Towards Māori futures-focused scenario assessment for freshwater management

What is a Historic Scenario?

DRAFT REPORT

October 2016

Prepared By:

Simon Harris, Ton Snelder and Gail Tipa

For any information regarding this report please contact:

Simon Harris

Phone: 0274 356 754

Email: simon@landwaterpeople.co.nz

LWP Ltd
PO Box 70
Lyttelton 8841
New Zealand

LWP Client Report Number:	2016-009
Report Date:	October 2016
LWP Project:	2016-009

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Executive Summary

1. The NPS-FM directs regional councils to develop regional plans for managing freshwater quality and quantity. Councils are required to identify community and Māori values that are associated with freshwater and to develop freshwater objectives that meet the desired environmental state of water bodies (i.e., National Objectives Framework). Councils must then develop policies, limits and other management actions, to achieve these freshwater objectives. This is widely known as the freshwater limit setting process.

2. Scenario assessment is widely used in the NPS-FM process, and it useful for setting objectives and limits in situations with high complexity and uncertainty. Scenarios are used to compare and evaluate, they provide context and coherence to the decision-making process, they help with understanding uncertainty, they can provide for learning and innovation, they are a communication tool, and they are able to provide a range of outputs for, and perspectives on, the decision being made. There are a number of factors that drive scenarios and their outputs towards a restricted set of considerations and outputs. These drivers can mean that the focus of a scenario assessment is deflected away from how to achieve Māori aspirations for freshwater.

3. The work represented in this report is part of the MBIE-funded Ngā Kete o Te Wānanga research programme[1], which is designed around the idea that the optimisation of synergies between mātauranga Māori, science and other knowledge systems will improve decision-making and collaborative management in New Zealand to address an increasing array of challenges. One of the case studies within Ngā Kete o Te Wānanga is focused in the Ōpihi catchment, South Canterbury, in partnership with Te Rūnanga o Arowhenua.

4. The past is an important reference point for Māori. Sets of scenarios that do not include an historic context for comparison have the potential to reduce the level and effectiveness of Māori engagement in the assessment process. This report considers a so-called "Historic Scenario", that is intended to reflect some of the important reference periods for Māori with the aim to increase their engagement in freshwater decision making. The development of a historic scenario also has the potential to bring together a variety of knowledge sources, including mātauranga Māori, from a range of fields of expertise as an integrated package to inform a more holistic understanding of the Māori freshwater management context (including values, aspirations, outcomes sought from/provided by previous research projects).

5. There are a range of approaches to developing scenarios. Scenarios can be defined according to whether they are, for example, Situational – i.e., define situations, or Developmental – i.e., relate to a sequence of events. Developmental scenarios break down further into trend based (most likely), contrasted (extremes), or horizon/normative (which starts with a situational scenario, then defines how that set of circumstances is achieved). Examples of the use of history in the scenario planning literature include extrapolating historic trends as a way of developing scenarios, the use of historic situations to calibrate models; and the use by environmental managers of historic state and variability to set management targets for an ecosystem.

[1] Ngā Kete o te Wānanga: Mātauranga: Science & Freshwater Management (C01X1318), is one of two projects funded as a result of Ministry of Business Innovation & Employment's (MBIE) 2013 Freshwater Management Sandpit. At the MBIE sandpit, facilitated discussions were held around the question "How can we develop and optimise synergies between science, mātauranga Māori, and other relevant factors to improve our freshwater management?". Ngā Kete o te Wānanga is a six year multidisciplinary programme that has been directed to work in two regions, Murihiku/Southland and Canterbury.

6. The historic scenario approach being proposed here is currently outside the generally accepted approaches to scenario based planning processes. Although the incorporation of the historic context into conventional scenario planning processes requires careful thought, it represents an opportunity to provide alternate approaches that support the new ways of thinking that are needed to achieve Māori aspirations for freshwater management.

7. Based on the published international literature three contrasting potential approaches to formulating the historic scenario have been considered in this report: “Point in Time”, “Coherent Identity” and “Cultural Biography”. The **Point in Time** approach would allow the conditions of a specific time to be investigated, and developed into a coherent and integrated package of information and would complement the information provided for conventional scenarios being developed as part of the freshwater limit setting process. However, such a scenario may also be limiting in that mātauranga developed by hapu/whānau is often spatially specific and informed by a range of influences/experiences that span a range of time periods. The knowledge gathered from different time periods can also cover different aspects of the catchment depending on the activities/uses that were current at that time (which may also be influenced by changes in the national and global context). Amongst other challenges, a single Point in Time scenario raises the issue of choosing the “right” time to represent “a Māori perspective”.

8. The concept in the landscape planning literature of landscapes as a **Coherent Identity** is analogous to an aging person, which even through physical changes retains the holistic coherence and continuity of personality. However the identity of the landscape is able to be disrupted by significant change, and it is likely that from a Māori perspective many catchments have had their identity altered. This type of scenario is likely to be an expression of the catchment in a state which retained its identity from a Māori perspective. This would enable the scenario to draw on a range of historic information sources, but not be exclusive to any one time period. The coherent identity approach would be relevant and would challenge the status quo in terms of conventional scenario approaches, but may be difficult to explain/communicate because it is not well codified.

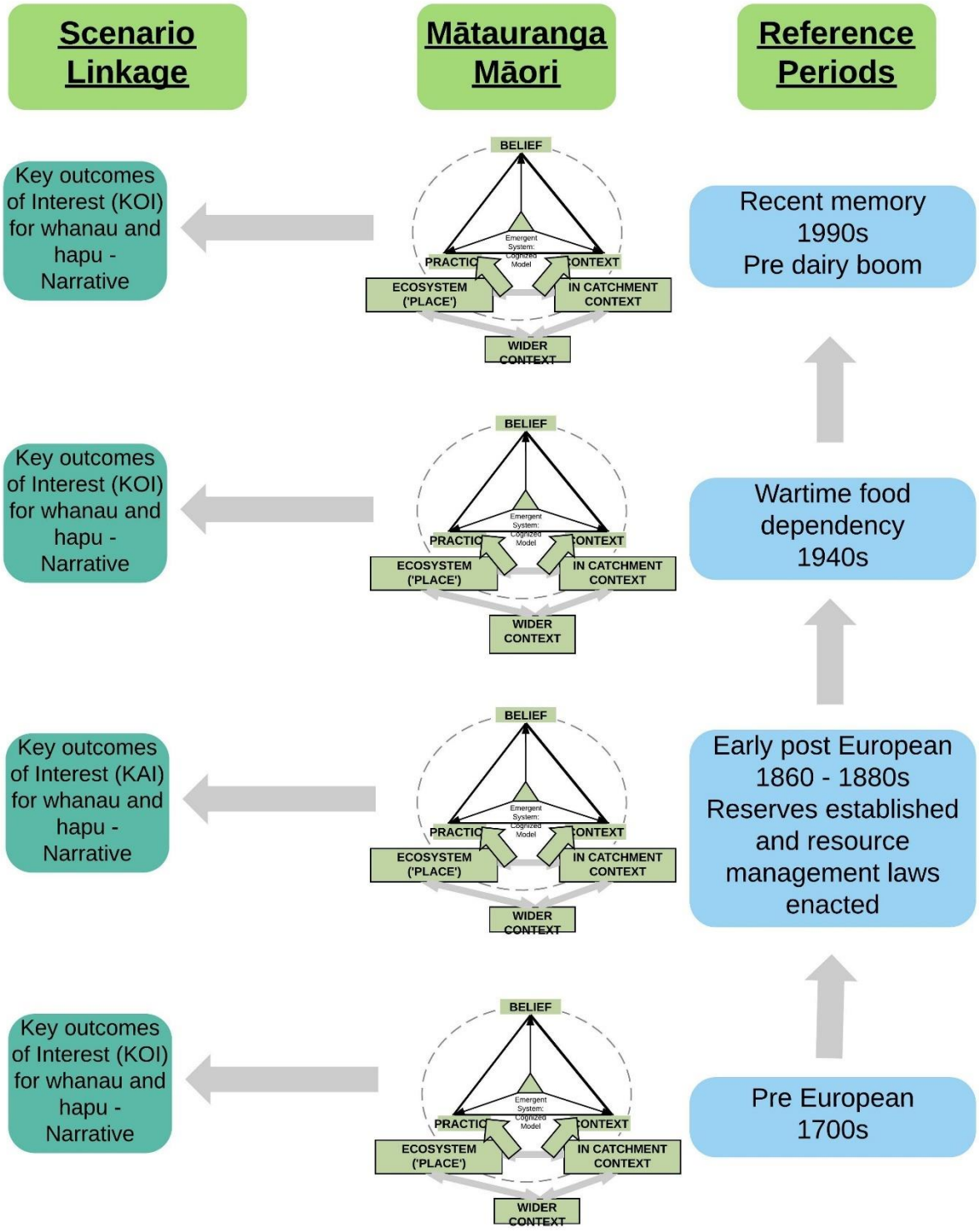
9. **Cultural Biography** uses the concept of “landscape as a cultural biography”, involving the physical, social, and individual perceptions of the landscape over time. This approach would provide a context within which written and oral histories, as well as the mātauranga of the current generations could be integrated with biophysical timelines to describe an alternative view of the catchment. This approach would enable the community to tell the story of the catchment and its interaction with Māori and with wider socioeconomic changes. Mātauranga evolves from whānau and hapu interacting with the catchment and reflects the context of what has happened in the catchment over time. Mātauranga would therefore help develop a rich understanding of the cultural context in a catchment. Developing a cultural biography could potentially be resource intensive, and would need to be carefully managed to ensure that it could be presented in form that can be assimilated within the scenario planning process.

