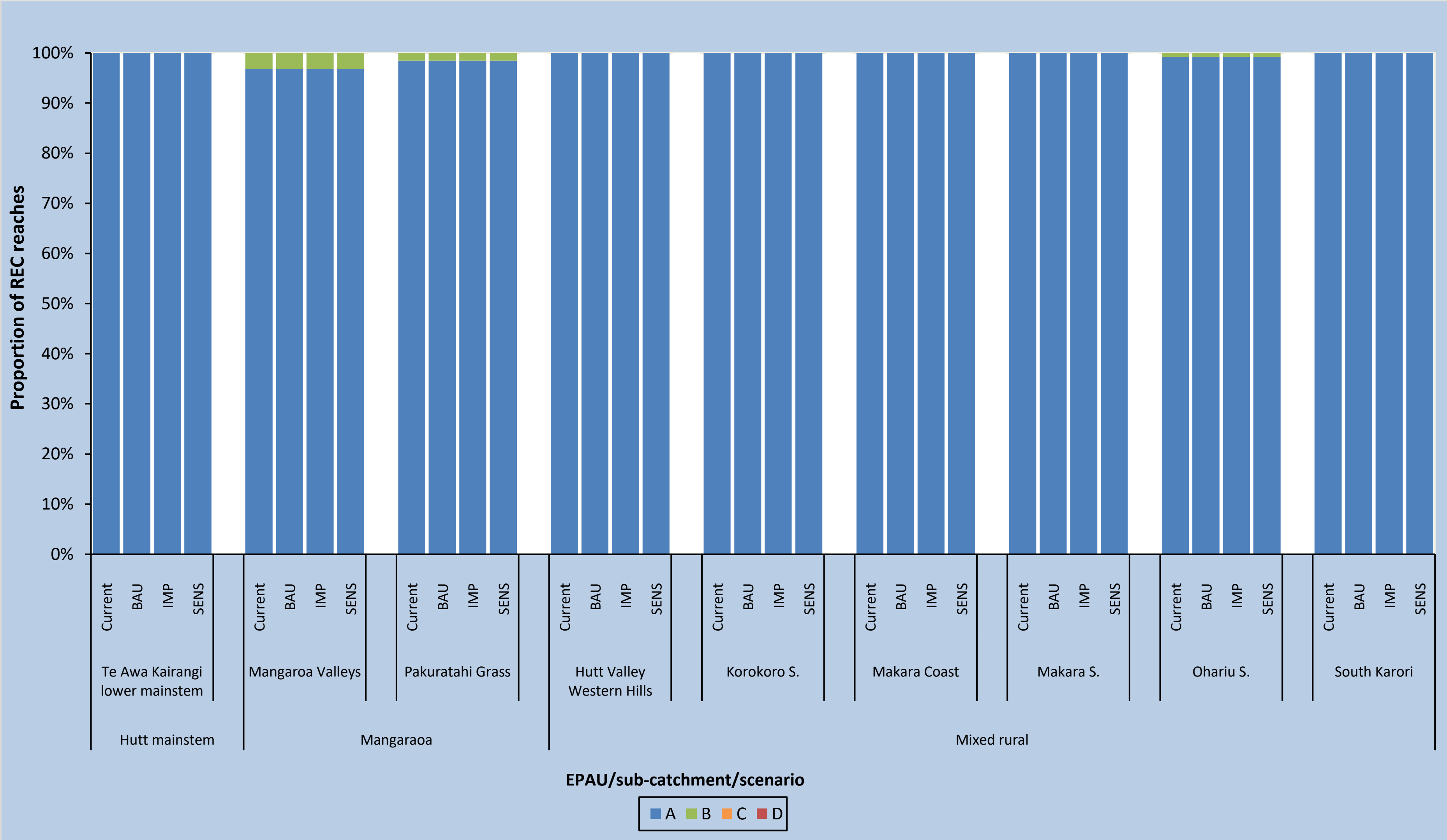

Figure 8: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted NH_4-N concentrations in the NPS-FM 2014 A, B, C and D NH_4-N attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

The expert panel outputs (Supplement 1) suggest that DIN attribute state is unlikely to change under any of the scenarios except in the Mangaroa Valley and Pakuratahi Grassland sub-catchments as:

- Nitrogen loads from diffuse and point source nitrogen discharges will be unchanged under BAU, and DIN concentrations will continue to reflect current state.
- Small but detectable reductions in DIN concentrations are expected in all sub-catchments under the Improved scenario as a consequence of stormwater capture (urban areas), a reduction in wastewater contamination (urban areas), stock exclusion, riparian planting and/or land retirement. However, it is expected that these reductions will not be sufficient to result in an attribute state shift.
- While even greater improvements in DIN are expected in all sub-catchments under the Sensitive scenario, these reductions are still predicted to be insufficient to cause an attribute state shift in most sub-catchments. The exceptions being the Mangaroa Valley and Pakuratahi Grassland sub-catchments where significant stock exclusion and riparian planting are expected to result in an attribute state improvement.

Most REC reaches (Figure 9 and Figure 10) and RSoE sites (Table 21) in all sub-catchments are expected to reman in the A or B attribute states for DIN under the BAU, Improved and Sensitive scenarios. However, under the sensitive scenario those reaches that are currently in the C state in the Mangaroa Valleys and Pakuratahi Grassland sub-catchments are expected to move in to the B state (Figure 10) and reaches currently in the D state are expected to move into the C state (Figure 10). This means that that the only reaches that are not expected to meet the proposed national bottom line under that scenario will be the ~1% in the Hutt River Valley Floor sub-catchment that are currently in the D state, (Figure 9), as well as the RSoE monitoring sites in the Karori Stream – Urban and Kaiwharawhara Stream sub-catchments (Table 21).

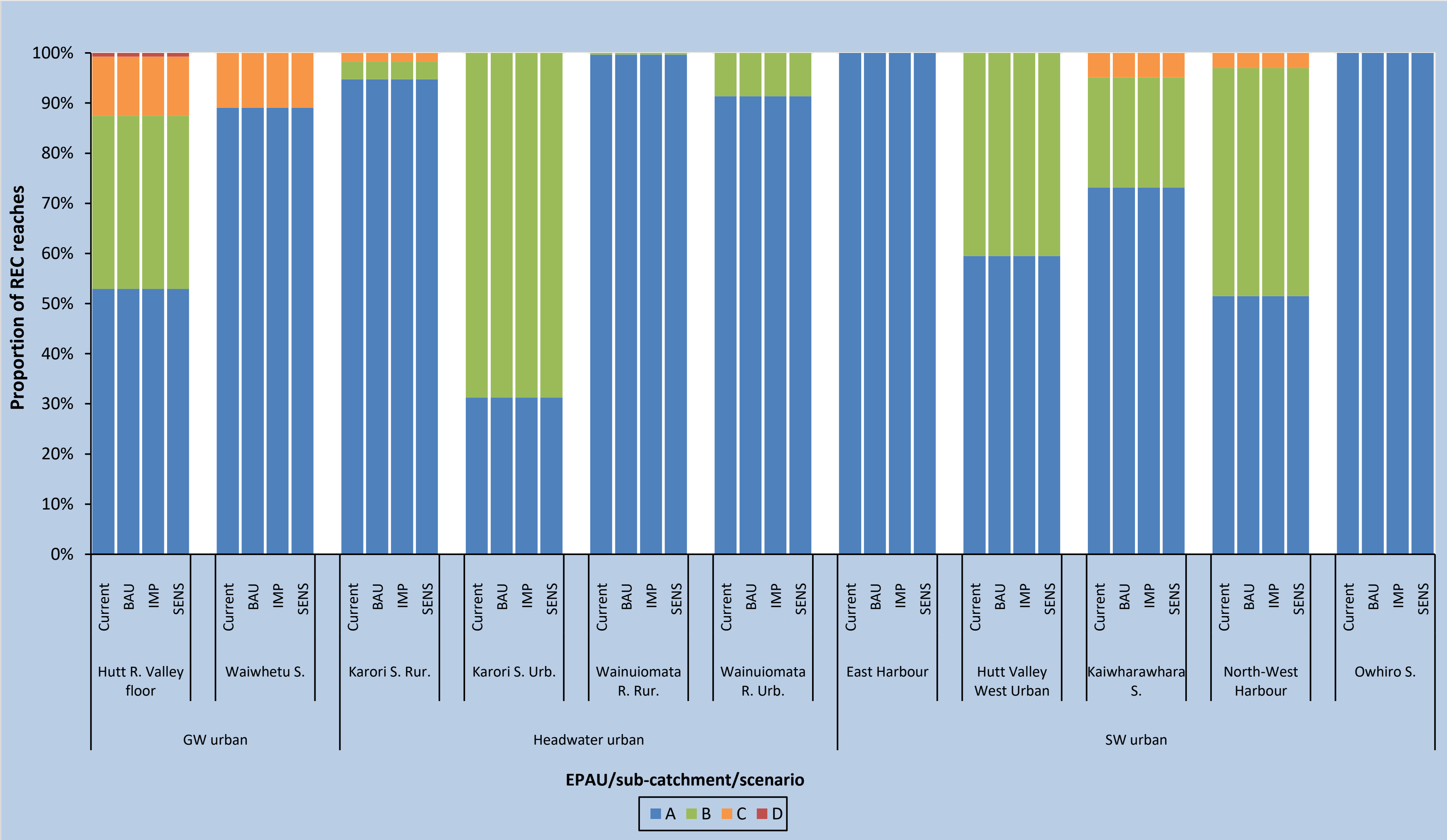

Figure 9: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted median DIN concentrations in the proposed 2019 NPS-FM A, B, C and D DIN attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

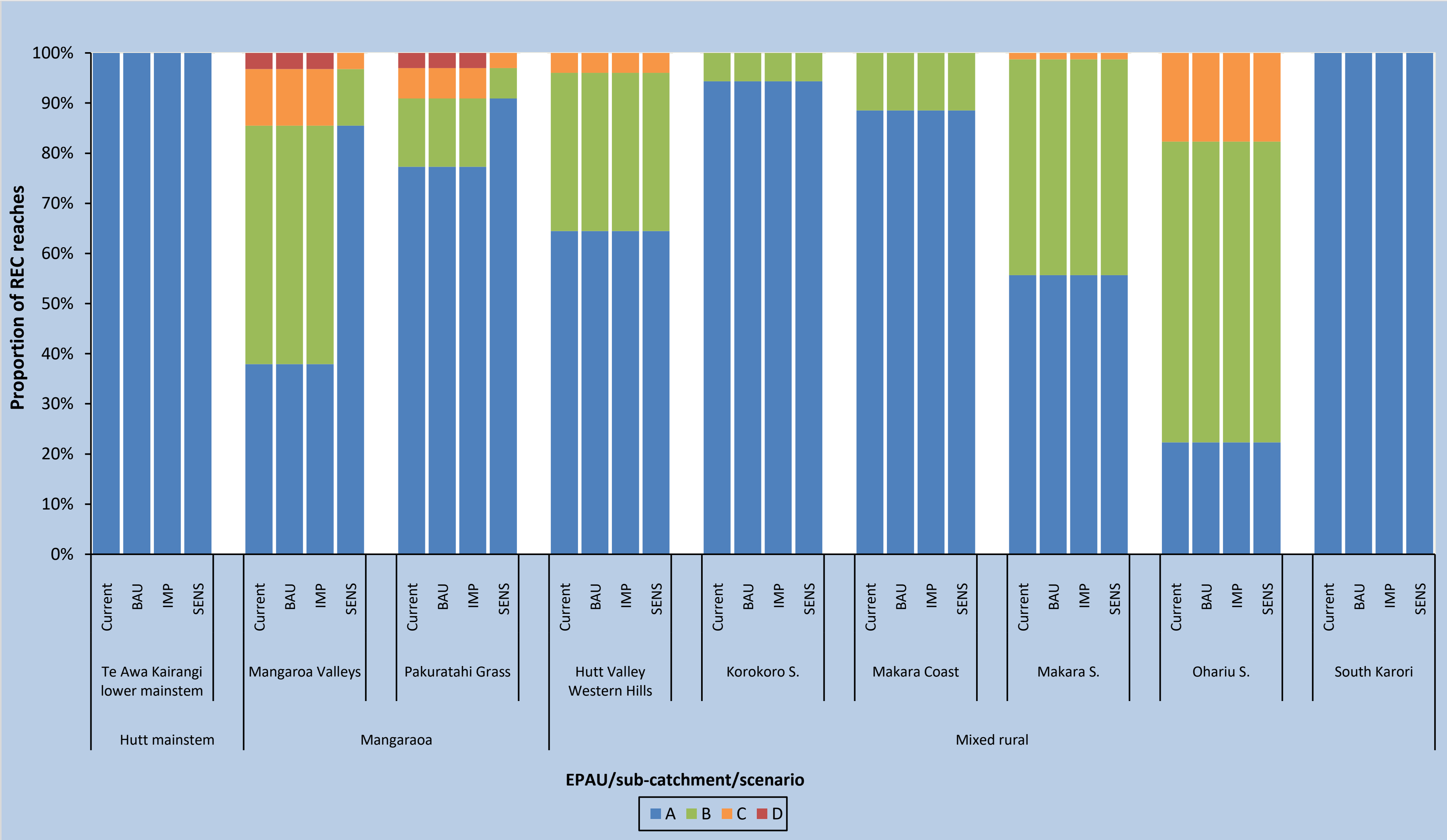

Figure 10: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted median DIN concentrations in the proposed 2019 NPS-FM A, B, C and D DIN attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

5.1.6. Dissolved reactive phosphorus

Dissolved reactive phosphorus (DRP) is the readily available component of phosphorus for plant uptake, and, as with DIN, the higher the DRP concentration the greater the risk of nuisance periphyton and macrophyte growths

The majority of REC reaches and RSoE sites in most sub-catchments (≥79%) are in either the C or D attribute state for DRP (under the 2019 proposed changes to the NPS-FM) (Figure 11 and Figure 12). However, in the Te Awa Kairangi mainstem sub-catchment all reaches are either in the A or B states, while in the Pakuratahi Grassland and South Karori reaches are spilt quite evenly (44:56 and 38:62 respectively) between the B and C states. The RSoE monitoring sites in most sub-catchments are also in the C or D attribute states (Table 22). However, all sites in the Te Awa Kairangi mainstem and Pakuratahi Grassland sub-catchments are in the A state, and the site in the Mangaroa Valley sub-catchment is in attribute state B (Table 22).

The expert panel outputs (Supplement 1) show that in most-sub-catchments DRP attribute state is unlikely to change under the different scenarios. However, an attribute state improvement is expected in some rural sub-catchments under the Improved scenario and in all rural sub-catchments under Sensitive. The reasoning for this is provided below:

- Under BAU, DRP concentrations are expected to rise in the rural sub-catchments on the west coast of the Whaitua (due to climate change increasing erosion) and decrease in the Mangaroa Valley and Pakuratahi Grassland sub-catchments (in response to stock exclusion). However, while detectable, it is not expected that these changes will result in an attribute state shift. In all other sub-catchments DRP concentrations are unlikely to change from current under the BAU scenario.
- Under the Improved scenario DRP concentrations are expected to decrease throughout the Whaitua, with these reductions driven by lessened wastewater contamination and improved stormwater treatment in urban sub-catchments and increased stock exclusion, riparian planting, land retirement and space planting in rural sub-catchments. However, these reductions are only expected to result in an improvement in attribute state in the sub-catchments in the Mangaroa/Pakuratahi EPAU where significant stock exclusion is assumed.
- The greatest reduction in DRP concentration is expected in rural areas under the Sensitive scenario, with an attribute state improvement expected in all rural sub-catchments. In contrast the assumed mitigations under this scenario are not expected to result in a shift in attribute state in urban sub-catchments except for those in the Headwater urban EPAU.

Based expert panels assessments the distributions of DRP attribute states in REC reaches and RSoE sites within the Hutt mainstem, Groundwater fed urban and Surface water fed urban EPAUs are not expected to change under the BAU, Improved or Sensitive Scenario with almost all reaches remaining in the C or D state (except in the Hutt Mainstem sub-catchment where they will remain in the A or B state) (Figure 11 and Figure 12). While the distribution of attribute states in the REC reaches and RSoE sites within the Mixed rural sub-catchments are also not expected to change under BAU, all reaches and GWRC RSoE sites within the Mangaroa/Pakuratahi Valleys EPAU are predicted to improve an attribute state under both the Improved and Sensitive scenarios (Table 22 and Figure 12). This means that most reaches in the Pakuratahi Grassland sub-catchment will be in A or B state (currently B or C state) under these scenarios, and most reaches in the Mangaroa Valley sub-catchment will be in the B or C state (currently C or D state). While not expected under the Improved scenario, an attribute state improvement is also predicted for all sub-catchments in the Headwater urban and Mixed rural EPAUs under the Sensitive Scenario, meaning most sites and reaches in those EPAUs will be in the B or C attribute state (currently C or D) (Table 22, Figure 11 and Figure 12)

Table 22: Predicted DRP attribute state (2019 proposed NPS-FM) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	D	D	D	C
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	C	C	C	B
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	A	A	A	A
		Hutt R.@ Manor Park	A	A	A	A
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	B	B	A	A
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	A	A	A	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	D	D	D	C
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	D	D	D	D
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	D	D	D	D

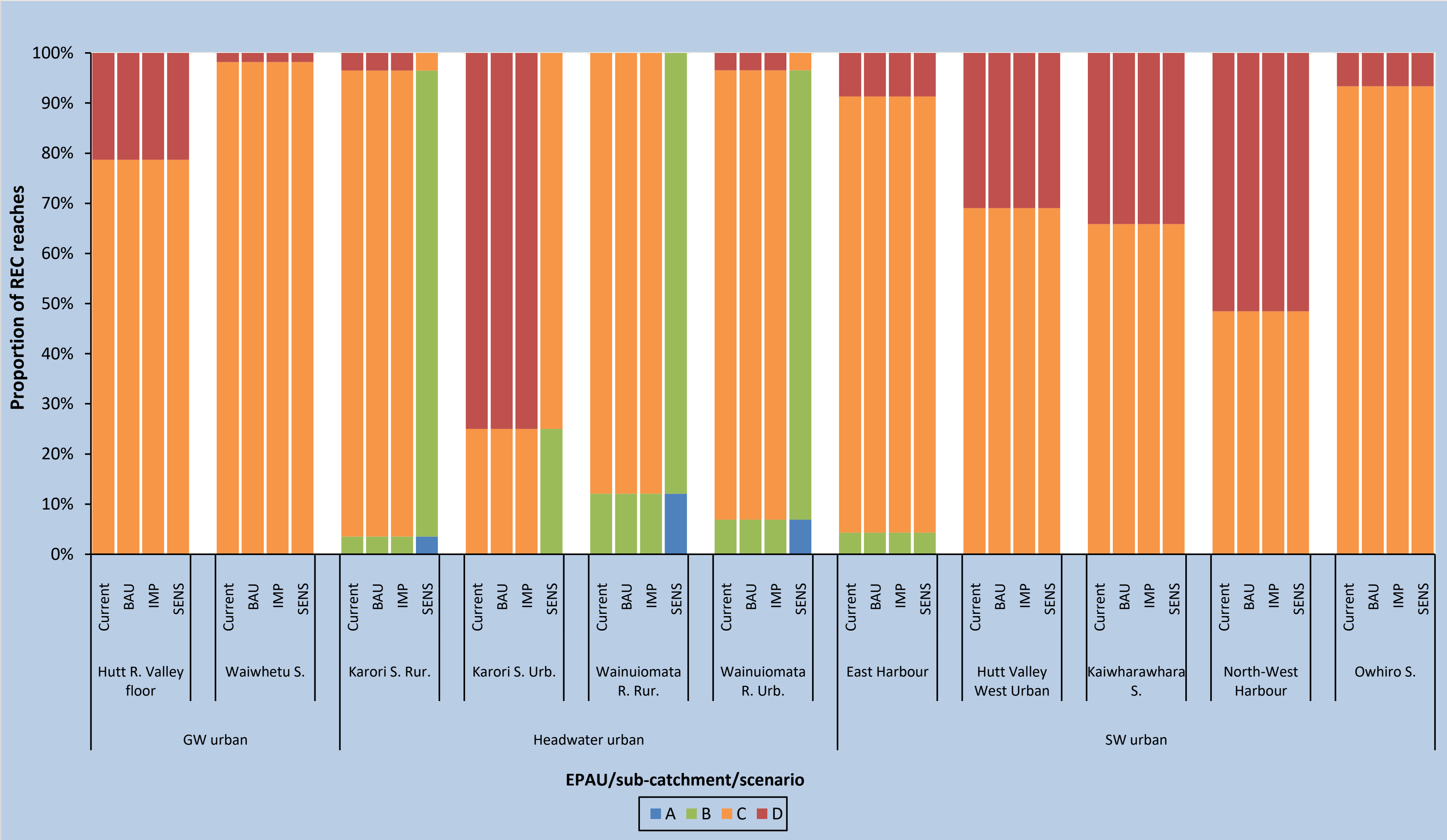

Figure 11: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted median DRP concentrations in the proposed 2019 NPS-FM A, B, C and D DRP attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

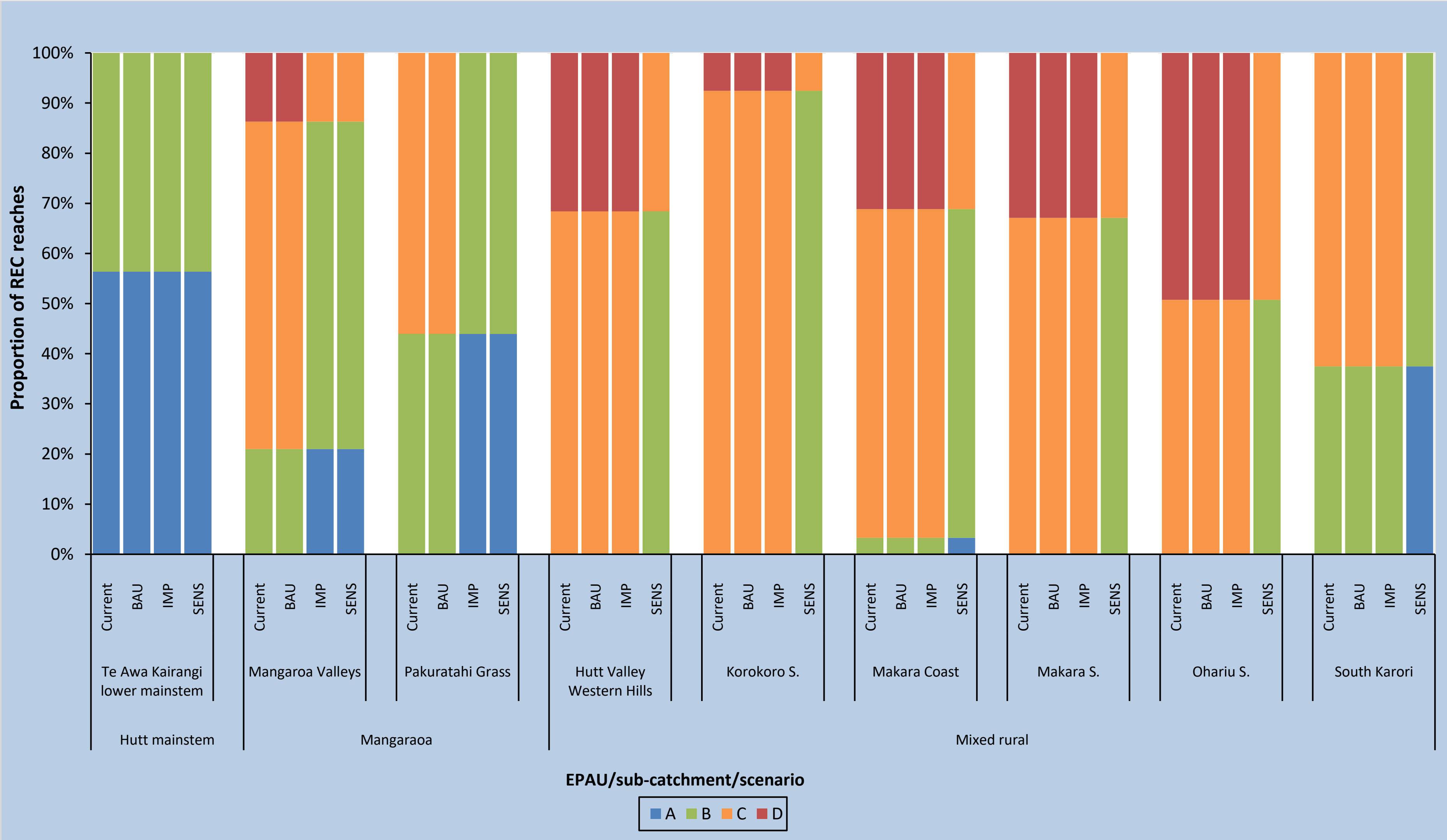

Figure 12: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 4 and 5 with predicted median DRP concentrations in the proposed 2019 NPS-FM A, B, C and D DRP attribute states under the different scenarios. Current state is based on modelling conducted by Larned *et al.* (2017).

5.1.7. Sediment input

Excessive input of fine sediment into rivers and streams has a range of negative effects on stream ecosystems. Excessive fine sediment deposition on the bed reduces food and benthic habitat availability to macroinvertebrates and fish by smothering periphyton and macrophytes and infilling interstitial spaces. In addition, sediment deposition can affect benthic macroinvertebrates and fish spawning by reducing dissolved oxygen near the substrate and physical smothering. At high concentrations, suspended sediments also have a range of direct and indirect negative ecological effects. Physical abrasion and reduced light penetration at high suspended sediment concentrations can reduce periphyton and macrophyte abundance, thereby limiting food availability to macroinvertebrates. This, combined with increased drift as macroinvertebrates are dislodged by sediment, can reduce macroinvertebrate abundance. Fish can also be impacted by high suspended sediment concentrations by reduced recruitment of migrating juveniles, clogged gills, reduced feeding performance, and reduced food availability.

The downscaled expert panel assessments for sediment input by RSoE site and sub-catchment are provided in Table 23 and Table 24 respectively and summarised below. Further detail behind these assessments are provided in the expert panel outputs contained in Supplement 1.

- Under BAU a small increase (degradation) in sediment input is expected in most sub-catchments due to the effects of climate change on flood frequency/magnitude and erosion (Table 23 and Table 24). The exceptions are the Mangaroa Valleys, Pakuratahi Grassland and Te Awa Kairangi mainstem sub-catchments where stock exclusion will offset the effects of climate change, resulting in a small decrease in sediment input (Table 23 and Table 24).
- The assumed mitigations are expected to result in a small improvement (decrease) in sediment input in most rural sub-catchments under the Improved scenario, despite the effects of climate change (Table 23 and Table 24). However, a moderate improvement is expected in the Mangaroa Valleys and Pakuratahi Grassland sub-catchments where extensive stock exclusion and riparian planting is assumed (Table 23 and Table 24). In contrast sediment input in urban sub-catchments is expected to remain unchanged from current under Improved (Table 23 and Table 24), with the positive effects of the assumed mitigations offsetting the detrimental effects of climate change.
- The increased level of rural and urban mitigation under the Sensitive scenario means that moderate improvements in sediment input are likely in all sub-catchments in the Headwater urban, Mangaroa/Pakuratahi Valleys and Mixed rural EPAUs, while small improvements are likely in sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs (Table 23 and Table 24). Only a small improvement is expected in the Te Awa Kairangi mainstem sub-catchment, as the effects of climate change on erosion in the Akatarawa, Upper Hutt and Whakatikei sub-catchments are not expected to be offset by the benefits of the assumed mitigations.

Table 23: Downscaled expert panel assessments for sediment input by GWRC RSoE site and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	Site	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	-1	+1	+2
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	-1	+1	+2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	0	+1	+1
		Hutt R.@ Manor Park	0	+1	+1
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	+1	+2	+2
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	+1	+2	+2
4 – Mixed rural	Makara S.	Makara S. @ Kennels	-1	+1	+2
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	-1	0	+1
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	-1	0	+1

Table 24: Downscaled expert panel assessments for sediment input by sub-catchment and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	-1	+1	+2
	Wainuiomata R. – Urb.	-1	+1	+2
	Wainuiomata R. – Rur.	-1	+1	+2
	Wainuiomata R. – Urb.	-1	+1	+2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	0	+1	+1
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	+1	+2	+2
	Pakuratahi Grass	+1	+2	+2
4 – Mixed rural	Hutt Valley Western Hills	0	+1	+2
	Korokoro S.	0	+1	+2
	Makara Coast	-1	+1	+2
	Makara S.	-1	+1	+2
	Ohariu S.	-1	+1	+2
	South Karori	-1	+1	+2
5 – Groundwater fed urban	Hutt River Valley floor	-1	0	+1
	Waiwhetu S.	-1	0	+1
6 – Surface water fed urban	East Harbour	-1	0	+1
	Hutt Valley West Urban.	-1	0	+1
	Kaiwharawhara S.	-1	0	+1
	North-West Harbour	-1	0	+1
	Owhiro S.	-1	0	+1

Note – The expert panel generally had a low-level of confidence in their assessments of how sediment input will change under the different scenarios, as they were primarily based on the modelled effects of climate change on flow which is subject to a high degree of uncertainty.

5.1.8. E. coli

Escherichia coli (*E. coli*) is a bacterium that naturally occurs in the lower intestines of humans and warm-blooded animals; for that reason, its presence in freshwater is indicative of faecal contamination. Water contaminated by faecal material contains a range of pathogenic bacteria, viruses and other micro-organisms (e.g., protozoa) that present a risk to the health of people conducting recreational activities where water is ingested, inhaled (as an aerosol), or comes into direct contact with sensitive areas (eyes, ears, open wounds). *E. coli* does not generally pose a significant risk to human health in itself. However, it is used as a Faecal Indicator Bacteria (FIB), meaning the level at which it is present can be used to quantify the risk of infection from faecal pathogens such as *Campylobacter, Salmonella, Giardia*, *Cryptosporidium* and Norovirus which are difficult or impractical to routinely measure directly in water. Consequently, *E. coli* is the primary attribute used in New Zealand to assess the microbiological health risks associated with contact with recreational freshwaters.

The majority (≥58% per sub-catchment) of REC reaches (Figure 13 and Figure 14) and RSoE sites (Table 25) in most sub-catchments in the Whaitua are currently predicted to be in either the D or E attribute state for *E. coli* regardless of land-use, meaning they are currently not considered 'swimmable'. Nevertheless, 56% to 74% of REC reaches in the Pakuratahi Grassland, Wainuiomata River – Rural and South Karori sub-catchments are in the swimmable attribute states (A, B or C states) (Figure 13 and Figure 14).

Table 25: Predicted *E. coli* attribute state (NPS-FM 2014 (amended 2017)) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. -Urb.	Karori S. @ Mountain Bike Pk	E	E	D	D
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	D	D	C	C
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	D	D	C	B
		Hutt R.@ Manor Park	D	D	C	B
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	D	D	C	B
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	B	B	A	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	E	E	E	D
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	E	E	C	C
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	E	E	C	C

The expert panel outputs (Supplement 1) suggest that the following changes in *E. coli* attribute state under the different scenarios:

- Under BAU, *E. coli* concentrations are expected to reflect current state throughout the Whaitua as rural land-use, riparian management (not including basic stock exclusion) and the condition of wastewater infrastructure will be largely unchanged under this scenario (*Note – The panel did not expect the stock exclusion practices assumed under this scenario would be sufficient to result in an attribute state improvement in targeted rivers*).

- Under the Improved scenario *E. coli* concentrations are expected to improve two attribute states throughout the sub-catchments in the Groundwater fed and Surface water fed EPAUs due to the elimination of dry-weather wastewater leaks and a reduction in the frequency of overflows. A one attribute state improvement is also expected in the sub-catchments in the Headwater Urban, Hutt mainstem and Mangaroa/Pakuratahi Valleys EPAU due to reduced wastewater contamination (urban areas only), increased stock exclusion, riparian planting, land retirement and space planting. In the sub-catchments in the Mixed rural EPAU, *E. coli* concentrations are expected to decrease under Improved, but an attribute state change is not likely.
- A two attribute state improvement in sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs is expected under the Sensitive scenario (same as Improved). A two-attribute state improvement is also expected in the Te Awa Kairangi lower mainstem, Mangaroa Valleys and Pakuratahi Grassland sub-catchments as a result of the greater stock exclusion and riparian planting compared to Improved. In all other sub-catchments, a one attribute state improvement is likely due to reduced wastewater contamination (Karori Stream and Wainuiomata River only), increased stock exclusion, riparian planting and land retirement.

Based on the assessment presented above, the distributions of *E. coli* attribute states in REC reaches and RSoE sites in all sub-catchments in the Whaitua are not likely to change under the BAU scenario, with the majority of reaches and sites remaining in the D or E state (Table 25, Figure 13 and Figure 14). However, under Improved:

- The attribute states of REC reaches and RSoE sites in the sub-catchments in the Mixed Rural EPAU will likely remain unchanged (Table 25, Figure 13 and Figure 14);
- The percentage of REC reaches that are swimmable (in the A, B or C state) is expected to increase from 18% to 76% in the Mangaroa Valleys sub-catchment and from 74% to 100% in the Pakuratahi Grassland sub-catchment (Figure 13 and Figure 14);
- 100% of reaches in the sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs are expected to become swimmable, and the percentage of swimmable reaches is expected to increase by 30% to 56% in the Te Awa Kairangi lower mainstem, Karori Stream – Rural, Wainuiomata River – Urban and Wainuiomata River – Rural sub-catchments, with most (≥57%) reaches being swimmable there (Figure 13 and Figure 14); and
- While all reaches in the Karori Stream – Urban sub-catchment are expected to improve an attribute state under the Improved scenario, most reaches (88%) will remain unswimmable (also applies to Sensitive scenario) (Figure 13).

Under the Sensitive scenario:

- The percentage of swimmable reaches in all sub-catchments in the Headwater urban, Groundwater fed urban and Surface water fed urban EPAUs are expected to be the same as under Improved (Table 25, Figure 13 and Figure 14);
- All reaches and RSoE sites in the Mangaroa Valleys, Pakuratahi Grassland, Te Awa Kairangi and South Karori sub-catchments are expected to become swimmable, (Table 25 and Figure 14); and
- In the remaining Mixed rural sub-catchments the proportion of reaches that will become swimmable under this scenario is expected to range from 27% to 83%, with total proportion of swimmable reaches ranging from 27% to 94% (up from 0% to 56%) (Table 25 and Figure 14).

5.1.9. Flow

Flow is an important driver of ecosystem health and recreational value; influencing habitat availability and diversity, plant growth and accrual, sediment transport and water quality.

The downscaled expert panel assessments for flow by RSoE site and sub-catchment are provided in Table 26 and Table 27 respectively. Further detail behind these assessments are provided in the expert panel outputs contained in Supplement 1. Under the BAU and Improved scenarios a moderate negative change in flow is expected in all sub-catchments except the Te Awa Kairangi mainstem where only a small change is expected (Table 26 and). This degradation is due to climate change increasing the frequency and/or magnitude of flood events throughout the Whaitua and reducing summer low flows in the sub-catchments on the east side of Wellington Harbour. Under the Sensitive Scenario the assumed rural and urban mitigations are expected to offset some of the effects of climate change in all sub-catchments except Karori Stream, Wainuiomata River and Te Awa Kairangi, resulting in only a small degradation in flow in the sub-catchments in the Mangaroa/Pakuratahi Valleys and Mixed rural EPAUs and no change in flow in the Groundwater fed urban and Surface water fed urban EPAUs (Table 26 and Table 27).

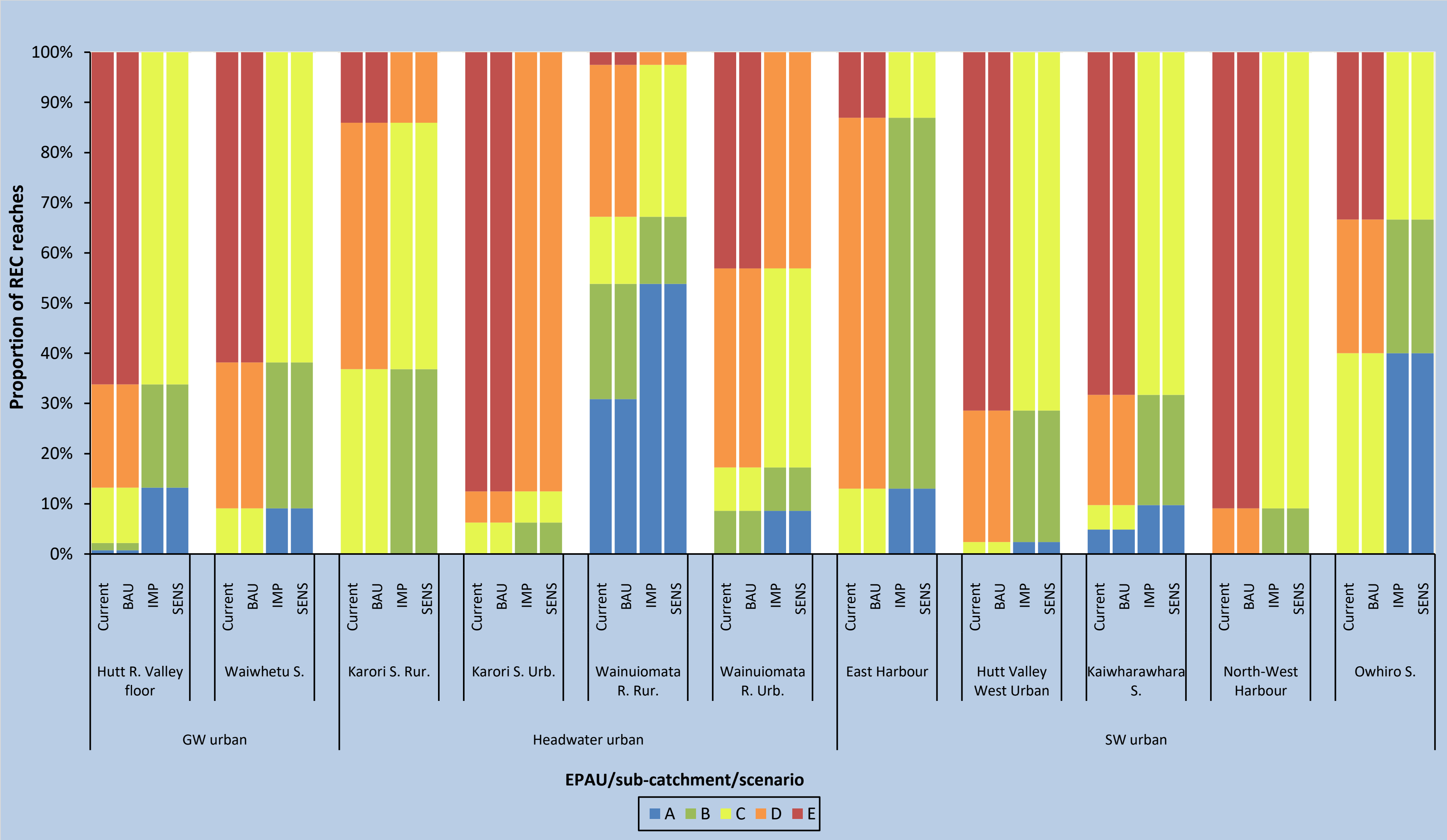

Figure 13: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted *E. coli* concentrations in the NPS-FM 2014 (amended 2017) A, B, C, D and E *E. coli* attribute states under the different scenarios. Current state is based on modelling conducted by Snelder *et al.* (2016)

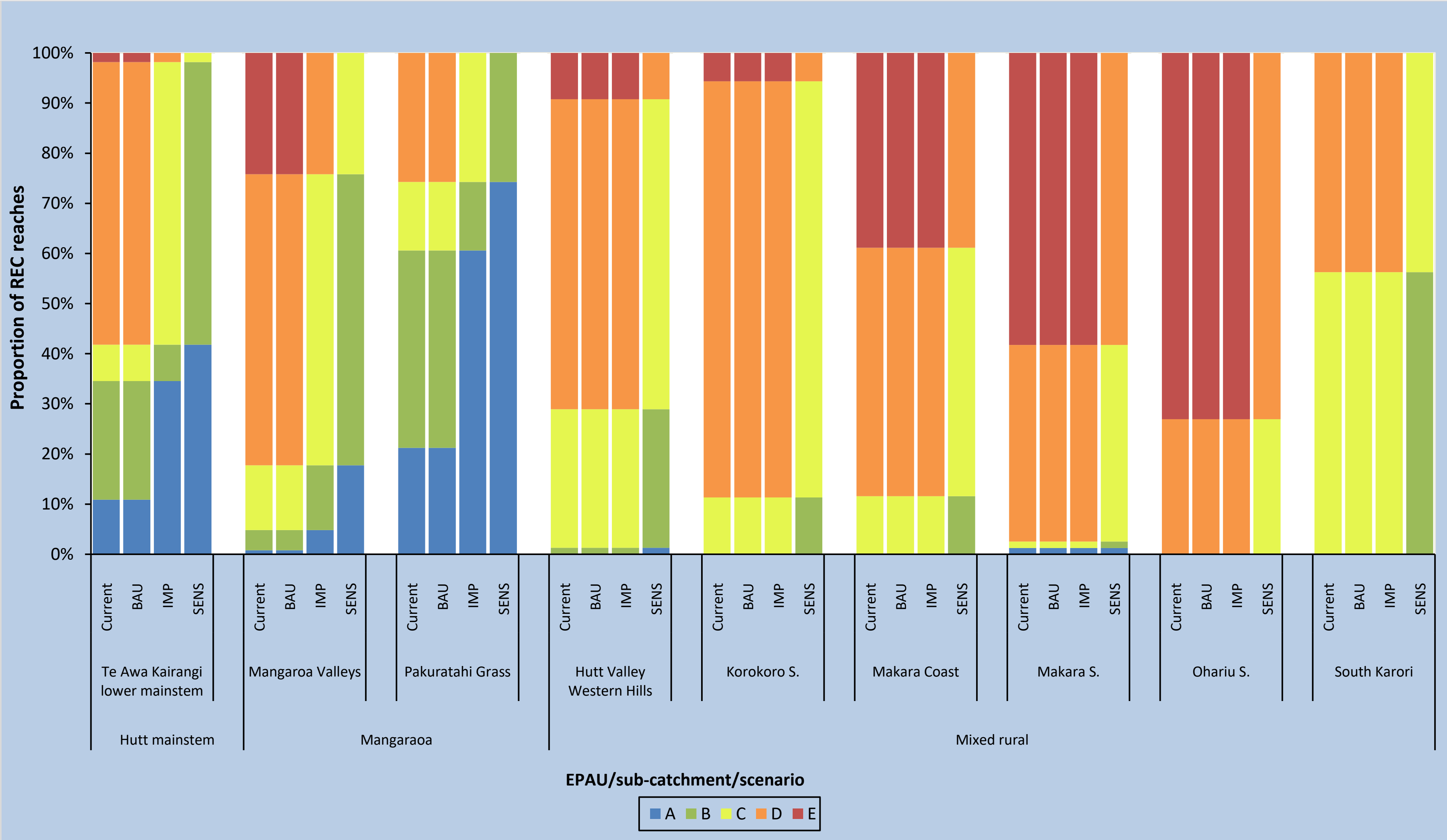

Figure 14: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted *E. coli* concentrations in the NPS-FM 2014 (amended 2017) A, B, C D, and E *E. coli* attribute states under the different scenarios. Current state is based on modelling conducted by Snelder *et al.* (2016)

Table 26: Downscaled expert panel assessments for flow by GWRC RSoE site and scenario.

A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	Site	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	-2	-2	-2
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	-2	-2	-2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	-1	-1	-1
		Hutt R.@ Manor Park	-1	-1	-1
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	-2	-2	-1
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	-2	-2	-1
4 – Mixed rural	Makara S.	Makara S. @ Kennels	-2	-2	-1
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	-2	-2	0
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	-2	-2	0

Table 27: Downscaled expert panel assessments for flow by sub-catchment and scenario.

A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	-2	-2	-2
	Wainuiomata R. – Urb.	-2	-2	-2
	Wainuiomata R. – Rur.	-2	-2	-2
	Wainuiomata R. – Urb.	-2	-2	-2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	-1	-1	-1
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	-2	-2	-1
	Pakuratahi Grass	-2	-2	-1
4 – Mixed rural	Hutt Valley Western Hills	-2	-2	-1
	Korokoro S.	-2	-2	-1
	Makara Coast	-2	-2	-1
	Makara S.	-2	-2	-1
	Ohariu S.	-2	-2	-1
	South Karori	-2	-2	-1
5 – Groundwater fed urban	Hutt River Valley floor	-2	-2	0
	Waiwhetu S.	-2	-2	0
6 – Surface water fed urban	East Harbour	-2	-2	0
	Hutt Valley West Urban.	-2	-2	0
	Kaiwharawhara S.	-2	-2	0
	North-West Harbour	-2	-2	0
	Owhiro S.	-2	-2	0

Note: The expert panel generally had a low-level of confidence in their assessments of how flow will change under the different scenarios, as they were heavily reliant on the modelled effects of climate change, which is subject to a high degree of uncertainty.

5.1.10. Periphyton

Periphyton are primary producers and an important foundation of many river and stream food webs, particularly in rivers with hard, cobbly substrate. Periphyton also stabilise substrata and serve as habitat for many other organisms. However, an over-abundance of periphyton can reduce ecological habitat quality. Large standing crops of periphyton can smother stream-bed substrate, thereby reducing the amount of suitable habitat available for fish and macroinvertebrates. High densities of periphyton can also cause large daily fluctuations in dissolved oxygen concentrations and pH, especially in slower flowing systems.

With the exception of the Te Awa Kairangi mainstem and Pakuratahi River Grassland sub-catchments where most reaches are in the A or B attribute state, predicted (based solely on nutrients) periphyton biomass in the majority of REC reaches in all sub-catchments is in attribute state C, with only a small proportion in the D or A state (Wainuiomata River sub-catchments only) (Figure 15 and Figure 16). Furthermore, all RSoE monitoring sites are currently in the C attribute state for periphyton biomass (Table 28).

