WORKSHOP PAPER

To: **Rangitāiki Freshwater Futures Community Group**

From: Nicola Green and Santiago Bermeo
Senior Planners (Water Policy)

Date: 06 June 2017

Subject: **Freshwater Futures Workshop 5 Overview and national update**

1 Overview

As outlined in previous workshops, we are working towards developing freshwater quality and quantity objectives, limits and methods to support key freshwater values[1] (see Figure 1).

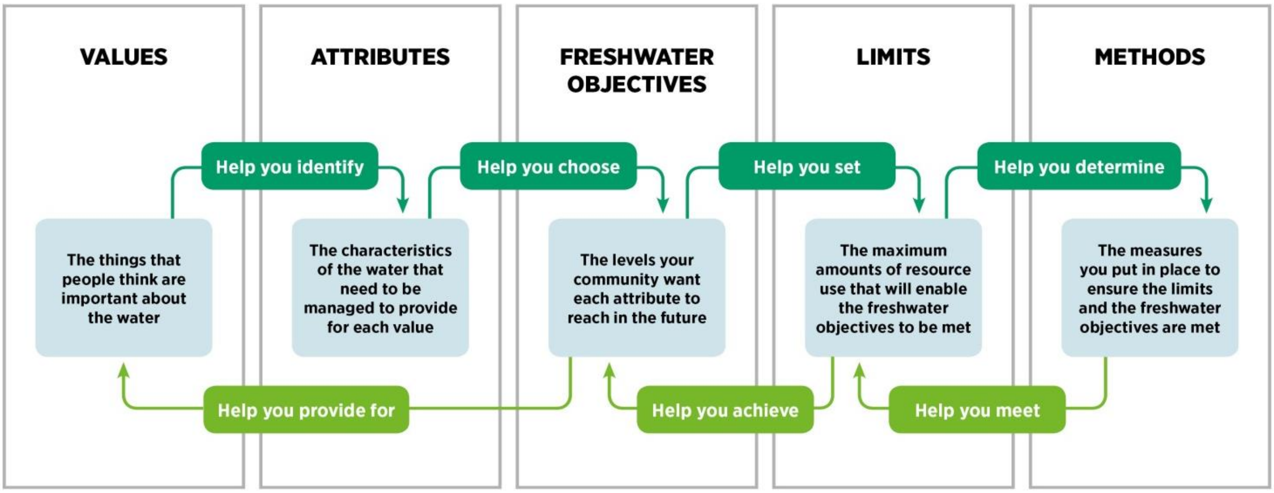

Figure 1: Main steps in the National Objectives Framework, National Policy Statement for Freshwater Management 2014 (NPSFM)

Table 1 summarises very briefly the work we have covered to date in community group workshops and general direction given by the group. Detail is provided within the notes for each workshop.

Table 1: Community Group workshop topics to date

Workshop	Topics	Direction given
1	Introduced the NPSFM process and group function. Discussed **freshwater values**.	
2	Presented **current state** water quality, quantity and ecology information for rivers, groundwater and wetlands.	
3	Discussed working draft **Regional**	General agreement that the draft

[1] In accordance with the National Objectives Framework outlined in Figure 1 and set down by the National Policy Statement for Freshwater Management 2014.

Workshop	Topics	Direction given
	Freshwater Value set, Freshwater Management Units for surface water, and freshwater values within these. Noted draft Freshwater Management Units for groundwater are yet to be determined, and will be based on hydrogeological units that will not necessarily match surface water boundaries.	Regional Freshwater Value Set is comprehensive – some additions and modifications suggested which have largely been added. Agreed in principle that draft FMUs seemed appropriate, but sought the ability to revisit as we progress and understand implications more fully.
4	Discussed **acceptability of the state of "in-river" values** within each draft FMU - A first step towards objective setting.	Detailed input has been summarised and sent to the group.

In workshop 5, we will continue to progress towards setting freshwater objectives for water quality and quantity as outlined in Figure 2. In particular, we will seek your feedback on "desired in-river freshwater state" statements drafted by staff from workshop 4 notes and start to talk about use values and their freshwater quality and quantity needs. Catchment and groundwater modelling are key tools that will help us in assessing management options and how they achieve objectives. We will spend some time talking with you about these as well. Table 2 outlines the content we will cover in the workshop.

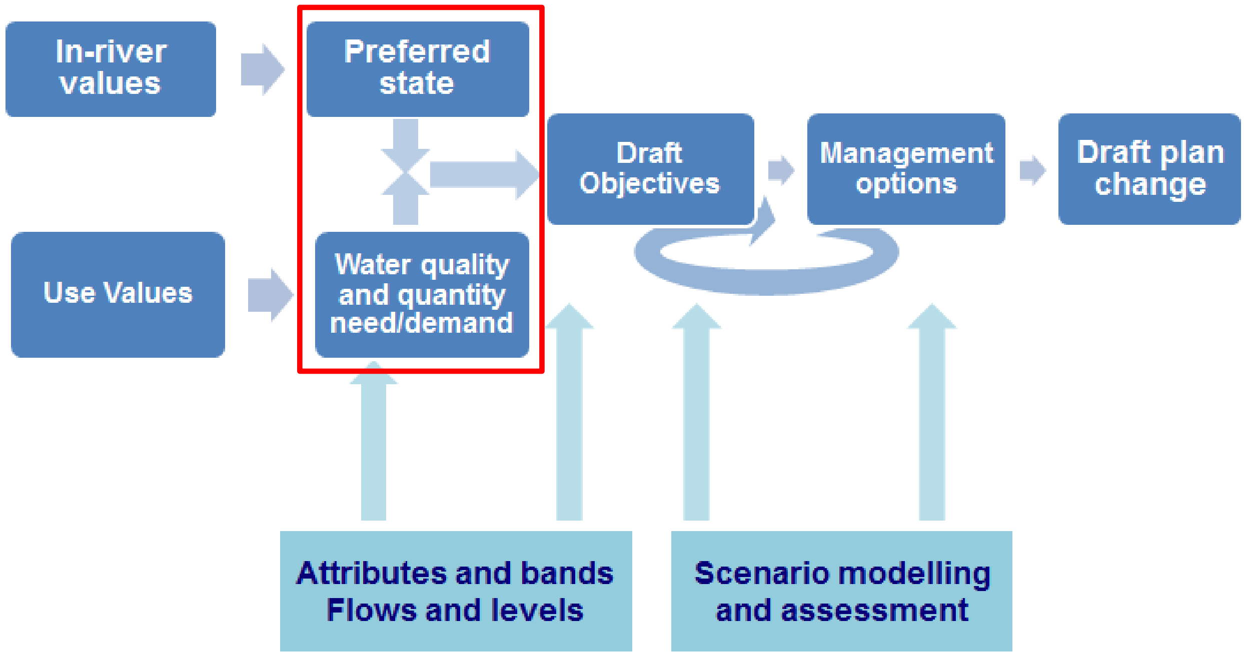

Figure 2: Process for developing freshwater objectives

Table 2: Community Group Workshop 5 topics

Topic	Content
National and regional update (see section 2 below)	**Purpose:** Note key changes of relevance to our work. Includes: • Resource Legislation Amendment Act • *Clean Water* consultation – proposed changes to the NPSFM • BOPRC Plans update • Recent relevant council decisions
Desired in-river state (workshop paper attached)	**Purpose:** Seek feedback on *desired in-river state* statements developed from workshop 4 Community Group input. • Present preliminary science recommendations for attributes and bands. • Acknowledge gaps requiring further work, particularly the need to

	engage with iwi on sites of cultural significance. **Feedback sought:** Have we got desired in-river state statements right?
Freshwater Issues (workshop paper attached)	**Purpose:** Summarise key freshwater quality and quantity resource management issues**.** **Feedback sought:** Agreement on key issues we will focus on going forward.
Use values (workshop paper attached)	**Purpose:** Understand current land use, allocation of water, discharges to water by industry per FMU and work progressing on economic value. • Present current land use. **Feedback sought:** • General understanding and agreement on the presented information and gaps.
Integrated catchment modelling (information sheet attached)	**Purpose:** Provide overview of integrated catchment modelling in progress. • Explain e-Water source model, input layers, what the model can/will do, outputs, data, limitations and uncertainties, and timeline. **Feedback sought:** • Understanding of how the modelling will work and contribute to process. • Feedback on accuracy of land use layer.
Causal Loop workshops update	**Purpose:** Summarise outcomes and potential use of the Causal Loop Workshops held with a sub-group of this Community Group
Next steps	**Purpose:** Outline upcoming process of developing scenarios and management options. **Feedback sought:** • What factors/criteria would you prefer to measure "success" of management options by? • Brainstorm of management options

2 National and regional freshwater management updates

2.1 Resource Management Act changes

The Resource Legislation Amendment Act 2017, which makes numerous changes to the Resource Management Act 1991, became law on 18 April 2017. More information can be found on the Ministry for the Environment website. The changes of most relevance for freshwater management are:

- provision to enable stock exclusion regulations;
- provision for use of models (e.g. OVERSEER) in Plans;
- provision for collaborative planning processes as an alternative to the current Schedule 1 process for Plan Changes;
- changes to s. 14(3)(b)(ii) to clarify that no resource consent is needed for stock drinking water, whether the stock is owned by an individual or a company (e.g. farming entity); and
- provision for iwi participation agreements/Mana whakahono a rohe. Regional plans are to be prepared in accordance with these.

In the context of our current work in the Rangitāiki and Kaituna-Pongakawa-Waitahanui Water Management Areas (WMAs), we don't expect these changes will have significant implications. Iwi participation agreements/Mana whakahono a rohe may confirm or supersede existing participation arrangements, subject to when these can be finalised.

2.2 *Clean Water* consultation

The Ministry for the Environment consulted on the following proposals between February and April 2017:
- national targets for making large streams and lakes suitable for swimming (80% by 2030 and 90% by 2040);
- a number of proposed changes to the NPSFM; and
- proposed stock exclusion regulations.

The document also opened for applications the $100m Freshwater Improvement Fund.

BOPRC made a submission on the proposals, which is available on the Community Group online portal. BOPRC generally supported the proposals but made recommendations to:
- align the proposed swimmability targets more closely with NPSFM implementation;
- reduce ambiguity/increase clarity;
- strengthen environmental considerations; and
- provide additional flexibility for regional management.

In advance of confirming final decisions, the Minister for the Environment requested that Regional Councils work with central government to develop draft plans by October 2017 for how the proposed 'swimmability' targets will be achieved. BOPRC is currently involved in this, noting that according to modelling and analysis by the Ministry for the Environment, 86% of the Bay of Plenty's large streams and lakes already meet the proposed swimming standards.

Final decisions on these national proposals are expected over the next couple of months, ahead of the General Election. We will need to take into account or give effect to any final decisions within the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMAs. For example, we may need to consider how national targets for swimming in large rivers and lakes align with community expectations and favoured swimming locations, national stock exclusion requirements may be in place and this would effectively be a nationally applicable 'method', refer to Figure 1.

2.3 Regional Policy and Plan changes

Region—wide Water Quantity (Proposed Plan Change 9)

Proposed Plan Change 9 sets a number of region-wide policies and rules in relation to managing water quantity as outlined in previous workshops. It sets region-wide interim allocation limits that are in place until WMA specific Plan Changes supersede them. Further submissions will be received in May 2017; hearings are set for October/November 2017 and final decisions by March 2018.

In the context of the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMA, there is opportunity to recommend more specific water quantity objectives, limits and methods that supersede the interim measures set by Plan Change 9. The policies and rules set by Plan Change 9 remain relevant other than where superseded by these WMA-specific changes.

Changes to Regional Policy Statement to recognise and provide for Te Ara Whanui/Pathways of the Rangitāiki River document (Proposed Change 3)

Nineteen submissions and six further submissions have been received on Proposed Change 3. Hearings are scheduled for 12 and 19 June 2017. Plan Change 12 provisions for Rangitāiki WMA will need to give effect Change 3. The Rangitāiki River Forum is a co-governance forum and decisions for Plan Change 12 relating to Rangitāiki WMA will go to the Forum for their advice/approval, although Council is the ultimate decision-maker. Te

Maru o Kaituna have notified a proposed river document *Kaituna, he taonga tuku iho – a treasure gifted to us*, which is open for public submissions until 24 July 2017. A change to the Regional Policy Statement will follow once that document is approved.

Lake Rotorua Nutrient Management (Proposed Plan Change 10)

Proposed Plan Change 10 introduces rules to limit the amount of nitrogen entering Lake Rotorua from land use in order to achieve lake water quality objective and limits set in the Regional Policy Statement and Regional Water and Land Plan (refer to Figure 1). The proposed rules set out how Nitrogen Discharge Allowances will be allocated to individual rural properties. Hearings on the Plan Change finished in early May 2017. Final decisions are expected in late June 2017.

There are no direct implications from Plan Change 10 for our work in the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMAs, but Council is considering the learnings and outcomes as we work towards Plan Change 12. The objective for Lake Rotorua was set in 2001, a decade before the NPSFM. The limit to support that objective was set in 2010 and the method the Plan Change is introducing now was determined in 2015, after significant engagement with Lake Rotorua stakeholders. A significant difference for Plan Change 12 is that we are considering objectives, limits and methods concurrently.

WORKSHOP PAPER

Bay of Plenty REGIONAL COUNCIL

To: **Rangitāiki Freshwater Futures Community Group**

From: Michelle Lee
Planner (Water Policy)

Date: 8 June 2016

Subject: **Draft desired in-river state statements – Have we got them right?**

1 Purpose

The purpose of this paper is to confirm Council staff have correctly interpreted the ***desired in-river state*** from your comments on the acceptability of in-river values made in the previous workshop.

We would like your feedback on the **bold-font** statements in section 4 and Appendix 3 of this paper.

This is a step towards drafting 'freshwater objectives' for draft freshwater management units (FMUs) under the National Policy Statement for Freshwater Management 2014 (NPSFM).

This paper also presents a recap of steps to date (section 3) and links values to science attributes (ie. measures).

2 Introduction

At the 8 November 2016 workshop, the Rangitāiki Freshwater Futures Community Group (the Group) detailed in-river values for the Rangitāiki Natural State, Middle-upper Rangitāiki and Lower Rangitāiki draft FMUs. Together we need to take these values and use-values, and in due course establish freshwater objectives based on them.

Freshwater objectives are the intended environmental outcomes (particularly water quality and level/flow) for a water body. They provide for the values (e.g. swimming) the community considers important, taking into account aspirations and the existing state/condition among other things. Freshwater objectives need to be set for each FMU and linked to the identified freshwater values.

To date, the Group has considered the values and conditions *in* rivers. In the coming workshops, the Group will consider land and water use values, and modelling results for different land and water use scenarios, before finally determining freshwater objectives for water bodies.

3 The Steps to Date

3.1 Freshwater Value Set, Freshwater Management Units and the current state of fresh water

At workshop 1, members were introduced to a working draft regional freshwater value set and provided feedback on whether it captured all freshwater values.

At workshop 2, scientists presented the current scientifically monitored freshwater state of the Rangitāiki. This was summarised again briefly in the *Workshop 4 briefing notes*.

