Australian Recreational Water Quality Guidelines

Administrative Report

Public consultation draft – January 2026

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Australian Recreational Water Quality Guidelines: Administrative Report

Summary

The National Health and Medical Research Council (NHMRC) has updated the *Guidelines for Managing Risks in Recreational Water (2008)*. These have been renamed the *Australian Recreational Water Quality Guidelines* (the Guidelines) to better reflect the scope of the guidance. These draft Guidelines are intended to replace the 2008 NHMRC Guidelines when they are finalised and published following public consultation.

In late 2018, NHMRC commenced the update to reflect current scientific evidence and align the guidance with international best practice. The update of the draft Guidelines was overseen by the Recreational Water Quality Advisory Committee.

A key change from the 2008 NHMRC Guidelines is a refined scope that focuses specifically on the health risks associated water quality, instead of physical risks such as drowning or animal attacks. The update also incorporates a new preventive risk management framework and updated chapters on hazards in recreational water including chemical, microbial, harmful algal and cyanobacterial blooms and radiological hazards.

These updates were informed by several contracted evidence reviews and adaption of recently published international guidance.

This document summarises the development process for drafting the updated Guidelines for public consultation. It will be updated prior to final publication.

Background

NHMRC issues guidelines under section 7(1) of the *National Health and Medical Research Council Act 1992* (the NHMRC Act). The draft *Australian Recreational Water Quality Guidelines* (the draft Guidelines) aim to provide a nationally consistent, best practice approach for managing recreational water quality. The primary aim of the draft Guidelines is to protect the health of humans from threats posed when using coastal, estuarine and freshwaters for recreational or cultural purposes.

The draft Guidelines are intended to form part of the National Water Quality Management Strategy, an Australian Government initiative in partnership with state and territory governments. The Guidelines contain information and guidance on health risks associated with recreational and cultural use of water bodies, including risks from exposure to:

- microbial pathogens from faecal and non-faecal sources
- other harmful organisms that may be present in water, including *Naegleria fowleri*
- harmful algal and cyanobacterial blooms
- chemical and radiological hazards.

The update to the draft Guidelines also includes a new preventive risk management framework which details the key elements for managing water quality at water sites used for recreational and cultural purposes.

While the Guidelines are not mandatory, they are intended to support State and Territory governments to develop legislation and standards appropriate for local conditions. Local councils, State and Territory authorities and other stakeholders have used the previous version of the Guidelines to develop policy, legislation, standards and action plans to manage recreational water environments. Many jurisdictions have directly referenced the 2008 NHMRC Guidelines rather than developing their own policies.

Development of the updated Guidelines

The *Guidelines for Managing Risks in Recreational Water* were first released in 2006 and last amended in 2008. The scope of the current guideline update was determined through early engagement with stakeholders, which identified priority areas requiring revision as well as the development of a new risk management framework tailored to Australian conditions. NHMRC conducted the scoping phase with expert advice from the Water Quality Advisory Committee, including:

- **Targeted Consultation Survey:** Conducted from 31 January to 3 March 2017, this survey invited key stakeholders to provide feedback. Stakeholders included environmental protection agencies, health departments, industry representatives and other stakeholders with an interest in recreational water quality. A total of 37 responses were received. The survey was used to identify sections of greatest importance to stakeholders, information gaps and emerging issues relating to recreational water quality. The Water Quality Advisory Committee reviewed the survey results in June 2017.
- **Comparative Analysis:** International, national and jurisdictional recreational water guidelines were compared with the existing NHMRC guidelines to provide additional evidence for areas requiring revision.

Based on this input NHMRC, with advice from the Water Quality Advisory Committee and the Environmental Health Standing Committee (enHealth), identified the critical areas for review as outlined in Box 1.

Box 1 – Identified priority areas of 2008 NHMRC Guidelines for review

Chapter 5 Microbial Quality of Recreational Water

- Guidance on single-sample water quality triggers for short-term water quality assessment.
- Determine the most appropriate methodology to conduct sanitary inspections for fresh and marine water.
- Relevance of the current indicator organism (*Enterococci*) compared to alternative indicator organisms (e.g. *E.coli*) for monitoring faecal contamination in recreational freshwater.

- Review of analytical methods for isolating and enumerating bacterial indicators including sample analysis times and any issues associated with analytical variability.
- Review of Quantitative Microbiological Risk Assessment (QMRA) approach to recreational water assessment to inform a methodology for inclusion in the Guideline.

Chapter 6 Cyanobacteria and Algae in Freshwater

Chapter 7 Cyanobacteria and Algae in Coastal and Estuarine water

- Toxigenic cyanobacteria species and their toxins including guideline values for total biovolume for all cyanobacteria in both fresh water and coastal estuarine water.

Chapter 8 Section 8.2.6 Free living microorganisms

- A narrative review of the literature on free living micro-organisms in recreational water including *Naegleria fowleri* and *Burkholderia pseudomallei*.

Chapter 9 Chemical hazards

- Understand the impacts of acid sulphate soils and emerging chemicals (e.g. endocrine disrupting chemicals) on recreational water and human health.
- Inform development of an updated approach to guidance for primary exposure to chemical hazards in recreational water.

To inform Chapters 2 (Monitoring), 5 (Microbial Quality), 6 (Cyanobacteria) and 9 (Chemical Hazards).

- Evaluation of approaches for assessing exposure through secondary contact recreational activities in relation to microbiological, cyanobacterial and chemical hazards.

In 2018, NHMRC commenced the current review as part of its ongoing commitment to public and environmental health. Key steps undertaken as part of the guidance development process are summarised in **Figure 1**. This process is consistent with standard processes undertaken for NHMRC internal guideline development and NHMRC Standards for Guidelines.

Figure 1. Overview of the guideline development process

Scoping	Prioritisation and scoping of topics by NHMRC, including targeted consultation with stakeholders • Approval to commence work sought from NHMRC CEO •Advice from Committee on scope of review, including evidence review methods
Evidence Review	• Research protocol drafts and advice sought from the Committee • Evidence reviews commenced after finalisation of Research Protocols • Committee feedback sought on draft reports and reports finalised by reviewers • Committee consider proposed guideline options and undertake an Evidence to Decision process to determine guideline recommendations
Draft guidance	• NHMRC and Committee draft guidance • Expert review and targeted consultation on draft guidance (EnHealth Water Quality Expert Reference Panel, Water Quality Advisory Committee, independent experts) • Feedback considered and revisions made to draft guidance where possible.
Public consultation	• Committee advice to release the draft Guidelines for public consultation • Council advice to issue the draft Guidelines for public consultation •CEO approval to release the draft Guidelines for public consultation • NHMRC to release draft guidance for public consultation (6 weeks)
Revision of guidance	• NHMRC and Committee to review public consultation submissions and revise the draft Guidelines as required • Review of revised guidance by independent experts and enHealth Water Quality Expert Reference Panel
Finalise guidance	• Committee advice to finalise the guidance and publish the Guidelines • Council advice to NHMRC CEO to publish updated Guidelines • Seek NHMRC CEO approval to publish the updated Guidelines • Publish updated Guidelines

Evidence reviews

Narrative reviews were conducted by contracted evidence reviewers for selected topics, following a prespecified research protocol covering:

- the human health risks from the specified hazards
- additional information such as monitoring and risk management approaches required to ensure protection of public health.

The following reviews were undertaken:

- chemical hazards in recreational water (Ecos Environmental Consulting)
- microbial quality of recreational water (Ecos Environmental Consulting)
- cyanobacteria and algae in recreational water (Australis Water Consulting)
- free-living organisms in recreational water (Commonwealth Scientific and Industrial Research Organisation (CSIRO)).

In addition, an evidence review of radiological water quality was conducted by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) in collaboration with NHMRC to support the development of the radiological hazards chapter.

Each review produced an evidence evaluation report summarising the state of the evidence for each research question. In addition, technical reports detailed the methods used to search for and critically appraise the evidence.

The Committee considered the findings of these reports when developing guideline recommendations and supporting guidance.

Consideration of additional evidence

The World Health Organization (WHO) published its updated *Guidelines for Safe Recreational Water Environments* in 2021 after the cut-off date for the contracted evidence reviews commissioned by NHMRC. As the WHO (2021) guidelines were not captured through the formal review process undertaken by independent expert reviewers, the Committee and NHMRC agreed that relevant components of the WHO (2021) guidelines should be considered alongside the commissioned reviews when drafting the Australian guideline content. This decision was made to ensure that the Australian guidelines align with international best practice, while remaining tailored to the national context.

To support this, the Committee reviewed the WHO (2021) guidelines and other recently published guidance from international agencies such as the United States Environmental Protection Agency (US EPA) and Health Canada, focusing on areas where new or updated recommendations could enhance or complement the findings of the contracted reviews. This assessment involved:

- comparing international recommendations with the 2008 NHMRC Guidelines and evidence base summarised in the contracted reviews
- evaluating the applicability of international guidance to Australian environmental, regulatory, and public health conditions

- identifying areas where adaptation was necessary to reflect local risk profiles, monitoring capabilities, and management frameworks.

