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Appendix A : Curricula vitae
Executive summary

This report provides a review of the draft National Policy Statement on Freshwater Management (NPS-FM) and the implications of the proposed changes for the upper reach of the Waikato River (Upper Waikato River) in which the Waikato Hydro-electric Scheme (WHS) is situated. Each of the hydro lakes formed from damming of the Waikato River are unique in terms of total storage, morphology, bathymetry and hydrodynamic behaviour. The Upper Waikato River therefore represents a situation in terms of New Zealand’s lake, river and stream habitats that does not fit neatly into a NPS-FM freshwater body type to which the various attributes in the NPS-FM apply.

The presence of the WHS and its characteristics has been recognised by the Waikato River Authority as the existing environment in its long-term planning to improve the health and wellbeing of the Waikato River.

The health and wellbeing of the Waikato River has been more recently considered through Waikato Regional Council’s Proposed Plan Change 1 (Healthy Rivers/Wai Ora, PC1) that sought to implement the current National Policy Statement on Freshwater Management (2017 NPS-FM) and the Vision and Strategy for the Waikato River (Vision and Strategy). This has involved a significant body of supporting science, which is relevant to our assessment of this NPS-FM.

PC1 has proposed long term objectives for four key contaminants, being nitrogen, phosphorus, sediment and microbial pathogens at sites on the Waikato River main stem and on its tributaries. Those long term objectives reflect the desired water quality to meet the Vision and Strategy while recognising the presence of the WHS and its relative influence on water quality, and we have supported this approach. The draft NPS-FM in its current form will require all regional councils to revise their plans to give effect to it and apply its attributes. How this will happen is unclear and is potentially different from the approach taken through PC1. Therefore some of the progress made through that process may be compromised through the adoption of the NPS-FM as proposed.

The draft NPS-FM includes a new definition of ecosystem health that includes five biophysical components and that a healthy freshwater ecosystem is one that can sustain indigenous aquatic life as would be found in a minimally disturbed condition. Linked to this is the addition of several new attributes, with the entire suite being compulsory and including bottom lines. The Action for healthy waterways document (MfE, 2019) discusses adaptive management (through an action plan approach) that will apply to some attributes.

The key differences in the proposed definition of ecosystem health relative to NPS-FM 2017 are the need to manage all five ecosystems components and to achieve a minimally disturbed condition. This is a much higher environmental bar relative to the 2017 NPS-FM (and followed by PC1) that describes a healthy ecosystem as one where ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change. It is also inconsistent with the Freshwater Science and Technical Advisory Group’s (STAG) recommendations that recognised the five biophysical elements and aimed to protect and enhance an ecosystems health appropriate to that freshwater body type (STAG, 2019).

An acceptable solution that in our view would be practical and achieve the objectives sought from the NPS-FM would be the following:

- **Adopt the wording used by the STAG to assess ecosystems health where** the five biophysical components contribute to freshwater ecosystem health, all of which are necessary to consider when defining the health, and designing the management of a water body.
- **More effective implementation of the adaptive management approach recommended by the STAG and supported by work commissioned by MfE to support the draft NPS-FM through:**
– Moving a range of attributes to Appendix 2b to allow for adaptive management of those attributes where the science is less clear with respect to the bands and management responses.
– Making some attributes compulsory monitoring attributes as opposed to attributes with bands and bottom lines where more data are required to support band and bottom line assessments.
– Requiring action to address declining trends through an action plan that encompasses all attributes in an integrated manner.

The changes are, in our view, necessary standalone changes that are needed regardless of amendments made to any other section of the NPS FM (including the hydro scheme ‘exception’ discussed below).

The NPS-FM provides a limited ‘exception’ for selected hydro schemes, and this report discusses the role that this plays across several topic areas and attributes. In our opinion the hydro scheme ‘exception’ itself is not a sufficient or effective way to address the water quality matters raised in our review and discussed above. We consider that the exception should be retained and amended to clarify its application.
1 Introduction


Objectives of the package are to:

1. Stop further degradation of freshwater resources.
2. Reverse past damage to restore them to a healthy state within a generation (30 years).
3. Address water allocation issues having regard to all interests including Maori, existing and potential users.

Mercury NZ Ltd (Mercury) asked Tonkin & Taylor Ltd (T+T) to undertake a review of the draft NPS-FM with a view to making a submission on the proposed amendments.

1.1 Report scope

Our review is focussed on the proposed changes to the National Objectives Framework (NOF) including the changes to the compulsory values (NPS-FM Appendix 1A), the suite of attributes included in Appendices 2A and 2B and the supporting science. We assess the implications of the proposed changes for the Upper Waikato reach of the Waikato River occupied by the Waikato Hydro-electricity Scheme (WHS) from Taupo Gates to Karapiro Dam (Upper Waikato River).

1.2 Report structure

Our report is presented in five sections as follows:

Section 2: provides an overview of the Waikato Hydro-electricity Scheme (WHS), summarises the recent history of the WHS, how the Upper Waikato River has been considered in a regional planning context and how the WHS reservoirs fit within the NOF.

Section 3: discusses the compulsory values and in particular the proposed definition of ecosystem health, the proposed adaptive management approach and issues associated with implementation from an Upper Waikato River perspective.

Section 4: discusses the proposed suite of NOF attributes with a focus on attributes applicable or potentially applicable to the Upper Waikato River and associated issues.

Section 5: discusses the components of the Specific Requirements section of the NPS-FM that are relevant to the Upper Waikato River.

Section 6: discusses exceptions for large hydro schemes and naturally occurring processes.

1.3 Contributing authors

This report has been prepared by Dean Miller (Principal Freshwater Scientist) and Peter Cochrane (Principal Environmental Scientist). Curricula vitae for the contributing authors are provided in Appendix A.
2 Waikato Hydro-electricity Scheme

2.1 Overview

The cascading hydro reservoir system in the Upper Waikato River comprises the “Upper Waikato Freshwater Management Unit (FMU)” in Waikato Regional Council’s proposed Plan Change 1 (PC1). The bulk of the water storage for the WHS is in Lake Taupo (93%), with combined storage of 7% within the eight cascading reservoirs. The dams and weirs making up the system take advantage of the approximately 330 m of fall between Taupo and Cambridge. The WHS is authorised by resource consents that expire 2041.

Each of the reservoirs is unique in terms of total storage, morphology, bathymetry and hydrodynamic behaviour. The tailrace of each of the eight dams comprises the upper reach or riverine zone for the next reservoir and each reservoir broadly comprises three longitudinal zones:

- Riverine zone – upper reach with a narrow basin and comparatively high flow.
- Transitional zone – broader deeper basin with reduced flow velocities.
- Lacustrine zone – a deeper lake-like zone with little flow velocity.

The Upper Waikato River therefore represents a situation in terms of New Zealand’s lake, river and stream habitats that does not fit neatly into the NPS-FM’s “Freshwater Body Type” categories to which the various NOF attributes apply (Appendices 2A and 2B of NPS-FM). The heavily modified nature of the Upper Waikato River overall and river to lake zonation pattern for each of the reservoirs result in significant uncertainty in terms of where and how the existing and proposed NOF attributes should be applied. This uncertainty has been present through the various iterations of NPS-FM to date, but is made more complex by the new attributes proposed and is particularly problematic for the proposed Appendix 2A attributes (for which it is compulsory to develop target states and associated resource use limits).

2.2 The history of upper Waikato River regime changes

The draft NPS-FM 2019 has introduced a new definition of ecosystem health, which we discuss in more detail in Section 3.1. The new definition relates a healthy ecosystem “as would be found in a minimally disturbed condition”, and this is reflected in several of the attributes. This raises the key question of what is the “minimally disturbed state” reference state for the Upper Waikato River in the context of the NPS-FM?

To address the above question it is useful to first briefly summarise the history of human modification to the flow regime and morphology of the upper Waikato River and to water levels in Lake Taupo. This is covered in detail in McConchie (2001) and summarised in the following paragraphs.

Arapuni was the first of the large hydro dams (and reservoirs) to be constructed and was operational from 1929. The next major development was the installation of the gates on Lake Taupo (1941). Lake Taupo has been managed in different ways since 1941 which has resulted in different patterns of water level change and variation in the outflows to the Waikato River. Four obvious regimes stand out (McConchie, 2001):

1 The uncontrolled lake (July 1905-August 1941): Spans the period from when regular monitoring of Lake Taupo levels first started, includes the construction of Arapuni Dam and extends to the commissioning of the control gates in 1941. At this time Lake Taupo was uncontrolled and the range over which it fluctuated during these 36 years.

2 War years (September 1941-November 1945): Covers the period during the Second World War, immediately following commissioning of the Taupo gates, when levels were held close to
the top of the natural level. At this time there were severe electricity shortages over the whole country. Taupo was held high over this period because of fears that Arapuni, which was the only station on the river, might not have enough water to generate. This strategy led to a persistent misunderstanding that the lake level was permanently raised above its natural level when the gates were commissioned.

3 Post war years – pre Tongariro Power Development (TPD) diversions (December 1945-January 1971): A period when Taupo was no longer being held deliberately high for prolonged periods, up until the commissioning of the western diversion of the TPD. The remainder of the dams and reservoirs of the WHS were constructed over this period.

4 Post TPD diversions (February 1971-present): The western diversion and Wairehu canal were commissioned in February 1971 and brought additional water from the headwaters of the Whanganui River into Lake Taupo. The eastern diversion of the TPD was commissioned in October 1979.

The changes to the morphology and flow regime on the Waikato River are not just because of one phase of construction or hydrological management. Rather the present regime is the result of significant incremental changes over a period of 50 years. The more or less final WHS has been in place for almost 50 years and since 1980 (after completion of the TPD diversions) the hydrological regime has remained largely unchanged.

The cascade of dams has transformed the relatively steep natural river valley and channel system into contiguous, long, narrow reservoirs in the flooded river valley. The only remaining section of relatively unmodified river between Taupo and Cambridge is between Aratiatia and the headwaters of Lake Ohakuri. It is also no longer possible to compare the current flow regime with the natural flow regime because of the effect of the TPD which increased the inflow into Lake Taupo by 25 % and the flow at Karapiro by around 20 %.

2.3 WHS resource consents and regional context

Environmental effects, including the effects of the scheme on the Waikato River were comprehensively assessed through the resource consent process for the WHS. The application was considered by independent hearing commissioners who concluded that the WHS met the statutory tests applicable to the consent application having considered the environmental effects of the operation of the WHS as well as the overall benefits of the hydro-electric scheme. Resource consents were granted to Mighty River Power (now Mercury) for a 35 year duration in May 2006 and expire in 2041. Consent conditions include water level controls and requirements for ongoing monitoring and regular consent condition reviews.

The overall Waikato River catchment was further considered in detail only a few years later as part of the Waikato River Independent Scoping Study (NIWA, 2010). The overall objective was to provide a sound and objective basis on which to make decision on priority actions to restore and protect the health and wellbeing of the Waikato River (to implement the Vision and Strategy for the Waikato River, 2008 (Vision & Strategy)). The influence of the WHS on the health and wellbeing of the Waikato River was considered specifically in Appendix 23. The overall conclusion was again that the benefits of the WHS outweigh the impacts and that monitoring of any impacts is an obligation under the conditions of consent. An important point that is recognised in the Study’s recommendations is that the removal of the dams would not restore the river to its original state.