At the third workshop, the Group considered freshwater values that apply to these areas and draft FMUs (note these will be revisited as work progresses).

3.2 Community members' views on the acceptability of the state of in-river values

Building on this information, the Community Group expressed the current 'acceptability' of in-river values for the three draft FMUs in the last (the fourth) workshop. A draft summary and analysis of the Groups' inputs were presented in *the notes for Workshop 4.* Members provided feedback and made corrections. The amended version is in Appendix One.

For some freshwater values, the group expressed the need for more information and/or that the knowledge needs to come from other appropriate sources (e.g. kaumatua knowledge on wai tapu and culturally significant sites in their rohe). This is being progressed.

Staff have used the workshop 4 outputs to draft the 'desired in-river state' for the FMUs (section 4). We now seek the Group's feedback and discussion on these in Workshop 5.

3.3 Preliminary recommendations for freshwater attributes

Attributes are the science-based measurable characteristics of a freshwater body which can be managed to enable particular values to be provided for (e.g. measuring *E. coli* to show that the water is swimmable).

Council's scientists have assessed thirty[2] potential attributes that may be useful for this purpose, and have provided preliminary recommendations (these are subject to external peer review). The nine compulsory attributes in the NPSFM and seven additional attributes are recommended along with state bands. Eleven of these attributes are for rivers (see Appendix Two). 'Freshwater objectives' are water quality concentrations or levels/flow of the identified attributes, necessary to provide for values. Attributes will also inform Council's freshwater monitoring plan.

Further work is required before attributes for groundwater and wetlands can be recommended. Similarly, attributes for measuring habitat and fish communities are the subject of further national research. Additional recommendations will be made as new research enables it.

The two hydro dam lakes in the Middle-upper Rangitāiki are a part of the Rangitāiki River. The group expressed they have values related to 'lakes' so lake attributes are relevant for these dam lakes (in the draft middle-upper Rangitāiki FMU).

Dissolved reactive phosphorus (DRP), dissolved inorganic nitrogen (DIN) and total suspended solids (TSS) are key attributes that we consider important to include, but for which no bands are currently developed. Significant research is currently underway (both regionally and nationally) on these attributes. Additional attributes (or revised attributes) will be recommended once more information from the research is available.

Note that the surface water catchment model (which is explained in a separate workshop paper) will model *E.coli,* nitrate and nitrite, total and dissolved reactive phosphorous and TSS.

[2] *E.coli*, enterococci, nitrate-nitrogen (NO_3-N), ammoniacal-nitrogen (NH_4-N), trophic level index (TLI), dissolved inorganic nitrogen (DIN), total nitrogen (TN), total phosphorus (TP), dissolved oxygen (DO), acidity (pH), dissolved reactive phosphorus (DRP), temperature, clarity, turbidity, faecal coliforms, metals, total suspended solids (TSS), pesticides, conductivity/salinity, biological oxygen demand (BOD), deposited sediment, colour, algae (periphyton) cover, algae - chlorophyll, cyanobacteria – benthic, cyanobacteria – planktonic, macrophytes (submerged plant indicators, SPI), invertebrates, fish (biotic index), habitat (assessments).

4 Draft *desired in-river state* in FMUs and recommended associated freshwater attributes

This section presents the draft 'desired in-river state'**[3]**, interpreted from member's input at the last workshop, for your comments.

Key attributes/measures are added to indicate how these desired in-river states could be measured.

In this section, the symbol " **?** " indicates measures that members have suggested, but it will require further research before they can be used as a freshwater attribute for objective and limit-setting. " ***** " indicates that the surface water catchment model will include this attribute.

4.1 Rangitāiki Natural State

We have interpreted that the desired in-river states in the draft Rangitāiki Natural State FMU to be:

RN1. **The water will continue to be swimmable without getting sick.**
Key attribute: *E. coli* (currently[4] in band B), pathogens (Giardia cysts)[?]

RN2. **The water will continue to support the natural form and character as it is now, while seeking opportunities to control and reduce pest plants and animals.**
Key attributes: water flow, habitat[?] , temperature, total suspended solids*, deposited sediment[?], algae, metal[?]

RN3. **The water will support the ecosystems' health, fishing and eeling in tributaries, and the tributaries' health is not affected by algae.**
Key attributes: nitrate (toxicity, currently in band A), ammonia (toxicity, currently in band A), dissolved oxygen, periphyton, temperature, pH, total suspended solids*, algae, benthic cyanobacteria, macrophytes, invertebrates, phosphorous*, metal[?], pesticides[?], fish[?]

RN3. **The water will continue to provide for fish and bird habitats. The level of sediment in the water will be managed for providing healthy habitats for mahinga kai species.**
Notes: Members noted species include whio, koura, whitebait (koaro, kōkōpu and galaxiids), trout and longfin tuna. Sediment and algae in the water were noted as particular concerns.
Key attributes: water flow, dissolved oxygen, temperature, invertebrates, total suspended solids*, deposited sediment[?], metal[?], pesticides[?], fish[?], habitat[?]

RN3. **The water will continue to provide for mahinga kai that is safe to eat as it is now.** Key attributes: *E. coli*, benthic cyanobacteria, macrophytes, invertebrates, metal[?], pesticides[?], pathogens (Giardia cysts)[?], faecal coliforms[?], fish[?], habitat[?]

RN4. **The water will continue to be suitable for wai tapu and cultural spiritual needs.**
Possible measures: water flow [preliminary information subject to tangata whenua knowledge input].

Community Group members shared observations on specific sites within this draft FMU. Most are not Council's regular monitoring sites, but these, along with other sites of significance, will be considered for future water quality and quantity modelling estimates. Identified locations include:

- Swimming: Whirinaki, Okahu Stream, their tributaries, and neighbouring streams in Whakatāne River headwaters.
- Ecosystem health, mahinga kai and fishing: Okahu Stream

[3] Appendix 3 has further simplified statements based on learnings from Kaituna and Pongakawa workshops
[4] This attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

- Wai tapu: State Highway 38, Te Whaiti nui a Toi Canyon and Mangamate Waterfall.

4.2 Middle-upper Rangitāiki

We have interpreted that the desired in-river states in the draft Middle-Upper Rangitāiki FMU to be:

RM1. **The water will continue to be good for swimming.**
Notes: The swimming experience could be improved by reducing sediment, filamentous algae, aquatic weed and human waste.
Key attribute: water level, *E.coli* (currently[5] in band A at Murupara, band B at SH5, below acceptable for swimming at Matahina Dam and Aniwhenua Canal), total suspended solids*, cyanobacteria - planktonic

RM2. **The water will support the natural form and character.** Key attributes: water flow, habitat?, temperature, total suspended solids*, deposited sediment?, algae.

RM3. **The water will support ecosystem health, significant indigenous species, mahinga kai and species that are important for fishing.**
Notes: Members noted opportunities should be taken to restore wetlands, remove weeds (blackberry, gorse and aquatic weed), plant riparian margins and include buffers between streams and forestry blocks. Species noted by members include longfin tuna inanga, koaro, banded kōkopu and/or giant kōkopu, koura, kakahi, watercress, whio and trout. More information is needed on koura, kakahi, kotuku, mallard and grey duck. Sediment reduction is a key concern.
Key attributes: nitrate (toxicity, currently in band B at Otamatea, band A at Murupara and Matahina), ammonia (toxicity, currently in band A at Murupara and Matahina), total nitrogen, total phosphorus, trophic level index, phytoplankton, periphyton/algae, dissolved oxygen, temperature, pH, total suspended solids*, benthic cyanobacteria, macrophytes, lake submerge plant index invertebrates, phosphorous*, metal?, pesticides?, fish?, habitat?

RM3. **The water quality and flow will provide for habitats of mahinga kai, native and/or fishing species, including reducing silt going into the river and affecting habitats.**
Notes: Members noted species include longfin tuna, whitebait (inanga, koaro, banded kōkopu and/or giant kōkopu), koura, kakahi, watercress, whio and trout.
Key attribute: nitrate (toxicity, currently in band B at Otamatea, band A at Murupara and Matahina), ammonia (toxicity, currently in band A at Murupara and Matahina), total nitrogen, total phosphorus, trophic level index, phytoplankton, periphyton/algae, dissolved oxygen, temperature, pH, total suspended solids*, silt?, benthic cyanobacteria, macrophytes, lake submerge plant index invertebrates, phosphorous*, metal?, pesticides?, fish?, habitat? [more information is needed on koura, kakahi, kotuku, mallard and grey duck].

RM4. **The water flow and quality will continue to provide for wai tapu, springs, sites of cultural significance and customary cultural ceremonial activities.**
Possible measures: appropriate cultural impact assessment (which Rangitāiki, group members suggested assessing the impacts on tuna/eel and physical connection, from modified landscape and waterways, artificial mixing of water and presence of human waste) [note more information to be added with tangata whenua knowledge input].

RM5. **The water flow and quality will continue to provide for transport/tauranga waka, and recreational uses including rafting.** Key attribute: water flow, *E.coli* (currently in band A, in relation to the annual median, at Murupara and at Matahina Dam and Aniwhenua Canal), tree log obstructions?.

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[5] This attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

Community group members shared important observations on specific sites within this draft FMU. Those identified locations are noted as follows.

- Swimming: Horomanga, Murupara, river downstream from wastewater treatment plants, Lake Aniwaniwa*.*
- Mahinga Kai: Koura – Aniwaniwa and its tributaries (where it became still-water). Kakahi – Gone throughout the Galatea and Matahina, where its habitat is affected by silt.
- Wai tapu and sites of cultural significance: Springs, Mangamate waterfall (note there are two streams of the same name – one by Galatea; one by Minginui) and other places in rivers are used for ritual activities [note more information to be added with tangata whenua knowledge input].
- Transport/tauranga waka: downstream from Murupara, rafting - between Murupara and Galatea.

4.3 Lower Rangitāiki

We have interpreted that the desired in-river states in the draft Lower Rangitāiki FMU to be:

RL1. **The river depth (including in summer) and water quality will continue to be good for swimming**. Key attributes: water flow, water level, *E.coli* (currently[6] *in band B at Te Teko, band A at Edgecumbe and Thornton), cyanobacteria – planktonic (currently no history of blooms recorded)*

RL2. **The water will support ecosystem health.**
Key attributes: water flow, nitrate (toxicity, currently in band A), ammonia (toxicity, currently in band A), dissolved oxygen, periphyton/algae, temperature, pH, total suspended solids*, benthic cyanobacteria, macrophytes, invertebrates, phosphorous*, metal?, pesticides?, fish?, habitat?

RL2. **The water flow, quality and hydrology will provide for improving ecosystem health, indigenous species, spawning areas, mahinga kai and species of importance for fishing.**
Notes: Members identified species include watercress, longfin tuna, shortfin tuna, whitebait (including inanga, koaro, banded kōkopu and/or giant kōkopu), kahawai, mullet, lamprey, parore, kakahi, kotuku, bittern, mallard and grey ducks and trout.
Key attribute: water flow, nitrate (toxicity, currently in band A, ammonia (toxicity, currently in band A, phytoplankton, periphyton/algae, dissolved oxygen, temperature, pH, total suspended solids*, benthic cyanobacteria, macrophytes, invertebrates, phosphorous*, metal?, pesticides?, fish?, habitat?.

RL3. **Wetlands will be suitable for water fowl habitat, such as for the presence of kotuku and bittern.** Key attributes: water level, habitats?

RL4. **Natural form and character will be improved.**
Notes: Members noted the Lower Rangitāiki River has been heavily modified including structural changes and pest plant and animal impacts
Key attributes: water flow, algae, wetland vegetation, erosion/total suspended solids*, modification?, wetland vegetation? [note more information to be added with tangata whenua knowledge input]

RL5. **Water will provide for wai tapu, sites of cultural significance and customary cultural ceremonial activities.** .
Key attributes: Information to be added with tangata whenua knowledge input.

RL6. **Water will continue to provide for transport / tauranga waka**.
Key attributes: water flow.

[6] This attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

Community group members shared important observations on specific sites within the Lower Rangitāiki draft FMU. Those identified locations are noted as follows.

- Swimming: Te Teko bridge diving, by Te Teko marae(s), Edgecumbe bridge, Thornton.
- Wai tapu and sites of cultural significance: sites near marae are used more often. Site of historical value open in rivers, swamps and original river courses. [Note more information to be added with tangata whenua knowledge input.]

Note: *Following consistent feedback at both Pongakawa-Waitahanui and Kaituna Community Group workshops, staff have streamlined the above statements with consistent wording, which clearly states whether to maintain or improve (see Appendix 3).*

5 Other in-river state observations/actions sought

Community Group members also expressed desired actions/activities not directly related to freshwater quality and quantity. These included:

- The observed gradual and sudden decline in native mahinga kai species numbers, such as whitebait, could be the result of:
    - overfishing: residents observed depleting parore in Thornton estuary in the past. It was believed to be depleted by netting practice.
    - flood events.
    - lack of fish passage for migratory native fish, where the dams are barriers, although catch and release brought some relief to fish migrating up-stream.
    - trout predation on smaller/juvenile native fish.
- People need to be informed when it is unsafe for swimming.
- Safer boat ramp needed.
- Addressing overgrown weeds on riparian margin, better access through private land, and better amenities will improve the access and experience of river swimming.
- There is a potential conflict of use downstream from Murupara (rafting between Murupara and Galatea). Navigation can be hindered by tree logs, and access to the water can be problematic at places. Access can be difficult (road access and down river side banks/cliffs).
- Remove some willows along the whole river bank.
- Mitigate or use alternative to ‘rock rip-rap’ river banks.
- Avoid and reduce the effects from channelling and drainage system.
- Wai tapu sites near marae are often being used, which can be better recognised with sign-posts and better access.
- Many wai tapu sites could be gone or diminished in areas where the landscape has been largely modified, affecting historical values of sites in rivers, swamps, and original river courses.

