HEALTHY WATERWAYS

HEALTHY Waterplay

Microbial Trigger Value Justification Paper

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T (07) 3177 9100 | **F** (07) 3177 9190 | **E** hwwinfo@healthywaterways.org
Level 4, 200 Creek Street, Spring Hill QLD 4004
PO Box 13086, George St, Brisbane QLD 4003
www.healthywaterways.org | Healthy Waterways Limited | ABN 77 137 943 554

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Members of the Human Health Scientific Expert Panel

- Assoc Prof Anne Roiko — Environmental Health, Environmental Toxicology and Risk Assessment, Climate Change and Health Department, Griffith University
- Dr David Cunliffe — Public Health, Department of Health, South Australia
- Dr James Smith — JJSMITH Consult
- Arron Hieatt — Department of Health, Queensland Government

Members of the Healthy Waterplay Program

- Brisbane City Council
- City of Gold Coast
- Ipswich City Council
- Lockyer Valley Regional Council
- Logan City Council
- Moreton Bay Regional Council
- Redland City Council
- Scenic Rim Regional Council
- Somerset Regional Council
- Sunshine Coast Council
- Noosa Council

Healthy Waterways Staff

- Anne Cleary — Healthy Waterplay Program Coordinator
- James Udy — Chief Scientist
- David Logan — Senior Science Officer

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Acronyms

AFRI	acute febrile respiratory illness
BAV	beach action value
GI	gastrointestinal
GM	geometric mean
NEEAR	National Epidemiological and Environmental Assessment of Recreational Water
NGI	NEEAR-GI illness
NOAEL	no observed adverse effect level
LOAEL	lowest observed adverse effect level
STV	statistical threshold value
US EPA	United States Environmental Protection Agency
WHO	World Health Organization (United Nations)
WQS	water quality standard(s)

1. Summary of recommendations

The purpose of this Justification Paper is to present the rationale behind the microbial trigger-value-based approach to managing primary and secondary contact with recreational waterways in South East Queensland.

The recommended method is to apply numeric microbial trigger values for short-term management responses for primary contact and secondary contact recreation areas. Microbial trigger values were chosen to indicate the need for further investigation into causes of potentially harmful levels of pathogens at a reasonable level of public health concern; and to prompt additional public health risk mitigation, if necessary. The trigger values (outlined in Box 1) are based on rationale derived from the categories set out in the Australian Government's National Health and Medical Research Council Guidelines for Managing Risk in Recreational Water, 2008. The trigger values presented herein are recommended for fresh, estuarine and marine waters in South East Queensland.

Box 1: Recommended Trigger Values

For both primary and secondary contact use of recreational waterways, respective one-off (single sample) microbial trigger values are recommended. These trigger values indicate when microbial indicator bacteria concentrations are sufficiently elevated to warrant either further investigation or action to reduce the risk of potential illness as a result of recreational use of a waterway.

Warning Trigger

The first one-off (single sample) value, known as the **warning trigger**, triggers intensive daily resampling and investigation within 24 h of receiving results:

- For **primary contact** this trigger value is equal to or greater than 200 enterococci per 100 mL
- For **secondary contact** this trigger value is equal to or greater than 1000 enterococci per 100 mL

Action Trigger

The second one-off (single sample) value, known as the **action trigger**, triggers immediate temporary closure of the recreational water area:

- For **primary contact** this trigger is equal to or greater than 500 enterococci per 100 mL.

Additional Considerations:

Primary Contact: If the response to the primary contact warning trigger results in three consecutive days where the counts are between 200-499 enterococci per 100 mL then the response should be elevated to an action trigger response and the site should be closed to primary contact recreation. Sites should remain closed to primary contact recreation until sampling results return to less than 200 enterococci per 100 mL for three consecutive samples. In the circumstance where the responsible agent has a thorough understanding of the recreational site, including understanding the catchment hydrology coupled with adequate monitoring data, and hence can justify reopening after two consecutive samples then this is deemed appropriate management. Further information on how to respond to primary contact trigger values is provided via the Regional Management Response Guideline Flowchart in Appendix 1.

Secondary Contact: If the response to the secondary contact warning trigger results in counts remaining equal to or greater than 1000 enterococci per 100 mL then the responsible agent should complete the secondary contact risk assessment matrix (provided in Appendix 2) to assess the risk to the recreational user and determine if a temporary site closure is necessary.

2. Introduction

The Australian Government's National Health and Medical Research Council Guidelines for Managing Risk in Recreational Water, 2008, (NHMRC Guidelines) serve as a tool for each state and territory to develop legislation and standards appropriate for local conditions and circumstances. The aim of the guidelines is to encourage the adoption of a nationally harmonised approach for the management of the quality of coastal, estuarine and freshwaters used for recreation. The NHMRC Guidelines are recognised as the authoritative reference on recreational water quality in Australia.

Within Queensland, the *Public Health Act 2005* (the Act) explicitly identifies water that 'includes drinking water, water used for recreational purposes, recycled water, waste water and sewage' when describing public health risks that are regulated. The Act assigns responsibility for regulating all public health risks associated with non-drinking water and non-recycled water (see section 11.1.b.iv) to local government. Under authority of the Act, and in line with advice from the NHMRC Guidelines, local governments of Queensland can set standards for management of recreational water appropriate for local conditions and circumstances. The Healthy Waterplay Program in South East Queensland works in partnership with local and state government to support regionally consistent monitoring, reporting and management of microbial quality of recreational water appropriate to the South East Queensland setting.