10. Of the options considered it seems likely that the Cultural Biography may be the best approach in terms of its ability to be adapted in a way that satisfies the requirements of both the current scenario process and Māori. In keeping with the exploratory/research objectives of the Ngā Kete o Te Wānanga project, it is suggested the exact nature of the Cultural Biography be developed within the project with the support of agencies.

11. In this report we propose a new approach, based on the Cultural Biography, to utilise mātauranga Māori and adapt the Indigenous Ecosystem Knowledge (IEK) process of Woodley (2002, 2005), which views IEK as an emergent property of context, practices and

beliefs (CBP). The proposed structure is shown in Figure 1, and focuses on developing narrative understanding of key outcomes of interest (KOIs) based on the outcomes that whānau, hapū and iwi wish to achieve for the catchment. For each of a set of Reference Point periods (see Figure 1 for examples of potential reference periods) in the catchment history, the project will develop an understanding of the CBP. The CBP will also be supported by social, economic and biophysical contextual information that will be derived from models and historical data.

Figure 1: Proposed structure for Cultural Biography



12. In terms of the types of supporting information required to populate a Cultural Biography, for example, a nutrient model has been developed that enables estimates of the nitrogen and phosphorus loads of the catchment at each reference period. A range of other models can potentially be applied to develop ecosystem and economic indicators, such as water

quality measures, macroinvertebrate community index (MCI), freshwater fish populations, hydrological regimes, and wetland extent.

13. The development of the cultural biography is experimental as, while there are parallels to the proposed approach in other disciplines, there do not appear to have been any studies where a cultural biography approach has been proposed in a context that explicitly recognises and provides for the rights and interests of an indigenous community. There is therefore no certainty that the Cultural Biography approach (as currently described in the international literature) is feasible, and there are a range of obstacles in collating information across the required areas, for example, the interactions between (and possible "fusion" of) mātauranga and western science approaches will need to be developed as the project proceeds. The models that have been identified to provide supporting information have not been applied previously in the manner proposed here, and their use in this context is untested and will need to be carefully thought through. The initial development and focus on the Opihi River should be seen as proof of concept, and there are likely to be gaps in the available information. However, such challenges are appropriate for a research-based project seeking to develop novel and innovative solutions, and therefore the iterative and on-going development of the concept and methods as required.

1 Background

The NPS-FM directs regional councils to develop regional plans for managing freshwater quality and quantity. Councils are required to identify community values that are associated with freshwater (for example environmental values such as ecosystem health, human health for recreation, and economic use values, namely contaminant assimilation and water supply) and to collect water quality and quantity information to assess the current state of water bodies within their regions. With reference to the current state and taking into account the rights and interests of Māori and community's values, councils are required to develop freshwater objectives that express numerically (where practicable) the desired environmental state of water bodies.

Freshwater objectives and limits represent a more pre-emptive mode of management that provides greater certainty than previous regional plans for both the freshwater values and the allowable resource use. Previous regional plans tended to focus on establishing the administrative basis for consenting future resource use, the details of which were evaluated case by case. The NPS-FM requirement to make decisions at the level of plans provides a greater ability to manage some of the cumulative effects of resource use through the use of limits and provides for greater certainty for both environmental outcomes and resource availability. However, the requirement to set numeric objectives and limits has created a significant increase in the information requirements of regional planning processes because of the implications of limiting resource use.

This report is the second in a series investigating the interaction between Māori and the use of scenarios in freshwater decision making. The previous report in this series "Towards Māori futures-focused scenario assessment for freshwater management: What's required? (Snelder et al. 2015[2]" provided a background to the use of scenarios in freshwater decision-making processes. The work represented in these LWP Ltd reports are part of the MBIE-funded Ngā Kete o Te Wānanga research programme[3], which is designed around the idea that the optimisation of synergies between mātauranga Māori, science and other knowledge systems will improve decision-making and collaborative management in New Zealand to address an increasing array of challenges. One of the case studies within Ngā Kete o Te Wānanga is focused in the Waitaki and Ōpihi catchments, South Canterbury. In the Waitaki / Opihi case study our tiers of engagement include: (1) Our partners (Te Rūnanga o Arowhenua, the Ngāi Tahu Rock Art Trust); (2) The agency leading the freshwater management process we are engaging in, i.e., Environment Canterbury; (3) Resource users, including Meridian Energy, Genesis Energy, and Irrigation Companies; (4) The agencies that provide implementation pathways, including Papatipu Rūnanga, Kai Tahu Ki Otago, and Te Rūnanga o Ngāi Tahu; and (5) Mana whenua.

Scenario assessment is being used in New Zealand to derive objectives and limits in situations with high complexity and uncertainty. This requires many trade-off decisions to be made between many potentially viable solutions. Scenarios can be used in a variety of ways,

[2] Snelder, T., Harris, S., Tipa, G. 2015. Towards Māori futures-focused scenario assessment for freshwater management: What's required?. LWP Contract Report prepared for NIWA. December 2015.

[3] Ngā Kete o te Wānanga: Mātauranga: Science & Freshwater Management (C01X1318), is one of two projects funded as a result of Ministry of Business Innovation & Employment's (MBIE) 2013 Freshwater Management Sandpit. At the MBIE sandpit, facilitated discussions were held around the question "How can we develop and optimise synergies between science, mātauranga Māori, and other relevant factors to improve our freshwater management?". Ngā Kete o te Wānanga is a six year multidisciplinary programme that has been directed to work in two regions, Murihiku/Southland and Canterbury.

including, to compare and evaluate potential solutions, providing context and coherence to the decision-making process, increasing understandings around uncertainty, providing for learning and innovation, and as communication tools as they are able to provide a range of outputs for, and perspectives on, the decision being made. There are a number of factors that currently drive conventional scenario development and their outputs towards a restricted set of considerations that means that the focus is not on how to achieve Māori aspirations for freshwater.

Māori have a range of aspirations in relation to freshwater that reflect their desire to continue to use waterways, in particular as mahinga kai. These aspirations are underpinned by key cultural values including mauri, whakapapa, manaakitanga, rangatiratanga and kaitiakitanga. It also requires Māori, as kaitiaki, to protect wāhi tapu and wāhi taonga in a catchment. This requires a consideration of factors beyond biophysical states of freshwater. There is a need for all values of importance to Māori to be represented in the scenario outputs, and for these values to be represented in an appropriate manner, which may not be numeric. Furthermore, the past is a very important reference for Māori, for example, as expressed in the whakataukī – *"Kia whakatōmuri te haere whakamua" (My past is my present is my future, I walk backwards into the future with my eyes fixed on my past).* Sets of scenarios that do not include an historic context for comparison have the potential to reduce Māori engagement in the assessment process.

A further unanticipated result of limiting the exposure of Māori to scenario assessments within the NPS-FM context may be that the wider benefits of scenario planning and assessment approaches may not be realised. If the experiences of Māori within the NPS-FM processes are negative, they may reluctant to use scenario planning as a tool that can aid their internal hapū/rūnanga/iwi planning.

Snelder et al. (2015) concluded that Māori engagement in NPS-FM scenario-based decision-making has the potential to be affected by:

a. A focus on problem-based scenarios that have pre-defined (normative) outcomes, rather than learning oriented scenarios that are iteratively developed with Māori and stakeholders.

b. Sets of scenarios that lack an historic context and therefore may lack an important frame of reference for Māori.

c. A focus on a narrow range of considerations, which are typically those that are able to be quantified.

d. The availability of a limited range of regulatory instruments that can be used to achieve objectives under the NPS-FM. Resolving this may require changes not just to the way in which scenarios are assessed but also the way in which natural resources and catchments are managed.

This report discusses the first three of these potential roadblocks to Māori engagement in freshwater decision-making by considering how a scenario or scenarios may be developed that improve the effectiveness of Māori engagement in freshwater management.

Snelder et al. (2015) identified that a critical point for Māori will be the availability of an appropriate point of comparison. For most NPS-FM processes the current situation is generally used as the point of comparison. However, the behaviour of Māori engaging in scenario planning processes, and the aspirations they articulate are shaped by tikanga and

informed by mātauranga. Discussions will involve an assessment against standards used in the past, both immediate and reaching back into the participant's whakapapa. For Māori therefore in assessing a situation, the point of departure has strong historic references.

Therefore, scenarios that acknowledge the historical context and associated values are likely to provide an important frame of reference for Māori. Research and development of methods that include this historic context in a way that brings these values and associated objectives into decision making is required (Snelder et al. 2015) and the development of a "Historic Scenario" is the focus of this report. The use of the term "Historic Scenario" is intended to be provisional, and as this research progresses it may be that a more appropriate terminology is developed that reflects the context of the approach, whilst also aligning within the wider use of scenarios in freshwater decision making.

2 Proposed Objectives

Based on the collective experiences of the authors, a review of the national and international literature, and the findings of Snelder et al (2015) we propose the following objectives for a successful development of a historic scenario that we can use to test the suitability of different approaches for achieving Māori aspirations for freshwater management. The historic scenario should:

1. Enable Māori to engage in development of the scenario and the associated freshwater limit setting process by representing their rights and interests in a catchment, their understanding of the functioning of the system, and describing their values in the deliberations on catchment management.
2. Present a different perspective on the catchment than the current or future scenarios.
3. Provide context for Māori values by placing them within an authentically Māori perspective of the catchment and its resources drawing on fundamental concepts that include whakapapa, mauri, manaakitanga, kaitakiakitanga, and tikanga.
4. Meet more typical requirements of scenarios in providing context and coherence to assessments of how all values vary under different conditions of the catchment and its resources.
5. Provides for an integrated assessment of a range of catchment values. The scenario should allow for the inclusion of Māori values and the evaluation of all values in an extensive and holistic manner.
6. Enable mutual learning by Māori and stakeholders of catchment interactions and processes, and the way in which different values move in relation to each other under various circumstances[4].
7. Be readily produced and require a reasonable level of resources to develop.
8. Provide for a range of qualitative and quantitative considerations to be included.