Appendix One

Summary of 'acceptability' of in-river freshwater values drawn from community group feedback

Rangitāiki Natural State draft freshwater management unit

- **Swimming** – Acceptable.
- **Natural form and character** – Acceptable. Natural character values can be improved by reducing invasive plants (both riparian and aquatic) and pest animal species for amenity, safety and reducing the risk of getting sick reasons. Manage effects of giardia in streams and rivers in Te Urewera. In relation to Okahu Stream and its tributaries, <u>and neighbouring streams in Whakatāne River headwaters, local communities want to know which streams are safe water supply sources</u>.
- **Ecosystem health** – Depends. Some tributaries are good, and some covered in algae.
- **Mahinga kai and significant, threatened or rare native fish species –** Unacceptable, due to observed decline in tuna, koura, koaro, kokopu, galaxids and whitebait, which could be caused by dams as fish migration barrier, sediment and trout predation. The recent flood events six months ago caused low fish numbers even now. Generally members are not concerned about food safety of mahinga kai species but the dwindling numbers.
  - **Fishing** and **ecosystem health** in Okahu Stream – Unacceptable, as no successful fishing and eeling is being observed.
  - ***Longfin tuna*** – Unacceptable, as migratory native fish, dams as barriers to life-cycle migrations. It has been difficult to find tuna since the flood events six months ago.
  - **Whitebait** (including **koaro**, **kōkopu** and **galaxiids**) – Unacceptable, as migratory native fish, dams as barriers to life-cycle migrations recognised as contributing to their decline. The trout predation was recognised as another factor. Recent flood events are followed by lingering low harvest in the tuna and whitebait fishing in Whirinaki.
  - ***Koura*** **–** Observed the dwindling number of koura in Aniwaniwa and tributaries around it. No acceptability of the water conditions specifically rated for koura.
  - ***Trout*** **–** Acceptable, apart from one group noted trout population is diminishing in some streams. Some identified that native fish suffered from trout predation.
  - **Whio** – Acceptable. Numbers increased, and it is looking positive.
  - ***Shags*** – Different views. One commented a particular type of shag is significant for Ngāti Whare. One commented that the black shag population is in drastic decline due to loss of food source. Another commented that waterfowl are in decline due to loss of lower wetland. No acceptability of the water conditions specifically rated for shags.
- **Wai tapu** at Te Whaiti nui a Toi Canyon – Acceptable.
- **Wai tapu** *at Mangamate waterfall* – Acceptable, but concerned that the water source may be affected by its farmland catchment.
- **Wai tapu along State Highway 38 – Unacceptable, due to road works removal of habitats, and reducing supply of mahinga kai. Concerns with erosion, gravel flow and that other natural hazard events could also threaten the wai tapu values.**
- **Some members noted that seeking tangata whenua knowledge about to wai tapu values was appropriate.**
- **Transport/tauranga waka** – Diverse views. Limited accessibility and navigability results in low popularity for using vessels on these waterways.

Mid-Upper Rangitāiki draft freshwater management unit

- **Swimming** (popular spots for water activities include Horomanga, Murupara, Aniwaniwa) – generally acceptable but room to improve. Members also expressed concerns about high level of sediment. For example, Lake Rotomā is a more attractive swimming location. In Aniwaniwa, the filamentous algae and aquatic weed made the experience less pleasant.
  Swimming below the Murupara sewage plant – unacceptable.
- **Rafting** (between Murupara and Galatea) – Acceptable, yet at times affected by seasonal and/or artificial low flow. Access can be difficult (road access and down river side banks/cliffs).
  - ***Swimming / rafting suggestion:*** access to river swimming could be improved with: better access (via private land and/or addressing overgrown weeds on riparian margin) and amenities.
  - Members noted people rely on science to know when it's unsafe for swimming.
- **Natural form and character** – neutral <u>with some variance of view to either side</u>. The river form and character is no longer natural as it was modified by existing structures (eg. stop-banks, channels dams and farmland) and pest impacts on vegetation.
- **Ecosystem health at riparian margin** – Unacceptable. Some natural habitat and ecosystems were lost through channelling/redirecting the water. Members suggested the condition can be improved by restoring wetlands, removing weeds (blackberry, gorse and aquatic weed), including buffers between streams and forestry blocks, and riparian planting.
- **Fishing of native species / Mahinga Kai** – Unacceptable. Partly due to lack of fish passage for migratory native fish. Catch and release brought relief to up-stream fish migration. The habitats are also affected by sediment. Some current practices have reduced silt and sediment going into the river compared to the past – hopefully the trends are improving.
  - ***Longfin tuna (eels)*** – Neutral to unacceptable. Abundance has diminished with development. Commercial eeling may have an impact.
  - ***Whitebait*** (including īnanga, koaro, banded kōkopu and/or giant kōkopu) – Unacceptable. Numbers declining, even in the stream named Kōkopu.
  - ***Koura*** **–** Unacceptable. Mahinga kai value lost as very little koura population left. The sediment build up at Aniwaniwa could have destroyed koura habitat. Also gone in tributaries where it became still-water. More information is needed on koura.
  - ***Kakahi*** – Gone. Throughout the Galatea and Matahina, where its habitat is affected by silt.
  - ***Watercress*** – Acceptable. Good watercress that is plentiful and tastes good.
  - ***Trout fishery*** (and other introduced species) – Acceptable/good. Sustaining healthy trout fishery, although a large number of trout deaths were witnessed in summer 2015.
  - ***Whio*** (blue duck) – Acceptable.
  - ***Kotuku*** (culturally significant shag) and bittern – Unsure.
  - ***Mallard*** *and* ***grey duck*** **–** In decline. Reasons unknown.
- **Wai Tapu and Sites of cultural significance:** There are many culturally significant places, and while knowledge is held by some tangata whenua members, there is not enough knowledge in the group to identify all sites and locations. Springs, Mangamate waterfall and other places in rivers are used for ritual activities. Some members have knowledge in local wai tapu sites. A number of factors have impacts on **wai tapu** and sites of cultural significance. Some mentioned in the workshop include:
  - Tuna contributes to the spiritual value of this river. Migration barriers (eg. Rangipo migrating eels) and low numbers of tuna diminishes the wai tapu value
  - Modified landscape and waterways (flood schemes and dams) violated cultural sites
  - The artificial mixing of Rangitāiki water with Flaxy and Wheao
  - Discharge of treated human waste or effluent to waterway, eg. Murupara sewage pond discharge affected the taniwha sites, offensive nature of effluent entering freshwater.
  - Access to sites for making physical connection.
- **Transport/tauranga waka –** Diverse views. Different navigation recreation takes place downstream from Murupara, with potential conflict of use. The navigation can be hindered by tree logs, and access to the water can be problematic at places.

Lower Rangitāiki draft freshwater management unit

- **River swimming** is a popular activity in this draft FMU. Responses noted that conditions for swimming are between neutral and acceptable. Members expressed concerns about swimming during low flows (and/or summer low flows) particularly the possibly of higher pollutant concentration and insufficient water depth for bridge diving. Members noted this stretch of river experiences multiple pressures from water and land use activities.
    - **Swimming** at Te Teko – Acceptable. Bridge diving is popular among local children. Local families also swim close to marae.
    - **Swimming** near the Edgecumbe Bridge – Acceptable (selectively). People are worried about dairy factory discharge, so would swim upstream. Also the swift flow means this location is not popular for swimming.
    - **Swimming** at Thornton (river mouth) – Acceptable. Algae growth at Thornton is not pleasant, but still swimmable. People swim in summer in the salt water, and this is perceived to be cleaner water.
    - **Swimming suggestion:** The access to river swimming could be improved with: safe boat ramp, mitigate or alternative to ‘rock rip rap’ river banks, and remove some willows along the whole river bank.
- **Natural form and characters** – Neutral lending unacceptable. Due to various existing modifications, erosion, algae growth and lack of wetland vegetation.
- **Ecosystem health** – Neutral to near unacceptable.
- **Fishing** for introduced species – Neutral. Trout fishing exists but infrequent.
- **Fishing** for native species – neutral and near unacceptable, due to overfishing, change in habitat and change in hydrology through channelling and drainage system.
    - ***Kahawai*** – Acceptable, but with concerns that catches are down.
    - ***Whitebait* –** Unacceptable. Concerns about lack of spawning area, habitat area, overfishing, gradual and sudden decline in harvest numbers.
    - ***Tuna (shortfin eels)*** – number in decline although seeing improvements in fish passage.
    - ***Watercress*** – Acceptable.
    - ***Kotuku*** and ***bittern*** – in decline, believed to be due to wetland draining.
    - ***Mallard*** and ***grey ducks*** – In decline. Reasons unknown.
    - ***Banded kōkopu*** – Unsure. Need information.
    - ***Mullet*** – Unsure. Need information.
    - **Lamprey –** Almost gone.
    - ***Parore* –** Gone. Believed to be depleted by netting in the Thornton estuary.
    - ***Kakahi*** (cultural significance) – Gone.
    - One group pointed out there is not enough information for members to score
- **Wai tapu –** The acceptability depends on site specifics. Wai tapu sites near marae are used more often, and can be better recognised with sign-posts and better access.
  Many wai tapu sites may be gone or diminished in areas where the landscape has largely modified, which affected historical values of sites in rivers, in swamps, and original river courses.
- **Transport/tauranga waka** – Acceptable.

Appendix Two

Preliminary recommendations for attributes and bands for rivers.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
Ecosystem Health (toxicity)	Nitrate-nitrogen	Annual median	A	≤1.0 mg/L	High conservation value system. Unlikely to be effects even on sensitive species.
			B	>1.0 and ≤ 2.4 mg/L	Some growth effect on up to 5% of species.
			C	>2.4 and ≤ 6.9 mg/L	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
			D	>6.9 mg/L	Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (>20mg/L).
		Annual 95th percentile	A	≤ 1.5 mg/L	High conservation value system. Unlikely to be effects even on sensitive species.
			B	>1.5 and ≤ 3.5 mg/L	Some growth effect on up to 5% of species.
			C	>3.5 and ≤ 9.8 mg/L	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
			D	> 9.8 mg/L	Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (>20mg/L).
	Ammoniacal nitrogen (based on pH8 and temperature of 20ºC)	Annual median	A	≤0.03 mg/L	99% species protection level: No observed effect on any species tested.
			B	>0.03 and ≤ 0.24 mg/L	95% species protection level: Starts impacting occasionally on the 5% most sensitive species.
			C	>0.24 and ≤ 1.3 mg/L	80% species protection level: starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
			D	>1.3mg/L	Starts approaching acute impact level (i.e. risk of death for sensitive species).
		Annual maximum	A	≤ 0.05 mg/L	99% species protection level: No observed effect on any species tested.
			B	>0.05 and ≤ 0.4 mg/L	95% species protection level: Starts impacting occasionally on the 5% most sensitive species.
			C	>0.4 and ≤ 2.2 mg/L	80% species protection level: starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
			D	> 2.2mg/L	Starts approaching acute impact level (i.e. risk of death for sensitive species).
Ecosystem Health	Dissolved oxygen (Summer period is 1 Nov to 30 Apr)	7-day summer mean minimum	A	≥8.0 mg/L	No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites.
			B	≥7.0 and < 8.0 mg/L	Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species.
			C	≥5.0 and <7.0 mg/L	Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost.
			D	<5.0 mg/L	Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity.
		1-day summer minimum	A	≥7.5 mg/L	No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites.
			B	≥5.0 and < 7.5 mg/L	Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species.
			C	≥4.0 and <5.0mg/L	Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost.
			D	<4.0 mg/L	Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity.
	Periphyton (based on monthly sampling over three years)	Exceeded no more than 8% of samples (default class)	A	≤50 mg chl-a/m^2	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
			B	>50 and ≤120 mg chl-a/m^2	Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat.
			C	>120 and ≤ 200 mg chl-a/m^2	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
			D	>200mg chl-a/m^2	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.
		Exceeded no more than 17% of samples (productive class)	A	≤50 mg chl-a/m^2	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
			B	>50 and ≤ 120mg chl-a/m^2	Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat.
			C	>120 and ≤ 200 mg chl-a/m^2	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat.
			D	>200 mg chl-a/m^2	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.
Ecosystem Health	pH (potential of hydrogen)	95th summer percentile	A	≥6.5 and ≤8.0	No stress caused by acidic or alkaline ambient conditions on any aquatic organisms that are present at matched reference (near-pristine) sites.
			B	>6.5 and <8.5	Occasional minor stress caused by pH on particularly sensitive freshwater organisms (via fish and insects).
			C	≥6.0 and ≤9.0	Stress caused on occasion by pH exceeding preference levels for certain sensitive insects and fish for periods of several hours each day.
			D	<6.0 or >9.0	Significant, persistent stress on a range of aquatic organisms. Likelihood of local species extinctions and destabilisation of ecosystems.
	Temperature (Summer period is 1 Nov to 30 Apr)	Summer Cox-Rutherford Index for lowland areas	A	≤18.0ºC	No thermal stress on any aquatic organisms that are present at matched reference (near-pristine) sites.
			B	≤20.0ºC	Minor thermal stress on occasion (clear days in summer) on particularly sensitive organisms such as certain insects and fish.
			C	≤24.0ºC	Some thermal stress on occasion with elimination of certain sensitive insects and absence of certain sensitive fish.
			D	>24.0 ºC	Significant thermal stress on a range of aquatic organisms. Risk of local elimination of keystone species with loss of ecological integrity.
		Summer Cox-Rutherford Index for	A	≤19.0ºC	No thermal stress on any aquatic organisms that are present at matched reference (near-pristine) sites.
			B	≤21.0ºC	Minor thermal stress on occasion (clear days in summer) on particularly sensitive organisms such as certain insects and fish.

Value/s	Attribute	Statistic	Band	Numeric attribute state			Narrative attribute state
		upland areas	C	≤25.0ºC			Some thermal stress on occasion with elimination of certain sensitive insects and absence of certain sensitive fish.
			D	>25.0 ºC			Significant thermal stress on a range of aquatic organisms. Risk of local elimination of keystone species with loss of ecological integrity.
	Benthic cyanobacteria	80th percentile	A	Cover < 20%.			Low risk of encountering toxic cyanobacteria due to their low cover.
			B	-			-
			C	Cover 20 – 50%			Moderate risk of encountering toxic cyanobacterial blooms reflecting increased cover of the streambed by this material.
			D	Cover > 50%, OR max dislodging and accumulating along river's edge			High risk of encountering toxic or potentially toxic cyanobacteria, and high risk that material will slough from the streambed and accumulate along the river banks.
	Macrophytes - rivers	Annual monitoring	A	<50% channel cross-sectional area or volume OR channel water surface area			Aquatic plants will have little adverse effects on recreational, drainage, aesthetic or ecological values.
			-	-			-
			-	-			-
			D	>50% channel cross-sectional area or volume OR channel water surface area			Aquatic plants likely to have significant adverse effects to one or more values for recreation, drainage, aesthetics or ecology..
				Biophysical classification			
				Volcanic Steep	Volcanic Gentle	Non-volcanic	
Ecosystem Health	Invertebrate communities	Annual monitoring: MCI scores	A	>120	>124	>115	MCI scores typical of healthy and resilient invertebrate communities, similar to natural reference conditions. Indicative of streams in "excellent" ecological condition.
			B	110 - 120	106 - 124	100 - 115	MCI scores show slight reductions, suggesting loss of some potentially sensitive taxa from what would be expected in a similar reference condition stream. Indicative of streams in "Good" ecological condition.
			C	100 - 110	88 – 106	87 – 100	MCI scores show moderate impacts, with a more noticeable reduction in the majority of sensitive taxa from what would be expected in a similar reference condition stream. Indicative of streams in "Fair" ecological condition.