When managing risks in recreational waters, the NHMRC Guidelines suggest an appropriate management approach is to classify sites based on identified pollution sources and real time predictors of contamination, which include microbial analyses. The NHMRC Guidelines provide a framework for determining a Recreational Waterway Suitability Grade of recreational water by a combination of sanitary inspection and microbial water quality assessment. The NHMRC Guidelines focus on the long-term categorisation and management of recreational waters and do not provide guidance on assessing a site at a particular point in time based on single microbial sample results, nor on short-term management actions in response to single high result microbial samples. As routine microbial monitoring, site classification, or other investigations often involve collection of a single-sample per site sampling, microbial trigger values are needed to determine when such individual results warrant acute management response actions in order to reduce immediate health risk from recreational waterway use.

The concept of trigger values is found within the Beach Action Value approach recommended by the US EPA 2012 Recreational Water Quality Review. The main constraint associated with this approach is that management actions are retrospective and can be implemented only after human exposure to the hazard. To protect public health it is important to ensure that routine microbial testing of recreational waterways, as outlined in this document, is coupled with sanitary inspections to identify pollution sources. Hence, there must be a commitment to proceed with all necessary steps to permit full classification of the area in accordance with the NHMRC Guidelines.

It is important to note that 'zero risk' is not an achievable or realistic goal when developing recreational water quality trigger values, due to variability in faecal indicator and pathogen concentrations and the uncontrolled nature of environmental waters. Available evidence suggests the most frequent adverse health outcome associated with exposure to faecally contaminated recreational water is enteric illness, such as self-limiting gastroenteritis. Transmission of pathogens that can cause gastroenteritis has been repeatedly reported in epidemiological studies, including studies demonstrating a dose-response relationship (Prüss, 1998). Published quantitative epidemiological studies enable the estimation of the degree of health protection (or, conversely, burden of disease) associated with any given range of water quality based on microbiological indicator concentrations. Further information on these key epidemiological studies is available in the bibliography (see Section 5.1).

Intestinal enterococci are currently considered the most suitable faecal indicator organism for both marine and freshwater as they meet all of the requirements outlined in section 5.3.5 of the NHMRC Guidelines. Direct enumeration of bacterial, viral and protozoan pathogens is rarely done in Australia, as there are insufficient data to develop guideline values and the costs of such testing are often prohibitive. In addition, testing for specific pathogens does not always describe the full scope of public health risk associated with recreational

waters. As a result, the proposed microbial trigger values are based on enterococci per 100 mL and are recommended for fresh, estuarine and marine waters.

This Justification Paper defines management response microbial trigger values for primary and secondary contact recreation (further explained in Section 3.2 and 3.3 respectively) for consistent application across South East Queensland. This Justification Paper explains the science and rationale behind the proposed microbial trigger values, as well as the recommended short-term management actions for implementation should a single sample exceed the respective trigger value. By defining these microbial trigger values, this document seeks to protect public health through promotion of a consistent approach to short-term assessment and management of recreational waters for use in conjunction with NHMRC Guideline recommended long-term assessment.

3. Current recreational water quality guidelines

3.1 Background

There are several different microbial standards for recreational water use throughout the world. A summary of key references is provided in Section 3.2 and 3.3 to help provide context to the guidelines for microbial trigger values for primary or secondary contact in recreational waters, as outlined in this document.

3.1.1 Primary and secondary contact

Recreational activities associated with environmental waterways can occur across a broad spectrum of exposures. For example, primary contact is typically considered swimming-like activities, while secondary contact includes activities such as rowing and fishing. Secondary contact involves lesser degrees of water exposure and will usually result in less water ingestion. Hence, secondary contact generally requires less stringent trigger values to achieve health protection equivalent to primary contact activities (Cheung et al., 1990, Dorevitch et al., 2011, Rijal et al., 2011, McBride, 2012, Schijven and de Roda Husman, 2006). Estimates and measurements of water ingestion rates have been published by Dorevich et al., 2011 and Rijal et al., 2011 and reviewed by McBride, 2012. McBride (2012) suggests that based on the evidence, secondary contact water ingestion rates are one tenth of those associated with primary contact.

To establish separate microbial trigger values for aquatic areas used entirely for secondary contact recreation, a clear understanding of the types of activities which may occur under this description is required. The World Health Organisation, in its Guidelines for Safe Recreational Water Environments: Volume 1- Coastal and Fresh Waters (WHO, 2003), has proposed a scheme for the classification of recreational water activities according to their degree of water exposure. The following descriptions (adapted from WHO, 2003), may be used as an initial guide when determining whether a specific recreational activity would be considered as either primary or secondary contact:

- *Primary contact:* Recreational activity in which the whole body or the face and trunk are frequently immersed or the face is frequently wetted by spray, and where it is likely that some water will be swallowed. Inadvertent immersion, through being swept into the water by a wave or slipping, would also result in whole body contact. Examples include swimming, surfing, waterskiing, whitewater canoeing/rafting/kayaking, windsurfing, diving or jet skiing.
- *Secondary contact:* Recreational activity in which only the limbs are regularly wetted and in which greater contact (including swallowing water) is atypical. Examples include rowing, sailing, canoe touring or fishing

Note: trigger values for secondary contact recreation should not be applied where an assessment has shown primary contact recreation to be an existing use.