Table 28: Predicted periphyton biomass attribute state (NPS-FM 2014) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	C	C	C	C
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	C	C	C	C
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	C	C	C	B
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	C	C	C	C

The expert panels outputs presented in Supplement 1 suggest the following changes in periphyton biomass attribute state under the different scenarios:

- Under BAU, a small increase in periphyton biomass is expected in sub-catchments to the east of Wellington Harbour where summer low flows are expected to decrease (higher water temperatures and longer accrual). However, REC reaches and RSoE sites are not expected to change an attribute state in any sub-catchment.
- Under the Improved scenario, riparian planting (increased shading, reduced water temperature, lower nutrient concentrations) and land retirement (reduced nutrient concentrations) are expected to result in small decreases in periphyton biomass in all sub-catchments in the Mangaroa/Pakuratahi Valleys and Mixed rural EPAUs (but an attribute state change is still not expected. Periphyton biomass in all other sub-catchments (including Te Awa Kairangi lower mainstem) is expected to remain unchanged from current under this scenario.

- Periphyton biomass is expected to decrease in all sub-catchments under the Sensitive scenario except the Te Awa Kairangi mainstem where it is likely to be unchanged However, an attribute state change improvement is only expected in reaches and sites in the sub-catchments in the Mangaroa/Pakuratahi Valleys EPAU. The expected reductions periphyton growth under this scenario are the result of reduced nutrient concentrations (land retirement and riparian planting) and increased shading (riparian planting).

The above assessment suggests that the majority of REC reaches (Figure 15 and Figure 16) and RSoE sites (Table 28) in most sub-catchments will remain in the C state for periphyton biomass under the BAU, Improved and Sensitive scenarios (Table 28, Figure 15 and Figure 16. However, under Sensitive most REC reaches and the RSoE site in the Mangaroa Valley sub-catchment will shift from the C state to B state (Table 20 and Figure 16), and 97% of reaches in the Pakuratahi Grassland will be in the A or B state (up from 58%) instead of the B or C state (Figure 16).

Note: The expert panel generally had a low-level of confidence in their assessments of how plant growth will change under the different scenarios, as they incorporated the modelled effects of climate change on flow, which is subject to a high degree of uncertainty. Furthermore, predicting the response of periphyton biomass to changes in flow, and nutrients is always difficult due to complicated driver-response relationships.

5.1.11. MCI

The aquatic macroinvertebrate community is an important component of river and stream ecosystems, and macroinvertebrate community health is a widely used indicator of ecosystem health. Sensitivity to habitat and water quality stressors differs between macroinvertebrate taxa; thus, the composition of macroinvertebrate communities in a stream can provide valuable information about how the state and trends in water quality and habitat are influencing ecosystem health. The macroinvertebrate community index (MCI) is an index of macroinvertebrate sensitivity to a wide range of environmental variables and is used to measure community health.

Predicted MCI in the majority (≥60%) of REC reaches in sub-catchments in the Headwater Urban, Hutt mainstem, Mangaroa/Pakuratahi Valleys and Mixed Rural EPAUs are in the A or B state (the exceptions being the Karori Stream – Urban and Mangaroa Valleys sub-catchments where only 25% to 53% of reaches are in the A or B state). In contrast less than 50% of reaches are predicted to be in the A or B state in all sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs except East Harbour. However, only the sub-catchments in the Groundwater fed urban EPAU are predicted to have a significant proportion (>20%) of reaches in the D state. While, measured MCI at most GWRC RSoE monitoring sites is in the B state, sites in the Headwater Urban and Surface water fed urban EPAUs are in the C state, and the site on the Waiwhetu Stream is in the D state (Table 29).

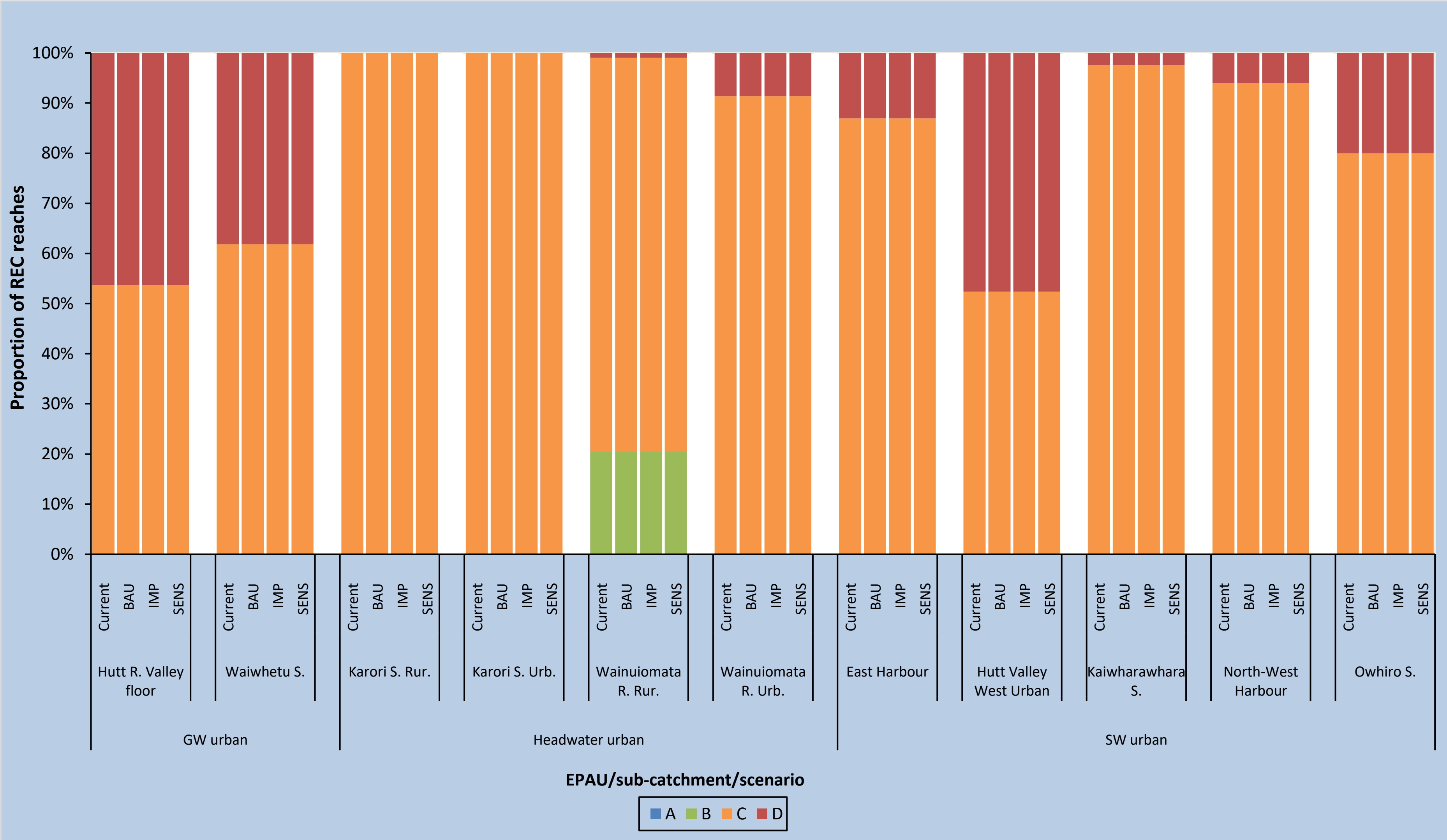

Figure 15: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted periphyton biomass in the NPS-FM 2014 A, B, C and D periphyton attribute states under the different scenarios. Current state is based on water quality modelling conducted by Larned *et al.* (2017), and nutrient criteria from Snelder *et al.* (2019).

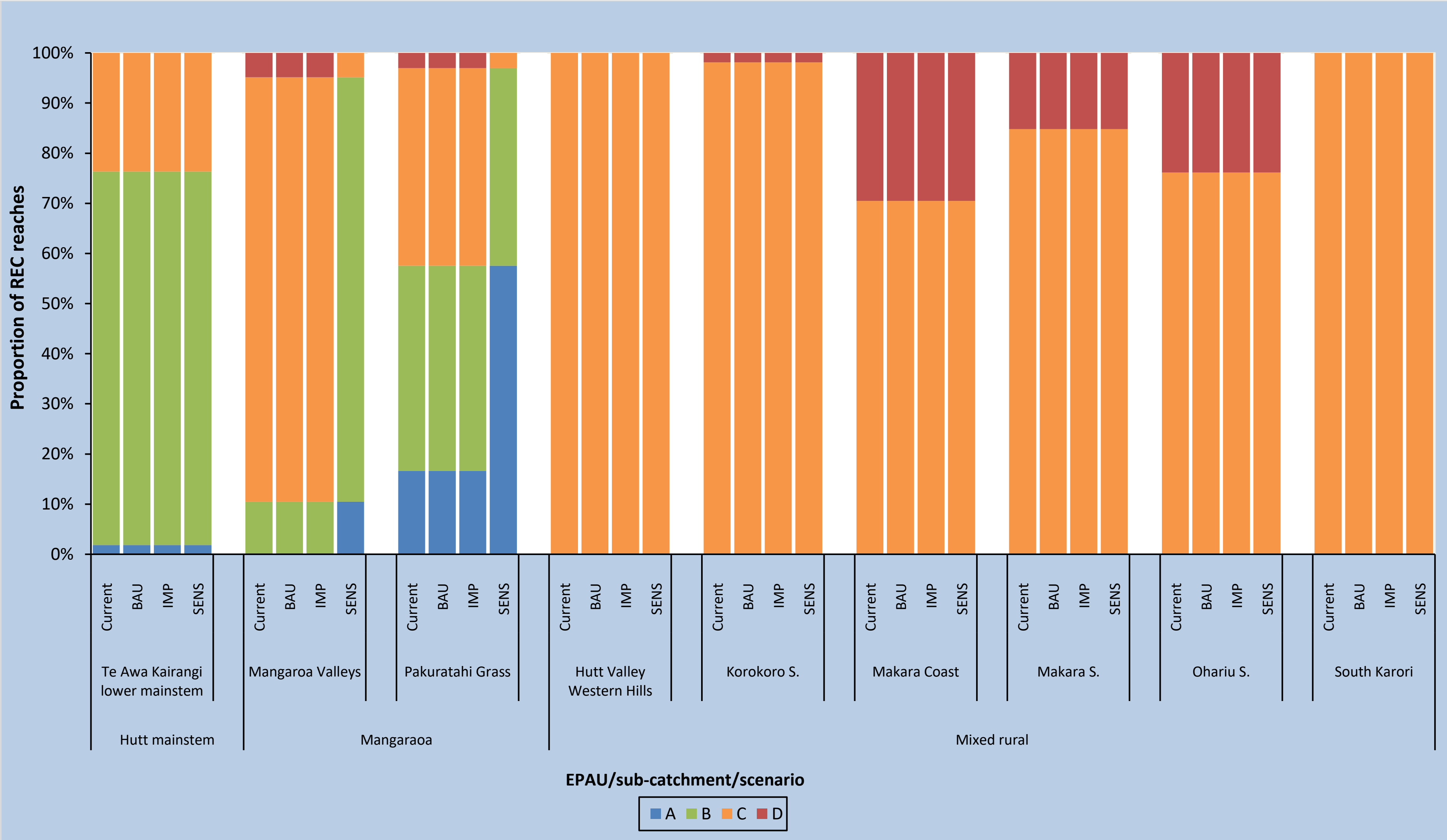

Figure 16: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted periphyton biomass in the NPS-FM 2014 A, B, C and D periphyton attribute states under the different scenarios. Current state is based on water quality modelling conducted by Larned *et al.* (2017), and nutrient criteria from Snelder *et al.* (2019).

Table 29: Predicted MCI attribute state (GWRC) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	C	C	C	B
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	C	C	C	B
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	B	B	B	B
		Hutt R.@ Manor Park	B	B	B	B
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	B	B	B	A
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	B	B	B	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	B	B	B	A
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	D	D	D	C
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	C	C	C	C

The expert panels outputs presented in Supplement 1 suggest that:

- Under BAU, small decreases in MCI are expected in all sub-catchments except Te Awa Kairangi lower mainstem. However, REC reaches and RSoE sites are not expected to change an attribute state anywhere in the Whaitua. The expected reductions in MCI under this scenario are attributed to changes in flow and increased periphyton growth (sub-catchments east of wellington harbour) and an increase in metal concentrations in urban sub-catchments.
- Stock exclusion, riparian planting, land retirement and reduced metal concentrations in urban sub-catchments under the Improved scenario are expected to result in small improvements in MCI in all sub-catchments except Te Awa Kairangi lower mainstem. However, an attribute state change is still not likely.
- Under the Sensitive scenario MCI is expected to increase in all sub-catchments in response to stock exclusion, riparian planting, land retirement and reduced metal concentrations in urban sub-catchments, except in the Te Awa Kairangi mainstem where it is expected to remain unchanged. These increases are expected to result in a one attribute state improvement in the reaches and sites in the Karori Stream – Urban, Wainuiomata River – Rural, Wainuiomata – Urban and Pakuratahi Grassland sub-catchments, and all sub-catchments in the Mixed rural and Groundwater fed urban EPAUs. A two attribute state improvement is also expected in the in the Mangaroa Valleys sub-catchment.

Under BAU and Improved the distribution of MCI attribute states across REC reaches and GWRC RSOE is expected to reflect current state in all sub-catchments (Table 29, Figure 17 and Figure 18). However, under the Sensitive scenario:

- In the Mangaroa Valley sub-catchment most REC reaches (85%) and the RSoE site will likely shift from the B or C state to the A state (Table 29 and Figure 18);
- The proportion of reaches in the Pakuratahi Grassland sub-catchment in the A state will likely increase from 52% to 85% (Figure 18);

- At least 70% of REC reaches in all sub-catchments in the Mixed rural EPAU, except Ohariu Stream, are expected to shift from the B state to the A state;
- In the Ohariu Stream, Waiwhetu Stream and Hutt River Valley Floor sub-catchments at least 70% of REC reaches are expected to be in the A or B state, up from 31% to 48%;
- The proportion of reaches in the Karori Stream – Urban sub-catchment in the A or B state is predicted to increase from 25% to 100%. Similarly, 100% of reaches in the urban and rural Wainuiomata River sub-catchments are expected to be in those attribute states (up from 67% and 81% respectively); and
- The distribution of attribute states at REC reaches and RSoE sites in the sub catchments in the Surface water fed urban EPAU and the Te Awa Kairangi mainstem and Karori Stream – Rural sub-catchments will likely remain unchanged from current (Table 29, Figure 17 and Figure 18).

Note: The expert panel generally had a low-level of confidence in their assessments of how macroinvertebrate community health will change under the different scenarios as they incorporated the modelled effects of climate change on flow, which is subject to a high degree of uncertainty. Furthermore, it is always difficult to predict the response of macroinvertebrates to changes in flow, toxicants and periphyton, due to complicated driver-response relationships.

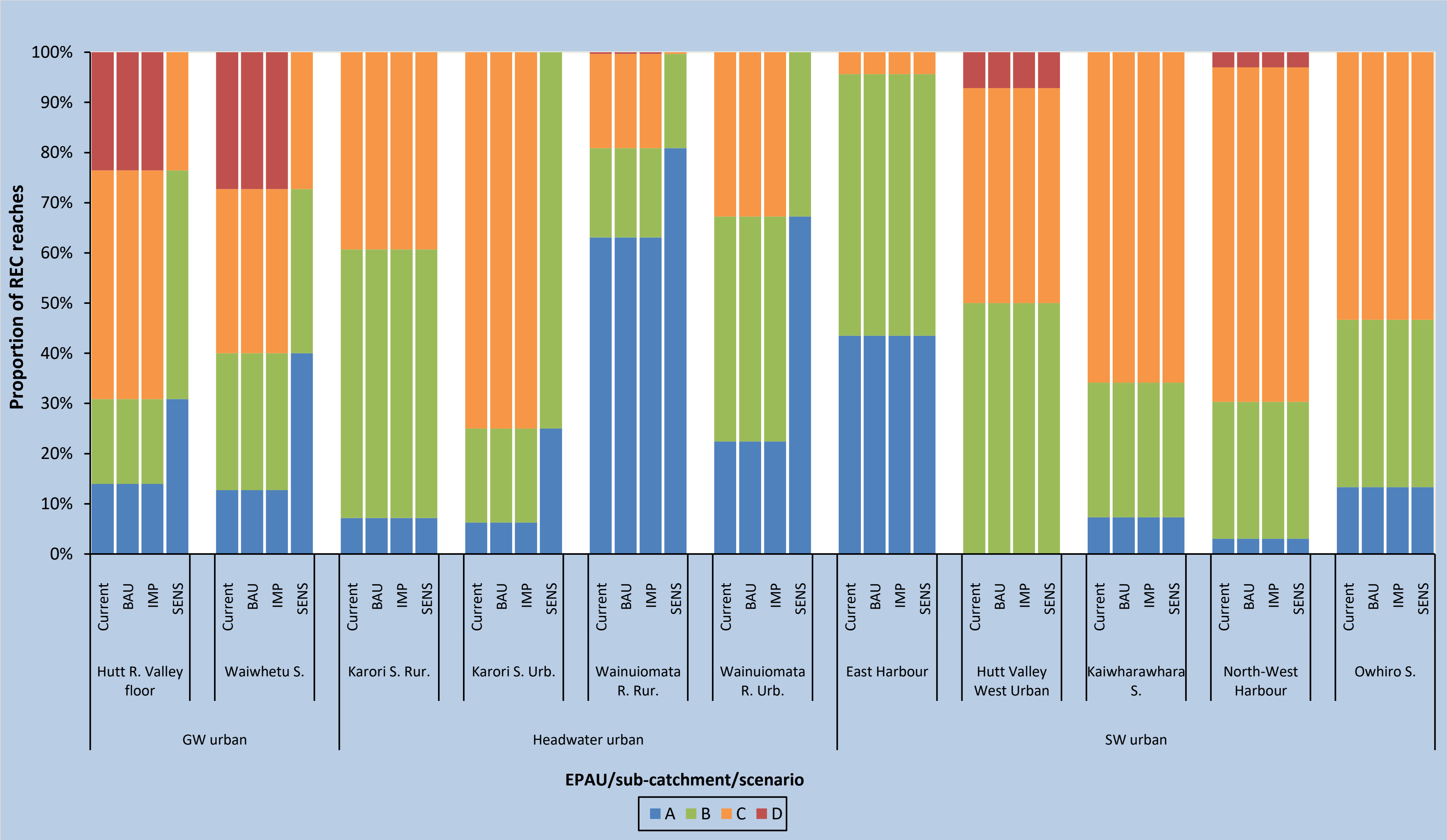

Figure 17: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted MCI in the Wellington-specific A, B, C and D attribute states under the different scenarios. Current state is based on modelling conducted by Clapcott & Goodwin (2014).

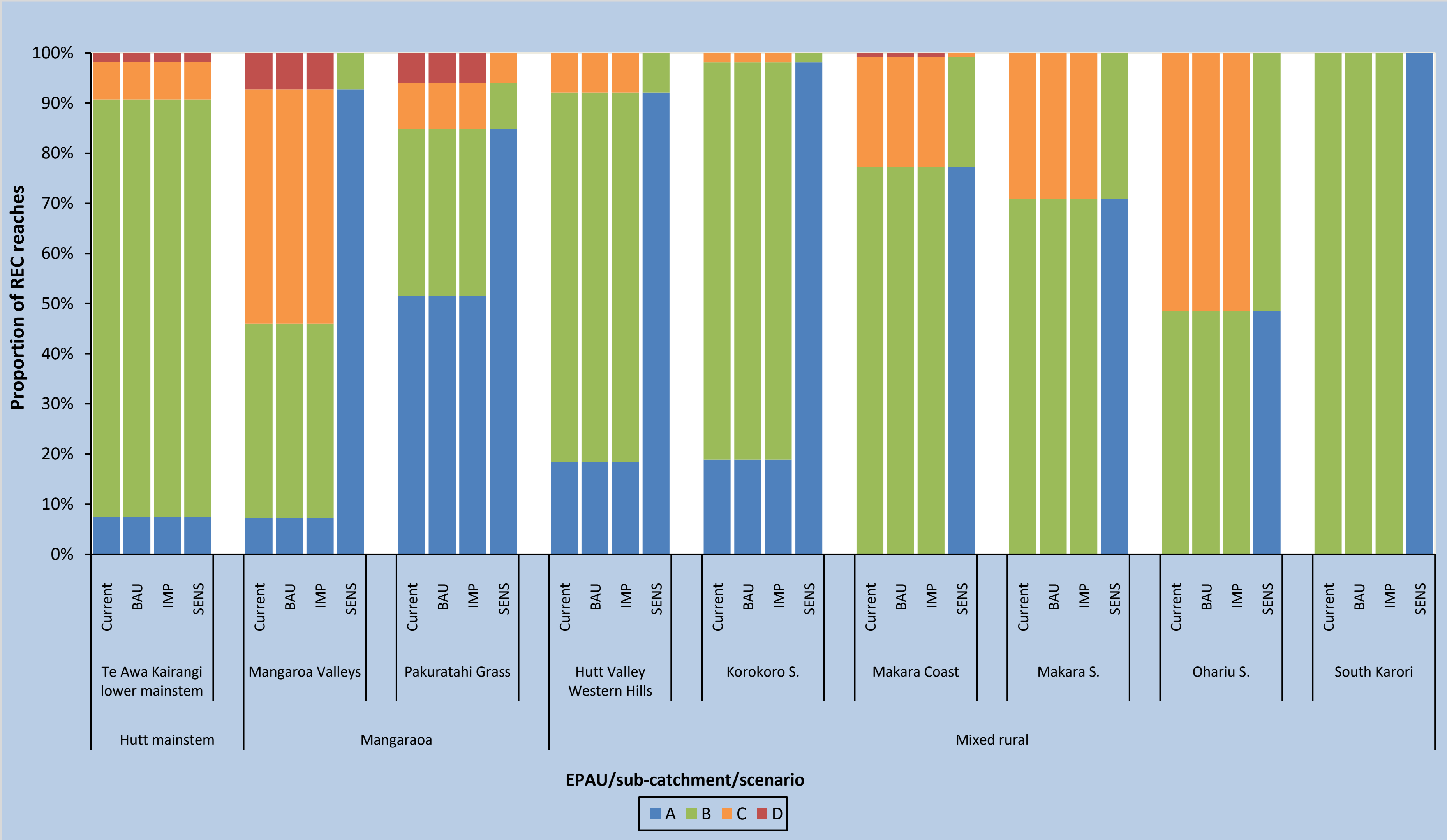

Figure 18: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted MCI in the Wellington-specific A, B, C and D attribute states under the different scenarios. Current state is based on modelling conducted by Clapcott & Goodwin (2014).

5.1.12. Fish

Fish are a key component of river and stream ecosystems and are a useful indicator of ecosystem health because they respond to both local and catchment-scale impacts. The majority of indigenous fish species are diadromous (migratory) so require connectivity to and from the sea. A healthy indigenous fish community is also dependent on water quality and habitat quality.

GWRC do not conduct regular fishing at their RSoE sites and there are no reach scale national or regional models that satisfactorily predict IBI. As such, the analysis in this section is based on IBI scores calculated for each REC reach in the Whaitua that was fished between 2000 and 2018 (MfE, 2019).

Currently at least 50% of fished REC reaches in all sub-catchments are in the A or B attribute state for IBI (based on the 2019 proposed changes to the NPS-FM) with the majority of fished reaches in most sub-catchments in attribute state A (Figure 19 and Figure 20). Only four sub-catchments have any fished reaches in the C attribute state and no sub-catchments have reaches in the D state (Figure 19 and Figure 20).

The panel concluded that while changes in water quality, flow, habitat periphyton growth and macroinvertebrate community health may affect fish abundance and community structure/composition in some sub-catchments under some scenarios, “a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species”. Accordingly, the distribution of fish IBI attribute states between fished REC reaches is expected to reflect current state under BAU, Improved and Sensitive in all sub-catchments (Figure 19 and Figure 20).

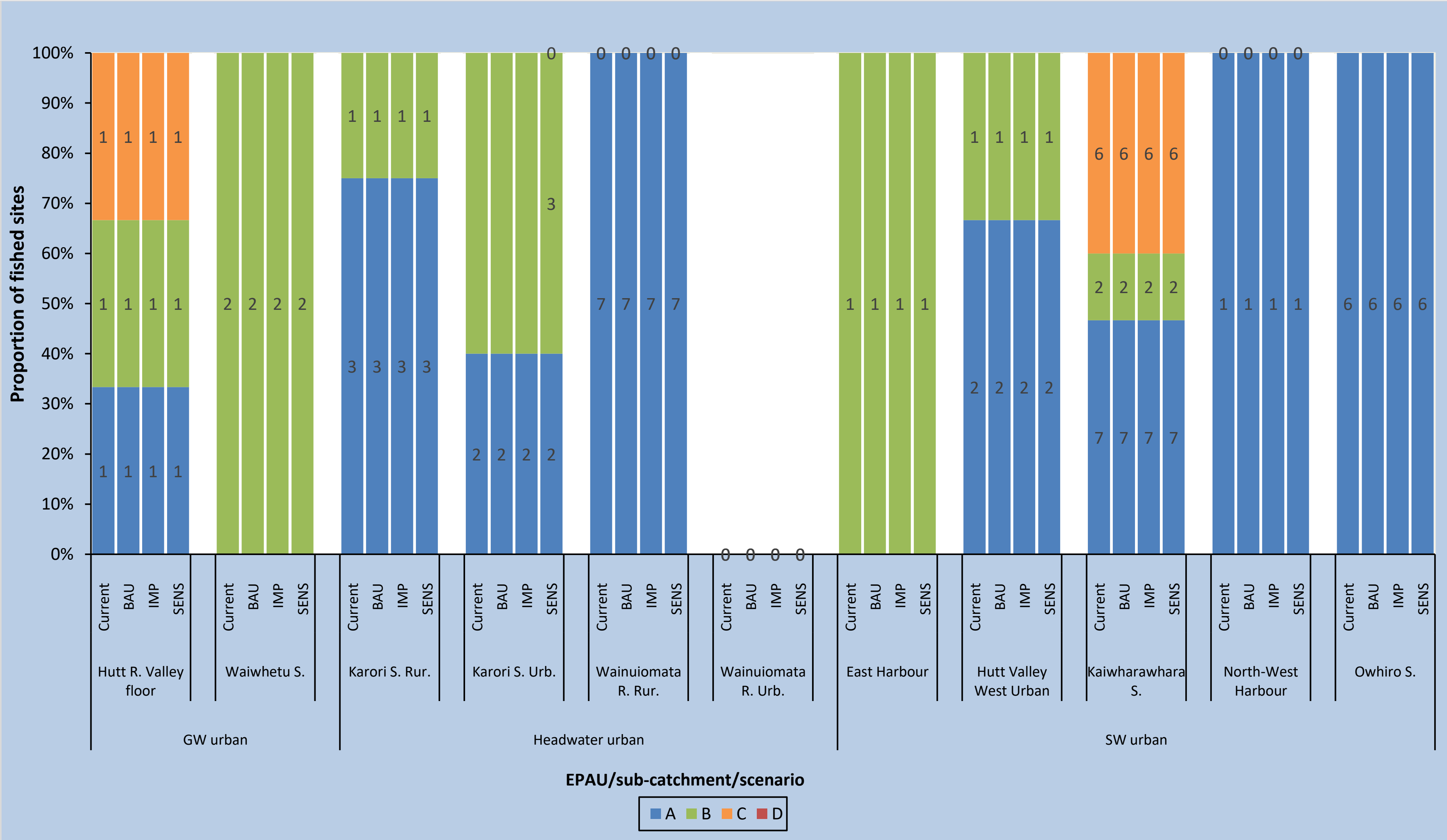

Figure 19: The percentage of fished REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted IBIs in the proposed NPS-FM A, B, C and D IBI attribute states under the different scenarios. Current state is based on the analysis conducted by MfE (2019). The number of fished reaches in each attribute state are denoted.

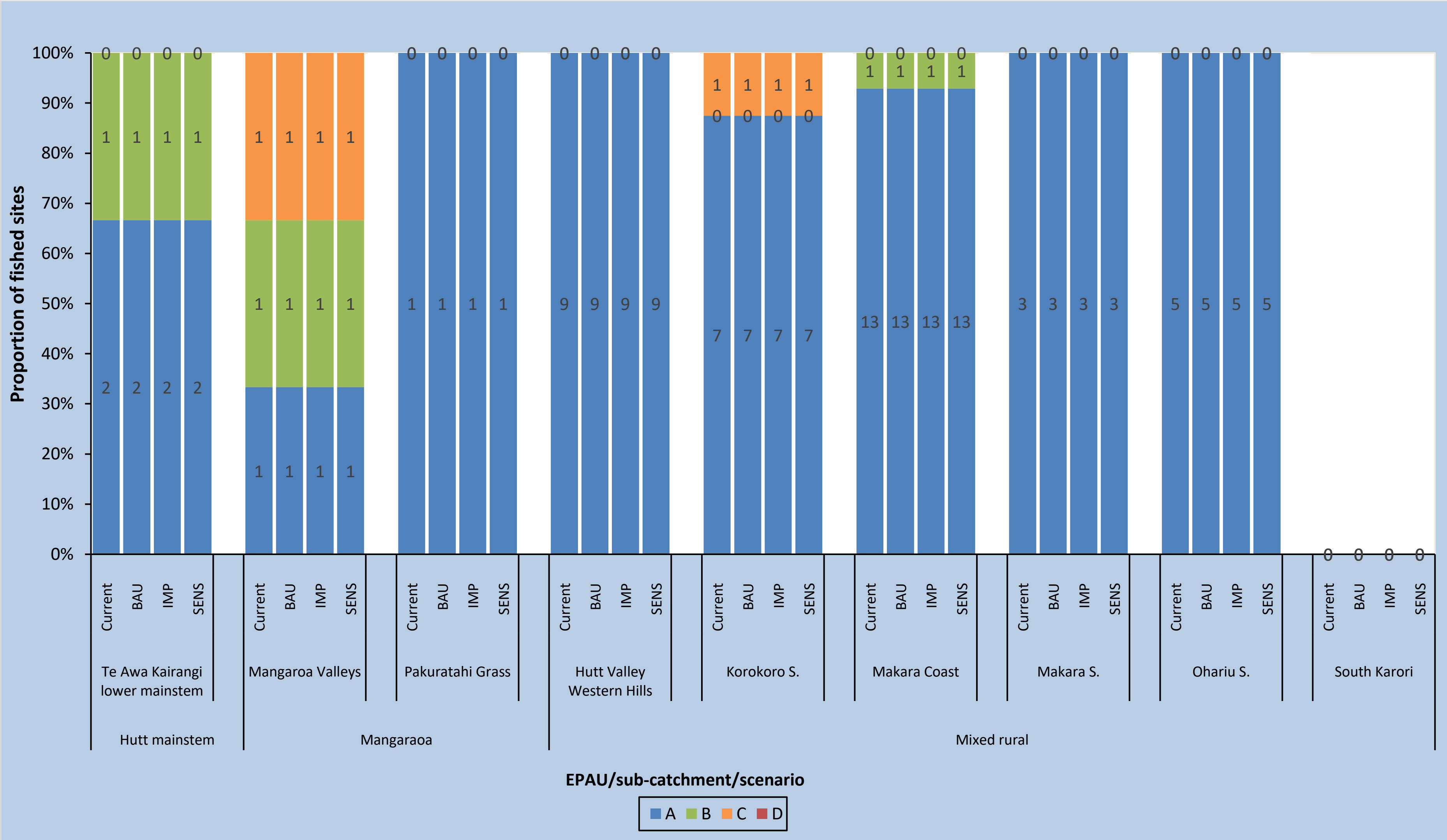

Figure 20: The percentage of fished REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted IBIs in the proposed NPS-FM A, B, C and D IBI attribute states under the different scenarios. Current state is based on the analysis conducted by MfE (2019). The number of fished reaches in each attribute state are denoted.

5.1.13. Ecosystem health

Ecosystem health is a phrase used to describe the suitability of a waterway to support healthy ecosystems, including a diversity and abundance of species and ecological processes. As a compulsory value in the NPS-FM 2014, the concept of ecosystem health is embedded in New Zealand's freshwater management framework and is the primary reason for managing almost all of the parameters assessed in Sections 5.1.1 to 5.1.12. There is currently no single indicator for ecosystem health. Thus, in their assessments the panel considered the following factors when considering how it will change under the different scenarios:

- Water quality;
- Water quantity;
- Physical habitat
- Aquatic biota;
- Instream processes; and
- How all of the aforementioned factors interact.

The downscaled expert panel assessments for Ecosystem health by RSoE site and sub-catchment are provided in Table 30 and Table 31 respectively and described below. Further detail behind these assessments are provided in the expert panel outputs contained in Supplement 1.

- Degraded water quality, poorer flow conditions, increased periphyton growth (in catchments to the East of Wellington Harbour) and decreased MCI under BAU will likely result in a small degradation in Ecosystem health in all sub-catchments in the Headwater Urban, Mangaroa/Pakuratahi Valleys and Mixed Rural EPAUs and a moderate degradation across the Groundwater fed urban and Surface water fed urban EPAUs (Table 30 and Table 31). The only sub-catchment where ecosystem health is not expected to change under BAU is the Te Awa Kairangi lower mainstem.
- Under the Improved scenario, riparian planting, land retirement and reduced metal concentrations in urban sub-catchments are expected to result in small improvements in ecosystem health in all sub-catchments except Mangaroa Valley, Pakuratahi Grassland and Te Awa Kairangi lower mainstem. In the Te Awa Kairangi mainstem a change in ecosystem health is unlikely under Improved, while a moderate improvement is likely in the Mangaroa Valley and Pakuratahi Grassland sub-catchments due to extensive stock exclusion and riparian planting.
- The effects of rural and urban mitigations on water quality, plant growth and macroinvertebrate community health under Sensitive is expected to result in a moderate improvement in ecosystem health in all sub-catchments, except the Te Awa Kairangi mainstem where it is expected to remain unchanged.

Note: The expert panel generally had a low-level of confidence in their assessments of how ecosystem health will change under the different scenarios due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the *effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.*

Table 30: Downscaled expert panel assessments for Ecosystem health by GWRC RSoE site and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	Site	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	-1	+1	+2
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	-1	+1	+2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	-1	0	0
		Hutt R.@ Manor Park	-1	0	0
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	0	+2	+2
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	0	+2	+2
4 – Mixed rural	Makara S.	Makara S. @ Kennels	-1	+1	+2
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	-2	+1	+2
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	-2	+1	+2

Table 31: Downscaled expert panel assessments for Ecosystem health by sub-catchment and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	-1	+1	+2
	Wainuiomata R. – Urb.	-1	+1	+2
	Wainuiomata R. – Rur.	-1	+1	+2
	Wainuiomata R. – Urb.	-1	+1	+2
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	-1	0	0
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	0	+2	+2
	Pakuratahi Grass	0	+2	+2
4 – Mixed rural	Hutt Valley Western Hills	-1	+1	+2
	Korokoro S.	-1	+1	+2
	Makara Coast	-1	+1	+2
	Makara S.	-1	+1	+2
	Ohariu S.	-1	+1	+2
	South Karori	-1	+1	+2
5 – Groundwater fed urban	Hutt River Valley floor	-2	+1	+2
	Waiwhetu S.	-2	+1	+2
6 – Surface water fed urban	East Harbour	-2	+1	+2
	Hutt Valley West Urban.	-2	+1	+2
	Kaiwharawhara S.	-2	+1	+2
	North-West Harbour	-2	+1	+2
	Owhiro S.	-2	+1	+2

5.1.14. Overall suitability for recreation

In this process Overall suitability for recreation means the suitability of a river for recreation both in terms of health risk for contact recreation and aesthetic/amenity value for all forms of recreation. As such the Expert Panel considered the following factors when assessing how this attribute will change under the different scenarios:

- Human health risks including;
  - *E. coli* concentrations; and
  - The presence of potentially toxic cyanobacteria.
- The aesthetics of the waterway including;
  - Water clarity;
  - Deposited sediment cover;
  - Periphyton growth;
  - The state of the riparian zone; and
  - Stock access.
- The availability of water to swim in (i.e., summer low flow conditions).

The downscaled expert panel assessments for Overall suitability for recreation by RSoE site and sub-catchment are summarised below and presented in Table 32 and Table 33. Further detail behind these assessments are provided in the expert panel outputs contained in Supplement 1.

- Small reductions in Overall suitability for recreation are expected under BAU in most sub-catchments due to a combination of reduced summer low flows and associated increases in periphyton growth (sub-catchments to the east of Wellington Harbour only) as well as increased sediment input leading to lower visual clarity and higher deposited sediment cover (Table 32 and Table 33). In contrast a small improvement is expected in the Mangaroa Valley and Pakuratahi Grassland sub-catchments due to reduced *E. coli* associated with stock exclusion (Table 32 and Table 33). None of the expected changes in water quality, flow or ecology are likely to have an impact on the already low recreational value of streams in the Hutt River Valley Floor and Waiwhetu sub-catchments under this scenario (Table 32 and Table 33).
- The assumed stock exclusion, riparian planting, land retirement, space planting and the large reduction in wastewater contamination in urban streams is expected to result in a moderate increase in Overall suitability for recreation in most sub-catchments under the Improved scenario (Table 32 and Table 33), with the primary driver being a reduction in *E. coli* concentrations rather than reduced sediment input. However, only small improvements are likely in the sub-catchments in the Mixed rural EPAU under this scenario as there is very little stock exclusion and an attribute state change in *E. coli* is not expected (Table 32 and Table 33)
- Under the Sensitive scenario a significant improvement in Overall suitability for recreation is likely in all sub-catchments except those in the Mixed rural EPAU. These improvements are due to the considerably reduced *E. coli* concentrations (two

attribute state improvement in most sub-catchments), reduced sediment input, and the 10 metre riparian planting around streams with stock exclusion. There will also likely be a significant improvement in people's perception of the waterways in the Headwater urban, Groundwater fed urban and Surface water fed urban EPAUs due to the elimination of almost all wastewater contamination. However, only a moderate improvement is expected in sub-catchments in the Mixed rural EPAU under this scenario as there is limited stock exclusion and riparian planting meaning smaller improvements in *E. coli* concentration and aesthetics compared to the sub-catchments in the Mangaroa/Pakuratahi Valleys EPAU.

Table 32: Downscaled expert panel assessments for overall suitability for recreation by GWRC RSoE site and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	Site	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	-1	+2	+3
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	-1	+2	+3
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	-1	+2	+3
		Hutt R.@ Manor Park	+1	+2	+3
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	+1	+2	+3
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	+1	+2	+3
4 – Mixed rural	Makara S.	Makara S. @ Kennels	-1	+1	+2
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	0	+2	+3
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	-1	+2	+3

5.2. Synthesis

From the results of the expert panel and downscaling processes the following conclusions have been drawn about how freshwater quality and ecology may change in Whaitua Te Whanganui-a-Tara under the different scenarios:

- Under the BAU scenario the attribute states of most parameters in most sub-catchments are unlikely to change from current state, although a one attribute state degradation is likely for Cu and Zn in the sub-catchments listed below due to an increase in impervious surface cover:
  - Karori Stream – Urban;
  - Wainuiomata River – Urban
  - East Harbour;
  - Hutt Valley West Urban
  - Kaiwharawhara Stream; and
  - Owhiro Stream

  Based on the assessment presented above, the likely changes in Cu attribute state at the RSoE monitoring sites are a shift from the C to D state in the Kaiwharawhara

Stream sub-catchment under BAU and a shift from the C state to the A state in the Waiwhetu Stream sub-catchment under Sensitive (Table 15)

As a result of this degradation, Cu concentrations at the RSoE monitoring site on the Kaiwharawhara Stream will likely shift from the C state to the D state, while Zn concentrations are expected to shift from the B state to the C state.

Table 33: Downscaled expert panel assessments for overall suitability for recreation by sub-catchment and scenario. A 0 represents no/negligible change, a +1/-1 represents a small improvement/degradation, a +2/-2 represents a moderate improvement/degradation and a +3/-3 represents a significant improvement/degradation.

EPAU	Sub-catchment	BAU	Improved	Sensitive
1 – Headwater urban	Karori S. – Rur.	-1	+2	+3
	Wainuiomata R. – Urb.	-1	+2	+3
	Wainuiomata R. – Rur.	-1	+2	+3
	Wainuiomata R. – Urb.	-1	+2	+3
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	-1	+2	+3
3 – Mangaroa/ Pakuratahi Valleys	Mangaroa Valleys	+1	+2	+3
	Pakuratahi Grass	+1	+2	+3
4 – Mixed rural	Hutt Valley Western Hills	-1	+1	+2
	Korokoro S.	-1	+1	+2
	Makara Coast	-1	+1	+2
	Makara S.	-1	+1	+2
	Ohariu S.	-1	+1	+2
	South Karori	-1	+1	+2
5 – Groundwater fed urban	Hutt River Valley floor	0	+2	+3
	Waiwhetu S.	0	+2	+3
6 – Surface water fed urban	East Harbour	-1	+2	+3
	Hutt Valley West Urban	-1	+2	+3
	Kaiwharawhara S.	-1	+2	+3
	North-West Harbour	-1	+2	+3
	Owhiro S.	-1	+2	+3

- Under the Improved scenario the following changes in attribute state are likely:
    - Zn concentrations are expected to improve by one attribute state in the Karori Stream – Urban, Wainuiomata River – Urban, Hutt River Valley floor and Waiwhetu Stream sub-catchments due to stormwater capture and treatment and the replacement of 50% of existing roofs constructed from materials containing Zn. This is expected to result in the RSoE monitoring sites on the Karori and Waiwhetu streams shifting from the D state to the C state
    - Extensive stock exclusion and riparian planting in the Mangaroa Valleys and Pakuratahi Grassland sub-catchments is likely to result in a one attribute state

improvement in dissolved reactive phosphorus concentrations. This means that most REC reaches in the Pakuratahi Grassland sub-catchment will be in A or B attribute state (currently B or C state) while most reaches in the Mangaroa Valley sub-catchment will be in the B or C state (currently C or D state).

  - The removal of dry weather wastewater contamination is likely to result in a two attribute state improvement in *E. coli* concentrations in all sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs. As a result, all REC reaches and RSoE sites will likely be in the 'swimmable attribute states (A, B or C). This is a significant improvement as in most of those sub-catchments less than 15% of reaches are predicted to be currently swimmable.
  - Reduced wastewater contamination in urban areas combined with stock exclusion and riparian planting is expected to result in a one attribute state improvement in the sub-catchments in the Headwater urban (also affected by reduced wastewater contamination), Hutt mainstem and Mangaroa/Pakuratahi Valleys EPAUs. The result of these improvements is that between 70% and 100% of REC reaches will likely be in the swimmable attribute states in these sub-catchments except Karori Stream – Urban (88% of reaches remain unswimmable).

- Under the Sensitive scenario the assumed urban and rural mitigations are likely to result in the following changes in attribute state:
  - Copper concentrations are likely to improve by two attribute states in the Hutt River Valley Floor and Waiwhetu Stream sub-catchments in response to stormwater capture and treatment. This will likely result in the RSoE site on the Waiwhetu Stream shifting from the C state to the A state.
  - Stormwater capture and treatment combined with the replacement of all roofs containing zinc are expected to result in a two attribute state improvement in zinc concentrations in sub-catchments in the Groundwater fed urban EPAU, and the Karori Stream – Urban and Wainuiomata River – Urban sub-catchments. Those mitigations are also expected to result in a one attribute state improvement in the Surface water fed urban EPAU. Accordingly, the RSoE sites on the Karori, and Waiwhetu streams will likely shift from the D attribute state to the B state, while the site on the Kaiwharawhara Stream will likely shift from the B state to the A state
  - DIN concentrations in the Mangaroa Valley and Pakuratahi Grassland sub-catchments are expected to improve one attribute state as a result of extensive stock exclusion and riparian planting. This shift is predicted to result in 85% of REC reaches in the Mangaroa Valley sub-catchment and 91% of reaches in the Pakuratahi Grassland being in the A state (up from 38% and 77% respectively).
  - DRP concentrations are expected to improve an attribute state in all sub-catchments in the Headwater urban, Mangaroa/Pakuratahi Valleys and

Mixed rural EPAUs. Accordingly, most RSoE sites and REC reaches in these sub-catchments are predicted to be in the B or C attribute state under this scenario (currently C or D).

- *E. coli* concentrations in the Headwater urban, Groundwater fed urban and Surface water fed urban are expected to change by the same number of attribute states as under Improved.
- A two attribute state improvement in *E. coli* concentrations is expected in the Hutt mainstem and Mangaroa/Pakuratahi Valleys EPAUs due to extensive riparian planting. As a result, the proportion of swimmable REC reaches (in the A, B or C state) is predicted to increase from 18% and to 76% in the Mangaroa Valleys sub-catchment and from between 42% and 75% to 100% in the Te Awa Kairangi mainstem and Pakuratahi Grassland sub-catchments.
- The extensive land retirement in the sub-catchments in the Mixed rural EPAU is expected to cause in a one attribute state improvement in *E. coli* concentrations. Consequently, the proportion of swimmable reaches is predicted to increase by between 27% to 83% depending on the sub-catchment, with total proportion of swimmable reaches ranging from 27% to 94% (up from 0% to 56%).
- Reduced nutrient concentrations (land retirement and riparian planting) and increased shading (riparian planting) is expected to decrease periphyton biomass by one attribute state in the sub-catchments in the Mangaroa/ Pakuratahi Valleys EPAU. As a result, 85% of REC reaches in the Mangaroa Valley sub-catchment are predicted to be in the B state (up from 10%), and 97% of reaches in the Pakuratahi Grassland sub-catchment are expected to be in the A or B states under this scenario (up from 58%).
- Stock exclusion, riparian planting, land retirement and reduced metal concentrations in urban sub-catchments are expected to result in a two attribute state improvement in the Macroinvertebrate Community Index in the Mangaroa Valleys sub-catchment. A one attribute state improvement is also expected in the sub-catchments in the Mixed rural and Groundwater fed urban EPAUs as well as the Karori Stream – Urban, Wainuiomata River – Rural, Wainuiomata River – Urban and Pakuratahi Grassland sub-catchments. These improvements are predicted to result in:
    - Most REC reaches (85%) and the RSoE site in the Mangaroa Valley sub-catchment shifting from the B or C state to the A state;
    - The proportion of reaches in the Pakuratahi Grassland sub-catchment in the A state increasing from 52% to 85%;
    - At least 70% of REC reaches in all sub-catchments in the Mixed rural EPAU, except Ohariu Stream, shifting from the B state to the A state;
    - At least 70% of REC reaches in the Ohariu Stream, Waiwhetu Stream and Hutt River Valley Floor sub-catchments being in the A or B state (up from 31% to 48%);

- The proportion of reaches in the A or B state in the Karori Stream – Urban sub-catchment increasing from 25% to 100%; and
- 100% of reaches in the urban and rural Wainuiomata River sub-catchments being in the A or B states up from 67% and 81% respectively.