The health and wellbeing of the Waikato River catchment, including the WHS, has been more recently considered through Waikato Regional Council’s Proposed Plan Change 1 (Healthy

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1 The WHS also plays a significant part in the management of high flows in the scheme to assist with the management of flood hazard in the Waikato River catchment. This is by collaborative agreement between Mercury, Genesis Energy (as operator of the Tongariro Power Scheme) and the Waikato Regional Council.
Rivers/Wai Ora, hereafter PC1) process that seeks to implement the NPS-FM and the Vision & Strategy. PC1 has a high level objective to achieve rivers that have improved water quality and are safe for food gathering along their entire length. PC1 involved extensive stakeholder and kaitiaki consultation and a significant body of supporting science. PC1 takes a long-term approach to its objective with water quality objectives/targets set over an 80 year timeframe. PC1 has focused on four contaminants, nitrogen, phosphorus, sediment and Escherichia coli, and on mitigating inputs of those contaminants at source. A decision on PC1 is pending.

The Upper Waikato River and associated tributary systems form the “Upper Waikato” FMU in PC1. Throughout the PC1 process the WHS, its cascade of reservoirs and its operating regime was considered as the existing environment and water quality objectives/targets set accordingly. The long-term numerical water quality objectives/targets for the Waikato River main stem were set on the basis of mitigation scenario modelling that considered the attenuation of nutrients, sediment and E. coli within the reservoirs. The selected scenario (Scenario 1) was considered to lead to water quality approaching a pre-development land cover (1863) scenario, albeit with the WHS in place.

Existing nutrient attributes within the NPS-FM cover three freshwater body types: Lakes, rivers and lake-fed rivers. There is explicit recognition in the NPS-FM that these different water body types will have different suites of attributes. All three freshwater body types are present between Taupo Gates and Port Waikato.

In terms of attribute development for PC1, an Expert Panel reviewed attributes contained in the NPS-FM and assessed how they might be applied to the Waikato-Waipa catchment. Where appropriate the water body type of these attributes was modified to improve its relevance. For example, the entire 336 km reach of the Waikato River from Taupo to Port Waikato was considered a “lake-fed river” on the basis of Lake Taupo and the hydro lakes and NPS-FM “Lake” attributes of total nitrogen (TN), total phosphorus (TP) and chlorophyll a (Chl a) were applied to the full reach. We note that several alternatives to the NPS-FM lake numeric attributes were proposed to identify numeric objectives/targets by the PC1 expert conferencing group.

Overall, from a regional perspective the WHS has been consistently considered as the existing environment for the purposes of long-term planning to improve the health and wellbeing of the Waikato River. The presence of the WHS has meant that flexibility in the application of NPS-FM attributes was necessary. PC1 has taken a “minimally disturbed condition” approach to setting long term water quality objectives for the Waikato River main stem but has not extended this to water quantity or the other components of ecosystem health.

2.4 Hydro reservoirs within the NPS-FM framework

As mentioned above the WHS reservoirs do not fit neatly within the NPS-FM freshwater body type categories, although “lake” attributes have been applied in PC1. Lake attributes (TN, TP and Phytoplankton (measured as Chl a)) have been included in the NOF since 2014 and have remained largely unchanged. The work that informed the original 2014 NOF tables included some consideration of hydro reservoirs and this consideration is summarised below.

In September 2012, NIWA produced a document titled “Classification and objective bands for monitored lakes” (Verburg, 2012). This document sorted monitored lakes into proposed classes and bands. In August 2012 a science panel made suggestions for a NOF for lakes. There is limited monitoring information on lakes in New Zealand and Verburg’s (2012) review was based on data from 118 lakes only, including four of the main hydro lakes on the Waikato River that make up part of the WHS; Ohakuri, Whakamaru, Waipapa and Karapiro. Although river monitoring data from tail race sites (rather from the reservoirs themselves) were used for those hydro-lakes.

All lakes in New Zealand were considered to fall into five different classes and within each class, four bands describe water quality status, ranging from excellent to unacceptable. Verburg (2012) did not
specifically state how these classes and bands were determined. Our review of wider lake literature identified that the Chl a annual median and TP breakpoints are consistent with the “Protocol for Monitoring Trophic Levels of New Zealand Lakes and Reservoirs” (Burns and Bryers, 2000). It is not explicitly clear how the TN attribute thresholds were derived.

The review undertaken in Verburg (2012) noted that the objectives for the different bands should be valid for natural lakes that are used for hydro-generation, such as lakes Taupo and Manapouri. However, the band’s objectives were not considered valid for developed hydro lakes, for example, lakes Benmore (in the Clutha Hydro Scheme) and Karapiro. The August 2012 science panel noted that developed hydro-lakes should have specific objectives. However, these were not determined.

The idea that hydrologically altered catchments, like the upper Waikato River, should be accommodated in the NOF is not a new concept and was further discussed in some detail in the NOF Reference Group report of October 2012, including a recommendation that the framework needs to include a clear definition of “hydrologically altered catchment”. However, this has not been progressed.

In summary, a significant body of work has been completed at a regional level to understand and account for the characteristics of the Upper Waikato River within PC1 to achieve the outcomes sought by the community Waikato River Iwi through the Vision and Strategy and within the framework set out by the NPS-FM and the 2014 NOF framework. It is our view that the 2019 NPS-FM should continue to take an approach that allows regional councils to reflect the particular characteristics of a catchment, including the permanency of the WHS in the case of the Upper Waikato River.

Introduction of the 2019 NPS-FM in its current form will require all regional councils to revise their plans to give effect to it. In the case of Waikato Regional Council it will need to assess if PC1 is consistent with it or whether it will need to revisit its plan. How attributes are to be applied to hydro schemes in the NPS-FM is unclear and should be clarified, where possible in a manner that does not undermine existing approaches that have been supported by consultation and science – as is the case for PC1.
3 Compulsory values (NPS-FM Appendix 1A)

This section we discuss the compulsory values with a focus on ecosystem health and with specific reference to the Upper Waikato River.

3.1 Ecosystem health

The draft NPS-FM includes a new definition of ecosystem health that introduces the concept that there are five biophysical components that should be managed. Linked to this is the addition of several new attributes, with the entire suite being compulsory and including bottom lines. The Action for healthy waterways document (MfE, 2019) discusses an adaptive management approach that will apply to some attributes. The adaptive management approach is in reference to the action plan approach to the attributes included in NPS-FM Appendix 2B.

3.1.1 Definition of ecosystem health

The key differences in the proposed definition of ecosystem health relative to NPS-FM 2017 are the inclusion of five biophysical components and the idea that a “healthy freshwater ecosystem” is one that can sustain indigenous aquatic life as would be found in a “minimally disturbed condition”.

The 2019 definition introduces five biophysical components that contribute to freshwater ecosystem health following the work of Clapcott et al. (2018). The components being aquatic life, habitat, water quality, water quantity and ecological processes. The work is comprehensive, robust and consideration of the five components provides a sound basis for adaptive management, which we discuss below. However, the way the five components were considered in the definition of ecosystem health by the Freshwater Science and Technical Advisory Group (STAG) in its 2019 report (STAG Report) differs to what has been proposed in the draft NPS-FM. The key differences are underlined below (our emphasis):

**STAG:** Five biophysical components contribute to freshwater ecosystem health, all of which are necessary to consider when defining the health of a water body and designing management interventions;...

**Draft NPS-FM:** There are 5 biophysical components that contribute to freshwater ecosystem health, and it is necessary that all of them are managed.

It is clear from the STAG Report that effort was applied to identify a suite of attributes that would cover each of the components. The STAG did not provide a view on which attributes would require management in terms of compulsory resource use limits (subsequently included in Appendix 2A) and which attributes would require action plans (subsequently included in Appendix 2B). In our view, the STAG Report wording is preferable because it allows for a more integrated approach when considering the five biophysical components and an overall objective for a waterbody. In comparison, we view the draft NPS-FM wording as potentially leading to management of components (and attributes) in isolation, regardless of the fact that management of a smaller number of components could result in the same overall outcome for freshwater ecosystem health. In our view the STAG Report wording is more consistent with an adaptive management approach (see below) and should replace that set out in the NPS-FM.

The proposed definition of ecosystem health in the draft NPS-FM places much more emphasis on achieving a “minimally disturbed condition” as the desired state (or A Band). Several of the new attributes refer to natural reference conditions or something similar in the narrative descriptions.
This is a much higher environmental bar relative to the 2017 NPS-FM which describes a healthy ecosystem as:

**NPS-FM 2017:** *In a healthy freshwater ecosystem ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change.*

In the case of the Upper Waikato River, the proposed definition is unclear. For the reasons set out in Section 2, the Upper Waikato River cannot reasonably be compared to a minimally disturbed condition for all five biophysical components in order to set objectives and attribute states. PC1 had arrived at a suitable “reference state” for water quality but this does not extend to water quantity, aquatic life, habitat or ecological process, all of which can only reflect the modified WHS regime.

Options and practical considerations for managing freshwater to achieve a reference condition, such as a minimally disturbed condition, are discussed in Schallenberg *et al.* (2011). The review notes that as all human (or human-mediated) influences can never be eliminated, the reference condition will never be achievable and may no longer be the optimal state to set as a goal for management or restoration. The Upper Waikato River case study is an example of this situation and demonstrates the need for regional discretion in establishing what a healthy ecosystem is for its waterbodies. In this respect the 2017 NPS-FM wording is preferable.

**Suggested amendments:**

- On the basis of our review we consider that the following definition of ecosystem health should be included in Appendix 1A clause 1 of the NPS-FM.

  *In relation to a waterbody in an FMU, ecosystem health refers to the extent to which the FMU supports an ecosystem appropriate to the type of waterbody (e.g., river, lake, wetland, or aquifer).*

  *Five biophysical components contribute to freshwater ecosystem health, all of which are necessary to consider when defining the health of a water body and designing management interventions and it is necessary that all of them are managed. They are:*

  - **Water quality** – the physical and chemical measures of the water, such as temperature, dissolved oxygen, pH, suspended sediment, nutrients and toxicants.
  - **Water quantity** – the extent and variability in the level or flow of water.
  - **Habitat** - the physical form, structure and extent of the waterbody, its bed, banks and margins, riparian vegetation and connections to the floodplain.
  - **Aquatic life** – the abundance and diversity of biota including microbes, invertebrates, plants, fish and birds.
  - **Ecological processes** – the interactions among biota and their physical and chemical environment such as primary production, decomposition, nutrient cycling and trophic connectivity.

  *In a healthy freshwater ecosystem, water quality, quantity, habitat and processes are suitable to sustain indigenous aquatic life, as appropriate to the type of waterbody as would be found in a minimally disturbed condition (before providing for other values).*

**3.1.2 Adaptive management**

We have reviewed Clapcott *et al.* (2018) and consider that the work to develop the framework is comprehensive but was landing at a point where the determination of ecosystem health was on the
basis of an overall score integrating all selected indicators (attributes in NPS-FM terms). The framework for biophysical ecosystem health is also considered as one part of an overall cycle of adaptive management, as shown on Figure 12 of Clapcott et al. (2018) and as included as Figure 3.1 below.