3.1.2 Marine and freshwater

At the same intestinal enterococci densities, the swimming associated illness rate is about five times higher in seawater bathers (Kay et al., 1994) than in freshwater swimmers (Ferley et al., 1989). This difference is due to the more rapid die-off of indicator bacteria than pathogens (especially viruses) in seawater. Therefore, application of values derived for seawaters to freshwaters would be likely to result in a lower illness rate in freshwater users, providing a conservative (i.e. more protective) guideline in the absence of suitable epidemiological data for freshwaters. Furthermore, salinity in estuaries is highly variable and it would be difficult to decide when or whether a freshwater or marine standard should be applied to a given location, if separate marine and freshwater guideline values were to be specified.

3.2 Primary contact recreation

3.2.1 NHMRC 2008 Guidelines for Managing Risks in Recreational Water

The current NHMRC Guidelines outline the derivation of percentile values for determining microbial water-quality assessment categories. These categories have been modified from WHO Guidelines for Safe Recreational Water Environments: Volume 1- Coastal and Fresh Waters, 2003. The microbiological values are expressed in terms of the 95th percentile of numbers of enterococci per 100 mL and represent levels of health risk based on the exposure conditions of key epidemiological studies (Wyer et al., 1999, Kay et al., 2004).

Note: the guideline values for primary contact recreation presented in Table 1 (adapted from Table 5.7, Guidelines for Managing Risks in Recreational Water, NHMRC, 2008) were derived from studies involving healthy adult bathers swimming in sewage impacted marine waters in a temperate climate. Thus, the guidelines do not relate specifically to children, the elderly or immunocompromised, who may have lower immunity and might require a greater degree of protection. There are no available data with which to quantify this and therefore no correction factors are applied. The guideline values were derived from studies in which the 'exposure' was a minimum of ten minutes of swimming involving three head immersions. They may therefore underestimate risk for activities involving higher likelihood of water ingestion or longer periods of water contact.

Table 1 Guideline values for microbial quality of primary contact recreational waters, NHMRC, 2008

Category[a]	95th percentile value for intestinal enterococci/100 mL (rounded values)	Basis of derivation	Estimation of probability
A	≤40	This value is below the NOAEL in most epidemiological studies.	GI illness risk: < 1% AFRI risk: < 0.3% The upper 95th percentile value of 40/100 mL relates to an average probability of less than one case of gastroenteritis in every 100 exposures. The AFRI burden would be negligible.
B	41–200	The 200/100 mL value is above the threshold of illness transmission reported in most epidemiological studies that have attempted to define a NOAEL or LOAEL for GI illness and AFRI.	GI illness risk: 1–5% AFRI risk: 0.3–1.9% The upper 95th percentile value of 200/100 mL relates to an average probability of one case of gastroenteritis in 20 exposures. The AFRI illness rate would be 19 per 1000 exposures or approximately 1 in 50 exposures.
C	201–500	This represents a substantial elevation in the probability of all adverse health outcomes for which dose–response data are available.	GI illness risk: 5–10% AFRI risk: 1.9–3.9% This range of 95th percentile values represents a probability of 1 in 20 to 1 in 10 risk of gastroenteritis for a single exposure. Exposures in this category also suggest a risk of AFRI in the range of 19–39 per 1000 exposures or a range of approximately 1 in 50 to 1 in 25 exposures.
D	> 501	Above this level there may be a significant risk of high levels of illness transmission.	GI illness risk: > 10% AFRI risk: > 3.9% There is a greater than 10% chance of illness per single exposure. The AFRI illness rate at the guideline value of 500 enterococci per 100 mL would be 39 per 1000 exposures or approximately 1 in 25 exposures.

Modified from WHO (2003); see Kay et al. (2004) for further discussion and formulae. AFRI = acute febrile respiratory illness; GI = gastrointestinal; NOAEL = no observed adverse effect level; LOAEL = lowest observed adverse effect level;
a: Categories A–D are the corresponding microbial assessment categories used as part of the classification procedure

3.2.2 US EPA 2012 Recreational Water Quality Criteria

The microbial trigger values presented in this paper (Box 1) are comparable with other international approaches. The level of acceptable risk, as defined by the risk of illness, is generally between 2-4% in each of the Health Canada (see Section 3.2.3) US EPA (this section) and European (see Section 3.2.4) references. For example, the US EPA works within an estimated illness rate of 3.2-3.6% which is comparable to the NHMRC Guideline's Category C (201–500 enterococci per 100 mL) which has an AFRI risk of 1.9–3.9%. The US EPA 2012 Recreational Water Quality Criteria consist of three components: magnitude, duration and frequency. The magnitude of the bacterial indicators are described by both a geometric mean (GM) and a statistical threshold value (STV) for the concentrations of indicator bacteria in samples. The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken. The STV proposed by US EPA is comparable to Category B, 41–200 enterococci per 100 mL, of the NHMRC Guidelines. Table 2 summarizes the magnitude component of the US EPA recommendations.