Value/s	Attribute	Statistic	Band	Numeric attribute state			Narrative attribute state
			D	<100	<88	<87	Reduction in MCI scores show large detrimental impacts, with a loss of all sensitive taxa from what would be expected in a similar reference condition stream. Indicative of streams in "Poor" ecological condition.
		Annual monitoring: EPT[7] richness	A	>12 EPT taxa	>11 EPT taxa	>9 EPT taxa	The number of sensitive EPT taxa typical of those found in reference condition streams.
			B	9 - 12 EPT taxa	7 – 11 EPT taxa	6 – 9 EPT taxa	Streams showing a slight reduction in the number of sensitive EPT taxa that are typically found in similar reference condition streams.
			C	6 – 9 EPT taxa	2 – 7 EPT taxa	3 – 6 EPT taxa	Streams showing a moderate reduction in the number of sensitive EPT taxa that are typically found in similar reference condition streams.
			D	<6 EPT taxa	<2 EPT taxa	<3 EPT taxa	Streams showing a large reduction in the number of sensitive EPT taxa that are typically found in similar reference condition streams.
		Annual monitoring: BoP_IBI[8]	A	>24	>47	>18	Streams supporting a range of invertebrate species that are very similar to those found in reference condition streams.
			B	16 - 24	36 - 47	7 - 18	Streams supporting a slightly reduced range of invertebrate species that would be expected in similar reference condition streams.
			C	7 – 16	26 - 36	3 - 7	Streams supporting a moderately reduced range of invertebrate species that would be expected in similar reference condition streams.
			D	<7	<26	<3	Streams supporting a greatly reduced range of invertebrate species that would be expected in similar reference condition streams.
Human Health for Recreation	Escherichia coli (*E.coli*)	Annual median	A	≤260/100mL			People are exposed to a very low risk of infection (<0.1%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
			B	>260 and ≤540/100mL			People are exposed to a low risk of infection (<1%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
			C	>540 and ≤1000/100mL			People are exposed to a moderate risk of infection (<5%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).

[7] EPT taxa is the number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) found at a site.
[8] BoP_IBI is the *Bay of Plenty Index of Biotic Integrity* measurement developed in 2017 by A.M. Suren, D. Van Nistelrooy and V. Fergusson.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
			D	>1000/100mL	People are exposed to a high risk of infection (>5%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	A	≤260/100mL	People are exposed to a low risk of infection (<1%) when undertaking activities likely to involve full immersion.
			B	>260 and ≤540/100mL	People are exposed to a moderate risk of infection (<5%) when undertaking activities likely to involve full immersion.
			>MAS	>540/100mL	People are exposed to a high risk of infection (>5%) when undertaking activities likely to involve full immersion.
	Cyanobacteria - Planktonic (lake-fed rivers)	80th percentile	A	≤0.5 mm^3/L OR ≤500 cells/mL	Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with freshwater).
			B	N/A	N/A
			C	>0.5 and ≤1.8mm^3/L (potentially toxic) OR >0.5 and ≤10 mm^3/L (all)	Low risk of health effects from exposure to cyanobacteria (from any contact with freshwater)
			D	>1.8mm^3/L (potentially toxic) OR >10 mm^3/L (all)	Potential health risks (e.g. respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with freshwater).

Recommended physical and chemical attributes <u>without</u> state bands for rivers.

Attributes	Values supported
Sediment related attributes (TSS, deposited sediment, visual clarity, light penetration)	Ecosystem Health, Human health for recreation, natural form and character, transport and Tauranga waka, irrigation and cultivation, commercial and industrial use, influence on other freshwater bodies, influence on coastal waters and receiving environments
Dissolved Inorganic Nitrate (DIN)	Ecosystem Health, influence on other freshwater bodies, influence on coastal waters and receiving environments
Dissolved Reactive Phosphorus (DRP)	Ecosystem Health, influence on other freshwater bodies, influence on coastal waters and receiving environments

Preliminary recommendations for attributes and bands for lakes

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
Ecosystem Health (trophic state)	Total nitrogen	Annual median (seasonally stratified and brackish)	A	≤160mg/m^3	Lake ecological communities are health and resilient, similar to natural reference conditions.
			B	>160 and ≤350mg/m^3	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
			C	>350 and ≤750mg/m^3	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>750mg/m^3	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.
		Annual median (polymictic)	A	≤300mg/m^3	Lake ecological communities are health and resilient, similar to natural reference conditions.
			B	>300 and ≤500mg/m^3	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
			C	>500 and ≤800mg/m^3	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>800mg/m^3	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.
	Total phosphorus	Annual median	A	≤10mg/m^3	Lake ecological communities are health and resilient, similar to natural reference conditions.
			B	>10 and ≤20mg/m^3	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
			C	>20 and ≤ 50mg/m^3	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>50mg/m^3	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
Ecosystem Health	Ammoniacal nitrogen	Annual median*	A	≤0.03mg/L	99% species protection level: No observed effect on any species tested.
			B	>0.03 and ≤0.24mg/L	95% species protection level: Starts impacting occasionally on the 5% most sensitive species.
			C	>0.24 and ≤1.3mg/L	80% species protection level: starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
			D	>1.3mg/L	Starts approaching acute impact level (i.e. risk of death for sensitive species).
		Annual maximum*	A	≤0.05mg/L	99% species protection level: No observed effect on any species tested.
			B	>0.05 and ≤0.4mg/L	95% species protection level: Starts impacting occasionally on the 5% most sensitive species.
			C	>0.4 and ≤2.2mg/L	80% species protection level: starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
			D	>2.2mg/L	Starts approaching acute impact level (i.e. risk of death for sensitive species).
	Phytoplankton	Annual median	A	≤2mg chl-a /m^3	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
			B	>2 and ≤ 5mg chl-a /m^3	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrient levels that are elevated above natural reference conditions.
			C	>5 and ≤12mg chl-a /m^3	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>12mg chl-a /m^3	Lake ecological communities have undergone or at high risk of a regime shift to a persistent degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.
		Annual maximum	A	≤10mg chl-a /m^3	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
			B	>10 and ≤ 25mg chl-a /m^3	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrient levels that are elevated above natural reference conditions.
			C	>25 and ≤60mg chl-a /m^3	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>60mg chl-a /m^3	Lake ecological communities have undergone or at high risk of a regime shift to a persistent degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
Ecosystem Health (trophic state)	Trophic Level Index (TLI)		A	≤3.3 TLI	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
			B	>3.3 and ≤4.2 TLI	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
			C	>4.2 and ≤5.1 TLI	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
			D	>5.1 TLI	Lake ecological communities are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.
	Lake Submerged Plant Indicators (LakeSPI, based on annual or biannual sampling)	Changes to calculated LakeSPI scores	A	0 – 5% reduction OR increase	Change to LakeSPI not indicated.
			B	>5 – 10% change	Change to LakeSPI possible.
			C	>10 - 15% change	Change to LakeSPI probable, OR introduction of new, potentially invasive species.
			D	>10 - 15% reduction	Change to LakeSPI indicated.
Human Health for Recreation	*E.coli* (Escherichia coli)	Annual median	A	≤260/100mL	People are exposed to a very low risk of infection (< 0.1%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
			B	>260 and ≤540/100mL	People are exposed to a low risk of infection (<1%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
			C	>540 and ≤1000/100mL	People are exposed to a moderate risk of infection (<5%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
			D	>1000/100mL	People are exposed to a high risk of infection (>5%) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	A	≤260/100mL	People are exposed to a low risk of infection (<1%) when undertaking activities likely to involve full immersion.
			B	>260 and ≤540/100mL	People are exposed to a moderate risk of infection (<5%) when undertaking activities likely to involve full immersion.
			>MAS	>540/100mL	People are exposed to a high risk of infection (>5%) when undertaking activities likely to involve full immersion.

Value/s	Attribute	Statistic	Band	Numeric attribute state	Narrative attribute state
Human Health for Recreation	Cyanobacteria - Planktonic	80th percentile	A	≤0.5 mm^3/L OR ≤500 cells/mL	Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with freshwater).
			B	N/A	N/A
			C	>0.5 and ≤1.8mm^3/L (potentially toxic) OR >0.5 and ≤10mm3/L (all)	Low risk of health effects from exposure to cyanobacteria (from any contact with freshwater).
			D	>1.8mm^3/L (potentially toxic) OR >10mm^3/L (all)	Potential health risks (e.g. respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with freshwater).

Appendix Three Streamlined desired states

Rangitāiki Natural State draft FMU

RN1. Water quality and quantity continues to be suitable for swimming.

RN2. The natural form and character of the river is maintained.

RN3. Water quality and quantity continue to provide for significant indigenous species, and mahinga kai and species that are important for fishing which are safe to eat.

RN4. Water quality and quantity continues to be suitable for wai tapu, sites of cultural significance, and customary cultural and ceremonial activities.

Middle-upper Rangitāiki draft FMU

RM1. Water quality and quantity is maintained and/or improved to be suitable for swimming.

RM2. Natural form and character is maintained and/or improved.

RM3. Water quality and quantity continue to provide for significant indigenous species, and mahinga kai and species that are important for fishing which are safe to eat.

RM4. Water quality and quantity continues to provide for wai tapu, springs, sites of cultural significance and customary cultural ceremonial activities.

RM5. Water quality and quantity continues to provide for transport/tauranga waka and recreational uses.

Lower Rangitāiki draft FMU

RL1. Water quality and quantity is maintained and/or improved to be suitable for swimming.

RL2. Water quality and quantity continue to provide for significant indigenous species, and mahinga kai and species that are important for fishing which are safe to eat.

RL3. Wetlands will be suitable for water fowl habitat, such as for the presence of kotuku and bittern.

RL4. Natural form and character is improved.

RL5. Water quality and quantity provides for wai tapu, sites of cultural significance and customary cultural ceremonial activities.

RL6. Water quality and quantity continues to provide for transport / tauranga waka.

WORKSHOP PAPER

To: **Rangitāiki Freshwater Futures Community Group**

From: Nicola Green
Senior Planner (Water Policy)

Date: 06 June 2017

Subject: **Issues in Rangitāiki Water Management Area**

1 Introduction

Science and community engagement reveals the key freshwater resource management issues listed below for the Rangitāiki Water Management Area (WMA). Work is progressing to assess our evidence base, uncertainties, and the scale and significance of these issues and their causes.

2 Key issues

1. Nitrogen is increasing in the upper Rangitāiki catchment[9]. Potential land use change and intensification pose a significant risk that nitrogen levels will continue to increase, affecting ecological health, amenity and recreation values.
2. The Matahina and Aniwaniwa Hydro-electric power (HEP) Dam Lakes are "human made" receiving water bodies in the Rangitāiki River. Sedimentation, nutrient enrichment and resulting algal/macrophyte growth affects dam operations, ecological health and recreational values[10].
3. There is current and potential future demand for water in the mid-upper Rangitāiki catchment to enable land use intensification and/or change in land use, but surface water and groundwater is fully allocated to consented irrigators and the HEP schemes[11].
4. There is increasing demand for water in the lower Rangitāiki River catchment and this may affect the upstream extent of the saline wedge, recreational and ecological values. Surface and groundwater are closely connected across the Rangitāiki Plains. Availability and effects are heavily dependent on the HEP scheme managed flow regime.
5. Monitoring results available for some recreation sites show *E. coli* concentrations do not meet the minimum acceptable state for swimming (full immersion) stated in the operative NPSFM. Some popular swimming spots are not monitored[10].
6. Tuna/eel and other indigenous fish species are heavily impacted by structural changes to/loss of habitat and obstacles to fish passage, and also by water quality, changes to flow regime and possibly harvesting. While this is not primarily caused by water quality and quantity management, this is a key freshwater issue for community members.

[9] Scholes, P. and Carter, R. (2015). Freshwater in the Bay of Plenty – Comparison against the National Objectives Framework. Bay of Plenty Regional Council, Environmental Publication 2015/04. ISSN: 11750-9372 (Print), 9471 (Online). April 2015.
[10] Scholes, P and McKelvey, T (2015). Recreational Waters Surveillance Report 2014/2015. Bay of Plenty Regional Council Environmental Publication 2015/2016. ISSN: 1175 9372 (Print)
ISSN: 1179 9471 (Online)
[11] Kroon, Glenys (2016). Assessment of water availability and estimates of current allocation levels October 2016. Bay of Plenty Regional Council

7. Sediment monitoring data is limited. The majority of this sediment load is likely to be generated in high rainfall events for which there is currently limited data available.
8. The Macro-invertebrate Community Index (MCI) values are lowest in streams/rivers draining pasture. MCI is relatively stable in the Rangitāiki catchment.
9. Lower Rangitāiki River and surrounding lowlands have been heavily modified to enable farming and flood management, as well as flow regime changes by HEP dam operations, and this has had significant effects on water quality, ecosystem health and habitat.
10. Soil phosphorous levels (using Olsen-P) under kiwifruit have increased significantly from 71 to 106 mg/kg between 1999/2000 and 2009 and the risk of runoff to water bodies is high, with potential effects on receiving environment ecological values. Olsen-P levels on dairying soils have also increased. Other soil quality issues include the increasing mineralisable N concentrations in dairying soils with the mean now above the target band, increasing the risk of N leaching, and the high anaerobically mineralisable N on sheep and beef soils[12].

[12] Carter, R., Suren, A., Fernandes, R., Bloor, M., Barber, J., and Dean, S. (2015). Rangitāiki Water Management Area: Current State and Gap Analysis. Bay of Plenty Regional Council Environmental Publication 2016/02. ISSN: 1175-9372(print),ISSN: 1179-9471 (online). March 2015.

http://www.boprc.govt.nz/media/99812/2010_22__soil_quality_in_the_bay_of_plenty_2010_update.pdf (Guinto/BOPRC, 2010)

WORKSHOP PAPER

To: **Rangitāiki Freshwater Futures Community Group**

From: Santiago Bermeo
Senior Planner (Water Policy)

Date: 12 June 2017

Subject: **Use values**

1 Introduction

The purpose of this paper is to summarise initial information on extractive freshwater use values collated by Council staff to date. Use values include irrigation, stock drinking water, domestic and municipal supply, industrial use, hydro-electricity generation and the capacity to assimilate contaminants.

In the previous workshop, the Community Group concentrated on 'in-river' values, but 'extractive/consumptive' use values are a major consideration as well. The information summarised in this paper is aimed at starting a discussion about these values.

Initial feedback from the Community Group is sought on the following information, in particular:

- the land use map;
- projected land use change; and
- other types of socio-economic information you consider would be helpful in our planning process.

The information summarised in this paper includes water allocation, water use metering requirements, point-source discharge consents, land use and estimated economic values of some industries.

The information contained in this paper was collated as part of a socio-economic baseline report being drafted in support of the planning process. A draft of the report, with more detail than this paper, will be made available on the Community Group internet portal. Once finalised, the report will include information on:

- tangata whenua connected to the Water Management Area (WMA);
- the social profile of the WMA population and population growth estimates;
- water allocation, metered use and consented discharge data for the WMA;
- land use data for the WMA, including projected land use change;
- information on Māori-owned land in the WMA; and
- estimated economic value of land and water-dependent industries.

2 Water allocation and metering

Figure 1A summarises surface water allocation (number of consents and rates allocated by draft Freshwater Management Unit and purpose) for the Rangitāiki WMA. Figure 1B summarises groundwater allocation (maximum yearly volumes allocated and number of consents by draft Freshwater Management Unit and purpose) for the Rangitāiki WMA. The location of surface and groundwater take consents in illustrated in Figure 2.

