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Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change

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Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change

20 June 2016

Mike Scarsbrook on behalf of Technical Leaders Group

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Introduction

Healthy Rivers: Wai Ora is a process for changing the Waikato Regional Plan in order to help protect and restore the health of the Waikato and Waipa rivers. The plan change seeks to reduce, over time, the levels of sediment, bacteria and nutrients (nitrogen and phosphorus) entering water bodies (including groundwater) and follows the National Objectives Framework (NOF) approach to setting freshwater objectives as set out in the National Policy Statement for Freshwater Management (2014). The NOF guides regional councils through a number of steps including describing Freshwater Management Units (FMUs), identifying values, defining attributes and setting freshwater objectives. The definition of attributes is a critical step in the development of freshwater objectives and subsequent management of values, as attributes provide measurable characteristics of fresh water, including physical, chemical and biological properties, which support particular values.

Appendix 2 of the National Policy Statement for Freshwater Management (2014; hereafter NPS-FM) defines a range of attributes relevant to ecosystem health and human health for recreation in lakes and rivers. It is widely recognised that the list of attributes provided is only a subset of potential attributes (MfE 2013). Hence, the NPS-FM provides scope (Policy CA2 c) i. B.) for regional councils to add further attributes as appropriate.

This report summarises the process, undertaken during development of the Healthy Rivers: Wai Ora plan change, for defining a suite of relevant attributes for three core values (i.e. human health for recreation, ecosystem health and mahinga kai). A key output of the process are recommendations on the suite of attributes appropriate for managing the three core values in lakes and rivers within Freshwater Management Units (FMUs) in the Waikato-Waipa catchment.

As has been the case for a number of aspects of the Healthy Rivers: Wai Ora plan change, determination of attributes has been a co-development process between the Technical Leaders Group (TLG) and the Collaborative Stakeholder Group (CSG). The TLG's role is to provide technical input and advice to the CSG, where decisions are made on elements of the plan. In the case of attribute development, the process was iterative, with initial advice from TLG modified through a series of discussions within the CSG that led to requests for further advice from TLG. Appendix 3 summarises the reports provided by the TLG to the CSG and associated decisions or recommendations made by the CSG.

Waikato context

Existing 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 (i.e. geographical scope of Healthy Rivers: Wai Ora).

The Waikato River is sourced from Lake Taupo and fed by more than 17,000 km of tributary streams (Collier et al. 2010). Eight hydro-electric dams occur between Taupo and Karapiro, creating a series of hydro-lakes that have increased the residence time of water in the river (Taupo to the sea) from around 5-6 days to around 40 days under low flow conditions (Collier et al. 2010). For these reasons the whole of the 336 km stretch of the Waikato River from Taupo to Port Waikato is considered to

be a lake-fed river. The designation as a lake-fed river influences the suite of relevant attributes as will be detailed below.

The Waipa River is the largest tributary of the Waikato and increases flow by around 26% on average at its confluence with the Waikato at Ngaruawahia (Collier et al. 2010). The choice of attributes relevant to the Waipa and other rivers throughout the catchment reflects their different hydrology, their values and drivers of those values.

There are more than 60 named lakes in the Waikato-Waipa catchment. Waikato Regional Council has classified lakes into five types – geothermal, volcanic, peat, riverine and dune (Dean-Speirs & Neilson 2014). The three geothermal lakes are not considered further as geothermal waters are outside the scope of the Healthy Rivers: Wai Ora plan change.

Peat lakes are the most numerous of the remaining lake types. Peat lakes tend to be small, with two-thirds having an area less than 10 ha. All 35 peat lakes have catchments dominated by non-native vegetation. Eight of these lakes are currently monitored by Waikato Regional Council (WRC).

There are four named dune lakes, all less than 10 ha in size and all with nearly 100% non-native vegetation. None are currently monitored by WRC, but three have historic data available.

The 15 riverine lakes include the largest shallow lakes in the catchment (Waikare, Whangape, Waahi). Four of the lakes are currently monitored.

The five volcanic lakes in the catchment are relatively poorly known. Only two of the five have any environmental data available.

Development of Healthy Rivers: Wai Ora attributes

Definition of relevant attributes for river, lake-fed river and lake freshwater body types within the Waikato-Waipa catchment has followed a systematic and iterative process (Fig. 1). The NPS-FM provides an initial suite of attributes (see Appendix 1), but the NPS-FM also recognises that additional attributes are likely to be relevant and applicable at the regional scale. An expert panel workshop was convened to develop a more complete set of attributes for freshwater body types in the Waikato-Waipa catchment. This suite of Waikato attributes was then refined through a number of Technical Leaders Group (TLG) workshop sessions and a number of discussions within the Collaborative Stakeholder Group, both with and without TLG advisory input.

Early in the process it became clear that recommendations on inclusion of attributes needed some objective criteria. A set of principles adopted by the National Objectives Framework Reference Group were adapted to the Healthy Rivers: Wai Ora process.

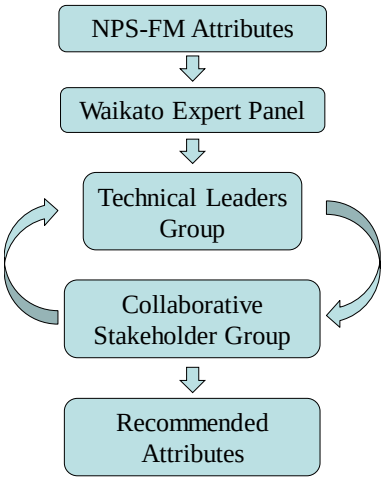

Figure 1. Process diagram showing steps in development of attributes appropriate to core values in Healthy Rivers: Wai Ora plan change.

National Policy Statement for Freshwater Management

Appendix 2 of the NPS-FM (2014) sets out a number of attributes used to measure the state of the two nationally compulsory values in lakes and rivers:

- Human Health for Recreation is measured against levels of *E. coli* (lakes and rivers) and planktonic cyanobacteria (lakes and lake-fed rivers)
- Ecosystem Health in lakes is measured against trophic state indicators (phytoplankton biomass, Total P and Total N concentrations) and levels of Ammoniacal-N (as a toxicant)
- Ecosystem Health in rivers is measured relative to levels of periphyton biomass (trophic state), nitrate-N and ammoniacal-N (as toxicants) and dissolved oxygen (below point sources only)

Policy CA2 of the NPS-FM sets out the process for regional councils to follow in developing freshwater objectives. In addition to the nationally compulsory values above, regional councils should consider other national values (e.g. mahinga kai), or other values the council considers appropriate at regional or local scales. Councils are then directed to identify the attributes considered applicable to each value, including the existing attributes in the NPS-FM.

Expert panel workshop

An expert panel workshop was convened by the TLG on 30 September 2014.The panel was made up of Waikato-based experts chosen by the Technical Leaders Group from the Technical Support Group:

- Bill Vant (WRC)
- Bruno David (WRC)
- Chris Hickey (NIWA)
- Chris Koroheke (AgResearch)
- David Hamilton (University of Waikato)
- John Te Maru (Waikato-Tainui College for Research and Development)
- Kevin Collier (University of Waikato)
- Ngaire Phillips (Streamlined Environmental)

The expert panel were chosen by the TLG for expertise and experience in aquatic ecology, matauranga maori, ecotoxicology and native biodiversity.