Table 2 US EPA 2012 Recreational Water Quality Criteria for enterococci

CRITERIA ELEMENTS	**Recommendation 1** **Estimated Illness Rate (NGI):** **36/1,000 primary contact recreators (3.6%)**		**Recommendation 2** **Estimated Illness Rate (NGI):** **32/1,000 primary contact recreators (3.2%)**	
	Magnitude		**Magnitude**	
Indicator	Geometric mean (cfu/ 100 mL)	Statistical threshold value (cfu/ 100 mL)	Geometric mean (cfu/ 100 mL)	Statistical threshold value (cfu/ 100 mL)
Enterococci (marine and fresh)	35	130	30	110

NEEAR = National Epidemiological and Environmental Assessment of Recreational Water; NGI = NEEAR-GI illness

In conjunction with the above recommended criteria, the US EPA also recommends the use of a Beach Action Value (BAV) as a conservative, precautionary tool for making beach notification decisions. The BAV is not a component of EPA's recommended criteria, but a tool that states may choose to use, without adopting it into their water quality standards (WQS), as a "do not exceed" value for beach notification purposes (such as advisories). The BAV (Table 3) was developed from the same water quality distribution as the criteria values in Table 2 and corresponds to the estimated 75th percentile of the enterococci water quality distributions. For states that choose to use a BAV, any single sample above the BAV could trigger a beach notification until another sample below the BAV is collected. While the GM and STV would be the applicable WQS, a BAV could be used at the state's discretion as a more conservative, precautionary tool for beach management decisions, similar to the approach of microbial trigger values for short-term management responses presented in this document.

Table 3 US EPA 2012 Recreational Water Quality Criteria Beach Action Value

Indicator	**Estimated Illness Rate (NGI): 36 per 1,000 primary contact recreators (3.6%)**	**OR**	**Estimated Illness Rate (NGI): 32 per 1,000 primary contact recreators (3.2%)**
	BAV (Units per 100 mL)		BAV (Units per 100 mL)

Enterococci - culturable (marine and fresh)	70 cfu		60 cfu

3.2.3 Health Canada 2012 Guidelines for Canadian Recreational Water Quality

The 2012 Health Canada Guidelines for Canadian Recreational Water Quality: Third Edition recommend enterococci guideline values for marine waters and *E. coli* guideline values for freshwater. These guideline values are outlined in Table 4.

Table 4 Health Canada Guidelines for Canadian Recreational Water Quality Guideline Values

	Marine waters: Enterococci	**Freshwaters: *Escherichia coli* (*E. coli*)**
Geometric mean concentration (minimum of five samples)	≤ 35 enterococci/100 mL	≤ 200 *E. coli*/100 mL
Single-sample maximum concentration	≤ 70 enterococci/100 mL	≤ 400 *E. coli*/100 mL

3.2.4 European Directive 2006/7/EC

Directive 2006/7/EC of the European parliament concerning the management of bathing water quality sets out guideline values for faecal indicator concentrations in marine and inland recreational waters. These values are outlined in table 5.

Table 5 Directive 2006/7/EC guideline values concerning the management of bathing water quality

	Excellent Quality	**Good Quality**
Inland waters	200 intestinal enterococci (cfu/100 mL)	400 intestinal enterococci (cfu/100 mL)
Coastal and transitional waters	100 intestinal enterococci (cfu/100 mL)	200 intestinal enterococci (cfu/100 mL)

3.3 Secondary contact recreation

3.3.1 Health Canada 2012 Guidelines for Canadian Recreational Water Quality

Health Canada has provided advice regarding water intended for secondary contact recreational water activities in their Guidelines for Canadian Recreational Water Quality: Third Edition, 2012. Their advice states that where a water area is intended to be used specifically for secondary contact recreation (i.e. where primary contact is not an existing use), the application of a factor of five to the geometric mean faecal indicator microorganism concentration used to protect primary contact recreation users may be used as follows:

- Freshwaters – *E. coli*: (5 x 200/100 mL) = 1000 *E. coli*/100 mL
- Marine waters – Enterococci: (5 x 35/100 mL) = 175 enterococci/100 mL

These values represent a risk management decision based on the assessment of the expected exposure scenarios and potential health risks for the recreational water user. They are intended to allow specified water areas to have a secondary contact use designation where this has been considered appropriate by the responsible local or regional authorities, while still providing some level of protection for secondary contact recreational users until epidemiologically based guideline values can be derived. In considering both the potential health risks and the benefits of recreational water use, it was concluded that this is a tolerable and reasonable approach to protect users engaged in a voluntary activity. These values are also consistent with advice provided by other jurisdictions (Saskatchewan Environment, 1997; Alberta Environment, 1999; U.S. EPA, 2002).

3.3.2 2000 ANZECC Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The older 2000 ANZECC Australian and New Zealand Guidelines for Fresh and Marine Water Quality used a similar approach to Health Canada, where the application of a factor of 6.67 to the median faecal indicator concentration used to protect primary contact recreation was adopted for secondary contact recreation. A summary from the ANZECC guidelines are presented in Table 6. These guidelines were based on the 1990 NHMRC Australian Guidelines for Recreational Use of Water.