Figure 3.1: Figure 12 from Clapcott et al. (2018) showing the Framework for freshwater biophysical ecosystem health as part of an adaptive management cycle.

In our view the intent of the framework is for an overall integrated score, which is different from how the attributes are presented in the draft NPS-FM. We think that the way the NOF is presented with reference to the NPS-FM itself could mean that a single attribute may determine overall state, that attributes may be considered individually, and that an action plan may then be prepared for each attribute. This appears to be the intent as outlined in the Action for Healthy Waterways discussion document (MfE, 2019):

*We also propose that councils be required to measure and monitor a broader range of ecosystem health attributes. In the event the attribute declines, or is below a national bottom line, regional councils would implement an action plan to achieve improvement.*

In our view, the consideration of attributes in isolation is inconsistent with an adaptive management approach to achieving overall objectives for a freshwater body, and inconsistent with the way Clapcott et al. (2018) presents the biophysical ecosystem health framework. The focus on single attributes in isolation increases the risk that effort is applied to managing causes or drivers that are less important influencers of overall ecosystem health.

In our view, for adaptive management to be effective then Regional Councils should be able to consider the selected attributes for a freshwater body as a whole and within a single action plan. There are interactions between attributes that may be best considered as a whole, as opposed to individually, to determine the best intervention in a catchment to achieve an improvement in environmental outcomes (for water quality and ecological health). This is consistent with how territorial authorities address management of stormwater and receiving environment effects (e.g. Hamilton City Council; T+T, 2019) and the PC1 approach to sub-catchment planning.

We note that the STAG identified the following knowledge gap in respect of adaptive management (STAG, 2019):
**Nationally consistent methods for monitoring compulsory values, guidance on the design of systems for data generation and analysis** (including system design, data collection, storage and analysis, and reporting protocols), and applied science to describe what is required to lift ecosystem health to meet community objectives and support adaptive management.

We agree with this view and consider that there is a need for more flexibility at regional level in respect of attributes and adaptive management, which is demonstrated by WRC’s PC1 example. In terms of solutions we recommend that the NPS-FM wording is amended in clauses 3.10 and 3.14 to allow for a single action plan for an FMU or freshwater body as determined by a regional council. We also recommend that attributes are re-organised in Appendix 2, including the addition of a third group (compulsory monitoring attributes) where the science is less clear with respect to bands and management responses. We discuss the later point further in Section 4.

**Suggested amendments:**

- Seek that the wording in NPS-FM is amended in clauses 3.10 and 3.14 to allow for a single action plan for an FMU or freshwater body as determined by a regional council; and
- Seek that attributes are re-organised in Appendix 2, including the addition of a third group of compulsory monitoring attributes.

### 3.2 Human contact

Section 3.7 of the draft NPS-FM requires regional councils to describe the environmental outcomes it wants to achieve for several values including Human Contact. Section 2 of Appendix 1A goes on to explain what the Human Contact value is: the extent to which waterbodies in an FMU support people being able to connect with water through a range of activities in a range of different flows. It then sets out the matters that need to be taken into account which includes pathogens, clarity, deposited sediment, plant growth (including macrophytes and periphyton), cyanobacteria and other toxicants.

At this point it’s worth noting that only a few of these have attributes listed in Appendix 2 of the NPS-FM. Section 3.9 requires that every regional council must set an attribute state for each attribute and for Human Contact (Section 3.9(2)b)), each attribute must be **above** the current state.

We interpret this to mean that for a pathogen such as *E. coli*, a regional council will be obliged to improve on the current state, regardless of the current state or how it relates to the outcomes it sets out to achieve to meet the requirements of Section 2 of Appendix 1A. This potentially poses a greater issue for waterbodies where the risk to human health is low (such as the monitored sites along the main stem and hydro reservoirs in the Upper Waikato River) than those where the risk is higher (such as the tributaries).

Consequently, it appears that implementation of the NPS-FM will drive further reductions in *E. coli* levels in the Upper and Lower Waikato River. However, those FMUs already have relatively low *E. coli* current state and further reductions might (a) be difficult to achieve and (b) not result in the overall reduction in health risk sought.

While matters associated with water quality per se are covered in Section 4 of our report, we consider that a key outcome sought from Section 2 of Appendix 1A, are those that affect the physical experience of human contact. This outcome may conflict with the management of the hydro lakes for hydro electricity generation, particularly around the management of the growth of nuisance aquatic plants\(^2\), and or the exposure of other macrophytes or periphyton to water users (either directly or indirectly) as a result of managing the levels of the reservoirs.

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\(^2\) This matter is also discussed in Section 4.3.3.
At present these issues are partially recognised through Section 3.22 (the ‘exception’ for large hydro schemes). However, as the management of this particular issue would most likely affect the operational flexibility of the scheme and its generation potential it is important that Section 3.22 is retained and its application to such issues made explicit.

**Suggested amendments:**

- Retain and strengthen Section 3.22 to ensure that the management of the hydro lakes for hydro-electricity is not adversely affected by the management of attributes which may result in exposure of water users to nuisance aquatic plants, other macrophytes or periphyton.
4 NOF attributes

4.1 Introduction

In this section we discuss the issues associated with the application of the proposed suite of NOF attributes in Appendices 2A and 2B as they relate to the reach of the Upper Waikato River occupied by the WHS.

The following sections focus on the attributes where we consider the scale of the potential issues to be a “high” or “medium” risk with regard to the application of that attribute to the Upper Waikato River. We highlight the attributes that demonstrate the need for an exception and where there is ambiguity between freshwater body type in respect of a lake/river/lake fed river and with the monitoring methods. We also highlight where there are issues related to the determination of “minimally disturbed condition” (including alternative terminology such as reference state or natural state) with reference to the Upper Waikato River.

We signal where in our view the attribute as proposed would be best placed in Appendix 2B to allow for adaptive management as discussed in the previous section and where attributes are best suited to a separate approach in which “compulsory monitoring” is required instead.

4.2 Attributes requiring limits (Appendix 2A)

In this section we step through the attributes included in Appendix 2A. Regional councils must monitor these attributes and these attributes must be maintained or improved. Regional Councils must develop target states and identify resource use limits to achieve the target attribute state.

4.2.1 Phytoplankton – Table 1

The phytoplankton attribute (trophic state) remains un-changed from NPS-FM 2017. The freshwater body type is “Lakes”. The attribute band descriptions (to which the numerics are linked) refer to “lake ecological communities are healthy and resilient, similar to natural reference conditions” (A band) or “nutrient levels that are elevated above natural reference conditions” (B and C bands). As discussed earlier in this report there is no relevant “natural reference condition” for Upper Waikato River reservoir ecological communities and the general definition of ecosystem health as proposed is not appropriate. It had previously been concluded that the phytoplankton band objectives were not valid for developed hydro reservoirs such as Karapiro (Verburg, 2012). We agree with that view.

This attribute has been applied to the Waikato River main stem within the Upper Waikato FMU (and middle and lower) in PC1. This is on the basis that the river is lake fed and that phytoplankton (as measured by chlorophyll a) is relevant to visual clarity and the ecological values of the main river. The phytoplankton attribute in Table 1 of NPS-FM 2019 applies to Lakes as the freshwater body type.

Suggested amendment:

- Seek an amended definition for ecosystem health as set out in Section 3.1.1 of this report.
4.2.2 Total nitrogen and total phosphorus (trophic state) – Tables 3 and 4

The TN and TP attributes are unchanged from the NPS-FM 2017. The same comments are generally applicable as per the discussion for phytoplankton above.

Suggested amendments:
- Seek an amended definition for ecosystem health as set out in Section 3.1.1 of this report.

4.2.3 Dissolved nutrients – Tables 5 and 6

New Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorous (DRP) attributes are proposed (as recommended by the STAG) as new Tables 5 and 6, Schedule 2A, NPS-FM (respectively). The attributes apply to “Rivers” and are related to eutrophication (algal and plant growth) and associated ecological health issues.

Key points from the STAG’s rationale for the inclusion of DIN and DRP include a view that the current provisions for managing nutrients in rivers are insufficient for maintaining or improving ecosystem health in rivers in which there is no conspicuous periphyton (so will capture soft bottomed waterways). Reducing DIN and DRP will contribute to improvements in ecosystem health by potentially reducing the prevalence of macrophytes, organic matter processing, conspicuous and non-conspicuous periphyton, changes in trophic structure and function, assimilation efficiency, and changes in fish and invertebrate communities.

STAG has proposed a new bottom line for nitrogen in rivers at an annual median of 1.0 mg/L of DIN which is a different measure to the toxicity attribute. STAG proposes a bottom line for DRP in rivers at an annual median of 0.018 mg/L. Section 3.9 of the STAG report points to DRP as one such attribute where the natural levels of DRP can be high and therefore the national bottom line could be difficult to meet. STAG considered that areas where this is an issue is provided for as an exception under the allowance for “natural variability”, although we take this to actually mean “naturally occurring processes”.

The NPS-FM’s recommended attribute tables were developed based on regression relationships between nutrients and metrics of macroinvertebrates, fish, periphyton and ecosystem metabolism, which have been combined through a ‘multiple lines of evidence’ approach. This included Fish IBI and ecosystem metabolism which may be relevant to large rivers but most datasets appear to be from wadeable streams.

In this respect the proposed attributes appear to be potentially more relevant to wadeable streams. However, as described, the attributes could apply to larger, non-wadeable rivers that support macrophyte growth like the Upper Waikato River for example. The issue with the application of dissolved nutrient targets to the main stem is the direct conflict with TN and TP targets (which were determined as appropriate in PC1). For example, the national bottom line for TN is 0.75 mg/L whereas the proposed bottom line for DIN (a component of TN) is 1.0 mg/L. This illustrates the need for regional flexibility for determining which attributes are the most relevant to a particular freshwater body type and in particular the Upper Waikato River.

While regression analysis may suggest covariance of nutrients with a biological metric, it does not mean a causal relationship exists. Specific recent published research by WRC scientists (Pingram et al. 2019) has demonstrated that nutrients are a weak driver of ecosystem health indicators (macroinvertebrates and fish) in Waikato streams. Therefore, from a Waikato River tributary perspective we consider that the compulsory requirement to establish targets and associated resource use limits for DIN and DRP could potentially drive inappropriate mitigation and

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3 This is discussed in the context of an exception for naturally occurring processes in Section 6.2.
management from an ecological health perspective. In our view, the DIN and DRP attributes should be moved from Appendix 2A to Appendix 2B.

Finally, we note that the DIN and DRP attribute tables do not include the same recognition of sensitive downstream environments as per the periphyton attribute (and related nutrient limit setting requirement). This is where desired conditions in nutrient sensitive receiving environments, the Waikato River main stem for example, can drive nutrient targets in tributaries. This seems sensible to include given the rationale for inclusion of DIN and DRP in the NOF.

On the basis of the above we consider that the proposed DIN and DRP attributes provide a good example of why an exception is needed for hydro schemes. In addition to the Section 3.22 exception we recommend that the following clarifications and amendments are sought with respect to the dissolved nutrient attributes in NPS-FM 2019.

