E. coli, nitrogen, phosphorus and sediment in the Waikato and Waipa rivers

Report for Collaborative Stakeholder Group

Healthy Rivers: Plan for Change/ Wai Ora: He Rautaki Whakapaipai

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Waikato Regional Council
Te Kaunihera ā Rohe o Waikato

Executive summary

This document gives an overview of the current water quality state, trends and contributions of contaminants in the Waikato and Waipa rivers. The focus is on the four main contaminants impacting the rivers: *E. coli*, nitrogen, phosphorus and sediment.

Diagrams are used to illustrate the range of effects increased levels of the contaminants can have on rivers. High levels of microbes can make it unsafe to swim, drink or eat food taken from the river. Increased levels of nitrogen and phosphorus can promote excessive plant growth, including toxic blue green algae. Increased sediment decreases visibility, which can be a safety hazard for swimming as well as affecting aquatic species and their habitat.

A summary of Waikato Regional Council water quality monitoring data is presented for six reaches: Upper Waikato River and tributaries, Lower Waikato River and tributaries, and Waipa River and tributaries. Both state and trend is reported. Data for shallow lakes is report where it is available.

The estimated contribution from a variety of sources is given for each contaminant. This is reported for the Upper Waikato catchment, the Lower Waikato catchment and the Waipa catchment. The sources are described as the inflow from upstream catchments, natural background, point sources and additional contribution from development. The additional contribution from development is only what is produced over and above the natural background level i.e. it is the amount contributed by land use other than trees.

There is a standard in the Waikato Regional Plan for *E. coli* levels for contact recreation. This standard is based on a Department of Health guideline which has since been updated by the Ministry for the Environment/Ministry of Health. Both threshold values are reported in the body of the report.

E. coli levels are excellent in the Upper Waikato River and satisfactory in the Lower Waikato River. The Waipa River and tributaries of the entire catchment have unsatisfactory levels. There is no trend for *E. coli*. The main source of *E. coli* in the Upper Waikato and Waipa catchments is additional contributions from development. The major contribution in the Lower Waikato catchment is from upstream.

Currently there are no thresholds in the Waikato Regional Plan or national guidelines for nitrogen or phosphorus. Waikato Regional Council has developed a reporting threshold based on preventing the excessive growth of nuisance plants.

Nitrogen levels are excellent to satisfactory in the Upper Waikato River and satisfactory to unsatisfactory in the Lower Waikato River. The Waipa River and tributaries for the entire catchment have unsatisfactory levels, as do the shallow lakes. The trend for nitrogen is a general deterioration for every reach of both rivers in the catchment. The main contribution of nitrogen in the Upper Waikato catchment is from natural background, for the Waipa catchment is additional contributions from development, whilst for the Lower Waikato catchment it is from upstream.

Phosphorus levels are excellent to satisfactory in the Upper Waikato River and satisfactory to unsatisfactory in the Waipa River and the Lower Waikato River. The tributaries for the entire catchment have unsatisfactory levels, as do the shallow lakes. The trend for phosphorus shows some improvement for the Upper Waikato River and the shallow lakes and is mixed for the Waipa River and the Lower Waikato tributaries. There is no trend for the Upper Waikato tributaries, the Waipa tributaries, and the Lower Waikato River. The main contribution of phosphorus in the Upper Waikato catchment is from natural background, for

the Waipa catchment it is from additional contributions from development, whilst for the Lower Waikato catchment it is from upstream.

Sediment can be measured in a number of ways. There is a standard in the Waikato Regional Plan for clarity for recreation, and turbidity is a related measure to clarity. Waikato Regional Council has also developed a reporting threshold based on an adequate amount of light for aquatic plants and animals.

Sediment levels are excellent in the Upper Waikato River and satisfactory to unsatisfactory in the Upper Waikato tributaries and the shallow lakes. The Waipa River, the Lower Waikato River and their tributaries have unsatisfactory levels. The trend for sediment is mixed in the Waipa River and the shallow lakes, and is deteriorating to some degree everywhere else. The main contribution of sediment for the entire catchment is additional contributions from development. The Lower Waikato catchment also has a large sediment contribution from upstream.

Contents

List of Figures

List of Tables

1 Introduction

The purpose of this document is to give an overview of the state, trend and contributions of nitrogen, phosphorus, sediment and bacteria in the Waikato and Waipa rivers. The document covers:

- the effect each contaminant can have on waterways
- the state and trend of each contaminant for different reaches of the rivers
- the estimated contributions of each contaminant from different sources.

This document is a summary of existing knowledge in technical reports and Waikato Regional Council (the council) monitoring data. It is intended to increase the level of understanding about each of the contaminants and the effects they are having on the rivers.

2 Interpretation

This section provides context for the effects, state, trends and contribution information provided in subsequent sections. These concepts apply to all four contaminants. Concepts specific to each contaminant are discussed in the respective sections.

2.1 Reaches of the river

A description of the geographical extent of the river reaches and shallow lakes, with the number of data collection sites contained in each reach is outlines in Table 1.

River reach or shallow lake	Description	Number of monitoring sites
Upper Waikato	From Huka Falls to Karapiro Dam	5
Upper Waikato tributaries	Tributaries streams entering the Upper Waikato River	12
Lower Waikato	From Karapiro Dam to Port Waikato	5
Lower Waikato tributaries	Tributaries streams entering the Lower Waikato River (excluding the Waipa River)	26
Waipa	From the headwaters to the confluence with the Waikato River at Ngaruawahia	5
Waipa tributaries	Tributaries streams entering the Waipa River	11
Shallow lakes	5 peat lakes - Ngaroto, Rotokauri, Rotomanuka, Rotoroa, Kaituna 3 riverine lakes - Whangape, Waahi, Waikare	20 for state 8 for trend

Table 1: Description and the number of monitoring sites contained in each reach of the river and shallow lake

See Appendix 1 Figure 6 for a map of the catchments.

2.2 Effect diagrams

The effect diagrams, or tree diagrams, are intended to show what effects can occur when there are increased levels of each of the contaminants. The diagrams illustrate the consequential impacts of increased contaminants, which result in negative effects on river attributes. The diagrams help start the conversation around "if we manage contaminant Q we could have better outcomes for attributes X, Y and Z". This information is intended to increase general awareness and understanding around why increases of these contaminants are concerning, and are not based on monitoring data i.e. the diagrams show what can happen when contaminant levels increase.