3 Options for the use of historic contexts in scenario planning.

The literature in scenario planning describes a range of approaches to developing scenarios. Godet (2000) and Georgantzas & Acar (1995) define scenarios according to whether they are

[4] In this context it should be seen as explorative rather than normative or reference (See Section 4.4 of the previous report).

situational – i.e., define situations, or developmental – i.e., relate to a sequence of events. Developmental scenarios break down further into trend based (most likely), contrasted (extremes), or horizon/normative (which starts with a situational scenario, then defines how that set of circumstances is achieved). Shoemaker (1995) indicates that scenarios should be:

a. Relevant but also challenge;

b. Internally consistent and plausible;

c. Archetypal in that they show fundamentally different futures – i.e., they should be sufficiently varied to demonstrate major rather than minor differences. This increases their use in helping to understand the importance of different aspects of the future;

d. Equilibrium state, in that they should express a plausibly stable situation.

These provide useful guidelines for the development of a scenario. However, the scenario planning literature tends to indicate historic situations are only used in an ancillary function in scenario development, rather than being the central focus of a scenario. Examples of scenario use in the scenario planning literature include:

- Extrapolating historic trends as a way of developing scenarios, with the discussion generally focused on how to undertake this and the appropriateness of using historic trends; or
- The use of historic situations to calibrate models (Dortmans & Eiffe, 2004; Vitel, et al., 2013);
- The use by environmental managers of historic state and variability to set management targets for an ecosystem (Millar, Stephenson, & Stephens, 2007), although this is only with reference to biophysical state.

This limited use of historic information is not unexpected, given the inherently future-focused nature of scenario planning. The literature indicates that the historic scenario approach being proposed here is outside the generally accepted approaches to scenario planning, and that their incorporation into traditional scenario planning requires careful thought. For example, typically in a scenario a plausible pathway exists between the current state and the scenario. While aquatic restoration and a range of biodiversity initiatives demonstrate that components of a historic scenario can be recreated, restored or rehabilitated, recreating the exact conditions of the historic scenario is unlikely because many of the physical changes that have resulted in the current state are irreversible and also because many of the social and cultural conditions that existed cannot be reproduced. The historic scenario therefore represents an approach for which new ways of thinking are needed.

For this analysis three contrasting potential approaches to the historic scenario were investigated. The first of these is the intuitively obvious “Point-in-Time” – that is a situational scenario that is similar to the traditional approach to scenario assessment. The other two, “Coherent Identity” and “Cultural Biography” draw on landscape planning literature, and develop new ways to think about the nature of the catchment and its relationship to the people who inhabit and use it.

3.1 Point-in-Time

The Point-in-Time historic scenario option is a situational scenario –representing a particular time in history. For example, a scenario might represent:

- The period around 1879 using written information recorded on mahinga kai;
- The period around Word War II (WWII) using written and oral history of the catchment to describe aspects such as feeding local hapū during periods of food shortages/restrictions;
- A time within the recollection of the current population.

The Point-in-Time approach would allow the conditions of a specific time to be investigated, and developed into a coherent and integrated package of information. It would meet the Shoemaker (1995) requirements in that a specific point in time would be relevant to the process, archetypal in defining a distinct alternative to the current or future scenarios, it would be internally consistent and plausible (as an occurrence, if not necessarily a plausible future state that is achievable from the current time), and if the a stable period were chosen would be sufficiently in equilibrium to satisfy the equilibrium state condition. A point in time historic scenario would parallel the information provided for other scenarios developed for the freshwater limit setting process, and would allow direct comparison of outcomes. It would provide a target for catchment management that was within its range of natural states, which is potentially intuitively appealing to many stakeholders.

From a cultural perspective, a "point in time" is difficult to reconcile with conceptualisations that emphasise the importance of a past-present-future continuum. Further, such a scenario may also be limiting in that the mātauranga represents the accumulation of generations of experiential learnings where information from different periods covers different aspects of the catchment depending on the activities that were current at that time. There is a risk therefore that a Point-in-Time historic scenario would not capture the full richness of Māori experience of the catchment. It will be extremely difficult to determine what mātauranga should be attributed to a particular point in time. A single Point-in-Time scenario would therefore raise the issue of which was the "right" time to represent "a Māori perspective".

3.2 Coherent Identity

An alternative situational scenario to the Point-in-Time option draws on the "coherent identity" concept used in landscape planning (Antrop M. , 2005). This is a more difficult concept to pin down, but draws on an "*understanding of landscapes as a dynamic interaction between natural and cultural forces in the environment"*. The coherence of a landscape is seen as the key to identity – the analogy is that of an aging person:

> *The metaphor of an aging person is (to some extent) appropriate to describe the meaning of identity, as well as the continuity and change of landscapes. During a lifetime one's physical appearance changes a lot. However, it is still easy to recognize the identity and character of a person one once knew, even after a long time and many physical changes. This illustrates the holistic coherence of a person and the continuity of his personality.* (Antrop M. , 2005)

Antrop (1997) uses the concept of *genius loci* in landscape planning, which is the distinctive atmosphere or characteristics of a landscape that emphasise and define the uniqueness of a place. He refers to these places that retain their identity as traditional landscapes, which contains the complex history of the place that can be read from its composition and its structure. The concept of *genius loci* or cultural identity is not confined to the built environment, and includes the landscape and soil, and in the freshwater context, waterbodies. Antrop (1997) notes that traditional landscapes retain their cultural identity are particularly vulnerable to intensive agriculture and land development. One immediate challenge regarding this use of

concept in an Aotearoa-New Zealand context concerns the terminology of Antrop (1997), as "cultural landscapes" and "cultural identify" have specific meanings to whānau and hapū that conflicts with conventional/international landscape planning terminology.

In this concept the identity of the landscape is able to be disrupted by significant change, and it is likely that from a Māori perspective many landscapes/catchments have had their identity altered – however, the cultural identity of whānau that stems from that landscape remains unchanged, though impacted. These complexities would be challenging to untangle and articulate. The information gathered would be arranged to show the relationship between the physical state of different parts of the catchment, and the associated demographic, social and cultural situation. In some cases, more than one state and relationship could be defined to show how relationships between the hapū and the catchment alter with the biophysical and social contexts, for example, increased food gathering in the catchment during WWII as a specific response to the conditions of that time.

The coherent identity approach would challenge the status quo in terms of defining scenarios in freshwater planning processes. The coherent identity approach would present challenges for Māori and stakeholders because of the difficulty in defining the concept in an Āotearoa-NZ context, because of the potential conflicts in terminology, and because of vagueness in codifying what defines the scenario.

3.3 Cultural Biography

A third option is the presentation of the historic scenario as a development scenario. This would also draw on the landscape planning literature using the concept of "landscape as a cultural biography".

> *In this interpretation, a cultural landscape biography is both a description of the history of the material landscape and of the world of social meanings and individual ideas grafted onto that landscape during various periods.* (Palanga, Spekb, & Stensekec, 2011)

This approach enables the use of indigenous knowledge, indigenous ecological knowledge (IEK), and in the New Zealand context mātauranga Māori, using a range of ethnographic techniques.

The cultural biography approach has three dimensions (Jacobs, 2006):

- Physical dimension, traditionally studied by natural science and classical geography;
- Social dimensions, comprising the norms, values, meanings and attitudes which surround the physical landscape; and
- Mindscapes, in which the individual perceptions of the landscape are influenced by our genes and individual life history.

The advantage of this approach is that it requires us to understand the perspective of whānau and hapū for each of these dimensions.

Palanga et al. (2011) identify the interaction between the three dimensions, and between expert and local knowledge as offering the most potential in terms of developing cultural biography approaches to landscape planning. They consider that this approach is:

> *"... reflected in the landscape biography which reveals both the continuous biographical timeline of the scientists, and the more place-oriented, unique individual narratives and meanings of residents and other local experts."* (Palanga, Spekb, & Stensekec, 2011).

Components of this approach were undertaken for the Wainono Lagoon, albeit from a biophysical perspective (Schallenberg & Saulnier-Talbot, 2014). In this example, core samples from the lake bed were analysed to assess the historic biophysical conditions, and these were linked to major events in the catchment history (land clearance, wetland drainage, land use change etc.), to show how the biophysical and socio-economic histories interacted. However, Schallenberg & Saulnier-Talbot (2014) did not recognise the significance of Wainono Lagoon to Ngāi Tahu and the lagoon's role in the initial settlement of the South Island eight hundred years ago. It also did not address the full range of matters that should be represented in a cultural biography, but it shows how at least two parts (socio-economic and biophysical) can be linked in a narrative description of the history of a catchment. Similarly, Sadgrove (2012) used a combination of historical information sources including journals of early Australian explorers, together with Aboriginal cultural practices in relation to water management, to demonstrate the historical occurrence of cyanobacterial blooms in central and southern Australia. He concludes the incorporation of cultural knowledge with scientific laws (*sic*) is a useful approach to conceptual modelling of biophysical processes.

The terminology of cultural biography is also used in archaeology in relation to artefacts (e.g., Feldman, 2009; O'Sullivan & van de Noort, 2012), where the context and development of an object or location over time is seen as an integral part of understanding its meaning.