Figure 1A – Rangitāiki WMA: surface water take allocation and consents

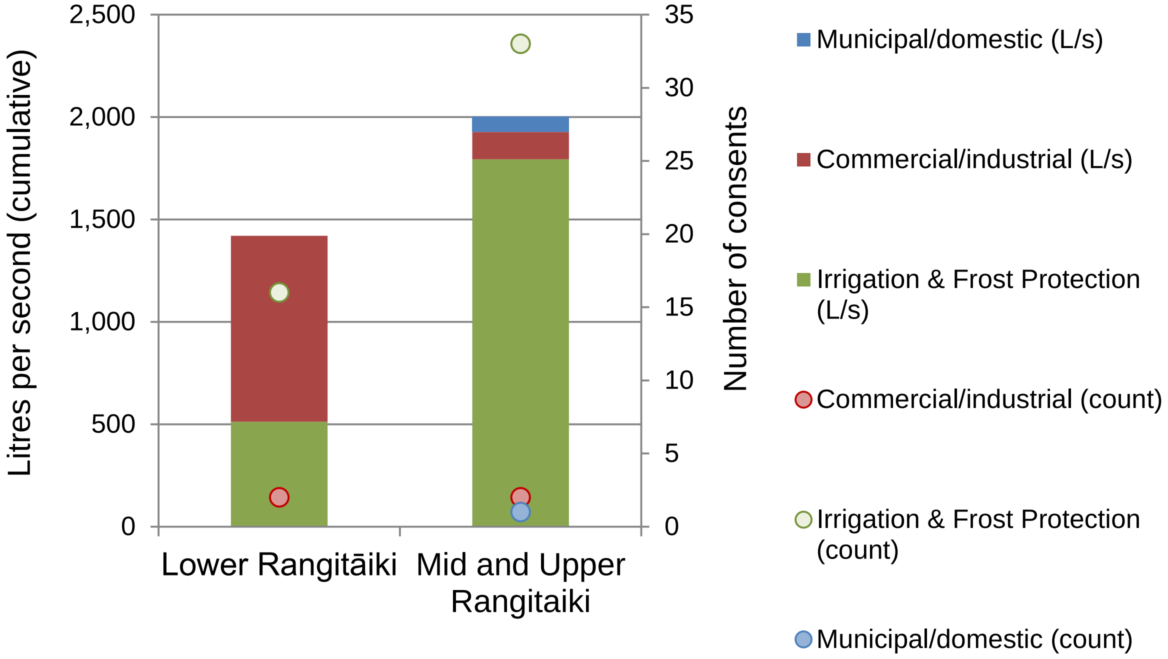


Figure 1B – Rangitāiki WMA: groundwater take allocation and consents

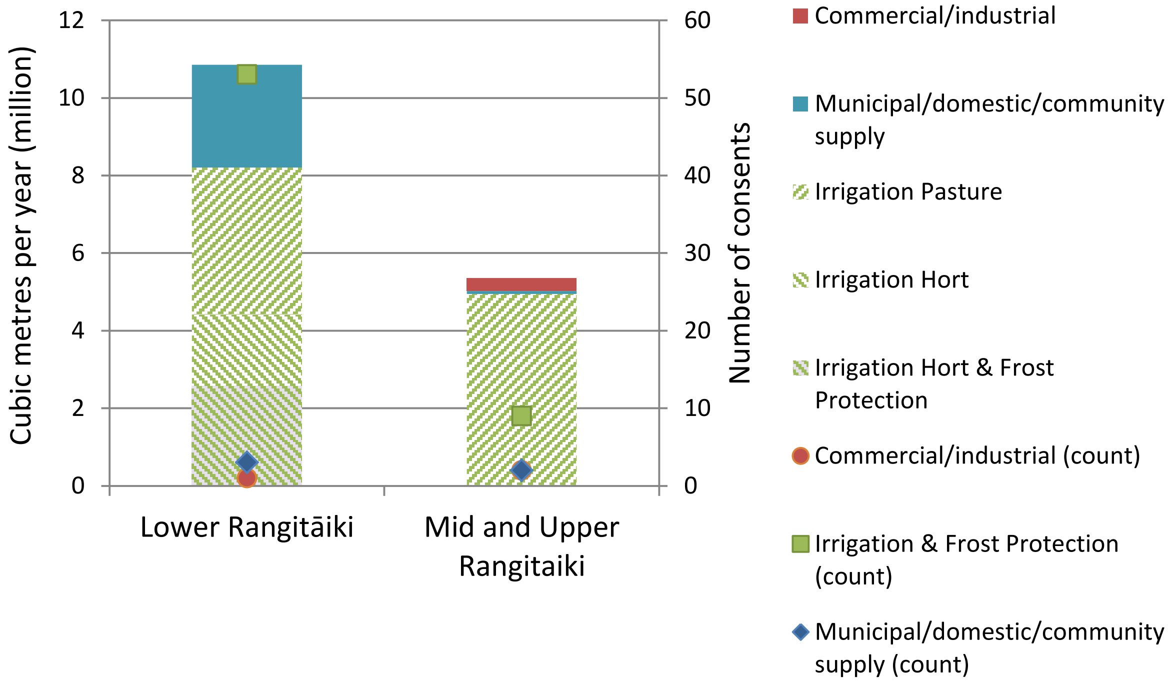
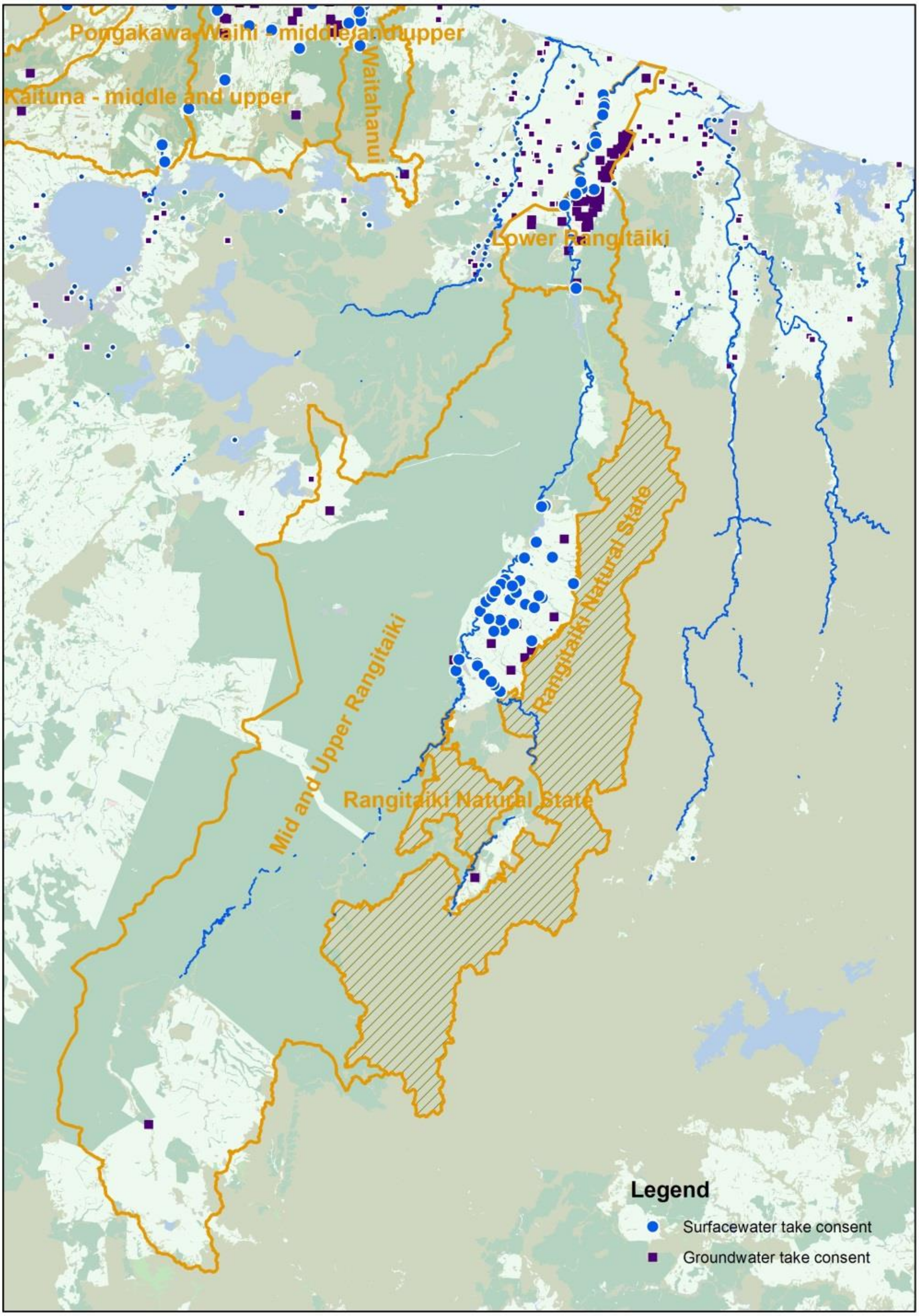


Figure 2 – Rangitāiki WMA: surface and groundwater take consent locations



As part of the region-wide proposed Water Quantity Plan Change (Proposed Plan Change 9), BOPRC has developed a water availability report which shows the level of allocation, relative to the region-wide interim allocation limits established by Plan Change 9.

The interim allocation limits are 10% of the Q5 7-day low flow[13] for surface water and 35% of the average annual aquifer recharge for groundwater.

Table 1 and Figures 3 and 4 show the level of allocation relative to the interim allocation limits in the Rangitāiki WMA.

Table 1 – Assessment of water availability and allocation relative to interim allocation limits for the Rangitāiki WMA (as of October 2016)

Surface Water Body	Q5 7-day low flow (L/s)	Allocable flow (L/s)	Allocated flow (L/s)	Remaining allocation (L/s)
Haumea Stream	780.0	78.0	100.3	0.0
Horomanga River	460.0	46.0	128.0	0.0
Mangakotukutuku Stream	95.0	9.5	58.8	0.0
Mangamate Stream	*	*	12.1	*
Mangamutu Stream	50.0	5.0	55.4	0.0
Omahuru Stream	*	*	33.3	*
Pokairoa Stream	*	*	125.0	*
Rangitāiki River at Murupara[14]	12,933.0	1,293.3	2,464.8	0.0
Rangitāiki River at Te Teko[2]	37,647.0	3,764.7	2,464.8	1,299.9
Te Kopua Stream	50.0	5.0	10.5	0.0
Te Rahu Stream	*	*	7.8	*
Whirinaki River	3917.0	391.7	542.5	0.0

Groundwater Zone	Annual average recharge (m^3/year, thousands)	Allocable volume (m^3/year, thousands)	Allocated volume (m^3/year, thousands)	Remaining allocation (m^3/year, thousands)
Edgecumbe Catchwater	9,593	3,358	719	2,638
Kope Orini 1	-	-	1,373	-
Mangamako area	-	-	3,405	-
Ngakauroa Stream	13,853	4,850	4,491	357
Nursery Drain	410	145	742	0
Rangitaiki Dunes	-	-	114	-
Reids Central Canal	16,441	5,756	786	4,970
Waikowhewhe area	-	-	1,537	-

[13] Five year, 7-day mean annual low flow is the 7-day low flow value which has a 20% probability of occurring in any one year.
[14] Subject to existing Hydro Electric Power Scheme

Figure 3 – Rangitāiki WMA: surface water allocation relative to interim allocation limits (October 2016)

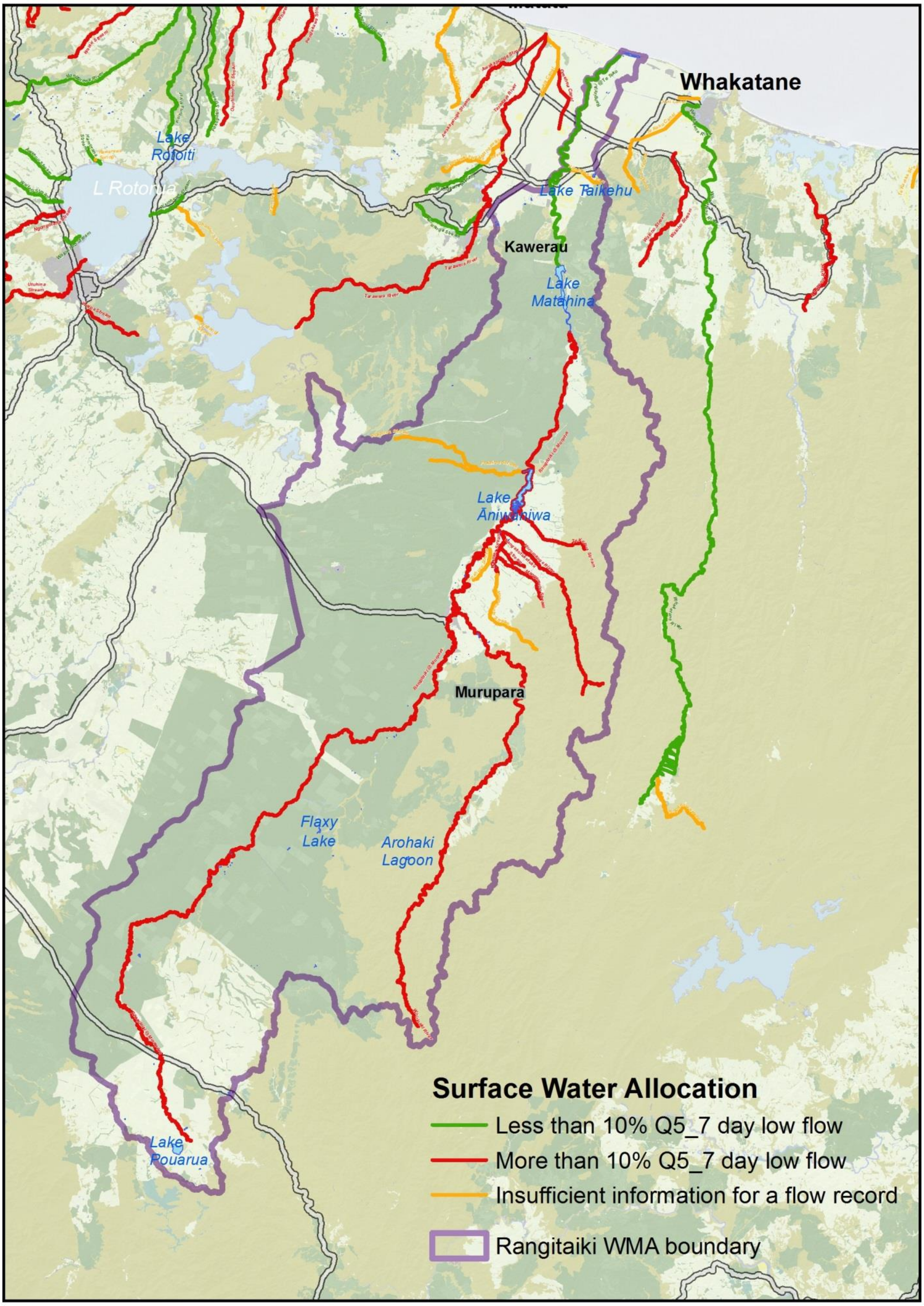
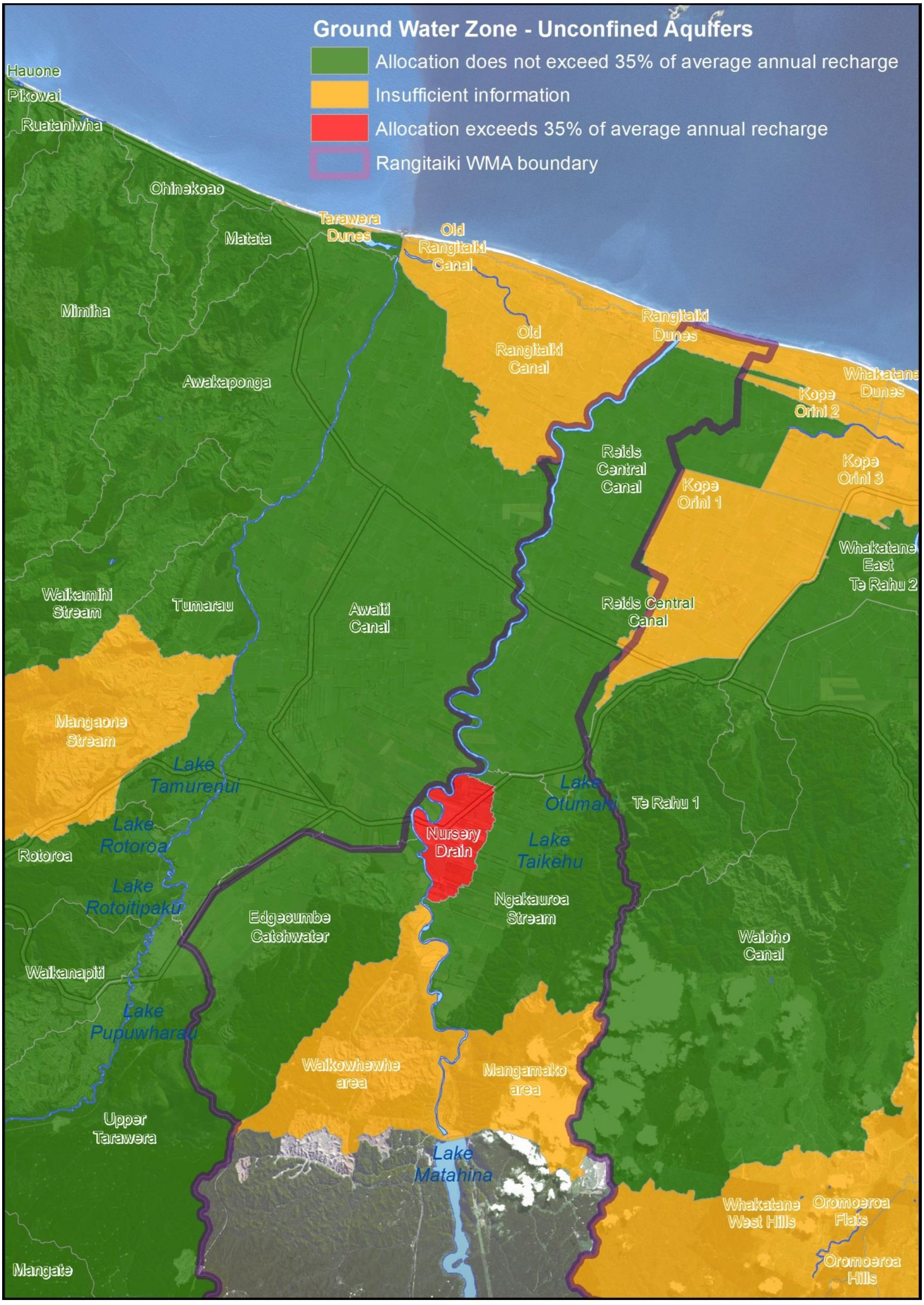