6. References

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Ministry for the Environment (MfE), 2019. Fish Index of Biotic Integrity in New Zealand rivers 1999–2018. Ministry for the Environment, Wellington, New Zealand.

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Snelder, T.H., Wood, S.A., Atalah, J., 2016. Strategic assessment of New Zealand's freshwaters for recreational use: a human health perspective: Escherichia coli in rivers and planktonic cyanobacteria in lakes (LWP Client Report No. 2016– 011). Land Water People, Christchurch, New Zealand.

APPENDICES

Appendix A: Expert Panel terms of reference (From GWRC)

Purpose and Objectives

Whaitua Te Whanganui-a-Tara (WTWT) has been established to set freshwater objectives for the Te Whanganui-a-Tara catchment, as part of GWRC's response to implementing the National Policy Statement for Freshwater Management (NPSFM 2014).

The purpose of the Freshwater Quality and Ecology Panel (the Panel) is to provide expert advice and judgement on the likely impacts to water quality and ecological indicators (i.e., nutrients, pathogens, MCI, fish) under three different scenarios. The panel's outputs are intended to be high-level assessments that will be considered alongside other scientific, social, cultural and economic information to help the Whaitua Committee set freshwater objectives.

The objectives of the Panel are:

- Refine the assessment methodology developed by Greater Wellington Regional Council (GWRC).
- Contribute as appropriate to a technical library which will include journal articles, reports, monitoring data, modelling information and any other publications relevant to the Te Whanganui-a-Tara catchment and/or which will inform the work of the Panel.
- Develop a shared understanding of the bio-physical state of surface water quality and ecology within the catchment, based on information in the technical library.
- Drawing on the technical library, evaluate three different scenarios that may influence indicators of water quality and ecology (primarily related to NPSFM attributes, but not limited to these).
- Produce a panel summary for each assessment unit for each of the various indicators which includes; using a set of criteria to determine the potential magnitude of change (in attribute state as per the NPSFM National Objectives Framework), the effect and level of confidence in the assessment, as well as some high-level explanatory comments.

Process

The overall programme of work consists of four workshops (refer section 4) plus the associated preparation.

The general methodology in regard to assessing the scenarios is as follows:

1. As part of the preparation, each panel member is to individually assess each assessment unit for each of the various indicators
2. In the workshop, each panel member is to disclose and discuss their assessment (for the specified assessment unit and indicator)
3. The panel will then discuss and decide **by consensus** the final "panel summary" for that assessment unit and indicator (with any major disagreements being noted)

4. Steps 2-3 are to be repeated until all assessment units and indicators have been evaluated.

Full details of the methodology will be described in a document which will be presented and discussed at the first workshop. As a result, some refinements to the methodology may be made.

Responsibilities and Expectations

GWRC will provide a Chair (Penny Fairbrother) for the workshops. One of the panel members (Michael Greer) will act as the lead panellist and facilitate the workshops and write up the final panel summaries.

There will be a total of six panel members and the intent is for each panel member to apply their expert knowledge to assess water quality and ecological changes under three different “management” scenarios.

It is expected that panel members will:

- Work in a timely manner to review appropriate information within the technical library and produce individual pre-assessments prior to the planned workshops.
- Operate without bias, prejudice or organisational agendas.
- Undertake the pre-assessments independently, using best judgement.
- Make a decision on all assessments, regardless of their level of confidence (which can be documented).
- Act professionally and respectfully towards other panel members during the workshops.
- Work together to come to a consensus decision on each of the final “panel summaries”.
    - If a panel member does not agree with a final panel summary and no resolution can be made, a note will be made expressing why there was disagreement, and the workshop will progress. It is expected that disagreements will be noted with sufficient detail that each panel member can be confident in their assessments use in any consequential RMA processes.
- Stand by the process, their individual assessments and the final decisions made (excepting where disagreement has been expressed and noted as per the above and/or where further information becomes available that significantly impacts a panel member’s understanding of an issue).
- Act ethically and professionally, and conduct their practice in accordance with:
    - The New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities.
    - The Environment Courts Code of Conduct for Expert Witnesses.

Timeframe and Administration

The expected workshop schedule is outlined below (Table 1). Note that the exact timing of the workshops will be subject to both time and availability of panel members and critical delivery dates for the Whaitua Committee.

A GWRC staff member will organise all workshops.

Table 1. Proposed workshop schedule

Date	Activity	Workload
December 2019	**Workshop 1 – Getting to know each other, setting context, approve ToR, discuss process and address questions.**	**Attendance at workshop (1 day) Preparation: Read Terms of Reference (ToR)**
Early February 2020	**Skype Call – Address outstanding questions re process, confirm schedule for remaining workshops.**	**Attendance on Skype Call (2 hours) Preparation: Review final methodology document**
Mid-February 2020	**Workshop 2 – Review and develop a shared understanding of the "current state" AND introduce BAU scenario.**	**Attendance at workshop (1 day) Preparation: Background reading of current state information**
Early March 2020	**Workshop 3 – BAU scenario assessment AND introduce Improved and Water Sensitive scenarios.**	**Attendance at workshop (1.5 days) Preparation: Background reading of relevant information AND individual pre-assessments for BAU scenario**
Mid-March 2020	**Workshop 4 – Improved and Water Sensitive scenario assessments.**	**Attendance at workshop (2 days) Preparation: Background reading of relevant information AND individual pre-assessments for Improved and Water Sensitive scenarios**

Panel Members and Key Contacts

Table 3 lists the panel members and various GWRC support staff.

Table 2. Contact details of panel members and GWRC support staff

Person	Organisation	Role	Contact email
Mark Heath	**GWRC**	**WTWT Bio-physical science Project Manager and Expert Panellist**	**Mark.Heath@gw.govt.nz**
Brent King	**GWRC**	**WTWT Bio-physical science Advisor**	**Brent.King@gw.govt.nz**
James Blyth	**GWRC (Contractor)**	**WTWT Bio-physical science Coordinator**	**James.blyth@gw.govt.nz**
John Phillips	**GWRC (Contractor)**	**WTWT Policy Advisor**	**John.Phillips@gw.govt.nz**
Penny Fairbrother	**GWRC**	**WTWT Project Management Support and Expert Panel Chair**	**Penny.Fairbrother@gw.govt.nz**
Emily Osborne	**GWRC**	**WTWT Project Coordinator**	**Emily.Osborne@gw.govt.nz**
Michael Greer	**Aquanet**	**Expert Panellist and Lead Panellist/Facilitator**	**michael@aquanet.co.nz**
Olivier Ausseil	**Aquanet**	**Expert Panellist**	**olivier@aquanet.co.nz**
Joanne Clapcott	**Cawthron**	**Expert Panellist**	**Joanne.Clapcott@cawthron.org.nz**
Ned Norton	**Land and Water People**	**Expert Panellist**	**ned@landwaterpeople.co.nz**
Stu Farrant	**Morphum Environmental**	**Expert Panellist**	**Stu.farrant@morphum.com**

Note: The ToR provided to the Expert Panel contained an estimate of hours in this section. This has been deleted here.

Conflicts of Interest

Panel members are expected to identify and manage any conflicts by:

- Declaring them to the GWRC Project Manager
- Genuinely considering all options without bias, prejudice or organisational agendas
- Genuinely contributing to consensus decision-making.

Appendix B: Summary of the attribute state framework used in this report.

Table 1: Attribute states for dissolved copper (toxicity) developed by GWRC.

Value	Ecosystem health		
Freshwater Body Type	Lakes and Rivers		
Attribute	Dissolved Copper (Toxicity)		
Attribute Unit	µg DCu/L (micrograms of dissolved Copper per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Median*	95th percentile	
A	≤1	≤1.4	99% species protection level: No observed effect on any species tested
B	>1 and ≤1.4	>1.4 and ≤1.8	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>1.4 and ≤2.5	>1.8 and ≤4.3	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	2.5	4.3	
D	>2.5	>4.3	Starts approaching acute impact level (i.e., risk of death) for sensitive species

Table 2: Attribute states for dissolved zinc (toxicity) developed by GWRC.

Value	Ecosystem health		
Freshwater Body Type	Lakes and Rivers		
Attribute	Dissolved Zinc (Toxicity)		
Attribute Unit	µg DZn/L (micrograms of dissolved Zinc per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Median*	95th percentile	
A	≤2.4	≤8	99% species protection level: No observed effect on any species tested
B	>2.4 and ≤8	>8 and ≤15	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>8 and ≤31	>15 and ≤42	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	31	42	
D	>31	>42	Starts approaching acute impact level (i.e., risk of death) for sensitive species

Values for this metal should be expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a standard hardness for ANZECC guidelines of 30 mg CaCO3/L. Criteria values for other hardness may be calculated as per the equation presented in the ANZECC 2000 guidelines.

Table 3: Attribute states for ammonia (toxicity) taken from Appendix 2 of the National Policy Statement for Freshwater Management (2014).

Value	**Ecosystem health**		
Freshwater Body Type	**Lakes and Rivers**		
Attribute	**Ammonia (Toxicity)**		
Attribute Unit	**mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)**		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median*	**Annual Maximum***	
A	**≤ 0.03**	**≤ 0.05**	**99% species protection level. No observed effect on any species.**
B	**>0.03 and ≤ 0.24**	**>0.05 and ≤ 0.40**	**95% species protection level. Starts impacting occasionally on the 5% most sensitive species.**
C	**>0.24 and ≤ 1.30**	**>0.40 and ≤ 2.020**	**80% species protection level. Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).**
National Bottom Line	**1.30**	**2.20**	
D	**>1.30**	**>2.20**	**Starts approaching acute impact level (i.e., risk of death) for sensitive species.**

*Based on pH 8 and temperature of 20°C

Compliance with the numeric attribute states should be undertaken after pH adjustment.

Table 4: Attribute states for Nitrate (toxicity) taken from Appendix 2 of the National Policy Statement for Freshwater Management (2014) (updated September 2017).

Value	**Ecosystem health**		
Freshwater Body Type	**Rivers**		
Attribute	**Nitrate (Toxicity)**		
Attribute Unit	**mg NO_3-N/L (milligrams nitrate-nitrogen per litre)**		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median	**Annual 95th Percentile**	
A	**≤ 1.0**	**≤ 1.5**	**High conservation value system. Unlikely to be effects even on sensitive species.**
B	**>1.0 and ≤ 2.4**	**>1.5 and ≤ 3.5**	**Some growth effect on up to 5% of species.**
C	**>2.4 and ≤ 6.9**	**>3.5 and ≤ 9.8**	**Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.**
National Bottom Line	**6.9**	**9.8**	
D	**>6.9**	**>9.8**	**Impacts on growth of multiple species, and starts approaching acute impact level (i.e., risk of death) for sensitive species at higher concentrations (> 20 mg/l).**

Note: This attribute measures the toxic effect of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent.

Table 5: Attribute states for *E. coli* taken from Appendix 2 of the National Policy Statement for Freshwater Management (2014) (updated September 2017).

Value	Human health for recreation				
Freshwater Body Type	Lakes and rivers				
Attribute	E. coli				
Attribute Unit	*E. coli* / 100ml (number of *E. coli* per hundred millilitres)				
Attribute State	Numeric Attribute State				Narrative Attribute State
	% exceedances over 540 cfu/100ml	% exceedances over 260 cfu/100ml	Median concentration (cfu/100ml)	95th percentile of *E. coli* /100ml	Description of risk of *Campylobacter* infection (based on *E. coli* indicator)
A (blue)	<5%	<20%	<130	<540	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 1% *.
B (green)	5-10%	20-30%	<130	<1000	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 2% *.
C (yellow)	10-20%	20-34%	<130	<1200	For at least half the time, the estimated risk is <1 in 1000 (0.1% risk). The predicted average infection risk is 3% *.
D (orange)	20-30%	>34%	>130	>1200	20-30% of the time the estimated risk is >50 in 1000 (>5% risk). The predicted average infection risk is >3% *.
E (red)	>30%	>50%	>260	>1200	For more than 30% of the time the estimated risk is >50 in 1000 (>5% risk). The predicted average infection risk is >7% *.

* The predicted average infection risk is the overall average infection to swimmers based on a random exposure on a random day, ignoring any possibility of not swimming during high flows or when surveillance advisory is in place (assuming that the *E. coli* concentration follows a lognormal distribution). Actual risk will generally be less if a person does not swim during high flows.

Table 6: Attribute states for Periphyton taken from Appendix 2 of the National Policy Statement for Freshwater Management (2014).

Value	**Ecosystem health**		
Freshwater Body Type	**Rivers**		
Attribute	**Periphyton (Trophic state)**		
Attribute Unit	**mg chl-a/m^2 (milligrams chlorophyll-a per square metre)**		
Attribute State	**Numeric Attribute State (Default Class)**	**Numeric Attribute State (Productive Class[1])**	**Narrative Attribute State**
	Exceeded no more than 8% of samples[2]	**Exceeded no more than 17% of samples[2]**	
A	**≤ 50**	**≤ 50**	**Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat**
B	**>50 and ≤ 120**	**>50 and ≤ 120**	**Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat**
C	**>120 and ≤ 200**	**>120 and ≤ 200**	**Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat**
National Bottom Line	**200**	**200**	
D	**>200**	**>200**	**Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat**

1. Classes are streams and rivers defined according to types in the River Environment Classification (REC). The Productive periphyton class is defined by the combination of REC “Dry” Climate categories (i.e., Warm-Dry (WD) and cool-Dry (CD)) and REC Geology categories that have naturally high levels of nutrient enrichment due to their catchment geology (i.e. Soft-Sedimentary (SS), Volcanic Acidic (VA) and Volcanic Basic (VB)). Therefore, the productive category is defined by the following REC defined types: WD/SS, WD/VB, WD/VA, CD/SS, CD/VB, CD/VA. The default class includes all REC types not in the Productive class.

2. Based on monthly monitoring regime. The minimum record length for grading a site based on periphyton (chl-a) is 3 years.

Table 7: Attribute states for dissolved inorganic nitrogen taken from the 2019 draft NPS-FM

Value	**Ecosystem health**		
Freshwater Body Type	**Rivers**		
Attribute	**Dissolved inorganic nitrogen**		
Attribute Unit	**mg DIN/L (milligrams dissolved inorganic nitrogen per litre)**		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Median*	**95th percentile**	
A	**≤ 0.24**	**≤ 0.56**	**Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DIN enrichment are expected.**
B	**>0.24 and ≤ 0.50**	**>0.56 and ≤ 1.10**	**Ecological communities are slightly impacted by minor DIN elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.**
C	**>0.5 and ≤ 1.0**	**>1.10 and ≤ 2.05**	**Ecological communities are impacted by moderate DIN elevation above natural reference conditions, but sensitive species are not experiencing nitrate toxicity. If other conditions also favour eutrophication, DIN enrichment may cause increased algal and plant growth, loss of sensitive macroinvertebrate & fish taxa, and high rates of respiration and decay.**
Proposed National Bottom Line	**1.0**	**2.05**	
D	**>1.0**	**>2.05**	**Ecological communities impacted by substantial DIN elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DIN enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia and nitrate toxicity are lost**

Groundwater concentrations also need to be managed to ensure resurgence via springs and seepage does not degrade rivers through DIN enrichment.

Numeric attribute state must be derived from the rolling median of monthly monitoring over five years.

Table 8: Attribute states for dissolved reactive phosphorus taken from the 2019 draft NPS-FM

Value	**Ecosystem health**		
Freshwater Body Type	**Rivers**		
Attribute	**Dissolved reactive phosphorus**		
Attribute Unit	**mg DRP/L (milligrams dissolved inorganic nitrogen per litre)**		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Median*	**95th percentile**	
A	**≤ 0.006**	**≤ 0.021**	**Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DRP enrichment are expected.**
B	**>0.006 and ≤ 0.010**	**>0.021 and ≤ 0.030**	**Ecological communities are slightly impacted by minor DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.**
C	**>0.010 and ≤ 0.018**	**>0.030 and ≤ 0.054**	**Ecological communities are impacted by moderate DRP elevation above natural reference conditions, but sensitive species are not experiencing nitrate toxicity. If other conditions also favour eutrophication, DRP enrichment may cause increased algal and plant growth, loss of sensitive macroinvertebrate & fish taxa, and high rates of respiration and decay.**
Proposed National Bottom Line	**0.018**	**0.054**	
D	**>0.018**	**>0.054**	**Ecological communities impacted by substantial DRP elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DIN enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost**

Numeric attribute state must be derived from the rolling median of monthly monitoring over five years.

Table 9: Wellington specific MCI grades developed by Clapcott and Goodwin (2014) applied to the MCI attribute state framework in the 2019 draft NPS-FM

Value	**Ecosystem health**						
Freshwater Body Type	**Rivers**						
Attribute	**Macroinvertebrates**						
Attribute Unit	**Macroinvertebrate Community Index (MCI) score**						
Attribute State	**River Class 1**	**River Class 2**	**River Class 3**	**River Class 4**	**River Class 5**	**River Class 6**	**Narrative Attribute State**
A	**≥130**	**≥130**	**≥130**	**≥130**	**≥120**	**≥120**	**Macroinvertebrate community, indicative of pristine conditions with almost no organic pollution or nutrient enrichment**
B	**≥120**	**≥105**	**≥105**	**≥110**	**≥100**	**≥100**	**Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution/nutrient enrichment.**
C	**≥110**	**≥80**	**≥80**	**≥90**	**≥80**	**≥80**	**Macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment.**
Proposed bottom Line	**110**	**80**	**80**	**90**	**80**	**80**	
D	**<110**	**<80**	**<80**	**<90**	**<80**	**<80**	**Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment.**

MCI scores to be determined using annual samples taken between December and March (inclusive) with either fixed counts with at least 200 individuals, or full counts, and with current state calculated as the five-year rolling average score. All sites in Deposited Sediment Classes 1, 5, and 11 per Table 18 are to use soft-sediment sensitivity scores and taxonomic resolution as defined in Table A1.1 in Clapcott *et al.* 2017 Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Cawthron: Nelson, New Zealand.

MCI to be assessed using the method defined in Stark JD, Maxted, JR 2007 A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166. 58, except for sites in deposited sediment classes 1, 5 and 11 per Table 18, which require use of the soft-sediment sensitivity scores and taxonomic resolution defined in Table A1.1 in Clapcott *et al.* 2017.

Table 10: Attribute states for the Fish index of Biotic Integrity taken from the 2019 draft NPS-FM

Value	**Ecosystem health**	
Freshwater Body Type	**Rivers**	
Attribute	**Fish (rivers)**	
Attribute Unit	**Fish Index of Biotic Integrity (F-IBI)**	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
A	**≥34**	**High integrity of fish community. Habitat and migratory access have minimal degradation.**
B	**<34 and ≥28**	**Moderate integrity of fish community. Habitat and/or migratory access are reduced and show some signs of stress.**
C	**<28 and ≥18**	**Low integrity of fish community. Habitat and/or migratory access is considerably impairing and stressing the community**
Proposed National Bottom Line	**18**	
D	**<18**	**Severe loss of fish community integrity. There is substantial loss of habitat and/or migratory access, causing a high level of stress on the community.**

Sampling is to occur at least annually between December and March (inclusive) following the protocols for at least one of the backpack electrofishing method, spotlighting method, or trapping method in Joy M, David B, and Lake M. 2013. New Zealand Freshwater Fish Sampling Protocols (Part 1): Wadeable rivers and streams. Palmerston North, New Zealand: Massey University.

The F-IBI score is to be calculated using the general method defined by Joy, M. K., & Death, R. G. (2004). Application of the Index of Biotic Integrity Methodology to New Zealand Freshwater Fish Communities. Environmental Management, 34(3), 415-428. but will exclude salmonids. *Based on pH 8 and temperature of $20^{o}C$

Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Supplement 1 – Expert Panel Outputs

24th September 2020

Report Prepared for Greater Wellington Regional Council

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Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Supplement 1 – Expert Panel Outputs

24th September 2020

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Quality Assurance			
Role	Responsibility	Date	Signature
Prepared by	Michael Greer	24/09/2020	
Approved for issue by:			
Status	Final		

SUPPLEMENT 1 TABLE CONTENTS

Table 1: Expert Panel assessment criteria

Change	Narrative
-3 (large -)	A significant degradation in concentration/state. A two attribute state decline likely (where applicable).
-2 (moderate -)	A noticeable degradation in concentration/state. A one attribute state decline likely (where applicable).
-1 (small -)	A detectable degradation in concentration/state. However, a decline in attribute state is unlikely (where applicable).
0 (no/negligible)	Changes in concentration/state non-existent or unlikely to be detectable.
+1 (small +)	A detectable improvement in concentration/state. However, an improvement in attribute state is unlikely (where applicable).
+2 (moderate +)	A noticeable improvement in concentration/state. A one attribute state improvement likely (where applicable).
+3 (large +)	A significant improvement in concentration/state. A two attribute state improvement likely (where applicable).
Effect	**Narrative**
-3 (strong -)	Changes in attribute are likely to result in a significant degradation of one or more higher-order attributes.
-2 (moderate -)	Changes in attribute are likely to result in a noticeable degradation of one or more higher-order attributes.
-1 (weak -)	Changes in attribute are likely to result in a small but detectable degradation of one or more higher-order attributes.
0 (no/negligible)	Changes in attribute unlikely to have a detectable effect on higher-order attributes.
+1 (weak +)	Changes in attribute are likely to result in a small but detectable improvement for one or more higher-order attributes.
+2 (moderate +)	Changes in attribute are likely to result in a noticeable improvement for one or more higher-order attributes.
+3 (strong +)	Changes in attribute are likely to result in a significant improvement for one or more higher-order attributes.
Confidence	**Reasons**
0 (not assessed)	• Not assessed as outside of scope or area of expertise.
1 (low)	• Data on current state of attribute not available for most of assessment unit and/or data exist but are of poor quality or conflicting. • Limited research available on the response of attributes to the changes applied in the scenario. • Relationships between attribute and key drivers not well understood or predictable (e.g. deposited sediment and sediment load).
2 (moderate)	• Data on current state of attribute available but have some limitations (i.e. poor spatial resolution) or basic modelling data available. • Effects of scenario changes on attributes partially transferable from proxy catchments or other research. • Relationships between attribute and key drivers well documented but not predictable (e.g. invertebrates).
3 (high)	• Data on current state of attribute available for much of the assessment unit or high-resolution modelling data available. • Effects of scenario changes on attributes reliably transferable from proxy catchments or other research. • Relationships between attribute and key drivers well understood and predictable (e.g. metal toxicity).

Table 2: BAU expert panel assessment for Assessment unit 1 – Headwater urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	-1	-1	2	Change:	Significant proportional increases in urban land cover are predicted under this scenario in both the Karori and Wainuiomata catchments and copper and zinc loads are likely to increase as a result. However, on an EPAU scale changes in concentration are likely to be small as urban development in both catchments is located near the top of relatively (in relation to urban landcover) large catchments with significant downstream dilution potential. This is especially true in the Wainuiomata River, where urban run-off is diluted by flows from the Wainuiomata Water Collection Area immediately downstream of the township. It is also important to note that copper and zinc concentrations in the Karori Stream as it flows through the urban area are in the C/D attribute states, limiting the potential for further degradation. *Note: While only small changes are expected on an EPAU scale, there is potential for localised moderate increases in dissolved metal concentrations in the streams draining areas with additional urban development . This applies to zinc as well as copper since an increase in paved surface area is likely to offset any potential reduction in roof yields.*
					Effect:	As only small increases in copper and zinc concentration are expected at the EPAU scale, the overall effects on macroinvertebrates and fish are likely to be weak. *Note: There is potential for localised moderate adverse effects in the streams draining new areas of urban development.*
					Confidence:	Despite the limited available current state data and the lack of transferable proxy catchment data, the panel is moderately confident that detectable increases in dissolved metal concentrations will occur as a result of new urban development.
	Nitrogen 1	0	0	2	Change:	Rural land-use will not change, and the condition of wastewater infrastructure will remain constant. Accordingly, nitrogen loads from diffuse and point source nitrogen discharges will be unchanged and ammonia and nitrate concentrations will continue to reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (urban or rural) under this scenario means the panel are confident that ammonia and nitrate concentrations will not change from current. Nevertheless, proxy catchment data are not transferable and state data comes largely from national scale models.
	Nitrogen 2	0	0	2	Change:	Rural land-use will not change under this scenario and the condition of wastewater infrastructure will remain constant. Accordingly, nitrogen loads from diffuse and point source

Tier	Attribute	Change	Effect	Confidence	Narrative	
						nitrogen discharges will be unchanged and DIN concentrations will continue to reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (urban or rural) under this scenario means the panel are confident that DIN concentrations will not change from current. Nevertheless, proxy catchment data are not transferable and state data comes largely from national scale models.
	Phosphorus	0	0	1	Change:	Rural land-use will not change, and the condition of wastewater infrastructure will remain constant. Accordingly, DRP should be unchanged.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (both urban and rural) under this scenario means the panel are confident that DRP concentrations will not change from current due to human activities. Nevertheless, there is considerable uncertainty around this assessment, as the impact of climate change on sediment derived phosphorus is difficult to predict. Furthermore, proxy catchment data are not transferable and state data comes largely from national scale models.
	Sediment input	-1	0	2	Change:	Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slope wash and slips), although regeneration in the lower catchment should offset these effects to a degree. Note: *If the rate of urban development increases there is also potential for moderate increases in the streams adjacent to new housing areas due to construction phase stormwater discharges.*
					Effect:	While increased sediment input could increase the risk of adverse effects on periphyton growth (via phosphorus), macroinvertebrates and fish (through deposition), and recreational value (through deposition and clarity), the panel agrees that on an EPAU scale these effects are unlikely to be detectable. There is, however, potential for localised adverse effects in streams adjacent to new construction sites.
					Confidence:	This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". Nevertheless, the panel

Tier	Attribute	Change	Effect	Confidence	Narrative	
						are confident that climate change will increase sediment input to some degree due to increased bank erosion, and that increases will not be significant due to regeneration in the lower catchment of both the Karori Stream and the Wainuiomata River.
	Faecal contamination	0	0	3	<u>Change:</u>	Rural land-use, riparian management and the condition of wastewater infrastructure are assumed to remain unchanged. Accordingly, *E. coli* concentrations are unlikely to shift from current state.
					<u>Effect:</u>	As no change is expected there is not expected to be an effect.
					<u>Confidence:</u>	The lack of any rural intensification or mitigation (rural or urban) under this scenario means the panel are confident concentrations will not change from current due to human activities. State data comes from two GWRC monitoring sites, approximately five territorial authority monitoring sites and national scale models. Proxy catchment data are not transferable
	Flow	-2	-2	1	<u>Change:</u>	Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, climate change is expected to reduce MALF by between 10% and 20% in the Wainuiomata catchment. *<u>Notes:</u>* • *Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".* • *The increase in impervious surface area is considered too small in relation to catchment size to have a noticeable effect on flow at the EPAU scale.*
					<u>Effect:</u>	Reductions in MALF in the Wainuiomata catchment will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods.
					<u>Confidence:</u>	As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"

Tier	Attribute	Change	Effect	Confidence	Narrative	
2	Plant growth	-1	-1	1	Change:	The panel agrees that the predicted reduction in MALF will increase the risk of periphyton growth, but an attribute state change is unlikely. *Notes:* • *This assessment only applies to the Wainuiomata River catchment, no change is expected in the Karori Stream catchment as a reduction in MALF is not expected there.* • *All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*
					Effect:	Panel members generally agree that as the lower Wainuiomata River is currently impacted by nuisance periphyton growth (supported by Snelder *et al.* (2019)), the potential for further effects is limited.
					Confidence:	This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships.
3	Macroinvertebrate community health	-1	-1	2	Change:	Macroinvertebrate communities in streams in the Wainuiomata catchment are likely to be impacted by increased temperature, periphyton growth, sediment input and flood disturbance. In the Karori catchments macroinvertebrate communities are likely to be impacted by an increase in sediment input and flood magnitude/frequency. *Notes:* • *There is potential for localised moderate reductions in macroinvertebrate community health in streams adjacent to new urban developments due to increased toxicity risk and sediment effects.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable degradation in macroinvertebrate community health means a direct degradation in ecosystem health is likely.

<table>
<tr><th>Tier</th><th>Attribute</th><th>Change</th><th>Effect</th><th>Confidence</th><th colspan="2">Narrative</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td><u>Confidence:</u></td><td>This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the complex relationships between flow, sediment input, plant growth and macroinvertebrate community health. Nevertheless, the panel are confident that any detectable change in macroinvertebrate community health will be in a negative direction.</td></tr>
<tr><td rowspan="3"></td><td rowspan="3">Fish diversity</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">3</td><td><u>Change:</u></td><td>While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.</td></tr>
<tr><td><u>Effect:</u></td><td>As no change is expected there is not expected to be an effect.</td></tr>
<tr><td><u>Confidence:</u></td><td>The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.</td></tr>
<tr><td>4</td><td>Ecosystem health</td><td>-1</td><td>N/A</td><td>1</td><td><u>Change:</u></td><td>The panel considers that the following components of ecosystem health are likely to change under this scenario:
• Habitat – Likely to degrade based on sediment input;
• Water quality – Likely to degrade based on increases in stormwater contaminants;
• Water quantity – Likely to degrade based on climate change predictions; and
• Aquatic biota – Likely to degrade based on macroinvertebrates and their suitability/availability to fish as a food source.
Overall, the panel agrees that a small detectable degradation is likely at the EPAU scale

<u>Notes:</u>
• There is potential for localised moderate reductions in ecosystem health in streams adjacent to new urban developments due to increased toxicity risk (water quality), sediment effects (habitat), hydrological changes (water quantity) and macroinvertebrate community health (aquatic biota).
• Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.
• The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.</td></tr>
</table>

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Effect:	N/A
					Confidence:	Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	-1	N/A	1	Change:	The predicted increase in sediment input combined with increased periphyton biomass and reduced summer low flows (Wainuiomata catchment only) may impact recreational users' enjoyment of the rivers and streams in this EPAU. However, as many of the reaches in this EPAU are already unsuitable for contact recreation due to elevated *E. coli* levels, which is not expected to change, the overall recreational value of most rivers and streams is unlikely to shift substantially from current.
					Effect:	N/A
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the difficulty in predicting how sediment transport and periphyton growth will respond to changes in flow.

Table 3: BAU expert panel assessment for Assessment unit 2 – Hutt main stem

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	-1	0	2	Change:	Urban development is expected to increase in the Hutt River catchment under this scenario, thus it is likely that copper and zinc concentrations will increase. However, the relatively small amount of existing urban landcover (~6% of catchment area) in the catchment is not having a marked effect on current dissolved metal concentrations, and it is unlikely that the small (~10%) predicted increase in impervious surface area under this scenario will result in a change in attribute state.
					Effect:	The panel considers it unlikely that copper or zinc concentrations will change to the extent that the risk of toxicity effects will be increased.
					Confidence:	While the panel is confident that copper and zinc concentrations will increase, they are not confident that this increase will be detectable. Furthermore, while monitoring data are available for two sites, reach scale modelling of state has not been conducted and proxy catchment data are not transferable.
	Nitrogen 1	0	0	2	Change:	Under this scenario, rural land-use will not change significantly, and the condition of wastewater infrastructure will remain constant. It is also assumed that the required stock exclusion in Assessment Unit 3 will not be enough to affect nitrogen loads reaching surface water. Accordingly diffuse and point source nitrogen discharges to the Hutt River will be unchanged and ammonia and nitrate concentrations will reflect current state. Mr Norton also notes the potential contribution of closed landfills to N-load, highlighting another potential source of N which will remain constant.
					Effect:	As no change is expected, there is not expected to be an effect.
					Confidence:	The lack of any rural intensification or effective mitigation (rural or urban) under this scenario means the panel are confident that ammonia and nitrate concentrations will not change significantly from current. Nevertheless, there is uncertainty around what the effects of converting the land to the east of the racecourse will be on diffuse nitrogen loads to the river. Proxy catchment data are not transferable and state data comes from three sites and national scale models.
	Nitrogen 2	0	0	2	Change:	Rural land-use will not change, and the condition of wastewater infrastructure will remain constant. Accordingly, nitrogen loads from diffuse and point source nitrogen discharges within this EPAU will not change. Furthermore, it is assumed that the required stock exclusion in Assessment Unit 3 will not be enough to affect nitrogen loads reaching surface water. Based on this, ammonia and nitrate concentrations will continue to reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Confidence:	The lack of any rural intensification or effective mitigation (rural or urban) under this scenario means the panel are confident that DIN concentrations will not change significantly from current. Nevertheless, there is uncertainty around what the effects of converting the land to the east of the racecourse will be on diffuse nitrogen loads to the river. Proxy catchment data are not transferable and state data comes from three sites and national scale models.
	Phosphorus	0	0	1	Change:	The Mangaroa River is a major contributor of DRP to the Hutt River (25% of load at Te Marua) and in isolation decreases in load from that catchment associated with stock exclusion may be detectable in the Hutt River. However, these decreases are likely to be offset by the increase in sediment bound P from catchments where climate change is predicted to increase bank and slope erosion. Furthermore, as the condition of wastewater infrastructure is assumed to remain constant there is no reason to expect DRP from urban sources to change significantly in this EPAU.
					Effect:	As no change is expected, there is not expected to be an effect.
					Confidence:	The panels confidence is low due to difficulties in predicting how stock exclusion in the Mangaroa will affect DRP load in the Hutt River, uncertainty associated with hydrological modelling from downscaled climate change models and a limited understanding of how climate change will affect the delivery of sediment bound P from other catchments. Proxy catchment modelling is also not transferable.
	Sediment input	0	0	1	Change:	Reductions in sediment load due to stock exclusion in Mangaroa catchment will likely be offset by the increase in sediment load from catchments where climate change is predicted to increase bank and slope erosion. *Note: If the rate of urban development increases there is also potential for moderate increases in sediment input to streams adjacent to new housing areas due to construction phase stormwater discharges.*
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panels confidence is low due to difficulties in predicting how stock exclusion in the Mangaroa will affect sediment load in the Hutt River, uncertainty associated with hydrological modelling from downscaled climate change models and a limited understanding of how climate change will affect the delivery of sediment from other catchments. While the panel is confident that some change is possible, they are not confident of its direction or magnitude, and acknowledge that it may vary spatially.

Tier	Attribute	Change	Effect	Confidence	Narrative
	Faecal contamination	0	0	2	<u>Change:</u> Rural land-use and the condition of wastewater infrastructure are assumed to remain generally unchanged, and it is unlikely that stock exclusion in the Mangaroa catchment will have an effect on attribute state in the Hutt Mainstem (see assessment for Mangaroa and Pakuratahi EPAU for additional information on *E. coli* sources). Accordingly, *E. coli* concentrations are unlikely to deviate from current state. *<u>Note:</u> There may be a minimal increase in inputs from dog and avian sources associated with an increase in impervious surface cover in urban areas (Dr Heath).* <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> There is monitoring data from three sites to support the results of the national scale state models and the lack of effective mitigation in urban or rural landcover means the panel is confident concentrations will not change from current due to human activities. However, proxy catchment modelling is not transferable.
	Flow	-1	-1	1	<u>Change:</u> Under this scenario mean annual flood is not expected to increase due to climate change but MALF is expected to reduce by between 10% and 20% under some emissions pathways. <u>Effect:</u> Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. *<u>Note:</u> The severity of these effects may be compounded by water allocation.* <u>Confidence:</u> This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	-1	-1	1	<u>Change:</u> The panel agrees that the predicted reduction in MALF will increase the risk of periphyton growth, but an attribute state change is unlikely. *<u>Note:</u> All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in*

Tier	Attribute	Change	Effect	Confidence	Narrative
					low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases. <u>Effect:</u> Panel members agree that most reaches in this EPAU are likely to be currently impacted by nuisance periphyton growth (supported by Snelder *et al.* (2019)). Accordingly, the potential for further effects is limited. <u>Confidence:</u> This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships.
3	Macroinvertebrate community health	-1	-1	1	<u>Change:</u> Macroinvertebrate communities are likely to be detrimentally impacted by increased dissolved metal concentrations, temperature and periphyton growth. However, does not consider an attribute state change in MCI likely: <u>Note:</u> *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.* <u>Effect:</u> Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable degradation in macroinvertebrate community health means a direct degradation in ecosystem health is likely <u>Confidence:</u> This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the complex relationships between flow, temperature, plant growth and macroinvertebrate community health. Periphyton growth and temperature are already likely to be having an adverse effect on macroinvertebrates in the Hutt River, and there is uncertainty around whether an increase in these factors due to climate change would have a significant effect on MCI; especially considering that other major drivers of community health (e.g. flood protection) will remain unchanged. The panel also notes that MCI may not be the most sensitive index to flow stress and may hide some of the impacts of climate change.
	Fish diversity	0	0	3	<u>Change:</u> While the predicted changes in dissolved metal concentrations, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Effect:</u> As no change is expected there is not expected to be an effect.
					<u>Confidence:</u> The panel are highly confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
	Ecosystem health	-1	N/A	1	<u>Change:</u> The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Unlikely to change based on sediment input; • Water quality – Likely to degrade based on increases in stormwater contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to degrade based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel considers that a small detectable degradation is likely at the EPAU scale *<u>Notes:</u>* • *While they accept the panels assessment, Dr Ausseil and Dr Greer question whether any degradation in ecosystem health will be detectable given that only small changes in any flow, periphyton biomass, contaminant concentrations and macroinvertebrate community health are expected. Dr Greer also notes that some potential drivers of ecosystem health, namely water abstraction and river engineering works, will not change.* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					<u>Effect:</u> N/A
					<u>Confidence:</u> Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities. Furthermore, while the panel is confident that any change will be negative, Dr Greer and Dr Ausseil are not convinced that this degradation will be detectable.
	Overall suitability for recreation	-1	N/A	1	<u>Change:</u> Higher periphyton biomass and reduced summer low flows may impact recreational users, enjoyment of the Hutt River under this scenario. However, as *E. coli* is not expected to change, a moderate degradation in recreational value is unlikely. *<u>Notes:</u>*

Tier	Attribute	Change	Effect	Confidence	Narrative	
						• *If the rate of urban development increases visual clarity may be reduced more often due to construction phase stormwater discharges (Dr Ausseil).* • *The Hutt River will continue to be impacted by occasional cyanobacteria blooms under this scenario.*
					Effect:	N/A
					Confidence:	This assessment is primarily based on the effects of climate change on flow, and there a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the difficulty in predicting how sediment transport and periphyton growth will respond to changes in flow.

Table 4: BAU expert panel assessment for Assessment unit 3 – Mangaroa/Pakuratahi Valleys

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	0	0	3	Change:	Under this scenario it is assumed that impervious surface cover will not change and that there will be no additional treatment of stormwater within the limited existing urban landcover. Thus, there is no reason to expect that dissolved metal concentrations will change from current. This conflicts with the proxy catchment results which are not transferable due to the presence of large roading projects in the proxy catchment (Horokiri). *Note: The Te Marua area was not considered as part of this assessment as it influences the Hutt mainstem more than the major surface water bodies in the EPAU.*
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited and proxy catchment data are not transferable, the lack of any urban intensification or mitigation under this scenario means the panel are highly confident that copper and zinc concentrations will not change from current.
	Nitrogen 1	0	0	2	Change:	Rural land-use will not change, and the condition of the limited wastewater infrastructure will remain constant. Furthermore, the required stock exclusion (assumed one metre setback) will not be enough to affect nitrogen loads reaching surface water. As diffuse and point source nitrogen discharges will be unchanged, ammonia and nitrate concentrations will reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the lack of any intensification or effective mitigation under this scenario means that the panel are confident that ammonia and nitrate concentrations will not change significantly from current and are highly confident that they will not be degraded. Nevertheless, the panel is split on whether stock exclusion will reduce nitrogen concentrations, with Dr Heath and Dr Clapcott noting a slight improvement. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data are partially transferable.
	Nitrogen 2	0	0	2	Change:	Rural land-use will not change, and the condition of the limited wastewater infrastructure will remain constant. It is also assumed that the required stock exclusion (assumed one metre setback) will not be enough to affect nitrogen loads reaching surface water. As diffuse and point source nitrogen discharges will be unchanged, DIN concentrations will reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the lack of any intensification or effective mitigation under this scenario means that the panel are confident that DIN concentrations will not change significantly from current

Tier	Attribute	Change	Effect	Confidence	Narrative
					and are highly confident that they will not increase. Nevertheless, the panel is split on whether stock exclusion will reduce nitrogen concentrations, with Dr Heath and Dr Clapcott noting a slight improvement. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is partially transferable.
	Phosphorus	+1	0	2	<u>Change:</u> Stock exclusion should reduce the amount of sediment bound phosphorus entering waterways via bank erosion. However, setbacks will be too narrow to strip phosphorus from overland flow, and critical source areas will not be managed under this scenario. Consequently, moderate or significant reductions in DRP are not expected. Increased sediment input associated with climate change may also partially offset the benefits of stock exclusion. <u>Effect:</u> Any reduction in DRP concentrations associated with stock exclusion is unlikely to be enough to have a noticeable effect on periphyton growth. This is supported by periphyton nutrient criteria modelling (Snelder *et al.*, 2019) which suggests that a 50% reduction in DRP would be needed to improve periphyton biomass in the Mangaroa River by one attribute state. *<u>Note:</u> A reduction in DRP concentrations may result in an increased risk of cyanobacteria blooms in the lower Pakuratahi (Dr Heath). However, this is by no means certain.* <u>Confidence:</u> The panel is confident that stock exclusion will reduce phosphorus inputs by reducing bank erosion and agree that a small improvement is the most likely outcome. However, there is some uncertainty around the degree of change, as the relative contribution of bank erosion and overland flow to phosphorus load is not known. Uncertainty also exists around the benefits of stock exclusion in relation to the effects of climate change on sediment bound phosphorus. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data are partially transferable.
	Sediment input	+1	+1	1	<u>Change:</u> Stock exclusion will reduce the amount of sediment entering waterways via bank erosion. However, the assumed setbacks are too narrow to strip sediment from overland flow, and critical source areas will not be managed under this scenario. Consequently, moderate or significant reductions in sediment input are not expected. Increased sediment input associated with climate change may also partially also offset the benefits of stock exclusion. <u>Effect:</u> Both deposited sediment and turbidity are high in many of the reaches in this EPAU and reduced sediment input may result in an improvement in these measures and benefits to macroinvertebrate and fish communities. However, as only small changes are expected, moderate or significant positive effects are unlikely.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panel is confident that stock exclusion will reduce sediment inputs by reducing bank erosion. However, while the panel is confident in the direction of change, there is uncertainty about the magnitude, with Dr Clapcott noting a +2. There is also uncertainty about whether the benefits of stock exclusion will be offset by the effects of climate change.
	Faecal contamination	+1	+1	2	Change: The incidence of stock defaecating directly into surface water will reduce under this scenario and this will reduce *E. coli* concentrations during dry weather. However, many of the reaches in this EPAU are in the D attribute state based on 95th %ile concentrations, indicating they are impacted by *E. coli* during rainfall events. As stock exclusion alone will have a minimal effect on *E. coli* entering streams via surface run-off, an attribute state improvement is unlikely for most reaches. Effect: While it is unlikely that streams currently considered unswimmable will become swimmable under this scenario, the overall health risks to recreational users will still be slightly reduced. Confidence: The panel is confident that *E. coli* concentrations will decrease, and that stock exclusion alone will not be enough to result in an attribute state improvement. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data are partially transferable.
	Flow	-2	-2	1	Change: Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change and MALF is expected to reduce by between 10% and 20% *Note: Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".* Effect: Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. Confidence: This assessment is based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That

Tier	Attribute	Change	Effect	Confidence	Narrative
					memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	-1	-1	1	Change: The panel agrees that the reduction in MALF will increase the risk of periphyton growth, but an attribute state change is unlikely. *Note: All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.* Effect: Panel members agree that as most reaches in this EPAU are likely to be currently impacted by nuisance periphyton growth (based on nutrient criteria modelling (Snelder *et al.*,2019)), the potential for further effects is limited. Confidence: This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships.
3	Macroinvertebrate community health	0	0	1	Change: While MCI in smaller streams may be improved due to a reduction in direct habitat disturbance by stock and a decrease in sediment input, the macroinvertebrate communities in larger reaches will be detrimentally impacted by increased temperature, periphyton growth and flood disturbance due to changes in flow predicted by climate change models. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.* Effect: As no change is expected there is not expected to be an effect. Confidence: Agreement was not reached for this attribute, with the panel's individual assessments ranging from +1 to -2. The final assessment made by the panel was decided by taking the average score rather than an agreed score. This reflects the complexity of the relationships between flow, sediment input, plant growth, habitat and macroinvertebrate community health.

Tier	Attribute	Change	Effect	Confidence	Narrative	
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow and plant growth may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	0	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input and reduced stock disturbance; • Water quality – Likely to improve slightly based on reductions in phosphorus; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Unlikely to change based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel considers that ecosystem health is unlikely to change at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					Effect:	N/A
					Confidence:	Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+1	N/A	1	Change:	The predicted reduction in *E. coli* will reduce the health risk to recreational users, and the greater exclusion of stock from waterways may improve the amenity and aesthetic experience for recreational users. However, sites that are currently unswimmable due to faecal contamination are likely to remain so. There is also potential for the benefits of reduced *E. coli* and increased stock exclusion to be offset somewhat by the effects of climate change (increased sediment input, higher periphyton biomass and reduced summer low flows),
					Effect:	N/A

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: There is significant uncertainty around the degree to which reductions in sediment input and *E. coli* associated with reduced stock access will be offset by the effects of climate change on sediment input, plant growth and summer low flows. This is a result of the high overall uncertainty associated with hydrological modelling and the difficulty in predicting how periphyton will respond to changes in flow.

