BEFORE THE HEARINGS PANEL

IN THE MATTER **of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council**

SECTION 42A REPORT OF MR BARRY WILLIAM GILLILAND ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. INTRODUCTION

Qualifications and experience

1. My name is Barry William Gilliland. I am employed as a Policy Advisor within the Policy Team at Horizons Regional Council.

2. I hold a Bachelor of Technology (Biotechnology) Hons (1975).

3. I have 34 years experience working for Horizons and its predecessor authorities in the area of resource management.
   i. 2003 to now – Member of the Policy Team contributing to Horizons' regional and corporate planning and providing water quality assistance to the Science Team. One of my responsibilities in this role is to manage Horizons' "swimming spot" programme.
   ii. 1990 to 2003 – Manager at Horizons overseeing the laboratory, consents, compliance and science teams at Horizons and its predecessor authorities.
   iii. 1975 to 1990 – experience at Horizons and its former authorities as the organisation's lead advisor on water quality matters including: planning, field work, sample analysis, data analysis, reporting and consent conditions. Worked as Team Leader of compliance monitoring team.

4. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Notes. I agree that the overriding duty to the Environment Court expressed in paragraph 5.2.1 of that code of conduct will be treated as a duty to the Hearing Panel.

Scope of evidence

5. The purpose of my evidence is to provide the Hearing Panel with:
   i. A brief historical context for the approach taken to water quality management in the Proposed One Plan.
   ii. A summary of contact recreation information gathered from monitoring "high use" swimming spots in the Region since 2004.
   iii. A summary of information about blue-green algal blooms and management of potential health-risk from toxins in "high-use" recreational lakes in the Region.

2. EXECUTIVE SUMMARY OF EVIDENCE

Historical Context

6. In this section I present evidence about the water quality management journey leading to the approach taken in the Proposed One Plan. That journey began in the Manawatu River catchment with untreated or very poorly treated wastewater being discharged into water bodies in the 1950s.

7. The key water quality issues of concern over this time have been:

1950s and 1960s – "Gross" pollution such as fat, blood and wool from poorly treated and untreated point source discharges.

1970s and 1980s – Sewage fungus growth, oxygen depletion, fish kills and water clarity issues below point source discharges.

1990 to 2000 – Contact recreation health-risk (enterococci and *E. coli*), nutrient enrichment and algal proliferations below point source discharges.

2000 onwards – Sediment, bacteria, nutrients and algal proliferations in all water bodies affected by non-point source discharges, and unresolved issues from some point sources.

8. Water quality management has largely focused on dealing with the effects of point source discharges. There has been a significant improvement in the quality of wastewater discharged by major municipal and industrial dischargers, and a major shift by almost all dairy farmers to discharge dairy shed wastewater onto land rather than into water.

9. It is considered that although there is still potential to improve point source discharges, particularly with regard to nutrient enrichment, the biggest water quality improvements will come from management of non-point sources in the future. These include management of nutrient inputs that support algal proliferations on riverbeds during summer, and the sources of sediment and bacteria entering water bodies following wet weather.

"Swimming Spot" Monitoring

10. In this section I present evidence from the "swimming spot" health-risk monitoring programme. The programme monitors health-risk indicator bacteria at "high use" sites and has been run each summer period since 2004. The key conclusions are:

i. The Region's coastal beaches are low risk in terms of swimmer health-risk.

ii. Swimming in rivers or streams is low risk during low flows, but the water bodies are adversely affected by non-point source discharges after rainfall events.

iii. Although extended low flow periods produce good water quality for swimmers, they also provide favourable conditions for proliferations of potentially toxic cyanobacterial (blue-green algal) mats in the Region's water bodies.

iv. Microbiological water quality is very good in key recreational lakes in the Region, but summer blooms of potentially toxic cyanobacteria (blue-green algae) compromise use.

This supports the approach taken in the Proposed One Plan to manage non-point source contaminants to achieve water quality improvement in the future.

Recreational Lakes – Use and Issues

11. In this section I present evidence obtained during the swimming spot health-risk programme, but specifically related to the blue-green algal proliferations in four high-use recreational lakes and their impact on lake use. The data show that microbiological quality in Lakes Horowhenua, Dudding, Wiritoa and Pauri is very good, but blue-green algae cell densities and toxins can exceed guidelines for their recreational use during summer. The unpredictable nature of blue-green algal blooms compromises the use of these lakes for major events, and in one case threatens the survival of a sailing club.

12. Management of sediment and nutrient inputs to these lakes in the Proposed One Plan appears to be a sensible first step. If this is not done, any remedial work carried out in the lakes themselves will be compromised by continued nutrient replenishment via surface water and/or groundwater inflows from their catchments.

3. EVIDENCE

Historical Context

13. The purpose of this section is to demonstrate that water quality improvement in Horizons' Region is a journey and that the approach proposed in the Proposed One Plan is the next logical step forward. This evidence is presented to assist the Hearing Panel to put the approach taken to water quality management in the Proposed One Plan in context with those taken by Horizons and its predecessor authorities in the past.

14. I use the Manawatu River catchment as a case study. My evidence is based on personal observations from carrying out water quality work and contributing to water quality management in the Manawatu catchment since 1975. For specific technical and

scientific information supporting the approach taken to water quality management in the Proposed One Plan, I refer the Hearing Panel to the evidence of Ms Kate McArthur.