2.3 State

Data for the current state of the Waikato and Waipa rivers and the shallow lakes in the catchment is reported as a 5 year median over monitoring sites, for the period 2008-2012.

2.4 Trends

Data for the trends of the Waikato and Waipa rivers is for the period 1993-2012, and 2002-2012 for the shallow lakes. See Table 2 for definitions used for each trend class.

Trend class	Description
no change	little or no change
general improvement	more than half of sites improved
some improvement	less than half of sites improvement
mixed	some sites improved, some sites no change, some sites deteriorated
some deterioration	less than half of sites deteriorated
general deterioration	more than half of sites deteriorated

Table 2: Definitions of trend class

2.5 Contributions

Results reported in this document present an initial Waikato Regional Council assessment of the relative contributions of contaminants from different sources. It is anticipated that more analysis of contributions will be undertaken. The relative contribution of contaminants was derived from a mix of methods, using an accounting/mass budgeting approach. Data for the total load in the rivers is measured by collecting samples from the river, as is the load contributed from each large point source discharge. The point source amount is subtracted from the total amount, leaving the contribution from natural background and additional contributions from development remaining, which are calculated.

All land naturally produces diffuse discharges of *E. coli*, nutrients and sediment. When the land is developed and used for purposes other than trees, such as for towns or farmland, it produces discharges in addition to its natural background levels. The natural background value is based on the amount of contaminants discharged from forested areas and is calculated based on land area. It is assumed that plantation forestry and indigenous vegetation contribute the same amount of contaminants. The additional contribution from development is only what is produced over and above the natural background level i.e. it is

the amount contributed by land use other than trees. See Figure 1 for a diagram illustrating natural background discharges from developed land.

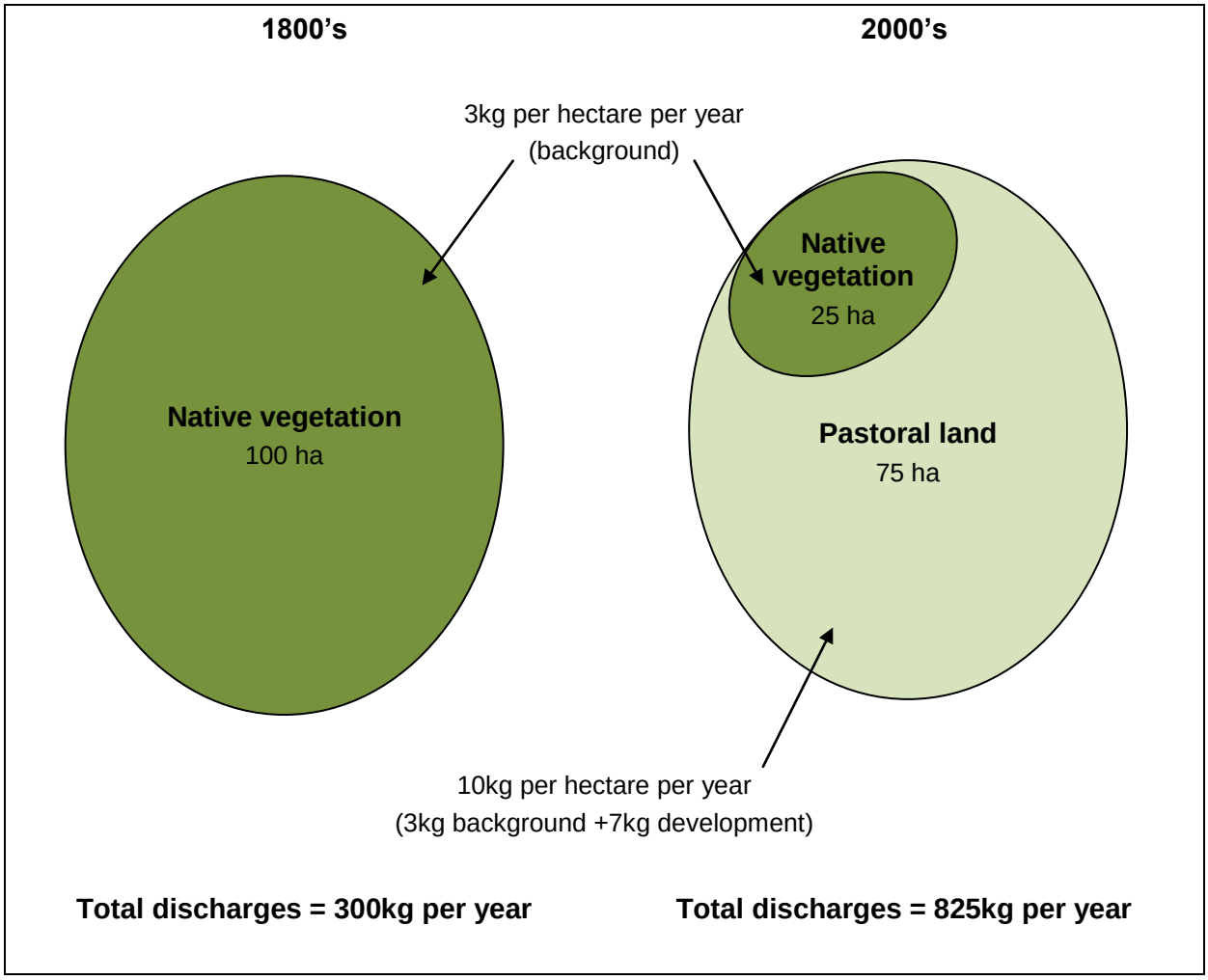

Figure 1: Example of natural background discharges and increases from development

In the example above the natural background discharge produced by native vegetation 200 years ago was 3kg per hectare per year. Over an area of 100ha this would result in 300kg of discharges per year. As the land was developed discharges increased above the natural background. So now, in addition to the 300kg per year of natural background (made up of 75kg from the native vegetation area and 225kg from the pastoral land area), the land discharges an additional 7kg per hectare from the 75ha of development. This additional contribution is 525kg. Combined, the 100ha now discharges 825kg.