Table 5: BAU expert panel assessment for Assessment unit 4 – Mixed rural

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	0	0	3	Change:	Under this scenario it is assumed that impervious surface cover will not change and there will be no additional treatment of stormwater within the limited existing urban landcover. Thus, there is no reason to expect that dissolved metal concentrations will change from current. This conflicts with the proxy catchment results which are not transferable due to the presence of large roading projects in the Horokiri proxy.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited and proxy catchment data are not transferable, the lack of any urban intensification or mitigation under this scenario means that the panel are highly confident that copper and zinc concentrations will not change from current.
	Nitrogen 1	0	0	3	Change:	Rural land-use practices will not shift under this scenario and the condition of the limited wastewater infrastructure will remain constant. As diffuse and point source nitrogen discharges will be unchanged, nitrate and ammonia concentrations will reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the lack of any intensification or mitigation under this scenario means the panel are highly confident that ammonia and nitrate concentrations will not change from current. Proxy catchment data are transferable.
	Nitrogen 2	0	0	3	Change:	Rural land-use practices will not shift, and the condition of the limited wastewater infrastructure will remain constant. Accordingly, DIN concentrations will remain at current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the lack of any intensification or mitigation under this scenario means that the panel are highly confident that DIN concentrations will not change from current. Proxy catchment data are transferable.
	Phosphorus	-1	0	2	Change:	Rural land-use, riparian management and the condition of the limited wastewater infrastructure are assumed to remain unchanged. Accordingly, DRP concentrations are unlikely to shift from current state as a direct result of human activities. However, an increase in flood frequency/magnitude caused by climate change may increase sediment input to the extent that there are small associated increases in DRP concentrations.
					Effect:	Small increases in DRP are unlikely to result in an increased risk in periphyton growth as already high concentrations are unlikely to be limiting growth.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: While state data are limited and proxy catchment data are not transferable, the lack of any intensification or mitigation under this scenario means that the panel are confident that DRP concentrations will not change as a direct result of human activities. However, there is some uncertainty about what the effects of climate change will be on flow, let alone sediment input and phosphorus.
	Sediment input	-1	-1	1	Change: The increased flood frequency/magnitude predicted by climate change models (especially in the Makara catchment) means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). Effect: Increased sediment input heightens the risk of adverse effects on periphyton growth (via phosphorus), macroinvertebrates and fish (through deposition) and recreational value (through deposition and clarity). Confidence: This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". *Note: Dr Ausseil has moderate confidence (2) in this assessment as, in his opinion, the risk of increased erosion due to climate change is high in the Makara catchment. Nevertheless, he accepts the panels final assessment.*
	Faecal contamination	0	0	2	Change: As rural land-use, riparian management and the condition of the limited wastewater infrastructure will not change, *E. coli* concentrations will reflect current state. Effect: As no change is expected there is not expected to be an effect. Confidence: While state data are limited, the lack of any intensification or mitigation under this scenario means that the panel are confident concentrations will not change from current due to human activities. However, there is some uncertainty about the sources of *E. coli* in this catchment, with Mr Norton noting that, given the low stocking rates in the area, there is potential for birds and wild animals to contribute to elevated concentrations in the Makara catchment,. Proxy catchment data are partially transferable.
	Flow	-2	-2	1	Change: Under this scenario mean annual flood is expected to increase significantly throughout this EPAU, with the greatest increases expected in the western catchments. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Note: Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".
					Effect:	Reductions in MALF in the catchments on the true right of the Hutt River will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods.
					Confidence:	As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"
2	Plant growth	-1	-1	1	Change:	All panel members agreed that the predicted reduction in MALF will increase the risk of periphyton growth. However, while everyone agreed that increased temperature would be a factor, the panel was split on the importance/likelihood of an increase in accrual period. Specifically, Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual. *Notes:* • *This assessment only applies in the catchments on the true right side of the Hutt River, no change (0) is expected in the western catchments (including Makara Stream).* • *All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*
					Effect:	Panel members generally agree that the catchments to the right of the Hutt are likely to be currently impacted by nuisance periphyton growth (supported by nutrient criteria modelling (Snelder *et al.*, 2019). Accordingly, the potential for further effects is limited.
					Confidence:	This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships.
3	Macroinvertebrate community health	-1	-1	1	Change:	In the catchments on the true right of the Hutt River macroinvertebrate communities are likely to be slightly affected by increased temperature, periphyton growth, sediment input and flood disturbance. In the western catchments macroinvertebrate communities are likely to be impacted by an increase in flood magnitude/frequency only. *Notes:* • *The effect of the increase in flooding on MCI in the western catchments is potentially moderate, and while the panel agreed that a -1 represents the most likely change at an EPAU scale, they note that an attribute state change is possible in those catchments.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable degradation in macroinvertebrate community health means a direct degradation in ecosystem health is likely.
					Confidence:	This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by complex relationships between flow, sediment input, plant growth and macroinvertebrate community health.
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel are highly confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	-1	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to degrade based on sediment input flow; • Water quality – Likely to slightly degrade based on increases in phosphorus and sediment; • Water quantity – Likely to degrade based on climate change predictions; and

Tier	Attribute	Change	Effect	Confidence	Narrative
					• Aquatic biota – Likely to degrade based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a small detectable degradation is likely at the EPAU scale *Notes:* • *There is potential for localised moderate reductions in ecosystem health in streams where Mean Annual Flood is expected to increase significantly (Dr (Ausseil).* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence in the magnitude of change is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities. However, the panel is highly confident that the direction of change will be negative.
	Overall suitability for recreation	-1	N/A	1	Change: The predicted increase in sediment input combined with a higher periphyton biomass and reduced summer low flows (Hutt catchments only) may impact recreational users' enjoyment of the rivers and streams in this EPAU. However, as many of the reaches in this EPAU are already unsuitable for contact recreation due to elevated *E. coli* levels, and faecal contamination is not predicted to change under this scenario, the overall recreational value of most rivers and streams is unlikely to be noticeably impacted. Effect: N/A Confidence: This assessment is primarily based on the effects of climate change on flow, and there a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the difficulty in predicting how sediment transport and periphyton growth will respond to changes in flow.

Table 6: BAU expert panel assessment for Assessment unit 5 – Groundwater/ surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	-1	-1	2	Change:	Impervious surface cover is expected to increase by ~10% in both the Hutt River valley floor and Waiwhetu Stream sub-catchments, which will result in detectable increases copper and zinc concentrations. However, as impervious surface cover is already high in both sub catchments (>25%) and the available monitoring data indicates copper and zinc concentrations in the Waiwhetu are elevated (attribute state C for copper and D for zinc), the potential for further degradation is limited and a full attribute state change is unlikely in most reaches. *Notes:* • *While only small changes are expected on an EPAU scale, there is potential for localised moderate increases in the streams draining new areas of urban development. This applies to zinc as well as copper as an increase in paved surface area is likely to offset any potential reduction in roof yields.* • *Climate change may compound the effects of the additional impervious surface cover on peak metal concentrations and increase the risk of acute toxicity effects due to greater accumulation of metals on impervious surfaces during longer (compared to current) periods of dry weather and greater mobilisation of those metals during higher (compared to current) intensity rainfall (Mr Farrant).*
					Effect:	As only small increases in copper and zinc concentrations are expected at the EPAU scale, the overall effect on macroinvertebrates and fish is likely to be weak. Note: *There is potential for localised moderate adverse effects in the streams draining new areas of urban development.*
					Confidence:	Despite the limited available state data, the panel is moderately confident that detectable increases in dissolved metal concentrations will occur as a result of new urban development. Proxy catchment modelling data are partially transferable.
	Nitrogen 1	0	0	2	Change:	Rural land-use practices will not shift significantly, and the condition of wastewater infrastructure will remain constant. As such, nitrogen loads from diffuse and point source nitrogen discharges will be unchanged and ammonia and nitrate concentrations will reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (urban or rural) under this scenario means the panel are confident that ammonia and nitrate concentrations will not change from current. Nevertheless, state data comes largely from national scale models and there is uncertainty around what the effects of converting the land to the east of the racecourse will be on diffuse nitrogen loads to groundwater fed streams. Proxy catchment modelling results are partially transferable.

Tier	Attribute	Change	Effect	Confidence	Narrative	
	Nitrogen 2	0	0	2	Change:	Rural land-use will not change under this scenario and the condition of wastewater infrastructure will remain constant. Accordingly, nitrogen loads from diffuse and point source nitrogen discharges will be unchanged and DIN concentrations will continue to reflect current state.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (urban or rural) under this scenario means the panel are confident that DIN concentrations will not change from current. Nevertheless, proxy catchment data are not transferable and state data comes largely from national scale models.
	Phosphorus	0	0	2	Change:	Rural land-use will not change, and the condition of wastewater infrastructure will remain constant. Accordingly, DRP should be unchanged. While a small amount of stock exclusion is predicted in some sub-catchments this is unlikely to have an effect on DRP due to the low stock numbers in those areas.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of agricultural intensification or any sort of mitigation (urban or rural) under this scenario means the panel are confident that DRP concentrations will not change from current due to human activities, despite the fact that state data comes largely from national scale models. However, there is some uncertainty around the impact of climate change on sediment derived phosphorus. Proxy catchment data are partially transferable.
	Sediment input	-1	-1	2	Change:	The increased flood frequency/magnitude predicted by climate change models means there is an increased risk of sediment input from both bank erosion and slope erosion (e.g.. slips). While a small amount of stock exclusion is predicted in some sub-catchments this is unlikely to have an effect on sediment input due to the low stock numbers. *Note: If the rate of development increases there is also potential for moderate increases in sediment input to streams adjacent to new housing areas due to construction phase stormwater discharges.*
					Effect:	Increased sediment input will increase the risk of adverse effects on periphyton growth (via phosphorus), macroinvertebrates and fish (through deposition), and recreational value (through deposition and clarity). While at the EPAU level scale these effects are likely to be weak, there is potential for localised moderate effects in streams adjacent to new construction sites.
					Confidence:	This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from

Tier	Attribute	Change	Effect	Confidence	Narrative
					downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
	Faecal contamination	0	0	3	<u>Change:</u> Rural land-use and the condition of wastewater infrastructure are assumed to remain largely unchanged and stock exclusion is only required in catchments where stock are unlikely to be present. Accordingly, *E. coli* concentrations are unlikely to shift from current state. <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> The lack of any intensification or mitigation under this scenario means the panel are confident concentrations will not change from current due to human activities. Proxy catchment data are partially transferable, state data comes from one GWRC monitoring site, approximately five territorial authority monitoring sites and national scale models.
	Flow	-2	-2	1	<u>Change:</u> Under this scenario mean annual flood is expected to increase by up to 40% due to climate change and MALF is expected to reduce by between 10% and 20%. While the effects of climate change on flow may not be as pronounced in this EPAU compared to the others, they will likely be compounded by the large areas of new impervious surfaces in greenfield developments. *<u>Note:</u> Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".* <u>Effect:</u> Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. <u>Confidence:</u> As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high".
2	Plant growth	-1	-1	1	<u>Change:</u> The panel agrees that the reduction in MALF will increase the risk of periphyton growth, but an attribute state change is unlikely.

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Notes:</u> • *All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.* • *This assessment does not apply in macrophyte dominated streams, where any change in plant growth is unlikely.*
					<u>Effect:</u> The panel considers that most reaches in this EPAU are likely to be currently impacted by nuisance periphyton growth (supported by nutrient criteria modelling (Snelder *et al.*, 2019)). Accordingly, the potential for further effects is limited.
					<u>Confidence:</u> This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships and it is not known how many of the streams in this EPAU have a macrophyte dominated plant community.
3	Macroinvertebrate community health	-1	-1	1	<u>Change:</u> Macroinvertebrate communities in the streams in this EPAU are likely to be impacted by increased temperature, periphyton growth, sediment input and flood disturbance. In the catchments where urban development is planned there is also potential for localised moderate adverse effects as a result of increased risk of metal toxicity and sediment effects. However, on an EPAU scale the panel agrees that a change in attribute state is unlikely. <u>*Note:*</u> *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					<u>Effect:</u> Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable degradation in macroinvertebrate community health means a direct degradation in ecosystem health is likely.
					<u>Confidence:</u> This assessment is partly based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by the complex relationships between flow, sediment input, plant growth and macroinvertebrate community health.
	Fish diversity	0	0	3	<u>Change:</u> While the predicted changes in sediment input, flow, plant growth, dissolved metal concentrations and macroinvertebrate community health may affect fish abundance and community structure/composition,

Tier	Attribute	Change	Effect	Confidence	Narrative	
						a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel are highly confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	-2	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to degrade based on sediment input; • Water quality – Likely to degrade based on increases in stormwater contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to degrade based on macroinvertebrates and their suitability/availability to fish as a food source. The panel considers that a moderate degradation is likely in streams where: • Ecosystem health is not significantly impacted by existing urban development; and • Significant proportional increases in impervious surface cover are expected. *Notes:* • *This assessment does not apply to those catchments that are heavily impacted by existing urban development and/or are not expected to have significant proportional increases in impervious surface cover. Only a small but detectable (-1) degradation in ecosystem health is expected in those systems.* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					Effect:	N/A
					Confidence:	Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities. Furthermore, while the panel are confident that any change will be negative, they are split on whether there is potential for a moderate degradation in this EPAU. Specifically, Dr Greer, Dr Heath and Mr Norton noted that the current state of most streams likely precludes anything more than a small negative change (-1) change.

Tier	Attribute	Change	Effect	Confidence	Narrative	
	Overall suitability for recreation	0	N/A	2	Change:	The predicted increase in sediment input combined with greater periphyton biomass and reduced summer low flows may impact recreational users' enjoyment of the streams in this EPAU. However, as almost all of the reaches in this EPAU are currently unsuitable for contact recreation due to elevated *E. coli* levels, and faecal contamination is not predicted to change under this scenario, the overall recreational value of most streams is unlikely to change substantially from current.
					Effect:	N/A
					Confidence:	Most of the streams in this EPAU are currently unsuitable for contact recreation due to very high levels of faecal contamination. As such, the panel is confident that the predicted changes in sediment, periphyton growth and summer low flows will not make these streams any less suitable. Nevertheless, there is uncertainty associated with the hydrological modelling which is compounded by the difficulty in predicting how sediment transport and periphyton growth will respond to changes in flow.

Table 7: BAU expert panel assessment for Assessment unit 6 - Surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	-2	-1	2	Change:	Impervious surface cover is expected to increase by >20% in the two largest open stream catchments in the EPAU, the Owhiro and the Kaiwharawhara, while smaller increases are expected elsewhere. As impervious surface cover is already high in this EPAU the potential for further degradation is somewhat limited. However, the panel agrees that a one attribute state change is possible in catchments with significant amounts of new urban development *Notes:* • *This assessment does not apply where new urban development is not planned.* • *Climate change may compound the effects of the additional impervious surface cover on peak metal concentrations and increase the risk of acute toxicity effects due to greater accumulation of metals on impervious surfaces during longer (compared to current) periods of dry weather and greater mobilisation of those metals during higher (compared to current) intensity rainfall (Mr Farrant).*
					Effect:	While dissolved metal concentrations will increase under this scenario, the potential for adverse effects on invertebrates and fish communities is limited. Most catchments in this EPAU are heavily urbanised and are unlikely to support species that are sensitive to further increases in stormwater contaminants.
					Confidence:	Despite the limited available state data, the panel is confident that moderate increases in dissolved metal concentrations will occur as a result of new urban development. Proxy catchment modelling data are also partially transferable.
	Nitrogen 1	0	0	3	Change:	As the condition of wastewater infrastructure will remain constant nitrogen loads will be unchanged, and ammonia and nitrate concentrations will reflect current state. *Note: Dr Ausseil notes that there is evidence that elevated nitrate and/or ammonia concentrations in the Owhiro Stream are partially the result of landfills (including closed sites) and that landfills are not considered in any of the scenarios assessed by the panel. This may also be the case for the Kaiwharawhara Stream.*
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The lack of any sort of effective (wastewater) mitigation under this scenario means that the panel are confident that ammonia and nitrate concentrations will not change from current even though state data comes largely from national scale models. Proxy catchment modelling results are partially transferable.
	Nitrogen 2	0	0	2	Change:	As the condition of wastewater infrastructure will remain constant nitrogen loads will be unchanged and DIN concentrations will reflect current state. *Notes:*

Tier	Attribute	Change	Effect	Confidence	Narrative
					• *Increased impervious surface cover could potentially increase atmospheric nitrogen deposition, which, in conjunction with associated increases in stormwater volumes, could result in a detectable increase in DIN concentrations and loads (Mr Farrant).* • *Concentrations are currently sufficiently high that a major change in land-use would be required to have a meaningful effect on DIN (Dr Ausseil).*
					Effect: As no change is expected there is not expected to be an effect.
					Confidence: The lack of any sort of effective (wastewater) mitigation under this scenario means that the panel are confident that DIN concentrations will not change from current, despite state data coming largely from national scale models. However, Mr Farrant's notes on atmospheric nitrogen deposition were not considered by the rest of the panel in their individual assessments, and the contribution of this process to future nitrogen loads is uncertain. Proxy catchment modelling results are partially transferable.
	Phosphorus	0	0	1	Change: As the condition of wastewater infrastructure will remain constant, DRP should be unchanged through most of the EPAU. Nevertheless, there may be small localised increases associated with an increase in impervious surface cover. *Note: The risk of small localised increases may be highest in the Owhiro Stream, as historical data indicates very low DRP concentrations (c. 0.005 mg/L) in that catchment. In contrast already elevated DRP concentrations in the Kaiwharawhara catchment means that small additional increases are less likely to be detected (Dr Ausseil).*
					Effect: As no change is expected there is not expected to be an effect.
					Confidence: The lack of any sort of effective (wastewater) mitigation under this scenario means the panel are confident that DRP concentrations will not change from current due to human activities (at the EPAU scale), despite state data coming largely from national scale models. However, there is some uncertainty around the impact of climate change on sediment derived phosphorus. Proxy catchment data are partially transferable.
	Sediment input	-1	-1	1	Change: Increased flood frequency/magnitude means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). *Note: If the rate of development increases there is also potential for moderate increases in the streams adjacent to new housing areas due to construction phase stormwater discharges.*
					Effect: Increased sediment input increases the risk of adverse effects on periphyton growth (via phosphorus), macroinvertebrates and fish (through deposition), and recreational value (through deposition and clarity). While at the EPAU level scale these effects are likely to be weak, there is potential for localised moderate effects in streams adjacent to new construction sites.

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Confidence:</u> This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". Furthermore, the panel is uncertain about the benefits of sediment and erosion control plans as it is unclear if they have been in use during the baseline period.
	Faecal contamination	0	0	3	<u>Change:</u> The condition of wastewater infrastructure is assumed to remain unchanged. Thus, *E. coli* concentrations are unlikely to shift from current state. <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> The panel are confident concentrations will not change from current due to human activities. Proxy catchment data are transferable. State data comes from one GWRC monitoring site, approximately ten territorial authority monitoring sites and national scale models.
	Flow	-2	-2	1	<u>Change:</u> Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River. The effects of climate change on flow will be compounded by an increase in impervious surface area (i.e. increased 'flashiness' in small to moderate rainfall events and reduced baseflow due to lower recharge). *<u>Note:</u> Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics"* <u>Effect:</u> Reductions in MALF in the catchments on the true right of the Hutt River will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. <u>Confidence:</u> As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high". There is also uncertainty around the location of infill

<table>
<tr><th>Tier</th><th>Attribute</th><th>Change</th><th>Effect</th><th>Confidence</th><th colspan="2">Narrative</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>housing within Wellington City, which makes it difficult to determine how flow will change in different parts of the EPAU.</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Plant growth</td><td rowspan="3">-1</td><td rowspan="3">-1</td><td rowspan="3">1</td><td><u>Change:</u></td><td>The panel agrees that the reduction in MALF will increase the risk of periphyton growth.

<u>Note:</u>
• This assessment only applies to the catchments on the true right side of the Hutt River, no change is expected in the catchments within Wellington city.
• All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.</td></tr>
<tr><td><u>Effect:</u></td><td>Panel members generally agree that the catchments to the true right of the Hutt are likely to be currently impacted by nuisance periphyton growth (supported by nutrient criteria modelling (Snelder et al., 2019)). Accordingly, the potential for further effects is limited.</td></tr>
<tr><td><u>Confidence:</u></td><td>This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Furthermore, how periphyton biomass will respond to changes in flow is difficult to predict due to complicated driver-response relationships and the fact that existing shading may mediate the effects of reduced summer low flows.

Measured state data are only available for one site and reach scale periphyton biomass modelling is based solely on nutrients.</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Macroinvertebrate community health</td><td rowspan="2">-1</td><td rowspan="2">-1</td><td rowspan="2">1</td><td><u>Change:</u></td><td>Macroinvertebrate communities in the streams in this EPAU are likely to be impacted by increased temperature (Hutt catchments only), periphyton growth (Hutt catchments only), sediment input and flood disturbance. In the catchments where urban development is planned there is potential for localised moderate adverse effects as a result of the increased risk of metal toxicity and sediment effects. However, on an EPAU scale an attribute state change is unlikely.

<u>Note:</u> The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.</td></tr>
<tr><td><u>Effect:</u></td><td>Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable degradation in macroinvertebrate community health means a direct degradation in ecosystem health is likely.</td></tr>
</table>

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: This assessment is primarily based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by complex relationships between flow, sediment input, plant growth and macroinvertebrate community health.
	Fish diversity	0	0	3	Change: While the predicted changes in sediment input, flow, plant growth, dissolved metal concentrations and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect: As no change is expected there is not expected to be an effect.
					Confidence: The panel are highly confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	-2	N/A	1	Change: The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to degrade based on sediment input and flow; • Water quality – Likely to slightly degrade based on increases in stormwater contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to degrade based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a moderate degradation is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					Effect: N/A
					Confidence: Confidence in the magnitude of change is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities. However, the panel is highly confident that the direction of change will be negative.
	Overall suitability for recreation	-1	N/A	1	Change: The predicted increase in sediment input combined with a higher periphyton biomass and reduced summer low flows (Hutt catchments only) may impact recreational users' enjoyment of the streams in

Tier	Attribute	Change	Effect	Confidence	Narrative	
						this EPAU. However, as almost all reaches are predicted to be currently unsuitable for contact recreation due to elevated *E. coli* levels, and faecal contamination is not predicted to change under this scenario, the overall recreational value of most streams is unlikely to change substantially from current.
					Effect:	N/A
					Confidence:	Most of the streams in this EPAU are currently unsuitable for contact recreation due to very high levels of faecal contamination. As such the panel is confident that there is limited potential for the predicted changes in sediment, periphyton growth and summer low flows to impact their recreational value further. Nevertheless, there is uncertainty associated with the hydrological modelling which is compounded by the difficulty in predicting how sediment transport and periphyton growth will respond to changes in flow.

Table 8: Improved expert panel assessment for Assessment unit 1 – Headwater urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	0	0	1	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 20% under this scenario, and the replacement of 50% of existing roofs constructed from material containing zinc will result in a commensurate reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in copper loads from existing surfaces reducing by 2% to 5% and zinc loads decreasing by between 35% and 40%. However, significant proportional increases in urban land cover are predicted under this scenario in both the Karori and Wainuiomata catchments, and the additional load from these surfaces will at least partially offset the reduction in loads from existing impervious surfaces. The potential for reduced loads from existing impervious surfaces to be offset by new urban development, combined with the fact that urban development is located near the top of relatively (in relation to urban landcover) large catchments, means that the panel expects that copper concentrations will remain largely unchanged at the EPAU scale, but small decreases in zinc concentrations are possible but not likely. *Notes:* • *While only small improvements in zinc are likely at the EPAU scale, there is potential for localised moderate improvements in streams draining existing urban areas.* • *The panels assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					Effect:	As only small (at most) reductions in zinc concentration are expected at the EPAU scale, and copper concentrations are not expected to change, the overall effect on macroinvertebrates, fish and ecosystem health are likely to be negligible. *Note: There is potential for localised weak positive effects in the streams draining existing urban areas. However, moderate localised effects are unlikely, as the effects of copper toxicity on sensitive species will not change.*
					Confidence:	The panel did not reach total agreement. Dr Ausseil's opinion was that reductions in zinc would be detectable at the EPAU scale, but the rest of the panel did not agree. The available state data is also limited, and proxy catchment data are not transferable.
	Nitrogen 1	+1	+1	2	Change:	**Changes in urban area** Under this scenario it is assumed that dry weather wastewater leaks are removed, which will reduce the input of ammonia and nitrate (oxidised from ammonia) into both the Karori Stream and Wainuiomata River across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may have a detectable effect on the distribution of

Tier	Attribute	Change	Effect	Confidence	Narrative
					ammonia concentrations in the Wainuiomata catchment (the frequency of overflows in Karori is not expected to change). Additional total nitrogen loads from new developments will only be 60% of those expected under BAU, and total nitrogen loads from commercial and industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture. **Changes in rural area** Extensive riparian management is expected under this scenario in the Wainuiomata catchment, and the predicted five metre vegetated buffer is likely to be effective (50-80% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads delivered to the targeted reaches. 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired or space planted under this scenario. However, this land is unlikely to be a major source of nitrogen. Thus, the effect of this on instream nitrate concentrations is likely limited. **Overall assessment** The assumed urban and rural mitigations are likely to reduce ammonia and nitrate concentrations in the rivers and streams in this EPAU. While the magnitude of this reduction is unclear, at the EPAU scale an attribute state change is not expected for either parameter, as both are expected to be in the A state in most reaches *Note: the GWRC monitoring site in the upper Karori is in the B attribute state for nitrate toxicity*.
					Effect: Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects in urban streams in the Wainuiomata catchment.
					Confidence: Proxy catchment data are not transferable and state data comes largely from national scale models. However, the panel is still confident that the direction of change will be positive and that there is limited potential for an attribute state improvement.
	Nitrogen 2	+1	0	2	Change: The removal of dry weather wastewater leaks in both the Karori Stream and Wainuiomata River should reduce DIN concentrations across all flows in the urban areas of this EPAU. Furthermore, stormwater capture on commercial/ industrial paved surfaces and major roads (20% reduction in total nitrogen load from these surfaces), combined with the reduction in wastewater overflow frequency in the Wainuiomata catchment, should reduce DIN concentrations in urban streams during high flow events.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Additional total nitrogen loads from new urban developments will also be 40% lower than those expected under BAU. Regarding the effects of the rural mitigations, the extensive riparian management expected under this scenario in the Wainuiomata catchment is likely to be effective (50-80% (Parkyn, 2004)) at reducing sub-surface and surface nitrogen loads to the targeted reaches. However, land retirement is not expected to have a noticeable effect on DIN concentrations in the Karori or Wainuiomata catchments. On balance the urban and rural mitigations expected under this scenario are likely to reduce DIN concentrations through much of the Wainuiomata and Karori catchments. However, at the EPAU scale an attribute state change is not expected as most reaches (96%) are already in the A state *Note: The GWRC monitoring site in the upper Karori is in the D attribute state, and national scale modelling suggests most of the surrounding reaches are either in the B or C state.*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely (only predicted under the Sensitive scenario in the Horokiri proxy catchment).
					Confidence:	Proxy catchment data are not directly transferable and state data comes largely from national scale models. However, the panel is still confident that the direction of change will be positive and that there is limited potential for an attribute state improvement. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	0	2	Change:	**Changes in urban area** Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into both the Karori and Wainuiomata across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may also have a detectable effect on the distribution of DRP concentrations in the Wainuiomata catchment (frequency of overflows in the Karori catchment is not expected to change). Furthermore, additional total phosphorus loads from new developments will only be 50% of those expected under BAU, and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture. **Changes in rural area**

Tier	Attribute	Change	Effect	Confidence	Narrative
					Extensive riparian management is expected under this scenario in the Wainuiomata catchment, and the predicted five metre vegetated buffer is likely to be effective (50% assumed) at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff. 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired or space planted under this scenario which will further reduce DRP concentrations. **Overall assessment** Urban and rural mitigations are likely to reduce DRP concentrations in the rivers and streams in the Wainuiomata River and Karori Stream catchments. However, at the EPAU scale an attribute state change is not expected. Analysis conducted by GWRC[1], suggests that at least a 15% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is possible, but the panel does not consider it likely due to naturally high phosphorus levels in the Wainuiomata catchment. There is also a much lower level of space planting and retirement assumed in this EPAU compared to the proxy catchments.
					<u>Effect:</u> Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely (not even predicted under the Sensitive scenario in the Horokiri proxy catchment).
					<u>Confidence:</u> Proxy catchment data are not transferable and state data comes largely from national scale models. However, the panel is still confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	<u>Change:</u> **Improvements in urban area** Under this scenario, it is assumed that additional sediment loads from new developments will be 80% less than under BAU, and that sediment loads from existing commercial/industrial paved surfaces and major roads will be reduced by 40% as a result of stormwater capture. **Improvements in rural area** The extensive riparian management expected under this scenario in the Wainuiomata catchment is likely to be effective at reducing the amount of sediment entering the targeted reaches via runoff. The degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge. In addition to

Tier	Attribute	Change	Effect	Confidence	Narrative
					reducing sediment input from run-off, stock exclusion will also significantly reduce bank erosion (proxy catchment modelling 80% reduction in stream bank erosion component of sediment load delivered to the targeted reaches). 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired or space planted under this scenario which will further reduce sediment input from slope erosion (slope wash and slips etc.). **Detrimental effects of climate change** Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slope wash and slips). **Overall assessment** Under this scenario, urban and rural mitigations are likely to reduce sediment input into the rivers and streams in the Karori and Wainuiomata catchments. However, a moderate or significant improvement is not expected at the EPAU scale, as any improvements resulting from these mitigations will be partially offset by the effects of climate change on flood frequency/magnitude and slope erosion.
					Effect: Reduced sediment input should improve deposited fine sediment cover, water clarity and turbidity. In many of the smaller streams in this EPAU, deposited fine sediment cover and turbidity are high, both in absolute terms (deposited sediment cover only) and relative to reference state. Thus, any reduction in sediment load in these systems could well have positive effects on ecosystem health and recreational value. However, through much of the EPAU deposited sediment is unlikely to be a major determinant of ecosystem health (generally <20% deposited cover) and only small reductions in sediment load are expected. Accordingly, it is the panels view that a weak positive effect is the most likely outcome.
					Confidence: The panels change assessment relies on the modelled effects of climate change on flow presented in the memorandum entitled “Predicted impact of climate change on key hydrological statistics”. That memorandum states that “the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions”. It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity.
	Faecal contamination	+2	+2	2	Change: **Changes in urban area** Under this scenario, it is assumed that dry weather wastewater leaks are removed which will reduce the input of *E. coli* to the urban streams in the Karori and Wainuiomata catchments across all flows.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Furthermore, additional *E. coli* loads from new developments will only be 10% of those expected under BAU. It is assumed that wastewater overflows will only occur in the four biggest rainfall events (annually). While this is a significant reduction in the Wainuiomata catchment (frequency of overflows in Karori is not expected to change), it will probably not result in a change in *E. coli* attribute state, as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations. **Changes in rural area** The stock exclusion practices assumed under this scenario should reduce direct faecal input from stock in streams. Furthermore, it is possible that a five-metre planted riparian margin will reduce the input of sediment bound and supernatant *E. coli* from run-off through filtering and infiltration respectively. Extensive riparian management is expected under this scenario in the lower Wainuiomata River which should significantly reduce *E. coli* concentrations in the targeted reaches at baseflow conditions. However, *E. coli* in the lower Wainuiomata is currently in the D attribute state due to 95 %ile concentrations, indicating run-off impacts during wet-weather events which may not be effectively controlled by riparian planting alone (critical source area control may also be needed). 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired or space planted under this scenario which will further reduce *E. coli* input. **Overall assessment** Currently *E. coli* concentrations in ~70% of reaches in the Karori catchment are in the D or E attribute state with the rest in C state. Most reaches in that catchment are failing to meet the swimmability threshold based on the percent exceeded metrics. Conversely, in the Wainuiomata catchment only urban reaches (due to all metrics) and the lower rural reaches of the mainstem (due to 95th percentile concentrations only) are in the D or E attribute state. While not directly transferable, proxy catchment modelling results are as follows: • In the Horokiri (rural) proxy catchment, all four *E. coli* metrics are currently in the D attribute state, but under the improved' scenario they were C (540), B (260), A (median) or D (95th). However, in this catchment the proportion of land in agricultural land-cover reduced from 44% to 20.6% under this scenario, which is far greater than the retirement assumed in the Karori and Wainuiomata catchments.

Tier	Attribute	Change	Effect	Confidence	Narrative
					• In the Porirua (urban) proxy catchment, all three dry weather metrics are currently in the E attribute state but will move to the D state under the improved scenario (the 95^{th} did not change, remaining in the state D). National scale modelling and analysis conducted by GWRC[1] suggests that that a 50% *E. coli* reduction (achieved under this scenario in both Horokiri and Porirua proxy catchments) will result in most (~80%) of the reaches that are currently unswimmable becoming swimmable. However, based on the same GWRC analysis, the panel does not consider that a two-attribute state improvement is likely at the EPAU scale. Effect: Reduced *E. coli* concentrations will noticeably reduce human health risks to recreational users. This is especially true in urban streams, where dry-weather human wastewater contamination will be removed (greater positive effect than indicated by the attribute state change). Confidence: The removal of dry-weather wastewater contamination means the panel is confident that the direction of change will be positive, and that an attribute state change is the most likely outcome. However, they note that the effects of riparian planting on wet-weather *E. coli* concentrations are poorly understood State data comes from two GWRC monitoring sites, approximately five territorial authority monitoring sites and national scale models. Proxy catchment data are not directly transferable [1]Modelling of E. coli reductions in the Whaitua
	Flow	-2	-2	1	Change: Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, MALF is expected to reduce by between 10% and 20% in the Wainuiomata catchment. The panel considers that while the urban mitigations assumed under this may have some localised benefits on flow, they unlikely to offset the effects of climate change in a meaningful way. This is supported by the urban hydrology modelling conducted as part of the Te Awarua-o-Porirua Collaborative Modelling Project (Ferguson, 2018). *Notes:* • *Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".* • *The increase in impervious surface area is considered too small in relation to catchment size to have a noticeable effect on flow at the EPAU scale.* Effect: Reductions in MALF in the Wainuiomata catchment will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely likely:

Tier	Attribute	Change	Effect	Confidence	Narrative
					• Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. <u>Confidence:</u> As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"
2	Plant growth	0	0	1	<u>Change:</u> At the EPAU scale the panel considers that periphyton biomass is unlikely to change for the following reasons: • **A shift in attribute state due to nutrient reductions is unlikely** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests that a >15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely. • **The benefits of riparian planting in the Wainuiomata catchment will most likely be offset by the effects of climate change** – Increased shading (and associated reductions in temperature) may reduce the risk of periphyton growth in the reaches targeted for riparian planting (five metre of riparian planting provides effective shading in streams <15 metres wide). However, on the other hand the expected reduction in summer low flows (MALF) will increase the risk of periphyton growth through increased temperature and accrual. *<u>Note:</u> All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.* <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> This assessment relies on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						[1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	1	Change:	The increased wintertime flood frequency/magnitude and lower summer low flows (Wainuiomata catchment only) expected under this scenario will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in sediment input, and associated decreases in cover and turbidity; the extensive riparian planting in the Wainuiomata catchment; and the localised reductions in the risk of acute ammonia toxicity and chronic zinc toxicity in urban areas means that, on an EPAU scale, there is likely to be a net small improvement in MCI. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely
					Confidence:	This assessment relies on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow, shading, sediment and toxicants due to complicated driver-response relationships.
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow, and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+1	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input and riparian management; • Water quality – Likely to improve based on reductions in nutrients and contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a small detectable improvement is likely at the EPAU scale *Notes:*

Tier	Attribute	Change	Effect	Confidence	Narrative
					• *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* <u>Effect:</u> N/A <u>Confidence:</u> Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	2	<u>Change:</u> The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will noticeably reduce human health risks to recreational users. The removal of wastewater from these streams will also improve people's perception of their recreational value. Reduced stock access combined with increased riparian planting in the Wainuiomata River will increase the rivers recreational value, despite reductions in summer low flows. Reduced sediment input should also improve aesthetics throughout the EPAU. <u>Effect:</u> N/A <u>Confidence:</u> There is a high level of uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for the urban and rural mitigations to offset these effects is unclear. However, the panel is confident that the removal of dry-weather wastewater contamination, the reduced frequency of wet-weather wastewater contamination (Wainuiomata catchment only) and the significant stock exclusion and riparian planting (Wainuiomata catchment only) will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Table 9: Improved expert panel assessment for Assessment unit 2 – Hutt main stem

Tier	Attribute	Change	Effect	Confidence	Narrative
1	Dissolved metals	+1	0	2	Change: Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 20% under this scenario, and the replacement of 50% of existing roofs constructed from material containing zinc will result in a commensurate reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in copper loads from existing surfaces reducing by ~7% at the catchment scale and zinc loads decreasing by ~28%. While additional development will offset the benefits of the assumed mitigations to some extent, both copper and zinc loads delivered to the Hutt River from the Assessment Unit 5 are expected to decrease, as are zinc loads from assessment unit 6. As such, the panel considers that a small net improvement is likely for both parameters. However, as the relatively small amount of existing urban landcover (~6% of catchment area) in the catchment is not having a marked effect on current dissolved metal concentrations (< ANZECC 95% protection guideline (Greer, 2018)), it is unlikely that the proposed mitigations, or the small (~10%) expected increase in impervious surface area, will result in a change in attribute state. Effect: The panel considers it unlikely that copper or zinc concentrations will change to the extent that the risk of chronic toxicity effects will be decreased on the EPAU scale. However, a reduction in localised acute toxicity effects near stormwater outfalls is possible. Confidence: While the panel is confident that copper and zinc concentrations will decrease, they are not confident that this decrease will be detectable. Furthermore, while monitoring data are available for two sites, reach scale modelling of state has not been conducted and proxy catchment modelling is not transferable.
	Nitrogen 1	+1	+1	2	Change: Reductions in nitrogen loads from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce nitrogen and ammonia concentrations in the Hutt Mainstem, as should the 75% reduction in overflow frequency at the Silverstream Stormwater Tank. However, concentrations of both parameters are already in the A state, thus an attribute state change is not possible. Effect: Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency at the Silverstream Stormwater Tank could reduce localised acute ammonia toxicity effects. Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Proxy catchment data are not transferable. However, measured state data is available for three sites, and national scale models are available.
	Nitrogen 2	+1	+1	2	<u>Change:</u>	Nitrogen loads discharged to the Hutt River from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce under this scenario, and concentrations in the Mainstem should decrease as a result. However, an attribute state change is not possible as all reaches are currently in the A state.
					<u>Effect:</u>	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely (only predicted under the Sensitive scenario in the Horokiri proxy catchment). Dr Heath notes that a reduction in DIN may reduce the frequency and magnitude of cyanobacteria blooms at multiple locations, such as downstream of the Pakuratahi and Mangaroa confluences and at Silverstream. However, this is by no means certain. *<u>Notes:</u>* • *The panel is confident if a reduction in DIN does have an impact on periphyton growth, it will be positive.* • *A reduction in DIN may reduce the frequency and magnitude of cyanobacteria blooms at multiple locations, such as downstream of the Pakuratahi and Mangaroa confluences and at Silverstream (Dr Heath). However, this is by no means certain.*
					<u>Confidence:</u>	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are not transferable. However, measured state data is available for three sites, and national scale models are available. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	<u>Change:</u>	Reductions in phosphorus loads from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/6 = removal of wastewater contamination) should reduce DRP concentrations in the Hutt Mainstem. However, on balance the panel did not consider an attribute change likely given the high proportion of reaches already in the A state (~45%[1]).
					<u>Effect:</u>	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to

Tier	Attribute	Change	Effect	Confidence	Narrative
					this EPAU, suggests that this level of reduction is unlikely (greater than predicted under the Sensitive scenario in the Horokiri proxy catchment). <u>Confidence:</u> The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are not transferable. However, measured state data is available for three sites, and national scale models are available. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	<u>Change:</u> The extensive riparian management expected under this scenario in the Mangaroa catchment, combined with the retirement and space planting in the Pakuratahi catchment and Assessment Unit 4 are likely to be reduce sediment input to the Hutt Mainstem. However, increased flood frequency/magnitude in the wider catchment due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). On balance, the panel considers that a small detectable reduction in sediment load is the most likely outcome at the EPAU scale. <u>Effect:</u> Small decreases in sediment input should improve deposited fine sediment cover, water clarity and turbidity, which impact ecosystem health and/or recreational value. However, at present these parameters are generally in a good state (fine sediment cover <20%; fine sediment cover and turbidity in the Draft NPS-FM A state), and any positive effects improvements are likely to be small. <u>Confidence:</u> The panels confidence is low due to difficulties in predicting how stock exclusion in the Mangaroa will affect sediment load in the Hutt River, uncertainty associated with hydrological modelling from downscaled climate change models and a limited understanding of how climate change will affect the delivery of sediment from other catchments.
	Faecal contamination	+2	+2	2	<u>Change:</u> *E. coli* loads discharged to the Hutt River from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce under this scenario. Thus, concentrations in the Main Steam are also likely to reduce. While the scale of this reduction is difficult to predict, based on the extent of the proposed urban and rural mitigations, the panel considers an attribute state improvement is likely. This is supported by national scale modelling and analysis conducted by GWRC[1] which suggests that the 50% reduction in *E. coli* predicted for the Horokiri proxy catchment and the 70% reduction predicted for the Porirua catchment would both be sufficient to shift 85% of reaches in the C. D and E attribute states to the A and B attribute states. <u>Effect:</u> Reduced *E. coli* concentrations will noticeably reduce human health risks to recreational users. This is especially true in reaches in the urban area, where dry-weather human wastewater contamination will be removed (greater positive effect than indicated by the attribute state change).

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: There is monitoring data from three sites to support the results of the national scale state models and the extent of the predicted urban and rural landcover means the panel is confident concentrations will decrease. Nevertheless, proxy catchment modelling is not directly transferable. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-1	-1	1	Change: Under this scenario mean annual flood is not expected to increase due to climate change but MALF is expected to reduce by between 10% and 20% under some emissions pathways.
					Effect: Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. *Note: The severity of these effects may be compounded by water allocation.*
					Confidence: This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	0	0	1	Change: At the EPAU scale the panel considers that periphyton biomass is unlikely to change for the following reasons: • **A shift in attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely. • **Any benefits of reduced nutrients on periphyton biomass will most likely be offset by the effects of climate change** – In isolation, reduced nutrients may result in some within attribute state reduction in periphyton biomass. However, this will be offset by the expected reduction in summer low flows (MALF), which will increase the risk of periphyton growth through increased temperature and accrual. *Notes:* • *All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF*

Tier	Attribute	Change	Effect	Confidence	Narrative
					indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases. • *Decreases in DIN, DRP and sediment input may result in the frequency and magnitude of cyanobacteria blooms being reduced (Dr Heath). However, there is low level of confidence in this assessment.* <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	0	0	1	<u>Change:</u> As under BAU, the reductions in summer low flows expected under this scenario due to climate change will have an adverse effect on macroinvertebrate community health throughout this EPAU. While reductions in sediment input and the risk of localised metal and ammonia toxicity effects will offset these effects, at the EPAU scale the panel considers that a change in MCI is unlikely. They do, however, note that moderate improvements may occur near the outfalls of stormwater discharges and the Silverstream Stormwater Tank. *<u>Note:</u> The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.* <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow, sediment and toxicants due to complicated driver-response relationships.
	Fish diversity	0	0	3	<u>Change:</u> While the predicted changes in flow, sediment input and localised metal and ammonia toxicity effects may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	0	N/A	1	<u>Change:</u> The panel considered how the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input; • Water quality – Likely to improve based on reduction in nutrients and contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to remain unchanged based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that any change in ecosystem health is likely to be negligible at the EPAU scale *<u>Notes:</u>* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* <u>Effect:</u> N/A <u>Confidence:</u> Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	2	<u>Change:</u> The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will noticeably reduce human health risks to recreational users, as will the reduction in agricultural faecal contamination from Assessment Units 3 and 4 The removal of wastewater will also improve people's perception of the recreational value of the lower reaches, and reduced sediment input will improve the aesthetics of the river. There is also a possibility that the frequency and magnitude of cyanobacteria blooms may decrease, although this is by no means certain. <u>Effect:</u> N/A <u>Confidence:</u> The panel is confident that the urban and rural mitigations assumed under this scenario will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Tier	Attribute	Change	Effect	Confidence	Narrative
					There is a high level of uncertainty around the effects of climate change on flow, sediment input and periphyton growth and cyanobacteria growth under this scenario.