Evidence to Decision process

Evidence reviews provide a comprehensive summary of the evidence but do not include recommendations (e.g. health-based guideline values). The term 'decision' is used to mean the resulting judgement of the evidence made by NHMRC and the Committee.

The draft Evidence to Decision tables (**Appendix A**) helped to inform Committee discussion and support transparent consideration of the findings from the evidence reviews undertaken by the Committee. These are draft only and will be revised as required pending consideration of feedback received during public consultation.

Drafting of guidance

The NHMRC Project Team commenced the review and update of the Recreational Water Quality Guidelines following Committee advice on priority areas for revision and the outcomes of targeted stakeholder consultation. At a 2 May 2016 meeting, the NHMRC Water Quality Advisory Committee identified and advised on areas for review, initiating the process for updating the Guidelines for Managing Risks in Recreational Water (2008). In 2018, the Recreational Water Quality Advisory Committee was established.

In May 2020, contracts were established with Ecos Environmental Consulting and Australis Water Consulting to conduct narrative reviews on chemical and microbial hazards, as well as cyanobacteria and algae in recreational water. After receiving feedback from the Committee, research protocols for these reviews were finalised in September 2020. In October 2020, CSIRO was engaged to undertake a narrative review on free-living organisms. The research protocol for this review was finalised in November 2020. Additionally, in September 2021, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) agreed to review radiological advice to support the management of risks associated with recreational water sources.

Key milestones were completed as below:

- November 2021: cyanobacteria and algae review completed
- June 2022: chemical and microbial hazards reviews completed
- August 2024: free-living organisms review completed
- October 2025: radiological hazards review completed,
- 2022 – 2025: drafting guideline content and evidence to decision processes
- August-November 2025: targeted consultation and expert review
- November 2025: advice from Committee to release draft Guidelines for public consultation.

Recreational Water Quality Advisory Committee advice

The NHMRC Recreational Water Quality Advisory Committee (the Committee) provides expert advice to NHMRC on public health issues related to recreational water quality. The Committee was established in 2018 with the primary role of reviewing and updating the Guidelines. Between 2018 and 2025, the Committee provided advice at 59 meetings of the Committee and its Subgroups during different stages of the evidence review and guideline development processes. The Committee advised on:

- the draft Research Protocols for the contracted evidence evaluations including scope and development of research questions
- the draft Evidence Evaluation and Technical Reports, initially through Subgroups and then the full Committee
- the development of candidate guideline options presented in Evidence to Decision tables
- the draft updated guidance (initially through the Subgroups and then full Committee)
- final guideline recommendations for public consultation and advice to the CEO to release the draft guidance for public consultation.

Survey on community water use and risk awareness

In 2022, NHMRC surveyed Aboriginal and Torres Strait Islander stakeholders and representatives to ensure the updated Guidelines reflect the values, knowledge systems, and lived experiences of First Nations communities. This process aimed to:

- seek First Nations perspectives on water quality risks, risk management, and risk communication
- consider ways to incorporate traditional knowledge and scientific evidence to improve national guidance
- establish and maintain respectful relationships with First Nations stakeholders throughout the guideline development process.

Initial contact was made with key individuals, Elders, community leaders, peak bodies, and experts to introduce the project and seek advice on preferred consultation methods. NHMRC sought initial feedback on the appropriateness of the survey format and consultation questions from several advisors.

Early feedback helped refine the language and questions to ensure cultural appropriateness and inclusivity. Stakeholders were then invited to participate through several channels:

- **Online survey** (via Survey Monkey) and a survey document (fillable online or as a hard copy)
- **Direct conversations** by phone or videoconference, arranged according to stakeholder preference
- **Face-to-face engagement** at the NATSIEH conference, where delegates could participate in the survey and discuss the project at the NHMRC exhibition space

The survey was distributed via email to a broad range of contacts, including Aboriginal and Torres Strait Islander peak bodies, community organisations, local councils, and individual stakeholders identified as having an interest in recreational water quality. Recipients were encouraged to share the survey within their networks to maximise participation.

The survey comprised several questions focused on:

- types and uses of water on Country
- current water quality management practices
- methods of risk communication within communities.

Most questions were presented in a multiple-choice format, with respondents given the option to provide additional free text answers where they wished to elaborate or share further insights.

NHMRC received seven consultation submissions in response to the Survey Monkey consultation from various individuals and organizations.

General feedback about the current guidelines and consultation approaches were collected in-person from various conversations held at the NHMRC consultation booth at the National Aboriginal and Torres Strait Islander Environmental Health (NATSIEH) conference held in Darwin in September 2022. Conference attendees included:

- Environmental and Public Health Officers
- Rangers
- Local Aboriginal and Torres Strait Islander Land Council Delegates
- Local, State and Federal Government Delegates
- Academics/Research Institutes

Relevant learnings from the conference presentations, and the National Aboriginal Community Controlled Health Organisation (NACCHO) workshop held at the conference was also collected and incorporated with the survey feedback.

Key themes from the survey responses were:

- Water is used for a wide range of purposes, including cultural, spiritual, economic, and daily activities. Its importance to community identity and wellbeing was strongly emphasised.
- Most respondents reported not being actively involved in water management decisions and expressed a desire for greater participation and recognition of traditional knowledge.
- Respondents access many types of water sources and identified risks such as drowning, infections, chemical contamination, and insufficient consultation.
- Information about water risks is mainly shared through word of mouth, meetings, rangers, clinics, social media, and signage. Stakeholders recommended education, local engagement, and culturally relevant communication to improve awareness and involvement.

A summary of the survey feedback and responses is available at **Appendix B.**

Targeted consultation

Members of the Environmental Health Standing Committee (enHealth) Water Quality Expert Reference Panel were invited to provide expert feedback on the draft guidance from August-November 2025 before public consultation. Panel membership of the enHealth Water Quality Expert Reference Panel includes jurisdictional representatives working in the field of drinking water quality and public health who can provide feedback on the feasibility and accuracy of NHMRC advice. Members of the NHMRC Water Quality Advisory Committee were also invited to comment on the draft Guidelines.

Feedback received on the draft Guidelines was generally supportive of the proposed updates, with several suggestions for further revisions. In response, specific edits were made to clarify or simplify language, address suggestions and to include additional references where needed. In some instances, feedback will be considered further by the Committee following public consultation. Some common areas of feedback included:

- editorial and structural suggestions to improve clarity, accuracy and accessibility
- the need for inclusive, consistent and clearly defined terminology, with technical content tailored to the target audience and Australian context
- calls for broader Australian examples and control measures to ensure relevance across all recreational water environments and aesthetic impacts
- requests for guidance and examples addressing a range of chemical hazards and management approaches
- concerns about screening values based on adult body weight rather than children, with suggestions to clarify the rationale and adjust values to better protect children
- practical challenges for local authorities in conducting routine chemical monitoring due to resource constraints
- expand consideration of exposure pathways, such as including water fountains and aerators in addition to sea-spray aerosols for inhalation exposure
- consideration of skin irritants and skin rashes, including the potential role of skin irritation assays
- suggestions to consider and address natural toxins (e.g. cane toad and algal toxins)
- requests for clear explanations and rationale for any variation from WHO guideline values or advice
- current data on species of cyanobacteria and the importance of toxin detection/testing and basing action and alert levels on evidence of toxicity wherever possible
- importance of the cultural significance of water for First Nations communities, with suggestions for inclusive implementation and co-developing resources in genuine partnership with traditional owner groups

A summary of the key issues raised through targeted consultation before public consultation and how these issues were addressed is provided in Appendix C. Issues that were not addressed prior to public consultation will be considered by the Committee with public consultation feedback.

Independent expert review

In addition to targeted consultation with jurisdictional experts, independent expert feedback on selected chapters of the draft Guidelines was undertaken in October and November 2025 prior to public consultation. The purpose of expert review was to seek feedback on whether the evidence evaluation undertaken was sound and reliable and ensure that the evidence had been appropriately synthesised and interpreted. Several experts were nominated by the Recreational

Water Quality Advisory Committee based on their recognised expertise in relevant fields. Expert reviewers were required to complete a Disclosure of Interests and a Confidentiality Deed Poll, as per NHMRC standard processes. Once eligibility was confirmed, reviewers were provided with the draft chapters and supporting evidence tables for their assessment.

Expert review prior to public consultation was undertaken by:

- *Chapter 5 - Harmful algal and cyanobacterial blooms* and supporting information
    - Dr Anusuya Willis (Commonwealth Scientific and Industrial Research Organisation)
    - Professor Michele Burford (Griffith University)
    - Dr Jonathan Puddick (Cawthron Institute)
    - Dr Michael Burch (Australis Water Consulting)
- *Chapter 4 - Other microbial hazards* and supporting information
    - Professor Karin Leder (Monash University)
    - Dr Rebekah Henry (Monash University).

Feedback received on the draft Guidelines was generally supportive of the proposed changes, with several suggestions for further revisions to improve the guidance and current state of knowledge. In response, specific edits were made to clarify or simplify language, address suggestions and to include additional references where needed. In some instances, expert feedback will be considered further by the Committee following public consultation.