Applying the Cultural Biography approach in the context of the Ngā Kete o Te Wānanga research programme would utilise the mātauranga that mana whenua have gathered through interacting with their catchment/cultural landscape over time, linking it through context to the biophysical and wider socioeconomic changes that occurred. In this sense it would be more than just a historic scenario – it would be the story of how the catchment got to where it is today, and the changes that occurred along the way. Mātauranga will provide a rich understanding of the cultural context, the interdependencies and interactions with the wider catchment/landscape.

There would also be room to explore the "mindscape" associated with the catchment, reflecting individual experiences and reactions to it. We anticipate that this dimension of the cultural biography is has parallels with concept mapping, i.e., visual representations of the mental models contributed by whānau for a catchment/landscape (e.g., (Tipa, TBC, 2014)). A concept map is essentially an individual's internal picture of how they see the world, which is shaped by their experiences. It is this internal picture that whānau draw upon to interpret different contexts and inform individual decision-making and action (Piaget, 1952; Craik, 1983). Mental models can therefore vary from person to person as they reflect an individual's assumptions, images, and stories. They are "*active - they shape how we act…they affect what we see*" (Senge, 1990). Accordingly, mental models are formed through personal experiences with the catchment, including early life learning in whānau, hapū and iwi contexts, exposure to the river environs, and other dimensions of whanau/hapū/iwi culture directly associated with the catchment/cultural landscape.

Drawing on a parallel concept, a cultural biography could be thought of as a number of layers that are built up by telling the story of the catchment and its people over time. This approach is directly relevant to the New Zealand's freshwater limit setting approach, would have considerable internal consistency particularly if the cultural, biophysical and socioeconomic

changes are able to be linked. ECan has adopted a conceptually similar approach with its 'storymap' web pages to communicate the outcomes from different scenarios.

The Cultural Biography satisfies the criteria that it be fundamentally different in its perspective on the catchment (archetypal), but would not necessarily be equilibrium state because of its focus on change.

A potential negative of the cultural biography approach is that it could potentially be resource intensive, and would need to be carefully managed to ensure that it could be presented in form that can be assimilated within the scenario planning process – for example, if the Cultural Biography became too large and unwieldy it would risk being marginalised.

3.4 Assessment of options

The three options presented span a range of potential approaches to developing and communicating a historic scenario. A comparison of their potential strengths and weaknesses against the objectives and criteria described in Section 2 is shown in Table 1. All options are capable of meeting the objectives to some degree, and it is likely that all options would provide additional benefits to the conventional scenario process. However, none of the options are ideal in the sense of producing a readily definable and easily understood historic scenario for inclusion into a scenario planning process. The key weaknesses of the options analysed in this report are:

- Point in time – limits the utilisation of mātauranga, risks the perception of the catchment as a static, quantitatively predictable phenomenon, and is the antithesis to the past-present-future philosophy of Māori that emphasises indivisibility
- Coherent identity – is a concept that is difficult to explain and codify. It is also difficult to demonstrate that any specific scenario is "coherent" and may risk being dismissed as "airy fairy" in a wider, more quantitatively based process (for example, a specific scenario may not be repeatable with a different set of actors).
- Cultural Biography – may be expensive to produce for a catchment in great detail, both from an information collection point of view and quantitative modelling perspective (because modelling of different catchment states over time may need to be repeated).

While it would be desirable to further adapt the scenario planning process itself to better accommodate the needs of Māori, the exigencies of the overall NPS-FM and RMA process, together with time and resource demands of planning, places limits on the extent to which the process can be altered. There is, therefore, a need to choose an approach that will best serve the needs of Māori and lead to better engagement in the freshwater limit setting process.

It is likely that no single option considered in this report will fulfil all the requirements/aspirations of Māori for engaging effectively with the freshwater limit setting process. A single point in time is unlikely to produce a satisfactory description of the catchment from a cultural point of view. The concept of coherent identity is possibly more relevant to the outcomes desired by Māori as it may have the potential to reflect, for example, aspirations to enhance the mauri of a catchment, or the broader, more holistic meanings encompassed by the terminology mahinga kai (i.e., beyond the biophysical) associated with the practise, the species, the knowledge system, and the ultimately the wellbeing of the communities these activities support.

Of the options considered, it seems likely that the Cultural Biography approach, may best satisfy the requirements of both scenario processes under NPS-FM and Māori. Further input

is required from local hapū on their preference for an approach, but if a cultural biography approach were to be taken, it could potentially use the narrative aspect of the Cultural Biography, but focus on aspects of the catchment that recognise and provide for an environment that sustains the cultural identity of whānau and hapū. For example, from a whānau and hapū perspective the cultural biography could be used to develop a historic scenario which focuses on:

- Taonga species such as tuna (freshwater eel), kākahi (freshwater mussel), kōura (freshwater crayfish), and whitebait (akin to cultural keystone species (Nobel, et al., 2016);
- Sites within the catchment used or to be restored as mahinga kai;
- Valued characteristics of cultural landscapes/catchments, e.g., gorges, springs, etc.;
- Water security (quantity and quality) for the marae, papakainga and reserves;
- Wāhi tupuna or cultural landscapes within sub-catchments that are dependent upon specific hydrological features and conditions.

In keeping with the exploratory approach in this research, it is suggested the exact nature of the Cultural Biography be developed through the Ngā Kete o Te Wānanga programme. In the following section we assess the types of information and tools that might be required to develop an integrated historic scenario.

Table 1: Comparison of historic scenario options with objectives and criteria. (See Section 2 for more detail)

Objective	Historic Scenario Option		
	Point in Time	**Coherent Identity**	**Cultural Biography**
1. Enable Māori to engage in development of the scenario and the associated freshwater limit setting process by representing their approach to understanding and describing values.	No	Possibly	Yes
2. Present a different perspective on the catchment from the usual current or future scenarios.	Yes	Yes	Yes
3. Provide context for Māori values in freshwater limit setting by placing them within an authentically Māori approach to understanding a catchment and its resources.	No	Possibly	Yes, parallels concepts describing a pathway through time
4. Meet more typical requirements of scenarios in providing context and coherence to collective groupings of indicators.	Yes	Partially, may be difficult to explain	Partially, coherence may be difficult to achieve
5. Provides for an integrated assessment of a range of catchment values. The scenario should allow for the inclusion of Māori values in an extensive and holistic manner. In particular it should relate to concepts of mauri, mātauranga and kaitiakitanga.	Yes	Yes	Yes
6. Enable mutual learning by Māori and other stakeholders.	Yes, although limited by the values that are relevant to the specific point in time	No	Yes, particularly in relation to changes in the catchment
7. Be readily produced and require a reasonable level of resources to develop.	Yes	Yes, but will depend on how it is framed	Potentially resource intensive to produce depending on existing information
8. Provide for a range of qualitative and quantitative considerations to be included.	Yes	Yes	Yes
Criteria	**Point in time**	**Coherent identity**	**Cultural Biography**
a. Relevant but also challenge	No	No	Yes
b. Internally consistent and plausible	Yes	Not necessarily	Yes
c. Show fundamentally different futures (archetypal).	Yes	Yes	Yes
d. Equilibrium state, in that they should express a plausibly stable situation	Yes	Not necessarily	No, changing over time

4 Framework, Information and Tools for Historic Scenario

This section assumes a Cultural Biography as the basis for developing the historic scenario. The section attempts to set out the major components of the biography and the information and tools that would hypothetically be needed for its development.

In conventional scenario planning, the work in developing a scenario is arranged around defining the underlying environment that contributes to a scenario, leading to an understanding of the trends and patterns and ultimately events that determine the nature of the scenario. These are described in the Iceberg Metaphor (Chermack, Lynham, & Ruona, 2001) as set out in Figure 2, which shows a focus on Events which are generated or affected by trends and patterns, which in turn are generated by the underlying structure of socio-political, economic and environmental conditions. There is therefore a great deal of underlying information that needs to be generated in order to fully describe and comprehend events that the scenario planners may be concerned with. However, much of the scenario planning literature has been developed for the business community, where socio-economic drivers and outcomes are the key issues.

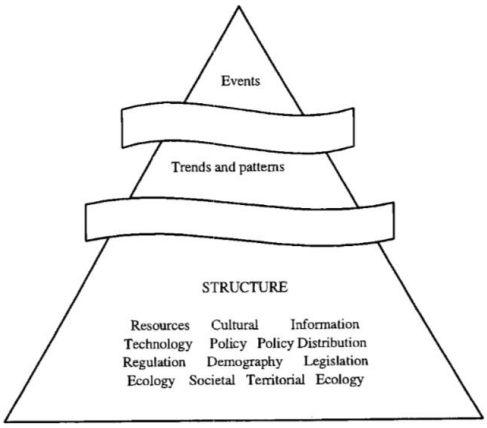


Figure 2: The Iceberg Metaphor (Chermack, Lynham, & Ruona, 2001)

In a study of cultural landscapes Vervloet *et al.* (2010) describe three potential interpretations of a landscape biography:

- Landscape biography considered from the perspective of the present inhabitants and user or consumers of the landscape;
- Landscape biography considered from the perspective of the inhabitants and users of the landscape from a recent or distant past; and
- Landscape biography considered as the narrative of the landscape, whereby all developments based on scientific research are depicted as completely as possible.

They reject the first interpretation because of the potential for the introduction of fantasy, and adopt primarily the third approach because it more fully describes the dynamics of the landscape and is not restricted to one perspective as the second approach would be. Nevertheless they incorporate aspects of the second approach when considering archaeological sites related to pre-Christian worship, which are not fully understandable

without considering them from the perspective of the inhabitants of the times when they were created.