The workshop was convened and facilitated by Mike Scarsbrook (TLG), Antoine Coffin (TLG) and Vicki Carruthers (WRC).

Purpose

The predefined purpose of the expert panel workshop was to populate a Waikato catchment-centric National Objectives Framework with appropriate attributes and attribute states relating to Human Health ('Swimmability'), Ecosystem Health ('Healthy Biodiversity') and Mahinga Kai ('Fishable').

The expectation was that the recommended attributes would be used to describe current state, assist with definition of change scenarios to aid CSG deliberations and provide a framework for eventual recommendation to the Healthy Rivers committee on limits and targets relating to the four main contaminants of interest (i.e., N, P, sediment and faecal bacteria) within defined Freshwater Management Units in the Waikato-Waipa catchment.

Expert panel members were asked to provide a broad overview. Questions from the expert panel about what was in or out of scope for the Healthy Rivers process were left to the Collaborative Stakeholder Group.

Workshop process

The Expert Panel Workshop reviewed three cores values identified by the Collaborative Stakeholder Group:

- Human Health ('Swimmable')
- Ecosystem Health ('Healthy Biodiversity')
- Mahinga kai ('Fishable')

For each value, the 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 their relevance to the Waikato-Waipa catchment. The expert panel also provided advice on other attributes deemed relevant to the measurement of the three values in Freshwater Management Units of the Waikato-Waipa catchment.

Set out below are the full set of attributes identified by the Expert Panel as relevant to the different values in the Waikato-Waipa catchment (Table 1). These include existing attributes from the NPS-FM, some modified and some unchanged, as well as several additional attributes. It was recognised that the additional attributes would need further development before inclusion.

Assumptions adopted for expert panel workshop process:

- 'Swimmability' is a value applied to all waterways, at all times of the year, and under all flow conditions, and
- Wetlands and groundwater were out of scope of the work brief.

Table 1. Attributes considered by expert panel in relation to three core values.

Value	Attribute (water body type)	Comments
'Swimmability' [See Note 1]	*E. coli* (lakes and rivers)	Primary contact (full immersion) standards in NPS-FM (2014) are appropriate
	Planktonic cyanobacteria (lakes and lake-fed rivers)	Planktonic Cyanobacteria attribute should be extended to include lowland river main stem reaches. [see Note 2]
	Water clarity (lakes and rivers)	Water clarity is an important attribute relating to 'Swimmability' [see Note 3]
	Narrative attributes relating to aesthetics, habitat condition and access	The panel recommended development of narrative attributes relating to the following: • Odour • Colour • Bed sediments • Aquatics weeds/algae • Debris/snags • Access • Bank condition/habitat (e.g. tree swings)
Ecosystem Health	Phytoplankton (lakes)	Existing NPS-FM
	Total Nitrogen (lakes)	Existing NPS-FM
	Total Phosphorus (lakes)	Existing NPS-FM
	Periphyton (rivers)	Existing NPS-FM. It was observed that periphyton issues are rare in the Waikato as a result of stream morphology (i.e. a predominance of 'soft-bottomed' streams) and shade conditions.
	Nitrate (rivers)	Existing NPS-FM. It was observed that nitrate concentrations seldom approach levels where direct, chronic toxicity occurs.
	Ammonia (lakes and rivers)	Existing NPS-FM
	Dissolved oxygen (rivers below point sources)	Existing NPS-FM
	Light climate (lakes and rivers)	The panel identified light climate as an important attribute relevant to ecosystem health in Waikato lakes (e.g. peat lakes) and large rivers (e.g. Waikato main stem).
	Submerged macrophytes (rivers)	The panel agreed that macrophyte biomass was an important attribute that was relevant to Ecosystem Health in Waikato rivers. [see Note 4]
	Nutrients (rivers)	Development of 'norms' for total and dissolved nutrients was considered appropriate for managing nutrient levels in streams and rivers that fall outside the application of TN and TP attributes. [Note 5]
Mahinga kai [see Note 6]	*E. coli*	Use primary contact standards
	Planktonic cyanobacteria	Use primary contact standards
	Heavy metals	Develop thresholds for main metals
	Catch per unit effort (CPUE)	
	Food chain intactness	The Macroinvertebrate Community Index was proposed as an integrator measure relating to the 'health' of the food chain.

Notes:

1. It was noted by several panel members that 'Swimmability' incorporates both human health attributes (e.g. risk of infection and rashes) as well as a range of attributes that determine physical safety (e.g. clarity, currents and snags) and aesthetics (e.g. colour, odour, bed

sediments, aquatic weeds and algae, bank condition and access). For example, water clarity influences people's choice of where to swim, but does not directly affect human health.

2. The planktonic cyanobacteria attribute as set out in the NPS-FM (2014) was considered appropriate for lakes and lake-fed rivers (i.e. main stem of Waikato River). The panel recommended extending the application of the attribute to lowland river main stem reaches. It was noted by Bill Vant (WRC, Water Quality Scientist) that residence time in some lowland tributaries is increased through hydraulic effects of Waikato River (i.e high water levels in the Waikato cause a damming effect in some tributaries). This includes the lower Waipa River (below Pirongia) and other lowland tributaries such as Mangawara River. WRC monitoring data indicates that cyanobacteria do accumulate in some lowland river reaches upstream of the Waikato River confluence and can reach concentrations exceeding the national bottom line (Bill Vant pers. comm.).
3. Further development of the water clarity attribute, including A-D band breakpoints, monitoring and compliance statistics was strongly supported by the expert panel. A draft water clarity attribute table (Table 2) was developed by the expert panel with the expectation that further development would be undertaken by TLG to fully develop the attribute.

Table 2. Draft attribute table for water clarity.

Value	'Swimmability'	
Freshwater Body Type	Lakes & rivers	
Attribute	Water clarity	
Attribute Unit	m (measured using agreed methods e.g. horizontal Black disc in rivers)	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
	Annual median of samples (excluding flood flows*)	**Lakes with naturally low clarity (e.g. peat-stained) will need to be treated separately**
A	≥4	Water clarity is deemed excellent for swimming (NIWA, 2010)
B	≥1.6 and <4	Water clarity is deemed suitable for swimming**
C	≥1.0 and <1.6	Water clarity is deemed marginally suitable for swimming**
Minimum acceptable state	**1.0**	
D	<1.0	Water clarity is deemed unsuitable for swimming

* WRC analysis of water clarity excludes the top 10% of flows

** Smith & Davies-Colley (1992)

4. There was concern noted about the potential for a macrophyte attribute to impact on Mahinga kai values, such as watercress (i.e. abundant watercress is desirable, but may breach an ecosystem health biomass/%cover standard). Restricting the attribute to submerged macrophytes could address this concern.
5. Development of 'norms' for total and dissolved nutrients was considered appropriate for managing nutrient levels in streams and rivers that fall outside the application of TN and TP attributes. This could be done in the same way as in ANZECC (2000). That is, the 80th percentile of monitored data for relatively undisturbed sites in the Waikato-Waipa catchment. Further work is needed to identify how these 'norms' would fit into a Waikato Objectives Framework. At the very least these 'norms' would be used in surveillance monitoring to support objectives set on river main stems in relation to TN and TP levels.
6. The Expert Panel members with specific expertise in Mahinga Kai, observed that this value can be broken into two themes:
    - Food is safe to eat
    - Food stocks are sufficient to be fit for purpose

    In relation to the former, the *E. coli* and Cyanobacteria attributes proposed under Human Health are relevant, as are many of the suggested narrative attributes proposed for 'Swimmability'. An additional Attribute around levels of heavy metals would also be appropriate and relevant to Waikato because of upstream geothermal inputs.