**Suggested amendments:**

- Seek that the Tables 5 and 6 be amended to refer to “wadeable streams and rivers” as the Freshwater Body Type to which the DIN and DRP attributes apply.
- Move the DIN and DRP attributes to Appendix 2B to allow for adaptive management.
- Seek amendments to NPS-FM to allow action plans to consider selected Appendix 2B attributes as a whole as opposed to individually.

### 4.2.4 Suspended fine sediment – Table 10

The draft NPS-FM includes an attribute for suspended fine sediment, measured as turbidity, and applies to “rivers and streams”. We are unclear as to why the specification of rivers and streams, when other attributes with limits refer to rivers only. This may not be of any consequence but should be clarified.

The attribute table is the same as proposed through the previous consultation (NOF Sediment Stage 3). The table notes are different and are of relevance as they set out some exceptions as to where the attribute applies.

#### 4.2.4.1 Background to the attribute

The proposed attribute includes bottom lines and bands setting out a range of ‘attribute states’, with a system for classifying rivers, reflecting that the natural levels of sediment in rivers varies widely across New Zealand. The attribute development process, which generally applied to both suspended fine sediment and deposited sediment (see later), broadly comprised:

- Development of a Sediment State Classification (SSC) for New Zealand rivers using River Environment Classification (REC) climate, topography and geology (CTG) variables and assessing the sediment state data for the various classifications.
- Development of reference state for the various classifications using a modelling approach.
- Development of bands for each of the SSC’s by relating the sediment data to paired ecological response data (fish for suspended fine sediment macroinvertebrates for deposited sediment). Available data were limited for this step.

In our view, the analysis supporting the numeric attribute bands has been somewhat hindered by the availability of the data that would be most suitable for the task, specifically attribute (sediment) data that are paired with ecological response data (macroinvertebrates and fish). The lack of data has necessitated some modelling approaches. There are also multiple layers of analysis and modelling in the attribute development process in general and there is uncertainty/potential for error at every step, which will aggregate through the process. This uncertainty has not been explicitly assessed and should be to better understand the certainty in the attribute state values.
Overall, it is our view that while the work has been rigorous, there is uncertainty and the process may have arrived at bottom line and attribute thresholds that are more refined than is practicable. For example, some of the bands have very narrow ranges and current levels of uncertainty could be a significant proportion of the bandwidth.

4.2.4.2 Where does it apply?

The “freshwater body type” to which the suspended fine sediment attribute generally applies is “Rivers and streams”, and is therefore potentially relevant to the Upper Waikato River. The table note states the attribute does not apply to some rivers and streams due to naturally occurring processes. Specifically in Note 3 attribute does not apply to:

“Selected lake-fed REC classes (particularly warm climate classes) where high turbidity may reflect autochthonous phytoplankton production (as opposed to organic/inorganic sediment derived from the catchment).”

The relevant REC classifications to the main stem of the Waikato River from Taupo to Karapiro are lake fed (topography/source of flow), volcanic acidic (geology), cool-wet (climate). This classification extends from Taupo to the mouth of the Waikato River at Port Waikato according to the supporting maps provided on NIWA’s website. Our review of the tributaries has identified that classifications are more variable but notably there is a transition from “cool wet” to “warm wet” at around Lake Maraetai.

4.2.4.3 Key issues

While there is a significant body of science behind this attribute, we have concerns around the resultant attribute bands and there are some issues for the Upper Waikato River with this attribute. Firstly, it is not clear if this attribute would apply to the Upper Waikato River given the Freshwater Body Type “Rivers and streams” as well as the table note stating the attribute would not apply in cases where naturally occurring processes result in high turbidity due to autochthonous phytoplankton production. This does occur in the Upper Waikato River and was one of the reasons lake attributes were applied to the Waikato River main stem for PC1.

The Upper Waikato River (along with the rest of the main stem of the Waikato River) is classified as SSC Class 10 for suspended fine sediment. The bottom line for this class is 1.5 FTU with the “A” band being <1.1 FTU, so 0.4 FTU difference. The National Environmental Monitoring Standard (NEMs 2017) sets out a standard for the accuracy of the measurement of turbidity to within +/-3 FNU for values less than 20 FNU or 15 % for FNU values of up to 750 FNU. It is obvious that it will be difficult to determine what band the Upper Waikato River might fall into given the inherent limitations on the accuracy of equipment currently available. For context, monthly data for 2016 from the Waikato River at the Narrows Boat Ramp ranged from 1.2 to 4.2 NTU, with a median of 1.7 NTU (Tulagi, 2017). The median is therefore below the applicable proposed bottom line (1.5 FTU).

The measurement statistic is not defined in the proposed attribute table, which will need to be clarified. We understand from the supporting science (Franklin et al. 2019) that the numeric values proposed in the attribute tables are for long term medians, so chronic exposure. This raises the question of the sampling method. The attribute table requires a minimum of two years of monthly grab sampling but there is no guidance under what conditions sampling should occur. Presumably sampling may encompass storm flows, which would influence the measurement statistic. Storm flow inputs of fine sediment to the WHS from the tributaries are likely the more important issue from a reservoir perspective.

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4As viewed on 15 October 2019 at: https://proposed-nps-fm-sediment.niwa.co.nz/
The reduction in suspended sediment as water passes through the hydro dams would result in an increased water clarity (reduction in turbidity) when considered in isolation. However, fine sediment as measured by turbidity includes organic and inorganic matter, will therefore be affected by processes such algal growth within the Upper Waikato River reservoirs. The Waikato River Catchment Water Quality Model (WRWQM; Rutherford et al., 2001) predicted the influence of the dams on factors including and water quality along the river main stem. The WRWQM predicts a three- to four-fold increase in suspended algal biomass (phytoplankton, measured as chlorophyll a) at Karapiro resulting from the dams. It also predicted the dams result in a reduction in the water clarity at Karapiro by 35 % (two metres to 1.3 metres) during summer low flows and 10 % during winter high flows.

Returning to the WRC data for 2016, the median turbidity was 0.48 NTU at the Taupo Gates compared to 1.7 NTU at the Narrows Boat Ramp. Work by Vant (2015) identified that on average the contribution of phytoplankton to visual clarity is 55 % throughout the WHS although there is variability seasonally. Vant’s overall conclusion was that although phytoplankton are an important cause of beam attenuation (a measure of clarity) in the river, so too are other constituents (e.g. silts and clays), and it appears that these often mask the effects of the phytoplankton.

On the basis of our review there is uncertainty in relation to:

- the attribute band development process;
- the freshwater body type to which the attribute would apply;
- in accuracy of measurement that is possible; and
- the ability to develop effective management responses.

Given this uncertainty, we consider that the suspended sediment attribute would better fit as a compulsory monitoring attribute (we suggest in an additional Appendix 2X, or within Appendix 2B but only if amendments are made to NPS-FM to allow action plans to consider selected Appendix 2B attributes as a whole.

**Suggested amendments:**

- Seek that the suspended sediment attribute is moved to Appendix 2B with amendments to allow action plans to consider Appendix 2B attributes as a whole.
- Seek revisions to the table are included to: (a) include a unit of measurement (b) clarify the process of measurement including that the attribute relates to chronic exposure and clarify how this works with respect to the frequency and conditions for sampling (c) re-consider the bands with respect to measurement limitations; OR
- Seek that the suspended sediment attribute is moved to a new Appendix 2X for attributes for which there is mandatory monitoring and reporting of trends in the attribute.

### 4.2.5 Escherichia coli – Table(s) 11 (and 23)

The draft NPS-FM includes two tables for *E. coli*. The NPS-FM 2017 table has been retained and is in Appendix 2A (Table 11). The value has been changed to ‘Human contact (human health)’. Table 11 applies to “Lakes and Rivers” and the only change to Table 11 appears to be the removal of the bottom line. A second *E. coli* table focusses on primary contact sites in lakes and rivers (Table 23) is included in Appendix 2B. The change in focus to primary contact sites appears to be the reason for the removal of the bottom line in Table 11.

There is general recognition within the scientific community that this attribute (or the values that it protects) needs urgent updating and the STAG has recommended a review of the science that the current threshold is based on, through a Quantitative Microbial Risk Assessment which would then
enable an update of the 2003 microbiological guidelines\textsuperscript{5}. In the interim, the proposal in this document sets clear standards for swimming at freshwater places where people popularly swim, or would if water quality was better. The bottom line for these places during the swimming season (1 November to 31 March) would be 540 \textit{E. coli} per 100 ml, which is similar to the A band in the current NPS-FW. The proposed changes will make the current requirements clearer.

Overall, we support the STAGs recommendation to undertake a microbial risk assessment and subsequent review the existing guidelines. Our view is that the NPS-FM should include a mechanism for a review of the bands and associated numerics in the light of the assessment.

\textbf{Suggested amendments:}

- A review of the recreational water quality guidelines through a Quantitative Microbial Risk Assessment should be completed as a priority; and
- The bands and numerics should be reviewed and updated in the light of that review.

\textbf{4.2.6 Cyanobacteria – Table 12}

The cyanobacteria attribute included in the draft NPS-FM (Table 12) is mostly unchanged from NPS-FM 2017. The value has been changed to ‘Human contact (human health)’. The attribute applies to “Lakes and lake fed rivers”, which represents the first mention of “lake fed rivers” in the NOF. We note that through PC1 it was determined to classify the Waikato River main stem as a lake fed river.

The STAG identified that urgent work is needed for cyanobacteria and specifically noted:

\textit{Toxic cyanobacteria in rivers, monitoring methods, tools for and evaluating risks, and thresholds for management action. There is an urgent need to update the 2009 guidelines for cyanobacteria in recreational waters following the review in 2018. There is increasing concern in several regions over the proliferation of toxic cyanobacteria in rivers that experience low flow conditions that may be associated with water allocation and may intensify with climate change in some areas. These bacterial growths are a hazard to dogs and potentially to bathers, especially children.}

Issues related to the monitoring methodologies raised in previous reviews of this attribute conducted by T+T (2017) on behalf of Mercury are still relevant. Key issues previously highlighted relate to:

- Cyanobacteria biovolume, limitations on its measurement for “all cyanobacteria” and “potentially toxic cyanobacteria” and the unknown risk profile associated with the Green and Red categories; and
- Monitoring regimes which are public health focussed and not representative of “all conditions”.

Recent work (the 2018 review conducted by Wood \textit{et al.} 2018) potentially resolves some of the issues T+T had raised previously around bio-volume and risk profile. The review proposes a new interim alert level framework – retains a biovolume “situation” for each alert level but also includes cell counts (for specific species of concern) at all three levels (surveillance, alert, action). However, this interim alert level framework is not reflected or recognised in the attribute states in the draft NPS-FM. In this respect the proposed attribute is somewhat behind the latest science and our previous review comments on this topic remain relevant.

The way cyanobacteria are monitored represents a risk in terms of compliance with NOF numeric attributes. The focus on cyanobacteria monitoring is for public health purposes and as such

\textsuperscript{5} The Microbiological water quality guidelines 2003 promote the use of catchment sanitary inspections alongside monitoring of water quality for various microbial indicators.
monitoring targets sites and time periods where people are more likely to be at risk. In particular the more frequent sampling that is undertaken when blooms are identified means the data set are more influenced by high readings. We suggest that the NOF should include guidance on monitoring.