Because the focus of the historic scenario is to develop and understand the interaction of Māori with the environment and importantly utilising their mātauranga in scenario planning and limit setting processes, this report rejects an approach that sets out to define a real or objective 'truth' about the catchment and its relationship to its inhabitants. It proposes instead a framework based on an understanding that mātauranga is embedded in the *beliefs*, *context* and *practices* of Māori. This follows Woodley (2002, 2005) who in relation to indigenous ecosystem knowledge (IEK) identifies the knowledge as an emergent property of people in a location and situation, and it is not therefore susceptible to reductionist extraction – see Figure 3. This approach can be found in other disciplines – for example in art history the origin, location and state of objects is seen as a product of the context of the period in which it was produced as well as the subsequent history it interacted with - for example specific ritual damage to artefacts of the vanquished by their foes relating to the beliefs and practices of that time (Feldman, 2009). Similarly Gebel (2010) uses a format of environmental, socioeconomic, and cognitive subsystems to describe the process of acquisition and harnessing of water through neolithic history.

The Cultural Biography approach therefore needs to describe the three elements in sufficient detail and richness to enable the interaction to be understood.

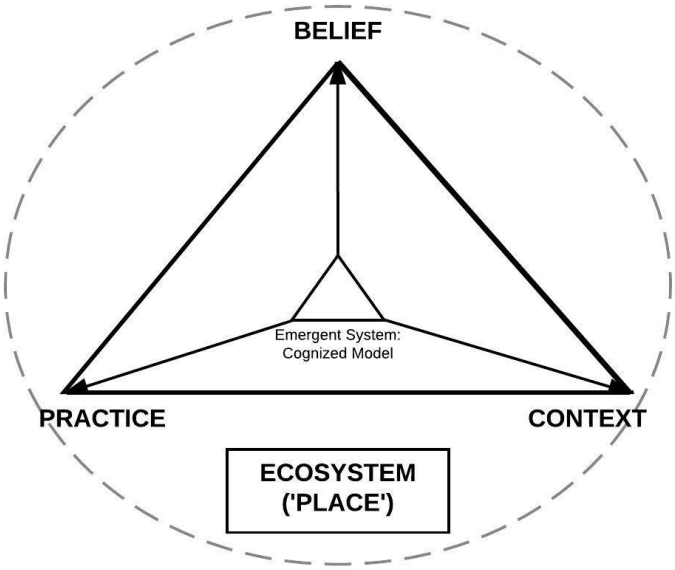


Figure 3: Conceptual framework showing the emergence of indigenous ecosystem knowledge (IEK) from a traditional system where knowledge is acquired within the local ecosystem (adapted from Woodley 2005)

The framework proposed by Woodley (2005) uses IEK as the overall framework, which in the New Zealand context would be mātauranga Māori, and incorporates more typical scenario analysis to develop the understanding of the context and ecosystem. This approach retains the primacy of purpose for the scenarios – that is in representing the views and understanding of whānau/hapū. Thus the scenario represents an amalgam of the expanded context and ecosystem information, and mātauranga (using the IEK framework) as shown in Figure 4. The framework can be usefully divided into three complementary and overlapping parts:

- Mātauranga Māori – forms the core of the cultural biography, and describes the context, practices and beliefs of whānau and hapū for each of the reference periods, and the transitions that occur between reference periods.
- Supporting information – a range of biophysical, economic social and other contextual information that supports and illuminates the context and practices.
- Reference periods – these are staging points in time in the history of the whānau and hapū, and the catchment that can be used in telling the cultural biography.

Each of these is discussed in greater detail below.

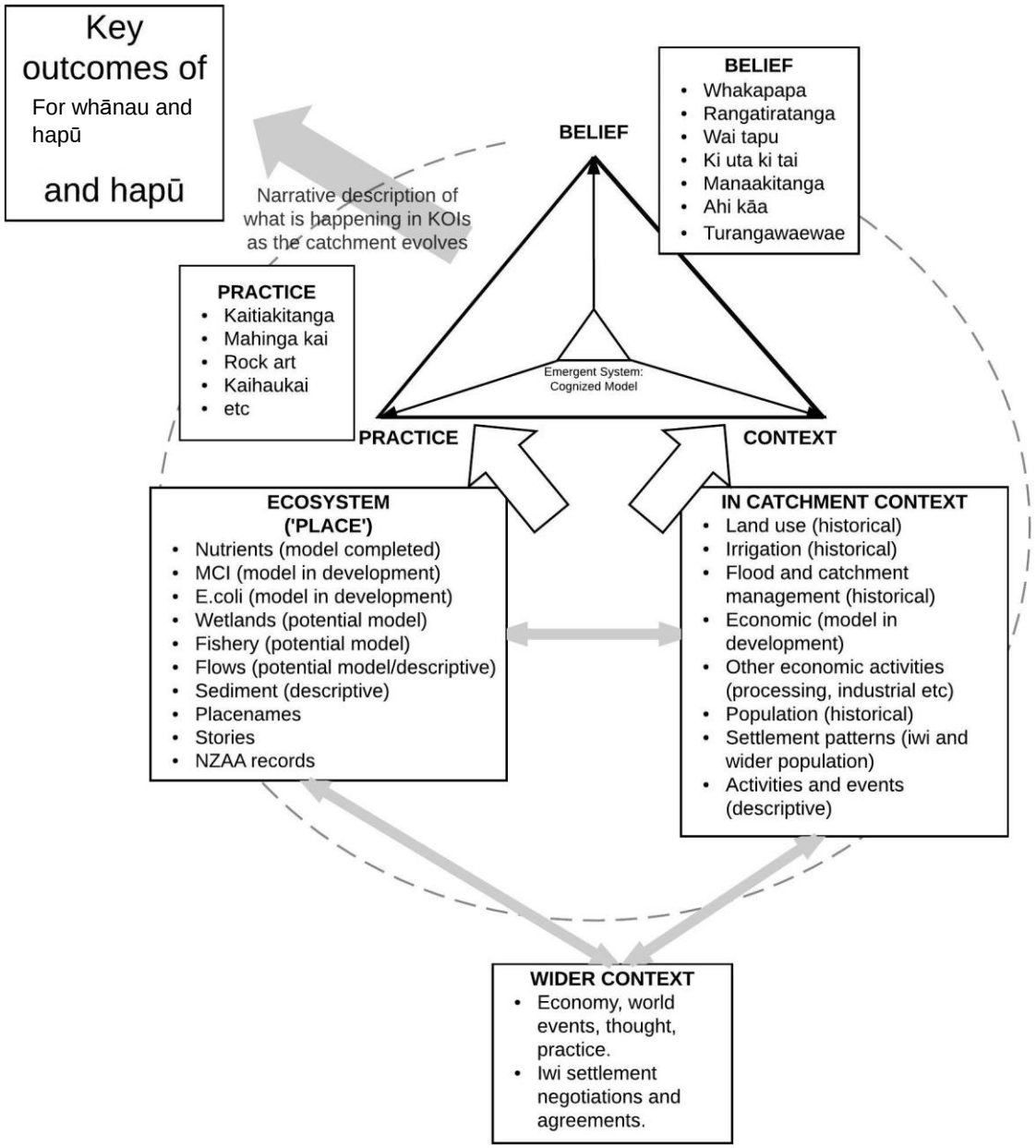


Figure 4: Expanded cultural biography framework incorporating mātauranga Māori framework and examples of the types of information that could support scenario developments

4.1 Mātauranga Māori

Mātauranga Māori is at the core of the cultural biography, and describes whānau and hapū experiences of the catchment over time. The aim here is not to idealise the state of the catchment or whānau and hapū experiences of it, but to describe how and why mana whenua interacted with it and how this changed over time. Mātauranga Māori can be drawn from a range of sources, including historical information sources (e.g., Cain, 2016) and interactions and discussions with whānau and hapū. This has been the focus of work within the Ngā Kete o Te Wānanga programme over the past three years, and the cultural biography approach will

be used to arrange the information (as well as that gathered during previous studies such as King, *et al*., (2011), Tipa *et al*. (2010), Stewart *et al*. (2011) into a particular framework that allows for its incorporation into the scenario process.

In a conventional catchment management scenario process there will be outcomes that are desired by the community across a range of social, economic and biophysical areas, and then a technical team will develop indicators that measure the state of those values so that outcomes for each scenario can be compared with the desired outcome. The CBP analysis is unlikely to develop quantitative indicators *per se* because this may not be appropriate in the context of presenting mātauranga Māori.

The approach proposed for the cultural biography is to identify key outcomes of interest (KOIs) based around the concepts developed in the [Outcomes] document developed by whānau and hapū. These include mahinga kai activities, management of wāhi tapu, and sustaining states of the catchment that support its mauri. It also includes protection for key taonga such as rock art. The KOIs will be narrative rather than quantitative, and will describe how context, practice and belief have evolved in relation to the KOIs.

It is intended that this process results in the KOIs being analogous to the quantitative biophysical, social and economic indicators used to reflect other values in the catchment. The intention in doing so is to facilitate the incorporation of Māori understandings and aspirations into the scenario processes whilst maintaining the integrity of the processes and people who have contributed to that knowledge.

4.2 Supporting information

The supporting information is intended to provide the contextual and ecosystem information that supports the Context and Practice apices of the IEK triangle. Typically, scenarios used in freshwater limit setting focus on particular biophysical outcomes – nutrient loads, periphyton growth, habitat availability etc. These in turn are driven by a smaller subset of drivers than set out in Figure 2 – for example, land use, intensity, other business activity, mitigations, policy settings etc. This narrower focus on a small range of drivers, although not always supported by whānau and hapū, is often justified based on the need to produce specific outputs within time and resource limitations.

While there will be resource and time limitations associated with the proposed Cultural Biography approach, there is still a need to develop a broader understanding of the structures that have driven the catchment and landscape changes. This must be handled carefully because the information needs can quickly multiply with a number of sites, periods and drivers.