    In relation to the latter, the Expert Panel suggested a catch-per-unit-effort (CPUE) attribute be developed, along with an integrated measure of food chain intactness (i.e. invertebrate communities).

Recommendations from Expert Panel Workshop

- Human Health
    a. Apply *E. coli* attribute as per NPS-FM
    b. Apply Planktonic Cyanobacteria attribute, but extend the Freshwater Body Type to include lowland river mainstem reaches
    c. Develop and apply a Water Clarity attribute to lakes and rivers in the Waikato-Waipa catchment
    d. Develop narrative statements relating to physical safety (e.g. clarity, currents and snags) and aesthetics (e.g. colour, odour, bed sediments, aquatic weeds and algae, bank condition and access) that are based on Tikanga and Matauranga Maori
- Ecosystem Health
    a. Apply Phytoplankton attribute as per NPS-FM, but extend the Freshwater Body Type to include the mainstem of the Waikato River and lowland river mainstem reaches
    b. Apply Total N attribute as per NPS-FM, but extend the Freshwater Body Type to include the mainstem of the Waikato River and lowland river mainstem reaches
    c. Apply Total P attribute as per NPS-FM, but extend the Freshwater Body Type to include the mainstem of the Waikato River and lowland river mainstem reaches

d. Do not apply the Periphyton Attribute as per NPS-FM, because of limited relevance in most streams and rivers in the Waikato-Waipa catchment. Develop a %cover Attribute for surveillance monitoring based on existing WRC methodology (http://waikatoregion.govt.nz/tr201403)
e. Apply Nitrate attribute as per NPS-FM
f. Apply Ammonia attribute as per NPS-FM
g. Apply Dissolved Oxygen attribute as per NPS-FM, but extend the Freshwater Body Type to include all rivers rather than just below point sources
h. Develop and apply a Light Climate attribute to lakes and large rivers in the Waikato-Waipa catchment
i. Develop and apply a Submerged Macrophyte attribute to rivers in the Waikato-Waipa catchment
j. Develop a set of 'norms' for total and dissolved nutrients that could be applied to rivers that are not covered by TN or TP attributes
k. Develop and apply a deposited sediment attribute for rivers
l. Develop and apply a Temperature attribute to rivers in the Waikato-Waipa catchment

- Mahinga kai
    a. Develop and apply *E. coli* and Cyanobacteria attributes to Mahinga Kai values
    b. Apply Catch-Per-Unit-Effort attribute to rivers in the Waikato-Waipa catchment
    c. Develop Heavy Metals attribute
    d. Develop Biotic Index attribute reflecting food chain intactness (e.g. MCI)

Attribute Assessment

Principles for Attribute Inclusion

In the process of developing the NOF, the Ministry for the Environment defined a set of principles that were subsequently used by officials and the NOF Reference Group to assess each potential attribute (Appendix 2). The five principles can be summarised as:

1. Does the attribute provide a measure of the value?
2. Are there agreed band thresholds, summary statistics and measurement protocols?
3. Do we know what to do to manage this attribute, do we understand the drivers and are there quantitative relationships that link the attribute state to resource use limits and/or management interventions?
4. Is there data of sufficient quality, quantity and representativeness to assess the current state of the attribute?
5. Can we assess the socio-economic implications of setting limits around this attribute?

The scope of the Healthy Rivers: Wai Ora Plan Change is restricted to improving the management of nitrogen (N), phosphorus (P), sediment and faecal bacteria. This scope is considerably narrower than that covered by the NOF. Therefore, with some minor changes the principles above were made more relevant to the Healthy Rivers: Wai Ora process:

1. Does the attribute provide a measure of the value?
2. Measurement and band thresholds
    - Are there established protocols for measurement of the attribute?

- Do experts agree on the summary statistic and associated time period?
- Do experts agree on thresholds for the numerical bands and associated band descriptors?

3. Management and limits
    - Do we know what to do to manage this attribute?
    - Are the four contaminants (N, P, sediment and faecal microbes) direct drivers of this attribute?
    - Do quantitative relationships link the attribute state to limits and/or management interventions to control N, P, sediment and faecal microbes?

4. Evaluation of current state
    - Is there data of sufficient quality, quantity and representativeness to assess the current state of the attribute within Waikato FMUs?

5. Implications
    - Can the social, cultural, economic and environmental implications of setting limits be assessed?
    - Are we able to model scenarios for these attributes within the Healthy Rivers: Wai Ora timeframe?

Assessment & rationale

In Table 3 below TLG set out an assessment of a wide range of Attributes discussed by CSG against the five principles defined above.

This assessment raised issues relating to a number of Attributes and these are addressed below:

Clarity – In early discussions at the Expert Panel Workshop an A-B threshold was set at 4.0 m. The CSG asked that the TLG consider whether this threshold should be 3.0 m, given concerns around the width of the B band (from 4.0 m to 1.6 m) (see Appendix 3). In this re-consideration TLG consulted with experts, in particular Dr Rob Davies-Colley from NIWA. The 4.0 m threshold reflected existing definitions of high quality waters used by WRC (http://www.waikatoregion.govt.nz/Environment/Environmental-information/Environmental-indicators/Freshwater/River-and-streams/river-water-quality-contact-recreation-techinfo/) and in the Waikato River Independent Scoping Study (WRISS; NIWA 2010). By way of contrast, the proposed thresholds used for B-C and C-D were based on a national research project carried out in the early 1990s (Smith & Davies-Colley 1992). In that study it was found that water clarity greater than 3.0 m was considered “Eminently suitable for use” for bathing (see Fig. 2). Therefore, it was recommended the A-B threshold be shifted from 4.0 m to 3.0 m to provide consistency in approach across the attribute.

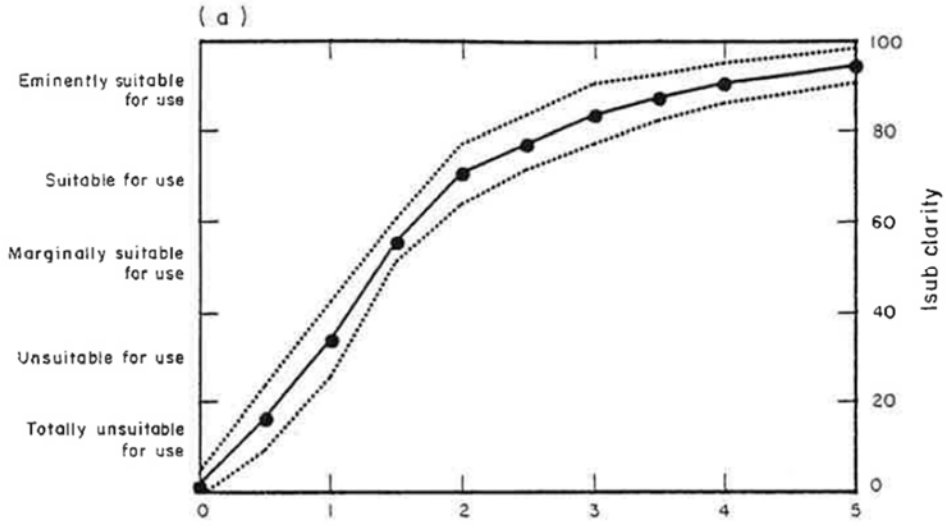

Figure 2. Clarity response curves for bathing. Note: X-axis is Black disc range (m). Reproduced from Smith & Davies-Colley (1992).