15. The first water quality legislation in New Zealand was the Water Pollution Act 1953. This was administered by the Pollution Advisory Council. At that time wastewater was discharged into water bodies with either no treatment or very basic treatment. The earliest report I have seen about surface water quality in the Manawatu River catchment relates to the state of the lower Manawatu and Oroua rivers in 1957[1]. By today's standards, the report paints a grim picture as the authors describe the very significant impacts of poorly treated or raw discharges entering the Oroua River, Manawatu River and several small water bodies feeding those rivers.

16. The Oroua River downstream of Feilding appears to be the most seriously affected. I include some observational quotes from the report (pages 14 & 15) as examples:

"*At Borthwick's freezing works the brown waste discharge was seen to discolour the whole flow of the river, which appeared grossly polluted."*

"Half a mile below the freezing works the water (at low flow) was very turbid and yellow coloured. There was a very strong smell and pieces of fat were seen on the water surface…The riverbed stones had a thick covering of sewage fungus."

"Above the drain carrying the Feilding Abattoir, woolscour, boiling down works, and septic tank effluents, pieces of sewage fungus were seen floating in the water, which lost most of its turbidity. This point is about 1½ miles below Borthwick's outfall. At the entry point of the waste drain the river water was discoloured red."

"*At the Awahuri Bridge, some 6 miles below Borthwicks, pieces of fat were still visible on the water surface. Mud on the bottom had a high smell."*

17. Observations on the Manawatu River (pages 36 & 37) include:

"*Sewage scum was visible on the water surface about half a mile below the stream* [NB: Palmerston North sewage was discharged into the Mangaone Stream at that time], *while floating sewage particles and pieces of algae were evident in the broad slow moving reach immediately above the Longburn bridge."*

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[1] Ministry of Works, 1957: *Pollution in the Manawatu & Oroua Rivers*. A report produced for the Pollution Advisory Council by the Ministry of Works in co-operation with Health & Marine Depts & D.S.I.R.

"The channel carrying the wastes from the Longburn meat works and the Kairanga Dairy Co enters the Manawatu about 50 yards upstream from the Longburn bridge. Two samples of material from the sludge banks lining this channel were analysed. That from the west side of the channel contained roughly equal parts of grey clay, fat and paunch content while from the east (or river) side contained about three parts sand mixed with fat and paunch contents…Beneath the bridge pieces of fat were seen floating in the water and stranded on the stone embankment. Pieces of sheepskin and mats of wool fibre were caught on sticks and stones as were tendrils of fungus, algae and fatty deposits."

"Below Jackeytown Road, about three miles below Longburn, the water was clear with no smell. The bottom was shingle with silty deposits in quiet areas. Some fat particles were seen on the bottom, but there was no evidence of sludge deposition."

18. I began work at the Manawatu Catchment Board and Regional Water Board in 1975. At that time the Board was building its capacity to implement the Water and Soil Conservation Act 1967. My primary role was to carry out water and wastewater quality sampling, laboratory analysis, and results reporting.

19. Wastewater treatment management at that time can be summarised as follows:

    i. In most cases municipal domestic sewage received some form of primary treatment to remove solids that settled or floated. This was usually done using a sedimentation tank or a large "septic tank." The only exception to this was the Levin sewage treatment plant, which included primary and secondary treatment processes and could be considered the most advanced sewage treatment plant in the Region at that time.

Figure 1. Feilding sewage treatment plant outfall (circa 1980)

ii. Industrial waste was discharged into water after rudimentary primary treatment or no treatment at all. There were many small dairy factories in the Board's area and although some factories irrigated wastewater onto land, milk wastes were often discharged directly into rivers and streams. There were two major freezing works in the Manawatu River catchment, at Longburn and Feilding. These used settling tanks, euphemistically called "savealls," to remove gross solids.

Figure 2. Dairy factory wash water incident - Mangatainoka River (circa 1990)

iii. Dairy shed inspections were just beginning and sheds were often found perched beside water bodies with no treatment of wastewater before entering the stream and often no space for that to happen. The Board's dairy shed inspectors were told that MAF dairy advisors recommended such locations because they provided easy water supply and wastewater disposal options. Although dairy shed wastewater discharges may appear to be of less consequence than major sewage and industrial wastewater discharges, a single discharge and/or the cumulative effects of several discharges on a small stream could cause significant degradation. I recall compliance staff discovering several untreated discharges from dairy sheds into a small water body near Eketahuna during the initial inspection programme in the late 1970s. It was no surprise that this water body was known locally as "Black Creek".

20. The purpose of primary treatment was to remove the easily settleable and floatable solids from wastewater. It was not designed to provide significant removal of fine suspended solids or dissolved oxygen depleting substances (measured as Biochemical Oxygen Demand, BOD). As a consequence, the most pressing water quality issue identified in the late 1970s was degradation of water quality by fine suspended solids and dissolved oxygen depleting substances (BOD) from point source discharges. Water quality below these discharges deteriorated during summer low flows.

21. The main observed impacts on water quality were poor water clarity, sewage fungus[2] growth on river beds and oxygen depletion during summer low flows. This culminated in fish kills due to oxygen depletion in the Mangatainoka River below the brewery outfall (1975), Tokomaru River below a dairy factory outfall (1976) and the Manawatu River south of Longburn as a result of the cumulative effects of five point source discharges (1978 and 1984).