The approach proposed here adapts from the Iceberg Metaphor structure (Figure 2) to the specific requirements of the freshwater limit setting process and the focus of the cultural biography on the CBP. We propose three parts:

1. the wider context,

2. the in-catchment context, and

3. the ecosystem state.

4.2.1 Wider Context

The wider context reflects the wider social and economic trends that affected the catchment, but are outside the influence of those in the catchment. These may include economic development and recessions, migration, wars and other conflicts, climatic changes, and political and regulatory changes that underlie some of the structural changes that occurred in the catchment. Of particular importance in this context are the various drivers for whānau, hapū and iwi including the wider cultural and demographic changes, Royal Commissions investigating the various struggles post European settlement, Court decisions, and agreements over time leading to Treaty settlements. Example information may include:

- Socio-economic conditions – wealth, unemployment, deprivation, war etc.
- Land sales, agreements,
- The reservation policies of the nineteenth century
- Settlement patterns and demography – movement in or out of catchment,
- Regulation and Policy – e.g., land purchases, ignoring agreements, encouragement/subsidy for development etc.
- Technology use in industrial and agricultural activities, for example, farming, dairy factories, meat processing, flax cultivation, flour milling etc.

It is anticipated that this information will be developed from a range of historical sources, will be reasonably high level, and will be presented in a narrative format.

4.2.2 In-catchment Context

This section will include any information we know or are able to derive about the state of the catchment at that time. It will describe land use patterns, practice and development; other discharges and impacts on water bodies (industrial, stockwater and town water takes and discharges) including:

- Land use – broad definitions
- Land practices – fertiliser use, cultivation, stocking rates etc.
- Land development activities – clearance, drainage, irrigation etc.
- Cultural uses derived from NZAA records and silent files held by whānau and hapū.
- Other discharges and impacts (e.g., factories, towns etc.)
- Economic indicators (model in development)
- Population and settlement patterns in the catchment, for both iwi and wider population.
- Any key activities and events.

Most of the information will be based on historical information available in the catchment, or interpolated from national statistics. Models will be developed to

determine key economic indicators from the indicators based on land use and other activity in the catchment.

4.2.3 Ecosystem State

The information on the state of the ecosystem will cover both the main contextual aspects of importance to whānau, hapū and iwi in relation to the KOIs, but also will attempt to provide quantitative indicators such as nutrient status, biotic indices such as MCI score, and hydrological regime. There will be some information available from historical sources as shown in Table 3, including traditional placenames, whakapapa and oral histories. .

Table 2: Data sources that could be accessed to understand the Ecosystem State

CULTURAL CONTEXT	DATA SOURCES
Whakapapa	• Whānau manuscripts • Iwi resource management plans • Māori Land Court Records • Whānau interviews
Te Taiao	• Original survey maps (e.g., Black maps) • Maps drawn by explorers • Journals of early explorers and surveyors • Examples of indigenous cartography • Past newspapers • Paintings (sourced from National Library) • Photographs (sourced from national and regional libraries) • Historic text • NZAA site records • Whānau interviews
Mahinga kai / resource base	• Cultural maps • Whānau manuscripts • Text from early ethnographers (e.g., Beattie) • Paintings (sourced from National Library) • Photographs (sourced from national and regional libraries) • NZAA site records • Whānau interviews

The proposed approach to describing the ecosystem state involves derivation of narrative and quantitative (indicator) values from mātauranga, quantitative modelling, and inferred estimates. This combination of indicators and narrative will describe the state of the freshwater resource (primarily biophysical and cultural aspects) across the timeline in a format that is compatible with the other scenario descriptions.

The key problem with developing quantitative indicators at this level of specificity for historic states of a catchment is the difficulty of working with models that are typically used in this context. Three main types of catchment nutrient models are mechanistic models, budgeting models or statistical methods. Mechanistic models are generally too complex and difficult to calibrate, and budgeting models which estimate inputs and outputs rely on unmeasured tranformations in the environment which can be problematic over an histocial time frame when there have been major changes in the catchment biophysical processes. Statistical methods use regression or machine learning techniques to fit an empirical model to observations of nutrient loads to a set of predictors that generally represent characteristics of the catchment including

topography, climate and land use. Restrictions on their ability to represent changing catchment conditions has limited their applicability (Elliott *et al.*, 2008), but statistical methods have been developed (Dodds & Oakes, 2004; McDowell *et al.*, 2012) to the point where it is a feasible to estimate contaminant loads and water quality measures at different times in a catchment's history. This is advantageous because a statistical model can be developed for the whole country, and is quicker and easier to apply than the mechanistic or budgeting model approaches.

As proof of concept, within the Ngā Kete o Te Wānanga research programme LWP (Snelder *et al.*, 2016) has used the concept of estimating loads using indicators of anthropogenic pressure to develop a statistical model of nutrient loads. This work is consistent with previous work that has developed statistical models of other ecological and water quality indicators. The models developed by LWP provide estimates of current nutrient loads and pre-European loads in New Zealand that could be used at a range of spatial scales. The model will be further developed to allow estimates of loads at intervening (between pre-European and current) periods in history. The national scale of those models would allow them to be used to support the approach to Cultural Biography nationally.

LWP has further investigated other statistical models that may be applicable for other ecosystem characteristics in the same circumstances. Potential indicators and model approaches identified include:

- N and P loads – based on the Snelder reference state model (see below) together with land use information.
- *E. coli* concentrations, and water clarity measures – use of existing models together with land use information.
- Macroinvertebrate Community Index (MCI) – use of existing model together with land use information.
- Wetlands – based on interpolation from DOC reference state estimates. Supplemented by local and oral history on wetlands, drainage and changes in the river flows and morphology.
- Fish populations – use of existing models together with land use and other (water resource use) information
- Flow regimes – use of existing models, current flow data and narrative descriptions based on any climate and water resource use information. Supplemented by local and oral history.
- Sediment – based on existing models and likely impact of land use and land use change around the reference point.

These are described in more detail in Table .

Table 3: Ecosystems State Indicators and proposed modelling approaches

Indicator	Model type	Inputs required from Cultural Biography	Source
N and P loads	Statistical – multivariate regression random forest	Estimates of intensive agriculture	Snelder, Larned, & McDowell, 2016
Various water quality measures including nutrient concentrations, visual clarity, and *E.coli.*			Reference State - McDowell, R.W., T.H. Snelder, N. Cox, D.J. Booker, and R.J. Wilcock, 2013. Establishment of Reference or Baseline Conditions of Chemical Indicators in New Zealand Streams and Rivers Relative to Present Conditions. Marine and Freshwater Research 64:387–400. Current state (for calibration) - Unwin, M., T. Snelder, D. Booker, D. Ballantine, and J. Lessard, 2010. Predicting Water Quality in New Zealand Rivers from Catchment-Scale Physical, Hydrological and Land Cover Descriptors Using Random Forest Models. NIWA Client Report: CHC2010-0.
MCI	Statistical – boosted regression tree and random forest	Agricultural land, urban land, surface water allocation	Clapcott, J.E., E. Goodwin, and T. Snelder, 2013. Predictive Models of Benthic Macroinvertebrate Metrics. Cawthron Institute Report, Cawthron Institute.
Fish	Statistical – machine learning Random Forest modelling.	Agricultural and urban land use, surface water resource use (including access restrictions), possibly also including introduction of exotic species (brown trout).	Crow SK, Booker DJ, Sykes JRE, Unwin M, Shankar U 2014. Predicting distributions of New Zealand freshwater fishes. NIWA Client Report CHC2014-145: 94 p.
Flow regimes	Statistical - multivariate regression random forest	Water resource use.	Snelder TH, Booker DJ 2013. Natural flow regime classifications are sensitive to definition procedures. River Research and Applications 29: 822-838 Booker, D. J., & Snelder, T. H. (2012). Comparing methods for estimating flow duration curves at ungauged sites. Journal of Hydrology. 434–435, 78–94
Wetland	Interpolation	Proportion of wetlands drained between prehistory - 2008	Gerbeaux, P. Department of Conservation, pers.comm. http://www.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Biodiversity/wetland-extent.aspx
Sediment	Qualitative	Land use, land clearance	

Ultimately, whānau will endeavour to "ground truth" the outputs of these models using NZAA records and matauranga Māori. Other sources that we will access to gain a fuller understanding of the beliefs and practices of Ngāi Tahu are outlined in Table 4.

Table 3: Data sources that could be accessed to understand the wider Cultural Context, Beliefs and Practices

CULTURAL CONTEXT, BELIEFS, PRACTICES	DATA SOURCES
Whakapapa	• Whānau manuscripts • Iwi resource management plans • Māori Land Court Records • Whānau interviews
Rangatiratanga	• Original Purchase Agreements • Māori Land Court minute books • Original land titles • Evidence submitted to hearings including Waitangi Tribunal • Petitions to Government • Findings of Royal Commissions • Legal descriptions for lands found in the New Zealand Gazette
Social – economic contexts	• Petitions to Government (found in AJHR) • Journals and reports of Government employees tasked with allocating reserves and assessing living conditions of Ngai Tahu • Evidence submitted to Royal Commissions and hearings including Waitangi Tribunal • Historic text • Whānau interviews

4.3 Reference Periods

The nature of a scenario and its description can vary from approach to approach in catchment management. For example, some approaches define a scenario as a state, and others regard it as an evolution of states of the catchment over time. The approach here is clearly intended to be an evolution over time, since the nature of a biography is to describe the evolution of a person or object over time. However, whilst the Cultural Biography is a narrative, in order to allow detail to be included in a coherent way, it is necessary to define some points in time in the evolution of the catchment. These arrange information for the participants in the decision-making process, and also allow states of the catchment to be fixed for modelling purposes – a land use, flow regime etc. can be defined and used to model various indicators.