Cyanobacteria (planktonic) – The proliferation of cyanobacteria in a water body is usually undesirable, although it can occur in even relatively pristine waters. Of particular concern is the potential for some species to produce toxins at certain times. These toxins can have adverse effects on human health (e.g. skin irritations). In the NPS-FM this attribute applies to lakes and lake-fed rivers. However, assessment of this attribute against the principles in Table 1 indicate issues with the extent of monitoring across the Waikato-Waipa and the level of knowledge about links between N, P, sediment and faecal contaminants and management of nuisance cyanobacteria. As a result, it is unlikely that scenario modelling of socio-economic implications and environmental outcomes will be possible within the Healthy Rivers timeframe. There are reasonable levels of information for some of the lake types (peat, riverine), but less for others (dune and volcanic) and this attribute is most relevant there.

Total N & Total P – There was discussion within the CSG around extending the TN and TP attribute to tributaries (see Appendix 3). At the national scale the bands for TN and TP were developed to relate to levels of eutrophication in lakes. The TLG has recommended extending the use of these bands to the Waikato River main stem, a lake-fed river with impoundments that increase residence time and provide the opportunity for algal growth. Existing TN and TP bands are less relevant for tributaries and the Waipa due to their short residence times. However, within an FMU it is possible to identify which tributary catchments are "hot-spots" for contributing nitrogen and phosphorus loads to the main stem. This knowledge has been incorporated into the scenario modelling so as to target mitigation actions to achieve the desired attribute states with respect to TN and TP in the main stem. Therefore TLG recommend that TN and TP levels in tributaries be used as indicators, but not Attributes.

Macrophytes (LakeSPI) – The condition and species composition of macrophytes in lakes is monitored in a number of shallow lakes in the region (Edwards & Clayton 2010). However, the drivers of macrophyte communities in shallow lakes are complex and a number of these drivers fall

outside the scope of Healthy Rivers (e.g. water levels, pest fish). Furthermore, the relationship between Ecosystem Health and macrophyte biomass is not linear. Extensive beds of native macrophytes can indicate healthy conditions, whereas similarly extensive beds of introduced and nuisance species may indicate degraded conditions. Therefore TLG recommend that Macrophytes not be included as an attribute.

Periphyton – Periphyton biomass is recognised as an important Attribute for Ecosystem Health in rivers. However, development of this attribute for the NOF focussed solely on wadeable, run-off fed, hard-bottomed streams and rivers (i.e., where substrate is suitable for attached algae) (Snelder et al. 2013). Many waterways in the Waikato-Waipa catchment have beds largely comprised of fine sediments (mud, silt and sand) that provide unsuitable habitat for attached algae. Snelder et al. (2013) estimated that up to 26% of New Zealand's streams and rivers by length will not support conspicuous amounts of periphyton due to their fine substrates.

There are areas within the catchment where substrates in streams are suitable for periphyton (e.g. Upper Waipa and its tributaries). Periphyton biomass is not currently monitored quantitatively by WRC, although percentage cover of various types is monitored annually to 3 yearly in the Regional Environmental Monitoring (REMS) surveys following the protocol of Collier et al. (2007). This monitoring indicates limited issues with periphyton at monitored sites – only 2 samples out of a total 146 samples showed periphyton cover greater than 55% (cut-off for nuisance growth levels). The vast majority of samples (90%) had periphyton cover less than 20% (indicative of high quality) and no evidence of periphyton proliferations (Collier & Hamer 2010). In smaller streams in the Waipa catchment (e.g., <6 m wide) stream shade is an effective mitigation method to reduce the incidence of summer blooms (Quinn et al. 1997; Davies-Colley & Quinn 1998), where these occur. In their national assessment Snelder et al. (2013) identified that many streams and rivers are sufficiently shaded so as to prevent conspicuous periphyton growths. TLG conclude that periphyton is of limited relevance as a measure of Ecosystem Health in Waikato-Waipa and recommend it not be included as an attribute.(Snelder et al. 2013)

Dissolved oxygen – This is included in the NOF as an attribute for sites below point source discharges. The attribute relies on intensive continuous monitoring during the summer period to calculate required compliance statistics. This level of monitoring is not realistic across the regional rivers water quality monitoring programme, although it would be prudent for WRC to begin such intensive monitoring in "at risk" waterways. WRC currently monitor dissolved oxygen continuously at two Waikato River sites (Hamilton and Tuakau).

Links between dissolved oxygen and the four contaminants of interest are indirect – the greater the plant/algal biomass the greater the potential for dissolved oxygen issues, but this will be modified by site-specific conditions such as flow, mixing and temperature. TLG did not recommend that Dissolved Oxygen be included as an attribute for Healthy Rivers: Wai Ora due to the cost of monitoring and the indirect link to the four contaminants (see Appendix 3). Point sources where discharges of organic material may cause dissolved oxygen issues are controlled activities and will have appropriate monitoring regimes already in place.

Temperature – Another important Attribute for Ecosystem Health, but outside of the scope of Healthy Rivers: Wai Ora, as it is not related to the four contaminants.

Deposited sediment – In stony-bottomed streams the deposition of fine sediment can have significant adverse effects on Ecosystem Health and other values (e.g. trout fishery). While some thresholds have been proposed nationally as part of an Envirolink tools project (Clapcott et al. 2011), there are currently insufficient monitoring data to describe current state and this attribute remains in the development stage. TLG recommend that deposited sediment not be included as an attribute at this stage.

Invertebrates – New Zealand has a long history of using macroinvertebrates as biological indicators. The most commonly used index (Macroinvertebrate Community Index; MCI) has been shown to be an effective indicator of a range of pressure gradients, including land use. There are nationally-accepted thresholds for A-D attribute states[1]. WRC monitors MCI at 62 sites throughout the Waikato-Waipa catchment. This includes both hard-bottomed and soft-bottomed sites. 44% of these sites fall in the 'A' band, 24% in the 'B' band, 13% in the 'C' band and 19% in the 'D' band. By FMU, the average MCI in the Upper Waikato is 122 (A), Mid Waikato is 80 (C-D boundary), Waipa is 115 (B) and Lower Waikato is 86 (C) (Collier & Hamer 2010).