The definition for each type of discharge and what it includes is contained in Table 3.

Type of discharge	Definition
inflow from upstream catchments	Load carried by water coming from upstream. Upstream of Upper Waikato = Lake Taupo Upstream of Waipa = n/a as this is the headwaters Upstream of Lower Waikato = Lake Taupo, Upper Waikato and Waipa This data is measured.
natural background	The base rate for the entire catchment. The load that would have been emitted from the catchment before it was developed ≈ 200 years ago and covered in vegetation. This is worked out on the area of the catchment, and includes plantation forestry, indigenous vegetation and the natural background for developed land, as they all are considered to have the same levels of discharges per unit area. This amount is calculated, and a change in the absolute number attributed to this will therefore change the additional contributions from development.
point sources	Moderate to large discharges that enter the waterways through a specific point eg a pipe. This includes municipal sewage and industrial discharges e.g. meat works, pulp and paper mill etc. This data is measured.
additional contributions from development	Diffuse source discharge from different land uses. Only the amount over the natural background is recorded against a land use. This is the manageable load. The 'natural' load emitted for that area of land is recorded under natural background. This includes stormwater runoff from urban areas, and runoff and leaching from pastoral land, arable land and horticulture. This amount is calculated.

Table 3: Contributions that have been calculated and a definition of what is included in each discharge type

Changing the amount associated with the background contribution would consequentially change the contribution of the additional contribution from development, as that is the last remaining amount when subtracted from the total load (point sources amount would not alter, as they are measured).

Contributions for nitrogen and phosphorus are reported quantitatively, whilst microbes and sediment qualitatively. The reason for this is connected to the nature of microbes and sediment; they are harder to assess, determine sources, determine transport methods and therefore to determine accurate measurements for contributors. Nitrogen and phosphorus are more easily modelled and can therefore be recorded as a numerical value.

3 *E.coli*

E. coli bacteria have been used as an indicator of the human health risk from harmful micro-organisms present in water. *E. coli* occurs widely in the faeces of warm-blooded animals, and at a high enough level to be easily and inexpensively measured by water sampling (Ritchie and Donnison, 2010).

Recreation, food gathering and drinking water can be affected by microbial contamination. Contact recreation is defined in the Ministry for the Environment/Ministry of Health guideline (2003, pg J2) as "recreational activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water". The standard in the Waikato Regional Plan for contact recreation is a median value of 126 *E. coli*/ 100mL, with no single-sample maximum exceeding 235 *E. coli*/ 100mL (Waikato Regional Council, 2007). This standard was based on a Department of Health guideline (1992), which has now been updated. The current Ministry for the Environment guideline is a sample 95th percentile less than 550 *E. coli*/ 100mL (Ministry for the Environment/Ministry of Health, 2003).

Using a different threshold can change whether a location meets or fails the standard. The Waikato Regional Plan threshold (based on the 1992 Ministry for the Environment guideline) is used for the "state" column in Table 4 below, while the new threshold is used in the "contact recreation guideline met" column. Some reaches of the river might meet the Waikato Regional Plan threshold, but fail to meet the 2003 Ministry for the Environment/Ministry of Health guidelines.

The nature of the new guideline is an 'all-or-nothing' approach; the guideline is either met, or it is not. This is different to the clarity measurement, which is the other variable measured for contact recreation, which is a single sample approach. All river samples can be considered, and the percentage of times the guideline is met can be recorded.

Microbes can also affect food taken from contaminated waterways. Ready-to-eat foods are defined as in the Food Standards as "food that is ordinarily consumed in the same state as that in which it is sold or distributed and does not include nuts in a shell and whole, raw fruits and vegetables that are intended for hulling, peeling or washing by the consumer" (FSANZ, 2001, pg 1). Watercress is at risk of contamination as washing the leaves as a preparation method does not significantly reduce the risk of contamination (NIWA, 2010).

Shellfish bio-accumulate pathogens (Donnison and Ross, 1999) but it is considered that boiling effectively removes this risk. However, some pathogens can survive steaming and marinating (Abad et. al., 1997; Hewitt and Greening, 2004; 2006). The guideline for microbial levels for shellfish gathering is very low, at 14 faecal coliforms/100 mL and not more than 10% of samples exceeding 43/100 mL over the shellfish gathering season (Ministry for the Environment/Ministry of Health, 2003). This is based on consumption of raw shellfish, however kaaeo/kaakahi are typically cooked before eating (Paul, 1996), which reduces the risk of illness (NIWA, 2010). Fish are unlikely to pose a health risk as fin fish are gutted and then heated to temperatures that kill pathogens. Whitebait are cooked without gut removal, but are typically fried at high temperatures and are caught as they are entering the river system from the sea (NIWA, 2010).

The drinking water standard is less than one *E. coli*/ 100 mL (Ministry of Health, 2008). Drinking water is treated in all urban areas. However, in rural areas water may not be treated sufficiently and so could pose human health risks (Eberhart-Philips et al., 1997; Till and McBride, 2004; NIWA 2010). Contaminated water can also affect stock drinking water (Waikato Regional Council, 2014a).

Thresholds for microbial levels are the same regardless of the characteristics of a particular reach of the river. This is because the level is set based on the effect the contaminants would have on humans, and it would not matter if you are swimming in a hydro lake in the Upper Waikato or in the floodplains of the Lower Waikato, the acceptable level of contaminants a bather is exposed to does not change. This also applies for food gathering and drinking water thresholds.