The previous guide to attributes released by MfE notes that sampling for cyanobacteria needs to reflect all conditions and at least provide the minimum data required to calculate the sample statistics to assess progress towards freshwater objectives. Such sampling may differ from that required for surveillance monitoring programmes that provide timely information to manage immediate health risks (MfE 2015). As pointed out previously, the current monitoring regime on the upper Waikato River is not representative of “all conditions”.

As a minimum we recommend that that specific guidance is included in NPS-FM covering monitoring site selection (so data are reflective of all conditions), minimum sampling frequency (during and outside of bathing season) and responses. We note that significant update work has been undertaken and is ongoing.

**Suggested amendments:**
- Add to the last line of the table: Regional Councils shall provide guidance on monitoring site selection (so data are reflective of all conditions), minimum sampling frequency (during and outside of bathing season) and responses.

### 4.3 Attributes requiring action plans (Appendix 2B)

In this section we step through the attributes included in Appendix 2B of the draft NPS-FM. Regional councils must monitor these attributes and these attributes must be maintained or improved. Regional councils must develop target states and action plans to achieve the target attribute state using an adaptive management approach.

As discussed in Section 3.1.2 we consider that attributes included in Appendix 2B should be able to be collectively addressed in an integrated action plan. We have also recommended that DIN and DRP and suspended sediment attributes would better fit in Appendix 2B and should either be moved into that Appendix or include a new Appendix designed for compulsory monitoring.

#### 4.3.1 Macroinvertebrates – Tables 13 and 14

Macroinvertebrates for wadeable streams and rivers (Table 13, NPS-FM) introduces QMCI and MCI scores with a bottom line for QMCI of 4.5 and MCI of 90. The proposed bottom line for MCI is higher (more stringent) than the previously discussed MCI bottom line score of 80 in Collier *et al.* (2014). The rationale for the increased bottom line is included in the STAG report. In summary, an MCI score of 80 corresponds with “probable severe pollution” and was viewed as low and beyond bounds of a healthy aquatic insect community. The corresponding QMCI score is 4.0.

Macroinvertebrates for wadeable streams and rivers (Table 14, NPS-FM) introduces Average Score Per Metric (ASPM) with a national bottom line of 0.3. The ASPM is a multi-metric index developed by Collier (2008). It is calculated from three metrics, the MCI, EPT taxon richness and %EPT abundance. These three metrics were selected from a suite of 17 candidate metrics for their ability to discriminate between reference sites and sites influenced by urbanisation or high levels of pastoral development in the Waikato region (Collier, 2008). ASPM appears to have been included as a more general measure of invertebrate community health whereas MCI primarily measures organic enrichment. A score for ASPM of 0.3 is equivalent to an MCI of 90. MCI, QMCI and ASPM can be calculated from the same data.

We generally support the inclusion of macroinvertebrate attributes in the NOF. The proposed macroinvertebrate attributes would not apply to non-wadeable rivers such as the Waikato River.
Unlike other related attributes however, Tables 13 and 14 specifically refer to “wadeable streams and rivers” as the freshwater body type. Mercury may wish for a definition of “wadeable streams and rivers” to be included in the NPS-FM in order to clearly exclude the Waikato River. We have reviewed various national monitoring protocol documents and consider that a modified definition based on the New Zealand freshwater fish sampling protocol (Joy et al. 2013) and WRC’s Regional Monitoring of Streams protocol (Collier & Kelley, 2005) is appropriate as follows:

**Wadeable** means waterbodies where 90% of the relevant reach of a FMU being sampled is no more than 0.6 m in depth and has an average wetted width of no more than 12 m that can be safely accessed at low flow so that representative samples can be collected from benthic, and/or other stable, productive habitats.

The three macroinvertebrate attributes proposed (two in Table 13 and one in Table 14) and the higher bottom lines raises some issues for soft bottomed Waikato streams and the way wadeable streams may be managed in the Waikato generally. The WRC has a specific and robust macroinvertebrate monitoring programme already underway, the data for which has been assessed in some detail and an alternative attribute method and table was proposed following causuing of water quality experts involved in PC1. The recommend PC1 attribute uses the same input data as the proposed NPS-FM but uses an alternative approach to “sensitivity scores” and as well as to the bands. This is another example of the need for regional flexibility with respect to attributes and adaptive management of Appendix 2B attributes as a whole.

**Suggested amendments:**

- Seek the inclusion of a definition for wadeable streams as set out above.
- Seek amendments to allow action plans to consider Appendix 2B attributes as a whole and to recognise regional processes which already implement these attributes.

### 4.3.2 Fish – Table 15

The STAG recommended the introduction of a table (Table 15, NPS-FM) specifying numeric biophysical values for fish using the Fish Index of Biotic Integrity (Fish IBI) which has been modelled for a number of regions, including the Waikato (Joy, 2007). According to the STAG report:

*Fish IBI is based on presence/absence of fish within different functional groups and takes existing conditions into account. It also considers altitude and distance inland (the two dominant drivers of fish species richness), as well as downstream impediments to longitudinal river connectivity (such as dams), mesohabitat composition and pest fish. As such, it is considered to be a holistic metric that responds to pressures that other attributes do not and a suitable attribute for managing native fish communities.*

A key point in this reasoning is that the Fish IBI takes into consideration impediments to longitudinal connectivity (such as dams or other fish passage barriers). We have previously reviewed the Waikato IBI and could not explicitly confirm that this is the case. The Fish IBI models the integrity of the fish population based on the presence or absence of species, distance inland and altitude. The probability prediction for a species is based on real data sourced from the New Zealand Freshwater Fish Data Base (FFDB) but does not explicitly take into account the presence of dams (or other barriers).

The resultant score from analysis of fish monitoring data using the Fish IBI provides an indication of habitat or migratory impairment, where certain species are not present for one or both of the limiting factors (distance inland and altitude). The IBI does not however distinguish between the two. In the case of barriers such as the WHS hydro-dams, where the provision for fish passage is not required, the IBI would potentially indicate a degraded system with a low attribute state. There would also be limited potential for improvement because new fish species are unlikely to appear at a
specific monitoring site by only undertaking traditional habitat rehabilitation methods (e.g. riparian planting). Therefore, for a regional IBI to be effective it would be reasonable for natural or man-made barriers to be specifically incorporated into the Fish IBI index by some means.

Another important point is where there is ambiguity as to where this attribute applies. The table heading states Table 15 – Fish (rivers) while the freshwater body type states “wadeable”. We note the sampling method referred to in the notes is specifically for wadeable streams.

In summary, the use of the Fish IBI to determine ecosystem health is restricted by manmade and natural barriers which are likely to influence attribute state and the potential for improvement. The intervention logic to improve Fish IBI is therefore unclear.

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**Suggested amendments:**

- Amend the Heading to “Table 15 Fish” (i.e. delete “(rivers)”).
- Amend the Freshwater Body Type to “Wadeable streams and rivers”.
- Seek amendments to allow action plans to consider Appendix 2B attributes as a whole.

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### 4.3.3 Submerged plants – Tables 16 and 17

New attributes are introduced for submerged plants including Table 16 (natives) and Table 17 (invasive species). The numeric attribute states in both tables are calculated from the results of a specific dive survey methodology (Clayton J & Edwards, 2006). It is not clear whether the assessment of the attribute states is against annual values or is averaged over (say) three years.

The bottom line for the native species index (Table 16) is 20%. Submerged plants (invasive species) for Lakes (Table 17) has a bottom line of 90%. The invasive index is a measure of invasion of native plant communities by invasive species. Dominant presence of hornwort and Egeria is noted as failing the bottom line if >90%. Index scores are expressed as a percentage of “maximum potential score”.

The maximum potential score is a modelled number based on maximum lake only (Clayton & Edwards, 2006). This is essentially a “calibration” step in the analysis that apparently allows dissimilar lakes to be directly compared but the authors also refer to the maximum potential score as a “reference condition”. Overall the maximum potential score step in the analysis appears overgeneralised and not particularly relevant to hydro reservoirs. Schallenberg & Schallenberg (2018) reviewed the use of Lake SPI for Waikato Lakes also considered that the calibration step is not appropriately explained and a potential weakness in the analysis. Further, the Schallenberg & Schallenberg (2018) conclude that Lake SPI is less suitable as a pressure indicator, but is a useful indicator of macrophyte community departure from a pre-European reference condition.

Lake SPI surveys have been previously completed for the Waikato hydro reservoirs by NIWA in 2009. Results show that most lakes are below bottom lines. This is mainly due to the presence and extent of hornwort. Little is known about the factors influencing hornwort biomass outside of habitat availability and management options are equally unknown. Consequently, if this attribute is adopted and applied to the Waikato River hydro reservoirs, the WHS could face potential management implications despite the fact that there is no known method for managing the cause of the breach of bottom lines.

In our view, the application of a “minimally disturbed condition” or reference condition should not be applicable to the hydro reservoirs. Combined with the limited knowledge on management options for hornwort, the submerged plant attribute provides a clear case for an exception with respect to the WHS reservoirs.
Suggested amendments:

- Exclude hydro reservoirs from the freshwater body type to which this attribute applies by inserting “Lakes – excluding hydro reservoirs”; and
- Seek a review of the Lake SPI methodology to provide clarity regarding the calibration step and to allow for the establishment of a reference point appropriate to the waterbody and consistent with the modified definition of ecosystem health we have recommended in Section 3.1.1.

4.3.4 Deposited fine sediment – Table 18

The deposited fine sediment attribute was developed generally following the same process as per suspended fine sediment, other than the response variable is macroinvertebrates (as opposed to fish). Refer to Section 4.2.4 for the detail.

The key difference for this attribute with respect to the Upper Waikato River is that it is clearly applied to “wadeable rivers and streams” as the freshwater body type and the required monitoring method is only applicable to wadeable streams and rivers. However, the Waikato River from Taupo to approximately Mercer is classified as DSC 3. The national bottom line applying to DSC class is 60% coverage of fines.

While the attribute as stated may not pose direct issues for the operation of the WHS with respect to the main stem. However, the input of sediment from the tributaries is a matter that is indirectly relevant to the WHS as reducing sediment inputs to the main stem reduces sedimentation of the hydro reservoirs which is a benefit to the WHS.

Deposited sediment was considered by the PC1 expert group and recommended as an attribute for inclusion for wadeable streams. Two options were proposed being (a) a numerical attribute for wadeable hard bottomed stream with a bottom line of 25% cover, and (b) a narrative attribute based on improvement over FMU scale (utilising the specific characteristics of WRC’s monitoring network and method).

In our view the inclusion of a definition for a wadeable stream in NPS-FM would confine the application of this attribute to the appropriate freshwater body type. Further, we consider that there are insufficient paired deposited sediment and ecological response data for the proposed band numerics to be reliable. In this respect we consider that this attribute should be moved to a new Appendix 2X as a ‘compulsory monitoring’ attribute so that an appropriate national dataset for attribute development can be generated.