The main issue with MCI as an attribute under the NPS-FM is the range of drivers that influence it (Clapcott & Goodwin 2014). In general MCI tends to decline with increasing land use intensity, whereas contaminant levels tend to increase. However, improvements in MCI may not occur simply from improving management of contaminant levels (i.e., the causative link is weak or non-existent). Physical habitat structure, temperature and flow conditions are all important drivers. There are also complex interactions between drivers. Therefore, it is not possible at this stage to predict the effectiveness of controls on N, P, sediment and *E. coli* alone on MCI outcomes. This severely limits our ability to undertake cost-benefit analysis for use of MCI as an attribute either at the national scale or within the Waikato. TLG recommend that MCI not be included as an attribute (see Appendix 3).

E coli (Mahinga kai) - For food species that are thoroughly washed and cooked prior to eating TLG consider it would be appropriate to use the same *E. coli* attribute bands as for primary contact recreation (i.e. swimming).

Faecal coliforms (Mahinga kai) – There are nationally accepted standards for assessing estuarine water quality relating to shellfish-gathering, but this attribute has been outside the scope of the NPS-FM and NOF. To TLG knowledge these Standards have not been applied to freshwater shellfish-gathering, and we do not know what the extent of freshwater shell-fish gathering for food is in the Waikato. Waikato Regional Council does monitor Faecal Coliforms at freshwater sites. Only four monitored sites achieve the "Satisfactory" level defined by WRC (see table below). These sites are Taupo Control Gates, Ohakuri tailrace, Whakamaru tailrace and Waiotapu Stream at Campbells Rd.

Without knowledge of the extent of freshwater shellfish gathering and the associated practices (e.g. are they consumed raw or cooked?) TLG are not able to make a firm recommendation on the inclusion of Faecal Coliforms as an attribute for Mahinga kai. However, it is clear that very few sites (and no sites in the lower river) would meet satisfactory levels.

[1] MCI score ≥120 is 'A', 'B' is 100-119, 'C' is 80-99 and 'D' is <80.

Note: Coliforms are bacteria that live in the intestines of warm-blooded animals (humans, pets, farm animals, and wildlife). Faecal coliform bacteria are a kind of coliform associated with human or animal wastes. Escherichia coli (E. coli) is part of the group of faecal coliforms.

WRC guidelines and standards used to assess estuarine water quality for shellfish-gathering.

Water quality variable (units)	Relevance	Categories		
		Excellent	Satisfactory	Unsatisfactory
Shellfish-gathering				
Faecal coliforms, median (no./100 mL)	Human health	<2	2 – 14	>14
Faecal coliforms, 90 percentile (no./100 mL)	Human health	<6	6 - 43	>43

http://www.waikatoregion.govt.nz/Environment/Environmental-information/Environmental-indicators/Coasts/Coastal-water-quality/Estuarine-water-quality-techinfo/#guidelines

Cyanobacteria (Mahinga kai) – TLG recommend the NOF bands for primary contact recreation (Cyanobacteria planktonic) are appropriate for this value.

Table 3. Proposed attributes for Healthy Rivers: Wai Ora and TLG's assessment against five principles.

Value	Attribute	Link to Value	Thresholds	Management	Evaluation of State	Implications
Human health	*E. coli*	Yes	Yes	Yes	Yes	Yes
	Clarity	Yes	Yes*	Yes	Yes	Yes
	Cyanobacteria (planktonic)	Yes	Yes	Limited	Limited	No
	Cyanobacteria (benthic)	Yes	No	Limited	No	No
Ecosystem health	Phytoplankton (lakes)	Yes	Yes	Yes	Yes	Yes
	TN	Yes	Yes	Yes	Yes	Yes
	TP	Yes	Yes	Yes	Yes	Yes
	Nitrate	Yes	Yes	Yes	Yes	Yes
	Ammonia	Yes	Yes	Yes	Yes	Yes
	Macrophytes (Lake SPI)	Yes	Yes	No	Limited	No
	Periphyton (rivers)	Yes	Yes	Yes	No	Yes
	Dissolved Oxygen	Yes	Yes	No	No	No
	Light climate	Yes	No	No	No	No
	Temperature	Yes	Yes	No	No	No
	pH	Yes	No	No	No	No
	Deposited sediment	Yes	No	Yes	No	No
	Invertebrates (MCI)	Yes	Yes	No	Yes	No
Mahinga kai	*E. coli*	Yes	Yes	Yes	Yes	Yes
	Faecal coliforms	Yes	Yes	Yes?	Yes	Yes
	Heavy metals	Yes	No	No	No	No
	Catch-per-unit-	Yes	No	No	No	No

	effort					
	Cyanobacteria	Yes	Yes	No	Limited	No

Recommended Attributes

Table 4 summarises TLG recommendations to the CSG on attributes for use in the Healthy Rivers: Wai Ora process.

In general, the adoption of existing attributes from the NPS-FM is recommended with the exception of periphyton in rivers, and dissolved oxygen in rivers (below point sources). The latter is excluded due to the indirect relationship between dissolved oxygen and the four contaminants. The periphyton attribute is excluded due to lack of relevance in many Waikato streams (i.e. many Waikato streams have soft bottoms and therefore do not provide a suitable habitat for conspicuous periphyton growth) and the available WRC monitoring data showing limited periphyton issues in small, hard-bottomed streams.

Some modification of existing NPS-FM attributes is recommended to increase relevance to Waikato-Waipa catchment conditions. For example, it is recommended that TN, TP and phytoplankton attributes apply over the entire length of the main stem of the Waikato River from Taupo Gates to Port Waikato. This recognises that the Waikato River is lake-fed, the eight hydro-dam affected reaches function as lakes and phytoplankton growth occurs along the entire river.

Of the additional attributes recommended by the original expert Panel, only water clarity has been developed to the point where it is able to be applied within Healthy Rivers: Wai Ora. Other attributes are either out of scope (e.g. heavy metals), or have not yet been developed to the point where they can meet criteria for inclusion (e.g. deposited sediment).

There is an on-going national discussion on the status of macroinvertebrate indices such as MCI (Macroinvertebrate Community Index) and their applicability as attributes under the NOF (Clapcott & Goodwin 2014). Indices such as MCI provide good indicators of land use impacts, but it is very difficult to link MCI to changes in concentrations of the four contaminants in a way that allows confidence in its use in limit setting at this time. For this reason, MCI is not recommended as a numerical attribute in Healthy Rivers: Wai Ora.

However, the value of MCI as an integrating measure of overall Ecosystem Health should not be ignored and it is recommended that MCI (and other macroinvertebrate indices) should continue to be monitored by WRC at representative sites throughout the Waikato-Waipa catchment.

Table 4. Summary of attributes and recommendations to Collaborative Stakeholder Group.