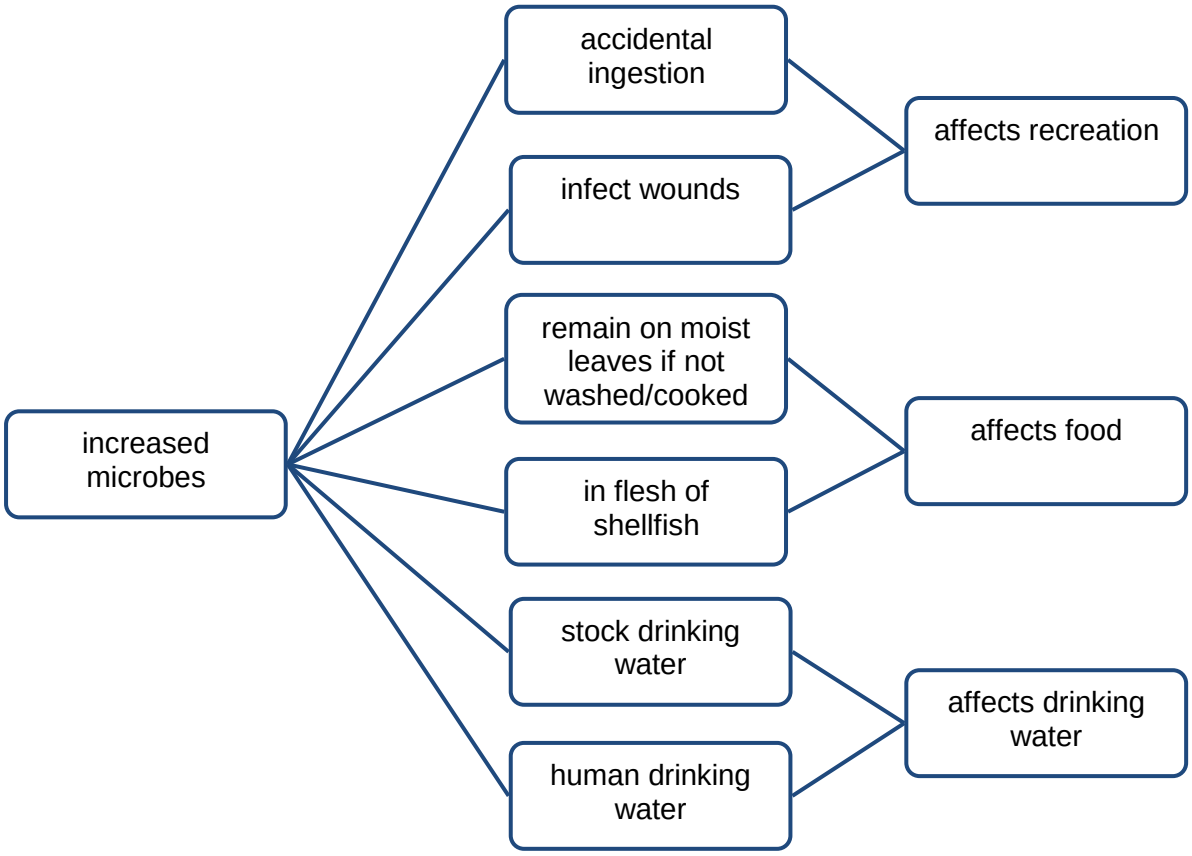

Figure 2: Diagram showing the effects increased levels of *E. coli* can have on river attributes
Sources: PCE, 2012; Waikato Regional Council, 2008

Where	Median number per 100mL	State[1] Satisfactory < 126 Excellent < 13	95th percentile number per 100mL Guideline met < 550	Contact recreation guideline met[2]	Trend 1993-2012	Source contribution
Upper Waikato River	5	excellent	60	yes	no change	Upstream contribution - small Natural background - moderate Point sources - small Additional contribution from development- large
Upper Waikato tributaries	160	unsatisfactory	1600	no	no change	
Waipa River	300	unsatisfactory	2600	no	no change	Upstream contribution - n/a Natural background - moderate Point sources - moderate (?)[3] Additional contribution from development - large
Waipa tributaries	250	unsatisfactory	1900	no	no change	
Lower Waikato River	90	satisfactory	2030	no	no change	Upstream contribution - large Natural background - moderate Point sources - small (?) Additional contribution from development - moderate
Lower Waikato tributaries	620	unsatisfactory	6300	no	no change	
Shallow lakes	no data	no data	no data	no data	no data	no data

Table 4: State, trends and contributions data for E. coli in the Waikato and Waipa River catchments

Sources:
State
Upper Waikato River and Lower Waikato River: Tulagi, 2013b
Upper Waikato tributaries, Lower Waikato tributaries, Waipa River and Waipa tributaries: Tulagi, 2013a[4]

Trends
Vant, 2013b

Shallow lakes
Vant, 2012

[1] Waikato Regional Plan (2007) contact recreation standard, based on the 1992 Department of Health guideline
[2] 2003 Ministry for the Environment/Ministry of Health guideline
[3] Question mark indicates contributions data has a lower level of confidence.
[4] Data from two NIWA Waipa River monitoring sites have also been included, see #2318569

4 Nutrients – nitrogen and phosphorus

Nitrogen and phosphorus are naturally occurring elements in the environment and are essential for plants to grow. They only become contaminants when the amounts are so concentrated that they have negative effects on the environment i.e. an overfertilisation of the waterway. These effects can be in the form of unwanted weed and algae growth, or, at very high concentrations of nitrogen, toxicity to organisms and drinking water. Nitrogen commonly occurs in water in two forms: nitrate and ammonia, and phosphorus exists mainly as phosphate (PCE, 2012).

At the time of writing this document there were no national thresholds for nitrogen or phosphorus levels. Waikato Regional Council's current approach for reporting levels of nutrients was developed as a starting point to enable the council to communicate the state of the rivers. Thresholds for nitrogen and phosphorus are currently the same regardless of the characteristics of a particular reach of the river. This approach may be reviewed during the limit setting process. The same level of nitrogen or phosphorus will affect different environments in different ways. For example, the hydro dams result is the Waikato River being broken into a series of lakes. The reduction in the movement of the water in the lakes gives algae and aquatic plants more time to grow. The effect of an increase in nitrogen in the hydro lakes will have different effects to the same increase in nitrogen in a free flowing section of the river.

An increase in nutrients can result in the growth of algae at such high rates that river clarity and colour is affected. This has implications for visual aesthetics, aquatic habitat and recreation. The contact recreation guideline is >1.6m horizontal sighting range (Ministry for the Environment, 1994). Clarity is a much more stringent measure to meet than changes in colour, so if clarity is managed then changes in colour measures should be satisfactory.

5 Nitrogen

Currently there are no national guidelines for nitrogen. The council has developed an approach for state of the environment reporting which is based on the upper quartile nitrogen values for 77 New Zealand rivers in NIWA's National Water Quality Network (after Smith and Maasdam 1994). These apply to waterways for the entire Waikato region. The levels are:

- unsatisfactory >0.5 g/m^3
- satisfactory <0.5 g/m^3 (based on the upper quartile values)
- excellent <0.1 g/m^3 (based on the lower quartile values).