Table 6 ANZECC Guidelines 2000

Parameter	Guideline
Primary contact	The median bacterial content in fresh and marine waters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL or 35 enterococci organisms/100 mL.
Secondary contact	The median value in fresh and marine waters should not exceed 1000 faecal coliform organisms/100 mL or 230 enterococci organisms/100 mL.

3.4 Site-specific trigger values

In support of the NHMRC guidelines, Dr Richard Lugg of the Department of Health, Western Australia developed an Excel spreadsheet called Enterotester, to calculate 95th percentiles of Enterococcal populations in Australian recreational waters. Using Enterotester, site-specific trigger values may be assigned to a recreational water site. Site-specific trigger values allow an authority to respond to unanticipated deterioration in water quality that is unusual for a specific site, rather than using the generic trigger values outlined in Section 3.2 and 3.3. There are two site-specific trigger values that can be calculated using the Enterotester tool:

- One-off Trigger value (99th percentile): when the site-specific enterococci count is exceeded after one sampling event.
- Two-in-a-row Trigger values (90th percentile): when the site-specific enterococci count is exceeded after two consecutive (within 24 h) sampling events.

Site-specific trigger values are not recommended in South East Queensland for use in short-term management based on single sample results. A primary driver for this recommendation is the consistency of the approach to management of recreational waterways, and the different purpose for the trigger value. While each site is likely to have site-specific conditions that alter the Recreational Waterway Suitability Grade, ultimately the level of contamination likely to present an increased risk of illness would remain the same. A consistent acute action trigger value also has the added benefit of reducing confusion for managers of recreational waters and for the public.

4. Recommended approach

4.1 Overview

This Justification Paper recommends application of numeric microbial trigger values for short-term management responses for primary contact and secondary contact recreation areas in South East Queensland. These trigger values (Box 1) are expected to trigger investigations or immediate management actions (e.g. site closures) to reduce the public health risk of primary and/or secondary contact recreation activities. The Australian Government's National Health and Medical Research Council Guidelines for Managing Risk in Recreational Water, 2008 are recognised as the authoritative reference on recreational water quality in Australia. Hence the primary contact trigger values (Box 1) are based on rationale derived from the categories set out in the NHMRC Guidelines. The NHMRC Guidelines do not provide guidance on secondary contact recreation. Hence, this document has adapted approaches used by Health Canada to set a microbial trigger value for short-term management responses for secondary contact. The recommended trigger values operate in a similar fashion to the Beach Action Value approach recommended by the US EPA 2012 Recreational Water Quality Review. The use of trigger values for short-term assessment and management should occur in conjunction with ongoing long-term monitoring, management and assessment of the site as outlined in the NHMRC Guidelines. The trigger values presented in this paper are in the units of 'enterococci per 100 mL' and are recommended for fresh, estuarine and marine waters.

Box 1: Recommended Trigger Values

For both primary and secondary contact use of recreational waterways, respective one-off (single sample) microbial trigger values are recommended. These trigger values indicate when microbial indicator bacteria concentrations are sufficiently elevated to warrant either further investigation or action to reduce the risk of potential illness as a result of recreational use of a waterway.

Warning Trigger

The first one-off (single sample) value, known as the **warning trigger**, triggers intensive daily resampling and investigation within 24 h of receiving results:

- For **primary contact** this trigger value is equal to or greater than 200 enterococci per 100 mL
- For **secondary contact** this trigger value is equal to or greater than 1000 enterococci per 100 mL

Action Trigger

The second one-off (single sample) value, known as the **action trigger**, triggers immediate temporary closure of the recreational water area:

- For **primary contact** this trigger is equal to or greater than 500 enterococci per 100 mL.

Additional Considerations:

Primary Contact: If the response to the primary contact warning trigger results in three consecutive days where the counts are between 200-499 enterococci per 100 mL then the response should be elevated to an action trigger response and the site should be closed to primary contact recreation. Sites should remain closed to primary contact recreation until sampling results return to less than 200 enterococci per 100 mL for three consecutive samples. In the circumstance where the responsible agent has a thorough understanding of the recreational site, including understanding the catchment hydrology coupled with adequate monitoring data, and hence can justify reopening after two consecutive samples then this is deemed appropriate management. Further information on how to respond to primary contact trigger values is provided via the Regional Management Response Guideline Flowchart in Appendix 1.

Secondary Contact: If the response to the secondary contact warning trigger results in counts remaining equal

to or greater than 1000 enterococci per 100 mL then the responsible agent should complete the secondary contact risk assessment matrix (provided in Appendix 2) to assess the risk to the recreational user and determine if a temporary site closure is necessary.

4.2 Primary contact trigger values

The recommended trigger values for primary contact outlined in Box 1 have been adapted from the water quality assessment categories of the NHMRC Guidelines (Table 1). The NHMRC Guidelines are recognised as the authoritative reference on recreational water quality in Australia. The NHMRC Guidelines are modified from WHO Guidelines for Safe Recreational Water Environments: Volume 1- Coastal and Fresh Waters, 2003. The values for the proposed microbial trigger values are comparable with other international approaches. The level of acceptable risk, as defined by the risk of illness, is generally between 2-4% in each of the Health Canada (see Section 3.2.3) US EPA (this section) and European (see Section 3.2.4) references. For example, the US EPA works within an estimated illness rate of 3.2-3.6% which is comparable to the NHMRC Guideline's Category C (201–500 enterococci per 100 mL) which has an AFRI risk of 1.9–3.9%.