Some common areas of feedback for the draft Chapter 5 - Harmful algal and cyanobacterial blooms and supporting information included:

- general support for the risk management approach and alert level framework as practical and protective of public health
- suggestions to provide Australia-specific context and examples, rather than relying mainly on international sources
- editorial and structural suggestions to improve clarity, accuracy and accessibility including corrections to nomenclature, taxonomy and terminology
- suggestions to provide clearer operational guidance, including site-specific risk assessments and consideration of climate change impacts
- suggestions to highlight further research gaps, such as research on toxin cell quotas, strain variability, and bloom dynamics
- suggestions for more comprehensive sample collection guidance and adaptation of international frameworks to Australian conditions
- support for the Evidence to Decision Framework and conservative guideline values, noting these may result in more frequent water body closures but are justified for health protection.

Some common areas of feedback for the draft Chapter 4 – Other microbial hazards and supporting information included:

- providing a clearer scope and rationale for inclusion/exclusion of microbial risks. The inclusion of some rare organisms (e.g. Chrombacterium violaceum, Shewanella spp.) was queried due to low case numbers and minor clinical significance
- structural suggestions regarding the presentation and formatting of organism-specific sections (i.e. standardise for consistency and ease of use)
- suggestions to more clearly define exposure pathways (faecal/urine vs. environmental) and grouping organisms by reservoir type for clarity
- review and consider recommendations for individual protective measures to be provided consistently across organisms
- provide clarification about current knowledge and/or expectation of management responsibilities of antimicrobial resistance (AMR) and its significance for each organism
- review source information in Table 4.2 for consistency, particularly regarding animal carriage and marine species
- suggest including climate change considerations beyond temperature (e.g. impacts of floods, soil reservoirs, and resuspension of solids)
- review risk management principles and provide more specific and actionable advice, and include explicit statements about data limitations
- incorporate assessment of source environments (soils/animal faeces) into the risk assessment framework
- include water quality characteristics such as turbidity and temperature in advice about operational monitoring.

A summary of expert review comments and how they were addressed is provided in Appendix D. Disclosure of Interests of expert reviewers is included in **Appendix E**.

Contributors

The Recreational Water Quality Advisory Committee (the Committee) provides expert advice to NHMRC on public health issues related to recreational water quality. The Committee was first established on 17 August 2018. The primary role of the Committee has been to review and update the *Guidelines for Managing Risks in Recreational Water (2008)* to produce the draft *Australian Guidelines for Recreational Water Quality*.

Committee members have expertise in the fields of water quality risk assessment and management, microbiology, toxicology, aquatic ecotoxicology, environmental and public health microbiology in wastewater treatment, environmental science, epidemiology and river health. Committee Members are also members of professional networks and consult within and outside these networks to provide expert advice on recreational water quality issues nationally and internationally.

Committee Members from 17 August 2018 - 31 December 2026 include:

- Professor Stuart Khan (Chair) – Head of School, School of Civil Engineering at the University of Sydney. Expertise in trace chemical contaminants in water, risk assessment, risk management and environmental engineering.
- Dr Ben van den Akker - Research wastewater scientist at SA Water. Adjunct Lecturer in the School of the Environment at Flinders University and Adjunct Research Fellow at University of South Australia. Expertise in environmental and public health microbiology relating to wastewater treatment and reuse.
- Dr Meredith Campey - Manager at Beachwatch Programs, Department of Planning, Industry and Environment, New South Wales. Expertise in marine science and recreational water quality.
- Dr Christine Cowie - Senior Research Fellow, Woolcock Institute of Medical Research, University of Sydney. Affiliate with the Centre for Air pollution, energy and health Research (CAR). Expertise in environmental epidemiology, and air pollution epidemiology.
- Dr Dan Deere - Independent consultant and Director of Water Futures. Visiting Fellow at the University of New South Wales. Expertise in water quality, risk management, data analysis, interpretation and modelling, auditing.
- Ms Sarah Holland-Clift - General Manager Corangamite Catchment Management Authority, Victoria. Expertise in environmental consultancy program coordination, weed management, carbon and emissions in agriculture and river health.
- Associate Professor Andrew Humpage - Independent Consultant, South Australia. Member of the World Health Organization Guidelines for Drinking Water Quality Chemicals Committee. Expertise in clinical biochemistry, histopathology, in vivo and in vitro toxicology, and genotoxicity, particularly in cyanobacterial toxins.
- Dr Greg Jackson - Director, Water Unit, Prevention Division, Department of Health, Queensland. Expertise in regulation and environmental science.
- Dr Muriel Lepesteur-Thompson - Senior Health Risk Advisor (Microbial) at the Environment Protection Authority Victoria (EPA). Adjunct Associate Professor, RMIT University. Expertise in microbial risk assessment (including quantitative microbial risk assessment) and risk management.
- Dr Richard Lugg - Independent Consultant Western Australia. Expertise in water quality and human health.
- Professor Susan Petterson - Professor, School of Medicine, Griffith University. Director, Water & Health Pty Ltd. Editor, Journal of Water and Health. Expertise in quantitative microbial risk assessment and risk assessment software development.
- Ms Rachael Poon - Senior Policy Officer, Agriculture Victoria, Department of Energy, Environment and Climate Action, Victoria. Expertise in regulation, microbiology and biotechnology.
- Professor Anne Roiko - Professor School of Medicine and Dentistry Griffith University. Adjunct Professor Australian Rivers Institute, Griffith University. Adjunct Professor, University of the Sunshine Coast. Research Advisor, WaterNSW. Researcher with the Hopkins Centre and the Cities Research Institute. Expertise in environmental epidemiology, quantitative microbial risk assessment and risk management.

- Dr Jenny Stauber – Independent Ecotoxicologist. Expertise in microbiology, environmental contamination and risk assessments.
- Dr Cameron Veal - Lead Water Quality (Public Health) at Seqwater, Queensland. Expertise in water quality and public health.
- Mr Lee Joachim (from 10 February 2023 until 31 December 2024) – Regional manager at 54 Reasons and freelance consultant. Expertise in public health and environmental health, including traditional knowledge in climate change and natural resource (including water) management, particularly in the Murray-Darling Basin region.

Several Subgroups were also convened to provide technical advice on specific sections of the Guidelines:

Risk Management Framework Working group

- Prof Susan Petterson (Subgroup Chair)
- Prof Anne Roiko
- Dr Ben van den Akker
- Dr Cameron Veal
- Dr Daniel Deere
- Dr Muriel Lepesteur-Thompson
- Ms Rachael Poon
- Prof Stuart Khan

Microbial Risks Subgroup

- Dr Muriel Lepesteur-Thomson (Subgroup Chair)
- Prof Anne Roiko
- Dr Ben van den Akker
- Dr Cameron Veal
- Dr Daniel Deere
- Dr Meredith Campey
- Dr Muriel Lepesteur-Thompson
- Ms Rachael Poon
- Dr Richard Lugg
- Ms Sarah Holland-Clift
- Prof Susan Petterson

Chemical Subgroup

- Dr Greg Jackson (Subgroup Chair)
- Dr Jenny Stauber

- Dr Muriel Lepesteur-Thompson
- Prof Stuart Khan

Cyanobacteria and algae Subgroup

- Dr Cameron Veal (Subgroup Chair)
- Dr Andrew Humpage
- Dr Ben van den Akker
- Dr Daniel Deere
- Ms Rachael Poon
- Ms Sarah Holland-Clift

Free-living Organisms Subgroup

- Prof Anne Roiko (Subgroup Co-Chair)
- Prof Susan Petterson (Subgroup Co-Chair)
- Dr Cameron Veal
- Dr Daniel Deere
- Dr Richard Lugg

NHMRC project team

A small project team from the Environmental Health Section in the Research Quality and Advice Branch provided project and secretariat support to the Committee, Subgroups, and evidence reviewers.

Declarations of Interest

Appointees to committees of NHMRC are required to disclose their interests consistent with Section 42A of the Act, and instructions issued under sections 16A and 16B of the Public Governance, Performance and Accountability Rule 2014 (made under subsection 29(2) of the *Public Governance, Performance and Accountability Act 2013*). Prospective members were specifically asked to identify, to the best of their ability, interests including:

- financial interests: an interest must be declared when benefits or losses either in money or in-kind have occurred or may occur at a level that might reasonably be perceived to affect a person's judgement in relation to fair decisions about evidence and their participation in group decision-making
- other relationships: an interest must be declared when a strong position or prejudice or familial connection or other relationship held by a person could reasonably, or be perceived to, affect a person's judgement in relation to fair decisions about evidence and their participation in group decision-making including making an effort to arrive at a consensus
- affiliations to or associations with any organisations or activities that could reasonably be perceived to be an influence due to a competing interest, either for or against the issues being considered by the committee

- any other influences that might reasonably be considered likely to affect the expert judgement of the individual, or lead to the perception by others that the judgement of the individual is compromised.

Under the Public Governance, Performance and Accountability Act 2013, Members have a responsibility to declare any interests to the whole Committee. Members also have a joint responsibility to decide on the management of any perceived or real conflict. No unmanageable conflicts were identified by the Committee or NHMRC during the development of the draft Guidelines.