[2] Sewage fungus is the term used for an assemblage of bacteria and fungi that grow in response to organic enrichment.

Figure 3. Sewage fungus "blanket" Tokomaru River (circa 1976)

22. The Board's response was to use water quality standards reported from the international literature (eg. United States Environmental Protection Agency) to formulate conditions for water rights to discharge granted under the Water and Soil Conservation Act 1967. The standards of the time focused on maintaining a healthy trout fishery as, in the absence of any data for indigenous fish species, trout were regarded as the most sensitive indicator species at that time. The conditions imposed on water rights essentially required major dischargers to upgrade treatment plants to a secondary treatment [3] standard, to reduce the amount of suspended sediment and BOD in wastewater discharges. In general, it was not practical to treat dairy factory wastewater in this way and most factories installed land irrigation systems rather than seeking to discharge into surface water.

23. The Board's approach to tackling suspended solids and BOD was largely successful. There were no further fish kills and sewage fungus growth and dissolved oxygen depletion were significantly reduced, but not eliminated. Research carried out by Dr John Quinn, a Massey University PhD student at that time, demonstrated that the presence of simple dissolved organic compounds in some wastewaters (eg. lactose in milk) promoted sewage fungus growth at very low concentrations. I refer the Hearing Panel to Dr Quinn's evidence for further details about his research and advice to the Board during that time. As a consequence of this research, water quality management

[3] Secondary treatment consists of biological processes that remove the soluble organic matter that escapes primary treatment. It also removes more of the suspended solids.

during the late 1980s focused on fine tuning the adverse effects of wastewater discharges on sewage fungus growth in the Manawatu Catchment, especially below Palmerston North and Feilding.

24. Monitoring of dairy shed wastewater disposal systems continued during the 1980s. Dairy farmers basically had two options for dealing with these point source discharges. These were discharge of untreated wastewater onto land, or discharge of treated wastewater from a "standard" two-pond system into a water body. Many dairy sheds were located beside small water bodies and there was insufficient dilution for discharge of treated wastewater into water during low flows, so farmers were often encouraged to use the discharge onto land option. It was also becoming apparent during the late 1980s and early 1990s that the Board's (and then Regional Council's) policy preference was for dairy shed wastewater to be discharged onto land, because of concerns about the cumulative effect of the many dairy shed wastewater discharges in the Manawatu catchment. Compliance staff provided early warning of this to farmers during routine inspections.

25. By the early 1990s, water clarity was improved and sewage fungus was rarely observed below major outfalls after reasonable mixing. However, water quality issues remained because secondary treatment processes did little to reduce bacteria and nutrient concentrations in point source discharges. Water clarity was now good enough to give the casual observer the impression it was safe to swim, but the health risk due to high concentrations of bacteria remained. Although sewage fungus was rarely observed, benthic algae now occupied habitat previously covered by the sewage fungus. This was seen as progress at that time because benthic algae were commonly observed in water bodies unaffected by large wastewater discharges, however, benthic algae also caused issues for river ecology, river users and aesthetics at low river flows wherever it was found.

26. Regional councils were formed in 1989 and the Resource Management Act 1991 was introduced shortly after. This gave regional councils the option of producing Regional Plans that carried statutory weight. In recognition of the issues and importance of the Manawatu River catchment, one of the first Regional Plans completed by Horizons was the *Manawatu Catchment Water Quality Regional Plan* (1998). Where previous decision-making had focused on achieving suitable water quality for maintaining a trout fishery and the aesthetics of the river, the Regional Plan raised the bar by establishing a management regime that sought water quality suitable for contact recreation in almost all water bodies in the Manawatu catchment.

27. Although there were policies and non-regulatory methods relating to non-point source discharges, in practice the primary focus of the Regional Plan and its implementation continued to be the management of point source discharges. Several new water quality standards were introduced. The most challenging were those for enterococci and Dissolved Reactive Phosphorus (DRP). Enterococci was the preferred freshwater contact recreation health-risk bacterial indicator at that time and DRP was considered to be the limiting nutrient for nuisance growths of algae.

28. Policy provisions in the *Manawatu Catchment Water Quality Regional Plan* (1998) also promoted discharges of contaminants to land rather than water. This had been signalled to farmers by compliance staff during dairy shed wastewater disposal inspections prior to the Plan becoming operative. Implementation of this policy resulted in a further shift by dairy farmers from discharge of treated dairy shed wastewater into water to discharge onto land. At the present time only 18 of the 935 (2%) resource consents held for discharge of dairy shed wastewater are for discharge into water, compared with about 50% in the early 1980s. I refer the Hearing Panel to the evidence of Ms Alison Russell for details about the current scale and impact of dairy shed wastewater disposal in the Region. I also refer the Hearing Panel to the evidence of Dr Jon Roygard, which deals with the environmental impact of dairy shed wastewater discharges and how that will be managed through the Proposed One Plan.

29. The Regional Plan acknowledged that much of the cost of achieving improved water quality would fall on point source dischargers. Although many of the standards came into force immediately, the Plan provided for incremental implementation of the more challenging standards to recognise this. The water quality standards for enterococci and DRP effectively required wastewater to be treated to a tertiary standard[4]. The plan was made operative in 1998, but standards for enterococci came into force on 1 June 2004 and those for DRP on 1 June 2009. The purpose of this was to ensure point source dischargers would be able to plan for any improvements to their wastewater treatment facilities required to meet the new standards.