Suggested amendments:

- Seek the inclusion of a definition for wadeable streams; and
- Move Table 18 to a new Appendix 2X for attributes for which there is mandatory monitoring and reporting of trends in the attribute.

4.3.5 Dissolved oxygen for rivers – Table 19

Table 19 in the draft NPS-FM presents a new attribute for dissolved oxygen for rivers. The attribute is the same as Table 9 NPS-FM but applies to “Rivers” generally as opposed to sites just downstream of point sources. Measurement is a 7-day continuous measurement at least once each summer. The bottom line is a 7-day mean minimum of 5.0 mg/L and 1-day mean minimum of 4.0 mg/L.
The STAG report sets out the rationale for inclusion:

- The dissolved oxygen attribute was originally applied to point sources as there is a direct and obvious cause-effect relationship and knowledge of how to manage them, which fits with the intervention logic used at the time the NPS-FM was developed.
- Dissolved oxygen is fundamental to provide for aquatic life. Accordingly, the dissolved oxygen measure should apply in all river reaches including, but not limited to, below point sources of pollution.

The STAG Report notes the following guidance and caveats that are relevant if contemplating the application of this attribute to rivers generally:

- Key management actions to improve dissolved oxygen concentrations in rivers are to:
  - increase shading and reduce nutrients to decrease growths of nuisance periphyton and submerged macrophytes,
  - provide adequate minimum and variable flows across complex habitats that encourage aeration,
  - reduce ecosystem respiration, and
  - manage high periphyton biomass as per the Periphyton Attribute Table.
- There is a need for further research to inform decisions on what is required to address breaches of desired attribute states and to address the lack of science available to help define and quantify the level of effort required to move a site from Band D to Band C or above.

Our view based on available data is that the riverine sections of the Upper Waikato River are unlikely to fall below the proposed bottom lines. However, the general recommendation from the Expert Group in PC1 was that dissolved oxygen was best implemented as a monitoring requirement. There was generally a lack of data from which to determine reference or current state. In our view the same data limitation applies with respect to the NPS-FM and in setting thresholds for the purpose of NOF attribute bands. We suggest that this attribute is included in a new Appendix 2X as a compulsory monitoring attribute, including guidance on the extent of monitoring expected. Once such further national monitoring data has been completed, further consideration of implementing bottom lines will be able to be undertaken with confidence in the supporting data.

**Suggested amendment:**

- Move Table 19 to a new Appendix 2X for attributes for which there is mandatory monitoring and reporting of trends in the attribute.

### 4.3.6 Lake bottom and mid-hypolimnetic dissolved oxygen – Tables 20 and 21

Tables 20 and 21 of the draft NPS-FM introduce new attribute tables for lake-bottom dissolved oxygen and mid-hypolimnetic dissolved oxygen respectively. Both apply to “lakes” as the freshwater body type. We note that monitoring of temperature is also required to accompany dissolved oxygen data for the data to be informative, although this is not specified.

The attribute tables appear to have been compiled by the STAG but there are no references provided in the STAG report as to how the numeric attribute states were derived, other than mid-hypolimnetic bands align with the River dissolved oxygen bands.

The lake bottom dissolved oxygen or Lakes (Table 20) applies to bottom 1 m of a lake and has a bottom line of 0.5 mg/L as a measured or estimated annual minimum. The driver for the bottom dissolved oxygen attribute is the risk of nutrient release from lake sediments under anoxic conditions.
The mid-hypolimnetic dissolved oxygen attribute (Table 21) specifically applies to “seasonally stratifying lakes” as the Freshwater Body Type. The main driver is stress on fish.

The rationale for inclusion as discussed in the STAG report raises some concerns. Several comments in the rationale section refer to avoiding long lasting degradation, and the attribute providing forewarning. It is important to note that broadly for natural Waikato lowland lakes it is too late for this attribute to provide forewarning. Other concerning comments in the general guidance and caveats imply significant issues in the available current state data, the extent that lakes “naturally” deoxygenate, and “we currently do not know how many naturally low dissolved oxygen lakes there are but the current, monitored database (biased in favour of lowland lakes) suggest there may be many of them”. We note that the STAG Report specifically noted (paragraph 13 on page 22):

Although there is a high degree of confidence in the ecological imperatives of the threshold numbers included in this attribute table, we don’t yet have a solid understanding of natural variation in bottom water dissolved oxygen concentrations and depletion rates and further work would be helpful to confirm our understanding of the robustness of the thresholds we have identified, especially with regard to pristine lakes.

Based on what we know of the hydro reservoirs of the Upper Waikato River there is a risk that some of the reservoirs or parts of the reservoirs would fall below the proposed bottom lines. Controlling nutrient inputs is the only solution that is vaguely inferred by the STAG, but no other mitigations are mentioned. In this respect the intervention logic is not sufficiently developed for this attribute.

Our overall impression is that these attributes have low scientific rigour compared to the other new attributes proposed and the implications of including these attributes in NPS-FM are not well considered. Our view is that these attributes are not ready for inclusion in Appendices 2A or 2B of the NOF and would be best included in a new Appendix 2X as a compulsory monitoring attribute which may develop into an attribute requiring an action plan once current state data, and an understanding of it, is sufficiently developed.

Suggested amendments:

- Move Tables 20 and 21 to a new Appendix 2X for attributes for which there is mandatory monitoring and reporting of trends in the attribute. This should including guidance on the extent of monitoring expected.

4.3.7 Ecosystem metabolism – Table 22

Table 22 of the draft NPS-FM introduces a new attribute for ecosystem metabolism. The attribute applies to all rivers, wadeable and non-wadeable. There are no attribute states or bottom lines proposed on the basis of a lack of data. The proposal is that regional councils will monitor and develop an action plan to respond to deteriorating trends.

The driver for this attribute appears to be to address “ecological processes”, the fifth “biophysical components of ecosystem health” that is not addressed specifically by any other attribute. Ecosystem metabolism provides for a functional link between water quality and biological attributes.

The collection of this monitoring data is not a trivial task. The STAG note that “this metric should be calculable whenever there are continuous dissolved oxygen measurements available and more data will allow these relationships to be refined”. There is no guidance on how widely it is expected that this dissolved oxygen data will be collected for rivers, for this particular attribute or the dissolved oxygen attribute.

Our view is that this attribute is not ready for inclusion in Appendices 2A or 2B of the NOF and would be best included in a new Appendix 2X as a compulsory monitoring attribute, including guidance on the extent of monitoring expected.
Suggested amendment:

- Move Table 22 to a new Appendix 2X for attributes for which there is mandatory monitoring and reporting of trends in the attribute. This should include guidance on the extent of monitoring expected.

4.3.8 **E. coli for primary contact sites – Table 23**

Refer to the discussion of the E. coli attribute in Section 4.2.5.
5 Specific requirements (Subpart 3)

5.1 Setting environmental flows and levels

As set out in Section 2, the development and operation of the WHS has resulted in changes to the flows and levels in the Waikato River and Lake Taupo. The effects of these are not necessarily confined to reaches of the Waikato River upstream of Karapiro, as the WHS has also resulted in changes to the fluvial characteristics of the Waikato River downstream of Karapiro through modified flow regimes\(^6\), and reduction in sediment supply. These processes, alongside other activities, has led to bed degradation and subsequent lowering of water levels which has impacted on water levels in wetlands and other surface water bodies in the Lower Waikato Catchment. Furthermore, changes to the levels in Lake Taupo (along with other factors such as subsidence) may also affect water levels in natural wetland surrounding the Lake.

The effects of hydroelectric schemes (or any other significant diversion and storage of water) are wide ranging and potentially significant.

In the context of the NPS-FM we think it would be very difficult for any regional council to set out a framework to manage these types of effects under the proposed Ecosystems Health Compulsory Values as set out in Appendix 1A, as it is highly likely that one or more of these values would be unable to be met.

We consider this to be a key reason supporting specific consideration for avoiding operational limitations adversely impacting of hydro schemes and a specific and effective exemption clause in the NPS-FM for such hydro schemes. As an alternative, the amendments recommended in Section 3.1.1 would enable a broader consideration of the matters that regional councils would need to consider for hydro-electric schemes in their regions.

5.2 Inland wetlands

Through the NPS-FM, regional councils would be required to identify all existing natural inland wetlands, monitor their health, set policies to protect them, and think about how to make restoration easier.

Through the draft proposed Freshwater National Environmental Standards for Freshwater (NES-FW) there would also be restrictions on activities considered the most destructive to inland and coastal wetlands: drainage, damming, diversion, water takes, reclamation, or disturbance of the bed, or clearance of indigenous vegetation.

Clause 3.15 of NPS-FM deals with ‘natural inland wetlands’. NES-FW places obligations on activities affecting ‘natural wetlands’ which excludes ‘constructed wetlands’. The definition of constructed wetland in the NPS-FM and NES-FW requires that the wetland is “constructed by artificial means”.

Wetlands on margins of hydro lakes are not ‘constructed’ as such and therefore may not meet the definition for ‘constructed wetlands’. Rather, the wetlands have developed in response to flooding of the former Waikato River valley as a result of the development of the WHS. The information note at the end of clause 3.15 lists wetlands connected with hydro-electric power generation as constructed wetlands. It would be preferable to link this clarification to the definition directly and to revise the use of ‘constructed’ to refer to ‘created’ so similar wording to make it fit for purpose.

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\(^6\) As outlined in Section 2.3, some of which helps reduce flooding in the lower catchment.
To support this position, we note that the significance criteria for biodiversity in the Waikato RPS exclude wetlands associated with hydro-electric generation but includes wetlands around Lake Taupo.

Suggested amendment:
- Improve the definitions in NPS-FM to provide a clear distinction between constructed and natural wetlands.

5.3 Fish passage

The Waikato River is the longest river in New Zealand running for 425 km from its source to the sea. A significant number of indigenous freshwater fish species are diadromous and move between freshwater and marine environments to complete their lifecycles. The Waikato River therefore provides a migration corridor for a number of fish species, including threatened fish species, to move between freshwater and marine habitats. Barriers to migration, including dams, can have a significant effect on fish species ability to complete their lifecycles.

Within the Waikato River, fish passage is unimpeded until the base of the Karapiro Dam. However, it is worth noting that fish communities in the section of the Waikato River above Karapiro were probably limited originally by natural barriers to fish migration (WRC, 2004). Prior to the construction of the hydro dams two major waterfalls on the Waikato River would have limited fish passage upstream. The Horahora Falls (15 km upstream of Karapiro Dam) would have limited swimming fish passage and the Arapuni Falls (25 km upstream of Karapiro Dam) are likely to have been a barrier to most climbing fish species. Therefore, the Karapiro Dam has limited access of 15 to 25 km of natural fish passage in the Waikato River main stem (WRISS, 2010).

New Zealand Freshwater Fish Passage Guidelines are specifically referred to in section 3.17 (5) of the NPS-FM. These guidelines are specifically for structures up to 4 meters in height. However, the fish passage principals and tools are applicable to solutions for larger structures. The table from these Guidelines provides general prioritisation criteria so is relevant to all barriers (Table 5.1, Guidelines).