Throughout the project, Members were reminded of their obligation to consider any interest that may have arisen since the last meeting or with any particular agenda items. All disclosures and determinations about interests were recorded in the minutes of the Committee meetings. Members' relevant expertise and a summary of their disclosed interests were accessible on the NHMRC website throughout the duration of the project.

The relevant expertise of the Committee and a summary of their disclosed interests during the term of their membership is at **Appendix E**. Disclosed interests of the contracted evidence reviewers and independent expert reviewers are also available at **Appendix E**.

Project funding

This work was funded by NHMRC with contributions from the Commonwealth and the States and Territories.

Acknowledgements

We acknowledge the valuable contributions of many individuals and groups to the development of the updated recreational water quality guidelines. In particular, we thank:

- The Chair and Members of the Recreational Water Quality Advisory Committee for their ongoing advice and support throughout the guideline development process since 2018.
- Independent reviewers who undertook narrative reviews of water quality risks in recreational water under challenging circumstances, including during the COVID-19 pandemic.
- The enHealth Water Quality Expert Reference Panel for their targeted consultation and expert advice on the draft guidance.
- Members of the NHMRC Water Quality Advisory Committee who participated in targeted consultation activities on the draft guidance.
- Expert reviewers who provided feedback on draft guidance prior to public consultation.
- Aboriginal and Torres Strait Islander stakeholders who advised on the design of the consultation process and those who shared feedback to help shape the guidance.
- NHMRC Public and Environmental Health Section staff for their sustained efforts and commitment to progressing the update to the Guidelines over the years.
- Individuals who contributed case studies for the committee's consideration.

The collective expertise and commitment of all of these individuals have been instrumental in ensuring the draft Guidelines are robust, inclusive, and informed by diverse perspectives. This process highlights the importance of collaboration and consultation to achieve evidence-based, practical guidance that supports public health and environmental outcomes.

References

NHMRC (2008). Guidelines for managing risks in recreational water. National Health and Medical Research Council. Canberra, ACT.

WHO (World Health Organization) (2021). Guidelines on recreational water quality. Volume 1: coastal and fresh waters. Geneva: WHO.

Appendix A – Evidence-to-Decision tables

Evidence to decision table – Microbial pathogens from faecal sources

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 1. Comparison of guideline options – microbial pathogens from faecal sources

Criteria	OPTION 1	OPTION 2	OPTION 3
Decision?	Maintain status quo NHMRC (2008). A classification matrix combining the categories for sanitary inspection category and microbial assessment category. Microbiological values are expressed in terms of the 95th percentile of intestinal enterococci per 100 mL and represent estimated levels of health risk.	Adopt and adapt NHMRC (2008) and WHO (2021). Adapt wording in current recommendation and adopt microbial assessment categories consistent with NHMRC (2008) and WHO (2021) for both marine and freshwater, and adapt WHO (2021) advice on applying risk management framework. Microbiological values are expressed in terms of the 95th percentile of intestinal enterococci per 100 mL and represent estimated levels of health risk.	Adapt Option 1 or 2 and for freshwater develop microbiological values for both intestinal enterococci and *Escherichia coli.*

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Criteria	OPTION 1	OPTION 2	OPTION 3
Draft recommendation	Preventive risk management practices should be adopted to ensure that designated recreational water bodies are protected against direct contamination with fresh faecal material, particularly of human or domesticated animal origin.	The health risks associated with faecal contamination for a recreational water site should be assessed by combining the outcomes of a sanitary inspection with a microbial water quality assessment. Preventive risk management practices should be adopted to ensure that designated recreational water bodies are protected against faecal contamination. Effective management oversight and public communication should be adopted to minimise microbial risks to public health.	As per Option 1 or 2. For freshwaters establish *Escherichia coli* criteria.

Table 2. **Discussion of evidence to decision factors for guideline options – microbial pathogens from faecal sources**

Criteria	Discussion of evidence to decision factors
Health evidence profile	The most significant hazards in recreational water bodies are microbial pathogens (viruses, bacteria, protozoan parasites and helminths) introduced by faecal contamination from above all humans, to some extent livestock, and to a lesser extent, wildlife. Most recreational water bodies are susceptible to faecal contamination. The act of recreating in a water body has been proven to contribute microbial pathogens. Epidemiological studies have shown that gastrointestinal and respiratory infections are associated with faecally contaminated recreational water (Kay et al. 1994; WHO 2021). In both NHMRC (2008) and WHO (2021), the approach to assessing microbial pathogen risk in recreational water is based on a microbial-based classification approach, combining a sanitary inspection category with a microbial water quality assessment category. The microbial water quality assessment categories are defined by microbiological values expressed in terms of the

Criteria	Discussion of evidence to decision factors
	95th percentile of intestinal enterococci per 100 mL and represent levels of risk of gastrointestinal illness and acute febrile respiratory illness based on exposure conditions of key epidemiological studies, as follows: • Category A: ≤40 intestinal enterococci/100 mL, representing gastrointestinal illness risk <1%, acute febrile respiratory illness <0.3% • Category B: 41-200 intestinal enterococci/100 mL, representing gastrointestinal illness risk 1-5%, acute febrile respiratory illness 0.3-1.9% • Category C: 201-500 intestinal enterococci/100 mL, representing gastrointestinal illness risk 5-10%, acute febrile respiratory illness 1.9-3.9% • Category D: >501 intestinal enterococci/100 mL, representing gastrointestinal illness risk >10%, acute febrile respiratory illness 3.9%. *Epidemiological evidence* A review by O'Connor (2022) did not identify recent epidemiological studies in Australia from which national health outcome targets can be derived. In the absence of high-quality, locally relevant epidemiological studies or pathogen surrogate monitoring data, default microbial water quality values for both NHMRC (2008) and WHO (2021) have been derived from Kay et al. (1994) and Fleisher et al. (1996). Kay et al. (1994) conducted the first randomised control study to evaluate the health effects associated with swimming in coastal waters in the United Kingdom (UK). The dose–response model relating enterococci concentration to the probability of gastroenteritis from the UK trials is considered the most precise dose-response relationship (WHO 2021). This is attributed to the enhanced control of bias facilitated by the randomised trial design (i.e. more precise measure of exposure facilitated by measurement of water quality close to the time and place of bathing). Fleisher et al. (1996) studied possible dose-response relationships among bathers exposed to marine waters contaminated with domestic sewage and subsequent risk of nonenteric illness. A significant dose–response relationship between acute febrile respiratory illness and faecal streptococci was reported by Fleisher et al. (1996). The risks of gastrointestinal illness and acute febrile respiratory illness are based on the 95th percentile of intestinal enterococci distribution from these key epidemiological studies. Possible thresholds for an increased risk of gastroenteritis at a concentration of 32 faecal streptococci/100 mL (Kay et al. 1994) and an increased risk of respiratory illness at a concentration

Criteria	Discussion of evidence to decision factors
	of 60 faecal streptococci/100 mL (Fleisher et al. 1996) were reported. Kay et al. (1994) do not suggest that enterococci caused the excess gastrointestinal in sea bathers but rather these microorganisms seem to be a good indicator of water quality. The risk of illness from recreation are based on the increased risk in the GI rate in swimmers compared to control groups. A tolerable GI risk of 1-10% is proposed, which is similar to reported background rates of GI ranging from 0.9-9.7% in the studies of Cabelli et al. (1982), Kay et al. (1994) and van Asperen et al. (1998). Several international jurisdictions have different standards for seawater and freshwater sites, utilising both enterococci and *Escherichia coli.* There is data from the literature supporting both enterococci and *Escherichia coli* as faecal indicator organisms for freshwater, but only enterococci for marine water. Researchers confirm that culturable *Escherichia coli* is associated with gastrointestinal illness and remains a useful indicator of contamination in freshwaters (Prüss 1998; Marion et al. 2010; Wiedenmann et al. 2006). The randomised controlled trials by Wiedenmann et al. (2006) identified an *Escherichia coli* guideline value using a no-observed-adverse-effect-level approach based on the risk of gastrointestinal illness and *Escherichia coli* concentrations. Wiedenmann et al. (2006) proposed criteria of 100 *Escherichia coli* /100 mL and 25 enterococci/100 mL and also introduced criteria for somatic coliphages (10/100 mL), and *Clostridium perfringens* (10/100 mL). However, WHO still recommends intestinal enterococci only for both freshwater and marine water, rather than intestinal enterococci and/or *Escherichia coli,* as it considers that no statistically significant relationship has been established for *Escherichia coli* that can support a dose-response guideline value (WHO 2021). As further empirical epidemiological data become available, it may be possible to use *Escherichia coli,* microbial source tracking markers and viral pathogens (Gitter et al. 2020; Schoen et al. 2020) or their indicators (e.g. phages), protozoa or helminths to assess health risk in recreational water bodies (WHO 2021). Applying the microbial water quality categories based on epidemiological studies conducted in marine waters to freshwaters may be more conservative given the potentially higher rate of die-off of faecal indicator organisms in seawater compared to freshwater. This would result in more pathogens in seawater than in freshwater for the same culture-derived density of faecal indicator organisms. However, a precautionary approach is supported given there is less dilution of effluent and stormwater in freshwater recreational areas compared to marine waters.
Exposure profile	The microbial assessment categories supported by intestinal enterococci concentrations are derived from a well-based continuous risk distribution that enabled risks of bathing to be segmented into suitable microbial assessment categories. While other countries used *E. coli* to delineate categories, none of them was derived from a comparable risk distribution that supported corresponding microbial assessment categories.