30. Implementation of the Manawatu Catchment Water Quality Regional Plan has resulted in a general improvement in the quality of point source discharges, especially in terms of microbiological quality at low flows. The current state of water quality in the Region is described in Ms Kate McArthur's evidence and, in very general terms I interpret her evidence to show that although there is still potential to improve a number of point

[4] Tertiary treatment includes removal of nutrients such as phosphorus and nitrogen, and practically all suspended and organic matter from wastewater.

source discharges, the largest water quality improvements will come from management of non-point sources in the future. These include management of nutrient inputs considered to support algal proliferations on river beds during summer and the sources of sediment and bacteria entering water bodies following wet weather.

31. The changing and ongoing nature of water quality management is illustrated by the recent identification of blue-green algal mat formation in a number of rivers in the Region during low summer flows, and the health-risk that they may pose to river users. This issue was identified after notification of the Proposed One Plan and has the potential to significantly compromise use of river reaches for both contact and passive recreation. Toxins in these mats can pose a health-risk to river users and their animals, especially dogs. I refer the Hearing Panel to the evidence of Ms McArthur, who addresses this issue.

Figure 4. A new water quality issue: a blue-green algae warning on Mangatainoka River (summer 2008-09).

32. The adverse effects of non-point source pollution were recognised in assessments of background water quality during the 1980s and 1990s, but were put aside in favour of tackling the obvious and significant adverse effects that point source discharges were having on water quality. The Proposed One Plan provides for a more hands-on

management of non-point source pollution, and in my opinion this is the next logical step in the water quality improvement journey for the Region.

"Swimming Spot" Monitoring

33. In this section I provide the Hearing Panel with an overview of the results of Horizons' swimming spot monitoring programme. The results of this programme provide information that supports a greater emphasis on managing the impact of non-point source discharges on microbiological quality on water bodies.

34. The swimming spot programme was started in 2004. The programme runs over the summer period, defined as 1 November to 30 April. Samples are taken weekly. Swimming spots are included in the programme on the basis of advice that they are "high use" sites. That generally means they are sites where the relevant Territorial Authority provide facilities to enhance use.

35. Seawater samples are analysed for enterococci and faecal coliforms. Freshwater samples are analysed for *E. coli*. These bacteria are currently considered the best indicators of microbiological health risk to swimmers. Health risk is assessed using the "traffic light system" generally outlined in the *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (Ministry for the Environment, 2003).

36. My role was to establish this programme and I continue to manage it each year. I have visited the sites on many occasions and have responsibility for reporting results.

37. Horizons has five years of data from this monitoring. The results can be summarised as follows:

    i. Coastal beaches have very good microbiological quality all the time, except for Kai Iwi Beach, just north of Wanganui, which has a higher risk due to combined contamination from the Kai Iwi Steam and Mowhanau Stream after rainfall.

    ii. Swimming spots close to the ranges or with less intensive land use, like the Upper Whanganui River, Pohangina River, Kahuterawa Stream, Tokomaru River and Ohau River, are low risk almost all the time. The risk increases after significant rainfall in the catchment, but only takes a short time to recover (say, 24 rain-free hours).

    iii. Microbiological water quality in the Region's larger rivers, such as the Lower Whanganui River, Rangitikei River, Oroua River and Manawatu River, is very

weather dependent. Rain in the catchment often causes risky water quality for swimming and recovery takes 3-4 rain-free days.

iv. Small coastal streams at Waitarere Beach and Himatangi Beach pose a variable and unpredictable risk to swimmers.

v. The Mowhanau Stream and Kai Iwi Stream, just north of Wanganui, show poor compliance with the guidelines. The Whanganui Public Health Unit has placed a health risk guidance notice at Mowhanau Beach as a precaution, although the Mowhanau Beach community has not reported any significant health effects as a result of existing recreational use.

Figure 5. Health Guidance Notice for Mowhanau Stream at Mowhanau Beach.

vi. Proliferation of blue-green algae (*Phormidium sp*) is being observed on the beds of many rivers. It poses a health-risk to people and animals during periods of extended low flows and causes a strong "musty" smell, eg. Manawatu catchment swimming spots were highly risky throughout the 2008-09 summer due to high percentage cover of *Phormidium sp*.

vii. The health risk from microbiological contamination in Duddings Lake and Lake Wiritoa is very low all the time, but there is a potential health risk from blue-green algae toxins from time to time, and a characteristic "mown grass" odour affects the recreational experience.

viii. Blue-green algal toxin levels in Lake Horowhenua and Lake Pauri are unpredictably variable and exceed the recreational guideline[5] from time to time, which compromises recreational use.

38. The results of the programme combined with my personal observations give me confidence that the following rule of thumb is accurate for swimming in the Region's larger rivers:

"*If it hasn't rained for three or more days and the water looks clean and clear it should be safe to swim*."

39. However, it may also be advisable to now add:

"*If the river bed is stony, beware smelly black slimy growths on stones if it hasn't rained for a few weeks*."