Table 10: Improved expert panel assessment for Assessment unit 3 – Mangaroa/Pakuratahi Valleys

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+1	0	2	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 20% under this scenario, and there may be a detectable localised reduction in copper and zinc concentrations in the Pakuratahi River below SH2. For the rest of the EPAU detectable changes in copper and zinc concentration are not expected due to the limited amount of existing impervious surface cover (limited potential for improvements through treatment), and the lack of urban intensification expected under this scenario. *Note: The Te Marua area was not considered as part of this assessment as it influences the Hutt mainstem more than the major surface water bodies in the EPAU.*
					Effect:	For most of this EPAU there is not expected to be an effect as concentrations are not expected to change. While a detectable reduction in dissolved metal concentrations is possible in the Pakuratahi River below SH2, it is also unlikely that this will have an effect as the risk of chronic toxicity effects is probably already low.
					Confidence:	While state data are limited, the limited amount of impervious surface cover and the lack of any urban intensification under this scenario means that for most of the EPAU the panel are highly confident that copper and zinc concentrations will not change from current. The panel is also confident that media treatment of stormwater from SH2 will reduce dissolved metal concentrations in the lower Pakuratahi. However, it is uncertain whether these reductions will be detectable, as current state is not known (concentrations may well be below laboratory detection limits).
	Nitrogen 1	+1	0	2	Change:	Extensive riparian management is expected under this scenario in both the Mangaroa and Pakuratahi catchments, and the predicted five metre vegetated buffer is likely to be effective (50-80% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads delivered to the targeted reaches. This combined with extensive space planting and retirement (~14% of Mangaroa catchment combined and 2.2% of Pakuratahi catchment) will reduce nitrate concentrations. However, at the EPAU scale an attribute state change is not expected, as all reaches are likely already to be in the A state. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means that for the most part ammonia concentrations will not change from current. However, very localised reductions may occur at crossing points.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means the risk of acute ammonia toxicity effects will also not change from current

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The level of rural mitigation under this scenario means that the panel are confident that the direction of change will be positive. They are also confident that current state of ammonia and nitrate concentrations precludes an attribute state shift for these parameters. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is partially transferable.
	Nitrogen 2	+1	+1	1	Change: The extensive riparian management expected under this scenario in the Wainuiomata catchment is likely to be effective (50-80% (Parkyn, 2004)) at reducing sub-surface and surface nitrogen loads to the targeted reaches, as should the widespread space planting and retirement (~14% of Mangaroa catchment combined and 2.2% of the Pakuratahi catchment). Accordingly, DIN concentrations should reduce throughout the EPAU. However, on balance the panel did not consider an attribute change likely given the high proportion of reaches already in the A state (55%[1]). *Note: Nitrogen input to the lower Mangaroa River from the surrounding peatland will not be reduced under this scenario (Dr Heath).* Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The available proxy catchment data suggests that this level of reduction is unlikely (only predicted in the proxy catchment under the Sensitive scenario). Confidence: The panel is confident in the direction of change, but did not reach agreement on the magnitude, with Dr Greer and Dr Clapcott noting that an attribute state change was possible in reaches not currently in the A state. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+2	+1	2	Change: Extensive riparian management is expected throughout this EPAU under this scenario, and the predicted five metre vegetated buffer is likely to be effective (50% assumed) at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff.14.4% of the Mangaroa catchment and 2.2% of the Pakuratahi catchment are also expected to be retired or space planted under this scenario which will further reduce DRP concentrations. Analysis conducted by GWRC[1], suggests a 15% reduction in DRP would result in ~45% of reaches shifting one DRP attribute state (generally C to B), while a 25% reduction would shift 70% of sites one attribute state. Under his scenario, a 25% reduction in DRP was the expected outcome for the Horokiri proxy catchment, which is similar to this EPAU in terms of expected retirement and space planting but

Tier	Attribute	Change	Effect	Confidence	Narrative
					has less assumed stock exclusion. Thus, the panel considers a one attribute state improvement likely. GWRC's[1] analysis indicates a two-attribute state improvement is unlikely in most reaches, even with a 40% reduction in DRP (only predicted under the Sensitive scenario in the Horokiri proxy catchment). <u>Effect:</u> Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (only predicted under the Sensitive scenario in the Horokiri proxy catchment). <u>Confidence:</u> The panel is confident that DRP concentrations will decrease, and that any change will be limited to a single attribute state. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+2	+2	2	<u>Change:</u> **Improvements due to mitigations** Stock exclusion will reduce the amount of sediment entering waterways via bank erosion, and the five-metre riparian margin will be effective at reducing the amount of sediment entering the targeted reaches via runoff. The degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge and the proxy catchment modelling assumes that the stream bank erosion component of the sediment load to the targeted reaches will be reduced by 80%. 14.4% of the Mangaroa catchment and 2.2% of the Pakuratahi catchment are expected to be retired or space planted under this scenario which will further reduce sediment input from slope erosion. **Detrimental effects of climate change** Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slope wash and slips). **Overall assessment**. Rural mitigations are likely to reduce sediment input into the rivers and streams in this EPAU. However, a significant improvement is not expected as the benefits of the mitigations will be partially offset by the effects of climate change on flood frequency/magnitude.

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Effect:</u> Both deposited sediment and turbidity is high in many of the reaches in this EPAU. Reductions in these metrics due to moderate decreases in sediment input will result in commensurate improvements to ecosystem health and recreational value.
					<u>Confidence:</u> The panel is confident that stock exclusion and riparian planting will reduce sediment inputs. However, there is uncertainty about whether the benefits of stock exclusion will be offset by the effects of climate change on flow.
	Faecal contamination	+2	+2	1	<u>Change:</u> 14.4% of the Mangaroa catchment and 2.2% of the Pakuratahi catchment are expected to be retired or space planted under this scenario which will reduce *E. coli* input from that land. The stock exclusion practices under this scenario should also reduce direct faecal input from stock in streams. Furthermore, it is possible that a five-metre planted riparian margin will reduce the input of sediment bound and supernatant *E. coli* from run-off through filtering and infiltration respectively. Extensive riparian management is expected under this scenario in the Mangaroa and Pakuratahi Rivers which should significantly reduce *E. coli* at baseflow conditions. However, *E. coli* in the Mangaroa River is currently in the D attribute state due to 95 %ile concentrations, indicating run-off impacts which may not be effectively controlled by riparian planting alone (critical source area control may also be needed). National scale modelling and analysis conducted by GWRC[1] suggests that that a 50% *E. coli* reduction (achieved under improved scenario in the Horokiri proxy catchments) will result in most (~80%) of the reaches that are currently unswimmable becoming swimmable. However, based on the same GWRC analysis, the panel does not consider that a two-attribute state is likely at the EPAU scale.
					<u>Effect:</u> Reduced *E. coli* concentrations will noticeably reduce human health risks to recreational users.
					<u>Confidence:</u> While the panel is confident that the direction of change will be positive, there is uncertainty around whether an attribute state improvement is likely, as it is unclear whether a five metre riparian buffer will be sufficient to reduce 95th percentile *E. coli* concentrations. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is transferable. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-2	-2	1	<u>Change:</u> Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change and MALF is expected to reduce by between 10% and 20% *<u>Note:</u> Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".*

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Effect:</u> Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will lkely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. <u>Confidence:</u> This assessment is based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	+1	+1	1	<u>Change:</u> At the EPAU scale the panel considers that periphyton biomass is likely to be reduced but is unlikely to change attribute state for the following reasons: • **A shift in attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (not even predicted under the Sensitive scenario in the Horokiri proxy catchment). • **The benefits of riparian planting will most likely be offset somewhat by the effects of climate change** – Increased shading (and associated reductions in temperature) may reduce the risk of periphyton growth in the reaches targeted for riparian planting (five metre of riparian planting provides effective shading in streams <15 metres wide). However, on the other hand the expected reduction in summer low flows (MALF) will increase the risk of periphyton growth through increased temperature and accrual. *<u>Note:</u> All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Effect:	A small reduction in periphyton biomass in this EPAU will likely have a small, but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value.
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	2	Change:	As under BAU, the increased wintertime flood frequency/magnitude and lower summer low flows expected under this scenario will have an adverse effect on macroinvertebrate community health throughout the catchments of the Mangaroa and Pakuratahi rivers. However, reductions in sediment input, and associated decreases in cover and turbidity; extensive riparian planting; and small reductions in periphyton biomass means that on the EPAU scale there is likely to be a net small improvement in MCI. Moderate localised improvements are also likely in those reaches where MCI is currently poor or fair and riparian planting will occur. *Note: The cumulative effects of multiple stressors are generally not additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	The level of riparian mitigation expected under this scenario means that the panel is confident in the direction of change. However, while the rest of the panel agreed a +1 change was the most likely outcome, it was Dr Ausseil opinion that a +2 was possible.
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+2	N/A	2	Change: The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input, and riparian management; • Water quality – Likely to improve based on reduction in nutrients and contaminants and water temperature mitigation from shading; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a moderate improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: The level of riparian mitigation expected under this scenario means the panel is confident in the direction of change, and that the improvement in ecosystem health would be noticeable. However, there is uncertainty in the hydrological, periphyton and invertebrate modelling and difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	2	Change: Decreases in *E. coli* concentrations will reduce the health risks to recreational users. Reduced stock access combined with increased riparian planting will also improve people's perceptions of the waterways in this EPAU and reduced sediment input should enhance their aesthetics. Effect: N/A Confidence: There is a high level of uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for rural mitigations to offset these effects is unclear. However, the panel is highly confident that the significant stock exclusion and riparian planting will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Table 11:Improved expert panel assessment for Assessment unit 4 – Mixed rural

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	0	0	3	Change:	Detectable changes in copper and zinc concentration are not expected due to the limited amount of existing impervious surface cover (limited potential for improvements through treatment), and the lack of urban intensification expected under this scenario.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the limited amount of impervious surface cover and the lack of any urban intensification under this scenario means that the panel are highly confident that copper and zinc concentrations will not change from current.
	Nitrogen 1	+1	0	3	Change:	While only limited stock exclusion is expected, the accompanying five metre vegetated buffer is likely to be effective (50-80% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads delivered to the targeted reaches. This combined with extensive space planting and retirement (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10% of Korokoro catchment; ~25% of Makara Coast; and ~35% Ohariu Stream catchment) will reduce nitrate concentrations. However, an attribute state change is not likely at the EPAU scale as concentrations in most reaches are probably already in the A state. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means that for the most part ammonia concentrations will not change from current. However, very localised reductions may occur at crossing points.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means the risk of acute ammonia toxicity effects will also not change from current
					Confidence:	The level of rural mitigation under this scenario means that the panel are confident that the direction of change will be positive. They are also confident that current state of ammonia and nitrate concentrations precludes an attribute state shift for these parameters. State data comes from one monitoring site and national scale modelling. Proxy catchment data are partially transferable.
	Nitrogen 2	+1	+1	2	Change:	The limited riparian management expected under this scenario should be effective (50-80% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads to the targeted reaches, as should the assumed widespread space planting and retirement. Accordingly, DIN concentrations should reduce throughout the EPAU. However, the panel did not consider an attribute change likely, given the high proportion of reaches already in the A state (55%[1]), and the large reductions in DIN required to shift

Tier	Attribute	Change	Effect	Confidence		Narrative
						the significant minority of reaches in the B state to the A (> than the 15% predicted for Horokiri proxy catchment under Sensitive scenario[1]).
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth. The available proxy catchment data suggests that this level of reduction is unlikely (only predicted under the Sensitive scenario).
					Confidence:	The level of rural mitigation under this scenario means the panel are highly confident that the direction of change will be positive. They are also confident that current state of DIN in this EPAU precludes an attribute state shift for this parameter. State data comes from monitoring at one site and national scale modelling. Proxy catchment data are partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	1	Change:	**Improvements due to mitigations** The limited stock exclusion will reduce the amount of sediment bound P entering targeted waterways via bank erosion, and the five metre riparian margin is likely to be effective (50% assumed) at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff. The significant amount of retirement and space planting should also reduce the amount of phosphorus transported to streams from that land. **Detrimental effects of climate change** An increase in flood frequency/magnitude caused by climate change may increase sediment input to the extent that there are small associated increases in DRP. **Overall assessment**. Rural mitigations are likely to reduce phosphorus input into the rivers and streams in this EPAU. However, a moderate or significant improvement is not expected as the benefits of the assumed mitigations will be partially offset by the effects of climate change on sediment input.
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (only predicted under the Sensitive scenario in the Horokiri proxy catchment).

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panels change assessment relies on the modelled effects of climate change on flow presented in the memorandum entitled "Predicted impact of climate change on key hydrological statistics". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". Furthermore, there is significant uncertainty around how the expected changes in flow would affect sediment delivery and, in turn, phosphorus. Trying to determine whether those effects would be counter-balanced by the positive effects of the mitigations assumed under this scenario adds further complexity. Nevertheless, the panel is confident that an attribute state change in either direction is unlikely. State data comes from monitoring at one sites and national scale modelling. Proxy catchment data are partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	Change: **Improvements due to mitigations** The limited stock exclusion will reduce the amount of sediment entering targeted waterways via bank erosion, and the five-metre riparian margin will likely to be effective at reducing sediment loads delivered to the targeted reaches via runoff. The exact degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge, and the proxy catchment modelling assumes that the stream bank erosion component of the sediment load delivered to the targeted reaches will be reduced by 80%. While significant stock exclusion is not expected under this scenario, widespread space planting and retirement is assumed (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10% of Korokoro catchment; ~25% of Makara Coast and ~35% Ohariu Stream catchment), which will reduce sediment input from this land. **Detrimental effects of climate change** Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). **Overall assessment**. Rural mitigations are likely to reduce sediment input into the rivers and streams in this EPAU. However, a moderate or significant improvement is not expected as the benefits of the assumed mitigations will be partially offset by the effects of climate change on flood frequency/magnitude.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Effect: Both deposited sediment and turbidity is high in many of the reaches in this EPAU, and improvements in these measures resulting from small reductions in sediment input will result in commensurate benefits to ecosystem health and recreational value. Confidence: The panels change assessment relies on the modelled effects of climate change and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Determining whether the negative effects of climate change are counter-balanced by the positive effects of the assumed mitigations adds further complexity.
	Faecal contamination	+1	+1	2	Change: The stock exclusion practices under this scenario should reduce direct faecal input from stock in the targeted streams, and it is possible that the five metre planted riparian margin will also reduce the transport of sediment bound and supernatant *E. coli* in run-off through filtering and infiltration respectively. However, only limited stock exclusion and riparian planting is expected under this scenario and while it may reduce *E. coli* at baseflow, it is unlikely to result in an attribute state improvement at the EPAU scale. Furthermore, *E. coli* concentrations in most reaches in this EPAU are currently in the D attribute state due to 95 %ile concentrations, indicating run-off impacts which may not be effectively controlled by riparian planting alone (critical source area control may also be needed). While significant stock exclusion is not expected under this scenario, widespread space planting and retirement is assumed (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10% of Korokoro catchment; ~25% of Makara Coast and ~35% Ohariu Stream catchment). It is likely that this will reduce the number of stock units in this EPAU and therefore have a small positive effect on the distribution of *E. coli* concentrations. Effect: Small reductions in faecal contamination could lead to a small, but detectable, reduction in health risk to recreational users. However, reductions in risk are unlikely to affect people's perception of the recreational value of the waterways in this EPAU and rivers that are currently unswimmable will likely remain so. Confidence: The panel is confident that *E. coli* concentrations will not increase as there is no intensification assumed under this scenario. They are also in agreement that the assumed rural mitigations are not sufficient to result in an attribute state improvement at the EPAU scale. Observed data are available for one site and modelling data are from a national scale model. Proxy catchment results are not directly transferable due to differences in the amount of stock exclusion.
	Flow	-2	-2	1	Change: Under this scenario mean annual flood is expected to increase significantly throughout this EPAU, with the greatest increases expected in the western catchments. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Note: Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics". Effect: Reductions in MALF in the catchments on the true right of the Hutt River will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. Confidence: As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"
2	Plant growth	+1	+1	1	Change: In the western catchments (Makara Stream, Ohariu Stream etc.) the panel considers that periphyton biomass is likely to decrease as in response to reduced nutrient concentrations and increased shading in reaches running through areas subject to stock exclusion, retirement and space planting. However, the panel believes that biomass in most reaches is unlikely to change an attribute state as: • The spatial extent of stock exclusion and riparian planting is limited; and • Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one periphyton biomass attribute state (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (not even predicted under the Sensitive scenario in the Horokiri proxy catchment). In the catchments on the true right side of the Hutt River periphyton biomass is not expected to change from current, as the benefits of riparian planting, retirement/space planting and nutrient reductions will most likely be offset by the effects of climate change, with reductions in summer low flows (MALF) increasing the risk of periphyton growth through temperature and accrual *Note: All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Effect:	In the western catchments a small reduction in periphyton biomass will likely have a small but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value. As no change is expected in the catchments on the true right side of the Hutt River there is not expected to be an effect.
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	1	Change:	The increased wintertime flood frequency/magnitude and lower summer low flows (catchments on the true right side of the Hutt River only) expected under this scenario will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in sediment input, and associated decreases in cover and turbidity; riparian planting and stock exclusion; widespread retirement/space planting; and small reductions in periphyton biomass (western catchments only) means that there is likely to be a net small improvement in MCI on the EPAU scale. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	This assessment is partly based on the modelled effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by complex relationships between flow, sediment input, plant growth and macroinvertebrate community health.

Tier	Attribute	Change	Effect	Confidence	Narrative	
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+1	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input, riparian management and retirement/space planting; • Water quality – Likely to improve based on reduction in nutrients; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a small detectable improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					Effect:	N/A
					Confidence:	Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+1	N/A	2	Change:	Decreases in *E. coli* concentrations will reduce the health risks to recreational users. Reduced stock access combined with increased riparian planting should also improve people's perceptions of the waterways in this EPAU and reduced sediment input and plant growth (western catchments only) should enhance their aesthetics. However, many of the reaches in this EPAU are currently unsuitable for contact recreation due to faecal contamination and, as this is not expected to change under this scenario, a moderate or significant improvement is unlikely.

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Effect:	N/A
					Confidence:	There is a high level uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for rural mitigations to offset these effects is unclear However, the panel is confident that the direct of change will be positive.

Table 12: Improved expert panel assessment for Assessment unit 5 – Groundwater/ surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+2	+1	2	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 20% under this scenario, and the replacement of 50% of existing roofs constructed from material containing zinc will result in a commensurate reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in copper loads from existing surfaces reducing by 12% to 13% and zinc loads decreasing by between 36% and 37% (depending on the catchment). Significant proportional increases in urban land cover are predicted in this EPAU under this scenario, and the additional load from these surfaces, while 70% lower than under BAU, will offset the reduction in loads from existing impervious surfaces to a degree. Using the scenario assumptions and the CLM outputs, Dr Greer calculated a net change of ~-30% for zinc and -10% for copper, which is supported by the proxy catchment results. Based on these calculations the panel agreed that an attribute state change was likely for zinc but not copper *Note: The panels assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					Effect:	Moderate reductions in zinc concentrations are expected at the EPAU scale, and this will have a small positive effect on macroinvertebrates, fish and ecosystem health. However, moderate effects are unlikely, as the effects of copper toxicity on sensitive species will not change.
					Confidence:	Measured state data comes from just one monitoring site and reach scale state modelling data are not available. However, CLM results are available and can be used to calculate future load reductions. Proxy catchment modelling is also transferable.
	Nitrogen 1	+1	+1	2	Change:	Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of ammonia and nitrate (oxidised from ammonia) across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may have a detectable effect on the distribution of ammonia concentrations in streams in the Valley Floor sub-catchment (frequency of overflows in Waiwhetu sub-catchment is not expected to change). Furthermore, additional total nitrogen loads from new developments will only be 40% of those expected under BAU, and total nitrogen loads from commercial/industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture. Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on nitrate and ammonia concentrations will not change.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						While the urban mitigations described above are likely to reduce ammonia and nitrate concentrations, at the EPAU scale an attribute state change is not expected for either attribute as both are expected to be in the A state in most reaches. Note: *The urban mitigations proposed under this scenario may not have a significant effect on the amount of nitrogen transported into streams via groundwater, which is not constrained by surface water catchment boundaries (Dr Ausseil).*
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects in the Valley Flood sub-catchment.
					Confidence:	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU.
	Nitrogen 2	+1	0	2	Change:	The removal of dry weather wastewater leaks should reduce DIN concentrations in urban streams across all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces and major roads (20% reduction in total nitrogen load from these surfaces), combined with the reduction in wastewater overflow frequency in the Valley Floor sub-catchment, should reduce DIN concentrations during high flow events. Additional total nitrogen loads from new urban developments will also be 40% lower than expected under BAU. Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DIN concentrations will not change. While DIN concentrations in urban streams should decrease, the panel did not consider an attribute change likely at the EPAU scale given the high proportion of reaches already in the A state (~65%[1]), and the large reductions in DIN (>15%[1]) required to shift the significant minority of reaches in the B state to the A state (reduction in Porirua proxy catchment = 10%[1]). Note: *The urban mitigations proposed under this scenario may not have a significant effect on the amount of nitrogen transported into streams via groundwater, which is not constrained by surface water catchment boundaries (Dr Ausseil).*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state

Tier	Attribute	Change	Effect	Confidence	Narrative
					for periphyton growth. The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 10%[1]). Furthermore, a change in nutrient status is unlikely to elicit a plant growth response in macrophyte dominated streams. *Note: The panel is confident if a reduction in DIN does have an impact on periphyton growth, it will be positive.* Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	Change: Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into urban streams across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may have a detectable effect on the distribution of DRP concentrations in the Valley Floor sub-catchment (frequency of overflows to the Waiwhetu sub-catchment is not expected to change). Furthermore, additional total phosphorus loads from new developments will only be 50% of those expected under BAU, and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture. Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DRP concentrations will not change. While the assumed mitigations are likely to reduce DRP concentrations in the urban rivers and streams in this EPAU, an attribute state change is not expected. Analysis conducted by GWRC[1], suggests a 40% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B), and only a 25% reduction was predicted for the Porirua proxy catchment[1]. Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data indicates that this level of reduction is unlikely (reduction in Porirua proxy catchment = 25%[1]). Nevertheless, the panel agree that a 25% reduction in DRP will still have a detectable effect on periphyton biomass, although they did note that it is unlikely to elicit a plant growth response in macrophyte dominated streams. Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	0	0	1	Change: Under this scenario it is assumed that additional sediment loads from new urban developments will only be 20% of those expected under BAU, and sediment loads from existing commercial/industrial paved surfaces and major roads will be reduced by 40% as a result of stormwater capture. While sediment input from impervious surfaces will be decreased under this scenario compared to BAU, increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). On balance, the panel believes that the positive effects of the urban mitigations will offset the detrimental effects of climate change, resulting in no net change. *Note: While they accept the panels assessment, it is still Dr Ausseil's and Mr Farrant's opinion that climate change may still result in an increase in sediment input despite the assumed urban mitigations.* Effect: As no change is expected there is not expected to be an effect. Confidence: This assessment is based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity. While they accept it, Dr Ausseil and Mr Farrant also do not fully agree with the panel's assessment, noting that a -1 change is a more likely outcome.
	Faecal contamination	3	3	2	Change: Under this scenario the following factors will affect *E. coli* concentrations: • The removal of dry weather wastewater leaks which will reduce the input of *E. coli* across all flows; • Additional *E. coli* loads from new developments will only be 10% of those expected under BAU, meaning wet-weather concentrations will not be substantially increased by additional developments; • The elimination of wastewater overflows in all but the four biggest rainfall events per year will reduce wet-weather *E. coli* concentrations in the Valley Floor sub-catchment (frequency of overflows to the Waiwhetu is not expected to change). However, this will probably not affect *E. coli* attribute state as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations; and

Tier	Attribute	Change	Effect	Confidence	Narrative	
						• Rural land-use practices will not shift significantly under this scenario, thus the (likely limited) impact of agricultural land-use on *E. coli* concentrations will not change. Human wastewater contamination is likely the main source of faecal contamination in this EPAU and removing it in all but four events per year should result in the elimination of the majority of the *E. coli* in its rivers and streams. Indeed, it is likely that the only notable remaining faecal contamination will be from stormwater contaminated with non-human sources (e.g. dog and bird faeces), which will only influence 95th percentile concentrations. As such, the panel considers that at an EPAU scale, *E. coli* concentrations are likely to improve two attribute states. This is supported by national scale modelling and analysis conducted by GWRC[1], which suggests that that a 70% *E. coli* reduction (achieved under improved scenario the Porirua proxy catchment) will result in most (~85%) reaches shifting from the D or E states to the B or C states.
					Effect:	Reduced *E. coli* concentrations will noticeably reduce human health risks to recreational users, and the removal of dry-weather human wastewater contamination means the health benefits will be greater than indicated by the panels attribute state change assessment (*E. coli* attribute states are based on the risk of *Campylobacter* infection and do not provide an accurate reflection of risk from other pathogens in rivers and streams contaminated with human wastewater).
					Confidence:	The removal of dry-weather wastewater contamination means that the panel is confident that the direction of change will be positive, and that a two attribute state change is the most likely outcome. Proxy catchment data are transferable, state data comes from one GWRC monitoring site, approximately five territorial authority monitoring sites and national scale models. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-2	-2	1	Change:	Under this scenario mean annual flood is expected to increase by up to 40% due to climate change and MALF is expected to reduce by between 10% and 20%. While the effects of climate change on flow may not be as pronounced in this EPAU compared to the others, they will likely be compounded by the large areas of new impervious surfaces in greenfield developments. *Notes:* • *While numerically this change score is the same as under BAU, the effects of climate change on flow, especially on the magnitude of small to moderate floods, may be less severe under this scenario due to the mitigations in greenfield areas and the installation of rain tanks.* • *Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics". The panel notes that the effects of climate change on flow*

Tier	Attribute	Change	Effect	Confidence	Narrative
					will not be as severe as under BAU, due to mitigation in Greenfield areas and the installation of rain tanks. <u>Effect:</u> Reductions in MALF will: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. <u>Confidence:</u> As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high".
2	Plant growth	0	0	1	<u>Change:</u> At the EPAU scale the panel considers that plant growth is unlikely to change for the following reasons: • **A shift in periphyton biomass attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely. • **Any benefits of reduced nutrients on periphyton biomass will most likely be offset by the effects of climate change** – In isolation, reduced nutrients may result in some within attribute state reduction in periphyton biomass. However, this will be offset by the expected reduction in summer low flows (MALF), which will increase the risk of periphyton growth through increased temperature and accrual. • **Reduced nutrient concentrations are unlikely to affect plant growth in macrophyte dominated streams.** • **Riparian planting is generally not expected. Thus, the effect of light availability on periphyton and macrophyte growth is not expected to change.** *<u>Note:</u> All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*

Tier	Attribute	Change	Effect	Confidence	Narrative	
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	This assessment is largely based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Predicting the response of periphyton biomass to changes in flow, and nutrients is also difficult due to complicated driver-response relationships. Proxy catchment nutrient results are transferable. However, measured state data are not available and reach scale periphyton biomass modelling is based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	1	Change:	The increased wintertime flood frequency/magnitude and lower summer low flows expected under this scenario will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in risk of chronic zinc toxicity and acute ammonia toxicity means that on the EPAU scale there is likely to be a net small improvement in MCI. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	This assessment is based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow, sediment and toxicants due to complicated driver-response relationships.
	Fish diversity	0	0	3	Change:	While the predicted changes in zinc toxicity, acute ammonia toxicity and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.

Tier	Attribute	Change	Effect	Confidence	Narrative
4	Ecosystem health	+1	N/A	1	Change: The panel considered how the following components of ecosystem health are likely to change under this scenario: • Habitat – Unlikely to change as sediment input and riparian management will stay the same; • Water quality – Likely to improve based on reduction in nutrients and toxicants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a small detectable improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	1	Change: The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will noticeably reduce human health risks to recreational users. The removal of wastewater from these streams will also improve people's perception of their recreational value. As sediment input and plant growth is not expected to shift, the aesthetic values of the rivers and streams in this EPAU is unlikely to change although reduced summer flows may have a small adverse effect on recreational value. Effect: N/A Confidence: The panel is highly confident that the removal of dry-weather wastewater contamination and the reduced frequency of wet-weather wastewater contamination (Valley Floor sub-catchment only) will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU. However, there was disagreement over the magnitude of this improvement. It was the view of most of the panel that the lack of change in aesthetic value, combined with the ongoing perception of wastewater contamination due to the four overflows per year meant that a significant improvement in recreational value was unlikely. In contrast, it was Dr Greer's opinion that

Tier	Attribute	Change	Effect	Confidence	Narrative
					most rivers becoming swimmable and the elimination of the vast majority of wastewater contamination constitutes a significant (+3) improvement.

Table 13: Improved expert panel assessment for Assessment unit 6 - Surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+1	+1	1	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 20% under this scenario, and the replacement of 50% of existing roofs constructed from material containing zinc will result in a commensurate reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in total copper loads from existing surfaces reducing by ~15% and total zinc loads decreasing by ~35%. Significant proportional increases in urban land cover are predicted in this EPAU under this scenario, and the additional metal loads from these surfaces will, at least partially, offset the reductions from existing impervious surfaces. Using the scenario assumptions and the CLM outputs, the panel assessed that on the EPAU scale a small but detectable net improvement was the most likely outcome for zinc, while a small detectable degradation was possible for copper. *Notes:* • *Net changes in load were originally calculated by Dr Greer, but these had to be re-calculated during the group assessment due to an error. Accordingly, while the panel considered the re-calculated loads and were comfortable they were 'in the ball park' they did not agree to have them specified in their final assessment.* • *While only small improvements in zinc are expected on an EPAU scale, there is potential for localised moderate improvements in streams running through urban areas where no new development is planned.* • *The panels assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					Effect:	Small reductions in zinc concentration are expected at the EPAU scale, and this will have a commensurate positive effect on macroinvertebrates, fish and ecosystem health. However, moderate effects, even at the local scale, are unlikely as the effects of copper toxicity on sensitive species will not change.
					Confidence:	Measured state data comes from just one monitoring site and reach scale state modelling data are not available. Furthermore, copper and zinc concentrations are likely to change in opposite directions. CLM results are available and can be used to estimate future load reductions. Proxy catchment modelling is also partially transferable.
	Nitrogen 1	+1	+1	2	Change:	Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of ammonia and nitrate (oxidised from ammonia) across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may have a detectable effect on the distribution of ammonia concentrations outside of the Kaiwharawhara and Owhiro Stream catchments (overflow frequency not expected to reduce there). Additional total

<table>
<tr><th>Tier</th><th>Attribute</th><th>Change</th><th>Effect</th><th>Confidence</th><th colspan="2">Narrative</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>nitrogen loads from new developments will also only be 40% of those expected under BAU, and total nitrogen loads from existing commercial/industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture.

While the urban mitigations described above are likely to reduce ammonia and nitrate concentrations, at the EPAU scale an attribute state change is not expected for either parameter as both are expected to be in the A state in most reaches.

<u>Note:</u> Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on nitrate and ammonia concentrations will not change.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td><u>Effect:</u></td><td>Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects outside of the Kaiwharawhara and Owhiro Stream catchments.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td><u>Confidence:</u></td><td>The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement.

Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU.</td></tr>
<tr><td></td><td>Nitrogen 2</td><td>+1</td><td>0</td><td>2</td><td><u>Change:</u></td><td>The removal of dry weather wastewater leaks should reduce DIN concentrations in urban streams across all flows. Furthermore, stormwater capture on existing commercial/industrial paved surfaces and major roads (20% reduction in total nitrogen load from these surfaces), combined with the potential reduction in wastewater overflow frequency in some streams, should reduce DIN concentrations during high flow events. Additional total nitrogen loads from new urban developments will also be 60% lower than expected under BAU.

While DIN concentrations in urban streams should decrease, the panel did not consider an attribute change likely at the EPAU scale given the high proportion of reaches already in the A state (~62%[1]), and the large reductions in DIN (>15%[1]) required to shift the significant minority of reaches in the B state to the A state (reduction in Porirua proxy catchment = 10%[1]).

<u>Note:</u> Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DIN concentrations will not change.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td><u>Effect:</u></td><td>Nutrient criteria modelling conducted by Snelder et al. (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state</td></tr>
</table>

Tier	Attribute	Change	Effect	Confidence	Narrative	
						for periphyton growth. The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 10%[1]). *Note: The panel are confident if a reduction in DIN does have an impact on periphyton growth, it will be positive.*
					Confidence:	The panel are confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	Change:	Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into urban streams across all flows. It is also assumed that wastewater overflows will only occur in the four biggest rainfall events (annually), which may have a detectable effect on the distribution of DRP concentrations in some streams (the frequency of overflows to the Kaiwharawhara and Owhiro streams is not expected to change). Furthermore, additional total phosphorus loads from new developments will only be 50% of those expected under BAU, and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 20% as a result of stormwater capture. While the assumed mitigations are likely to reduce DRP concentrations in the urban rivers and streams in this EPAU, an attribute state change is not expected. Analysis conducted by GWRC[1], suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B), and only a 25% reduction was predicted for the Porirua proxy catchment[1]. *Note: Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DRP concentrations will not change.*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 25%[1]). Nevertheless, the panel agree that a 25% reduction in DRP would still have a detectable effect on periphyton biomass.
					Confidence:	The panel are confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	0	0	1	<u>Change:</u> Under this scenario it is assumed that additional sediment loads from new urban developments will only be 20% of those expected under BAU, and sediment loads from existing commercial/industrial paved surfaces and major roads should be reduced by 40% as a result of stormwater capture. While sediment input from impervious surfaces will be decreased under this scenario, especially when compared to BAU, predicted increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). On balance, the panel believes that the positive effects of the urban mitigations will offset the detrimental effects of climate change, resulting in no net change. <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> This assessment is based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity.
	Faecal contamination	3	3	2	<u>Change:</u> Under this scenario the following factors will affect *E. coli* concentrations: • The removal of dry weather wastewater leaks which will reduce the input of *E. coli* across all flows; • Additional *E. coli* loads from new developments will only be 10% of those expected under BAU, meaning wet-weather concentrations will not be substantially increased by additional developments; • The elimination of wastewater overflows in all but the four biggest rainfall events per year will reduce wet-weather *E. coli* concentrations in some streams (the frequency of overflows to the Owhiro and Kaiwharawhara streams is not expected to change). However, this will probably not affect *E. coli* attribute state as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations; and • Rural land-use practices will not shift significantly under this scenario, thus the (likely limited) impact of agricultural land-use on *E. coli* concentrations will not change. Human wastewater contamination is likely the main source of faecal contamination in this EPAU and removing it in all but four events per year should result in the elimination of the majority of the *E. coli* in its rivers and streams. Indeed, it is likely that the only notable remaining faecal contamination will be from stormwater contaminated with non-human sources (e.g. dog and bird faeces), which will only influence 95th percentile concentrations. As such, the panel considers that at an EPAU scale,

Tier	Attribute	Change	Effect	Confidence	Narrative
					E. coli concentrations are likely to improve two attribute states. This is supported by national scale modelling and analysis conducted by GWRC[1], which suggests that that a 70% *E. coli* reduction (achieved under improved scenario the Porirua proxy catchment) will result in most (~85%) reaches shifting from the D or E states to the B or C states. <u>Effect:</u> Reduced *E. coli* concentrations will noticeably reduce human health risks to recreational users, and the removal of dry-weather human wastewater contamination means the health benefits will be greater than indicated by the panels attribute state change assessment (*E. coli* attribute states are based on the risk of *Campylobacter* infection and do not provide an accurate reflection of risk from other pathogens in rivers and streams contaminated with human wastewater). <u>Confidence:</u> The removal of dry-weather wastewater contamination means that the panel are confident that the direction of change will be positive, and that a two attribute state change is the most likely outcome. Proxy catchment data are transferable, state data comes from one GWRC monitoring site, approximately ten territorial authority monitoring sites and national scale models. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-2	-2	1	<u>Change:</u> Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River. The effects of climate change on flow will be compounded by an increase in impervious surface area. *<u>Note:</u> Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics"* <u>Effect:</u> Reductions in MALF in the catchments on the true right of the Hutt River will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high". There is also uncertainty around the location of infill housing within Wellington City, which makes it difficult to determine how flow will change in different parts of the EPAU.
2	Plant growth	0	0	1	Change: At the EPAU scale the panel considers that periphyton biomass is unlikely to change for the following reasons: • **A shift in state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely. • **Any benefits of reduced nutrients on periphyton biomass in the catchments in the true right of the Hutt River will most likely be offset by the effects of climate change** – In isolation, reduced nutrients may result in some within attribute state reduction in periphyton biomass in these streams. However, this will be offset by the expected reduction in summer low flows (MALF), which will increase the risk of periphyton growth through increased temperature and accrual. • **Riparian planting is generally not expected. Thus, the effect of light availability on periphyton growth is not expected to change.** *Note: All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*
					Effect: As no change is expected there is not expected to be an effect.
					Confidence: This assessment is largely based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Predicting the response of periphyton biomass to changes in flow, and nutrients is also difficult due to complicated driver-response relationships. Proxy catchment nutrient results are transferable. However, measured state data are only available for one site and reach scale periphyton biomass modelling is based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	1	Change: The increased wintertime flood frequency/magnitude and lower summer low flows expected under this scenario due to climate change will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, small reductions in risk of chronic zinc toxicity and acute

<table>
<tr><th>Tier</th><th>Attribute</th><th>Change</th><th>Effect</th><th>Confidence</th><th colspan="2">Narrative</th></tr>
<tr><td rowspan="6"></td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td></td><td>ammonia toxicity means that on the EPAU scale there is likely to be a net small improvement in MCI. The panel notes, however, that this improvement is not likely to be as large as expected for Assessment Unit 5.

<u>Note:</u> The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.</td></tr>
<tr><td><u>Effect:</u></td><td>Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A detectable improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.</td></tr>
<tr><td><u>Confidence:</u></td><td>This assessment is based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow and toxicants due to complicated driver-response relationships.</td></tr>
<tr><td rowspan="3">Fish diversity</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">3</td><td><u>Change:</u></td><td>While the predicted changes in zinc toxicity, acute ammonia toxicity and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.</td></tr>
<tr><td><u>Effect:</u></td><td>As no change is expected there is not expected to be an effect.</td></tr>
<tr><td><u>Confidence:</u></td><td>The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.</td></tr>
<tr><td>4</td><td>Ecosystem health</td><td>+1</td><td>N/A</td><td>1</td><td><u>Change:</u></td><td>The panel considered how the following components of ecosystem health are likely to change under this scenario:
Habitat – Unlikely to change as sediment input and riparian management will stay the same;
Water quality – Likely to improve based on reduction in nutrients and toxicants;
Water quantity – Likely to degrade based on climate change predictions; and
Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source.
Overall, the panel agrees that a small detectable improvement is likely at the EPAU scale

<u>Notes:</u>
Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.</td></tr>
</table>

Tier	Attribute	Change	Effect	Confidence	Narrative
					• *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	1	Change: The elimination of dry-weather wastewater leaks and the reduction in overflow frequency in some streams will noticeably reduce human health risks to recreational users. The removal of wastewater from these streams will also improve people's perception of their recreational value. As sediment input and plant growth is not expected to change, the aesthetic values of the rivers and streams in this EPAU is unlikely to change although reduced summer flows in the catchments on the true right of the Hutt River may have a small adverse effect on recreational value. Effect: N/A Confidence: The panel is highly confident that the removal of dry-weather wastewater contamination and the reduced frequency of wet-weather wastewater contamination (not expected in the Kaiwharawhara or Owhiro catchments) will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU. However, there was disagreement over the magnitude of this improvement. It was the view of most of the panel that the lack of change in aesthetic value, combined with the ongoing perception of wastewater contamination during the four overflows per year meant that a significant improvement in recreational value was unlikely. In contrast, it was Dr Greer's opinion that most rivers becoming swimmable and the elimination of the vast majority of wastewater contamination constitutes a significant (+3) improvement.

Table 14: Sensitive expert panel assessment for Assessment unit 1 – Headwater urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+1	0	2	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 50% to 80% under this scenario, and the replacement of all existing roofs constructed from material containing zinc will result in a 97% reduction in zinc load from these surfaces. Based on the available contaminant load model data this should result in copper loads from existing surfaces reducing by 6% to 12% (depending on the catchment) and zinc loads decreasing by between 71% and 80%. However, significant proportional increases in urban land cover are predicted under this scenario in both the Karori and Wainuiomata catchments, and the additional load from these surfaces, while less than expected under BAU (assumed to be at least 70% based on the Improved scenario assumptions), will at least partially offset the reduction in loads from existing impervious surfaces. The potential for reduced loads from existing impervious surfaces to be offset by new urban development, combined with the fact that urban development is located near the top of relatively (in relation to urban landcover) large catchments means that the panel expects only small detectable decreases in zinc concentrations at the EPAU scale. They also expect that any change in copper concentration to be negligible. *Note: While only small improvements in zinc are expected on an EPAU scale, there is potential for localised significant improvements in the streams draining existing urban areas. The panels assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					Effect:	As only small reductions in zinc concentration are expected at the EPAU scale and copper concentrations are not expected to change, the overall effect on macroinvertebrates, fish and ecosystem health are likely to be negligible. *Note: There is potential for localised moderate positive effects in the streams draining existing urban areas. Significant localised effects resulting from reductions in zinc are unlikely, as the effect of copper toxicity on sensitive species will not change.*
					Confidence:	There was some disagreement among the panel about the magnitude of the potential change in zinc concentrations, with half the panel originally recording a +2 score and the other half recording a +1. Nevertheless, the panel is highly confident in the direction of change, and the potential for moderate localised improvements in zinc concentration. State data are limited, and proxy catchment data are not transferable.
	Nitrogen 1	+1	+1	2	Change:	**Changes in urban area**

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Under this scenario, it is assumed that dry weather wastewater leaks are removed which will reduce the input of ammonia and nitrate (oxidised from ammonia) into both the Karori Stream and Wainuiomata River at all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may have a detectable effect on the distribution of ammonia concentrations in the Wainuiomata catchment (frequency of overflows in Karori is not expected to change). Additional total nitrogen loads from new developments will also be significantly lower than those expected under BAU (reduction assumed to be at least 40% based on the Improved scenario assumptions), and total nitrogen loads from commercial/industrial paved surfaces and major roads should be reduced by 40% to 60% as a result of stormwater capture. **Changes in rural area** Extensive riparian management is expected under this scenario in the Wainuiomata catchment, and the predicted ten metre vegetated buffer is likely to be very effective (70%-90% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads to the targeted reaches. 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired under this scenario. However, this land is unlikely to be a major nitrogen source and any resulting changes in nitrate concentrations are likely to be limited. **Overall assessment** The assumed urban and rural mitigations are likely to reduce ammonia and nitrate concentrations in the rivers and streams in the Karori and Wainuiomata catchment. While the magnitude of this reduction is unclear, at the EPAU scale an attribute state change is not expected for either attribute, as both are likely to be in the A state in most reaches *Note: the GWRC monitoring site in the upper Karori is in the B attribute state for nitrate toxicity*.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects in urban streams in the Wainuiomata catchment.
					Confidence:	Proxy catchment data are not transferable and state data comes largely from national scale models. However, the panel is still confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement.
	Nitrogen 2	+1	0	2	Change:	The removal of dry weather wastewater leaks in both the Karori and Wainuiomata, should reduce DIN concentrations at all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces

Tier	Attribute	Change	Effect	Confidence		Narrative
						and major roads (40%-60% reduction in total nitrogen load from these surfaces), combined with the reduction in wastewater overflow frequency in the Wainuiomata catchment, should reduce DIN concentrations in urban streams during high flow events. Additional total nitrogen loads from new urban developments will also be significantly lower than expected under BAU (reduction assumed to be at least 40% based on the Improved scenario assumptions). Regarding the effects of the rural mitigations, the extensive riparian management expected under this scenario in the Wainuiomata catchment is likely to be very effective (70%-90% (Parkyn, 2004)) at reducing sub-surface and surface nitrogen loads to the targeted reaches. However, land retirement is not expected to have a noticeable effect on DIN concentrations in the Karori or Wainuiomata catchments. In short, the urban and rural mitigations expected under this scenario are likely to reduce DIN concentrations through much of the Karori and Wainuiomata catchments. However, at the EPAU scale an attribute state change is not expected as most reaches (96%) are already in the A state. *Note: The GWRC monitoring site in the upper Karori is in the D attribute state, and national scale modelling suggests most of the surrounding reaches are either in the B or C state.*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests that at least a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The panel considers that such a reduction in TN is unlikely at the EPAU scale. *Note: While a 15% reduction in TN was predicted for the Horokiri proxy catchment, these data are not are transferable to this EPAU as there is far less retirement expected in the Karori and Wainuiomata catchments.*
					Confidence:	Proxy catchment data are not transferable and state data comes largely from national scale models. However, the panel is still confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua.
	Phosphorus	+2	+1	2	Change:	**Changes in the urban area** Under this scenario, it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into the Karori and Wainuiomata catchments at all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may have a detectable effect on the distribution of DRP concentrations in the Wainuiomata catchment (frequency of overflows in Karori is not expected to change). Additional total phosphorus loads from new

Tier	Attribute	Change	Effect	Confidence	Narrative
					developments will be significantly less than those expected under BAU (reduction assumed to be at least 50% based on the Improved scenario assumptions), and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 40% to 60% as a result of stormwater capture. **Rural area** Extensive riparian management is expected under this scenario in the Wainuiomata catchment, and the predicted 10 metre vegetated buffer is likely to be very effective at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff (50%- 55% assumed based on proxy catchment modelling assumptions and Parkyn (2004)). 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired under this scenario which will further reduce DRP concentrations. **Overall assessment** Urban and rural mitigations are likely to reduce DRP concentrations in the rivers and streams in this EPAU, and an attribute state change is expected at the EPAU scale. Analysis conducted by GWRC[1], suggests that a 25% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B).While not directly transferable to this EPAU, the available urban and rural proxy catchment data suggests that this level of improvement is possible (25% and 40% reduction in Porirua and Horokiri proxy catchments respectively). Accordingly, the panel considers that there is potential for a +2 change despite the naturally high phosphorus levels in the Wainuiomata catchment.
					Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most reaches to shift one DRP attribute state for periphyton growth (C to B). A reduction of this magnitude was not even predicted for the Horokiri proxy catchment under this scenario, despite the far greater level of land retirement in that catchment compared to this EPAU. Thus, while the panel considers that a reduction in DRP will reduce periphyton growth rates, they do not consider that it will result in a change in periphyton biomass attribute state at the EPAU scale.
					Confidence: Proxy catchment data are not directly transferable and state data comes largely from national scale models. There is also uncertainty around the potential for DRP concentrations to reduce significantly in the Wainuiomata catchment, given the naturally high background levels. However, the panel is still confident that the direction of change will be positive, and that the extent of the rural and urban mitigations means that an attribute state change is possible.