Value	Attribute	In NPS-FM	Freshwater Body Types applicable in Waikato-Waipa	Recommendation	Currently monitored by WRC
Human Health	*E. coli*	Yes	Lakes, rivers & lake-fed rivers	Apply as per Appendix (primary contact only)	Yes
	Planktonic cyanobacteria	Yes	Lakes and lake-fed rivers	Apply as per Appendix, but extend to include lowland river main stem reaches	Limited
	Water clarity	No	Lakes, rivers & lake-fed rivers	Apply developed clarity attribute as per Appendix	Yes
	Safety and aesthetics	No	Lakes, rivers & lake-fed rivers	Out of scope for Healthy Rivers: Wai Ora	No
Ecosystem Health	Phytoplankton	Yes	Lakes & lake-fed rivers	Apply as per Appendix, but extend to include Waikato main stem	Yes (Waikato main stem and some shallow lakes)
	Total Nitrogen	Yes	Lakes & lake-fed rivers	Apply as per Appendix, but extend to include Waikato main stem	Yes (Waikato main stem and some shallow lakes)
	Total Phosphorus	Yes	Lakes & lake-fed rivers	Apply as per Appendix, but extend to include Waikato main stem	Yes (Waikato main stem and some shallow lakes)
	Periphyton	Yes	Rivers	Do not apply the Periphyton (chlorophyll *a*) attribute. Develop a %cover indicator for surveillance monitoring based on existing WRC methodology (http://waikatoregion.govt.nz/tr201403)	No
	Nitrate	Yes	Rivers & lake-fed rivers	Apply as per Appendix	Yes
	Ammonia	Yes	Lakes, rivers & lake-fed rivers	Apply as per Appendix	Yes
	Dissolved oxygen	Yes	Rivers (below point sources)	Out of scope for Healthy Rivers: Wai Ora	Spot measures only
	Macrophytes	No	Rivers	Develop indicator for surveillance monitoring (http://waikatoregion.govt.nz/tr201403)	No
	Deposited sediment	No	Rivers	Contribute to develop of national attribute for deposited sediment	No
	Temperature	No	Rivers & lake-fed rivers	Out of scope for Healthy Rivers: Wai Ora	Spot measures only
	Light climate	No	Lakes, rivers & lake-fed rivers	see clarity attribute	No
Mahinga Kai	*E. coli*	No	Lakes, rivers & lake-fed rivers	Apply as per Appendix (primary contact only)	Yes
	Planktonic Cyanobacteria	No	Lakes & lake-fed rivers	Apply as per Appendix	Limited
	Catch-per-unit-effort	No	Lakes, rivers & lake-fed rivers	Out of scope for Healthy Rivers: Wai Ora	No
	Heavy metals	No	Rivers & lake-fed rivers	Out of scope	Some

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Appendix 1– Details of TLG recommended attributes (all except Clarity are taken directly from the NPS-FM Appendix 2, page 24).

Value	Ecosystem health		
Freshwater Body Type	Lakes		
Attribute	Phytoplankton (Trophic state)		
Attribute Unit	mg/m³ (milligrams chlorophyll-a per cubic metre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median	Annual Maximum	
A	≤2	≤10	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>2 and ≤5	>10 and ≤25	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
C	>5 and ≤12	>25 and ≤60	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
National Bottom Line	**12**	**60**	
D	>12	>60	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Value	Ecosystem health		
Freshwater Body Type	Lakes		
Attribute	Total Nitrogen (Trophic state)		
Attribute Unit	mg/m^3 (milligrams per cubic metre)		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median	Annual Median	
	Seasonally Stratified and Brackish*	Polymictic	
A	≤160	≤300	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>160 and ≤350	>300 and ≤500	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
C	>350 and ≤750	>500 and ≤800	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions
National Bottom Line	**750**	**800**	
D	>750	>800	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

* Intermittently closing and opening lagoons (ICOLs) are not included in brackish lakes.

Value	Ecosystem health	
Freshwater Body Type	Lakes	
Attribute	Total Phosphorus (Trophic state)	
Attribute Unit	mg/m^3 (milligrams per cubic metre)	
Attribute State	Numeric Attribute State	Narrative Attribute State
	Annual Median	
A	≤10	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>10 and ≤20	Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrients levels that are elevated above natural reference conditions.
C	>20 and ≤50	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrients levels that are elevated well above natural reference conditions.
National Bottom Line	50	
D	>50	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Periphyton (Trophic state)		
Attribute Unit	mg chl-a/m² (milligrams chlorophyll-a per square metre)		
Attribute State	**Numeric Attribute State (Default Class)**	**Numeric Attribute State (Productive Class[1])**	**Narrative Attribute State**
	Exceeded no more than 8% of samples[2]	**Exceeded no more than 17% of samples[2]**	
A	≤50	≤50	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
B	>50 and ≤120	>50 and ≤120	Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat.
C	>120 and ≤200	>120 and ≤200	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat.
National Bottom Line	**200**	**200**	
D	>200	>200	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.

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

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

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

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

* Based on pH 8 and temperature of 20^0C.

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

Value	Ecosystem health		
Freshwater Body Type	Rivers (below point sources)		
Attribute	Dissolved Oxygen		
Attribute Unit	mg/L (milligrams per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	7-day mean minimum[1] (Summer Period: 1 November to 30th April)	1-day minimum[2] (Summer Period: 1 November to 30th April)	
A	≥8.0	≥7.5	No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites.
B	≥7.0 and <8.0	≥5.0 and <7.5	Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species.
C	≥5.0 and <7.0	≥4.0 and <5.0	Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost.
National Bottom Line	**5.0**	**4.0**	
D	<5.0	<4.0	Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity.

1. The mean value of 7 consecutive daily minimum values.

2. The lowest daily minimum across the whole summer period.

Value	Human health for recreation		
Freshwater Body Type	Lakes and rivers		
Attribute	*E. coli**		
Attribute Unit	*E. coli*/100 mL (number of *E. coli* per hundred millilitres)		
Attribute State	Numeric Attribute State	Sampling Statistic	Narrative Attribute State
A	≤260	Annual median	People are exposed to a very low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating)
		95th percentile	People are exposed to a low risk of infection (up to 1% risk) when undertaking activities likely to involve full immersion.
B	>260 and ≤540	Annual median	People are exposed to a low risk of infection (less than 1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a moderate risk of infection (less than 5% risk) when undertaking activities likely to involve full immersion. 540 / 100ml is the **minimum acceptable state** for activities likely to involve full immersion.
C	>540 and ≤1000	Annual median	People are exposed to a moderate risk of infection (less than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating). People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities likely to involve immersion.
National Bottom Line	1000	Annual median	
D	>1000	Annual median	People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).

*Escherichia coli

Value	Human health for recreation	
Freshwater Body Type	Lakes and lake fed rivers	
Attribute	Cyanobacteria - Planktonic	
Attribute Unit	Biovolume - mm^3/L (cubic millimetres per litre) OR Cell Count - cells/mL (cells per millilitre)	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
	80th percentile*	
A	≤0.5 mm^3/L biovolume equivalent for the combined total of all cyanobacteria OR ≤500 cells/mL of total cyanobacteria	Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with fresh water).
B	N/A	
C	>0.5 and ≤1.8 mm^3/L biovolume equivalent of potentially toxic cyanobacteria OR >0.5 and ≤10 mm^3/L total biovolume of all cyanobacteria	Low risk of health effects from exposure to cyanobacteria (from any contact with fresh water).
National Bottom Line	**1.8 mm^3/L Biovolume equivalent of potentially toxic cyanobacteria OR 10 mm^3/L total biovolume of all cyanobacteria**	
D	Biovolume equivalent of >1.8 mm^3/L of potentially toxic cyanobacteria OR >10 mm^3/L total biovolume of all cyanobacteria	Potential health risks (eg, respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with fresh water).

* The 80th percentile must be calculated using a minimum of 12 samples collected over 3 years. 30 samples collected over 3 years is recommended.