40. The data indicate a strong relationship between water level/flow and health-risk for all the inland freshwater swimming spots monitored in the Region. They generally meet swimming spot guidelines at low flows, but exceed guidelines after rainfall events. I provide a graph of data for the Rangitikei River at Vinegar Hill as an example of this (Figure 6).

[5] Horizons uses a recreational guideline of 20 ug total microcystins/L derived from Chorus and Bartram, 1999: *Toxic Cyanobacteria in Water – A guide to their public health consequences, monitoring and management*. World Health Organisation. (Note: a NZ guideline for managing cyanobacteria in recreational waters is currently in preparation.)

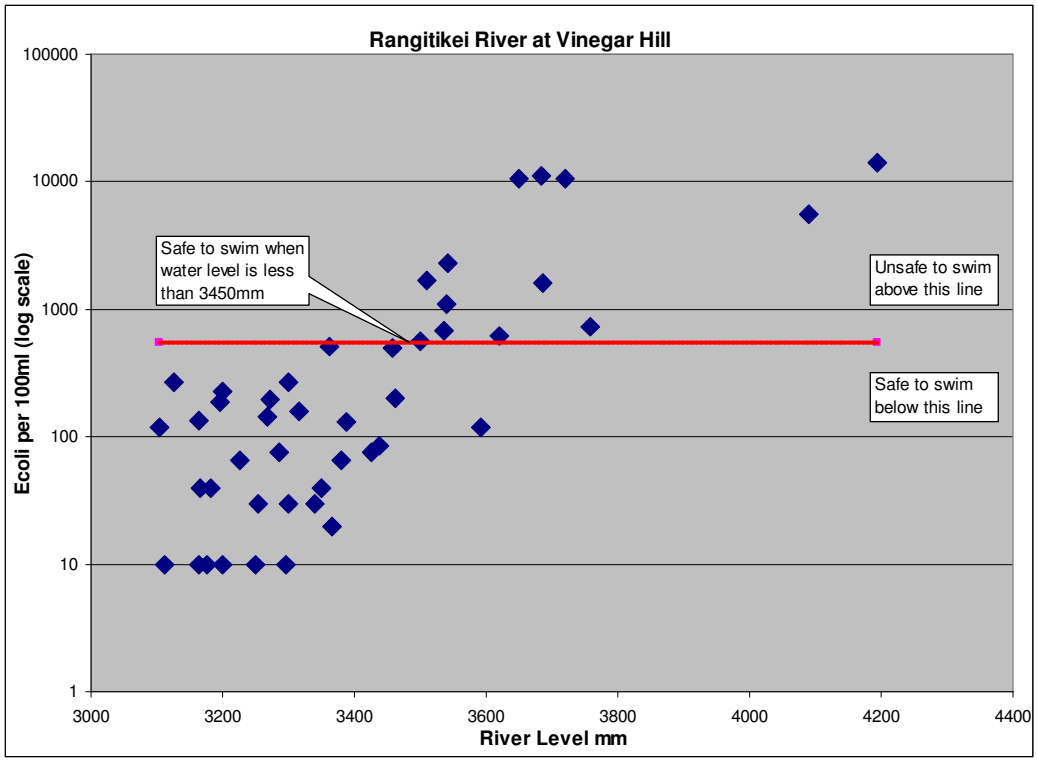

Figure 6. Effect of increasing water level/flow on health risk indicator bacteria *E. coli*

41. This relationship is exploited to provide "real-time" health-risk information for swimmers during summer. Swimmers can telephone Horizons' Waterline Freephone 0508 435 663 or use the website to get the current river level and compare it to a "safe" water level determined from previous monitoring. This means that swimmers know the risk status of the water body before heading off to go swimming.

42. This relationship also has significance as evidence to support water quality management in the Proposed One Plan. *E. coli* are not likely to be coming from point source discharges because swimming spots are generally remote from, and therefore unaffected by, point source discharges. In any case, if *E. coli* were entering rivers from point sources, I would expect the concentration to increase as the water level/flow (and therefore the dilution) decreased. The data show the opposite trend. *E. coli* concentration increases with increasing water level or flow. I interpret that to mean the *E. coli* at swimming spots is derived from non-point sources. This is consistent with my on-site observations that *E. coli* concentrations exceed guideline values after rainfall in a catchment causes elevated water flows and discolouration at swimming spots, so the source of faecal contamination is clearly indirect (see the evidence of Dr Davies-Colley).

43. I also note that overall bacterial water quality in the Region for the 2007-08 summer season was the best observed during the four years of monitoring. The results for some of the more popular swimming spots in the Region are shown in Figure 7. The location of these sites is depicted in Figure 8.