We have adopted the term 'reference periods' to describe the points we will refer to in the cultural biography. Care should be taken because the term 'reference' is used in different ways in scenario literature. Reference state is used by some biophysical scientists to refer to the 'original', i.e., pre-human or pre-European state of the catchment (e.g. Dodds & Oakes, 2004; McDowell *et al.*, 2012). In other scenario planning literature (e.g., Vitel C. , *et al*., 2013) 'reference' is used to describe a future state against which other scenarios should be compared. In each case however the term *reference* is used to describe a point of comparison, and in this sense the use of the terminology *reference periods* is consistent.

The use of reference periods reflects the approach used in the landscape literature in relation to cultural biography approach. For example, Antrop (2005) describes three periods in European history that differ markedly in their impacts on the cultural landscape. The novel approach here is to use more clearly differentiated and narrower time periods, which allows for the development of more specific biophysical information, but risks disrupting the narrative of the catchment. The utility of using reference periods in this way will need to be observed through the cultural biography development process and the positives and negatives should be considered as part of the evaluation phase.

The reference periods that have been agreed with Ngāi Tahu are chosen to represent key illustrative times in the history of the catchment. They are:

- Pre-European – the 1700s on a broad scale have been chosen, representing a time after the successive waves of Māori settlement but before substantial contact with Europeans began in the last decade of the 18th century. It represents a period of stable and established pre-European Māori community life.
- Land alienation and clearance – the period from 1860 to 1880 saw the major runs in the catchment taken up by European settlers, and clearance of forest and scrub to make way for pasture. The start of the period coincides with the increased recognition of Arowhenua Pā as a Māori settlement, the establishment of Temuka, imposition of reserves in the catchment including Arowhenua, Waipopo, Orari, and Ruakapuka Waitarakao. The period culminates with the recording by H.K. Taiaroa of mahinga kai sites across the central South Island, and so represents an important written recording point in Māori catchment history.
- Wartime food dependency – the period during World War II was one of considerable hardship for Māori who were not eligible for welfare and suffered under the rationing regime, and whose men had gone to war. Many Māori returned to the catchment, and traditional food gathering supported their nutrition over this period. The period also predates the major flood control schemes in the catchment.
- Recent memory – pre dairy boom. The irrigation and dairy boom in the Orari-Opihi catchment commenced in the 1990s, but increased significantly from ~2000 onward with the (then) high payout above $5/kgMS. The period 1980 to mid-1990s also predates the development of the Opuha dam (commissioned 1998), which resulted in other significant land use and flow changes in the catchment, so represents a useful point of comparison.

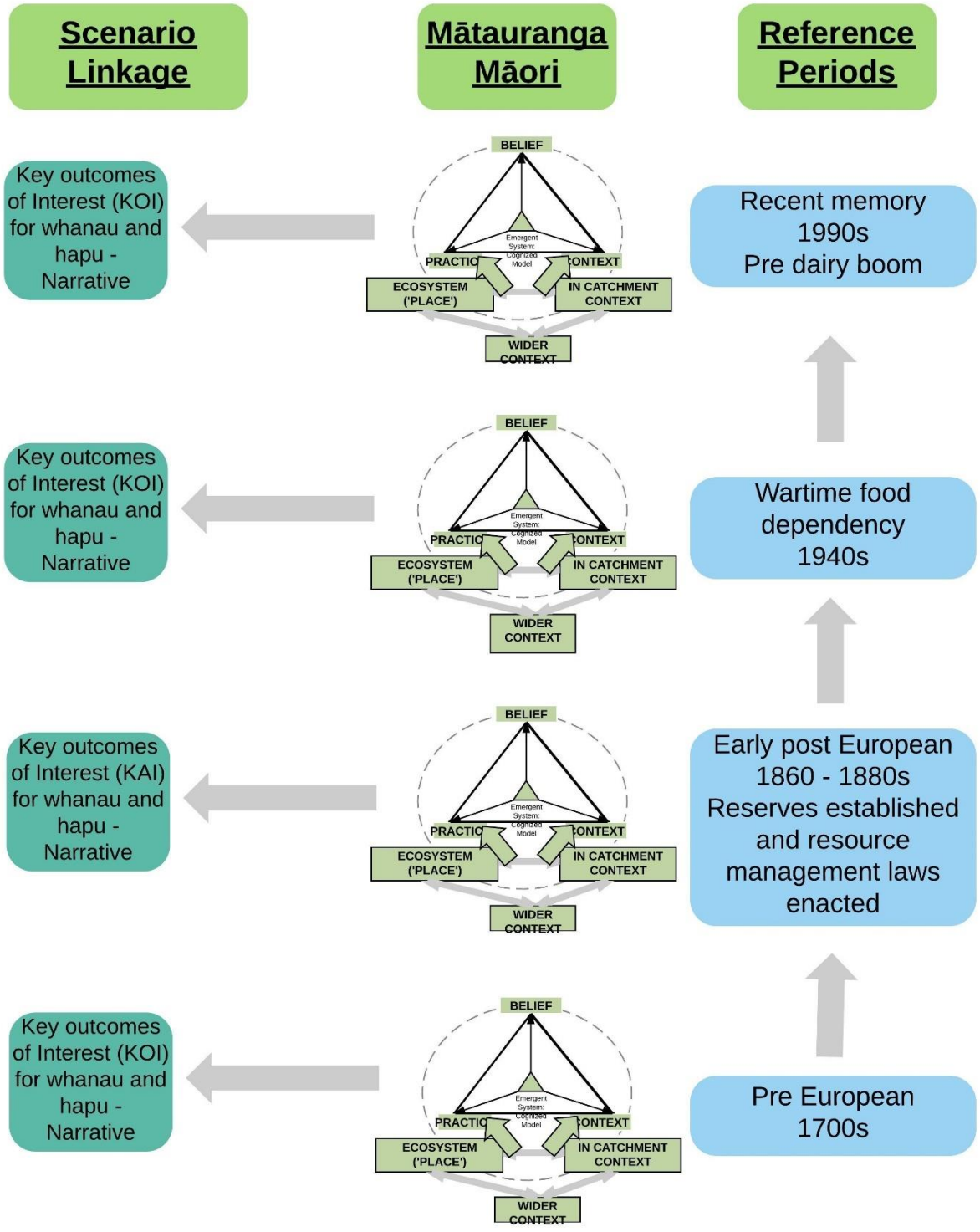
4.4 Constructing a Cultural Biography

The Cultural Biography is the story of how values of importance to whānau, hapu and iwi have changed over time, and how these have been influenced by changes in the catchment and wider environment. The elements of the Cultural Biography are shown in Figure 5. For each of the reference periods in the catchment history (right hand side of the diagram) a focused assessment of the context (wider context, in-catchment context, and ecosystem state) utilising mātauranga will be undertaken, and this will be used as context for the beliefs and practices of whānau, hapū and iwi at that time. The mātauranga-based assessment will be used to describe how KOIs, which are those areas whānau and hapū have targeted within their desired outcomes for the catchment, have changed over time.

The outputs of the Cultural Biography will be primarily narrative, but there will also be a set of quantified indicators based on the context and modelling that are able to be aligned with

indicators used elsewhere in the western focused biophysical, economic and social assessments.

Figure 5: Proposed structure for a Cultural Biography



The development of this approach is experimental because while there are a range of examples where landscape or cultural biographies have been developed, or where IEK has been used to provide input into planning processes, there does not appear to have been a previous example of the concept of cultural biography applied in a comprehensive way in the IEK sphere. There is therefore no certainty that the Cultural Biography approach is feasible, as there are a range of obstacles in collating information across the multiple disciplines, as well as the intersections between mātauranga and western sciences approaches that will need to be developed as the project proceeds. Furthermore resources are limited for what is potentially an ambitious project. The initial approach on the Opihi River should therefore be seen as proof of concept. The interactions between information sources, models and mātauranga will be refined as the project proceeds, and choices will be made along the way about the range of indicators and outcomes that can be included.

It is expected that there will be substantial gaps in the information available, and these should not be seen as limitations of the approach since the value of the Cultural Biography rests on the overall narrative rather than its individual components. It is also expected that there will need to be considerable resort to qualitative and inferred information in a number of cases because of the lack of detailed underlying data.

These caveats are not unexpected in a research project, and there will need to be a consideration of how the information is used within the overall freshwater limit setting process to understand which parts of the approach have value and should be expanded, and which parts provide little gain for the additional effort involved.