Tier	Attribute	Change	Effect	Confidence	Narrative
					[1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+2	+1	1	Change: **Improvements in urban area** Under this scenario it is assumed that additional sediment loads from new developments will be significantly less than those expected under BAU (reduction assumed to be at least 80% based on the Improved scenario assumptions), and that sediment loads from existing commercial/industrial paved surfaces and major roads will be reduced by 75% to 90% due to stormwater capture. Stormwater retention/rain tanks in both new and existing developments will also shift the frequency of channel forming flows closer to pre-development state (Ferguson, 2018), and this will reduce the bank erosion component of sediment load in urban streams. **Improvements in rural area** The extensive riparian management expected under this scenario in the Wainuiomata catchment is likely to be very effective at reducing the amount of sediment entering the targeted reaches via runoff. The exact degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge. In addition to reducing sediment input from run-off, stock exclusion will also significantly reduce bank erosion (proxy catchment modelling 80% reduction in stream bank erosion component of sediment load delivered to the targeted reaches). 8% of the Karori catchment and 1% of the Wainuiomata catchment are expected to be retired under this scenario which will further reduce sediment input from slope erosion. **Detrimental effects of climate change** Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). **Overall assessment** Urban and rural mitigations are likely to reduce sediment input into the rivers and streams in this EPAU, and these reductions are likely to be greater than expected under Improved as: • The extent of stock exclusion is slightly greater; • Riparian vegetation should be more effective at stripping sediment from run-off (ten metre vs. five metre buffer width); and • Land that was to be spaced planted under Improved will be retired. While the benefits of the assumed mitigations will be partially offset by the effects of climate change, their extent and effectiveness mean that the panel still considers a moderate improvement in sediment input likely.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Effect: Reduced sediment input should improve deposited fine sediment cover, water clarity and turbidity. In many of the smaller streams in this EPAU, deposited fine sediment cover and turbidity are high, both in absolute terms (deposited sediment cover only) and relative to reference state. Thus, any reduction in sediment load in these systems could well have positive effects on ecosystem health and recreational value. However, through much of the EPAU deposited sediment is unlikely to be a major determinant of ecosystem health (generally <20% deposited cover) and only small reductions in sediment load are expected. Accordingly, it is the panel's view that a weak positive effect is the most likely outcome.
					Confidence: The panel's change assessment relies on the modelled effects of climate change on flow presented in the memorandum entitled "Predicted impact of climate change on key hydrological statistics". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity.
	Faecal contamination	+2	+3	1	Change: **Changes in urban area** Under this scenario, it is assumed that dry weather wastewater leaks are removed which will reduce the input of *E. coli* to the urban streams the Karori and Wainuiomata catchments at all flows. Furthermore, additional *E. coli* loads from new developments will significantly less than those expected under BAU (reduction assumed to be at least 90% based on the Improved scenario assumptions). It is assumed that wastewater overflows will only occur in the two biggest rainfall events (annually). While this is a significant reduction in the Wainuiomata catchment (frequency of overflows in Karori is not expected to change), it will probably not result in a change in *E. coli* attribute state, as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations. **Rural area** Extensive riparian management is expected under this scenario in the lower Wainuiomata catchment which should significantly reduce both dry-weather and wet-weather *E. coli* concentrations. The assumed stock exclusion practices should reduce direct faecal input from stock into the targeted reaches. Furthermore, compared to the five-metre buffer assumed under the Improved scenario, a ten metre planted riparian margin is likely to be far more effective at reducing the input of *E. coli* during rain events. The additional width will not only increase the amount of sediment bound *E. coli* that will be filtered from run-off by the vegetation, but should also increase the amount of supernatant *E. coli* that infiltrates into the ground before reaching the stream.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						8% of the Karori catchment and 1% of the Wainuiomata catchment are also expected to be retired under this scenario which will further reduce *E. coli* input. **Overall assessment** A high proportion of baseflow faecal contamination will be eliminated under this scenario by the removal of dry-weather wastewater leaks and stock exclusion (Wainuiomata only, unlikely to currently be a problem in Karori). The removal of wastewater overflows (Wainuiomata only), and stormwater capture from commercial/industrial paved surfaces and major roads (e.g. removal of non-human sources e.g. dog poo) will also reduce wet-weather *E. coli* concentrations in the urban areas, as will riparian planting in the lower Wainuiomata River catchment. National scale modelling and analysis conducted by GWRC[1] suggests that that a 70% *E. coli* reduction (achieved under improved scenario in both Horokiri and Porirua proxy catchments) will result in most (~80%) of the reaches that are currently unswimmable becoming swimmable. However, based on the same GWRC analysis, most of the panel does not consider that a two-attribute state improvement is likely.
					Effect:	Reduced *E. coli* concentrations will significantly reduce human health risks to recreational users. This is especially true in urban streams where human wastewater contamination will effectively be eliminated (greater positive effect than indicated by the attribute state change).
					Confidence:	The removal of human and agricultural faecal contamination means the panel is confident that the direction of change will be positive. The panel agree that a one-attribute state is the most likely outcome (+2); however, Dr Greer, Dr Ausseil and Mr Farrant consider that a two-attribute state change is possible (+3). The effects of riparian planting on wet-weather *E. coli* concentrations are also poorly understood. State data comes from two GWRC monitoring sites, approximately five territorial authority monitoring sites and national scale models. Proxy catchment data are not directly transferable [1]Modelling of E. coli reductions in the Whaitua.
	Flow	-2	-2	1	Change:	Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, MALF is expected to reduce by between 10% and 20% in the Wainuiomata catchment. While the panel acknowledges that the urban mitigations assumed under this will have some localised benefits on flow (Ferguson, 2018), they do not expect them to offset the effects of climate change at the EPAU scale as impervious surface cover represents only a small proportion of the total area of the Karori and Wainuiomata catchments. *Notes:*

Tier	Attribute	Change	Effect	Confidence	Narrative	
						• *Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological* statistics*".* • *The increase in impervious* surface *area is considered too small in relation to catchment size to have a noticeable effect on flow at the EPAU scale.*
					Effect:	Reductions in MALF in the Wainuiomata catchment will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods.
					Confidence:	As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"
2	Plant growth	+1	+1	1	Change:	At the EPAU scale the panel considers that while periphyton biomass will improve, it is unlikely to change attribute state for the following reasons: • **A shift in attribute state due to nutrient reductions is unlikely** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests that a >15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely. • **The benefits of riparian planting in the Wainuiomata catchment will most likely be offset by the effects of climate change** – Increased shading (and associated reductions in temperature) may reduce the risk of periphyton growth in the reaches targeted for riparian planting (five metre of riparian planting provides effective shading in streams <15 metres wide). However, on the other hand the expected reduction in summer low flows (MALF) will increase the risk of periphyton growth through increased temperature and accrual. *Note: All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.*

Tier	Attribute	Change	Effect	Confidence	Narrative
					Effect: A small reduction in periphyton biomass in this EPAU will likely have a small but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value. Confidence: This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+2	+1	1	Change: As under BAU and Improved, the increased wintertime flood frequency/magnitude and lower summer low flows (Wainuiomata Catchment only) expected under this scenario due to climate change will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in sediment input and associated decreases in deposited sediment cover and turbidity; the extensive riparian planting in the Wainuiomata catchment; reduced periphyton biomass and the localised reductions in the risk of acute ammonia toxicity and chronic zinc toxicity in urban areas means that, on the EPAU scale, there is likely to be a net moderate improvement in MCI. This change is a larger than that predicted under the Improved scenario, which is a result of the greater reductions in metal concentrations, sediment input and plant growth under this scenario. *Notes:* • *While MCI will improve (+1) in reaches running through the rural parts of the Karori catchment, the panel considers an attribute state improvement is unlikely due to an absence of riparian planting;* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.* Effect: Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A moderate improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely Confidence: This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow, shading, sediment and toxicants due to complicated driver-response relationships

Tier	Attribute	Change	Effect	Confidence	Narrative
	Fish diversity	0	0	3	Change: While the predicted changes in metal concentrations, sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species. Effect: As no change is expected there is not expected to be an effect. Confidence: The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+2	N/A	1	Change: The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input, and riparian management; • Water quality – Likely to improve based on reduction in nutrients and contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a moderate improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+3	N/A	2	Change: The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will noticeably reduce human health risks to recreational users. The complete elimination of almost all wastewater contamination from these streams will also significantly improve people's perception of their recreational value. Reduced stock access combined with increased riparian planting in the Wainuiomata River will noticeably reduce human health risk and increase the rivers recreational value, despite reductions in summer low flows. Reduced sediment input should also improve aesthetics throughout the EPAU.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Effect: N/A Confidence: There is a high level of uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for the urban and rural mitigations to offset these effects is unclear. However, the panel is confident that the removal of dry-weather wastewater contamination, the reduced frequency of wet-weather wastewater contamination (Wainuiomata catchment only) and the significant stock exclusion and riparian planting (Wainuiomata catchment only) will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Table 15: Sensitive expert panel assessment for Assessment unit 2 – Hutt main stem

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+1	0	3	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by between 50% and 80% under this scenario, and the replacement of all existing roofs constructed from material containing zinc will result in a 97% reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in copper loads from existing surfaces reducing by ~15% at the catchment scale and zinc loads decreasing by ~56%. While additional development will offset the benefits of the assumed mitigations to some extent, both copper and zinc loads delivered to the Hutt River from Assessment Unit 5 (Groundwater/surface water fed predominantly urban streams) are expected to significantly decrease, as are zinc loads from Assessment Unit 6 (Surface water fed predominantly urban streams). As such, the panel considers that a small net improvement is likely for both parameters. However, as the relatively small amount of existing urban landcover (~6% of catchment area) in the catchment is not having a marked effect on current dissolved metal concentrations (< ANZECC 95% protection guideline (Greer, 2018)), it is unlikely that the proposed mitigations, or the small (~10%) expected increase in impervious surface area, will result in an attribute state change.
					Effect:	The panel considers it unlikely that copper or zinc concentrations will improve more than an attribute change. Thus, the risk of toxicity effects will be largely unchanged and will remain low at the EPAU scale. However, a reduction in localised acute toxicity effects near stormwater outfalls is possible.
					Confidence:	The panel is confident that copper and zinc concentrations will decrease and are confident that this decrease will be detectable. Monitoring data are available for two sites but reach scale modelling of state has not been conducted and proxy catchment data are not transferable.
	Nitrogen 1	+1	+1	2	Change:	Reductions in nitrogen loads from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination from urban areas) should reduce nitrogen and ammonia concentrations in the Hutt Mainstem, as should the 83% reduction in overflow frequency at the Silverstream Stormwater Tank. While these reductions are likely to be greater than those predicted under Improved, an attribute state change is still not expected as concentrations of both parameters are already in the A state.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency at the Silverstream Stormwater Tank could reduce localised acute ammonia toxicity effects.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are not transferable. However, measured state data is available for three sites, and national scale models are available.
	Nitrogen 2	+1	+1	2	Change: Nitrogen loads discharged to the Hutt River from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce under this scenario, and concentrations in the Mainstem should decrease as a result. While these reductions are likely to be greater than those expected under Improved, an attribute state change is not possible as all reaches are already in the A state Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The available proxy catchment data, while not directly transferable to this EPAU, suggests that this level of reduction is unlikely. While a 15% reduction in TN was predicted for the Horokiri proxy under this scenario, rural mitigations were assumed to apply to a far greater percentage of that catchment than this EPAU. *Notes:* • *The panel is confident that if a reduction in DIN does have an impact on periphyton growth, it will be positive.* • *A reduction in DIN may reduce the frequency and magnitude of cyanobacteria blooms at multiple locations, such as downstream of the Pakuratahi and Mangaroa confluences and at Silverstream (Dr Heath). However, this is by no means* certain. Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are not transferable. However, measured state data is available for three sites, and national scale models are available. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	Change: Reductions in phosphorus loads from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce DRP concentrations in the Hutt Mainstem. While these reductions are likely to be greater than those predicted under Improved, the panel still did not consider an attribute change likely given the high proportion of reaches already in the A state (~45%[1]). Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a >40% reduction in DRP would be needed for most sites to shift one DRP attribute

Tier	Attribute	Change	Effect	Confidence	Narrative	
						state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely. Only a 40% reduction in DRP was predicted for the Horokiri proxy under this scenario, and rural mitigations were assumed to apply to a far greater percentage of that catchment than this EPAU.
					Confidence:	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are not directly transferable. However, measured state data is available for three sites, and national scale models are available. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	Change:	Sediment input to the Hutt River from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = stormwater management) should reduce under this scenario, and load in the Mainstem should decrease as a result. However, increased flood frequency/magnitude in the wider catchment due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). On balance, the panel considers that a small detectable reduction in sediment load is the most likely outcome at the EPAU scale, and that this reduction will be greater than predicted under Improved.
					Effect:	Small decreases in sediment input should improve deposited fine sediment cover, water clarity and turbidity, which impact ecosystem health and/or recreational value. However, at present these parameters are generally in a good state (fine sediment cover <20%; fine sediment cover and turbidity in the Draft NPS-FM A state), and any improvements are likely to be small.
					Confidence:	The panels confidence is low due to difficulties in predicting how stock exclusion in the Mangaroa will affect sediment load in the Hutt River, uncertainty associated with hydrological modelling from downscaled climate change models and a limited understanding of how climate change will affect the delivery of sediment from other catchments.
	Faecal contamination	+3	+3	2	Change:	*E. coli* loads discharged to the Hutt River from Assessment Units 3 through 6 (3/4 = stock exclusion, riparian planting and retirement; 5/ 6 = removal of wastewater contamination) should reduce under this scenario. Thus, concentrations in the Main Steam are also likely to reduce. While the scale of this reduction is difficult to predict, based on the extent of the proposed urban and rural mitigations, the panel considers a two-attribute state improvement is likely. This is supported by national scale modelling and analysis conducted by GWRC[1] which suggests that the 70% reduction in *E. coli* predicted for the Horokiri proxy catchment and the 80% reduction predicted for the Porirua catchment would both be sufficient to shift 96% of reaches in the C. D and E attribute states to the A and B attribute states.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Effect: Reduced *E. coli* concentrations will significantly reduce human health risks to recreational users. This is especially true in reaches in the urban area, where dry-weather human wastewater contamination will be removed (greater positive effect than indicated by the attribute state change). Confidence: There is monitoring data from three sites to support the results of the national scale state models and the extent of the predicted urban and rural landcover means the panel is confident concentrations will decrease. Nevertheless, proxy catchment modelling is not directly transferable. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-1	-1	2	Change: Under this scenario mean annual flood is not expected to increase due to climate change but MALF is expected to reduce by between 10% and 20% under some emissions pathways. Effect: Reductions in MALF will likley: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. *Note: The severity of these effects may be compounded by water allocation.* Confidence: This assessment is primarily based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	0	0	1	Change: At the EPAU scale the panel considers that periphyton biomass is unlikely to change for the following reasons: • **A shift in attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (B to A). The available proxy catchment data, which is not directly transferable to this EPAU, suggests that this level of reduction is unlikely. • **Any benefits of reduced nutrients on periphyton biomass will most likely be offset by the effects of climate change** – In isolation, reduced nutrients may result in some within attribute state reduction in periphyton biomass. However, this will be offset by the expected reduction in summer low flows (MALF), which will increase the risk of periphyton growth through increased temperature and accrual. *Notes:*

Tier	Attribute	Change	Effect	Confidence	Narrative	
						• *All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.* • *Decreases in DIN, DRP and sediment input may result in the frequency and magnitude of cyanobacteria blooms being reduced (Dr Heath). However, there is low level of confidence in this assessment.*
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	0	0	1	Change:	The reductions in summer low flows expected under this scenario due to climate change will have an adverse effect on macroinvertebrate community health throughout this EPAU. While reductions in sediment input and the risk of localised metal and ammonia toxicity effects will offset these effects, at the EPAU scale the panel considers that a change in MCI is unlikely. They do, however, note that moderate improvements may occur near the outfalls of stormwater discharges and the Silverstream Stormwater Tank. Note: *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of macroinvertebrates, to changes in flow, sediment and toxicants due to complicated driver-response relationships.

Tier	Attribute	Change	Effect	Confidence	Narrative
	Fish diversity	0	0	3	Change: While the predicted changes in flow, sediment input and localised metal and ammonia toxicity effects may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species. Effect: As no change is expected there is not expected to be an effect. Confidence: The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	0	N/A	1	Change: The panel considered how the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input; • Water quality – Likely to improve based on reduction in nutrients and contaminants; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to remain unchanged based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a detectable change is unlikely at the EPAU scale. *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+3	N/A	3	Change: The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will significantly reduce human health risks to recreational users', as will the reduction in agricultural faecal contamination from the Assessment Units 3 and 4.The removal of wastewater will also improve people's perception of the recreational value of the lower reaches, and reduced sediment input will improve the aesthetics of the river. There is also a possibility that the frequency and magnitude of cyanobacteria blooms may decrease, although this is by no means certain. Effect: N/A

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panel is confident that the urban and rural mitigations assumed under this scenario will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Table 16: Sensitive expert panel assessment for Assessment unit 3 – Mangaroa/Pakuratahi Valleys

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+1	0	2	Change:	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 50% to 80% under this scenario, and there may be a detectable localised reduction in copper and zinc concentrations in the Pakuratahi River below SH2. For the rest of the EPAU detectable changes in copper and zinc concentration are not expected due to the limited amount of existing impervious surface cover (limited potential for improvements through treatment), and the lack of urban intensification expected under this scenario. *Note: The Te Marua area was not considered as part of this assessment as it influences the Hutt mainstem more than the major surface water bodies in the EPAU.*
					Effect:	For most of this EPAU there is not expected to be an effect as concentrations are not expected to change. While a detectable reduction in dissolved metal concentrations is possible in the Pakuratahi River below SH2, it is also unlikely that this will have an effect as the risk of chronic toxicity effects is probably already low.
					Confidence:	While state data are limited, the limited amount of impervious surface cover and the lack of any urban intensification under this scenario means that for most of the EPAU the panel are highly confident that copper and zinc concentrations will not change from current. The panel is also confident that media treatment of stormwater from SH2 will reduce dissolved metal concentrations in the lower Pakuratahi. However, it is uncertain whether these reductions will be detectable, as current state is not known (concentrations may well be below laboratory detection limits).
	Nitrogen 1	+1	+1	2	Change:	Extensive riparian management is expected under this scenario in both the Mangaroa and Pakuratahi catchments, and the assumed ten metre vegetated buffer is likely to be very effective (70-90% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads delivered to the targeted reaches. This combined with extensive retirement (~14% of Mangaroa catchment and 2.2% of Pakuratahi catchment) will reduce nitrate concentrations, and these reductions will be greater than under Improved. However, at the EPAU scale an attribute state change is not expected, as all reaches are likely to already be in the A state. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means that for the most part ammonia concentrations will not change from current. However, very localised reductions may occur at crossing points.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change by an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed

Tier	Attribute	Change	Effect	Confidence	Narrative	
						effluent etc.) in this EPAU means the risk of acute ammonia toxicity effects will also not change from current
					Confidence:	The level of rural mitigation under this scenario means that the panel are confident that the direction of change will be positive. They are also confident that current state of ammonia and nitrate concentrations precludes an attribute state shift for these parameters. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is partially transferable.
	Nitrogen 2	+2	+2	2	Change:	The extensive riparian management expected under this scenario should be very effective (70%-90% (Parkyn, 2004)) at reducing sub-surface and surface nitrogen loads to the targeted reaches, as should the assumed retirement (~14% of Mangaroa catchment and 2.2% of the Pakuratahi catchment). As such, DIN concentrations should reduce throughout the EPAU, and these reductions should be greater than expected under Improved. All things considered; the panel believes an attribute change is likely in the ~45% of reaches not currently in the A state[1]. Notes: • *When making this assessment the panel was aware that it contradicts analysis conducted by GWRC[1], which suggests that the 15% reduction in DIN predicted for the Horokiri proxy catchment would not result in an attribute state improvement in most reaches.* • *Nitrogen input to the lower Mangaroa River from the surrounding peatland will not be reduced under this scenario (Dr Heath).*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth (B to A). The available proxy catchment data suggests that this level of reduction is likely (predicted under the Sensitive scenario in the Horokiri catchment). Note: *A reduction in DIN alone is unlikely to result in a periphyton biomass attribute state change (Dr Heath).*
					Confidence:	The panel is confident in the direction of change and agree that an attribute state improvement is likely. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+2	+1	2	Change:	Extensive riparian management is expected throughout this EPAU under this scenario, and the predicted 10 metre vegetated buffer is likely to be very effective at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff (50-55% assumed based on proxy catchment modelling assumptions and Parkyn (2004)). 14.4% of the Mangaroa catchment and 2.2%

Tier	Attribute	Change	Effect	Confidence		Narrative
						of the Pakuratahi catchment are also expected to be retired under this scenario which will further reduce DRP inputs. Analysis conducted by GWRC[1], suggests a 40% reduction in DRP would result in ~95% of reaches shifting one DRP attribute state (generally C to B), but would not result in any reaches improving two attribute states. A 40% reduction in DRP was the expected outcome in the Horokiri proxy catchment under this scenario. Thus, the panel considers a one attribute state change the most likely outcome for this EPAU, given its similarities in expected retirement and space planting with the Horokiri proxy catchment, and the far greater level of assumed stock exclusion.
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely. Thus, while the panel considers that a reduction in DRP under this scenario will reduce periphyton growth rates, and that these reductions in growth will be greater than those expected under Improved, they do not consider that it will be sufficient to result in a change in periphyton biomass attribute state at the EPAU scale.
					Confidence:	The panel is confident that DRP concentrations will decrease, and that any change will be limited to a single attribute state. State data comes from monitoring at two sites and national scale modelling. Proxy catchment data is transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+2	+2	2	Change:	**Improvements due to mitigations** Stock exclusion will reduce the amount of sediment entering waterways via bank erosion, and the ten-metre riparian margin will likely be very effective at reducing the amount of sediment entering the targeted reaches via runoff. The exact degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge, and the proxy catchment modelling assumes that the stream bank erosion component of the sediment load to the targeted reaches will be reduced by 80%. The extent of stock exclusion under this scenario is slightly more than under Improved, and riparian vegetation should also be more effective at stripping sediment from run-off. 14.4% of the Mangaroa catchment and 2.2% of the Pakuratahi catchment are expected to be retired under this scenario which will further reduce sediment input from slope erosion **Detrimental effects of climate change**

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). **Overall assessment**. Rural mitigations are likely to reduce sediment input into the rivers and streams in this EPAU. However, a significant improvement is not expected as any improvements resulting from these mitigations will be partially offset by the effects of climate change on flood frequency/magnitude.
					Effect:	Both deposited sediment and turbidity are high in many of the reaches in this EPAU and improvements in these measures resulting from moderate reductions in sediment input will result in commensurate benefits to ecosystem health and recreational value.
					Confidence:	Both deposited sediment and turbidity are high in many of the reaches in this EPAU. Reductions in these metrics due to moderate decreases in sediment input will result in commensurate improvements to ecosystem health and recreational value.
	Faecal contamination	+3	+3	2	Change:	14.4% of the Mangaroa catchment and 2.2% of the Pakuratahi catchment are expected to be retired under this scenario which will reduce *E. coli* input from that land. The stock exclusion practices under this scenario should also reduce direct faecal input from stock in streams. Furthermore, compared to the five-metre buffer assumed under the Improved scenario, a ten-metre planted riparian margin is likely to be far more effective at reducing the input of *E. coli* during rain events. The additional width will not only increase the amount of sediment bound *E. coli* that will be filtered from run-off by the vegetation, but it should increase the amount of supernatant *E. coli* that infiltrates into the ground before reaching the stream. Extensive riparian management is expected under this scenario in the Mangaroa and Pakuratahi Rivers which should significantly reduce *E. coli* at across all flow conditions. National scale modelling and analysis conducted by GWRC[1] suggests that that a 70% *E. coli* reduction (achieved under improved scenario in the Horokiri proxy catchment) will result in ~70% of reaches improving by either two (~60%) or three (~10%) attribute states, with most (93%) of the reaches that are currently unswimmable becoming swimmable. Consequently, the panel considers +2 the most appropriate change score.
					Effect:	Significant reductions in *E. coli* concentrations will have a commensurate effect on human health risks to recreational users.
					Confidence:	The removal of most agricultural faecal contamination means the panel is confident that the direction of change will be positive, and that the magnitude of change will be significant. While the effects of riparian planting on wet-weather *E. coli* concentrations are poorly understood, the panel is confident

Tier	Attribute	Change	Effect	Confidence	Narrative
					that it will have a greater impact under this scenario than under Improved due to the greater potential for infiltration/filtration and the additional distance between stock and the waterway. Proxy catchment data are transferable and state data comes from monitoring at two sites and national scale modelling [1]Modelling of E. coli reductions in the Whaitua[1]Modelling of E. coli reductions in the Whaitua
	Flow	-1	-1	1	Change: Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change and MALF is expected to reduce by between 10% and 20% *Note: Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".* Effect: Reductions in MALF will likely: • Increase water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reduce fish and invertebrate habitat space; • Increase periphyton habitat space; and • Reduce recreational opportunities. Increases in mean annual flood will likely: • Increase sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alter fish and invertebrate habitat structure, diversity and availability; and • Increase the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. Confidence: This assessment is based on the modelled effects of climate change on flow presented in the memorandum entitled "*Predicted impact of climate change on key hydrological statistics*". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions".
2	Plant growth	+2	+2	2	Change: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests that the reductions in DIN and DRP expected under this scenario will not be sufficient to result in an attribute state change (40% reduction in DRP required). However, the panel considers that, in combination, reduced nutrient concentrations and increased shading provided by the extensive riparian planting in the Mangaroa catchment will most likely result in an improvement in periphyton biomass attribute state at the EPAU scale. Furthermore, they consider that the detrimental effects of climate change on periphyton growth (i.e. lower summer low flows (MALF)

Tier	Attribute	Change	Effect	Confidence	Narrative	
						leading to increased temperature and accrual) will be outweighed by the positive effects of decreased nutrients and light availability.
					Effect:	A moderate reduction in periphyton biomass in this EPAU will likely have a commensurate positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value.
					Confidence:	This assessment relies heavily on the assumed effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict the response of periphyton biomass to changes in flow, shading and nutrients due to complicated driver-response relationships. Determining whether the effects of climate change will be offset by the positive effects of mitigations adds another level of complexity. Nevertheless, the panel is confident that any change in periphyton biomass will be in a positive direction. Proxy catchment nutrient results are not directly transferable. Furthermore, state data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+2	+2	2	Change:	As under BAU and Improved, the increased wintertime flood frequency/magnitude and lower summer low flows expected under this scenario due to climate change will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in sediment input, and associated decreases in cover and turbidity; decreased dissolved metal concentrations (lower Pakuratahi only) extensive riparian planting; reduced habitat disturbance by stock, and reductions in periphyton biomass means that on the EPAU scale there is likely to be a net moderate improvement in MCI. Significant localised improvements are also possible in those reaches where MCI is currently poor or fair and riparian planting will occur. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A moderate improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	The level of riparian mitigation expected under this scenario means that the panel is confident in the direction and magnitude of change. Nevertheless, uncertainty always exists when predicting the response of macroinvertebrates to changes in flow, habitat, plant growth, sediment and toxicants due to complicated driver-response relationships.

Tier	Attribute	Change	Effect	Confidence	Narrative
	Fish diversity	0	0	3	<u>Change:</u> While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species. <u>Effect:</u> As no change is expected there is not expected to be an effect. <u>Confidence:</u> The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+2	N/A	2	<u>Change:</u> The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input, and riparian management; • Water quality – Likely to improve based on reduction in nutrients and contaminants and water temperature mitigation from shading; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. *<u>Notes:</u>* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* <u>Effect:</u> N/A <u>Confidence:</u> The level of riparian mitigation expected under this scenario means that the panel is confident in the direction of change, and that the improvement in ecosystem health would be noticeable. However, there is uncertainty in the hydrological, periphyton and invertebrate modelling and difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
4	Overall suitability for recreation	+3	N/A	2	<u>Change:</u> Significant decreases in *E. coli* concentrations will significantly reduce the health risks to recreational users. Reduced stock access combined with extensive riparian planting should improve people's perceptions of the waterways in this EPAU and reduced sediment input should enhance their aesthetics. <u>Effect:</u> N/A

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: There is a high level of uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for rural mitigations to offset these effects is unclear. However, the panel is highly confident that the significant stock exclusion and riparian planting will decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU.

Table 17: Sensitive expert panel assessment for Assessment unit 4 – Mixed rural

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	0	0	3	Change:	Detectable changes in copper and zinc concentration are not expected due to the limited amount of existing impervious surface cover (limited potential for improvements through treatment), and the lack of urban intensification expected under this scenario.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	While state data are limited, the limited amount of impervious surface cover and the lack of any urban intensification under this scenario means that the panel are highly confident that copper and zinc concentrations will not change from current.
	Nitrogen 1	+1	0	3	Change:	While only limited stock exclusion is expected in this EPAU under this scenario, the accompanying ten metre vegetated buffer is likely to be very effective (70-90% (Parkyn, 2004)) at reducing the sub-surface and surface nitrogen loads delivered to the targeted reaches. This, combined with extensive retirement (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10% of Korokoro catchment; ~25% of Makara Coast and ~35% Ohariu Stream catchment) will reduce nitrate concentrations, and these reductions will be greater than those expected under Improved. However, an attribute state change is not likely at the EPAU scale as concentrations in most reaches are probably already in the A state. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means that for the most part ammonia concentrations will not change from current. However, very localised reductions may occur at crossing points.
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. The absence of point source discharges likely to contain ammonia (e.g. human wastewater, dairy shed effluent etc.) in this EPAU means the risk of acute ammonia toxicity effects will also not change from current
					Confidence:	The level of rural mitigation under this scenario means that the panel are confident that the direction of change will be positive. They are also confident that current state of ammonia and nitrate concentrations precludes an attribute state shift for these parameters. State data comes from one monitoring site and national scale modelling. Proxy catchment data are partially transferable.
	Nitrogen 2	+1	+1	2	Change:	The limited riparian management expected under this scenario should be very effective (70%-90% (Parkyn, 2004)) at reducing sub-surface and surface nitrogen loads to the targeted reaches, as should the assumed widespread retirement. Accordingly, DIN concentrations should reduce

Tier	Attribute	Change	Effect	Confidence	Narrative	
						throughout the EPAU, and by a larger amount than expected under the Improved scenario. However, the panel did not consider an attribute change likely given the high proportion of reaches already in the A state (55%[1]), and the large reductions in DIN required to shift most of the reaches in the B state to the A (> than the 15% predicted for Horokiri proxy catchment[1]).
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth. While such reductions were expected in the Horokiri proxy catchment, the panel did not consider this transferable given the differences in the level of stock exclusion between the proxy catchment and this EPAU.
					Confidence:	The level of rural mitigation under this scenario means the panel are highly confident that the direction of change will be positive. They are also confident that current state of DIN in this EPAU precludes an attribute state shift for this parameter. State data comes from monitoring at one site and national scale modelling. Proxy catchment data are partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+2	+1	2	Change:	**Improvements due to mitigations** The limited stock exclusion will reduce the amount of sediment bound P entering targeted waterways via bank erosion, and the predicted 10 metre vegetated buffer is likely to be very effective at reducing total and dissolved phosphorus delivered to the targeted reaches via runoff (50-55% assumed based on proxy catchment modelling assumptions and Parkyn (2004)). The significant amount of assumed retirement should also reduce the amount of phosphorus transported to streams from that land. **Detrimental effects of climate change** An increase in flood frequency/magnitude caused by climate change may increase sediment input to the extent that there are small associated increases in DRP. **Overall assessment**. Rural mitigations are likely to reduce phosphorus input into the rivers and streams in this EPAU, and, based on the extent of retirement assumed under this scenario, the panel considers a moderate improvement (one attribute state) the most likely outcome. A significant improvement is

Tier	Attribute	Change	Effect	Confidence	Narrative	
						not expected as the benefits of the assumed mitigations will be partially offset by the effects of climate change on sediment input.
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely.
					Confidence:	The panel's change assessment relies on the modelled effects of climate change on flow presented in the memorandum entitled "Predicted impact of climate change on key hydrological statistics". That memorandum states that "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high and care should be taken to not overstretch on conclusions from any of the predictions". Furthermore, there is significant uncertainty around how the expected changes in flow would affect sediment delivery and, in turn, phosphorus. Trying to determine whether those effects would be counter-balanced by the positive effects of the mitigations assumed under this scenario adds further complexity. Nevertheless, the panel is confident that an attribute state change in either direction is unlikely. State data comes from monitoring at one sites and national scale modelling. Proxy catchment data are partially transferable. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+2	+2	1	Change:	**Improvements due to mitigations** The limited stock exclusion will reduce the amount of sediment entering targeted waterways via bank erosion, and the five metre riparian margin will likely be very effective at reducing sediment loads delivered to the targeted reaches via runoff. The exact degree to which loads will be reduced is unclear, but a review by Parkyn (2004) found that up to 91% of sediment can be stripped from sheet flow just a few metres from the pastures edge, and the proxy catchment modelling assumes that the stream bank erosion component of the sediment load delivered to the targeted reaches will be reduced by 80%. The extent of stock exclusion under this scenario is slightly more than under Improved, and riparian vegetation should also be more effective at stripping sediment from run-off. This combined with the additional retirement under this scenario means that reductions in sediment input will be greater than under the improved scenario. While significant stock exclusion is not expected under this scenario, widespread retirement is assumed (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10%

Tier	Attribute	Change	Effect	Confidence	Narrative	
						of Korokoro catchment; ~25% of Makara Coast and ~35% Ohariu Stream catchment), which will reduce sediment input from this land. **Detrimental effects of climate change** Increased flood frequency/magnitude due to climate change means there is an increased risk of sediment input from both bank erosion and slope erosion (i.e. slips). **Overall assessment**. Rural mitigations are likely to reduce sediment input into the rivers and streams in this EPAU, and these reductions will be greater than expected under the Improved scenario. However, a significant improvement is not expected as the benefits of the assumed mitigations will be partially offset by the effects of climate change on flood frequency/magnitude.
					Effect:	Both deposited sediment and turbidity is high in many of the reaches in this EPAU, and improvements in these measures resulting from moderate reductions in sediment input will result in commensurate benefits to ecosystem health and recreational value.
					Confidence:	The panels change assessment relies on the modelled effects of climate change and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. Trying to determine whether negative climate change effects are counter-balanced by the positive effects of the mitigations assumed under this scenario adds further complexity.
	Faecal contamination	+2	+2	1	Change:	While limited, the stock exclusion practices under this scenario should reduce direct faecal input from stock in the targeted streams Furthermore, compared to the five metre buffer assumed under the Improved scenario, a ten metre planted riparian margin is likely to be far more effective at reducing the input of *E. coli* during rain events. The additional width will not only increase the amount of sediment bound *E. coli* that will be filtered from run-off by the vegetation, but it should increase the amount of supernatant *E. coli* that infiltrates into the ground before reaching the stream. While significant stock exclusion is not expected under this scenario, widespread retirement is assumed (~15% of Hutt Valley Western Hills, Makara Stream and South Karori catchments; ~10% of Korokoro catchment; ~25% of Makara Coast and ~35% Ohariu Stream catchment). It is likely that this will reduce the number of stock units in this EPAU and therefore have a positive effect on the distribution of *E. coli* concentrations. National scale modelling and analysis conducted by GWRC[1] suggests that that a 70% *E. coli* reduction (achieved under improved scenario in the Horokiri proxy catchments) will result in ~98%

Tier	Attribute	Change	Effect	Confidence	Narrative
					of reaches improving by either two (~92%) or three (~6%) attribute states, with most (99%) of the reaches that are currently unswimmable becoming swimmable. However, the proxy catchment results are not directly transferable due to differences in the amount of stock exclusion (far less in this EPAU compared to the proxy catchment). As such the panel considers a one attribute state improvement the most likely outcome.
					<u>Effect:</u> Moderate reductions in *E. coli* concentrations will have a commensurate effect on health risk to recreational users.
					<u>Confidence:</u> The panel is confident that *E. coli* concentrations will decrease due to the mitigation assumed under this scenario. They are also in agreement that the assumed rural mitigations are not sufficient to result in a two attribute state improvement at the EPAU scale. Observed data are available for one site and modelling data is from a national scale model. Proxy catchment results are not directly transferable due to differences in the amount of stock exclusion. [1]Modelling of E. coli reductions in the Whaitua
	Flow	-1	-1	1	<u>Change:</u> Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change, with the greatest change expected in the western catchments. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River. However, it is the panels view that the significant amount of land retirement under this scenario is likely to partially offset the effects of climate change, and while small detectable changes in MALF and mean annual flood are expected, moderate changes, like those expected under BAU and Improved, are not. *<u>Note:</u> Assessment based on modelling results presented in "Predicted impact of climate change on key hydrological statistics".*
					<u>Effect:</u> Small reductions in MALF in the catchments on the true right of the Hutt River will probably result in small: • Increases in water temperatures, leading to increased plant growth and increased thermal stress on fish and invertebrates; • Reductions in fish and invertebrate habitat space; • Increases in periphyton habitat space; and • Reductions in recreational opportunities. Small increases in mean annual flood will probably result in small: • Increases in sediment input through bank and slope erosion, which will have adverse effects on invertebrate and fish populations; • Alterations in fish and invertebrate habitat structure, diversity and availability; and

Tier	Attribute	Change	Effect	Confidence	Narrative
					• Increases in the frequency and/or magnitude at which invertebrate and fish populations are disturbed by floods. Confidence: As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high"
2	Plant growth	+1	+1	1	Change: In the western catchments (Makara Stream, Ohariu Stream etc.) the panel considers that periphyton biomass is likely to decrease as a result of reduced nutrient concentrations and increased shading in reaches running through areas subject to stock exclusion, retirement and space planting. They also note that reductions in periphyton will be greater under this scenario than under Improved. However, the panel believes that biomass in most reaches is unlikely to change an attribute state as: • The spatial extent of stock exclusion and riparian planting is limited; and • Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one periphyton biomass attribute state (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (not even predicted under the Sensitive scenario in the Horokiri proxy catchment). In the catchments on the true right side of the Hutt River periphyton biomass is not expected to change from current, as the benefits of riparian planting, retirement/space planting and nutrient reductions will most likely be offset by the effects of climate change, with reductions in summer low flows (MALF) increasing the risk of periphyton growth through temperature and accrual *Note: All members agree that increased temperature will be a factor in the increased periphyton growth caused by climate change. However, the panel was split on the likelihood of an increase in accrual period. Dr Heath was undecided on whether a reduction in MALF indicates an increase in low flow duration/periphyton accrual, while the rest of the panel based their assessment on the assumption that accrual period will increase as MALF decreases.* Effect: In the western catchments a small reduction in periphyton biomass will likely have a small but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value. As no change is expected in the catchments on the true right side of the Hutt River there is not expected to be an effect. Confidence: Proxy catchment nutrient results are transferable. State data are limited, with measured data from just one site and modelling based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua

Tier	Attribute	Change	Effect	Confidence	Narrative	
3	Macroinvertebrate community health	+2	+2	1	Change:	The increased wintertime flood frequency/magnitude and lower summer low flows (catchments on the true right side of the Hutt River only) expected under this scenario will have an adverse effect on macroinvertebrate community health throughout this EPAU. However, reductions in sediment input, and associated decreases in cover and turbidity; riparian planting and stock exclusion; widespread retirement/space planting; and small reductions in periphyton biomass (western catchments only) means that on the EPAU scale there is likely to be a net moderate improvement in MCI. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A moderate improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	This assessment is partly based on the modelled effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. The uncertainty in the climate change flow modelling is compounded by complex relationships between flow, sediment input, plant growth and macroinvertebrate community health.
	Fish diversity	0	0	3	Change:	While the predicted changes in sediment input, flow, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+2	N/A	1	Change:	The panel considers that the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input, riparian management and retirement/space planting; • Water quality – Likely to improve based on reduction in nutrients; • Water quantity – Likely to degrade based on climate change predictions; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Overall, the panel agrees that a moderate improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.*
					Effect:	N/A
					Confidence:	Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+2	N/A	2	Change:	Moderate decreases in *E. coli* concentrations will noticeably reduce the health risks to recreational users, with more than 50% of reaches that are currently unswimmable becoming swimmable. Reduced stock access combined with increased riparian planting and retirement should also improve people's perceptions of the waterways in this EPAU and reduced sediment input and plant growth (western catchments only) should enhance their aesthetics.
					Effect:	N/A
					Confidence:	There is a high level uncertainty around the effects of climate change on flow, sediment input and periphyton growth under this scenario, and the potential for rural mitigations to offset these effects is unclear However, the panel is confident that the direction of change will be positive.

Table 18: Sensitive expert panel assessment for Assessment unit 5 – Groundwater/ surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative
1	Dissolved metals	+3	+2	2	Change: Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by 50% to 80% under this scenario, and the replacement of 100% of existing roofs constructed from material containing zinc will result in a 97% reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in copper loads from existing surfaces reducing by 26% to 27% and zinc loads decreasing by between 73% and 75% (depending on the catchment). Significant proportional increases in urban land cover are predicted in this EPAU under this scenario, and the additional load from these surfaces, while less than under BAU (reduction assumed to be >70% based on Improved scenario assumptions) will at least partially offset the reduction in loads from existing impervious surfaces. Using the scenario assumptions and the CLM outputs, Dr Greer calculated a net change of ~-70% for total zinc load and -25% for total copper load. This is supported by the proxy catchment results, which indicate a two-attribute state change is possible for both parameters. *Note: The panel's assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					Effect: Reductions in zinc and copper concentrations will have a moderate positive effect on macroinvertebrates, fish and ecosystem health. Significant positive effects are not expected, as the impact on the most sensitive species will not be realised unless all aspects of the "urban stream syndrome" are addressed.
					Confidence: Measured state data comes from just one monitoring site and reach scale state modelling data are not available. However, CLM results are available and can be used to calculate future load reductions. Proxy catchment modelling is transferable.
	Nitrogen 1	+1	+1	2	Change: Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of ammonia and nitrate (oxidised from ammonia) across all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may also have a detectable effect on the distribution of ammonia concentrations in streams in the Valley Floor sub-catchment (frequency of overflows in Waiwhetu sub-catchment is not expected to change). Furthermore, additional total nitrogen loads from new developments will be significantly less than those expected under BAU (reduction assumed to be >40% based on Improved scenario assumptions), and total nitrogen loads from commercial/industrial paved surfaces and major roads should be reduced by 40% to 60% as a result of stormwater capture. Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on nitrate and ammonia concentrations will not change.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						While the urban mitigations described above are likely to reduce ammonia and nitrate concentrations, at the EPAU scale an attribute state change is not expected for either parameter as they are expected to be in the A state in most reaches. Note: *The urban mitigations proposed under this scenario may not have a significant effect on the amount of nitrogen transported into streams via groundwater, which is not constrained by surface water catchment boundaries (Dr Ausseil).*
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects in the Valley Flood sub-catchment.
					Confidence:	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU.
	Nitrogen 2	+1	0	2	Change:	The removal of dry weather wastewater leaks should reduce DIN concentrations in urban streams across all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces and major roads (40-60% reduction in total nitrogen load from these surfaces), combined with the reduction in wastewater overflow frequency in the Valley Floor sub-catchment, should reduce DIN concentrations during high flow events. Additional total nitrogen loads from new urban developments will also be significantly lower than expected under BAU (reduction assumed to be >40% based on Improved scenario assumptions). Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DIN concentrations will not change. While DIN concentrations in urban streams should decrease, the panel did not consider an attribute change likely at the EPAU scale given the high proportion of reaches already in the A state (~65%[1]), and the large reductions in DIN (>15%[1]) required to shift the significant minority of reaches in the B state to the A state (reduction in Porirua proxy catchment = 10%[1]). Note: *The urban mitigations proposed under this scenario may not have a significant effect on the amount of nitrogen transported into streams via groundwater, which is not constrained by surface water catchment boundaries (Dr Ausseil).*

Tier	Attribute	Change	Effect	Confidence	Narrative
					<u>Effect:</u> Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth. The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 10%[1]). Furthermore, a change in nutrient status is unlikely to elicit a plant growth response in macrophyte dominated streams. *<u>Note:</u> The panel is confident if a reduction in DIN does have an impact on periphyton growth, it will be positive.*
					<u>Confidence:</u> The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	<u>Change:</u> Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into urban streams across all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may also have a detectable effect on the distribution of DRP concentrations in the Valley Floor sub-catchment (frequency of overflows to the Waiwhetu is not expected to change). Furthermore, additional total phosphorus loads from new developments will ≤50% of those expected under BAU (based on Improved scenario assumptions), and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 40% to 60% as a result of stormwater capture. Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DRP concentrations will not change. While the assumed mitigations are likely to reduce DRP concentrations in the urban rivers and streams in this EPAU, an attribute state change is not expected. Analysis conducted by GWRC[1], suggests a 40% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B), and only a 25% reduction was predicted for the Porirua proxy catchment[1].
					<u>Effect:</u> Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 25%[1]). Nevertheless, the panel agree that a 25% reduction in DRP would still have a detectable effect on periphyton biomass, although they did note that it is unlikely to elicit a plant growth response in macrophyte dominated streams.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	Change: **Improvements due to mitigations** Under this scenario it is assumed that additional sediment loads from new urban developments will be significantly less than those expected under BAU (reduction assumed to be >80% based on Improved scenario assumptions), and sediment loads from existing commercial/industrial paved surfaces and major roads should be reduced by 75% to 90% as a result of stormwater capture. Stormwater retention/rain tanks in both new and existing developments will also shift the frequency of channel forming flows closer to pre-development state (Ferguson, 2018), and this will reduce sediment input from bank erosion during high flows. **Detrimental effects of climate change** The panel's "Flow" assessment notes that the effects of climate change on flow will be offset by the benefits of by urban mitigations (see below). Accordingly, sediment load in streams running through developed land should be unaffected by climate change. However, an increase in flood magnitude and frequency due to climate change will still increase the potential for catastrophic erosion events (i.e. large slips) in non-developed areas, regardless of the urban mitigations **Overall assessment** On balance, the panel believes that the positive effects of the urban mitigations will offset the detrimental effects of climate change in undeveloped areas, resulting in a small, but detectible, positive net change. *Note: While they accept the panels assessment, it is still Dr Ausseil's and Mr Farrant's opinion that climate change may still result in an increase in sediment input despite the assumed urban mitigations.*
					Effect: Reduced sediment input should improve deposited fine sediment cover, water clarity and turbidity. In many of the smaller streams in this EPAU, deposited fine sediment cover and turbidity are high, both in absolute terms (deposited sediment cover only) and relative to reference state. Thus, any reductions in those systems could well have positive effects on ecosystem health and recreational value. However, the groundwater fed nature of many streams in this EPAU means that it may take

Tier	Attribute	Change	Effect	Confidence	Narrative
					some time for these effects to be realised, due to long-term legacy effects from historic sediment discharges. Confidence: This assessment is partly based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity. While they accept it, Dr Ausseil and Mr Farrant do not fully agree with the panel's assessment, noting that no change in sediment input is a more likely outcome.
	Faecal contamination	+3	+3	3	Change: Under this scenario the following factors will affect *E. coli* concentrations: • The removal of dry weather wastewater leaks which will reduce the input of *E. coli* across all flows; • *E. coli* loads from commercial/industrial paved surfaces and major roads should be reduced by 90% as a result of stormwater capture, effectively eliminating non-human sources from these surfaces during wet-weather and reducing 95th percentile *E. coli* concentrations; • Additional *E. coli* loads from new developments will be significantly less than those expected under BAU (reduction assumed to be >90% based on Improved scenario assumptions), meaning wet-weather concentrations will not be substantially increased by additional developments; • The elimination of wastewater overflows in all but the two biggest rainfall events per year will reduce wet-weather *E. coli* concentrations in the Valley Floor sub-catchment (frequency of overflows to the Waiwhetu is not expected to change). However, this will probably not affect *E. coli* attribute state as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations; and • Rural land-use practices will not shift significantly under this scenario, thus the (likely limited) impact of agricultural land-use on *E. coli* concentrations will not change. In summary, human wastewater contamination is likely the main source of faecal contamination in this EPAU and removing it in all but two events per year should result in the elimination of the majority of the *E. coli* in its rivers and streams across all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces and major roads should significantly reduce the other notable source of wet-weather faecal contamination, stormwater contaminated with non-human faecal sources (e.g. dog and bird faeces). The panel considers that at an EPAU scale, *E. coli* concentrations are likely to improve at least two attribute states and note that improvements will be greater than those expected under the Improved

Tier	Attribute	Change	Effect	Confidence	Narrative	
						scenario. This is supported by national scale modelling and analysis conducted by GWRC[1], which suggests that that an 80% *E. coli* reduction (achieved under Sensitive scenario the Porirua proxy catchment) will result in ~95% of currently unswimmable reaches becoming swimmable, with ~28% of sites shifting two attribute states and ~70% of sites shifting three attribute states.
					Effect:	Reduced *E. coli* concentrations will significantly reduce human health risks to recreational users, and the removal of dry-weather and most wet-weather human wastewater contamination means the health benefits will be greater than indicated by the panels attribute state change assessment. *E. coli* attribute states are based on the risk of *Campylobacter* infection and do not provide an accurate reflection of risk from other pathogens in rivers and streams contaminated with human wastewater.
					Confidence:	The removal of dry-weather wastewater contamination means that the panel is confident that the direction of change will be positive, and that a two-attribute state improvement (at a minimum) is likely in most reaches. Proxy catchment data are transferable, state data comes from one GWRC monitoring site, approximately five territorial authority monitoring sites and national scale models. [1]Modelling of E. coli reductions in the Whaitua
	Flow	0	0	1	Change:	Under this scenario mean annual flood is expected to increase by up to 40% due to climate change and MALF is expected to reduce by between 10% and 20%. However, stormwater retention/rain tanks in both new and existing developments will likely result in runoff volume and target flow rate exceedance frequency in urban areas returning to almost pre-development levels (Ferguson, 2018). As such the panel considers a no net change in flow the most likely outcome, with climate change effects offset by the benefits of the assumed mitigations.
					Effect:	As there is not change, there is not expected to be an effect *Note: The expected effects of climate change on sediment input is related to effects of rainfall on erosion rather than in-stream hydrology.*
					Confidence:	As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high". Determining whether the effects of climate change will be counter-balanced by the positive effects of mitigations adds another level of complexity.
2	Plant growth	+1	+1	1	Change:	At the EPAU scale the panel considers that plant growth will likely decrease. However, a moderate improvement is unlikely for the following reasons: • **A shift in periphyton biomass attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and

Tier	Attribute	Change	Effect	Confidence	Narrative
					analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely. • **Reduced nutrient concentrations are unlikely to affect plant growth in macrophyte dominated streams.** • **Riparian planting is generally not expected thus the effect of light availability on periphyton and macrophyte growth is not expected to change.** *Note: It is Dr Heath's opinion that periphyton growth will not change under this scenario and that a 0 is the most appropriate change score.*
					Effect: A small reduction in plant growth in this EPAU will likely have a small but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value.
					Confidence: How periphyton biomass will respond to changes in nutrient concentrations is difficult to predict due to complicated driver-response relationships, and this is evidenced by Dr Heath's disagreement with the panel's overall assessment. Furthermore, it is not known how many of the streams in this EPAU have a macrophyte dominated plant community, and there is a high degree of uncertainty in the panels flow change predictions, which were relied upon for this assessment. Proxy catchment nutrient results are transferable. However, measured state data are not available and reach scale periphyton biomass modelling is based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+2	+2	1	Change: The panel considers that significant reductions in the risk of chronic zinc and copper toxicity, decreased acute ammonia toxicity risk and small reductions in sediment input and plant growth will result in a moderate improvement in macroinvertebrate community health, with MCI in most reaches improving an attribute state. However, significant improvements are not expected, as some aspects of the "urban stream syndrome" will not be fully addressed (i.e. habitat modification) meaning sensitive species will likely remain impacted. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect: Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A moderate improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.