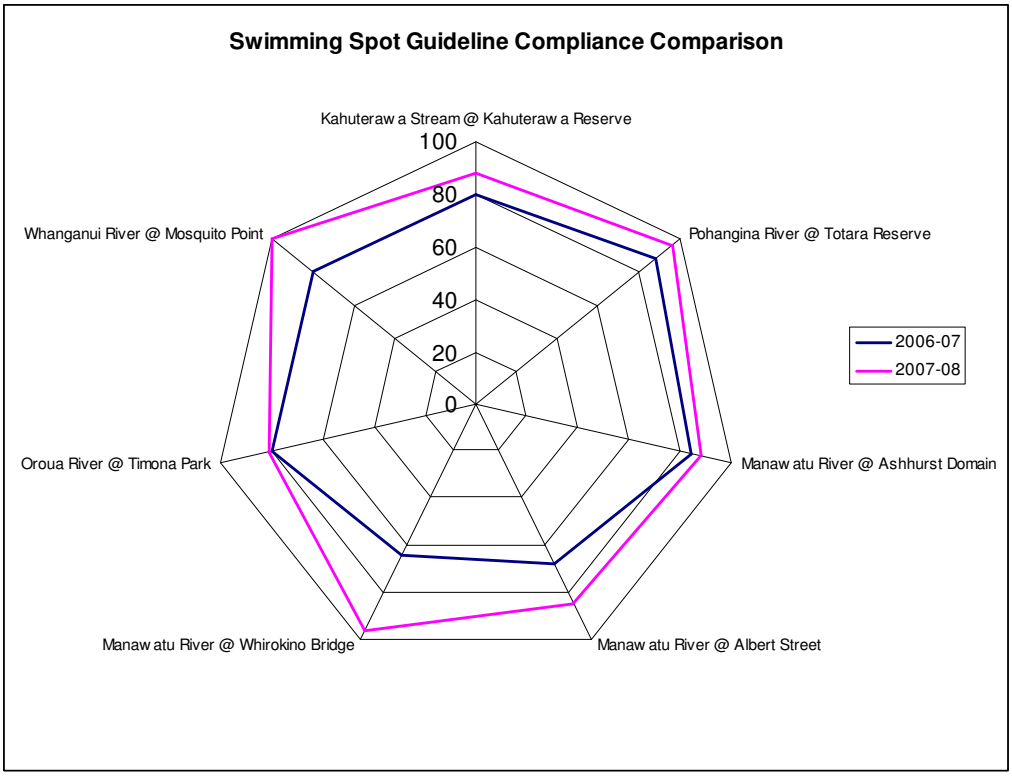

Figure 7. Comparison of swimming guideline compliance for 2006-07 and 2007-08 (Note: The outer ring is 100% compliance, so the bigger the area covered by the data for each year, the better the water quality was for swimming.) See Figure 8 for location map.

44. The average guideline compliance for the rivers shown in Figure 7 is 78% for the 2006-07 summer season and 91% for 2007-08 summer season. In general terms, this would mean the swimming spots were safe for 23 more days in 2007-08 than in the previous summer. I recall that the key difference between the two seasons was the particularly low rainfall experienced in the Region between 1 January and 30 April 2008. Under low rainfall situations, the amount of non-point source discharge is reduced, and in my view this is the reason for the measured overall improvement in *E. coli* concentration.

45. I need to provide a cautionary note at this point. The extended low flow period experienced in 2007-08 also provided favourable conditions for proliferations of potentially toxic benthic mats of blue-green algae in some of these rivers, which resulted in Horizons issuing river use warnings for the first time.

46. In my opinion, these results (shown in Figure 7) provide additional evidence that management of non-point sources is required to achieve further water quality improvements.