Criteria	Discussion of evidence to decision factors
	As further empirical epidemiological data become available, it may be possible to use *Escherichia coli*, microbial source tracking markers and viral pathogens or their indicators (e.g. phages), protozoa or helminths to assess health risk in recreational water bodies. It is important to recognise the limitations of faecal indicator organisms: their relative susceptibility to environmental factors compared to pathogens may underestimate risk to human health. Hence, the importance of sanitary inspections in characterising the risks of recreational water bodies is emphasised in these Guidelines.
Health benefits vs harms	Epidemiological data is primarily collected from healthy adults, as is the case with the dose-response relationships used in quantitative microbial risk assessment studies. Relying solely on the microbial water quality assessment therefore may underestimate risks to children. In some instances, animals (e.g. birds, livestock and domestic animals) can have a significant impact on faecal indicator bacteria used to measure microbial water quality. As a result, the use of faecal bacteria alone as an indicator of risk to human health could result in an overestimation of public health risk where the indicator organisms derive from sources other than human excreta and management actions that are unnecessary (Smith et al. 2020). Option 2 embeds the preventive risk management framework to assessing and managing risk. Option 2 emphasises the importance of sanitary inspections in characterising risk to better understand the sources of faecal contamination.
Values and preferences (consumers, communities)	Increased water site closures as a result of implementing either guideline options 1 or 2 might have impacts on consumers and communities even from a perceived risk (e.g. economic, environmental, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress in communities, such as if recreational activities are restricted or if there is also serious damage to the environment. Both guideline options 1 and 2 could potentially result in restricted or lack of access to recreational water sites which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. Managing perceptions when using faecal indicator organisms is important as their presence does not immediately cause gastrointestinal illness in bathers but rather these microorganisms are an indicator of water quality and the potential for faecal sources of pollution that contain microbial pathogens. It is reasonable to assume that the public would have an expectation that:

Criteria	Discussion of evidence to decision factors
	• information is provided in a timely manner when there is an elevated risk • efforts are made to minimise the deterioration of water bodies available for recreation • there is information available to make informed choices.
Acceptability (other key stakeholders)	The classification approach to managing microbial pathogen risk for all options is well-established practice in Australia and is consistent with the current guidance in NHMRC (2008). The risk management framework proposed under option 2 encourages preventative measures to abate pollution sources aligned with community expectations and facilitates a management oversight proportionate to the level of risk based on the classification outcome. Waterway managers would expect to have a greater diversity of tools available to assess and manage risks such as quantitative microbial risk assessment, microbial source tracking and predictive modelling. These tools may have utility on a site specific basis, however, would require validation and considerable resources. It is acknowledged that some freshwater sites might only have *Escherichia coli* data available to use in the risk assessment of recreational water bodies; despite NHMRC guidelines in 2008 adopting only enterococci. For sites that have been utilising *Escherichia coli* as the faecal indicator organism, for the purposes of characterising microbial risk from faecal contamination, an interim period of monitoring both *Escherichia coli* and enterococci can help facilitate the transition to enterococci.
Feasibility	Both guideline options are considered feasible as the classification matrix is already adopted by managers of water bodies in Australia. Noting the limitations in solely relying on microbial water quality indicators to assess risk, the classification matrix combines the tools available to help inform action rather than a pass/fail. The classification matrix: • emphasises faecal contamination from humans, with lesser importance placed on faecal contamination from other sources • enables local management to respond to sporadic or limited areas of contamination and thereby upgrade a recreational water body's classification, provided that appropriate and effective actions are taken to control exposure • provides triggers for actions to reduce risk • provides incentives for taking action locally and reducing pollution • produces a generic statement of the level of risk, thereby supporting informed personal choice, and it helps to identify appropriate management and monitoring actions.

Criteria	Discussion of evidence to decision factors
	Given the need for extensive pathogen data, QMRA is not a feasible option for most waterway managers, and therefore may only have utility on a site specific basis.
Health equity impacts	These guideline options address the risks from microbial pathogens in recreational water bodies for most of the population, but in some cases may underestimate risks to children particularly where potential sources of faecal contamination are not adequately assessed. It is not feasible to tailor advice to the individual requirements of people with specialised medical needs. Remote communities have limited access to resources and laboratories to enable routine monitoring of water quality. Sanitary inspection is an integral component to assessing risk and managing risk, potentially reducing the reliance on routine water quality monitoring for such communities.
Resource impacts	No resource impacts are anticipated as no change to the microbial assessment category currently described in the NHMRC (2008) is proposed. However, both guideline options 1 and 2 may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. The proposed guidelines places increased importance on the role of sanitary inspections in characterising risks and prevention of faecal sources. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 3. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – microbial pathogens from faecal sources

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	While this guideline option provides a precautionary level of protection using the best available evidence for microbial risk assessment in recreational water, option 2 is considered a stronger guideline recommendation as it recommends embedding key aspects of the preventive risk management approach into current practice.
Option 2	This guideline option was selected based on what is considered the best available evidence for microbial risk assessment in recreational water, with consideration of impacts resulting from unnecessary water site closures on communities and other stakeholders. This option also provides guidance on managing risks within a preventive risk management framework.
Option 3	This option was not selected as no statistical relationship has been established for *Escherichia coli* that can support a dose-response guideline value.

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Evidence to decision table – Other microbial hazards in recreational water

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 4. Comparison of guideline options – other microbial hazards

Criteria	OPTION 1	OPTION 2
Decision?	Retain existing advice relating to other microbial hazards in NHMRC (2008).	Adapt preventive risk management approaches from NHMRC (2008) and WHO (2021), focusing on available options for managing risk of exposure.
Draft recommendation	No specific guideline recommendations established for microbial hazards other than faecal pathogens. For free-living organisms (such as *Naegleria fowleri*) (paraphrased from current recommendation for dangerous aquatic organisms): Direct contact with dangerous aquatic organisms should be avoided. Where risks associated with dangerous aquatic organisms are known, appropriate warning signs should be clearly displayed.	Recreational water users and responsible entities should be aware that serious infections can result from exposure to microbial hazards that are naturally present in surface waters, especially among immunocompromised individuals. Site specific risks should be assessed as part of a preventive risk management approach. Where the risk assessment of a water site identifies that the local environment supports the presence of microbial hazards, the emphasis should be on managing the risk of exposure and raising public awareness to take personal preventive measures. Where environmental conditions at a water site support *Naegleria fowleri*, health advice should include information to help recreational water users understand the elevated risk associated with activities where water is likely to enter the nasal passage.

Table 5. Discussion of evidence to decision factors for guideline options – other microbial hazards

Criteria	Discussion of evidence to decision factors:
Health evidence profile	Microbial hazards, including some free-living and opportunistic human pathogens, present in untreated waters used for recreation and cultural practices have been associated with a range of mild to severe health effects including localised to serious life-threatening systemic infections. Epidemiological evidence on the dose–response relationship for infections caused by these microbial hazards is scarce and insufficient to establish a guideline value. Some of these microbial hazards cause diseases that are notifiable in Australia (refer to the National Notifiable Disease Surveillance System). Given the potential health significance of *Naegleria fowleri* and *Burkholderia pseudomallei* in Australian waters, an independent review of the evidence in recreational water was commissioned by NHMRC (Puzon et al. 2024) and is used to inform the update to the guidelines.
Exposure profile	Exposure to free-living and opportunistic pathogens, including *Naegleria fowleri* and *Burkholderia pseudomallei* can occur through ingestion, skin contact, or inhalation of aerosols during activities such as swimming or water skiing. These organisms may proliferate under specific environmental conditions like warm temperatures and stagnant water. Exposure risk varies by location, season, and activity type.
Health benefits and harms	The proposed recommendations in Options 1 and 2 offer several public health benefits, including reducing exposure to high-risk environments and enhancing community awareness through signage and education. However, the absence of quantitative criteria may lead to inconsistent application across jurisdictions. Overly cautious messaging could discourage recreational and cultural water use or cause undue concern, and implementing signage and outreach may require significant resources, especially in remote or high-use locations.
Values and preferences (consumers, communities)	Community values and preferences reflect a strong desire for safe, accessible recreational water environments. While awareness of microbial hazards may be limited, communities will likely support precautionary measures—such as signage and public health messaging—when risks are clearly communicated. There may be less community support for any measures that may be taken to restrict activities that increase exposure through the nasal passage, particularly in warmer climates where there is increased recreational and cultural water use.