Value	'Swimmability'	
Freshwater Body Type	Lakes, rivers &lake-fed rivers	
Attribute	Water clarity	
Attribute Unit	m	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
	Annual median of samples	
A	≥3	Water clarity is deemed eminently suitable for swimming **
B	≥1.6 and <3	Water clarity is deemed suitable for swimming**
C	≥1.0 and <1.6	Water clarity is deemed marginally suitable for swimming**
Minimum acceptable state	**1.0**	
D	<1.0	Water clarity is deemed unsuitable for swimming**

** Smith & Davies-Colley (1992)

APPENDIX 2. Guiding principles for NOF Attribute Development (NOF Reference Group Meeting, Wellington, 2-3 September 2015)

This section explains the fundamental purpose of attributes in the NOF and the guiding principles that were used to develop them.

The NPS-FM 2014 requires councils to set freshwater objectives and limits in regional plans. The purpose of the NOF is to assist councils with this.

To achieve this requirement of the NPS-FM 2014 all attributes were assessed against guiding principles, some of which are included below, that were divided into five categories. This provided a logical stepwise approach to assess each attribute. In some instances steps will be revisited as this can be an iterative process.

1. Link to the National value
    - Is the attribute required to support the value?
    - Does the attribute represent the value?

2. Measurement and band thresholds
    - Are there established protocols for measurement of the attribute?
    - Do experts agree on the summary statistic and associated time period?
    - Do experts agree on thresholds for the numerical bands and associated band descriptors?

3. Relationship to limits and management
    - Do we know what to do to manage this attribute?
    - Do we understand the drivers associated with the attribute?
    - Do quantitative relationships link the attribute state to resource use limits and/or management interventions?

4. Evaluation of current state of the attribute on a national scale
    - Can we adequately assess the current state of the attribute at a national scale, including the extent, magnitude, and location of failures to meet the proposed bottom line for the attribute?
    - The data is of sufficient quality, quantity and representativeness to assess the current state of the attribute on a national scale.

5. Implications of including the attribute in the NOF
    - What are the socio-economic impacts of implementing the attribute at a national scale?

APPENDIX 3 TLG-CSG process

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
CSG5	Presentation: Freshwater Attributes DM# 3140287v1		
CSG7 **30/31 Oct 2014** **DM# 3208894v5** (workshop notes) **Doc# 3192593** (agenda)	Presentation: Population of a Waikato Objectives Framework (**Doc# 3210866**) TLG suggestion to CSG on attributes **Human health** • *E. Coli* attribute as per NPS-FM NOF • Planktonic Cyanobacteria (also known as blue/green algae) attribute as per NOF to main stem which is influenced by the hydro-lakes, but extend also to include sections of some lowland river tributaries • Water clarity attribute to lakes and rivers (not in NOF) • Narrative statements relating to physical safety and aesthetics (based on Tikanga and Mātauranga Maori) • 'E. coli' attribute sampling statistics – the 'annual median' and '95th percentile' • Considered for narrative attributes for swimmability, linking to traditional knowledge. **Ecosystem health** • Phytoplankton, TN and TP attribute as per NPS-FM to the main stem, but	• Do the attributes for swimming, e.g. *E. coli* apply to all the waterways, and all the time? • What is the process for seeking exemptions from the NPS due to natural factors? For example, peat lakes that are naturally high in N. • Are there lowland lakes with naturally high sediment? • Are all these attributes relevant to our scope? E.g. temperature	Attributes considered out of scope: • Heavy metals • Flows and levels (quantity) • Temperature • Swimming choice factors such as trees with swinging ropes. Attributes within scope: • *E. coli* • Sediment (CSG questioned whether suspended sediment could be used instead of deposited) • Clarity Attributes that *may* be considered: • Light climate (but this could be covered by clarity) • Macrophytes • N and P in small streams

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
	extend the freshwater body type to include sections of some lowland rivers. • Do not apply the Periphyton (attached algae) as per NPS-FM – limited relevance in the Waikato-Waipa catchment • Develop a set of nutrient indicators that could be applied to rivers that are not covered by TN or TP attributes – could be use to identify 'hotspots' or high value areas within FMU • Nitrate & Ammonia (toxicity) attributes as per NPS-FM • Dissolved Oxygen attribute as per NPS-FM, but extend the Freshwater Body Type to include all rivers rather than just below point sources • Develop a "light climate" attribute to lakes and large rivers in the Waikato-Waipa catchment (could be same as Clarity) • Develop a Submerged Macrophyte attribute for rivers • Develop a Deposited Sediment attribute for wadeable rivers • Develop a Temperature attribute for rivers **Mahinga kai**		

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
	• *E. Coli* (likely to be more stringent than swimming) • Cyanobacteria *(shellfish)* • Heavy metals • Catch-Per-Unit-Effort (bands could be linked to different purposes such as individual needs vs hui) Many of the suggested attributes sit outside of the scope of our project (the 4 contaminants). However the panel took a broader view of water quality to provide the CSG with some context of the areas that aren't being covered and provide other projects with information they need to fill the gaps.		
CSG8 **2/3 Dec 2014** **DM#3236781v3** (workshop notes)	Presentation: State of Waikato and Waipa Waterways - Dr Mike Scarsbrook Doc# 3237698 • Overview provided of rivers, land and lakes using last five years of data.	• Data used by the TLG • Could the band status be tracked over 5 year periods? • Trends and variability- is it different for a longer (10 year) period, due to recent droughts in last 2 of 5 years? Is there a trend, especially in relation to changing land use? What is the seasonal variability?	
CSG9 **9/10 Feb 2015** **DM#3286363v2** (facilitation	Presentation: Clarity attribute- Bill Vant DM# 3286338 Report: Waikato Objectives Framework	• Clarity effects in geothermal tributaries • Cumulative effects of Waipa	• In relation to clarity: • a narrative description. i.e: • A= excellent clarity for

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
notes)	Summary of Attributes and recommendations to Collaborative Stakeholder Group DM# 3278995	and Upper Waikato on Lower Waikato • State of tributaries and sources of sediment in them • Actions that can mitigate • How many years samplings are used to assess • Comparison within other rivers nationally • Source paper (national study on water clarity • Want to know what the percentage of people found 1m acceptable (3m instead of 4m for A). • Do we set the excellent at 3m or 4m?	swimming. • B= good clarity for swimming. • C= acceptable clarity for swimming. • D= unacceptable clarity for swimming.
CSG10 **5/6 Mar 2015** **DM#3300658v6** (workshop notes)	Report: Managing for Ecosystem Health in the Waikato River: Interactions between phytoplankton, nutrient availability, flow and temperature DM# 3314981 Presentation: Recap- Waikato Objectives Framework Summary of Attributes DM# 3237698 • Discussion on nutrient-related attributes WOF summary of attributes handed out DM#3278995	• effects of nitrate/ammonia toxicity, and which species are affected at which levels (referred to Nitrate ANZEC guidelines (Chris Hickey)). • where vulnerable/threatened species (to nitrate/ammonia) are located. • Relativity of N and P access to nutrient reports	N & P, monitor in tributaries as well.
CSG12 **4/5 June 2015**	Presentation: Maori attributes – tohu Maori (DM#3427538) Attributes for Healthy Rivers	• What WRC limits and	To adopt the list of attributes as recommended in report (noting