Tier	Attribute	Change	Effect	Confidence	Narrative
					Confidence: Predicting the response of macroinvertebrates, to changes in toxicants, sediment and plant growth is difficult due to complicated driver-response relationships.
	Fish diversity	0	0	3	Change: While the predicted changes in metal toxicity, acute ammonia toxicity, sediment input, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is extremely unlikely as it would require the introduction or extirpation of one or more species. Effect: As no change is expected there is not expected to be an effect. Confidence: The panel is very confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species.
4	Ecosystem health	+2	N/A	1	Change: The panel considered how the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input (noting that riparian habitat will stay the same); • Water quality – Likely to improve based on reduction in nutrients and toxicants; • Water quantity – Likely to stay the same due to climate change effects being offset by the benefits of the assumed mitigations; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a moderate improvement is likely at the EPAU scale *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.* • *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* Effect: N/A Confidence: Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.

<table>
<tr><th>Tier</th><th>Attribute</th><th>Change</th><th>Effect</th><th>Confidence</th><th colspan="2">Narrative</th></tr>
<tr><td rowspan="3"></td><td rowspan="3">Overall suitability for recreation</td><td rowspan="3">+3</td><td rowspan="3">N/A</td><td rowspan="3">2</td><td>Change:</td><td>The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will significantly reduce human health risks to recreational users. The removal of wastewater from these streams will also improve people’s perception of their recreational value.

In contrast to the Improved scenario, summer low flows are not expected to change under this scenario, and sediment input and plant growth should decrease slightly. As such, there should be a small improvement in the aesthetic and amenity values of the rivers and streams in this EPAU, which was not expected under Improved.</td></tr>
<tr><td>Effect:</td><td>N/A</td></tr>
<tr><td>Confidence:</td><td>The panel is highly confident that the removal of dry-weather wastewater contamination and the reduced frequency of wet-weather wastewater contamination (Valley Floor sub-catchment only) will significantly decrease the risk to human health and improve people’s perceptions of the rivers and streams in this EPAU. However, the potential for improvements in aesthetic and amenity values is less certain.</td></tr>
</table>

Table 19: Sensitive expert panel assessment for Assessment unit 6 - Surface water fed predominately urban

Tier	Attribute	Change	Effect	Confidence	Narrative	
1	Dissolved metals	+2	+1	1	<u>Change:</u>	Copper and zinc loads from existing commercial/industrial paved surfaces and major roads are expected to reduce by between 50% and 80% under this scenario, and the replacement of 100% of existing roofs constructed from material containing zinc will result in a 97% reduction in zinc load from these surfaces. Based on the available contaminant load model data, this should result in total copper loads from existing impervious surfaces (across the entire EPAU) reducing by ~35% and total zinc loads decreasing by ~75%. Significant proportional increases in urban land cover are predicted in this EPAU under this scenario, and the additional load from these surfaces, while less than under BAU (reduction assumed to be >70% based on Improved scenario assumptions) will at least partially offset the reduction in loads from existing impervious surfaces. Using the scenario assumptions and the CLM outputs, the panel assessed that on the EPAU scale a moderate net improvement was the most likely outcome for zinc, while a small but detectable improvement was possible for copper. <u>*Notes:*</u> • *Net changes in load were originally calculated by Dr Greer, but these had to be re-calculated during the group assessment due to an error. Accordingly, while the panel considered these numbers when making their assessment and are comfortable they are now "in the ball-park" they did not agree to have them specified in their final assessment* • *While only moderate improvements in zinc are expected on an EPAU scale, there is potential for localised significant improvements in streams running through urban areas where no new development is planned.* • *The panel's assessment is limited to copper and zinc and does not consider other dissolved metals found in stormwater such as nickel, cadmium, chromium and lead.*
					<u>Effect:</u>	Moderate reductions in zinc concentrations are expected, and this will have a positive effect on macroinvertebrates, fish and ecosystem health. However, these effects are likely to be small at the EPAU scale (moderate localised effects possible) as the effects of copper toxicity on sensitive species will generally not change.
					<u>Confidence:</u>	Measured state data comes from just one monitoring site and reach scale state modelling data are not available. Furthermore, copper and zinc concentrations are likely to change in opposite directions. CLM results are available and can be used to estimate future load reductions. Proxy catchment modelling is also partially transferable.
	Nitrogen 1	+1	+1	2	<u>Change:</u>	Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of ammonia and nitrate (oxidised from ammonia) across all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may have a detectable effect on the distribution of ammonia concentrations outside of the Kaiwharawhara and

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Owhiro Stream catchments (overflow frequency not expected to reduce there). Furthermore, additional total nitrogen loads from new developments will be significantly less than those expected under BAU (reduction assumed to be >40% based on Improved scenario assumptions), and total nitrogen loads from commercial/industrial paved surfaces and major roads should be reduced by 40% to 60% as a result of stormwater capture. While the urban mitigations described above are likely to reduce ammonia and nitrate concentrations, at the EPAU scale an attribute state change is not expected for either parameter as both are expected to be in the A state in most reaches. Notes: • *Dr Ausseil and Mr Farrant pointed out that the urban mitigations proposed under this scenario may not have a significant effect on the amount of nitrogen transported into streams from open and closed landfills. Dr Ausseil notes that these may be the reason for elevated nitrate concentrations in the Owhiro and Kaiwharawhara streams.* • *Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on nitrate and ammonia concentrations will not change.*
					Effect:	Nitrate and ammonia concentrations in most reaches in this EPAU are not expected to change an attribute state. As the attribute state thresholds for these parameters are linked to established toxicity thresholds, a substantial shift in chronic toxicity risk (currently low) is not expected. However, the reduction in wastewater overflow frequency could reduce the risk of localised acute ammonia toxicity effects outside of the Kaiwharawhara and Owhiro Stream catchments.
					Confidence:	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU.
	Nitrogen 2	+1	0	2	Change:	The removal of dry weather wastewater leaks should reduce DIN concentrations in urban streams at all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces and major roads (40-60% reduction in total nitrogen load from these surfaces), combined with the reduction in wastewater overflow frequency (not applicable to the Owhiro and Kaiwharawhara catchments), should reduce DIN concentrations during high flow events. Additional total nitrogen loads from new urban developments will also be significantly lower than expected under BAU (reduction assumed to be >40% based on Improved scenario assumptions). Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DIN concentrations will not change.

Tier	Attribute	Change	Effect	Confidence	Narrative
					While DIN concentrations in urban streams should decrease, the panel did not consider an attribute change likely at the EPAU scale given the high proportion of reaches already in the A state (~62%[1]), and the large reductions in DIN (>15%[1]) required to shift the significant minority of reaches in the B state to the A state (reduction in Porirua proxy catchment = 10%[1]). *Notes:* • *Dr Ausseil and Mr Farrant pointed out that the urban mitigations proposed under this scenario will not have any effect on the amount of nitrogen transported into streams from open and closed landfills, because these are not specifically considered under the scenario assumptions. Dr Ausseil notes that these may be the reason for the existing elevated DIN concentrations in the Owhiro and Kaiwharawhara streams.* • *Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on nitrate and ammonia concentrations will not change.*
					Effect: Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a 15% reduction in TN would be needed for most sites to shift one nitrogen attribute state for periphyton growth. The available proxy catchment data suggests that this level of reduction is unlikely (reduction in Porirua proxy catchment = 10%[1]). Note: *The panel is confident if a reduction in DIN does have an impact on periphyton growth, it will be positive.*
					Confidence: The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Phosphorus	+1	+1	2	Change: Under this scenario it is assumed that dry weather wastewater leaks are removed which will reduce the input of DRP into urban streams across all flows. It is also assumed that wastewater overflows will only occur in the two biggest rainfall events (annually), which may also have a detectable effect on the distribution of DRP concentrations (not applicable to the Owhiro and Kaiwharawhara catchments where overflow frequency is assumed to be ≤ two per year). Furthermore, additional total phosphorus loads from new developments will only ≤50% of those expected under BAU (based on Improved scenario assumptions), and total phosphorus loads from commercial/industrial paved surfaces and major roads should be reduced by 40-60% as a result of stormwater capture. While the assumed mitigations are likely to reduce DRP concentrations in the urban rivers and streams in this EPAU, an attribute state change is not expected. Analysis conducted by GWRC[1],

Tier	Attribute	Change	Effect	Confidence	Narrative	
						suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state (C to B), and only a 25% reduction was predicted for the Porirua proxy catchment[1]. *Note: Rural land-use practices will not shift significantly under this scenario, thus the impact of agricultural land-use on DRP concentrations will not change.*
					Effect:	Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests a >40% reduction in DRP would be needed for most sites to shift one DRP attribute state for periphyton growth (C to B). The available proxy catchment data indicates that this level of reduction is unlikely (reduction in Porirua proxy catchment = 25%[1]). Nevertheless, the panel agree that a 25% reduction in DRP would still have a detectable effect on periphyton biomass.
					Confidence:	The panel is confident that the direction of change will be positive, and that there is limited potential for an attribute state improvement. Proxy catchment data are transferable. However, state data comes largely from national scale models as there is only one GWRC monitoring site in this EPAU. [1] Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
	Sediment input	+1	+1	1	Change:	**Improvements due to mitigations** Under this scenario it is assumed that additional sediment loads from new urban developments will be significantly less than those expected under BAU (reduction assumed to be >80% based on Improved scenario assumptions), and sediment loads from existing commercial/industrial paved surfaces and major roads should be reduced by 75-90% as a result of stormwater capture. Stormwater retention/rain tanks in both new and existing developments will also shift the frequency of channel forming flows closer to pre-development state (Ferguson, 2018), and this will reduce sediment input from bank erosion during high flows. **Detrimental effects of climate change** The panels “Flow” assessment notes that the effects of climate change on flow will be offset by the benefits of by urban mitigations (see below). Accordingly, sediment load in streams running through developed land should be unaffected by climate change. However, an increase in flood magnitude and frequency due to climate change will still increase the potential for catastrophic erosion events (i.e. large slips) in non-developed areas, regardless of the urban mitigations **Overall assessment**

Tier	Attribute	Change	Effect	Confidence	Narrative	
						On balance, the panel believes that the positive effects of the urban mitigations will offset the detrimental effects of climate change in undeveloped areas, resulting in a small but detectible positive net change. Note: *While they accept the panels assessment, it is Dr Ausseil's and Mr Farrant's opinion that climate change may still result in an increase in sediment input despite the assumed urban mitigations.*
					Effect:	Reduced sediment input should improve deposited fine sediment cover, water clarity and turbidity. In many of the smaller streams in this EPAU, deposited fine sediment cover and turbidity are high, both in absolute terms (deposited sediment cover only) and relative to reference state. Thus, any reductions in those systems could well have positive effects on ecosystem health and recreational value.
					Confidence:	This assessment is partly based on the effects of climate change on flow, and there is a high degree of uncertainty associated with hydrological modelling from downscaled climate change models. It is also difficult to predict how changes in flow will affect sediment delivery and determining whether those effects will be counter-balanced by the positive effects of mitigations adds another level of complexity. While they accept it, Dr Ausseil and Mr Farrant do not fully agree with the panel's assessment, noting that no change (0) in sediment input is a more likely outcome.
	Faecal contamination	+3	+3	3	Change:	Under this scenario the following factors will affect *E. coli* concentrations: • The removal of dry weather wastewater leaks which will reduce the input of *E. coli* across all flows; • *E. coli* loads from commercial/industrial paved surfaces and major roads should be reduced by 90% as a result of stormwater capture, effectively eliminating non-human sources from these surfaces during wet-weather and reducing 95th percentile *E. coli* concentrations; • Additional *E. coli* loads from new developments will be significantly less than those expected under BAU (reduction assumed to be >90% based on Improved scenario assumptions), meaning wet-weather concentrations will not be substantially increased by additional developments; • The elimination of wastewater overflows in all but the two biggest rainfall events per year will reduce wet-weather *E. coli* concentrations (not applicable to the Owhiro and Kaiwharawhara catchments). However, this will probably not affect *E. coli* attribute state as it is unlikely that overflows are currently occurring at a sufficient frequency to influence 95th percentile concentrations; and • Rural land-use practices will not shift significantly under this scenario, thus the (likely limited) impact of agricultural land-use on *E. coli* concentrations will not change.

Tier	Attribute	Change	Effect	Confidence	Narrative	
						In summary, human wastewater contamination is likely the main source of faecal contamination in this EPAU and removing it in all but two biggest events each year should result in the elimination of the majority of the *E. coli* in its rivers and streams across all flows. Furthermore, stormwater capture on commercial/industrial paved surfaces and major roads should significantly reduce the other notable source of wet-weather faecal contamination, stormwater contaminated with non-human faecal sources (e.g. dog and bird faeces). The panel considers that at an EPAU scale, *E. coli* concentrations are likely to improve at least two attribute states and note that improvements will be greater than those expected under the improved scenario. This is supported by national scale modelling and analysis conducted by GWRC[1], which suggests that that an 80% *E. coli* reduction (achieved under Sensitive scenario in the Porirua proxy catchment) will result in all currently unswimmable reaches becoming swimmable, with ~24% of sites shifting two attribute states and ~76% of sites shifting three attribute states.
					Effect:	Reduced *E. coli* concentrations will significantly reduce human health risks to recreational users, and the removal of dry-weather and most wet-weather human wastewater contamination means the health benefits will be greater than indicated by the panels attribute state change assessment. *E. coli* attribute states are based on the risk of *Campylobacter* infection and do not provide an accurate reflection of risk from other pathogens in rivers and streams contaminated with human wastewater.
					Confidence:	The removal of dry-weather wastewater contamination means that the panel is confident that the direction of change will be positive, and that a two-attribute state improvement (at a minimum) is the most likely outcome. Proxy catchment data are transferable, state data comes from one GWRC monitoring site, approximately ten territorial authority monitoring sites and national scale models. [1]Modelling of E. coli reductions in the Whaitua
	Flow	0	0	1	Change:	Under this scenario mean annual flood is expected to increase significantly throughout this EPAU due to climate change. Furthermore, MALF is expected to reduce by between 10% and 20% in the catchments on the true right of the Hutt River. However, stormwater retention/rain tanks in both new and existing developments will likely result in runoff volume and target flow rate exceedance frequency in urban areas returning to almost pre-development levels (Ferguson, 2018). As such the panel considers a no net change in flow the most likely outcome, with climate change effects offset by those of the assumed mitigations.
					Effect:	As there is not change, there is not expected to be an effect

Tier	Attribute	Change	Effect	Confidence	Narrative	
						Note: The expected effects of climate change on sediment input is related to effects of rainfall on erosion rather than in-stream hydrology.
					Confidence:	As stated in Thomson (2020) "the overall uncertainty associated with hydrological modelling from downscaled climate change models is high". Determining whether the effects of climate change will be counter-balanced by the positive effects of mitigations adds another level of complexity.
2	Plant growth	+1	+1	1	Change:	At the EPAU scale the panel considers that periphyton biomass will likely decrease. However, an attribute state improvement is unlikely for the following reasons: • **A shift in periphyton biomass attribute state due to nutrient reductions is unlikely at the EPAU scale** – Nutrient criteria modelling conducted by Snelder *et al.* (2019) and analysis conducted by GWRC[1] suggests at least a 15% reduction in TN and/or a >40% reduction in DRP would be needed for most reaches to shift one attribute state for periphyton growth (C to B). The available proxy catchment data suggests that this level of reduction is unlikely; and • **Riparian planting is generally not expected thus the effect of light availability on periphyton growth is not expected to change.** *Note: It is Dr Heath's opinion that periphyton growth will not change under this scenario and that a 0 is the most appropriate change score.*
					Effect:	A small reduction in plant growth in this EPAU will likely have a small but detectable positive effect on macroinvertebrate and fish communities, ecosystem health and recreational value.
					Confidence:	How periphyton biomass will respond to changes in nutrient concentrations is difficult to predict due to complicated driver-response relationships, and this is evidenced by Dr Heath's disagreement with the panel's overall assessment. Furthermore, there is a high degree of uncertainty in the panels flow change predictions, which were relied upon for this assessment. Proxy catchment nutrient results are transferable. However, measured state data are only available for one site and reach scale periphyton biomass modelling is based solely on nutrients. [1]Modelling of total nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton reductions in the Whaitua
3	Macroinvertebrate community health	+1	+1	1	Change:	The panel considers that moderate reductions in the risk of chronic zinc toxicity, decreased acute ammonia toxicity risk and small reductions in sediment input and plant growth will result in small improvements in macroinvertebrate community health, and that these improvements will be greater than those expected under the Improved scenario. However, MCI in most reaches is not expected to change an attribute state, as some aspects of the "urban stream syndrome", including copper toxicity

Tier	Attribute	Change	Effect	Confidence	Narrative	
						and habitat modification, will not be fully addressed. Accordingly, sensitive species will likely remain impacted by urban development. *Note: The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1 and 2 attributes.*
					Effect:	Macroinvertebrates are a key component of ecosystem health, processing organic matter and providing food for fish. A small improvement in macroinvertebrate community health means a direct improvement in ecosystem health is likely.
					Confidence:	Predicting the response of macroinvertebrates, to changes in toxicants, sediment and plant growth is difficult due to complicated driver-response relationships.
	Fish diversity	0	0	2	Change:	While the predicted changes in metal toxicity, acute ammonia toxicity, sediment input, plant growth and macroinvertebrate community health may affect fish abundance and community structure/composition, a shift in diversity is unlikely as it would require the introduction or extirpation of one or more species.
					Effect:	As no change is expected there is not expected to be an effect.
					Confidence:	The panel is confident that the abiotic and biotic changes predicted under this scenario will not result in the introduction or extirpation of one or more species. However, Dr Heath questioned the potential for shortjaw kokopu to recolonise streams where water quality and habitat quality is improved (Dr Greer notes that this seems very unlikely).
4	Ecosystem health	+2	N/A	1	Change:	The panel considered how the following components of ecosystem health are likely to change under this scenario: • Habitat – Likely to improve based on sediment input (noting that riparian habitat will stay the same); • Water quality – Likely to improve based on reduction in nutrients and toxicants; • Water quantity – Likely to stay the same due to climate change effects being offset by the benefits of the assumed mitigations; and • Aquatic biota – Likely to improve based on macroinvertebrates and their suitability/availability to fish as a food source. Overall, the panel agrees that a moderate improvement is likely at the EPAU scale. *Notes:* • *Ecological processes were not assessed, and it is not possible to conclude where these would change given uncertainty around periphyton, although there may possibly be some improvement in nutrient transformations.*

Tier	Attribute	Change	Effect	Confidence	Narrative
					• *The cumulative effects of multiple stressors are not always additive, they can be synergist or antagonistic. Accordingly, the change score applied to this attribute does not necessarily reflect the sum of the effect scores for the relevant Tier 1, 2 and 3 attributes.* <u>Effect:</u> N/A <u>Confidence:</u> Confidence is low due to compounding uncertainty in the hydrological, periphyton and invertebrate modelling and the difficulties in predicting the effects of flow, habitat and water quality on the abundance, structure, composition and diversity of plant, fish and invertebrate communities.
	Overall suitability for recreation	+3	N/A	2	<u>Change:</u> The elimination of dry-weather wastewater leaks and the reduction in overflow frequency will significantly reduce human health risks to recreational users. The removal of wastewater from these streams will also improve people's perception of their recreational value. In contrast to the Improved scenario, summer low flows are not expected to change under this scenario, and sediment input and plant growth should decrease slightly. As such, there should be a small improvement in the aesthetic and amenity values of the rivers and streams in this EPAU, which was not expected under Improved. <u>Effect:</u> N/A <u>Confidence:</u> The panel is highly confident that the removal of dry-weather wastewater contamination and the reduced frequency of wet-weather wastewater contamination (not applicable to the Owhiro and Kaiwharawhara catchments where overflow frequency is assumed to be ≤ two per year) will significantly decrease the risk to human health and improve people's perceptions of the rivers and streams in this EPAU. However, the potential for improvements in aesthetics and amenity values are less certain.

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Signed by:

Dr Olivier Ausseil ______________________

Dr Joanne Clapcott ______________________

Mr Stuart Farrant ______________________

Dr Michael Greer ______________________

Dr Mark Heath ______________________

Mr Ned Norton ______________________

Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Supplement 2 – Predicted Attribute State Distribution by Sub-catchment

24th September 2020

Report Prepared for Greater Wellington Regional Council

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Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Supplement 2 – Predicted Attribute State Distribution by Sub-catchment

24th September 2020

Report prepared for Greater Wellington Regional Council by:

Michael Greer
Mark Heath (Greater Wellington Regional Council)

Aquanet Consulting Limited

Quality Assurance			
Role	Responsibility	Date	Signature
Prepared by	Michael Greer	24/09/2020	
Approved for issue by:			
Status	Final		

SUPPLEMENT 2 TABLE CONTENTS

Table 1: Predicted number and %age of REC reaches in each DIN attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	54 (95%)	2 (4%)	1 (2%)	0 (0%)
		BAU	54 (95%)	2 (4%)	1 (2%)	0 (0%)
		Improved	54 (95%)	2 (4%)	1 (2%)	0 (0%)
		Sensitive	54 (95%)	2 (4%)	1 (2%)	0 (0%)
	Karori S. – Urb.	Current	5 (31%)	11 (69%)	0 (0%)	0 (0%)
		BAU	5 (31%)	11 (69%)	0 (0%)	0 (0%)
		Improved	5 (31%)	11 (69%)	0 (0%)	0 (0%)
		Sensitive	5 (31%)	11 (69%)	0 (0%)	0 (0%)
	Wainuiomata R. – Rur.	Current	313 (100%)	1 (0%)	0 (0%)	0 (0%)
		BAU	313 (100%)	1 (0%)	0 (0%)	0 (0%)
		Improved	313 (100%)	1 (0%)	0 (0%)	0 (0%)
		Sensitive	313 (100%)	1 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	53 (91%)	5 (9%)	0 (0%)	0 (0%)
		BAU	53 (91%)	5 (9%)	0 (0%)	0 (0%)
		Improved	53 (91%)	5 (9%)	0 (0%)	0 (0%)
		Sensitive	53 (91%)	5 (9%)	0 (0%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	55 (100%)	0 (0%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	47 (38%)	59 (48%)	14 (11%)	4 (3%)
		BAU	47 (38%)	59 (48%)	14 (11%)	4 (3%)
		Improved	47 (38%)	59 (48%)	14 (11%)	4 (3%)
		Sensitive	106 (85%)	14 (11%)	4 (3%)	0 (0%)
	Pakuratahi Grass	Current	51 (77%)	9 (14%)	4 (6%)	2 (3%)
		BAU	51 (77%)	9 (14%)	4 (6%)	2 (3%)
		Improved	51 (77%)	9 (14%)	4 (6%)	2 (3%)
		Sensitive	60 (91%)	4 (6%)	2 (3%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	49 (64%)	24 (32%)	3 (4%)	0 (0%)
		BAU	49 (64%)	24 (32%)	3 (4%)	0 (0%)
		Improved	49 (64%)	24 (32%)	3 (4%)	0 (0%)
		Sensitive	49 (64%)	24 (32%)	3 (4%)	0 (0%)
	Korokoro S.	Current	50 (94%)	3 (6%)	0 (0%)	0 (0%)
		BAU	50 (94%)	3 (6%)	0 (0%)	0 (0%)
		Improved	50 (94%)	3 (6%)	0 (0%)	0 (0%)
		Sensitive	50 (94%)	3 (6%)	0 (0%)	0 (0%)
	Makara Coast	Current	108 (89%)	14 (11%)	0 (0%)	0 (0%)
		BAU	108 (89%)	14 (11%)	0 (0%)	0 (0%)
		Improved	108 (89%)	14 (11%)	0 (0%)	0 (0%)
		Sensitive	108 (89%)	14 (11%)	0 (0%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
4 – Mixed rural	Makara S.	Current	44 (56%)	34 (43%)	1 (1%)	0 (0%)
		BAU	44 (56%)	34 (43%)	1 (1%)	0 (0%)
		Improved	44 (56%)	34 (43%)	1 (1%)	0 (0%)
		Sensitive	44 (56%)	34 (43%)	1 (1%)	0 (0%)
	Ohariu S.	Current	29 (22%)	78 (60%)	23 (18%)	0 (0%)
		BAU	29 (22%)	78 (60%)	23 (18%)	0 (0%)
		Improved	29 (22%)	78 (60%)	23 (18%)	0 (0%)
		Sensitive	29 (22%)	78 (60%)	23 (18%)	0 (0%)
4 – Mixed rural	South Karori	Current	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	73 (53%)	47 (34%)	16 (12%)	1 (1%)
		BAU	73 (53%)	47 (34%)	16 (12%)	1 (1%)
		Improved	73 (53%)	47 (34%)	16 (12%)	1 (1%)
		Sensitive	73 (53%)	47 (34%)	16 (12%)	1 (1%)
	Waiwhetu S.	Current	48 (89%)	0 (0%)	6 (11%)	0 (0%)
		BAU	48 (89%)	0 (0%)	6 (11%)	0 (0%)
		Improved	48 (89%)	0 (0%)	6 (11%)	0 (0%)
		Sensitive	48 (89%)	0 (0%)	6 (11%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	23 (100%)	0 (0%)	0 (0%)	0 (0%)
	Hutt Valley West Urban	Current	25 (60%)	17 (40%)	0 (0%)	0 (0%)
		BAU	25 (60%)	17 (40%)	0 (0%)	0 (0%)
		Improved	25 (60%)	17 (40%)	0 (0%)	0 (0%)
		Sensitive	25 (60%)	17 (40%)	0 (0%)	0 (0%)
	Kaiwharawhara S.	Current	30 (73%)	9 (22%)	2 (5%)	0 (0%)
		BAU	30 (73%)	9 (22%)	2 (5%)	0 (0%)
		Improved	30 (73%)	9 (22%)	2 (5%)	0 (0%)
		Sensitive	30 (73%)	9 (22%)	2 (5%)	0 (0%)
	North-West Harbour	Current	17 (52%)	15 (45%)	1 (3%)	0 (0%)
		BAU	17 (52%)	15 (45%)	1 (3%)	0 (0%)
		Improved	17 (52%)	15 (45%)	1 (3%)	0 (0%)
		Sensitive	17 (52%)	15 (45%)	1 (3%)	0 (0%)
6 – Surface water fed urban	Owhiro S.	Current	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	15 (100%)	0 (0%)	0 (0%)	0 (0%)

Table 2: Predicted number and %age of REC reaches in each DRP attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	0 (0%)	2 (4%)	53 (93%)	2 (4%)
		BAU	0 (0%)	2 (4%)	53 (93%)	2 (4%)
		Improved	0 (0%)	2 (4%)	53 (93%)	2 (4%)
		Sensitive	2 (4%)	53 (93%)	2 (4%)	0 (0%)
	Karori S. – Urb.	Current	0 (0%)	0 (0%)	4 (24%)	12 (75%)
		BAU	0 (0%)	0 (0%)	4 (13%)	12 (75%)
		Improved	0 (0%)	0 (0%)	4 (13%)	12 (75%)
		Sensitive	0 (0%)	4 (25%)	12 (38%)	0 (0%)
	Wainuiomata R. – Rur.	Current	0 (0%)	38 (12%)	276 (88%)	0 (0%)
		BAU	0 (0%)	38 (12%)	276 (88%)	0 (0%)
		Improved	0 (0%)	38 (12%)	276 (88%)	0 (0%)
		Sensitive	38 (12%)	276 (88%)	0 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	0 (0%)	4 (7%)	52 (90%)	2 (3%)
		BAU	0 (0%)	4 (7%)	52 (90%)	2 (3%)
		Improved	0 (0%)	4 (7%)	52 (90%)	2 (3%)
		Sensitive	4 (7%)	52 (90%)	2 (3%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	31 (56%)	24 (44%)	0 (0%)	0 (0%)
		BAU	31 (56%)	24 (44%)	0 (0%)	0 (0%)
		Improved	31 (56%)	24 (44%)	0 (0%)	0 (0%)
		Sensitive	31 (56%)	24 (44%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	0 (0%)	26 (21%)	81 (65%)	17 (14%)
		BAU	0 (0%)	26 (21%)	81 (65%)	17 (14%)
		Improved	26 (21%)	81 (65%)	17 (14%)	0 (0%)
		Sensitive	26 (21%)	81 (65%)	17 (14%)	0 (0%)
	Pakuratahi Grass	Current	0 (0%)	29 (44%)	37 (56%)	0 (0%)
		BAU	0 (0%)	29 (44%)	37 (56%)	0 (0%)
		Improved	29 (44%)	37 (56%)	0 (0%)	0 (0%)
		Sensitive	29 (44%)	37 (56%)	0 (0%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	0 (0%)	0 (0%)	52 (68%)	24 (32%)
		BAU	0 (0%)	0 (0%)	52 (68%)	24 (32%)
		Improved	0 (0%)	0 (0%)	52 (68%)	24 (32%)
		Sensitive	0 (0%)	52 (68%)	24 (32%)	0 (0%)
	Korokoro S.	Current	0 (0%)	0 (0%)	49 (92%)	4 (8%)
		BAU	0 (0%)	0 (0%)	49 (92%)	4 (8%)
		Improved	0 (0%)	0 (0%)	49 (92%)	4 (8%)
		Sensitive	0 (0%)	49 (92%)	4 (8%)	0 (0%)
	Makara Coast	Current	0 (0%)	4 (3%)	80 (66%)	38 (31%)
		BAU	0 (0%)	4 (3%)	80 (66%)	38 (31%)
		Improved	0 (0%)	4 (3%)	80 (66%)	38 (31%)
		Sensitive	4 (3%)	80 (66%)	38 (31%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
4 – Mixed rural	Makara S.	Current	0 (0%)	0 (0%)	53 (67%)	26 (33%)
		BAU	0 (0%)	0 (0%)	53 (67%)	26 (33%)
		Improved	0 (0%)	0 (0%)	53 (67%)	26 (33%)
		Sensitive	0 (0%)	53 (67%)	26 (33%)	0 (0%)
	Ohariu S.	Current	0 (0%)	0 (0%)	66 (51%)	64 (49%)
		BAU	0 (0%)	0 (0%)	66 (51%)	64 (49%)
		Improved	0 (0%)	0 (0%)	66 (51%)	64 (49%)
		Sensitive	0 (0%)	66 (51%)	64 (49%)	0 (0%)
4 – Mixed rural	South Karori	Current	0 (0%)	6 (38%)	10 (63%)	0 (0%)
		BAU	0 (0%)	6 (38%)	10 (63%)	0 (0%)
		Improved	0 (0%)	6 (38%)	10 (63%)	0 (0%)
		Sensitive	6 (38%)	10 (63%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	0 (0%)	0 (0%)	107 (78%)	30 (22%)
		BAU	0 (0%)	0 (0%)	107 (78%)	30 (22%)
		Improved	0 (0%)	0 (0%)	107 (78%)	30 (22%)
		Sensitive	0 (0%)	0 (0%)	107 (78%)	30 (22%)
	Waiwhetu S.	Current	0 (0%)	0 (0%)	54 (100%)	0 (0%)
		BAU	0 (0%)	0 (0%)	54 (100%)	0 (0%)
		Improved	0 (0%)	0 (0%)	54 (100%)	0 (0%)
		Sensitive	0 (0%)	0 (0%)	54 (100%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	0 (0%)	1 (4%)	20 (87%)	2 (9%)
		BAU	0 (0%)	1 (4%)	20 (87%)	2 (9%)
		Improved	0 (0%)	1 (4%)	20 (87%)	2 (9%)
		Sensitive	0 (0%)	1 (4%)	20 (87%)	2 (9%)
	Hutt Valley West Urban	Current	0 (0%)	0 (0%)	29 (69%)	13 (31%)
		BAU	0 (0%)	0 (0%)	29 (69%)	13 (31%)
		Improved	0 (0%)	0 (0%)	29 (69%)	13 (31%)
		Sensitive	0 (0%)	0 (0%)	29 (69%)	13 (31%)
	Kaiwharawhara S.	Current	0 (0%)	0 (0%)	27 (66%)	14 (34%)
		BAU	0 (0%)	0 (0%)	27 (66%)	14 (34%)
		Improved	0 (0%)	0 (0%)	27 (66%)	14 (34%)
		Sensitive	0 (0%)	0 (0%)	27 (66%)	14 (34%)
	North-West Harbour	Current	0 (0%)	0 (0%)	16 (48%)	17 (52%)
		BAU	0 (0%)	0 (0%)	16 (48%)	17 (52%)
		Improved	0 (0%)	0 (0%)	16 (48%)	17 (52%)
		Sensitive	0 (0%)	0 (0%)	16 (48%)	17 (52%)
	Owhiro S.	Current	0 (0%)	0 (0%)	14 (93%)	1 (7%)
		BAU	0 (0%)	0 (0%)	14 (93%)	1 (7%)
		Improved	0 (0%)	0 (0%)	14 (93%)	1 (7%)
		Sensitive	0 (0%)	0 (0%)	14 (93%)	1 (7%)

Table 3: Predicted number and %age of REC reaches in each NO_3-N attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	57 (100%)	0 (0%)	0 (0%)	0 (0%)
	Karori S. – Urb.	Current	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Rur.	Current	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	314 (100%)	0 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	58 (100%)	0 (0%)	0 (0%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	55 (100%)	0 (0%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		BAU	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		Improved	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		Sensitive	120 (97%)	4 (3%)	0 (0%)	0 (0%)
	Pakuratahi Grass	Current	64 (97%)	2 (3%)	0 (0%)	0 (0%)
		BAU	64 (97%)	2 (3%)	0 (0%)	0 (0%)
		Improved	64 (97%)	2 (3%)	0 (0%)	0 (0%)
		Sensitive	64 (97%)	2 (3%)	0 (0%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	76 (100%)	0 (0%)	0 (0%)	0 (0%)
	Korokoro S.	Current	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	53 (100%)	0 (0%)	0 (0%)	0 (0%)
	Makara Coast	Current	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	122 (100%)	0 (0%)	0 (0%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
4 – Mixed rural	Makara S.	Current	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	79 (100%)	0 (0%)	0 (0%)	0 (0%)
	Ohariu S.	Current	130 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	130 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	130 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	130 (100%)	0 (0%)	0 (0%)	0 (0%)
4 – Mixed rural	South Karori	Current	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	136 (99%)	1 (1%)	0 (0%)	0 (0%)
		BAU	136 (99%)	1 (1%)	0 (0%)	0 (0%)
		Improved	136 (99%)	1 (1%)	0 (0%)	0 (0%)
		Sensitive	136 (99%)	1 (1%)	0 (0%)	0 (0%)
	Waiwhetu S.	Current	54 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	54 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	54 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	54 (100%)	0 (0%)	0 (0%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	23 (100%)	0 (0%)	0 (0%)	0 (0%)
	Hutt Valley West Urban	Current	42 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	42 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	42 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	42 (100%)	0 (0%)	0 (0%)	0 (0%)
	Kaiwharawhara S.	Current	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	41 (100%)	0 (0%)	0 (0%)	0 (0%)
	North-West Harbour	Current	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	33 (100%)	0 (0%)	0 (0%)	0 (0%)
	Owhiro S.	Current	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	15 (100%)	0 (0%)	0 (0%)	0 (0%)

Table 4: Predicted number and %age of REC reaches in each NH_4-N attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	57 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	57 (100%)	0 (0%)	0 (0%)	0 (0%)
	Karori S. – Urb.	Current	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Rur.	Current	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	314 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	314 (100%)	0 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	58 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	58 (100%)	0 (0%)	0 (0%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	55 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	55 (100%)	0 (0%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		BAU	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		Improved	120 (97%)	4 (3%)	0 (0%)	0 (0%)
		Sensitive	120 (97%)	4 (3%)	0 (0%)	0 (0%)
	Pakuratahi Grass	Current	65 (98%)	1 (2%)	0 (0%)	0 (0%)
		BAU	65 (98%)	1 (2%)	0 (0%)	0 (0%)
		Improved	65 (98%)	1 (2%)	0 (0%)	0 (0%)
		Sensitive	65 (98%)	1 (2%)	0 (0%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	76 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	76 (100%)	0 (0%)	0 (0%)	0 (0%)
	Korokoro S.	Current	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	53 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	53 (100%)	0 (0%)	0 (0%)	0 (0%)
	Makara Coast	Current	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	122 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	122 (100%)	0 (0%)	0 (0%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
4 – Mixed rural	Makara S.	Current	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	79 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	79 (100%)	0 (0%)	0 (0%)	0 (0%)
	Ohariu S.	Current	129 (99%)	1 (1%)	0 (0%)	0 (0%)
		BAU	129 (99%)	1 (1%)	0 (0%)	0 (0%)
		Improved	129 (99%)	1 (1%)	0 (0%)	0 (0%)
		Sensitive	129 (99%)	1 (1%)	0 (0%)	0 (0%)
4 – Mixed rural	South Karori	Current	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	16 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	123 (90%)	14 (10%)	0 (0%)	0 (0%)
		BAU	123 (90%)	14 (10%)	0 (0%)	0 (0%)
		Improved	123 (90%)	14 (10%)	0 (0%)	0 (0%)
		Sensitive	123 (90%)	14 (10%)	0 (0%)	0 (0%)
	Waiwhetu S.	Current	46 (85%)	8 (15%)	0 (0%)	0 (0%)
		BAU	46 (85%)	8 (15%)	0 (0%)	0 (0%)
		Improved	46 (85%)	8 (15%)	0 (0%)	0 (0%)
		Sensitive	46 (85%)	8 (15%)	0 (0%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	23 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	23 (100%)	0 (0%)	0 (0%)	0 (0%)
	Hutt Valley West Urban	Current	39 (93%)	3 (7%)	0 (0%)	0 (0%)
		BAU	39 (93%)	3 (7%)	0 (0%)	0 (0%)
		Improved	39 (93%)	3 (7%)	0 (0%)	0 (0%)
		Sensitive	39 (93%)	3 (7%)	0 (0%)	0 (0%)
	Kaiwharawhara S.	Current	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	41 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	41 (100%)	0 (0%)	0 (0%)	0 (0%)
	North-West Harbour	Current	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	33 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	33 (100%)	0 (0%)	0 (0%)	0 (0%)
	Owhiro S.	Current	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	15 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	15 (100%)	0 (0%)	0 (0%)	0 (0%)