Criteria	Discussion of evidence to decision factors:
Acceptability (other key stakeholders)	Option 2 is likely to be more acceptable to public health authorities and site managers, particularly where precautionary communication is already part of standard practice. However, acceptability may vary across stakeholder groups. For example, local communities who rely on recreational water sites for cultural, social or economic activities may perceive signage or access restrictions as disproportionate or stigmatising, especially in the absence of visible contamination or illness. Similarly, site managers in remote or resource-limited areas may face challenges in implementing signage or communicating risks without additional support.
Feasibility	Implementation of the proposed guideline recommendations in Option 2 are technically feasible but context-dependent. Warning signage and public communication strategies are relatively low-cost and can be deployed by most local authorities. However, feasibility may be constrained in remote or resource-limited settings where routine environmental monitoring or hazard mapping is not currently undertaken. Detection for some of these microbial hazards requires specialised laboratory techniques not routinely available to all jurisdictions. Therefore, implementation of proactive risk management may require additional investment in capacity-building, particularly in areas with known environmental conditions conducive to these pathogens (e.g. warm, stagnant freshwater bodies). The precautionary nature of Option 2 supports feasibility by allowing site managers to act on known or suspected risks without requiring complex risk modelling.
Health equity impacts	Communities in remote or resource-limited areas where these pathogens are more likely to occur due to environmental conditions may face greater implementation challenges if Option 2 is selected. These include limited capacity for environmental monitoring, fewer resources for signage and communication, and reduced access to alternative recreational water sites. Additionally, Aboriginal and Torres Strait Islander communities and other groups with strong cultural or subsistence ties to affected water bodies may be disproportionately impacted by access restrictions or perceived stigmatisation. To mitigate these risks, implementation should be accompanied by culturally appropriate engagement and communication strategies, and consideration of local context and values.

Criteria	Discussion of evidence to decision factors:
Resource impacts	The resource implications of implementing either guideline option are likely to be context dependent. In jurisdictions where environmental health units already have established communication protocols and signage infrastructure, the additional resource burden is likely to be minimal. However, in areas where these systems are not in place, particularly in remote or regional communities, there may be a need for investment in signage, public communication materials, and staff training to support implementation or to monitor compliance. Option 2 does not necessitate ongoing laboratory testing or complex modelling. This reduces the need for specialised technical resources and supports feasibility in lower-resource settings. Where site specific risk assessments are undertaken, additional resources may be required to support environmental investigations or expert consultation. Resources for effective stakeholder engagement and risk communication to ensure consistent application and public understanding of risk and awareness of risk minimisation practices will be required.

Table 6. **Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – other microbial hazards**

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1:	While this guideline option provides some level of protection for managing risks from dangerous aquatic organisms such as free-living organisms in recreational water, option 2 is considered a stronger guideline recommendation as it reflects current best practices for managing known or suspected risks where thresholds cannot be established.

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 2:	The proposed recommendation reflects a precautionary risk-based approach that relies on site specific understanding and public awareness of the risks with an emphasis on managing the risk of exposure through communication strategies where hazards are known or suspected. In the case where environmental conditions at a site potentially support *N. fowleri*, the recommendation highlights the importance of health advice including information to help recreational water users understand the elevated risk associated with activities where water is likely to enter the nasal passage. Given the rarity but severity of health outcomes associated with some of these microbial hazards, and the lack of routine monitoring or established thresholds, this guideline option enables site managers to act on known or suspected risks without requiring complex modelling or laboratory testing, which may be impractical in many settings. This approach is consistent with NHMRC (2008) and WHO (2021) and can be implemented within a preventive risk management framework.

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Evidence to decision tables – harmful algal and cyanobacterial blooms water quality in recreational water – cyanotoxins

Evidence to decision – Microcystins and nodularins

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 7. Comparison of guideline options – microcystins and nodularins

Criteria	OPTION 1	OPTION 2	OPTION 3
Decision?	Adapt Falconer (1994), as cited in Kuiper-Goodman et al. (1999), used in NHMRC (2008) [noting that exposure assumptions are to be updated].	Adapt Fawell (1999), used by WHO (2021) and NZ (2024)	Adapt Heinze (1999), used by US EPA (2019) and Health Canada (2022)
Draft recommendation	Fresh recreational water bodies should not contain ≥ 4 µg/L microcystin-LR* or equivalent toxins, including nodularins. *This guideline value represents the sum value of all microcystins and nodularins present. A toxicity equivalence factor of one should	Recreational water bodies should not contain ≥ 8 µg/L of microcystin-LR* or other microcystins toxins and nodularins *This guideline value represents the sum value of all microcystins and nodularins present. A toxicity equivalence factor of one should be used for all microcystin and nodularin congeners.	Recreational water bodies should not contain ≥ 3 µg/L of microcystin-LR* or equivalent toxins, including nodularins *This guideline value represents the sum value of all microcystins and nodularins present. A toxicity equivalence factor of one should be used for all microcystin and nodularin congeners.

Criteria	OPTION 1	OPTION 2	OPTION 3
	be used for all microcystin and nodularin congeners.		

Table 8. **Discussion of evidence to decision factors for guideline options – microcystins and nodularins**

Criteria	Discussion of evidence to decision factors:
Health evidence profile	The guideline values are derived for microcystin-LR toxicity equivalents (TE). Microcystin-LR (MC-LR) is one of the most common microcystins, and the only one with enough toxicology data to support guideline development. MC-LR is considered one of the most potent microcystin variants. In most cases summing the quantities of all microcystin analogues detected for comparison with the guideline value will be protective of water users. NHMRC 2008 Based on Falconer et al. (1994): NHMRC (2008) recommends that microcystins in fresh recreational water bodies should not exceed 10 µg/L based on Falconer et al. (1994). This study measured a reasonable range of relevant toxicity endpoints in pigs, which are considered to be more physiologically similar to humans than rodents; however, only male pigs were studied and a NOAEL could not be identified. In addition, a crude cyanobacterial extract was administered to the pigs in drinking water, which contained a poorly defined suite of at least 9 microcystins that were imprecisely quantified (3-fold range of toxin content estimated by 3 different methods). The guideline values in this Evidence to Decision Table have been calculated using the equation in WHO (2020) and not the equation provided in NHMRC (2008). WHO (2021) & NZ (2024) Based on Fawell et al. (1999): The WHO (2021) provisional recreational guideline value for microcystins of 24 µg/L is based on Fawell et al. (1999) (WHO 2020). This study was undertaken in mice of both sexes dosed orally by gavage with purified MC-LR. More dose groups studied compared to Heinze 1999, covering an appreciably wider dose range that produced a NOAEL. There is evidence that there may be fundamental differences in the mechanisms leading to hepatocellular death between rats on one hand and mice and humans on the other (Woolbright et al. 2017). Woolbright et al. (2017) compared the effects of MCLR on rat and human hepatocytes in vitro and mouse hepatocytes in vivo and concluded that while cell death in rat cells was mediated via an apoptotic pathway, in mice and humans a necrotic process was induced. It may therefore be the case that a study using mice may be a better basis for human risk

Criteria	Discussion of evidence to decision factors:
	assessment. However, the 13 week study was longer than the short term exposure scenario of this guideline. In addition, dosing was undertaken by gavage so dose material was precisely administered but the bolus dose to the intestine once daily may limit absorption to the period of small intestinal transit. US EPA (2019) & Health Canada (2022) Based on Heinze (1999): Heinze (1999) used by US EPA (2019) and Health Canada (2022) administered purified MC-LR in drinking water to male rats (less precision than gavage regarding administered dose due to dripping and other losses but more physiologically appropriate dose method). The length of the study was 28 days, which is closer to guideline scenario. Appropriate range of toxicity endpoints measured. The dose and critical effects that the EPA used from Heinze (1999) to establish the reference dose are supported by a Guzman and Solter (1999) study, also conducted in rats. However, only male rats used and only 2 dose groups plus controls were observed and a NOAEL could not be identified. Discussion: The uncertainty about the dose material used in Falconer (1994) (regarding both the mixed strain of microcystins and the actual dose administered to the animals through drinking water) lowers the certainty in the study findings and its suitability as a key study to derive a guideline value. NHMRC (2008) also added an additional uncertainty factor in the guideline calculation to account for potential carcinogenicity (microcystin-LR has been classified as Group 2B – possibly carcinogenic to humans (IARC 2010) based on evidence of an indirect mechanism of action but inadequate evidence of cancer in humans and animals). However, this is not considered necessary as the IARC (2010) findings are not considered sufficient evidence or a suitable endpoint to derive a guideline value relevant to short-term exposures to microcystins. The key studies used by WHO (2020) and US EPA (2019) (Fawell et al. (1999) and Heinze (1999) respectively) were considered to be higher confidence than Falconer (1994), which was not selected by these agencies to derive their respective guideline values following a review of the evidence. Although the duration of the Heinze (1999) study was shorter and more applicable to the exposure duration envisaged for application of the short-term guideline value for microcystins, the Fawell et al. (1999) study considered more animals of both sexes over more dose ranges that resulted in a NOAEL. In addition, the advantages of the Fawell et al. (1999) study mean that an additional uncertainty factor is not needed for extrapolation from a LOAEL to a NOAEL, which would increase the total uncertainty and reduce confidence in the derivation of the short-term guideline value. For this reason, the NOAEL derived by Fawell et al. (1999) was selected by WHO (2020) as the basis for the short-term and recreational guideline values, as well as the lifetime guideline value. Nodularin, primarily produced by *Nodularia spumigena*, is structurally similar to microcystins and exerts similar toxicity to microcystin-LR at its main target site in the liver (NHMRC 2011). There is insufficient toxicological and epidemiological data to establish a separate health-based guideline value for nodularin (NHMRC 2011). However, given nodularin has an identical