To prevent excessive growth of nuisance plants, the council considers total nitrogen levels in water should be less than 0.5 grams per cubic metre.[5]

[5] Waikato Regional Plan, Chapter 3.10 Lake Taupo Catchment, Objective 1 states that: The effects of nutrient discharges in the catchment are mitigated such that by 2080 the water quality of Lake Taupo is restored to its 2001 levels as indicated by: mean 70.3mg/m^3 Total Nitrogen, standard deviation 19.1 (Waikato Regional Plan, 2007). This equates to approximately 0.07g/ m^3 Total Nitrogen, and would therefore fall into the excellent category in the above classification.

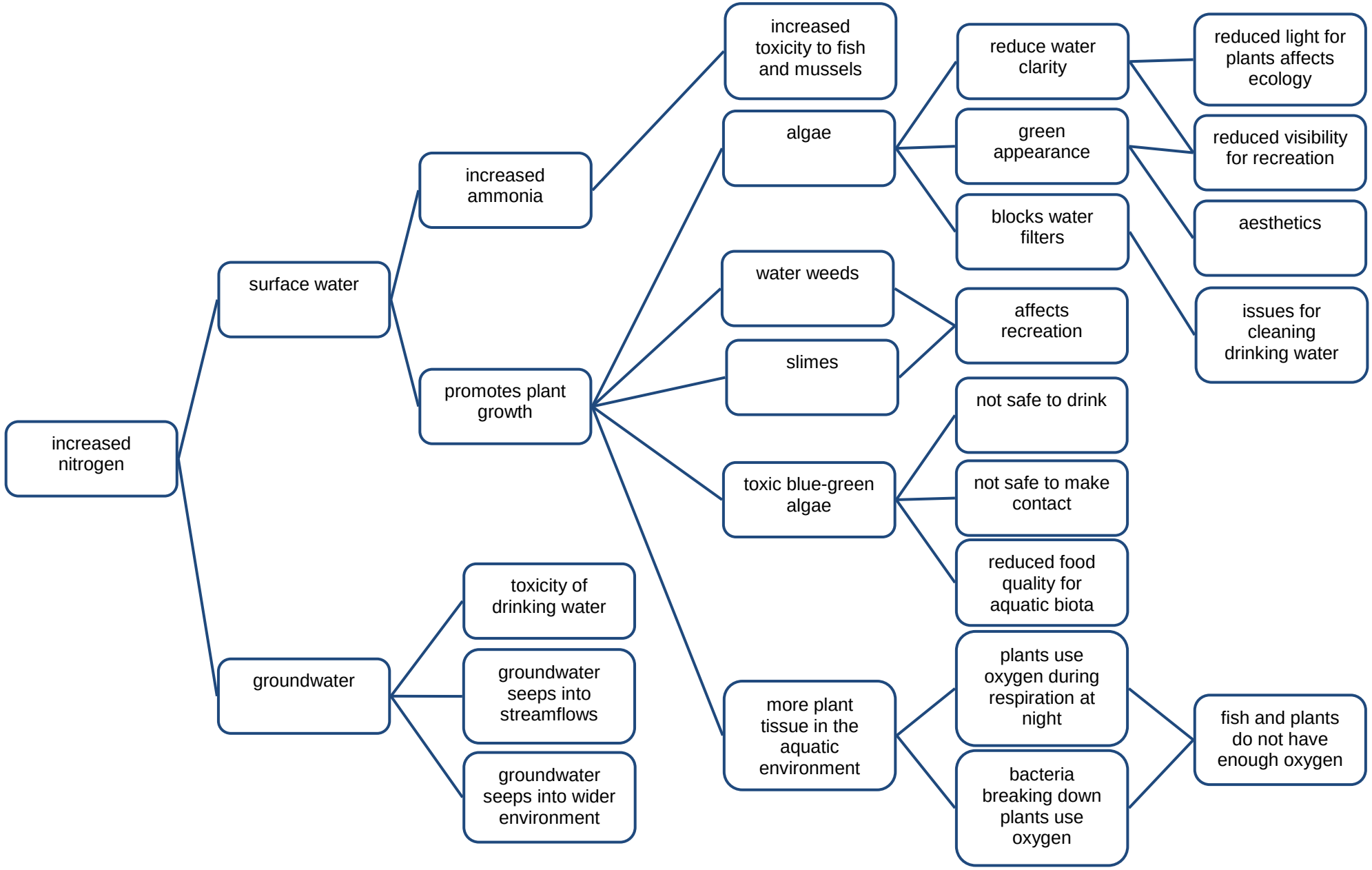

Figure 3: Diagram showing the effects increased levels of nitrogen can have on river attributes
Sources: PCE, 2012; Waikato Regional Council, 2008

Where	average grams per m^3	State Satisfactory < 0.5g/m^3 Excellent < 0.1 g/m^3	Trend 1993-2012 for rivers 2002-2012for lakes	Source contributions
Upper Waikato River	0.220	excellent to satisfactory	general deterioration (1.7% p.a.)	Upstream contribution - 12% Natural background - 50% Point sources - 7% Additional contribution from development- 31%
Upper Waikato tributaries	1.330	unsatisfactory	general deterioration (3.4% p.a.)	
Waipa River	0.820	unsatisfactory	general deterioration (1.5% p.a.)	Upstream contribution - n/a Natural background - 25% Point sources - 3% Additional contribution from development - 73%
Waipa tributaries	1.050	unsatisfactory	some deterioration (0.9% p.a.)	
Lower Waikato River	0.680	satisfactory to unsatisfactory	general deterioration (1.4% p.a.)	Upstream contribution - 63% Natural background - 9% Point sources - 5% Additional contribution from development- 23%
Lower Waikato tributaries	1.950	unsatisfactory	some deterioration (0.6% p.a.)	
Shallow lakes	1.65	unsatisfactory	general deterioration	

Table 5: State, trends and contributions data for total nitrogen in the Waikato and Waipa River catchments

Sources:
State
Upper Waikato River and Lower Waikato River: Tulagi, 2013b
Upper Waikato tributaries, Lower Waikato tributaries, Waipa River and Waipa tributaries: Tulagi, 2013a[6]

Trends
Vant, 2013b

Shallow lakes
Vant, 2012

[6] Data from two NIWA Waipa River monitoring sites have also been included, see #2318569

6 Phosphorus

Currently there are no national guidelines for phosphorus. The council has developed an approach for state of the environment reporting which is based on the upper quartile phosphorus values for 77 New Zealand rivers in NIWA's National Water Quality Network (after Smith and Maasdam 1994). These apply to waterways for the entire region. The levels are:

- unsatisfactory >0.04 g/m^3
- satisfactory <0.04 g/m^3 (based on the upper quartile values)
- excellent <0.01 g/m^3 (based on the lower quartile values).