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6 Glossary of Te Reo Māori and terms used in this report

Ahi kā	Burning fires of occupation - title to land through occupation by a group, generally over a long period of time. The group is able, through the use of Burning fires of occupation. Title to land through occupation by a group, generally over a long period of time
Conceptual model	A conceptual model is a model made of the composition of concepts, which are used to help people know, understand, or simulate a subject the model represents
Explorative scenarios	Scenarios that explore potential future states based on a range of different drivers, both internal and external. They are used to describe a range of possible states and are not intended to be predictive
Hapū	Māori sub-tribe
Hui	Gathering, meeting
Iwi	Māori tribal group
Kaihaukai	A term that describes the sharing and exchanging of traditional foods - an important customary practice for Māori
Kaitiaki	Guardians
Kaitiakitanga	The exercise of customary custodianship usually by those who hold mana whenua status for a particular area or resource. Encompasses the management, use and nurturing of environments in ways that protect mauri while supporting the cultural health of tāngata whenua
Kākahi	Freshwater mussel
Ki Uta Ki Tai	Refers to the passage of waters from their source, through a network of tributaries onto lower floodplains, to the interface with the coast and out to the sea. This concept is used by Māori to describe their holistic understanding of aquatic ecosystems and how the health and wellbeing of the people is intrinsically linked to that of the natural environment
Kōura	Freshwater crayfish
Mahinga kai	Places where foods are procured and/or produced
Mana whenua	People with customary authority over land
Manaakitanga	Hospitality, show kindness and respect to, look after
Māori	Indigenous people of Āotearoa-New Zealand
Marae	Sacred meeting place, courtyard in front of the wharenui (meeting house)
Mātauranga	Is a holistic perspective encompassing all aspects of knowledge and seeks to understand the relationships between all component parts and their interconnections to gain an understanding of the whole system. It is based on its own principles, frameworks, classification systems, explanations and terminology. Mātauranga Māori is a dynamic and evolving knowledge system and has both qualitative and quantitative aspects

Mauri	Essential life force or principle, a quality inherent in all things both animate and inanimate
MBIE	Ministry of Business, Innovation and Employment
Ngāi Tahu	The principal Māori iwi (tribe) of the southern region of Āotearoa-New Zealand, with its tribal authority, Te Rūnanga o *Ngāi Tahu*
Normative scenarios	These types of scenarios aim to assess how a particular state can be achieved, or a particular threat avoided. Examples might be the achievement of a specific water quality state
NPS-FM	National Policy Statement – Freshwater Management 2014
Rangatiratanga	Leadership, right to exercise authority, chiefly autonomy, self-determination, self-management, ability to lead, ownership
Reference scenarios	These types of scenarios aim to assess "what is expected to happen". Examples include forecasts and 'what-if' analyses. These types of scenarios aim to provide realistic assessments (predictions) of probable future states
RMA	Resource Management Act
Rūnanga	The governing council or administrative group of a hapū or iwi, traditional Māori assembly or tribal gathering
Scenarios	Scenarios are a communication tool that allows different stakeholders to share their beliefs about how the system works or responds and how it may change in the future. Each scenario represents a potential state of a system, with the indicators of different stakeholder values reported so that stakeholders can see how their values of importance vary across a suite of scenarios.
Tāngata whenua	People of the land, locals, residents, people born of the whenua.
Taonga	Goods, possessions, effects, treasure, gifts, something prized.
Te Reo	Māori language
Te Taiao	The environment
Tikanga	Correct procedure, protocol, custom, habit, lore, method, manner, rule, code
Tuna	Freshwater eels
Turangawaewae	A place to stand, home ground, place where one has rights of residence and belonging through kinship and whakapapa
Wāhi tapu	Spiritual places of significance to tāngata whenua
Wāhi taonga	Places of significance to tāngata whenua
Wāhi tupuna	Places that are important to Māori for their ancestral significance and their associated cultural and traditional values
Wai tapu	Wai tapu represent the places where rituals and ceremonies are performed. Rituals and ceremonies include, but are not limited to, tohi (baptism), karakia (prayer), waerea (protective incantation), whakatapu (placing of raahui), whakanoa (removal of raahui), and tuku iho (gifting of knowledge and resources for future generations)
Whakapapa	Genealogical connection, relationships within and between species and relationships among phenomena of different kinds
Whakataukī	Proverb, where that the person who first said it first is not known

Whānau	Families

Appendix A Nutrient model description

The nutrient model that estimates N and P loads and concentrations (Snelder, Larned, & McDowell, 2016) uses a national dataset of monthly or quarterly observations of nutrient concentrations at approximately 750 river sites across New Zealand for durations between five to 25 years. It estimates loads of four nutrient indicators: total nitrogen (TN), total phosphorus (TP) and the inorganic dissolved components, nitrate nitrogen (NO3-N) and dissolved reactive phosphorus (DRP).

The model uses the digital drainage network (Snelder & Biggs, 2002) to represent catchment spatially, and four categories of predictor variables were derived from associated spatial databases:

- The topographic characteristics, mean catchment slope and elevation, were evaluated from the DEM.
- Catchment land cover of catchments was derived from the national Land Cover Database-3 (LCDB3) which differentiates 33 categories based on analysis of satellite imagery from 2008 (lris.scinfo.org.nz).
- Catchment geology was derived from the Land Resources Inventory (LRI).
- Climatic attributes describing aspects of temperature and rainfall were derived from climate records.

Catchments were then classified using a modified River Environment Classification (REC) approach which described eight categories of catchment (see Table). The modelling then developed a statistical model (random forest) based on the predictor variables to estimate the N and P loads for each modified REC class.

Plots indicated strong relationships between the amount of intensive agriculture upstream of a site (usIntensiveAg) and the transformed yields for most nutrient species and modified REC classes (Figure). The usIntensiveAg gradient was poorly represented for some of the combinations of modified REC class and nutrient species. For example, the CW/M and CX/H classes had no sites with high values of usIntensiveAg and the CD/L class had few sites with low values of usIntensiveAg (Figure). While there were mostly positive relationships between usIntensiveAg and the yields, there was considerable scatter and significant variability in the yield at low values of usIntensiveAg (Figure).

Table 1. Original REC classification levels, categories, and notation. Some classes with low occupancy were merged with environmentally adjacent classes as described in the text.

Defining characteristic	Categories	Notation	Category membership criteria
Climate ($10^3 – 10^4$ km^2)	Warm-extremely-wet	WX	Warm: mean annual temperature ≥12°C
	Warm-wet	WW	Cool: mean annual temperature < 12°C
	Warm-dry	WD	Extremely Wet: mean annual effective
	Cool-extremely-wet	CX	precipitation[1]≥1500 mm
	Cool-wet	CW	Wet: mean annual effective precipitation > 500
	Cool-dry	CD	and < 1500 mm
			Dry: mean annual effective precipitation ≤500mm
Topography ($10^2 – 10^3$ km^2)	Glacial-mountain	GM	GM: M and % permanent ice > 1.5%
	Mountain	M	M: > 50% annual rainfall volume above 1000m ASL
	Hill	H	H: 50% rainfall volume between 400 and 1000m
	Low-elevation	L	ASL
	Lake	Lk	L: 50% rainfall below 400 m ASL
			Lk: Lake influence index[2]> 0.033

1. Effective precipitation = annual rainfall – annual potential evapotranspiration

2. See Snelder and Biggs (2002) for a description.

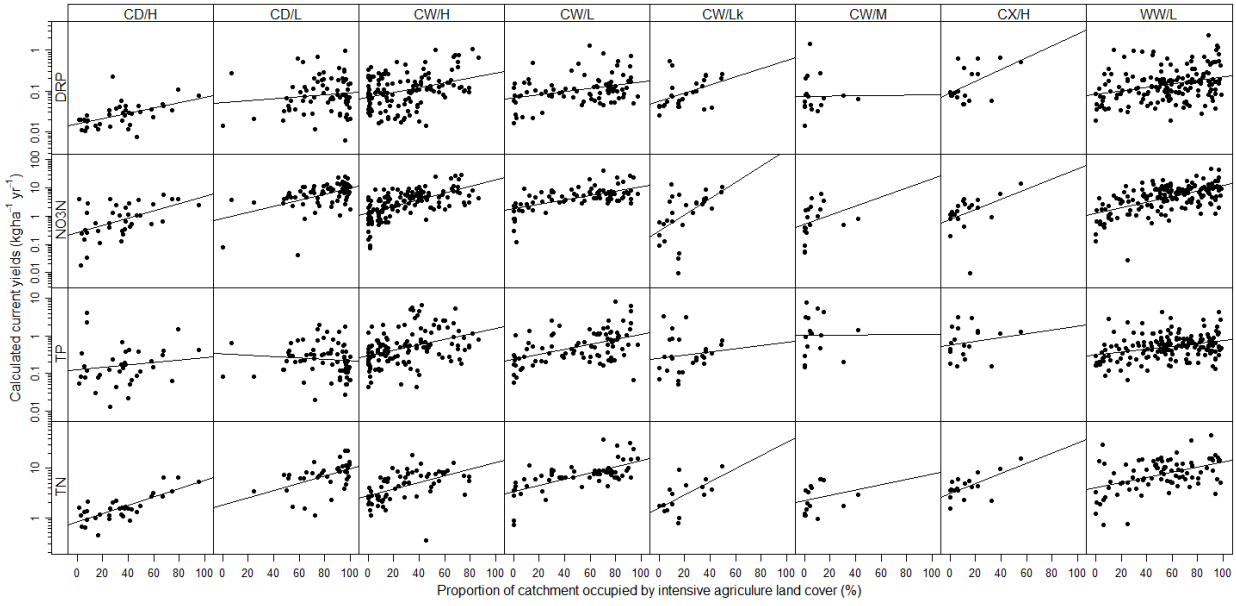

Figure 1. Relationship between nutrient yields and usIntensiveAg within modified REC classes.

The reduced ANCOVA models of the TN and NO_3-N yield explained 55% and 47% of the between-sites variation, and explained 24% and 25% of the variation in TP and DRP yield between sites. While there remains significant unexplained variability in the loads, the model is appropriate for use as a broad scale estimate of the likely response of N loads in a

catchment to increased intensification in the catchment. Less of the P loads are explained, but all modelling approaches have significant difficulty with predicting P loads, and the modelling is therefore likely to be appropriate as an 'indicative estimate' of P loads. It should be noted that the approach proposed may require some quantitative or qualitative adaptation of the model to reflect issues that the model is not able to reflect, such as changes in land use practice and intensity, and the impact of other discharges (e.g., meat processing discharges). The extent to which these additional items are incorporated quantitatively or qualitatively will need to be determined at the next stage of the project.