4.2.1 Primary contact warning trigger value

Microbial water quality assessment categories of A and B (up to 200 enterococci per 100 mL) can receive a Recreational Waterway Suitability Grade of Very Good, Good or Fair depending on the susceptibility of the site to faecal influence, as determined by the Sanitary Inspection Category (Table 5.13, NHMRC 2008). Microbial water quality assessment category C (201 – 500 enterococci per 100 mL) introduces the first instance where a site can receive a Recreational Waterway Suitability Grade of Poor. In addition, equal to or greater than 201 enterococci per 100 mL represents a substantial elevation in the probability of all adverse health outcomes for which dose-response data are available. Hence, equal to or greater than 200 enterococci per 100 mL is recommended as the warning trigger value for primary contact. The value has been rounded to 200 for the sake of convenience. If a single sample result of equal to or greater than 200 enterococci per 100 mL is received for a primary contact site then an immediate (within 24 h of receiving results) management response of intensive daily resampling and investigation is recommended.

4.2.2 Primary contact action trigger value

The recommended action trigger value for primary contact is equal to or greater than 500 enterococci per 100 mL. This value aligns with the microbial water quality assessment category D in the NHMRC Guidelines and represents a level above which there may be a significant risk of illness (Table 1). If a single sample result of equal to or greater than 500 enterococci per 100 mL is received for a primary contact site, then temporary closure of the recreational water area should occur within 24 h of receiving the result. Sites should remain closed to primary contact recreation until sampling results return to less than 200 enterococci per 100 mL for three consecutive samples. In the circumstance where the responsible agent has a thorough understanding of the recreational site, including understanding the catchment hydrology coupled with adequate monitoring data, and hence can justify reopening after two consecutive samples then this is deemed appropriate management. Further information on how to respond to primary contact trigger values is provided via the Regional Management Response Guideline Flowchart in Appendix 1.

4.3 Secondary contact trigger values

There are a number of estimates and measurements available which compare exposures to water from secondary contact recreation with exposures to water from primary contact recreation. These range from 5 fold (Health Canada, 2012) to 10 fold (McBride, 2012). In this paper the more conservative factor of 5 has been applied. The secondary contact trigger value is based on the application of a factor of five to the faecal indicator concentration used to protect primary contact recreation users, similar to the approach adopted by Health Canada (refer to section 3.3). Secondary contact recreation activities involve lesser degrees of water contact, resulting in less water ingestion and thus require less stringent trigger values to achieve equivalent

health protection. Trigger values for secondary contact recreation should not be applied where an assessment has shown primary contact recreation to be an existing use.

4.3.1 Secondary contact warning trigger value

The recommended warning trigger value for secondary contact is equal to or greater than 1000 enterococci per 100 mL. This value is derived from a factor-of-five application to the primary contact warning trigger value. If a single sample result of equal to or greater than 1000 enterococci per 100 mL is received for a secondary contact site then an immediate (within 24 h of receiving results) management response of intensive daily resampling and investigation is recommended. If the response to the secondary contact warning trigger results in counts remaining equal to or greater than 1000 enterococci per 100 mL then the responsible organisation should complete the secondary contact risk assessment matrix (provided in Appendix 2) to assess the risk to the recreational user and determine if a temporary site closure is necessary.

5 Bibliography

5.1 Key studies

Kay D, et al., (1994) Predicting likelihood of gastroenteritis from sea bathing; results from randomized exposure. Lancet, 344(8927): 905–909.

Kay et al. conducted the first ever randomised "trial" of an environmental exposure to measure the health effects of this activity. The trial was spread over four summers in four UK resorts and 1216 adults took part. Adverse health effects were identified when faecal streptococci concentrations exceeded 32 per 100 mL. (Note: for the proposes of recreational water monitoring faecal streptococci and enterococci can be considered sufficiently similar as to be the same. For information on the description of equivalence of faecal streptococci and enterococci see Box 5.5 of the NHMRC Guidelines)

Link here

Fleisher JM, et al., (1996) Marine waters contaminated with domestic sewage: nonenteric illnesses associated with bather exposure in the United Kingdom. American Journal of Public Health, 86(9): 1228–1234.

This study identified possible dose-response relationships among bathers exposed to marine waters contaminated with domestic sewage and subsequent risk of nonenteric illness. Four intervention follow-up studies were conducted within the United Kingdom. Healthy volunteers (n = 1273) were randomized into bather and nonbather groups. Fecal streptococci exposure was predictive of acute febrile respiratory illness, while fecal coliform exposure was predictive of ear ailments. Estimated thresholds of effect occurred at bather exposures above 60 fecal streptococci and 100 fecal coliform per 100 mL of water, respectively.