In the absence of a specific exception, and leaving resource consents aside, there does not appear to be any clause in Section 3.17 NPS-FM that would prevent the hydro reservoirs being identified and subsequently prioritised as existing structures that impede fish passage including the WHS dams. Consequently, there is a possibility that the WHS could be adversely affected by the NPS-FM’s provisions related to fish passage. To avoid such adverse effects on the WHS, changes to the definition of constructed wetland and section 3.17 NPS-FM should be advanced.

Suggested amendment:
- Seek that NPS-FM Section 3.17 is amended to exclude any scheme or its constituent structures unless where such schemes already operate fish passage facilities.

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*See Section 5.1.*
6 Exceptions

6.1 Exceptions for large hydro schemes

The NPS-FM has proposed a form of ‘exception’ for large hydro schemes, ostensibly to recognise the significance of hydro-electric generation in helping the Government meets its climate change mitigation objectives and that these objectives may be in conflict with the NPS-FM.

The exception proposal in clause 3.22 of the draft NPS-FM is however ambiguous and inconsistent. For example, clause 3.22 sub-clause (2) refers to generation capacity, storage and operational flexibility of a Scheme while subsequent sub-clauses refer to structures only. Furthermore the management of a particular water quality issue may not affect generation capacity, storage and operational flexibility, but may have implications or impacts on generation output. For example, should the growth of nuisance aquatic plants, and or the exposure of other macrophytes or periphyton to water users (either directly or indirectly) lead to a managing the levels of the reservoirs (refer to Section 3.2).

6.2 Exceptions for naturally occurring processes

Section 3.23 of the draft NPS-FM provides for exceptions for waterbodies that are affected by natural processes to the extent that current state is worse than the national bottom line. This still requires regional councils to set attribute targets and to achieve an improvement of that state to the extent that this is feasible given the natural process. The NPS-FM describes a naturally occurring process as one that could have occurred before the arrival of humans.

We also note that in the attributes themselves some recognise this condition. For example, the suspended sediment attribute in Table 10 identifies and excludes glacially fed streams and rivers, highly coloured brown water streams, and some lake fed rivers.

Section 3.9 of the STAG report points to DRP as one such attribute where the natural levels of DRP are high, but considers that areas where this is an issue is provided for as an exception under the allowance for natural variability (which we assume is what is described in Section 3.23 of the NPS-FM as a naturally occurring processes and in 3.8 (2) as “natural variability” with respect to identifying current state).

Waterways draining the central volcanic plateau of the North Island have naturally high DRP concentrations (WRC, 2002; Timperley, 1983). These waterways are therefore unlikely to meet the national bottom line for DRP, so there is merit in this approach to recognise the challenges faced by local variations. The central volcanic plateau sits across Horizons, Bay of Plenty and Waikato Regional Council administrative areas, so the issue is probably more sub-national than local/regional.

While an exception seems a relatively straightforward solution to address natural processes that influence water quality, the inclusion of a simple exception clause (for DRP for instance) becomes potentially problematic as this parameter also informs the periphyton attributes (Table 2), and starts to impact on how the ecosystem health compulsory value can be successfully implemented.

To address this issue we recommend modification to the 2017 version of the NPS-FM definition of ecosystem health (as proposed above in Section 3.1.1) to enable the ecosystems biophysical values and associated attributes to be considered as a whole. To enable this recommendation to be effective it should be accompanied by amended wording in clauses 3.10 and 3.14 to allow for a single action plan for an FMU or freshwater body (Section 3.1.2).
7 Applicability

This report has been prepared for the exclusive use of our client Mercury NZ Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by: Authorised for Tonkin & Taylor Ltd by:

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Dean Miller Peter Cochrane
Principal Freshwater Scientist Project Director

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Schallenberg, M; Kelly, D; Clapcott, J; Death, R; MacNeil, C; Young, R; Sorrell, B; Scarsbrook, M. 2011. Approaches to assessing ecological integrity of New Zealand freshwaters. Published by the Department of Conservation.

Timperley, MH 1983 Phosphorus in spring waters of the Taupor Volcanic Zone, Chemical Geology 38.


Appendix A: Curricula vitae

- Dean Miller
- Peter Cochrane
Dean Miller has eighteen years' post graduate experience in environmental consulting. Dean specialises in resource evaluation and management work in freshwater environments with specific areas of expertise in water quality, aquatic ecology, fish passage and integrating ecological principles with engineering design.

Dean undertakes project work in the water, energy, waste, land and transport sectors and for a range of local authority, industry, utility and developer clients throughout New Zealand. Dean’s project experience includes provision of specialist water quality and ecology advice, coordination of large scale ecological evaluations, the design and implementation of monitoring and field assessment programmes, assessment of ecological effects for small and large projects affecting aquatic environments and technical review of ecology assessments for regional and local authorities. Dean regularly appears as an expert witness.

**Expertise**
- Water and sediment quality
- Ecological evaluation and monitoring
- Fish passage assessment and design
- Assessment of environmental effects
- Expert witness
- Environmental management

**Experience**

**Turitea Windfarm, Mercury Energy, 2018 to present**
Lead freshwater ecologist on the project. Coordinated baseline monitoring and prepared aquatic ecology monitoring and adaptive monitoring and management plans for the construction phase of the project.

**Tekapo Gate A, Genesis Energy, 2017**
Senior Freshwater Ecologist Project Manager on the Tekapo Gate A upgrade project. Undertook ecological and water quality assessments and managed T+T’s other environmental inputs into the AEE for the project.

**Tongariro Power Scheme Monitoring, Genesis Energy, 2014 to present**
Senior Freshwater Ecologist on the Tongariro Power Scheme monitoring project for Genesis Energy. Project role has included field work and technical review of project deliverables.

**Assessment of Waikato River water quality against freshwater NPS attributes, Mercury Energy, 2014**
Undertook an evaluation of Waikato River and Hydro Lake water quality against proposed national objectives framework of the NPS for freshwater management. Provided technical review and advice in support of MRP submissions on of NPS amendments and the Healthy Rivers Regional Plan Change.

**Healthy Rivers Plan Change, Waikato, Mercury Energy, 2018 to present**
Prepared and presented specialist water quality evidence for the plan change hearing on behalf of Mercury. Participated in expert conferencing and joint witness statement preparation.

**National Policy Statement for Freshwater Management Science Advice, Mercury Energy, 2014 to present**
Trusted advisor to Mercury providing ongoing advice on water quality and ecology matters on the NPS-FM, including implications for the operation of hydro-schemes.

**Huntly Power Station Stormwater Discharge Reporting, Genesis Energy, 2012**
Prepared the annual consent compliance report for stormwater discharges from the HPS to the Waikato River and prepared a template for ongoing reporting.

**Kaimai HEPS water quality and ecology, Trustpower, 2018**
Prepared a review and gap analysis for environmental information for the Kaimai HEPS. Developed a comprehensive investigation and monitoring programme for the scheme. The work has a dual purpose of informing Trustpower’s submission and interaction with Regional Policy development as well as informing future resource consent processes.

**Hairini Transmission Line, Transpower, 2018**
Ecological assessments covering works in the intertidal marine environment and fringing wetland habitat.

**Waikato Expressway: Huntly Section, NZTA, 2014 to 2017**
Lead freshwater ecologist responsible for undertaking and coordinating comprehensive water quality, stream habitat, macroinvertebrate and fish community surveys for streams along the proposed Waikato Expressway route past Huntly. Prepared freshwater ecology inputs into the AEE for the project, including site values assessment, mitigation, consultation with regulatory authorities and ecological compensation planning.

**Hamilton City comprehensive stormwater discharge consent, Hamilton City Council, 2010 to present**
Prepared a detailed and integrated receiving environment effects focussed monitoring programme for Hamilton City Council that met consent requirements while addressing multiple HCC monitoring drivers. Coordinated the implementation of the monitoring plan including stream and

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lake monitoring, flow proportional stormwater monitoring and containment load assessment for the Waikato River and city wide fish passage assessments.

**Hamilton City integrated catchment management plans, Hamilton, 2018 to present**
Managed comprehensive data collection projects to inform ICMP projects for Kirikiriroa and Mangakotukutuku catchments in Hamilton City. Investigations covered stream water and sediment quality, macroinvertebrate survey, fish survey and assessment and prioritisation of stream restoration works.

**Peka Peka to Otaki: Wellington, Fletcher Construction Ltd, 2017 to present**
Lead ecologist responsible for preparation and implementation of the Ecological Management Plan for the project.

**Lake Kimihia Restoration Scoping Study, Huntly, 2010**
Prepared a scoping report on water quality and ecological restoration options for Lake Kimihia, on behalf of NZTA and Solid Energy NZ. The work evaluated existing state, identified knowledge gaps and involved a programme of stakeholder interviews to develop realistic objectives. The report was used by Solid Energy and Waahi Whaanui to support their successful bid for Waikato River Authority funding for restoration work around the lake margins.

**Southern Links: Waikato, Hamilton City Council and NZTA, 2017 to present**
Lead freshwater ecologist responsible for undertaking and coordinating comprehensive water quality, stream habitat, macroinvertebrate and fish community surveys for streams impacted by the proposed Southern Links Road. Prepared freshwater ecology inputs into the Ecological Management and Monitoring Plan required by the Designation.

**Ashburton Aquatic Park Charitable Trust – Lake Hood Aquatic Park, Ashburton, 2008 to 2010**
Design and implementation of a lake ecological health and water quality monitoring programme at Lake Hood, a man-made recreational lake. Coordination of the ecological investigations for the Lake Hood extension consenting project including a detailed modelling assessment of likely water quality under different management scenarios.

**South-western Multimodal Airport Rapid Transport (SMART), NZTA, 2018**
Led the freshwater input into the Scheme Assessment Report (Phase II) including an assessment of ecological values of freshwater streams, an assessment of significance, an assessment of potential environmental effects, and recommendations to avoid, remedy, or mitigate potential adverse effects and recommendations on alignment options that present the lowest ecological risk.

**Greater Wellington Regional Council - C&D Landfill Extension Consents, Wellington, 2014**
Provided expert ecological review services to Greater Wellington Regional Council as part of the consent process and presented technical evidence at council hearings.

**SH35 Fish Passage: Bay of Plenty, NZTA, 2017 to 2018**
Lead freshwater ecologist responsible for planning and coordinating an investigation into the effectiveness of mussel spat ropes as a fish passage solution at road culverts.

**Fish passage at Watercare headworks infrastructure crossings, Watercare, 2005 to 2007**
Investigation of fish passage issues and road and pipeline crossings of streams and of on-line flow monitoring weir structures. The project included development of a database of structures, issues and potential fish passage improvements.

**Wainui Stream Fish Pass, Taharoa, New Zealand Steel, 2008 to 2012**
Fisheries studies on the Wainui Stream, Taharoa for New Zealand Steel Ltd. Undertook an investigation of inanga spawning activity and habitat quality in the lower Wainui Stream and conducted intensive surveys of native fish movement through the Wainui Stream fish pass.

**Waiouru Wastewater Treatment Plant, NZ Defence Force, 2012 to present**
Preparation of a freshwater ecology technical report assessing the effects of the Waiouru WWTP discharge on the Waitangi Stream receiving environment. Stakeholder consultation and presentation of technical ecological evidence at council hearings. Coordination of the compliance monitoring programme following successful granting of consents.