Figure 4 - Rangitāiki WMA: groundwater allocation relative to interim allocation limits (October 2016)



As part of the Plan Change 12 process, we have to recommend more specific water quantity allocation limits and associated settings (e.g. minimum flows, minimum groundwater levels and reliability/flow restrictions) to replace the region-wide interim settings established by proposed Plan Change 9.

Proposed Plan Change 9 also introduces a requirement for all consented water takes, and some permitted water takes, to have a water meter. For consented takes that don't already require meters under the national regulations[15], the proposed Plan Change 9 requirement would only apply in consent renewal and for any new consents.

Table 2 shows the percentage of consents by draft Freshwater Management Unit in the Rangitāiki WMA that require a water meter under the national regulations, and the current level of compliance (i.e., meters installed). Discrepancies could be due to non-compliance, or to situations where water is no longer abstracted (e.g. a historical consent which is no longer exercised and the consent holder has no pump or irrigation equipment). The table does not show compliance with reporting requirements.

Table 2 – Water metering requirements under the national regulations and current level of compliance

	Surface water		Groundwater		Overall total	
	Required	Installed	Required	Installed	Required	Installed
Lower Rangitāiki	94%	63%	84%	70%	**86%**	**68%**
Mid and Upper Rangitāiki	90%	72%	85%	77%	**88%**	**73%**
Total by WMA	**91%**	**69%**	**84%**	**71%**	**87%**	**70%**

BOPRC is working on compiling metered water use information for the Rangitāiki WMA and hopes to report back to the Community Group shortly.

The three major hydropower schemes on the Rangitāiki River, Matahina, Aniwhenua (at Āniwaniwa) and Flaxy-Wheao, are significant water users in the catchment. Although their use is largely non-consumptive, in that the water is returned to the catchment, they do effectively have an allocation of flow. Together the three schemes have a generating capacity of approximately 130 megawatts and generate an annual average of 540 gigawatt hours (GWh), which is sufficient to supply about 70,000 average New Zealand households[16], or 20 percent of the region.

[15] The Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 require all consented takes greater than 5 litres per second (or equivalent) to have a water meter.

[16] One gigawatt hour (GWh) is required to meet the average consumption of 131 residential connections. Trustpower calculation based on Ministry of Economic Development, New Zealand Energy Data File, 2010, Tables G.6a.

3 Discharge consents

Figure 5 summarises point source discharge consents (number of consents by purpose and draft Freshwater Management Unit) for the Rangitāiki WMA. Figure 6 illustrates the location of these discharge consents.

Figure 5 – Rangitāiki WMA: discharge consents

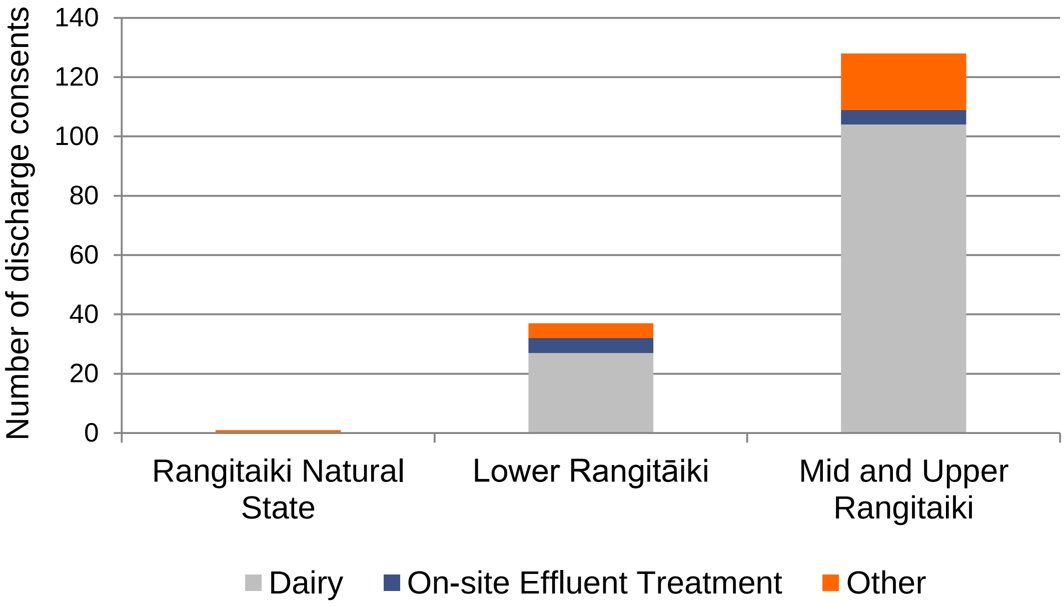
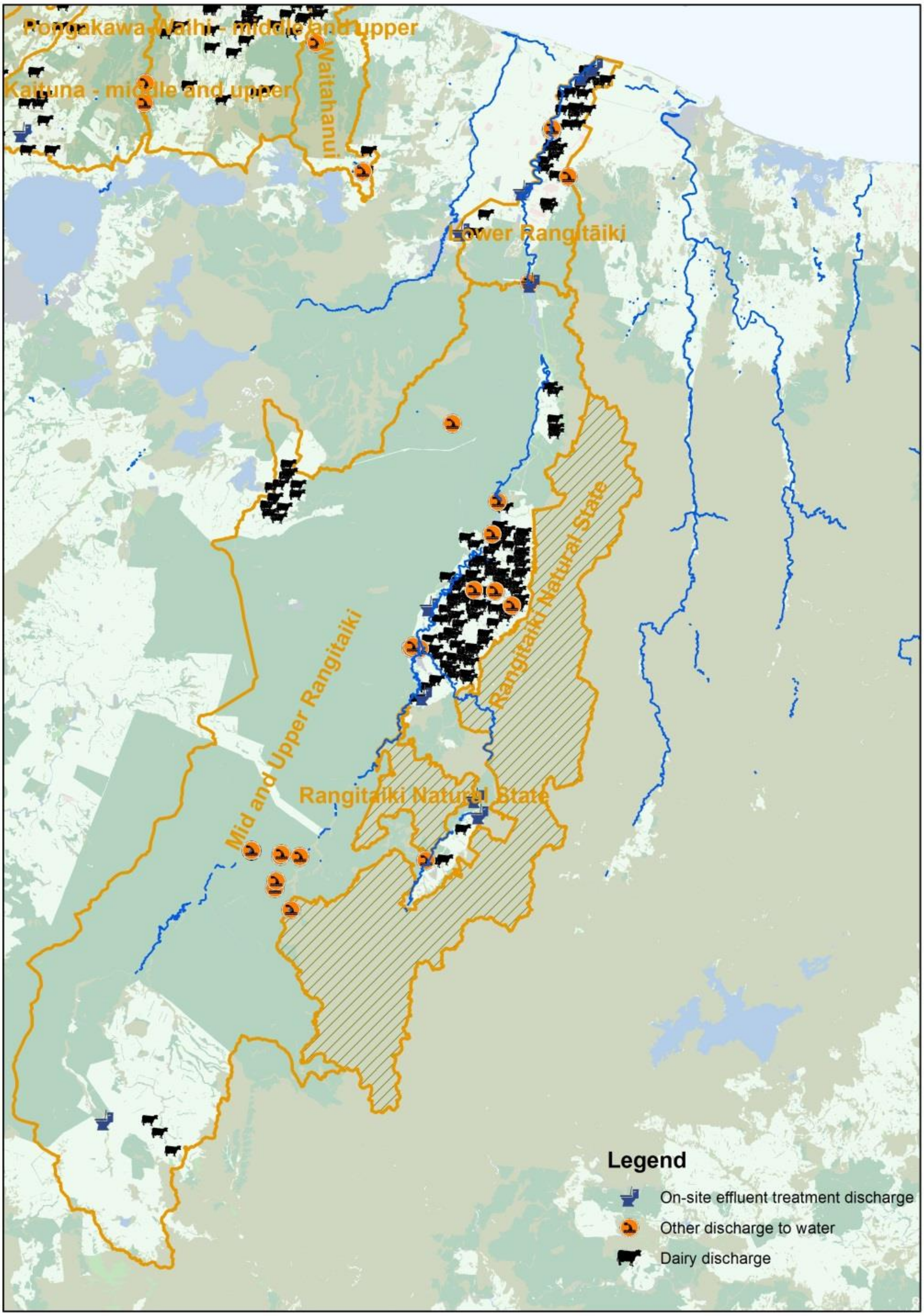


Figure 6 – Rangitāiki WMA: discharge consent location



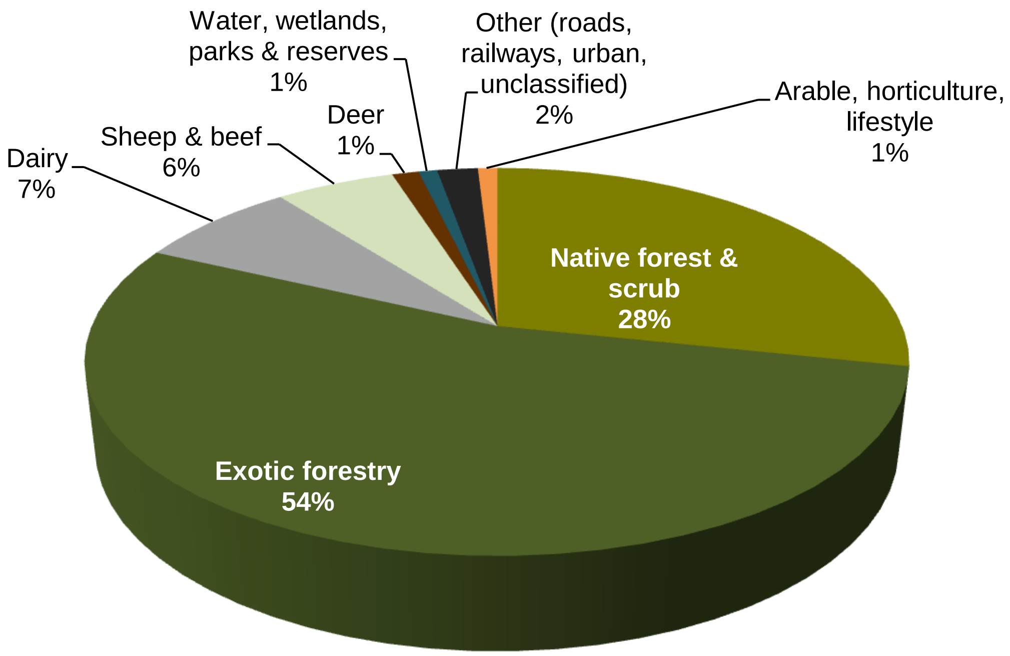
4 Land use data

Figure 7A shows the distribution of land use in the WMA.

Figure 7B shows the distribution of these land uses by Land Use Capability class[17], where 1 is the highest capability and 8 is the lowest capability.

Figure 7C shows a map of land use in the catchment and also identifies Māori-owned land. A larger version of the map has been provided to Community Group members to confirm accuracy. Land use data will be a key input into the catchment modelling work which is supporting our planning process.

Figure 7A - Distribution of land use in the Rangitāiki WMA



Land Use	Hectares
Exotic forestry	158,640
Native forest & scrub	83,682
Dairy	22,290
Sheep & beef	16,496
Other	5,629
Deer	3,708
Arable, horticulture, lifestyle	2,717
Water, wetlands, parks & reserves	2,572
Total	**295,734**

[17] The Land Use Capability (LUC) rating indicates the ability of a piece of land to sustain agricultural production, where class 1 is the highest capability and class 8 is the lowest. The rating is based on an assessment of a piece of land's rock type, soil, slope, susceptibility to erosion, vegetation cover, climate and the effects of past land use. LUC is included in the New Zealand Land Resources Inventory, which is a national database of physical land resource information maintained by Landcare Research.