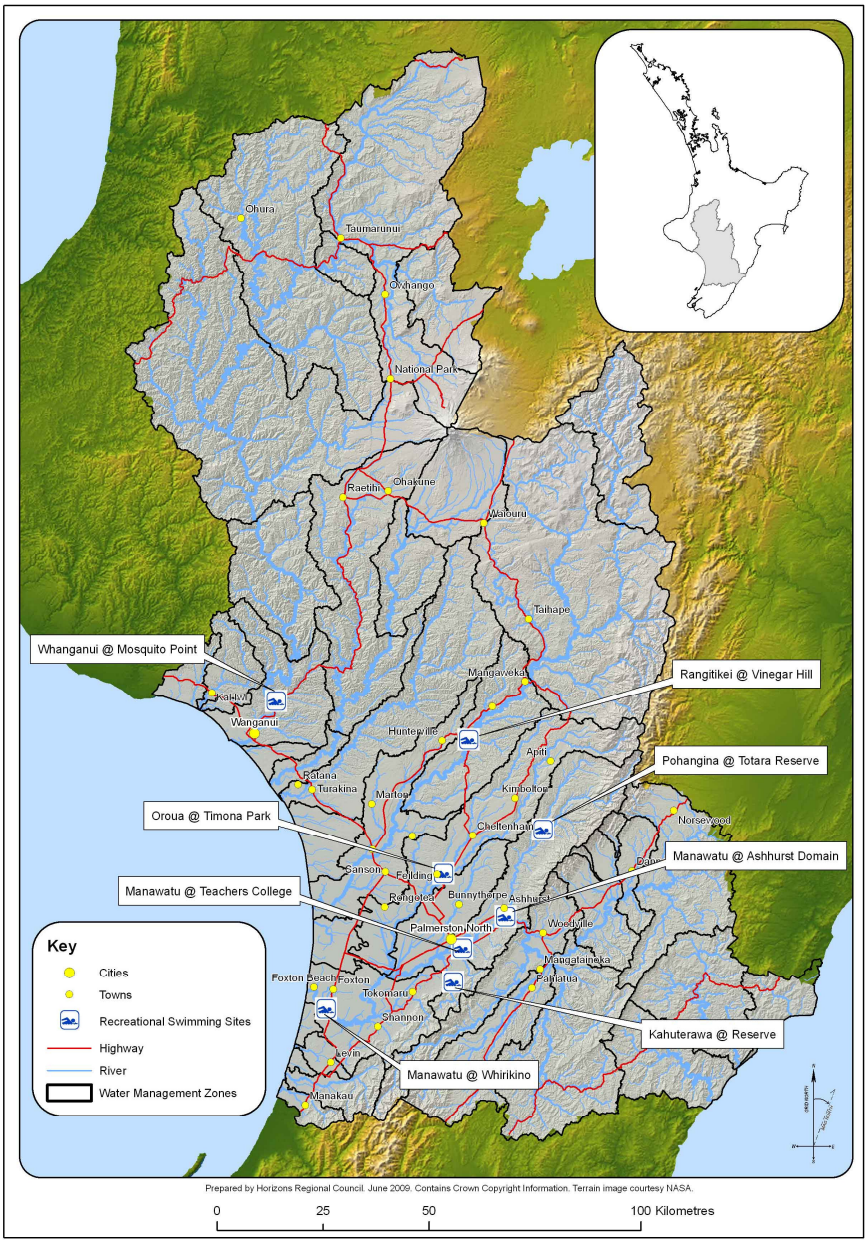

Figure 8. Locations of popular freshwater swimming spots in the Region for which data is presented in Figure 7.

Recreational Lakes – Use and Issues

47. In this section, I provide the Hearing Panel with an overview of recreational lakes in the Region. This evidence is based on my involvement with water quality management at Lake Horowhenua since 1975 and information obtained for Duddings Lake, Lake Pauri and Lake Wiritoa as part of Horizons' swimming spot programme. My evidence will describe the current recreational use of the lakes, microbiological quality, blue-green algal blooms (also known as cyanobacteria), and the implications for recreational use.

48. Four lakes along the west coast of the Region can be considered recreational "gems." These are Lake Wiritoa, Lake Pauri, Duddings Lake, and Lake Horowhenua.

49. Lake Wiritoa is extensively used for water-based recreation, such as swimming, canoeing, power boating, water skiing, jet skiing, triathlon, and fishing. It is the base for the Wanganui Water Ski Club and the site of the Scoutlands Lakeside Caravan and Camping Park.

50. Lake Pauri is a private lake used by its owners for power boating and water skiing. It is also used by the Wanganui Sailing Club as a base for training activities for junior sailors, through an arrangement with the landowners.

51. Duddings Lake is the site of a holiday and picnic park. The lake is used for swimming, boating, water skiing, and jet skiing. Along with the adjacent park, it typically attracts more than 200 visitors on a pleasant summer weekend.

52. Lake Horowhenua, although not currently used as a swimming lake, is used for waka regatta, rowing and sailing. It is the home base for the Horowhenua Sailing Club, Horowhenua Rowing Club and Kotuku Sea Scouts. The lake also has significance for tangata whenua as a source of the traditional foods tuna (eels) and kākahi (freshwater mussels).

53. *E. coli* testing as part of the swimming spot programme shows that microbiological water quality in these lakes is high all the time. Unlike swimming spots in flowing waters, there is no evidence to indicate they are adversely affected by rainfall events. The only exception to this are very localised high *E. coli* concentrations caused by a high density of waterfowl along the Mua Upoko Domain foreshore at Lake Horowhenua.

54. Although microbiological quality is very good, recreational use of all these lakes is at risk from blue-green algal blooms. Some blue-green algae have the ability to produce natural toxins known as cyanotoxins. These toxins are a threat to humans and animals when consumed in drinking water or during recreational activities. There are a number of different toxins and their mode of action is diverse. Some toxins cause relatively minor effects such as skin rashes, but others can affect liver function or the nervous system.

Figure 9. Blue-green algae bloom in Lake Horowhenua (January 2005)

55. Blue-green algae blooms have been observed in all the monitored lakes. Surveillance monitoring of health risk is carried out using estimates of cell density. When estimates of cell density exceed 100,000 blue-green algal cells per millilitre, there may be a potential health risk from blue-green algal toxins, and a toxin test is carried out. Figure 10 shows the results of tests for total microcystins (a common blue-green algal toxin) in the four high-use recreational lakes. Although the data indicates the guideline is exceeded frequently in Lakes Pauri and Lake Horowhenua, this needs to be tempered with the fact that testing is only carried out when it is expected that toxins will be present. It therefore paints an unnecessarily pessimistic picture. However, the data accurately portrays the fact that toxin levels in Lake Horowhenua, Lake Wiritoa and Lake Pauri do

in fact exceed total microcystin levels used by the World Health Organisation[5] to determine recreational guidelines, and the New Zealand draft guideline, by a considerable margin from time to time.