Criteria	Discussion of evidence to decision factors:
	mode of action to microcystin in animals and is considered to present at least the same risk to human health as microcystin if ingested (NHMRC 2011), the guideline value for microcystins can be considered relevant for nodularin. Regarding differences between agencies in deriving guideline values: • no uncertainty factor was included by WHO (2020) for database deficiencies to calculate their provisional short-term and recreational guideline values. WHO (2020) note that the point of departure is based on a sufficiently relevant period of exposure, which is short for the envisaged scenarios. • Health Canada (2022) and US EPA (2019) apply an uncertainty factor of 3 to account for deficiencies in the database for microcystin exposure (US EPA 2015). • Health Canada (2022) applies an allocation factor of 0.8, whereby the majority of exposure to microcystins is expected to be through water ingestion during recreational activities; the remaining 0.2 allows for allocation to other non-negligible exposures from other media (Krishnan and Carrier 2013).
Exposure profile	Microcystins are the most significant water quality issue in relation to cyanobacterial blooms in south-eastern Australia. In Australia, they are produced predominantly by *Microcystis aeruginosa*, but can occasionally be produced by *Dolichospermum* spp. Globally, *Microcystis* strains and field samples dominated by *Microcystis* spp. are reported to contain chiefly microcystin-LR, -RR and -YR in varying proportions (TCiW 2021) A small number of severe health effects have been plausibly attributed to recreational exposure that can be linked to microcystin exposure (Giannuzzi et al. 2011; Vidal et al. 2017). Globally, human fatalities are known from exposure to microcystins in drinking water (Jochimsen et al. 1998). Microcystins have been linked to animal deaths, particularly in dogs and livestock. The cyanobacterium *N. spumigena* occurs primarily in brackish water. It forms blooms in estuarine lakes in Australia, New Zealand and Europe, and can also occur in brackish inland lakes in Australia (Wood 1975). In addition to these saline environments, there are also frequent blooms of toxic *N. spumigena* in freshwater lakes of the lower River Murray, South Australia (Baker and Humpage 1994). Reports of fatal dog poisonings have been attributed to nodularin.
Health benefits vs harms	The proposed guideline values are concentrations that aim to manage risks before reaching higher levels where there is known harms to health. Lower guideline values are more conservative options compared to higher guideline values.

Criteria	Discussion of evidence to decision factors:
	However, the choice of guideline option should balance the need for conservatism against the highest quality evidence and whether the health endpoints under consideration (if using animal studies) are relevant and critical to humans and consider appropriate levels of uncertainty in their derivation. Lowering the guideline value may result in an increase of exceedances detected in water bodies and resulting site closure which can have broader impacts on communities.
Values and preferences (consumers, communities)	Human exposure to cyanotoxins is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. The visible presence of some algal blooms (such as mats, scums, discolouration of water) can be readily noticeable and have health effects from particles, even if cyanotoxins are not necessarily present. Increased water site closures as a result of implementing any of the guideline options while under investigation might have impacts on consumers and communities even from a perceived risk (e.g. economic, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress to communities if activities are restricted. All of the proposed guideline options could potentially result in restricted or lack of access to recreational water sites, which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or disasters. Consumption of cyanotoxins through food caught or collected from waters may be of particular concern in communities that rely on waters as a source of food. There could be a misconception that these guidelines are protective for the consumption of seafood or that the scope of these guidelines should include health-guideline values for the safe consumption of seafood. If risks do exist, some sites may already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.

Criteria	Discussion of evidence to decision factors:
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. Given this complexity, and in line with the approach outlined in the Risk Management Framework, the proposed guideline values are intended to be included as part of an alert level framework that provides an option for everyone depending on the level of risk and the level of local resources and needs. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required.
Feasibility	All of the proposed guideline options are technically feasible as they are readily measurable using current commercial analytical techniques. However, the feasibility of implementing broader risk assessment and risk management processes as part of the proposed Risk Management Framework, particularly in the event of detected exceedances, will be resource dependent. Some water managers will find it unfeasible (or already find it challenging) to undertake some of the actions recommended as part of the broader risk management process, such as undertaking routine monitoring and implementing improvement programs to reduce point sources of pollution. However, the guidance provided regarding the alert level framework is intended to help provide options for water managers to assess the level of risk from cyanotoxins in their local area if analytical capabilities to measure concentrations against guideline values are less readily available.
Health equity impacts	While some guideline values are more conservative than others based on the point of departure determined from different animal studies, all of the proposed guideline options are intended to be protective of individuals and the general population with consideration for sensitive and vulnerable groups as they are derived based on worst-case assumptions for the most sensitive population group (children playing in recreational water and accidentally swallowing water). The proposed guideline values are based on ingestion and do not consider impacts on susceptible populations from inhalation

Criteria	Discussion of evidence to decision factors:
	or dermal exposure (which may be significant); however, these impacts can be considered as part of the alert level framework and broader risk management planning. Unnecessary site closures or restricted activities on water bodies may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Guideline values for cyanotoxins are intended to provide water managers with a more accurate assessment of the level of risk in their area if required as part of the alert level framework.
Resource impacts	All guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 9. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – other microbial hazards

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not considered to be based on the best available evidence, given that several studies considered to be of higher confidence (see Options 2 and 3) were selected as the basis for deriving guideline values following recent reviews by other agencies.
Option 2	This guideline option was considered to be the best available evidence to derive a guideline value of 8 µg/L for microcystins and nodularin. Relative to other studies, Fawell et al. 1999 included more dose groups and an appreciably wider dose range that produced a NOAEL that could be used to derive a guideline value for microcystins. An additional uncertainty factor of 3 for database deficiencies was considered appropriate to acknowledge the limitations of currently available chronic studies for microcystins. It was also agreed that this guideline value represents the sum value of all microcystins and nodularin present. It was agreed that a toxicity equivalence factor of one should be used for all microcystin and nodularin congeners.
Option 3	Although there is confidence in the study outcomes reported by Heinze (1999) and the study was shorter and more applicable to the exposure duration envisaged for recreational activities, unlike Fawell et al. 1999, the study did not produce a NOAEL, which increases the total uncertainty in this guideline option.

Table 10. Candidate guideline options for microcystin and supporting studies

Parameter	NHMRC (2008)	WHO (2021)/NZ (2024)	US EPA (2019)/Health Canada (2022)
Critical study	Falconer et al. (1994) (as cited in Kuiper-Goodman et al. 1999)	Fawell et al. (1999)	Heinze (1999)
Study population	Pigs (Male)	Mice (Female and Male)	Rats (Male)
Form studied	Extract from *Microcystis aeruginosa* (strain not reported). The extract contained at least seven MC variants, with MC-YR tentatively identified as the major constituent	Microcystin-LR	Microcystin-LR
Exposure route	Oral (drinking water)	Oral (gavage)	Oral (drinking water)
Study timeframe	44 days	13 weeks	28 days
Critical Effect	Hepatoxicity Liver injury (evident from histopathology and changes in serum enzymes) was observed at the two highest dose levels. As one pig was also affected at the lowest dose level, the LOAEL was 280 µg/kg bw/day. Further HPLC analysis of the variants determined that this LOAEL was equivalent to 100 MC-LR µg/kg bw/day.	Hepatoxicity Only light hepatic damage was observed at the LOAEL of 200 µg/kg bw per day in a limited number of treated animals. At the highest dose tested (1 mg/kg bw/day), all the animals showed hepatic lesions, consistent with the known action of MC-LR.	Hepatoxicity Slight to moderate liver lesions with necrosis and increased liver weight and enzymes associated with tissue damage. Increased liver weight and slight to moderate liver lesions with haemorrhages in rats.
Point of Departure (PoD)	100 µg/kg bw/day (LOAEL)	40 µg/kg bw/day (NOAEL)	50 µg/kg bw/d (LOAEL)

Parameter	NHMRC (2008)	WHO (2021)/NZ (2024)	US EPA (2019)/Health Canada (2022)
Uncertainty factors[1]			
UF_A	10	10	10
UF_H	10	10	10
UF_L	5	N/A	3
UF_D	10 (based on concerns with carcinogenicity)	Nil (3 for database limitations) (note WHO did not include UF_D)	3
UF_S	0.32 (study duration) is the conversion from 44 days exposure in the pig study, to a recreational water exposure period of 14 days per year.	Nil – not considered necessary when using a subchronic study to derive a guideline value for short-term exposures (Nil – considered sufficient if UF_D is included)	Nil
Total UF	1600 (or 500 if not including UF_D or UF_S)	100 (or 300 if UF_D included)	Health Canada approach: 900 US EPA approach: rounded to 1000
Reference dose = PoD/Total UF (µg/kg bw/day)	0.0625 (0.2)	0.4 (0.13)	Health Canada approach: 0.056 US EPA approach: 0.050
International guideline values [assumption values]	NHMRC (2008): 10 µg/L (child) [100mL/day, 15 kg]; 44 µg/L (adult) [100 mL/day, 70 kg]	WHO: 8 µg/L (child) [250 mL/day, 15 kg] Allocation factor = 1	Health Canada: 10 µg/L (child) [103 mL/day, 23 kg]. Allocation factor = 0.8.