To prevent excessive growth of nuisance plants, the council considers that total phosphorus levels in water should be less than 0.04 grams per cubic metre[7].

[7] Waikato Regional Plan, Chapter 3.10 Lake Taupo Catchment, Objective 1 states that: The effects of nutrient discharges in the catchment are mitigated such that by 2080 the water quality of Lake Taupo is restored to its 2001 levels as indicated by: mean 5.57mg/m^3 Total Phosphorus, standard deviation 1.4 (Waikato Regional Council, 2007). This equates to approximately 0.005g/ m^3 Total Phosphorus, and would therefore fall into the excellent category in the above classification.

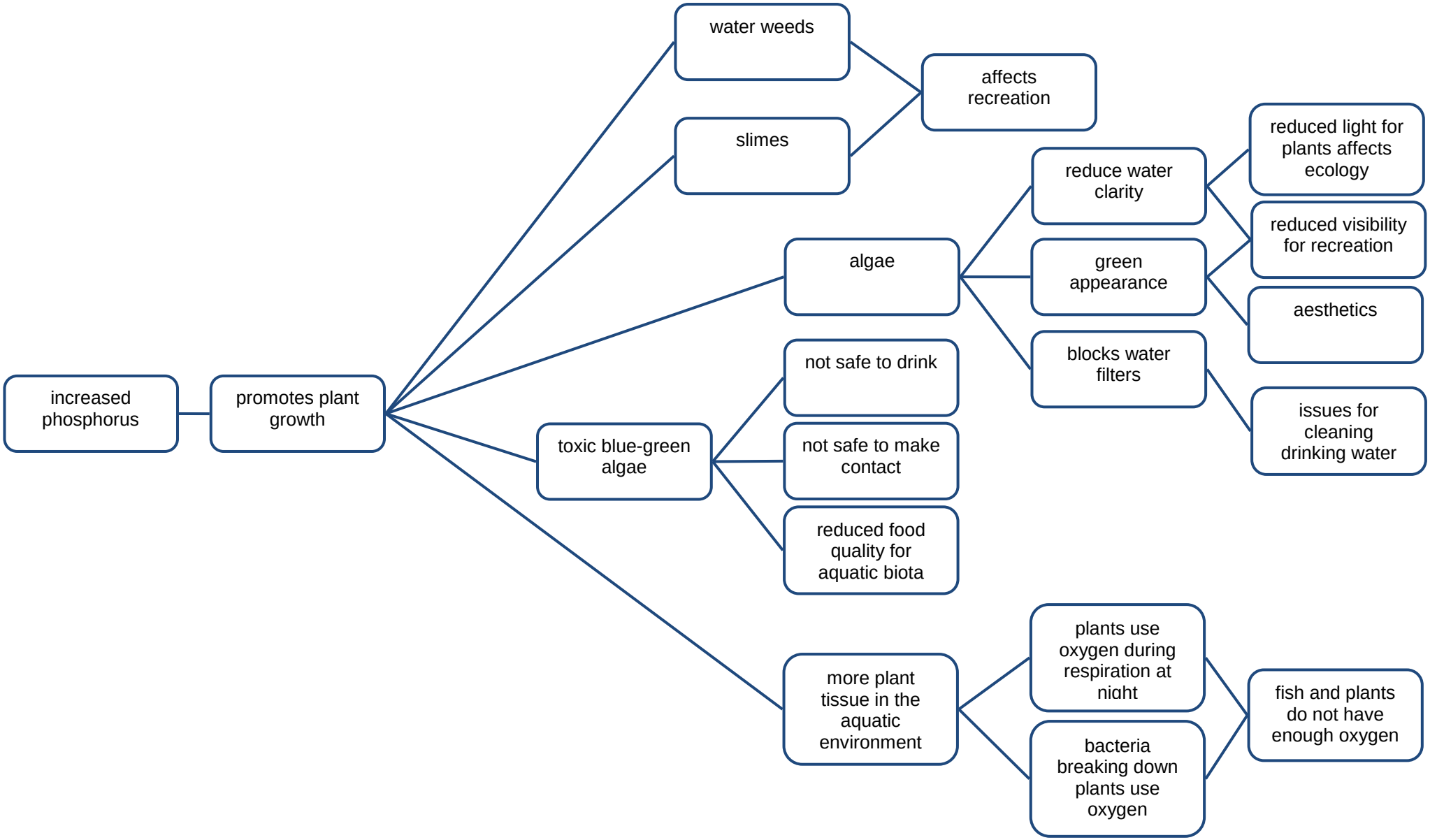

Figure 4: Diagram showing the effects increased levels of phosphorus can have on river attributes
Sources: PCE, 2012; Waikato Regional Council, 2008

Where	average grams per m^3	State Satisfactory < 0.04 g/m^3 Excellent < 0.01 g/m^3	Trend 1993-2012 for rivers 2002-2012 for lakes	Source contributions
Upper Waikato River	0.021	excellent to satisfactory	some improvement (-0.6% p.a.)	Upstream contribution - 13% Natural background - 55% Point sources - 10% Additional contribution from development - 22%
Upper Waikato tributaries	0.096	unsatisfactory	no change	
Waipa River	0.049	satisfactory to unsatisfactory	mixed	Upstream contribution - n/a Natural background - 30% Point sources -7% Additional contribution from development - 61%
Waipa tributaries	0.080	unsatisfactory	no change	
Lower Waikato River	0.057	satisfactory to unsatisfactory	no change	Upstream contribution - 51% Natural background - 9% Point sources -14% Additional contribution from development- 26%
Lower Waikato tributaries	0.130	unsatisfactory	mixed	
Shallow lakes	0.120	unsatisfactory	some improvement	