Table 5: Predicted number and %age of REC reaches in each *E. coli* attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D	E
1 - Headwater urban	Karori S. – Rur.	Current	0 (0%)	0 (0%)	21 (37%)	28 (49%)	8 (14%)
		BAU	0 (0%)	0 (0%)	21 (37%)	28 (49%)	8 (14%)
		Improved	0 (0%)	21 (37%)	28 (49%)	8 (14%)	0 (0%)
		Sensitive	0 (0%)	21 (37%)	28 (49%)	8 (14%)	0 (0%)
	Karori S. – Urb.	Current	0 (0%)	0 (0%)	1 (6%)	1 (6%)	14 (88%)
		BAU	0 (0%)	0 (0%)	1 (6%)	1 (6%)	14 (88%)
		Improved	0 (0%)	1 (6%)	1 (6%)	14 (88%)	0 (0%)
		Sensitive	0 (0%)	1 (6%)	1 (6%)	14 (88%)	0 (0%)
	Wainuiomata R. – Rur.	Current	97 (31%)	72 (23%)	42 (13%)	95 (30%)	8 (3%)
		BAU	97 (31%)	72 (23%)	42 (13%)	95 (30%)	8 (3%)
		Improved	169 (54%)	42 (13%)	95 (30%)	8 (3%)	0 (0%)
		Sensitive	169 (54%)	42 (13%)	95 (30%)	8 (3%)	0 (0%)
	Wainuiomata R. – Urb.	Current	0 (0%)	5 (9%)	5 (9%)	23 (40%)	25 (43%)
		BAU	0 (0%)	5 (9%)	5 (9%)	23 (40%)	25 (43%)
		Improved	5 (9%)	5 (9%)	23 (40%)	25 (43%)	0 (0%)
		Sensitive	5 (9%)	5 (9%)	23 (40%)	25 (43%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	6 (11%)	13 (24%)	4 (7%)	31 (56%)	1 (2%)
		BAU	6 (11%)	13 (24%)	4 (7%)	31 (56%)	1 (2%)
		Improved	19 (35%)	4 (7%)	31 (56%)	1 (2%)	0 (0%)
		Sensitive	23 (42%)	31 (56%)	1 (2%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	1 (1%)	5 (4%)	16 (13%)	72 (58%)	30 (24%)
		BAU	1 (1%)	5 (4%)	16 (13%)	72 (58%)	30 (24%)
		Improved	6 (5%)	16 (13%)	72 (58%)	30 (24%)	0 (0%)
		Sensitive	22 (18%)	72 (58%)	30 (24%)	0 (0%)	0 (0%)
	Pakuratahi Grass	Current	14 (21%)	26 (39%)	9 (14%)	17 (26%)	0 (0%)
		BAU	14 (21%)	26 (39%)	9 (14%)	17 (26%)	0 (0%)
		Improved	40 (61%)	9 (14%)	17 (26%)	0 (0%)	0 (0%)
		Sensitive	49 (74%)	17 (26%)	0 (0%)	0 (0%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	0 (0%)	1 (1%)	21 (28%)	47 (62%)	7 (9%)
		BAU	0 (0%)	1 (1%)	21 (28%)	47 (62%)	7 (9%)
		Improved	0 (0%)	1 (1%)	21 (28%)	47 (62%)	7 (9%)
		Sensitive	1 (1%)	21 (28%)	47 (62%)	7 (9%)	0 (0%)
	Korokoro S.	Current	0 (0%)	0 (0%)	6 (11%)	44 (83%)	3 (6%)
		BAU	0 (0%)	0 (0%)	6 (11%)	44 (83%)	3 (6%)
		Improved	0 (0%)	0 (0%)	6 (11%)	44 (83%)	3 (6%)
		Sensitive	0 (0%)	6 (11%)	44 (83%)	3 (6%)	0 (0%)
	Makara Coast	Current	0 (0%)	0 (0%)	14 (12%)	60 (50%)	47 (39%)
		BAU	0 (0%)	0 (0%)	14 (12%)	60 (50%)	47 (39%)
		Improved	0 (0%)	0 (0%)	14 (12%)	60 (50%)	47 (39%)
		Sensitive	0 (0%)	14 (12%)	60 (50%)	47 (39%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:				
			A	B	C	D	E
4 – Mixed rural	Makara S.	Current	1 (1%)	0 (0%)	1 (1%)	31 (39%)	46 (58%)
		BAU	1 (1%)	0 (0%)	1 (1%)	31 (39%)	46 (58%)
		Improved	1 (1%)	0 (0%)	1 (1%)	31 (39%)	46 (58%)
		Sensitive	1 (1%)	1 (1%)	31 (39%)	46 (58%)	0 (0%)
	Ohariu S.	Current	0 (0%)	0 (0%)	0 (0%)	35 (27%)	95 (73%)
		BAU	0 (0%)	0 (0%)	0 (0%)	35 (27%)	95 (73%)
		Improved	0 (0%)	0 (0%)	0 (0%)	35 (27%)	95 (73%)
		Sensitive	0 (0%)	0 (0%)	35 (27%)	95 (73%)	0 (0%)
4 – Mixed rural	South Karori	Current	0 (0%)	0 (0%)	9 (56%)	7 (44%)	0 (0%)
		BAU	0 (0%)	0 (0%)	9 (56%)	7 (44%)	0 (0%)
		Improved	0 (0%)	0 (0%)	9 (56%)	7 (44%)	0 (0%)
		Sensitive	0 (0%)	9 (56%)	7 (44%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	1 (1%)	2 (1%)	15 (11%)	29 (21%)	90 (66%)
		BAU	1 (1%)	2 (1%)	15 (11%)	29 (21%)	90 (66%)
		Improved	18 (13%)	29 (21%)	90 (66%)	0 (0%)	0 (0%)
		Sensitive	18 (13%)	29 (21%)	90 (66%)	0 (0%)	0 (0%)
	Waiwhetu S.	Current	0 (0%)	0 (0%)	5 (9%)	15 (28%)	34 (63%)
		BAU	0 (0%)	0 (0%)	5 (9%)	15 (28%)	34 (63%)
		Improved	5 (9%)	15 (28%)	34 (63%)	0 (0%)	0 (0%)
		Sensitive	5 (9%)	15 (28%)	34 (63%)	0 (0%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	0 (0%)	0 (0%)	3 (13%)	17 (74%)	3 (13%)
		BAU	0 (0%)	0 (0%)	3 (13%)	17 (74%)	3 (13%)
		Improved	3 (13%)	17 (74%)	3 (13%)	0 (0%)	0 (0%)
		Sensitive	3 (13%)	17 (74%)	3 (13%)	0 (0%)	0 (0%)
	Hutt Valley West Urban	Current	0 (0%)	0 (0%)	1 (2%)	11 (26%)	30 (71%)
		BAU	0 (0%)	0 (0%)	1 (2%)	11 (26%)	30 (71%)
		Improved	1 (2%)	11 (26%)	30 (71%)	0 (0%)	0 (0%)
		Sensitive	1 (2%)	11 (26%)	30 (71%)	0 (0%)	0 (0%)
	Kaiwharawhara S.	Current	2 (5%)	0 (0%)	2 (5%)	9 (22%)	28 (68%)
		BAU	2 (5%)	0 (0%)	2 (5%)	9 (22%)	28 (68%)
		Improved	4 (10%)	9 (22%)	28 (68%)	0 (0%)	0 (0%)
		Sensitive	4 (10%)	9 (22%)	28 (68%)	0 (0%)	0 (0%)
	North-West Harbour	Current	0 (0%)	0 (0%)	0 (0%)	3 (9%)	30 (91%)
		BAU	0 (0%)	0 (0%)	0 (0%)	3 (9%)	30 (91%)
		Improved	0 (0%)	3 (9%)	30 (91%)	0 (0%)	0 (0%)
		Sensitive	0 (0%)	3 (9%)	30 (91%)	0 (0%)	0 (0%)
	Owhiro S.	Current	0 (0%)	0 (0%)	6 (40%)	4 (27%)	5 (33%)
		BAU	0 (0%)	0 (0%)	6 (40%)	4 (27%)	5 (33%)
		Improved	6 (40%)	4 (27%)	5 (33%)	0 (0%)	0 (0%)
		Sensitive	6 (40%)	4 (27%)	5 (33%)	0 (0%)	0 (0%)

Table 6: Predicted number and %age of REC reaches in each peri. attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	0 (0%)	0 (0%)	57 (100%)	0 (0%)
		BAU	0 (0%)	0 (0%)	57 (100%)	0 (0%)
		Improved	0 (0%)	0 (0%)	57 (100%)	0 (0%)
		Sensitive	0 (0%)	0 (0%)	57 (100%)	0 (0%)
	Karori S. – Urb.	Current	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		BAU	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		Improved	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		Sensitive	0 (0%)	0 (0%)	16 (100%)	0 (0%)
	Wainuiomata R. – Rur.	Current	0 (0%)	64 (20%)	247 (79%)	3 (1%)
		BAU	0 (0%)	64 (20%)	247 (79%)	3 (1%)
		Improved	0 (0%)	64 (20%)	247 (79%)	3 (1%)
		Sensitive	0 (0%)	64 (20%)	247 (79%)	3 (1%)
	Wainuiomata R. – Urb.	Current	0 (0%)	0 (0%)	53 (91%)	5 (9%)
		BAU	0 (0%)	0 (0%)	53 (91%)	5 (9%)
		Improved	0 (0%)	0 (0%)	53 (91%)	5 (9%)
		Sensitive	0 (0%)	0 (0%)	53 (91%)	5 (9%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	1 (2%)	41 (75%)	13 (24%)	0 (0%)
		BAU	1 (2%)	41 (75%)	13 (24%)	0 (0%)
		Improved	1 (2%)	41 (75%)	13 (24%)	0 (0%)
		Sensitive	1 (2%)	41 (75%)	13 (24%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	0 (0%)	13 (10%)	105 (85%)	6 (5%)
		BAU	0 (0%)	13 (10%)	105 (85%)	6 (5%)
		Improved	0 (0%)	13 (10%)	105 (85%)	6 (5%)
		Sensitive	13 (10%)	105 (85%)	6 (5%)	0 (0%)
	Pakuratahi Grass	Current	11 (17%)	27 (41%)	26 (39%)	2 (3%)
		BAU	11 (17%)	27 (41%)	26 (39%)	2 (3%)
		Improved	11 (17%)	27 (41%)	26 (39%)	2 (3%)
		Sensitive	38 (58%)	26 (39%)	2 (3%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	0 (0%)	0 (0%)	76 (100%)	0 (0%)
		BAU	0 (0%)	0 (0%)	76 (100%)	0 (0%)
		Improved	0 (0%)	0 (0%)	76 (100%)	0 (0%)
		Sensitive	0 (0%)	0 (0%)	76 (100%)	0 (0%)
	Korokoro S.	Current	0 (0%)	0 (0%)	52 (98%)	1 (2%)
		BAU	0 (0%)	0 (0%)	52 (98%)	1 (2%)
		Improved	0 (0%)	0 (0%)	52 (98%)	1 (2%)
		Sensitive	0 (0%)	0 (0%)	52 (98%)	1 (2%)
	Makara Coast	Current	0 (0%)	0 (0%)	86 (70%)	36 (30%)
		BAU	0 (0%)	0 (0%)	86 (70%)	36 (30%)
		Improved	0 (0%)	0 (0%)	86 (70%)	36 (30%)
		Sensitive	0 (0%)	0 (0%)	86 (70%)	36 (30%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state: A	B	C	D
4 – Mixed rural	Makara S.	Current	0 (0%)	0 (0%)	67 (85%)	12 (15%)
		BAU	0 (0%)	0 (0%)	67 (85%)	12 (15%)
		Improved	0 (0%)	0 (0%)	67 (85%)	12 (15%)
		Sensitive	0 (0%)	0 (0%)	67 (85%)	12 (15%)
	Ohariu S.	Current	0 (0%)	0 (0%)	99 (76%)	31 (24%)
		BAU	0 (0%)	0 (0%)	99 (76%)	31 (24%)
		Improved	0 (0%)	0 (0%)	99 (76%)	31 (24%)
		Sensitive	0 (0%)	0 (0%)	99 (76%)	31 (24%)
4 – Mixed rural	South Karori	Current	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		BAU	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		Improved	0 (0%)	0 (0%)	16 (100%)	0 (0%)
		Sensitive	0 (0%)	0 (0%)	16 (100%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	0 (0%)	0 (0%)	73 (53%)	64 (47%)
		BAU	0 (0%)	0 (0%)	73 (53%)	64 (47%)
		Improved	0 (0%)	0 (0%)	73 (53%)	64 (47%)
		Sensitive	0 (0%)	0 (0%)	73 (53%)	64 (47%)
	Waiwhetu S.	Current	0 (0%)	0 (0%)	34 (63%)	20 (37%)
		BAU	0 (0%)	0 (0%)	34 (63%)	20 (37%)
		Improved	0 (0%)	0 (0%)	34 (63%)	20 (37%)
		Sensitive	0 (0%)	0 (0%)	34 (63%)	20 (37%)
6 – Surface water fed urban	East Harbour	Current	0 (0%)	0 (0%)	20 (87%)	3 (13%)
		BAU	0 (0%)	0 (0%)	20 (87%)	3 (13%)
		Improved	0 (0%)	0 (0%)	20 (87%)	3 (13%)
		Sensitive	0 (0%)	0 (0%)	20 (87%)	3 (13%)
	Hutt Valley West Urban	Current	0 (0%)	0 (0%)	22 (52%)	20 (48%)
		BAU	0 (0%)	0 (0%)	22 (52%)	20 (48%)
		Improved	0 (0%)	0 (0%)	22 (52%)	20 (48%)
		Sensitive	0 (0%)	0 (0%)	22 (52%)	20 (48%)
	Kaiwharawhara S.	Current	0 (0%)	0 (0%)	40 (98%)	1 (2%)
		BAU	0 (0%)	0 (0%)	40 (98%)	1 (2%)
		Improved	0 (0%)	0 (0%)	40 (98%)	1 (2%)
		Sensitive	0 (0%)	0 (0%)	40 (98%)	1 (2%)
	North-West Harbour	Current	0 (0%)	0 (0%)	31 (94%)	2 (6%)
		BAU	0 (0%)	0 (0%)	31 (94%)	2 (6%)
		Improved	0 (0%)	0 (0%)	31 (94%)	2 (6%)
		Sensitive	0 (0%)	0 (0%)	31 (94%)	2 (6%)
	Owhiro S.	Current	0 (0%)	0 (0%)	12 (80%)	3 (20%)
		BAU	0 (0%)	0 (0%)	12 (80%)	3 (20%)
		Improved	0 (0%)	0 (0%)	12 (80%)	3 (20%)
		Sensitive	0 (0%)	0 (0%)	12 (80%)	3 (20%)

Table 7: Predicted number and %age of REC reaches in each MCI attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	4 (7%)	30 (54%)	22 (39%))	0 (0%)
		BAU	4 (7%)	30 (54%)	22 (39%)	0 (0%)
		Improved	4 (7%)	30 (54%)	22 (39%)	0 (0%)
		Sensitive	4 (7%)	30 (54%)	22 (39%)	0 (0%)
	Karori S. – Urb.	Current	1 (6%)	3 (19%)	12 (75%)	0 (0%)
		BAU	1 (6%)	3 (19%)	12 (75%)	0 (0%)
		Improved	1 (6%)	3 (19%)	12 (75%)	0 (0%)
		Sensitive	4 (25%)	12 (75%)	0 (0%)	0 (0%)
	Wainuiomata R. – Rur.	Current	198 (63%)	56 (18%)	59 (19%)	1 (0%)
		BAU	198 (63%)	56 (18%)	59 (19%)	1 (0%)
		Improved	198 (63%)	56 (18%)	59 (19%)	1 (0%)
		Sensitive	254 (81%)	59 (19%)	1 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	13 (22%)	26 (45%)	19 (33%)	0 (0%)
		BAU	13 (22%)	26 (45%)	19 (33%)	0 (0%)
		Improved	13 (22%)	26 (45%)	19 (33%)	0 (0%)
		Sensitive	39 (67%)	19 (33%)	0 (0%)	0 (0%)
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	4 (7%)	45 (83%)	4 (7%)	1 (2%)
		BAU	4 (7%)	45 (83%)	4 (7%)	1 (2%)
		Improved	4 (7%)	45 (83%)	4 (7%)	1 (2%)
		Sensitive	4 (7%)	45 (83%)	4 (7%)	1 (2%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	9 (7%)	48 (39%)	58 (47%)	9 (7%)
		BAU	9 (7%)	48 (39%)	58 (47%)	9 (7%)
		Improved	9 (7%)	48 (39%)	58 (47%)	9 (7%)
		Sensitive	115 (93%)	9 (7%)	0 (0%)	0 (0%)
	Pakuratahi Grass	Current	34 (52%)	22 (33%)	6 (9%)	4 (6%)
		BAU	34 (52%)	22 (33%)	6 (9%)	4 (6%)
		Improved	34 (52%)	22 (33%)	6 (9%)	4 (6%)
		Sensitive	56 (85%)	6 (9%)	4 (6%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	14 (18%)	56 (74%)	6 (8%)	0 (0%)
		BAU	14 (18%)	56 (74%)	6 (8%)	0 (0%)
		Improved	14 (18%)	56 (74%)	6 (8%)	0 (0%)
		Sensitive	70 (92%)	6 (8%)	0 (0%)	0 (0%)
	Korokoro S.	Current	10 (19%)	42 (79%)	1 (2%)	0 (0%)
		BAU	10 (19%)	42 (79%)	1 (2%)	0 (0%)
		Improved	10 (19%)	42 (79%)	1 (2%)	0 (0%)
		Sensitive	52 (98%)	1 (2%)	0 (0%)	0 (0%)
	Makara Coast	Current	0 (0%)	92 (77%)	26 (22%)	1 (1%)
		BAU	0 (0%)	92 (77%)	26 (22%)	1 (1%)
		Improved	0 (0%)	92 (77%)	26 (22%)	1 (1%)
		Sensitive	92 (77%)	26 (22%)	1 (1%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
4 – Mixed rural	Makara S.	Current	0 (0%)	56 (71%)	23 (29%)	0 (0%)
		BAU	0 (0%)	56 (71%)	23 (29%)	0 (0%)
		Improved	0 (0%)	56 (71%)	23 (29%)	0 (0%)
		Sensitive	56 (71%)	23 (29%)	0 (0%)	0 (0%)
	Ohariu S.	Current	0 (0%)	63 (48%)	67 (52%)	0 (0%)
		BAU	0 (0%)	63 (48%)	67 (52%)	0 (0%)
		Improved	0 (0%)	63 (48%)	67 (52%)	0 (0%)
		Sensitive	63 (48%)	67 (52%)	0 (0%)	0 (0%)
4 – Mixed rural	South Karori	Current	0 (0%)	16 (100%)	0 (0%)	0 (0%)
		BAU	0 (0%)	16 (100%)	0 (0%)	0 (0%)
		Improved	0 (0%)	16 (100%)	0 (0%)	0 (0%)
		Sensitive	16 (100%)	0 (0%)	0 (0%)	0 (0%)
5 – Groundwater fed urban	Hutt R. Valley floor	Current	19 (14%)	23 (17%)	63 (46%)	32 (23%)
		BAU	19 (14%)	23 (17%)	63 (46%)	32 (23%)
		Improved	19 (14%)	23 (17%)	63 (46%)	32 (23%)
		Sensitive	42 (31%)	63 (46%)	32 (23%)	0 (0%)
	Waiwhetu S.	Current	7 (13%)	15 (28%)	17 (31%)	15 (28%)
		BAU	7 (13%)	15 (28%)	17 (31%)	15 (28%)
		Improved	7 (13%)	15 (28%)	17 (31%)	15 (28%)
		Sensitive	22 (41%)	17 (31%)	15 (28%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	10 (43%)	12 (52%)	1 (4%)	0 (0%)
		BAU	10 (43%)	12 (52%)	1 (4%)	0 (0%)
		Improved	10 (43%)	12 (52%)	1 (4%)	0 (0%)
		Sensitive	10 (43%)	12 (52%)	1 (4%)	0 (0%)
	Hutt Valley West Urban	Current	0 (0%)	21 (50%)	18 (43%)	3 (7%)
		BAU	0 (0%)	21 (50%)	18 (43%)	3 (7%)
		Improved	0 (0%)	21 (50%)	18 (43%)	3 (7%)
		Sensitive	0 (0%)	21 (50%)	18 (43%)	3 (7%)
	Kaiwharawhara S.	Current	3 (7%)	11 (27%)	27 (66%)	0 (0%)
		BAU	3 (7%)	11 (27%)	27 (66%)	0 (0%)
		Improved	3 (7%)	11 (27%)	27 (66%)	0 (0%)
		Sensitive	3 (7%)	11 (27%)	27 (66%)	0 (0%)
	North-West Harbour	Current	1 (3%)	9 (27%)	22 (67%)	1 (3%)
		BAU	1 (3%)	9 (27%)	22 (67%)	1 (3%)
		Improved	1 (3%)	9 (27%)	22 (67%)	1 (3%)
		Sensitive	1 (3%)	9 (27%)	22 (67%)	1 (3%)
	Owhiro S.	Current	2 (13%)	5 (33%)	8 (53%)	0 (0%)
		BAU	2 (13%)	5 (33%)	8 (53%)	0 (0%)
		Improved	2 (13%)	5 (33%)	8 (53%)	0 (0%)
		Sensitive	2 (13%)	5 (33%)	8 (53%)	0 (0%)

Table 8: Predicted number and %age of fished REC reaches in each IBI attribute state by scenario and sub-catchment.

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
1 - Headwater urban	Karori S. – Rur.	Current	3 (75%)	1 (25%)	0 (0%)	0 (0%)
		BAU	3 (75%)	1 (25%)	0 (0%)	0 (0%)
		Improved	3 (75%)	1 (25%)	0 (0%)	0 (0%)
		Sensitive	3 (75%)	1 (25%)	0 (0%)	0 (0%)
	Karori S. – Urb.	Current	2 (40%)	3 (60%)	0 (0%)	0 (0%)
		BAU	2 (40%)	3 (60%)	0 (0%)	0 (0%)
		Improved	2 (40%)	3 (60%)	0 (0%)	0 (0%)
		Sensitive	2 (40%)	3 (60%)	0 (0%)	0 (0%)
	Wainuiomata R. – Rur.	Current	7 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	7 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	7 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	7 (100%)	0 (0%)	0 (0%)	0 (0%)
	Wainuiomata R. – Urb.	Current	N/A			
		BAU				
		Improved				
		Sensitive				
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Current	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		BAU	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		Improved	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		Sensitive	2 (67%)	1 (33%)	0 (0%)	0 (0%)
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Current	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		BAU	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		Improved	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		Sensitive	1 (33%)	1 (33%)	1 (33%)	0 (0%)
	Pakuratahi Grass	Current	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	1 (100%)	0 (0%)	0 (0%)	0 (0%)
4 – Mixed rural	Hutt Valley Western Hills	Current	9 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	9 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	9 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	9 (100%)	0 (0%)	0 (0%)	0 (0%)
	Korokoro S.	Current	7 (88%)	0 (0%)	1 (13%)	0 (0%)
		BAU	7 (88%)	0 (0%)	1 (13%)	0 (0%)
		Improved	7 (88%)	0 (0%)	1 (13%)	0 (0%)
		Sensitive	7 (88%)	0 (0%)	1 (13%)	0 (0%)
	Makara Coast	Current	13 (93%)	1 (7%)	0 (0%)	0 (0%)
		BAU	13 (93%)	1 (7%)	0 (0%)	0 (0%)
		Improved	13 (93%)	1 (7%)	0 (0%)	0 (0%)
		Sensitive	13 (93%)	1 (7%)	0 (0%)	0 (0%)

EPAU	Sub-catchment	Scenario	Number and proportion of reaches in attribute state:			
			A	B	C	D
4 – Mixed rural	Makara S.	Current	3 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	3 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	3 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	3 (100%)	0 (0%)	0 (0%)	0 (0%)
	Ohariu S.	Current	5 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	5 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	5 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	5 (100%)	0 (0%)	0 (0%)	0 (0%)
4 – Mixed rural	South Karori	Current	N/A			
		BAU				
		Improved				
		Sensitive				
5 – Groundwater fed urban	Hutt R. Valley floor	Current	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		BAU	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		Improved	1 (33%)	1 (33%)	1 (33%)	0 (0%)
		Sensitive	1 (33%)	1 (33%)	1 (33%)	0 (0%)
	Waiwhetu S.	Current	0 (0%)	2 (100%)	0 (0%)	0 (0%)
		BAU	0 (0%)	2 (100%)	0 (0%)	0 (0%)
		Improved	0 (0%)	2 (100%)	0 (0%)	0 (0%)
		Sensitive	0 (0%)	2 (100%)	0 (0%)	0 (0%)
6 – Surface water fed urban	East Harbour	Current	0 (0%)	1 (100%)	0 (0%)	0 (0%)
		BAU	0 (0%)	1 (100%)	0 (0%)	0 (0%)
		Improved	0 (0%)	1 (100%)	0 (0%)	0 (0%)
		Sensitive	0 (0%)	1 (100%)	0 (0%)	0 (0%)
	Hutt Valley West Urban	Current	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		BAU	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		Improved	2 (67%)	1 (33%)	0 (0%)	0 (0%)
		Sensitive	2 (67%)	1 (33%)	0 (0%)	0 (0%)
	Kaiwharawhara S.	Current	7 (47%)	2 (13%)	6 (40%)	0 (0%)
		BAU	7 (47%)	2 (13%)	6 (40%)	0 (0%)
		Improved	7 (47%)	2 (13%)	6 (40%)	0 (0%)
		Sensitive	7 (47%)	2 (13%)	6 (40%)	0 (0%)
	North-West Harbour	Current	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	1 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	1 (100%)	0 (0%)	0 (0%)	0 (0%)
	Owhiro S.	Current	6 (100%)	0 (0%)	0 (0%)	0 (0%)
		BAU	6 (100%)	0 (0%)	0 (0%)	0 (0%)
		Improved	6 (100%)	0 (0%)	0 (0%)	0 (0%)
		Sensitive	6 (100%)	0 (0%)	0 (0%)	0 (0%)

Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Addendum 1 – Consideration of NPS-FM 2020 sediment attributes

24th September 2020

Report Prepared for Greater Wellington Regional Council

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Whaitua Te Whanganui-a-Tara Water Quality and Ecology Scenario Assessment: Addendum 1 – Consideration of NPS-FM 2020 Sediment Attributes

10th February 2022

Report prepared for Greater Wellington Regional Council by:

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Quality Assurance			
Role	Responsibility	Date	Signature
Prepared by	Michael Greer	10/02/2022	
Approved for issue by:			
Status	Final		

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1. Introduction

1.1. Context

It is well established in scientific literature that suspended sediment, clarity and deposited fine sediment are important characteristics that affect values such as ecosystem health and amenity and recreation. However, predicting the effects of environmental management actions (e.g., management of erosion-prone land, riverbank erosion and stormwater sources) on these characteristics in rivers is complex and difficult.

Work undertaken by the Freshwater quality and Ecology Expert Panel (hereafter referred to as 'the panel' or the 'expert panel') in early 2020 estimated the effects of management scenarios on a more predictable attribute described as "fine sediment input" (the amount of sediment entering the river network). The panel qualitatively considered the effects of this predicted "fine sediment input" attribute on several known important in-river characteristics including visual clarity and deposited sediment (see Table 1 in the main report for attribute description) but did not make predictions about future changes in attribute states for these parameters.

The National Policy Statement for Freshwater (NPS-FM) 2020, which was released after the expert panels assessments were made, contains compulsory numeric sediment attributes for both suspended sediment (measured as visual clarity) and deposited fine sediment (measured as percentage cover of the bed). The panel has been asked to consider how it can assist the Whaitua Committee by informing on these new compulsory sediment attributes using available information.

1.2. Predicting change in response to catchment management

Predicting the effects of management scenarios (e.g., management of erosion-prone land, riverbank erosion and stormwater sources) on the absolute numeric attribute state of clarity and deposited fine sediment in rivers is complex and difficult. This difficulty is probably at least part of the reason why sediment attributes have only recently been added as compulsory attributes in the NPS-FM, despite their importance for indicating ecosystem health and recreation values having long been recognised.

1.2.1. Current knowledge and research

Substantial research effort has been underway nationally over the last decade or so to attempt to develop models for predicting the response of clarity and deposited fine sediment to management actions. Our understanding of the current state of model development is:

- For predicting the numeric response of clarity to management: Models have been developed and recently employed by Ministry for the Environment to estimate the effects nationally of possible management measures on the suspended sediment (turbidity) attribute that was part of the draft NPS-FM released by Government in September 2019 (For example, see Neverman *et al.*, (2019)).
  That modelling will need to be reconfigured to assess the clarity attribute that has now replaced the draft turbidity attribute in the new (August 2020) NPSFM. Our

point here is that these models are very recent and not currently set up to assess the response of the new clarity attribute to Whaitua Te Whanganui-a-Tara scenarios. It is our observation that regional councils generally are only just now able to start thinking about how to deal with the new NPS-FM attributes and make use of these models in future.

- For predicting the numeric response of deposited fine sediment to management: Despite considerable research effort attempting to build such models we are not aware of any currently available for this purpose at Whaitua scale.

1.2.2. Stream morphology effects on sediment management responses

The physical characteristics of different streams also impact how they might respond to changes in sediment management. For example, relatively steep hill-fed streams tend not to accumulate deposited fine sediment but may suffer degraded visual clarity due to poor land management. Their response to reduced sediment load could be a reasonably immediate improvement in clarity and no change to deposited fine sediment. By contrast, a low-gradient groundwater-fed stream might have substantial bed sedimentation due to accumulating occasional sediment inputs over a long period of time, but stable flows and low water velocities cause good visual water clarity due to high deposition/ low re-suspension rates. Reducing the input load of sediment to this kind of stream would only produce a slow improvement to deposited fine sediment cover (unless assisted by mechanical sediment removal), because it may take a long time for the legacy sediment deposited on the bed to be naturally flushed out by infrequent floods.

1.2.3. Climate change

Climate change is expected to affect sediment in numerous complex and uncertain ways. Thus, predictions for clarity and deposited fine sediment are going to be quite uncertain, even when quantitative models become available in future. Importantly, however, this does not need to inhibit decision-making, given that the importance of the sediment attributes are well documented and that the likely direction of change under different scenario management actions is easy to assess.

1.3. Expert panel advice on NPS-FM sediment attributes

1.3.1. Current state

GWRC monitoring data for visual clarity and deposited fine sediment at 13 sites in the Whaitua can be used to define current state (i.e., in A, B, C, D terms) at those locations. There are also models available that estimate current state for both clarity and deposited fine sediment in every River Environment Classification[9] (REC) reach in the Whaitua.

The panel has seen both the monitored and modelled current state results for the Whaitua provided by GWRC staff. The monitored results are obviously the most reliable, but they are

[9] The REC is a database of catchment spatial attributes, summarised for every segment in New Zealand's network of rivers

only available at a few locations. On the other hand, the modelled estimates provide a useful indicative estimate of likely current state across the whole of the Whaitua but should only be used to estimate broad scale patterns (e.g., state at assessment unit scale); it is not reasonable to expect they will be accurate at fine sub-catchment scale.

1.3.2. Scenario changes

To assist the Whaitua Committee in this situation the panel think it is reasonable to apply expert judgement to coarsely estimate the direction and relative magnitude of change between scenarios. We think it is reasonable in the circumstances to apply the panel's earlier assessment of "fine sediment input" to estimate the likely direction and approximate magnitude of change to the "visual clarity" attribute. However, we do not consider the same approach to be appropriate for "deposited sediment" for a number of reasons; including the potential for this attribute to be decoupled from/lag behind changes in "fine sediment input" (see Section 1.2.2). We would have moderate to high confidence in the direction of any changes in "visual clarity" but only low confidence in the future absolute state for the reasons laid out above in Section 1.2.

1.3.3. Summary

To summarise, there is uncertainty even in our estimates of the current numeric attribute state for clarity and deposited fine sediment, because only a limited number of sites are monitored in the Whaitua, and we must rely on models as a coarse estimate of state everywhere else. Furthermore, we have no ability currently to quantitatively model how clarity and deposited fine sediment would change under the scenarios. Quantitative predictions of how clarity responds to management will likely be possible in the medium-term future and this will be useful, but the Whaitua Committee should be aware that these will be estimates with significant uncertainty bands around them. For now, we can provide uncertain categorical estimates of changes in visual clarity, but not deposited fine sediment.

2. Methods

The current and future attribute states of "visual clarity" were assessed using the methodologies described in Section 3 of the main report, with changes under the Business as usual (BAU), Improved and Sensitive scenarios determined from the expert panels assessments for the "fine sediment input" attribute.

3. Results

Visual clarity affects aquatic ecosystem health due to the impact it has on the ability of aquatic biota to see their surroundings and each other, and the influence it has over light penetration, and consequently, plant photosynthesis. Visual clarity is also a proxy for suspended sediment concentration. At high concentrations (low visual clarity), suspended sediments have a range of direct and indirect negative ecological effects. Increased drift as macroinvertebrates are dislodged by sediment which can reduce macroinvertebrate abundance. Fish can also be impacted by high suspended sediment concentrations by reduced recruitment of migrating juveniles, clogged gills, reduced feeding performance, and reduced food availability. Furthermore, visual clarity is a key determinant of a river's aesthetics and recreational value.

The majority of REC reaches in most sub-catchments (≥56%) are in expected to be in either the C or D attribute state for visual clarity (under the NPS-FM 2020) (Figure 1 and Figure 2). However, in the Hutt River Valley floor, Waiwhetu Stream, Pakuratahi Grassland, East Harbour and Hutt Valley West Urban sub-catchments most (>52%) reaches are predicted to be in attribute state A or B. The RSoE monitoring sites in most sub-catchments are in the A or B attribute states (Table 1). However, sites in the Wainuiomata River – Rural and Makara Stream sub-catchments are in the D attribute state (Table 1).

The expert panel outputs for the sediment input attribute (Supplement 1) show that in most sub-catchments visual clarity attribute state is unlikely to change under the different scenarios. However, an attribute state improvement is expected in some sub-catchments under the Improved scenario and in all rural and some urban sub-catchments under Sensitive. The reasoning for this is provided below:

- Under BAU a small increase (degradation) in sediment input is expected in most sub-catchments due to the effects of climate change on flood frequency/magnitude and erosion. The exceptions are the Mangaroa Valleys, Pakuratahi Grassland and Te Awa Kairangi mainstem sub-catchments where stock exclusion will offset the effects of climate change, resulting in a small decrease in sediment input. Small changes in sediment input are not expected to result in an attribute state change in visual clarity.
- The assumed mitigations are expected to result in a small improvement in sediment input and visual clarity in most rural sub-catchments under the Improved scenario, despite the effects of climate change. However, in the Mangaroa Valleys and Pakuratahi Grassland sub-catchments, where extensive stock exclusion and riparian planting is assumed, a moderate improvement in sediment input and a one attribute state improvement in visual clarity are expected. In contrast, sediment input and visual clarity in urban sub-catchments are expected to remain unchanged from current under Improved, with the positive effects of the assumed mitigations offsetting the detrimental effects of climate change.
- The increased level of rural and urban mitigation under the Sensitive scenario means that a moderate improvement in sediment input and a one attribute state improvement in visual clarity is likely in all sub-catchments in the Headwater urban, Mangaroa/Pakuratahi Valleys and Mixed rural EPAUs, while small improvements in these attributes are likely in sub-catchments in the Groundwater fed urban and Surface water fed urban EPAUs. Only a small improvement in sediment input and visual clarity is expected in the Te Awa Kairangi mainstem sub-catchment, as the effects of climate change on erosion in the Akatarawa, Upper Hutt and Whakatikei sub-catchments are not expected to be offset by the benefits of the assumed mitigations.

Based on the expert panel's assessments, the distributions of visual clarity attribute states in REC reaches and RSoE sites within the Hutt mainstem, Groundwater fed urban and Surface water fed urban EPAUs are not expected to change under the BAU, Improved or Sensitive Scenario with most reaches remaining in the C or D state (except in the Hutt River Valley floor, Waiwhetu Stream, East Harbour and Hutt Valley West Urban sub-catchments where they will remain in largely the A or B state) (Figure 1 and Figure 2).

The distribution of attribute states in the REC reaches and RSoE sites within the mixed rural sub-catchments are also not expected to change under BAU. However, all reaches and GWRC RSoE sites within the Mangaroa/Pakuratahi Valleys EPAU are predicted to improve an attribute state under both the Improved and Sensitive scenarios (Table 1 and Figure 2). This means that most reaches in the Pakuratahi Grassland sub-catchment will be in A state (majority of reaches currently distributed between the A and B states) under these scenarios, and most reaches in the Mangaroa Valley sub-catchment will be in the C state (currently D state). While not expected under the Improved scenario, an attribute state improvement is also predicted for all sub-catchments in the Headwater urban and Mixed rural EPAUs under the Sensitive Scenario, meaning most sites and reaches in those EPAUs will be in the C attribute state (currently D) (Table 1, Figure 1 and Figure 2). The exception being the Wainuiomata River – Rural sub-catchment where most reaches will be in either the B or C state (currently C or D state)

Table 1: Predicted visual clarity attribute state (NPS-FM 2020) at GWRC monitoring sites under the different scenarios compared to current state.

EPAU	Sub-catchment	Site	Curr.	BAU	Imp.	Sens.
1 – Headwater urban	Karori S. – Urb.	Karori S. @ Mountain Bike Pk	B	B	B	A
	Wainuiomata R. – Rur.	Wainuiomata R. D/S of White Br.	D	D	D	C
2 – Hutt mainstem	Te Awa Kairangi lower mainstem	Hutt R.@ Boulcott	B	B	B	B
		Hutt R.@ Manor Park	A	A	A	A
3 – Mangaroa/Pakuratahi Valleys	Mangaroa Valleys	Mangaroa R. @ Te Marua	D	D	C	C
	Pakuratahi Grass	Pakuratahi R. 50m Below Farm Ck	A	A	A	A
4 – Mixed rural	Makara S.	Makara S. @ Kennels	D	D	D	C
5 – Groundwater fed urban	Waiwhetu S.	Waiwhetu S. @ Whites Line E.	A	A	A	A
6 – Surface water fed urban	Kaiwharawhara S.	Kaiwharawhara S. @ Ngaio G.	A	A	A	A

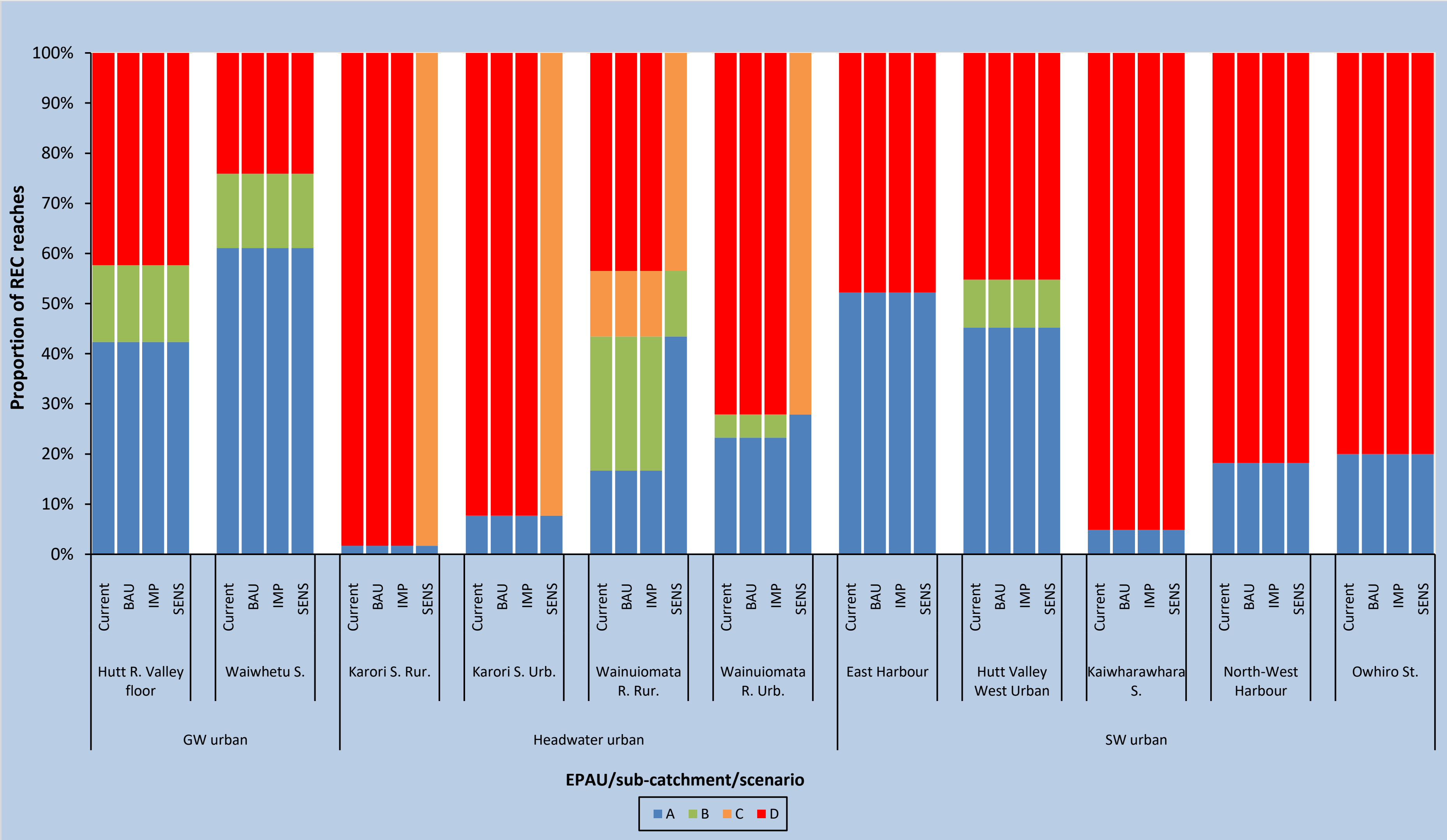

Figure 1: The percentage of REC reaches within each assessed sub-catchment in EPAU 1, 5 and 6 with predicted visual clarity in the NPS-FM 2020 A, B, C and D attribute states under the different scenarios. Current state is based on modelling conducted by Larned et al. (2017)

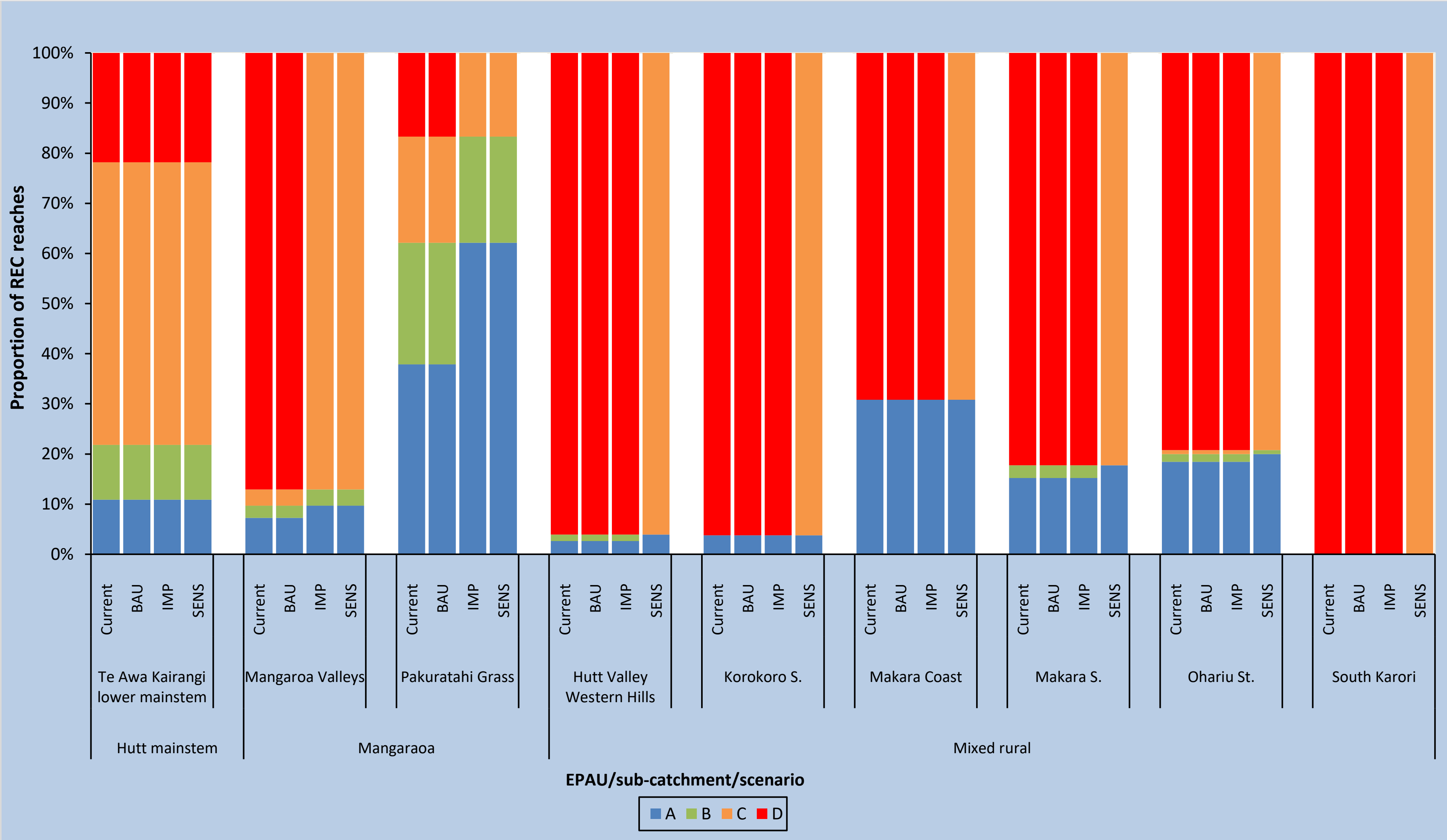

Figure 2: The percentage of REC reaches within each assessed sub-catchment in EPAU 2, 3 and 4 with predicted visual clarity in the NPS-FM 2020 A, B, C and D attribute states under the different scenarios. Current state is based on modelling conducted by Larned et al. (2017)

4. References

Larned, S.T., Snelder, T.H., Unwin, M., 2017. Water Quality in New Zealand Rivers: Modelled water quality state (NIWA Client Report No. CHC2016- 070). NIWA, Christchurch, New Zealand.

Neverman, A., Djanibekov, U., Soliman, T., Walsh, P., Spiekermann, R., Basher, L., 2019. Impact testing of a proposed sediment attribute: identifying erosion and sediment control mitigations to meet proposed sediment attribute bottom lines and the costs and benefits of those mitigations (Manaaki Whenua – Landcare Research Contract Report: LC3574) Manaaki Whenua – Landcare Research. Palmerston North, New Zealand.

APPENDICES

Appendix A: Summary of the attribute state framework used in this report.

Table 1: Attribute states for suspended fine sediment taken from Appendix 2A of the National Policy Statement for Freshwater Management (2020).

Value	Ecosystem health				
Freshwater Body Type	Rivers				
Attribute	Visual clarity				
Attribute Unit	Metres				
Attribute State	**Numeric Attribute State by Sediment Class**				**Narrative Attribute State**
	1	**2**	**3**	**4**	
A	≤1.78	≤0.93	≤2.95	≤1.38	Minimal impact of suspended sediment on instream biota. Ecological communities are similar to those observed in natural reference conditions.
B	<1.78 and ≥1.55	<0.93 and ≥0.76	<2.95 and ≥2.57	<1.38 and ≥1.17	Low to moderate impact of suspended sediment on instream biota. Abundance of sensitive fish species may be reduced.
C	<1.55 and >1.34	<0.76 and >0.61	<2.57 and >2.22	<1.17 and >0.98	Moderate to high impact of suspended sediment on instream biota. Sensitive fish species may be lost.
National Bottom Line	**1.34**	**0.61**	**2.22**	**0.98**	
D	<1.34	<0.61	<2.22	<0.98	High impact of suspended sediment on instream biota. Ecological communities are significantly altered, and sensitive fish and macroinvertebrate species are lost or at high risk of being lost.

The minimum record length for grading a site is the median of 5 years of at least monthly samples (at least 60 samples).

Councils may monitor turbidity and convert the measures to visual clarity.

See Appendix 2C Tables 23 and 26 for the definition of suspended sediment classes and their composition.

- The following are examples of naturally occurring processes relevant for suspended sediment:
- naturally highly coloured brown-water streams
- glacial flour affected streams and rivers
- selected lake-fed REC classes (particularly warm climate classes) where low visual clarity may reflect autochthonous phytoplankton production.