Figure 7B – Land use in the Rangitāiki WMA by Land Use Capability class

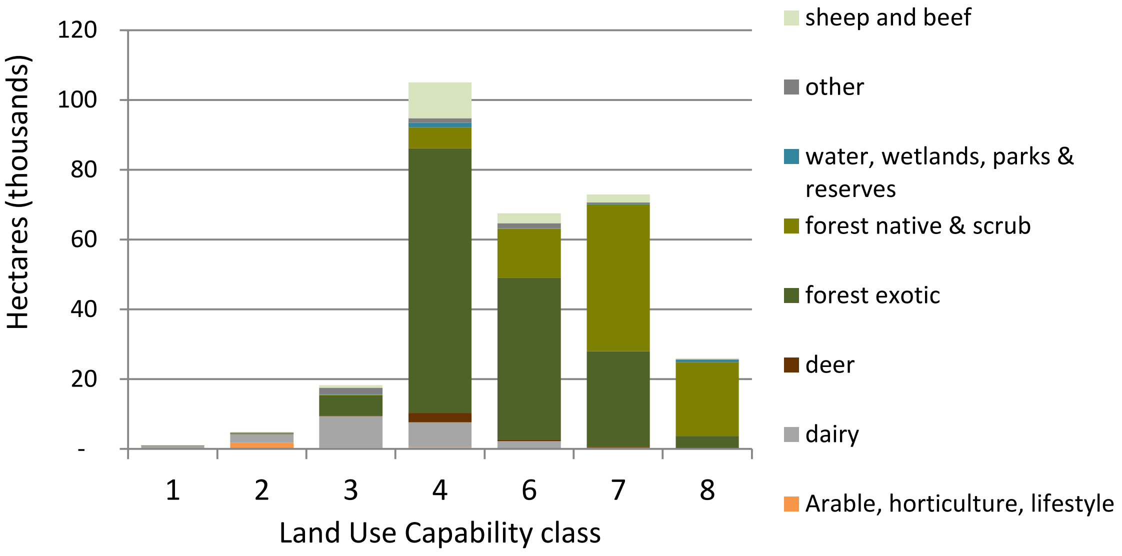
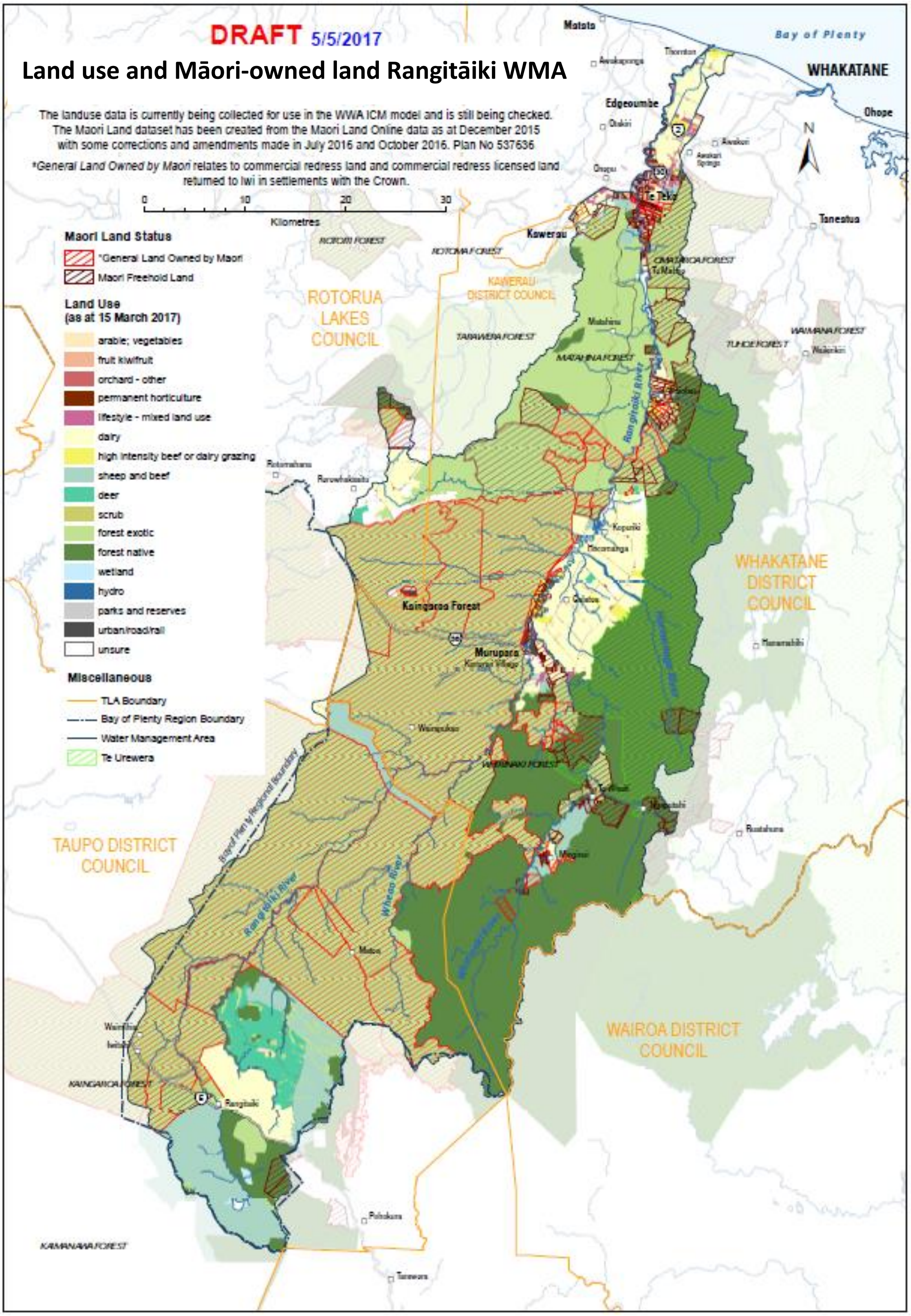


Figure 7C – Land use and Māori-owned land in the Rangitāiki WMA



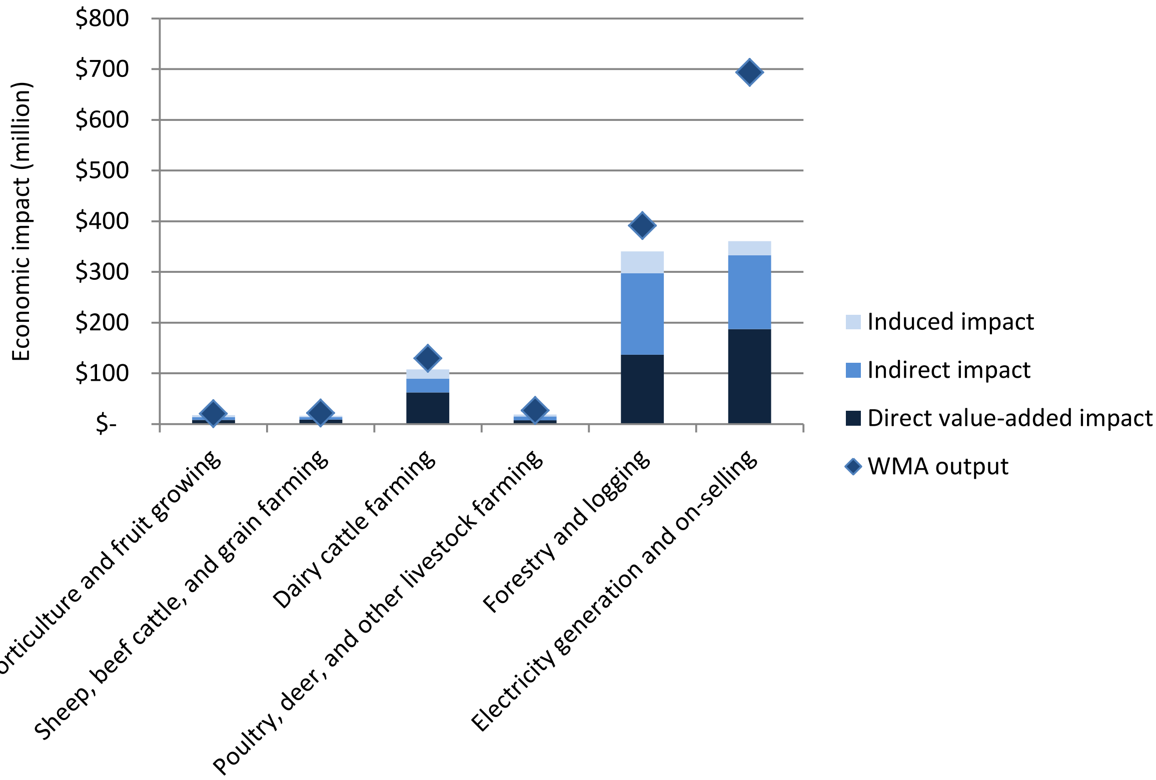
5 Estimated economic value

Figures 8A and 8B summarise the results of basic analysis on the economic value of the main land and water-based industries in the WMA.

It is estimated that the six main industries shown generated an output of $1.28 billion in 2012-13. Of this, $410 million was direct value-added, which in turn generated an indirect impact to the wider regional economy of $352 million and an induced impact of $98 million. When considered together, the total economic impact of these industries to the Bay of Plenty region was $860 million, or 7.6% of the regional GDP. Electricity generation created the most economic value, followed by forestry and dairy farming.[18]

In terms of employment, the six industries are estimated to have directly employed 1,691 people in 2012-13, while generating indirect and induced employment for a further 1,269 and 601 people respectively.

Figure 8A – Multiplier analysis: estimated economic impact of the main land and water-based industries in the Rangitāiki WMA in 2012-13



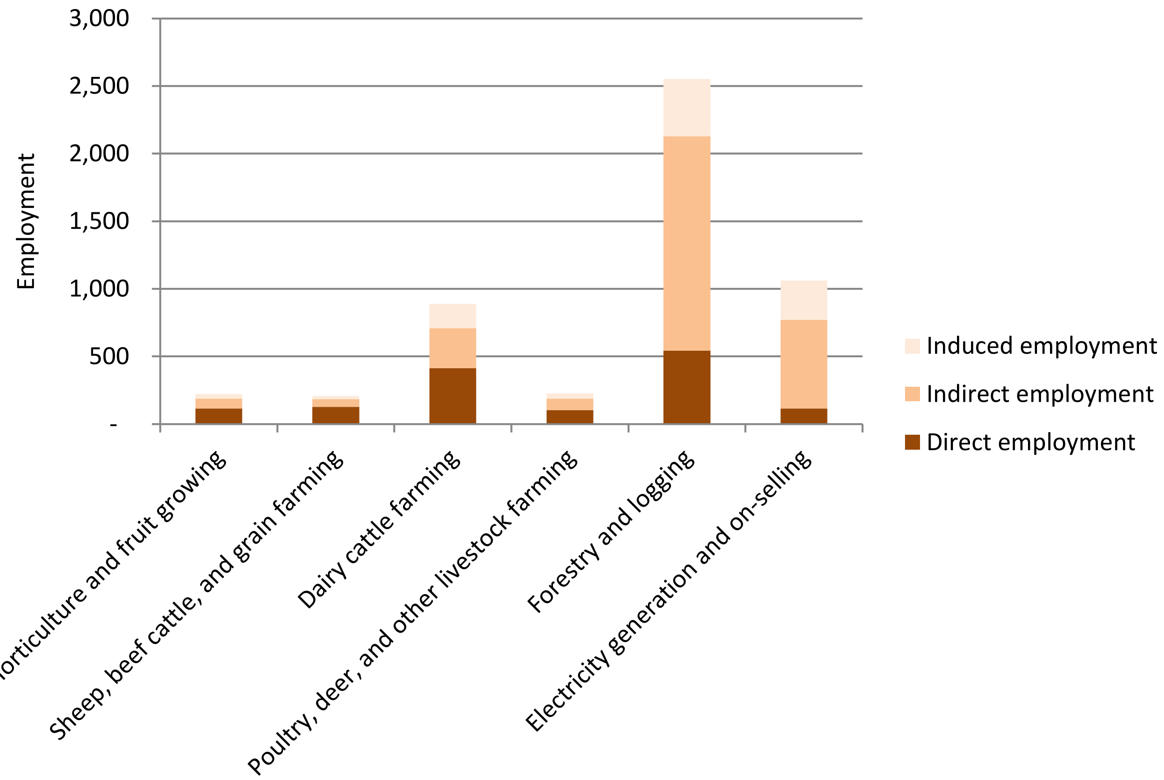
[18] **Output:** Price multiplied by quantity of goods and services produced.

Direct value-added: Value of output not including value of inputs. The sum of returns to land, labour and capital; in accounting terms, it is the same as earnings before interest, tax, depreciation and amortisation (EBITDA) plus wages.

Indirect impact: Economic impact on other businesses in the regional economy which either directly or indirectly supply goods and services to primary production.

Induced impact: Flow-on effects from expenditure of household incomes earned in the primary sector and in those sectors providing supporting goods and services in the regional economy.

Figure 8B – Multiplier analysis: estimated employment generated by the main land and water-based industries in the Rangitāiki WMA in 2012-13



BOPRC staff have been seeking information on the economic value of other water-dependent industries in the WMA, such as tourism, and information on the economic value of in-stream uses (e.g. fishing, swimming, etc.).

To date it has been difficult to source quantitative information on these values. We would welcome community group member feedback on possible ways to fill these gaps, and other socio-economic information members may hold that may contribute to our planning process.

WORKSHOP PAPER

To: **Rangitāiki Freshwater Futures Community Group**

From: Justin Connolly
Consultant/Researcher
(Deliberate Consulting/Waikato University)

Date: 12 June 2017

Subject: **Update on causal loop workshops for the Rangitāiki Water Management Area**

1 Summary

Ten members of the Rangitāiki Freshwater Futures Community Group volunteered to take part in an experimental approach to considering the freshwater issues of the catchment. They attended a workshop in December 2016 and a follow up workshop in February 2017 for a presentation of the results.

The experimental approach attempted to develop a <u>*causal loop diagram*</u> of the freshwater system in the Rangitāiki. This is a simplified but comprehensive attempt to understand the major <u>*factors impacting on or impacted by freshwater*</u> and <u>*how they influence each other*</u>.

The first workshop lasted six-hours and the causal loop diagram was developed in that time.

2 What is a causal loop diagram?

A causal loop diagram is a simple yet comprehensive representation of a system. One of the key concepts that underpins this approach is trying to understand the ***structure of a system***, as this has a direct impact on the ***behaviour of factors within the system***. Often, these behaviours can be counterintuitive to what might be expected, and the places where action or intervention may have the most influence are not where most people might expect them to be.

Understanding where the best interventions can be made is likely to come from understanding any common patterns that might be found in whatever system map is developed. This second stage was not able to be fully developed in the limited time of this experiment.