Table 6: State, trends and contributions data for total phosphorus in the Waikato and Waipa River catchments

Sources:
State
Upper Waikato River and Lower Waikato River: Tulagi, 2013b
Upper Waikato tributaries, Lower Waikato tributaries, Waipa River and Waipa tributaries: Tulagi, 2013a[8]

Trends
Vant, 2013b

Shallow lakes
Vant, 2012

[8] Data from two NIWA Waipa River monitoring sites have also been included, see #2318569

7 Sediment

Erosion is a natural process, and even clear waterways can turn brown during flood events. However, the clearing of trees from land, and the intensity of some land uses on particular soil types, has meant that the amount of erosion, and the associated load of sediment entering waterways, has increased to a point which has negative effects on the environment. Sediment is also a major source of phosphorus (discussed in section 6 above) as phosphate sticks to particles of soil and is carried into water (PCE, 2012).

Sediment can be measured in a number of ways. The measure used here is NTU (Nephelometric Turbidity Units) which measures the turbidity of water, reflecting the amount of suspended sediment in the water (Waikato Regional Council, 2014b). The threshold used by the council for reporting is <5 NTU. This is the amount needed for adequate light for aquatic plants and animals and is based on the results of a study on the adverse effects of low levels of underwater light in some South Island streams (see Davies-Colley et. al. 1993 and Quinn et. al. 1993).

The Ministry for the Environment 1994 contact recreation guidelines are based on a measure that is related to turbidity: clarity. As mentioned in Section 4 Nutrients, the threshold for clarity is >1.6m horizontal sighting range (Ministry for the Environment, 1994). This measurement is done by black disc[9], and broadly speaking this corresponds to a low to moderate level of turbidity. For example, in the Upper Waikato River it typically corresponds to a turbidity of 2 to 3 NTU. The nature of black disc measurement means a single sample approach can be taken, meaning that every sample can be considered, and the percentage of time the samples meet the guideline can be recorded. This is not the case for *E. coli*, which is the other contact recreation measure. The standard in the Waikato Regional Plan (2007) is also >1.6m black disk horizontal visibility.

Thresholds for clarity are the same regardless of the characteristics of a particular reach of the river. This is because the level is set based on the effect the contaminants would have on humans, and it would not matter if you are swimming in a hydro lake in the Upper Waikato or in the floodplains of the Lower Waikato, the acceptable level of visibility, and conversely safety risks, should not change.

[9] Clarity is measured using a black disc attached to a tape measure, and an underwater viewing box (Waikato Regional Council, 2014b).

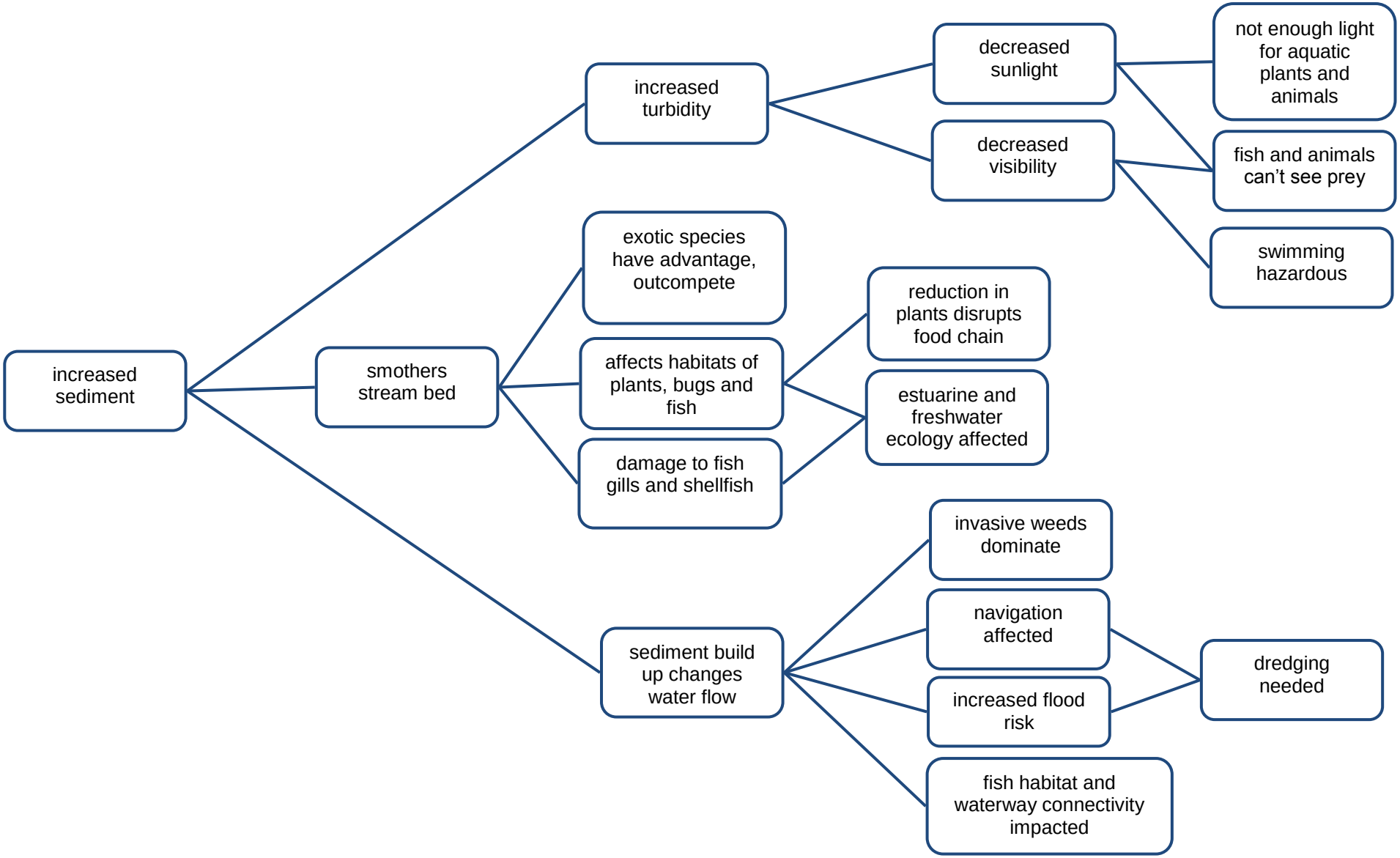

Figure 5: Diagram showing the effects increased levels of sediment can have on river attributes