<table>
<tr><th>CSG/Date/DM Ref</th><th>Reports/presentations from TLG</th><th>Further Information Requested by CSG</th><th>CSG Agreements/Recommendations</th></tr>
<tr>
<td>DM#3419983 (workshop notes)
Doc# 3403245 (agenda pack)</td>
<td>could include abundance of native fish and access to the rivers.
Value of swimming is generally less of a focus in iwi plans than mahinga kai
Cultural Health Index is popular in the North Island
<u>Paper</u>: Water Quality Attributes for Healthy River: Wai Ora Plan Change (DM#3411171)
Recommendations from the TLG on the suite of attributes applicable to the Plan Change
Justification for the possible exclusion of a number of attributes.
<table>
<tr><th>Value</th><th>Attribute</th><th>TLG recommendation</th></tr>
<tr><td>Human Health</td><td>E. coli</td><td>Include as previously recommended</td></tr>
<tr><td></td><td>Clarity</td><td>Include with modified A-B threshold</td></tr>
<tr><td></td><td>Cyanobacteria (planktonic)</td><td>Include in Shallow Lakes FMU only</td></tr>
<tr><td>Ecosystem Health</td><td>Phytoplankton (lakes)</td><td>Include as previously recommended</td></tr>
<tr><td></td><td>TN</td><td>Include as previously recommended. Do not extend to tributaries</td></tr>
</table>
</td>
<td>monitoring are already in place for Dissolved Oxygen and point sources.

CSG to bring back info from networks on:
new information on MCI (not previously presented to the CSG)
new information on N + P as attributes in tributaries (not previously presented to the CSG)</td>
<td>plankton applies to lake-fed rivers)
and DO to be confirmed/reconsidered at a later CSG
and recommend DO, MCI are picked up again in Waikato Regional Plan review process;
and continued monitoring of MCI, N + P in tributaries.
3m A band threshold for clarity selected given there is also a ‘no further degradation’ requirement in place
MCI – recommend this be part of wider review process for Waikato Regional Plan – causative relationship to our 4 contaminants not sufficiently strong.
N+P in tributaries/Waipa – useful to monitor, to manage - but effects present themselves in main stem so set the attribute there.</td>
</tr>
</table>

CSG/Date/DM Ref	Reports/presentations from TLG			Further Information Requested by CSG	CSG Agreements/Recommendations
		TP	Include as previously recommended. Do not extend to tributaries		
		Nitrate	Include as previously recommended		
		Ammonia	Include as previously recommended		
		Macrophytes (Lake SPI)	Do not include		
		Periphyton (rivers)	Do not include		
		Dissolved Oxygen	Include as previously recommended (below point source discharges)		
		Temperature	Do not include		
		pH	Do not include		
		Deposited sediment	Do not include		
		Fish	Do not include		
		Invertebrates (MCI)	Do not include		
	Mahinga kai	*E. coli*	Apply as for Human Health above		
		Faecal coliforms	Do not include (at this stage)		
		Catch-per-unit-effort	Do not include		

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
	<table><tr><td></td><td>Cyanobacteria (planktonic)</td><td>Apply as for Human Health above</td></tr></table>		

CSG13
2/3 July 2015
DM#3439320
(workshop notes)
Agenda Pack
DM#3433551
	<u>Reports</u>
	• Nutrients and phytoplankton (chlorophyll-a) in the Waikato River Agenda Pack Item 7 (DM#3445653)
	• TLG recommendation on the use of Macroinvertebrate Community Index (MCI) as an attribute (DM#3455173)
		• Cause and effect link with the four contaminants.
		• Can increases in N lead to more release of P from sediment? If so, will this influence the nutrient limiting of N and P? →Follow up on when CSG can get bioassay reports.
		• If water clarity improves due to reduced sediment, will this lead to more phytoplankton due to increased light climate? How would the nutrient limiting dynamics be affected by this, either positively or negatively?
		• CSG request that the TLG come back to the CSG with a report on DO as an attribute related to
		• Env/NGO provided a paper on 'MCI as an attribute in the Waikato and Waipa River Catchments' **DM#3458720**
			Follow Up on Attributes **DM#3458965**
			
			Confirmed the following list of attributes:
			Human Health
			• E. coli
			• Clarity- Include with modified A-B threshold
			• Cyanobacteria (planktonic)- Include in Shallow Lakes FMU only
			Ecosystem Health
			• Phytoplankton (lakes and lake-fed rivers)
			• Total Nitrogen
			• Total Phosphorus
			  • Apply proposed TN/TP at mainstream sites
			  • Do not apply A-D bands on TN/TP concentrations at tributary sites
			  • Loads of TN/TP from tributaries are accounted for in the catchment model and individual land users can still be held

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
			responsible via various policy options • Nitrate • Ammonia Mahinga Kai • E. coli- apply as for human health (above) • Cyanobacteria (planktonic) Macroinvertebrate Community Index recommendations: • CSG sees MCI as an important indicator of ecosystem health and want to see it given weight in the wider policy process and monitoring regime. • That it be included in SOE monitoring. • That it be included as part of the Integrated Assessment and Anticipated Environmental Results for HRWO. • It is noted the Waikato Regional Plan review can take into account any changes in NOF from 2016 review Recommendation: TN and TP in tributaries to be reconsidered as attributes once

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
			modelling results are available.
CSG14 **10/11 Aug 2015** **DM#3471459** (workshop notes)	Report: TLG recommendation on the use of Dissolved Oxygen as an attribute for Waikato-Waipa Catchment under WRC Plan Change 1 (**DM#3471897**) • TLG recommends excluding DO as an attribute.		Dissolved Oxygen to be excluded as an attribute

CSG16b
21 Sept 2015
Doc#3510572
(agenda pack)
	Reports:
	• Nutrients reports final package and synthesis DM# 3539475
	  • Summary of the studies that address relationships between N, P and algae in the Waikato River system.
	• TLG response to Lake Type FMU's DM# 3539452
	  • Background information to address CSG questions relating to lakes FMU's management and attributes.		

CSG18 **13/14 Oct 2015** **DM#3577749** (workshop notes)	Presentation: Lakes DM# 3580294 TLG Recommendations: • That there is no decline in the water quality of any lake • That all the lakes are at least above the National Bottom Line for Chlorophyll-a, TN, TP and cyanobacteria		• "No decline" not enough- make the lakes the best they can be • Focus on Chlorophyll-a target (control inputs) • Total N in peat lakes overstates what is available to algae because extractant

CSG/Date/DM Ref	Reports/presentations from TLG	Further Information Requested by CSG	CSG Agreements/Recommendations
	• All the lakes are above the minimum acceptable state for swimming (*E. coli* in B band, clarity above 1m)		measures N in tannin • Ask NOF to consider extractant/TN level for peat lakes so it measures TN in a way that relates to effects in Chlorophyll-a • Peat lakes can only ever be B for P/Chlorophyll-a • Should we set up a process in Plan Change for catchment plans for each lake?
CSG21 **17/18 Dec 2015** **Doc#3637855** (agenda pack)	<u>Report:</u> Setting Water Body Targets and Limits Doc# 3626243 • Summary of the steps CSG and TLG has followed to set attributes and bands for each of the modelled or monitored water bodies in the catchment.		