Link here

Prüss, A., (1998) Review of epidemiological studies on health effects from exposure to recreational water, International Journal of Epidemiology, 27: 1-9

Prüss demonstrated that the body of evidence worldwide showed clear dose–response relationships linking faecal indicator concentrations with rates of minor illness acquisition. This article reviews 37 studies on uncontrolled water such as sea, lakes and rivers. It was found that most studies reported a dose-related increase of health risk in swimmers with an increase in the indicator-bacteria count in recreational waters. The review strongly suggests a causal dose-related relationship between gastrointestinal symptoms and recreational water quality measured by bacterial indicator counts.

Link here

Wade, T. J., Pai, N., Eisenberg, J. N., & Colford Jr, J. M., (2003). Do U.S. Environmental Protection Agency water quality guidelines for recreational waters prevent gastrointestinal illness? A systematic review and meta-analysis. Environmental Health Perspectives, 111(8): 1102.

This review suggests that enterococci and, to a lesser extent, *E. coli* are adequate indicators of GI illness in marine water, but feacal coliforms are not. There was evidence that risk of GI illness was considerably lower in studies with indicator densities below the guidelines proposed by U.S. EPA for both enterococci and *E. coli*, providing support for use of these values for regulatory purposes. In freshwater, *E. coli* was a more reliable and consistent predictor of GI illness than is enterococci.

Link here

Kay D, et al., (2004) Derivation of numerical values for the World Health Organization guidelines for recreational waters. Water Research 38:1296–1304.

This paper explains the scientific rationale and mathematical basis of the microbial water-quality assessment categories proposed by the WHO Guidelines and the NHMRC Guidelines.

Link here

Pond, K., (2005) Water recreation and disease - plausibility of associated infections: Acute effects, sequelae and mortality, ISBN 1843390663, IWA publishing.

The first three chapters review literature and provide evidence of adverse health outcomes associated with recreational water use and also discuss special factors that lead to more severe disease and/or sequelae as an evaluation of disease severity. The next three chapters provide the evidence review for severe outcomes from bacteria, protozoa/trematodes and viruses that may be encountered in recreational water.

Link here

Dale, K., Kirk, M., Sinclair, M., Hall, R., & Leder, K. (2010) Reported waterborne outbreaks of gastrointestinal disease in Australia are predominantly associated with recreational exposure. Australian and New Zealand Journal of Public Health, 34(5): 527-530.

This study showed that there have been few waterborne outbreaks detected in Australia, and most of those reported have been associated with recreational exposure. However, there are difficulties in identifying and categorising gastroenteritis outbreaks, as well as in obtaining microbiological and epidemiological evidence, which can result in misclassification or underestimation of water-associated events.

Link here

Wade, T. J., Sams, E., Brenner, K. P., Haugland, R., Chern, E., Beach, M., ... & Dufour, A. P. (2010) Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: a prospective cohort study. Environmental Health, 9(66): 1-14.

This study provides the first evidence of a relationship between gastrointestinal illness and estimates of faecal indicator organisms determined by qPCR at marine beaches.

Link here

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Kay D., Bartram J., Prüss A., Ashbolt N., Dufour A., Wyer M., Fleisher J., Fewtrell L. and Rogers A. (2004). Derivation of numerical values for the World Health Organization guidelines for recreational waters. Water Research 38:1296–1304.

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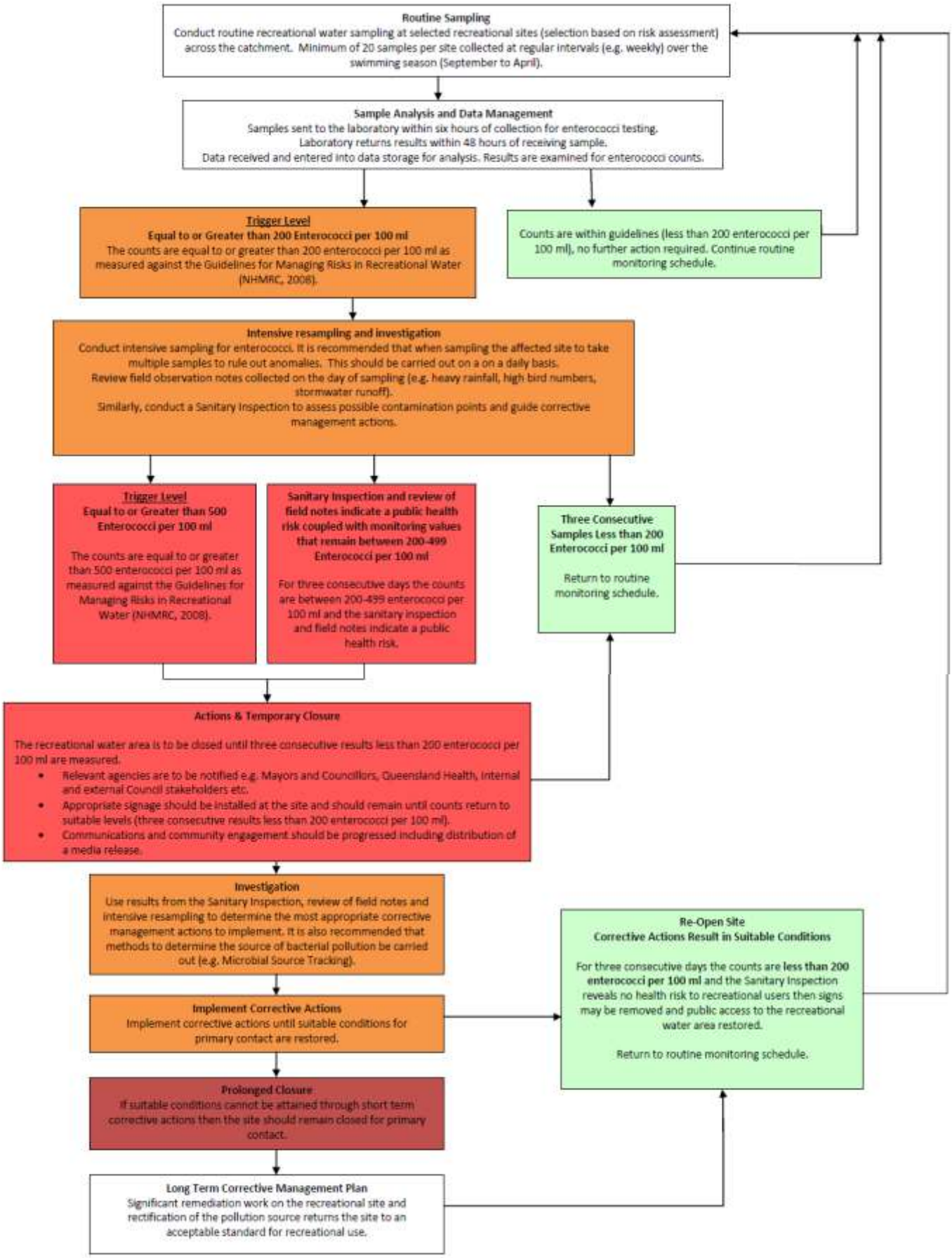
Appendix 1: Microbial testing of recreational waters regional management response guideline flowchart (for primary contact)