Sources: PCE, 2012; Waikato Regional Council, 2008

Where	average NTU	State Satisfactory < 5 Excellent < 2	% of time contact recreation guideline met[10]	Trend 1993-2012 for rivers 2002-2012for lakes	Source contributions
Upper Waikato River	1	excellent	75%	general deterioration (1.4% p.a.)	Upstream contribution - moderate Natural background - moderate Point sources - small Additional contribution from development - large
Upper Waikato tributaries	7	satisfactory to unsatisfactory	15%	some deterioration (0.6%)	
Waipa River	9	unsatisfactory	35%	mixed	Upstream contribution - n/a Natural background - moderate Point sources - small Additional contribution from development - large
Waipa tributaries	12	unsatisfactory	25%	some deterioration (1.1% p.a.)	
Lower Waikato River	8	unsatisfactory	10%	general deterioration (1.1% p.a)	Upstream contribution - large Natural background - moderate Point sources - small Additional contribution from development - large
Lower Waikato tributaries	27	unsatisfactory	10%	some deterioration (1.8% p.a.)	
Shallow lakes	≈ 5.0[11]	satisfactory to unsatisfactory	15%	mixed	

Table 7: State, trends and contributions data for sediment in the Waikato and Waipa River catchments

Sources:
State
Upper Waikato River and Lower Waikato River: Tulagi, 2013b
Upper Waikato tributaries, Lower Waikato tributaries, Waipa River and Waipa tributaries: Tulagi, 2013a[12]

Trends
Vant, 2013b

Shallow lakes
Vant, 2012

[10] Waikato Regional Plan (2007) contact recreation standard, based on the 1994 Ministry for the Environment guideline
[11] Estimated from Secchi disc depth
[12] Data from two NIWA Waipa River monitoring sites have also been included, see #2318569

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Appendix 1

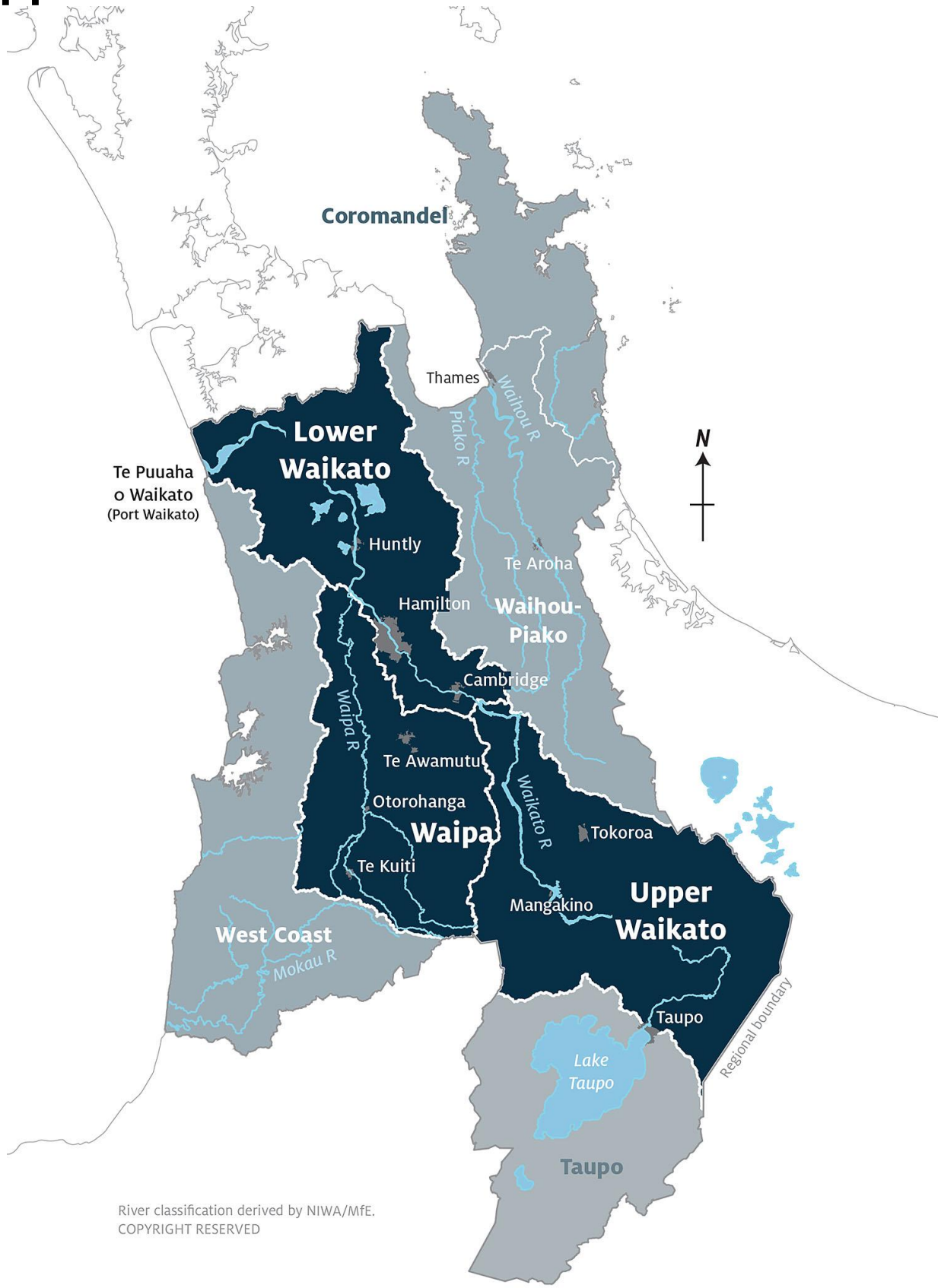

Figure 6: Map of the Waikato and Waipa River catchment