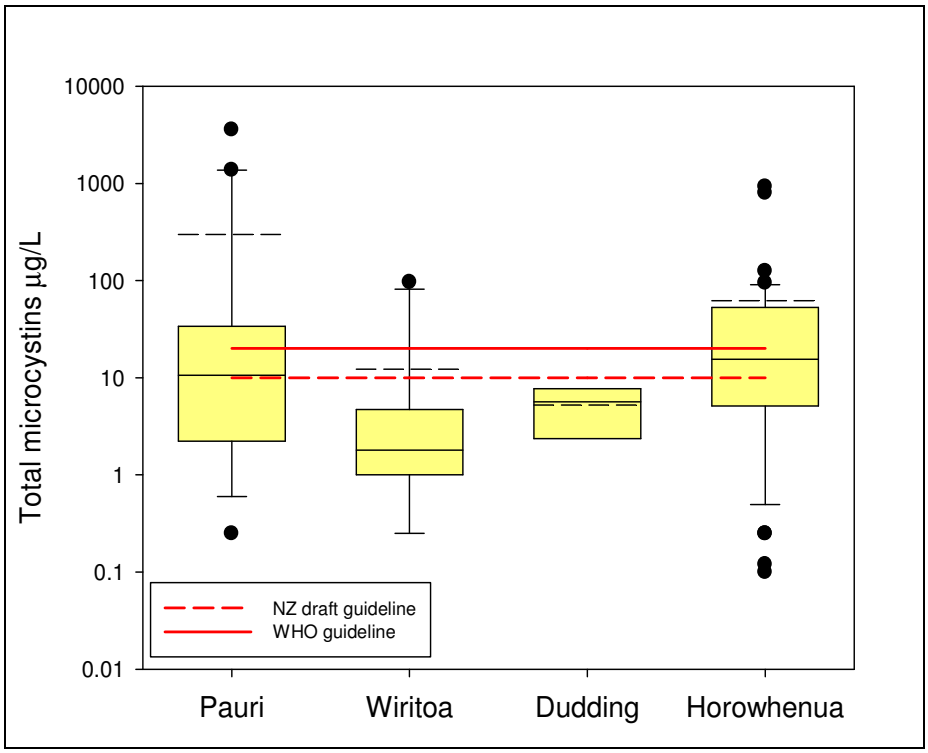

Figure 10. Log_{10} total microcystins measured using ELISA test on cyanobacteria blooms at four lakes in Horizons' Region. Boxes represent upper and lower quartiles with median (straight) and mean (dashed) mid point lines, whiskers are 10th and 90th percentiles, and black dots are outliers. Contact recreation guidelines are in red.

56. Warnings have been issued to lake users advising of the health risk during these outbreaks and recreational use of the lakes discouraged. This has curtailed lake use and programmed events at those times and cast doubt on the suitability and availability of these lakes as venues for regional and national events in the future. In the case of Lake Horowhenua, it has caused such a decline in membership that the very survival of the Horowhenua Sailing Club is at risk.

Figure 11. "Amber" health risk warning at Lake Horowhenua (January 2004).

57. Blue-green algae are a symptom of an unhealthy lake, not the cause. I saw blue-green algae in Lake Horowhenua during the initial sampling programme in 1975. It is probable that blue-green algae blooms have occurred in the other lakes for many years. They have been recorded recently simply because Horizons has begun monitoring recreational water quality.

58. In general terms, what goes into a lake takes a long time to come out again because it falls onto the lake bed or, in the case of phosphorus, is adsorbed to the lake bed sediments. This is especially relevant for Duddings Lake, which appears to have no outflow, and Lake Wiritoa and Lake Pauri, which overflow only intermittently.

59. There are a number of in-lake remedial actions available, but they tend to be expensive (eg. dredging), environmentally risky (eg. chemical treatment) or long term (eg. aeration), or all of these things. The "SolarBee" technology used in Wanganui's Virginia Lake is proving to be a potentially good option for control of blue-green algal growths in that lake. It has been operating since December 2008 and there have been no blue-green algal

blooms in that time. The effectiveness of this technology in the long-term is not known, but it is a very promising start. I note, however, that the "SolarBee" controls blue-green algal proliferations by causing a current across the lake surface that is not favourable for blue-green algal growth. It does not address the issue of nutrient enrichment and there remains the potential for dissolved oxygen depletion when the bottom waters "turn over" in late autumn or early winter. This means it controls the symptoms of an enriched lake, but does not cure them.

60. Whether or not in-lake remedial action is taken, minimising inputs of sediment and nutrients to these lakes appears to be a sensible first step. If this is not done, any remedial work carried out in the lakes themselves will be compromised by continued replenishment via surface water and/or groundwater inflows from their catchments. Horizons has recognised this by including the catchments of Lake Horowhenua, Duddings Lake, Lake Wiritoa, Lake Pauri and others in the Proposed One Plan as Water Management Zones, where intensive farming land use activities will be controlled in the future.

61. Control of sediment and nutrient inputs has begun at Lake Horowhenua. Management in the late 1970s and early 1980s focused on diversion of the treated sewage discharge from Levin. It was estimated that this discharge contributed about 86% of the phosphorus entering the lake. Diversion of the sewage occurred in 1986. Since then, the focus has been on re-vegetation of the riparian margins of the lake and key inflow streams to reduce sediment and nutrient inputs to the lake. The riparian margin of the lake has been re-vegetated by the lake's Māori owners and work has been carried out by Horizons and landowners to re-vegetate the riparian margins of two inflow streams. However, there are several market gardening ventures and other intensive land uses in the catchment, and the potential adverse effects of these land uses on lake water quality needs to be addressed. As a consequence, the Lake Horowhenua catchment is included as a Water Management Zone where management of intensive farming land use activities will be specifically controlled (Proposed One Plan, Part II, Table 13.1)

62. For further information on the current state of water quality in these lakes, appropriate water quality standards and how nutrient inputs are managed in the Proposed One Plan I refer you to the evidence presented by Ms Kate McArthur and Mr Max Gibbs.

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