Appendix 2: Secondary contact risk assessment matrix

For recreational waterways where only secondary contact activities occur, the warning trigger value is equal to or greater than 1000 enterococci per 100 mL. This value triggers intensive daily resampling and investigation within 24 h of receiving results. If the resampling results in values remaining equal to or greater than 1000 enterococci per 100 mL then the responsible agent needs to determine the most appropriate management action for that secondary contact recreational waterway, including considering if a site closure is necessary. To determine the most appropriate action the responsible agent should use the below risk assessment matrix. When completing the below matrix, the responsible agent should consider the period following when the sampling with the high results occurred. A high and very high risk rating should result in an immediate, temporary closure of the site to secondary contact recreation until sampling values return to less than 1000 enterococci per 100 mL.

Characteristics of Secondary Contact	**RISK**				
	Very High	**High**	**Medium**	**Low**	**Very Low**
Are there vulnerable* people partaking in secondary contact activity	Yes				No
Number of people on average partaking in a secondary contact activity during a visit (include consideration of any specific planned events [e.g. Scout Jamboree], such events could also increase the degree of exposure and likelihood of ingestion)	Equal to or greater than 500 people partaking in secondary contact activities	Equal to or greater than 100 people and less than 500 people partaking in secondary contact activities	Equal to or greater than 50 people and less than 100 people partaking in secondary contact activities	Equal to or greater than 1 person and less than 50 people partaking in secondary contact activities	No people partaking in secondary contact activities
Degree of exposure: frequency and duration of use	Long visits occur every day following the sample being taken	Short visits occur every day following the sample being taken	Long visits occur every week following the sample being taken	Short visits occur every week following the sample being taken	Long and short visits occur every month or less following the sample being taken
Percentage of people partaking in secondary contact activity where the likelihood of accidental ingestion of water is high**	Equal to or greater than 75% of people	Equal to or greater than 50% and less than 75% of people	Equal to or greater than 25% and less than 50% of people	Equal to or greater than 10% and less than 25% of people	Less than 10% of people

* Certain groups in the community may be more vulnerable to contracting illness and infection than others. Children under five years old, the elderly, people with compromised immune systems and people with open cuts and wounds are generally most at risk.

** Some secondary contact activities have a greater likelihood of accidental water ingestion than other secondary contact activities. For example activities such as canoe polo as well as white water rafting, canoeing or kayaking would be considered to have a very high likelihood of accidental water ingestion. Activities such as canoe and kayak touring, dragon boating, fishing and sailing would be considered to have a lower likelihood of accidental water ingestion. However, any of these activities can become high risk activities depending on the level of skill of the recreational users.

Characteristics of Secondary Contact	RISK				
	Very High	High	Medium	Low	Very Low
Are there vulnerable people partaking in secondary contact activity	10				1
Number of people on average partaking in a secondary contact activity during a visit (include consideration of any specific planned events [e.g. Scout Jamborees], such events could also increase the degree of exposure and likelihood of ingestion)	10	8	5	2	1
Degree of exposure: frequency and duration of use	10	8	5	2	1
Percentage of people partaking in secondary contact activity where the likelihood of accidental ingestion of water is high**	10	8	5	2	1

Health Risk	Score
Very High	Greater than 20
High	16-20
Medium	11-15
Low	5-10
Very Low	Less than 5