**Whangamarino Weir Repair Works, Department of Conservation, 2012**
Coordinated the construction project for the repair of the Whangamarino Weir, a major water level control structure for the Whangamarino RAMSAR site. The work included engineering designs, preparation of tender and contract documents, contract management and supervision of the works.

**Mangakotukutuku Stream Restoration, Stream Care Group, 2014**
Prepared a restoration plan for an urban stream including ecologically sensitive engineering options for erosion control and concept designs for in-stream habitat features for at risk native fish species. The Waikato River Clean Up Trust funded project also includes the restoration of a floodplain wetland with a view to introduce black mudfish.

**Education**
BSc (Tech), Biology, 2000
MSc(Hons), Biology, 2002

**Qualifications/Memberships**
New Zealand Freshwater Sciences Society (NZFSS) Member
Peter Cochrane
Discipline Manager - Water Engineering
Natural Resources

Peter is a principal of Tonkin & Taylor Ltd, Project Director and a senior environmental scientist with 30 years’ experience in water resource management. Peter specialises in sustainable water management, including the management of urban stormwater and the assessment of catchment scale hydrological changes brought about by land use changes. Peter provides peer review and expert evidence to councils on development proposals and has assisted council planning staff in on a variety of projects requiring expert advice on water management issues. Peter has also provided expert advice to applicants in the fields of water management including water supply and catchment response to land development.

Peter was a contributing author to NZ’s first State of the Environment Report and from 1994 to 1996 led the Ministry for the Environment’s State of the Environment Indicators Programme.

Expertise
- Environmental investigations and assessment of effects
- Provision of strategic water management advice
- Preparation and presentation of expert evidence
- Peer review

Experience
Lower Waikato Waipa Flood Control Scheme: Lake Waikare Northern Outlet Control Gate, Waikato, Waikato Regional Council. 2014 to present.
Project Director and expert
Assessment of effects of discharges of sediment and nutrients from Lake Waikare on the Whangamarino Wetland. Review of sediment runoff into Lake Waikare and Whangamarino catchments, including lake bed survey of Waikare, monitoring of water levels and suspended sediment discharged into the wetland from Lake Waikare establishment of sediment and nutrient budget, including consideration of catchment wide run-off sources, re-suspension of sediment from Lake Waikare, erosion of Pungarehu Canal, and exacerbation of sedimentation brought about by the Whangamarino Weir. Provision of expert opinion in pre-hearing meetings and presentation of expert evidence at council hearings and Environment Court Mediation. Peter Co-ordinated an expert working group to identify and report on potential treatment options and has lead the development of an adaptive management plan for the management of sediment discharges from the Lake.

Tauranga City Groundwater and Multi-hazard Assessments Tauranga City Council, 1998 - present
Project manager and project director responsible for the delivery of a programme of works to help Tauranga City Council understand the nature of groundwater resources across the City and the influence of groundwater and groundwater levels on stormwater management, flooding, and liquefaction hazard.
This included an initial study of groundwater and the effects of urban development in Papamoa on groundwater levels, flow in the Wairakei Stream and flooding, with a review and evaluation of 10 year’s data collection by TCC to understand changes in groundwater levels brought about by development of Papamoa East area.
This informed a broader assessment of catchment hydrogeology, development of a water balance and assessment of the effects of further development in Papamoa East/ Wairakei Catchment on groundwater levels, flooding and flow in the Wairakei Stream to inform the development of a Structure Plan.
Additional work included assessment of soakage as a primary disposal option for Wairakei and investigation of soakage failures associated high density developments at Mt Maunganui.

Peter has recently lead the development of a model to enable TCC to understand the effects of sea level risk on groundwater levels across the City to help TCC understand the implications of this on its infrastructure, has recently completed an integrated assessment of groundwater, coastal inundation and liquefaction hazards for the Te Tumu development area.

National River Managers Stocktake, Christchurch, Regional River Managers, 2016-2017
Project Director responsible for the delivery of a National stocktake, cost benefit analysis and evaluation of the regional river management sector to understand the national state of the management of flood control, river management and drainage schemes by regional councils, identify the challenges facing the sector and to provide a nationally aggregated cost benefit analysis of flood control schemes.

Hamilton City comprehensive stormwater discharge consent, Hamilton City Council 2000 to present
Project manager and project director responsible for the delivery of a programme of work to enable HCC to obtain and work within a comprehensive stormwater discharge consent.
Peter led an assessment of effects of urban stormwater discharges on water quality in the Waikato River, its urban tributaries and Lakes. This involved the evaluation of flow proportional stormwater monitoring and containment loads to the Waikato River, the assessment of effects on water and

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sediment quality, eco-toxicity and biological assessment, the assessment of pressures on local tributaries from urban stormwater and the development of a comprehensive management and monitoring plans.

Peter led the HCC’s consultation which enabled consent to be granted without the need for a hearing.

Peter has continued to advise HCC on the implementation and operation of its consent for the past 15 years, including the development of a stormwater management plan, and monitoring plan, a comprehensive re-assessment of water quality and contaminant loads in 2017 and the revision and preparation of an integrated receiving environment effects focussed monitoring programme in 2018 and 2019 to ensure compliance with its comprehensive stormwater discharge consent, to help HCC understand the effects of its urban activities on surface water quality and riparian habitats, and to enable it to respond to targets set by the Waikato Regional Council via its Healthy Rivers Plan Change.

Southshore Hazards, Christchurch, Christchurch City Council, 2018

Project Director Scientist

Multi-hazard assessment of risks to residential property at New Brighton South New Brighton and Southshore to inform land use policy development by Christchurch City Council and other stakeholders. Establishment of criteria for analysis of liquefaction, flooding and inundation that provide thresholds for potential damage to property and assessment of these hazards under current and potential future sea level scenarios (where flooding and inundation is expected to increase and groundwater levels are expected to rise).

Consultation with key stakeholders including local authority staff, Councillors, and Regenerate Christchurch (the statutory body established to oversee and manage the regeneration of residential red zone land in the greater Christchurch area).

Kaiapoi Residential Red Zone, Christchurch, CERA 2015

Senior Scientist

Member of the technical evaluation panel evaluating environmental, planning and hazard issues associated with long term planning of the Residential Red Zone land at Kaiapoi, Kairaki and The Pines. This the assessment multi-criteria evaluation of potential land use options taking into account liquefaction and lateral spread and other seismic hazards, foundation engineering constraints, current and projected fluvial and coastal flooding, elevated groundwater levels, cultural and ecological values and planning considerations.

Avon Otakaro Regeneration Plan, Christchurch, Regenerate Christchurch 2018

Scientist


Huntly Section Waikato Expressway 2010-present (ACENZ Silver Award Winner 2015)

Project Director responsible for the overall delivery of all geotechnical and environmental investigations to support the preparation of a Scheme Assessment Report Addendum (SARA), Assessment of Environmental Effects (AEE) and Specimen Design for the Huntly Section of the Waikato Expressway.

Peter’s role was to coordinate all the visual, archaeological, acoustic, ecological, contaminated land and drainage investigations and the preparation and delivery of assessment reports covering visual and landscape effects, noise and archaeological effects, terrestrial, wetland and freshwater ecology (including specific investigations in to long tail bats), stormwater and contaminated land to support applications for regional consents specimen design and to meet the requirements of Designation Conditions. Peter co-ordinated the development of an integrated environmental mitigation plan to support Notices of Requirement for Alterations to Designation and resource consent applications.

Peter attended project meetings, including risk and challenge workshops, provided information for public open days, attended open days on behalf of NZTA, and attended workshops with the NZTA’s tangata whenua working group.

Project director responsible for T+T’s inputs to assist NZTA with the construction supervision of the Huntly Section – due to open 2020.

Cambridge Section of the Waikato Expressway, Hamilton, Fulton Hogan

Project Manager

Project Manager responsible for the delivery of all environmental design elements to support a Design & Construct bid by Fulton Hogan for the Cambridge Section of the Waikato Expressway. Peter’s role was to coordinate all the ecological, contaminated land and drainage investigations and the preparation of design reports covering terrestrial, wetland and freshwater ecology (including long tail bats), groundwater and stormwater effects and contaminated land to support the development of a design and project cost to construct the Cambridge Section, whilst meeting consent and designation conditions and complying with the Principal’s Requirements.

Implications of National Policy Statement on Freshwater Quality, Hamilton, Mighty River Power

Project Director

Assessment of implications of implementation of the NPS on water quality in hydro lakes in the Waikato Hydroelectric System, including potential to breach water quality standards in hydro lakes including a result of changes in catchment land use in the Waikato River catchment.

Assessment of nutrient inputs via groundwater into the Waikato Hydro system and likely time of arrival in surface waters.

NSP-FM, Hamilton, Mercury

Project Director and Senior Scientist

Project Director responsible for the provision of technical advice to Mercury Energy on technical papers to support the
development of the National Policy Statement on Freshwater Management. This work included critical analysis and assessment of the implications for Mercury Energy on a range of matters addressed in supporting technical information including the use of MCI for non-wadeable streams, implications on proposed attribute limits for chlorophyll, cyanobacteria, nitrogen and phosphorus, based on catchment loads and trends in the Waikato River for selected hydro lakes, and interpretation of attribute states for E coli based on human health risks.

**Healthy Rivers, Hamilton, Mighty River Power**

Project Director responsible for the delivery of a critical review of research and technical information used to develop the Waikato Regional Council's Healthy Rivers Plan Change, to help Mighty River Power (Mercury) to understand the implications of the plan change on its operation of the Waikato hydroelectric power scheme. This work included the critical assessment of nutrient loads and recent trends concentrations in the Waikato River, including research into historical trends within the River, assessment of the effects of groundwater nutrient inputs and likely timing.

**Modelling of thermal loading from the Huntly Power Station to the Waikato River Genesis Energy Ltd 2010**

Project director responsible for the collection, analysis and modelling of the discharge of cooling water from the Huntly Power Station to the Waikato River. This involved hydrodynamic modelling of the River and modelling of the thermal plume for up to 5km downstream of the outfall, subsequent calibration of model using temperature data and assessment of this against consent conditions limiting discharge from the power station based on the measurement of temperature at one compliance point.

**Tekapo A Spillway upgrade Genesis Energy 2017**

Scientist responsible for the investigation of the potential effects of spillway upgrade on groundwater levels and flows and on likely dewatering requirements associated with a proposal to construct, operate and maintain a new intake gate at Lake Tekapo to address the low seismic performance of the surge tank and head gate at the Tekapo A Power Station.

**NZ Steel Stormwater quality, Christchurch, NZ Steel 2018**

Technical evaluation and preparation of a submission on the effects of zinc runoff from steel cladding products on water quality and in respect of an application by Christchurch City Council for a comprehensive stormwater discharge consent to land and water in Christchurch.

**NPS-FM Sediment Attributes, Hydro-generators 2019**

Project Director and scientist responsible for the provision of advice to a consortium of hydro-generators on the implications of the proposed NoF for suspended and deposited sediment on hydro-generation.

**Education**

BSc, Earth Sciences, 1986, Waikato University, New Zealand

MSc(Hons), Earth Sciences, 1988, Waikato University, New Zealand