3 What the group did

The group worked through two main sessions in the workshop:

1. Identifying major factors that impact or are impacted by freshwater
2. Mapping out how these factors are connected to and influence each other

A comprehensive diagram was developed in this first workshop. It was limited to the amount of time available and it is generally agreed that if more time was available a more fully developed diagram may be able to be developed.

4 Major factors identified

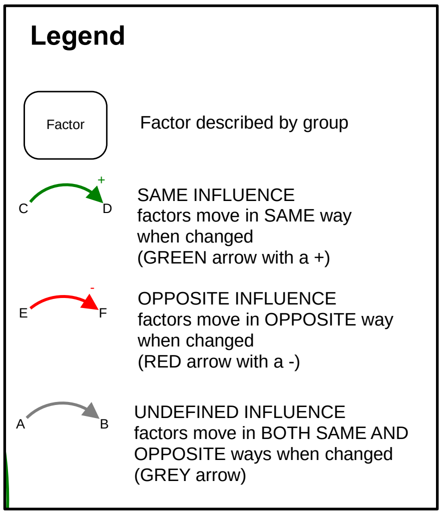
Two main overarching factors were identified as aspirational by participants. These were **sustainable development** (being development that improved social, economic, environmental and cultural indicators) and **improved Mauri** (life force) of the river. These were overarching and not included in the diagram directly. Other factors identified were:

Factor	Description
Water Quality	The water quality of the Rangitāiki River.
Water Quantity	The water quantity in the Rangitāiki River.
Community Vibrancy	The general social and cultural wellbeing of the community overall.
Financial vibrancy	A broad measure of the financial vibrancy of the community overall. Businesses are profitable and individuals are financially secure.
Adaptable land use	The durability and ability of businesses to adapt and be flexible in response to drivers in the business environment.
Irrigation	Abstracting water and applying it to productive farmland and horticulture.
Population	The *number* of people in the area represented (as opposed to their *vibrancy*.
Structures	All *river related* infrastructure in the WMA. Relates to flood protection, irrigation, electricity generation etc.
Technology	This factor describes advances and/or changes in physical (e.g. mechanical) and economic technology (e.g. contracting methods).
Water Allocation	The act of determining access to, and the distribution of, water amongst users of all types.
Land Characteristics	The natural or modified features and characteristics of the land.
Rainfall	Patterns and levels of rainfall.
Temperature	Patterns and levels of temperature.

5 How these factors are connected

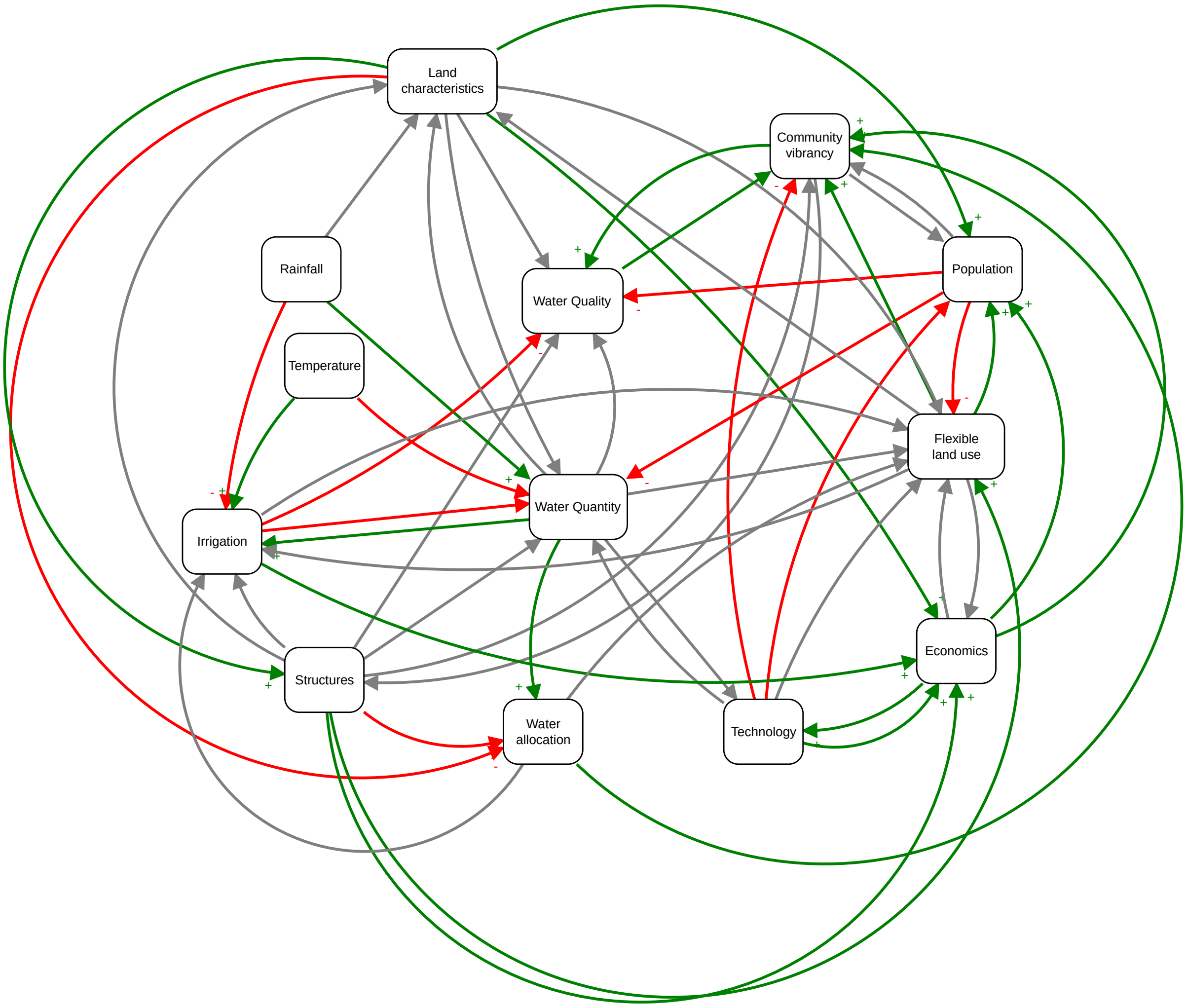
The resulting causal loop diagram is shown on the next page. It is very comprehensive and reflects the understanding of the freshwater system in the Rangitāiki that was held by the group. It is useful to study the CLD in parts, which limited space does not allow here.

The legend describes the two types of influences that can be identified between factors. A SAME influence, where the influence makes the factor change in the same direction; and an OPPOSITE influence, where the influence makes the



factors change in the opposite direction.

Overarching aspirations: Sustainable development and improved Mauri



6 Using the causal loop diagram

Various ways of using the causal loop diagram are possible in the future. It may be further developed and certain problems focused on in order to provide more insight into particular issues. It may be referred back to and the impacts of proposed actions discussed qualitatively, if they are not able to be quantified in other modelling.

If further development or refinement of the causal loop diagram is undertaken, it is recommended that it is further analysed for _common patterns_ of behaviours, or _archetypes_. These can provide useful insight to areas of intervention in the system and identify where action may have the most impact.

Some possible common patterns were reported back to the volunteers in the second workshop. Yet it is acknowledged that because the CLD was not fully developed these common patterns may need to be refined further. However, the analysis of any CLD for common patterns is strongly recommended as these tend to provide significant insight into how the _structure_ of the system influences the _behaviour_ of the system.

For more details of common patterns or system archetypes, see *The Fifth Discipline – the art of the learning organisation* by Peter Senge (1990).

Integrated Catchment Modelling of the Kaituna-Pongakawa-Waitahanui and Rangitāiki Water Management Areas

Summary

The integrated catchment model being developed for Kaituna-Pongakawa-Waitahanui Water Management Area (WMA) and Rangitāiki WMA will provide a simplified representation of how water and certain contaminants move through the catchment.

The models help **estimate** the source and extent of water quality and quantity issues in a catchment. The model may be used to examine the likely effects of future land management, land and water use, and climate-change scenarios (potential futures). All models have limitations and uncertainties particularly where data is scarce, which will be reported alongside any outputs.

Integrated catchment modelling involves a combination of models working together. The eWater SOURCE model is the framework model. Other models that represent specific physical processes feed in to the eWater SOURCE model, including Agricultural Production Systems Simulator (APSIM), OVERSEER (on-farm scale nutrient budget model), SEDNET (constructs sediment and nutrient budgets) and Soil Moisture Balance models (to estimate how much water runs off the land and how much infiltrates into the ground).

The model will report daily values at specified locations across the catchment for Flow, Total Suspended Solids - Turbidity (sediment), NH4-H (Ammonia), NOx-N (Nitrate Nitrite Nitrogen), TN (Total Nitrogen), DRP – TP (Dissolved Reactive Phosphorus – Total Phosphorus), *E.coli* (bacteria).

1 Nature of the hydrological model and its purpose

Hydrological modelling plays an important role in freshwater management. Hydrological models are simplified, conceptual representations of a part of the hydrologic cycle (i.e., how water moves through a system). They are populated and run by specialists with experience in hydrology and modelling. Models are tools used to understand complex processes. They can be used to help inform policy and decision making for water resource sharing. Models help estimate the source and extent of water quality and quantity issues in a catchment.

A model may be used to identify 'hotspots' in a region. Once calibrated these models may be used to examine the likely effects of future land management, land use, and climate-change scenarios. The model can do this by representing rainfall runoff and nutrient generation from land and transport through surface water and groundwater systems. The model then generates predictions for stream flow and in-stream nutrient concentrations.

Integrated catchment modelling is a combination of models to utilise the best performance of different sub-models. It is important that the primary ‘framework’ model has the capacity to allow sub-models to work together effectively in an integrated way. Bay of Plenty Regional Council examined a range of nationally and internationally available computer based models against criteria to choose the most suitable solution. The scoring indicated that the eWater SOURCE model is the best choice for BOPRC’s catchment management. BOPRC has engaged the services of specialist hydrological modellers experienced in the use of the eWater SOURCE software to populate and run the model.

BOPRC's goal is to have two functioning integrated surface catchment models; one model for the Kaituna- Pongakawa-Waitahanui Water Management Area and the other for the Rangitāiki WMA.

The two integrated surface catchment models operate with dependencies on other process based models (models that try to represent the physical processes observed in the real world) such as:

- Agricultural Production Systems Simulator (APSIM)
- OVERSEER - an on-farm scale nutrient budget model;
- SEDNET - defines a stream network as a series of links extending between stream junctions, and constructs sediment and nutrient budgets for each link; and
- Soil Moisture Balance models – estimates how much rainfall is lost through evaporation /evapotranspiration, how much runs off the land into surface waterbodies and how much infiltrates into the ground.

Together they are linked to the eWater SOURCE model which acts as an integrator of the results.

2 Parts of the model / sub models including the relationships between sub-models

The model framework operates at varying spatial (location) and temporal (time) scales depending on the requirements of each catchment. It can be used to consider effects at different locations and after different periods of time. The study area is divided into a catchment grid where the functions in the catchments are expected to have similar properties. The framework includes:

Framework components	Inputs
Gridded catchment climate data	National Institute of Water and Atmospheric Research (NIWA) climate computer
Rainfall runoff modelling	Soil Moisture Water Balance
Contaminant generation modelling (including Total Nitrogen and Phosphorus, Nitrate, Dissolved Reactive Phosphorus, Ammonia, Sediment and *E.Coli*)	'Baseflow' (groundwater-derived flow) and 'Quickflow' (direct runoff) export rates
River hydrology and hydrogeology	Council river flow gauging and catchment studies
Water allocation rules and consents (including irrigation demand and use)	Consent data
Surface water and groundwater interactions	MODFLOW groundwater model and technical studies on hydrology
Flow and constituent conservation and attenuation	Submodels such as SEDNET, APSIM, Soil Plant Atmosphere System Model (SPASMO)
Calibration	Council State of the Environment (SOE) data

The first step in any model build is the development of stream flow and the water balance between climate, rainfall runoff, groundwater storage to stream flows and groundwater levels. The following steps are required:

1. Climate generation and distribution.
2. Rainfall runoff modelling for naturalised (without any takes) flows.
3. Inclusion of water allocation (consented and permitted takes, water demand for irrigation including dam operations).
4. Flow calibration observed for current landuse (calibration is the process where the reliability or accuracy of the model is tested by assessing how well it is able to reproduce or match historically observed behaviour).

Each constituent in the generation framework needs to be balanced to the observed concentrations in groundwater and surface water, involving the following steps:

1. Mass distribution between ‘quickflow’ and ‘baseflow’.
2. Load calculations at a sub-catchment scale.
3. Development of attenuation (reductions in contaminant concentration) functions.
4. Load calculations at a stream reach scale.

3 Outputs from the model – the contaminants considered

The model will report daily values at ‘nodes’ (specified locations) across the catchment for the following constituents:

- Flow
- Total Suspended Solids - Turbidity (sediment)
- NH4-H (Ammonia)
- NOx-N (Nitrate Nitrite Nitrogen)
- TN (Total Nitrogen)
- DRP – TP (Dissolved Reactive Phosphorus – Total Phosphorus)
- *E.coli* (bacteria)

Through reporting modules, the eWater SOURCE model can quickly present statistics /results for scenarios including flow (Mean Daily Flow, one in five year low flow), loads (mean annual loads in tons/year or tons/km’s/year) and stream concentrations (median, 95 %ile, 5%ile). They can include summer and winter variation, lag times within land use, and groundwater attenuation.

4 Use of the model - scenarios and mitigation

The catchment models will generate and distribute flows, loads and concentrations from land use activities to both groundwater and surface water. The model will enable scenarios (different future states) to be run to estimate the consequences of land use changes and develop a solution framework by applying mitigations.

5 Limitations

Any model is the product of the data available to construct the model and complete the calibration. The level of confidence in the proposed models is higher in areas of the catchment where long term data has been collected. The further upstream from the data collection point, the lower the model confidence. The integrated catchment model will predict changes in conditions at a catchment scale well and make predications for changes at a sub-catchment scale, so it will be well suited to considering effects across the WMAs.

The land use inputs are from distributed actual farm data based on common factors such as soil and climate conditions, with assumptions for stocking rates and farm systems. Again, this means that the model will predict the consequences from land use change at a refined sub-catchment scale. However, predictions at a property scale are not possible unless the property was very large.

An advantage of the eWater SOURCE model framework is that new data can be easily added to improve the model resolution over time.

6 Uncertainty

The **model uncertainty** is determined by defined statistical assessments which look at the fit (how big the difference is) of the modelled data to the observed. This is an international method for determining model calibration performance.

To measure the **accuracy**, an assessment of the fit between the objective functions in the model can be made to determine if the ‘best’ solution was reached from the attribute selections by the modellers. The attribute fit can be tested statistically by multiple model runs with different attributes.

The last test is for the **model stability or precision** which is a sensitivity analysis on inputs to see how they individually affect the results. An input to the model is changed to determine what scale of effect it has on the model output predictions.

7 Future Work

At a later date, the eWater SOURCE models can be integrated with MODFLOW groundwater models (see separate Information sheet).