Parameter	NHMRC (2008)	WHO (2021)/NZ (2024)	US EPA (2019)/Health Canada (2022)
	Allocation factor = 1		US EPA: 8 µg/L (child) [210 mL/day, 31.8 kg].
Resulting adaption to Australian guideline value[2]	3.75 (12) µg/L (child)	24 (8) µg/L	Health Canada approach: **3.36 µg/L** US EPA approach: **3 µg/L**

NOAEL – no observable adverse effect level; LOAEL – lowest observable adverse effect level; UF – uncertainty factor.

1. Uncertainty factors: UF_A = Interspecies uncertainty factor - uncertainty factor for extrapolation from animals to humans; UF_H = Intraspecies uncertainty factor for human variability; UF_L = LOAEL uncertainty factor for use of LOAEL rather than a NOAEL; UF_D = Database deficiency factor - uncertainty factor to account for the limited database of toxicological studies; UF_S = Uncertainty factor for extrapolation from a subchronic to a chronic study (accounts for the difference in exposure duration and potential for effects to be more pronounced over longer periods).

2. Guideline values for cyanotoxins in recreational water were calculated using the equation below (based on WHO (2020)) using default assumption values for bodyweight and accidental ingestion for children (15 kg, 250 mL) as children are considered to be the most susceptible population group for accidental ingestion of recreational water (see Information sheet - Exposure assumptions). These calculations assume a relative source contribution of 100% for cyanotoxin exposure from recreational water bodies (i.e. other exposures such as drinking water/soil are considered negligible during an acute event) and daily accidental ingestion volume of 250 mL to account for the expected acute exposure scenarios for harmful algal and cyanobacterial blooms.

Guideline value (µg/L) = [NOAEL or LOAEL (µg/kg bw/day) x bodyweight (kg bw) x relative source contribution] ÷ [Accidental ingestion volume (L/day) x total UF].

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Evidence to decision - Cylindrospermopsins

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 11. Comparison of guideline options – cylindrospermopsins

Criteria	OPTION 1	OPTION 2
Decision?	Retain existing approach from NHMRC (2008) and Health Canada (2022)	Adapt Humpage and Falconer (2003), used by WHO (2021)/NZ (2024) and US EPA (2019)
Draft recommendation	No guideline value established for cylindrospermopsins.	Cylindrospermopsins in freshwater and brackish water bodies should not exceed a concentration of 6 µg/L.

Table 12. Discussion of evidence to decision factors for guideline options – cylindrospermopsins

Criteria	Discussion of evidence to decision factors
Health evidence profile	NHMRC 2008 & Health Canada (2022): No guideline value was established for cylindrospermopsins by these agencies. WHO (2021) & NZ (2024) & US EPA (2019) Based on Humpage and Falconer 2003: The available acute, short-term, and subchronic studies for cylindrospermopsin (Bazin et al. 2012; Humpage and Falconer 2002; 2003; Reisner et al. 2004; Terao et al. 1994; Shaw et al. 2001) support the liver and kidneys as the primary targets for cylindrospermopsin toxicity, with effects on red blood cells also evident (US EPA 2019).

Criteria	Discussion of evidence to decision factors
	The reference dose for cylindrospermopsin was derived from the 11-week critical study by Humpage and Falconer (2002, 2003). This study was an 11-week study in mice, and the critical effect identified was kidney toxicity. Humpage and Falconer (2002, 2003) identified a NOAEL of 30 µg/kg/day and a LOAEL of 60 µg/kg/day for increases in relative kidney weight in mice treated with purified cylindrospermopsin by gavage for 11 weeks. There were indications of reduced renal function effects, decreased urinary protein, and red blood cell effects (including increased bilirubin, spleen weight and polychromasia, indicative of hemolysis) at doses above the LOAEL (US EPA 2019). Given the limited evidence base, Humpage and Falconer (2003) was considered to be the best available study on which to base a guideline value for cylindrospermopsin by the US EPA (2019) and a provisional guideline value by WHO (WHO 2021; 2020). Due to similar toxicity observed in cylindrospermopsin congeners (based on limited evidence), WHO recommends that total cylindrospermopsins are assessed as molar equivalents (WHO 2020).
Exposure profile	In Australia, *R. raciborskii* and *C. ovalisporum* (*Umezakia natans*) are the most abundant cylindrospermopsin producers with a high bloom frequency, though the correlation between cylindrospermopsins concentration and biovolume is generally weak (TCiW 2021). Concentrations reported often range between < 1 and 10 µg/L, occasional up to maximally 800 µg/L (TCiW 2021). *Raphidiopsis raciborskii* (formerly *C. raciborskii*) has been found in many water supply reservoirs in northern, central and southern Queensland and also occurs in the Murray-Darking River system. Cylindrospermopsin is believed to have been the causative agent in the Palm Island "mystery disease" poisoning incident in Queensland in 1979, in which 148 people were hospitalised (Byth 1980). It was subsequently shown that water from Solomon Dam on Palm Island contained blooms of toxic *C. raciborskii* (Hawkins et al. 1985). *Microcoleus* (*Phormidium*) does occur within the benthos of some reservoirs in South Australia and can produce cylindrospermopsin and geosmin (Gaget et al. 2017). Cattle deaths have been attributed to consumption of *Cylindrospermopsis raciborskii*-contaminated water, although toxin analyses were not conducted (Saker et al. 1999). Cylindrospermopsins are produced by strains of various species within a number of cyanobacterial genera, primarily in the order *Nostocales*. They have most frequently been reported from the genera *Raphidiopsis* (formerly *Cylindrospermopsis*), *Aphanizomenon* (some species of which are now classified as *Cuspidothrix* and some as *Chrysosporum*), *Anabaena* (some species of which are now classified as *Dolichospermum*) and *Umezakia*. Known CYN producers within the order Oscillatoriales

Criteria	[Discussion of evidence to decision factors]()
	include *Microseira* (formerly *Lyngbya*), *Phormidium* and *Oscillatoria*, many of which are primarily benthic (i.e. grow on sediments or other submerged surfaces) (WHO 2020).
Health benefits vs harms	Not all cylindrospermopsin producers form surface scums or strong discolouration; those that do not may be overlooked by visual inspection. Furthermore, cylindrospermopsin dissolved in water may persist after the cylindrospermopsin-producing cyanobacteria have disappeared and so cyanobacterial biovolumes or chlorophyll a cannot always be relied upon. Therefore, and also because concentrations associated with cyanobacterial blooms can vary substantially, toxin analyses should be performed, if possible, when cylindrospermopsin is suspected (WHO 2021). These guideline values are concentrations that aim to manage risks before reaching higher levels where there is known harms to health. Given the occurrence of cyanobacteria in Australia that produce cylindrospermopsins, a guideline value provides a tool for managing and responding to harmful algal and cyanobacterial blooms that have the potential to produce cylindropspermopsins. The data from toxin analyses may allow restrictions of site use to be avoided or lifted where these were based on biovolume or chlorophyll a concentrations.

Criteria	Discussion of evidence to decision factors
Values and preferences (consumers, communities)	Human exposure to cyanotoxins is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. The visible presence of some algal blooms (such as mats, scums, discolouration of water) can be readily noticeable and have health effects from particles, even if cyanotoxins are not necessarily present. Increased water site closures as a result of implementing any of the guideline options while under investigation might have impacts on consumers and communities even from a perceived risk (e.g. economic, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress to communities if activities are restricted. All of the proposed guideline options could potentially result in restricted or lack of access to recreational water sites, which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or disasters. Consumption of cyanotoxins through food caught or collected from waters may be of particular concern in communities that rely on waters as a source of food. There could be a misconception that these guidelines are protective for the consumption of seafood or that the scope of these guidelines should include health-guideline values for the safe consumption of seafood. If risks do exist, some sites may already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.

Criteria	Discussion of evidence to decision factors
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. Given this complexity, and in line with the approach outlined in the Risk Management Framework, the proposed guideline values are intended to be included as part of an alert level framework that provides an option for everyone depending on the level of risk and the level of local resources and needs. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required.
Feasibility	All of the proposed guideline options are technically feasible as they are readily measurable using current commercial analytical techniques. However, the feasibility of implementing broader risk assessment and risk management processes as part of the proposed Risk Management Framework, particularly in the event of detected exceedances, will be resource dependent. Some water managers will find it unfeasible (or already find it challenging) to undertake some of the actions recommended as part of the broader risk management process, such as undertaking routine monitoring and implementing improvement programs to reduce point sources of pollution. However, the guidance provided regarding the alert level framework is intended to help provide options for water managers to assess the level of risk from cyanotoxins in their local area if analytical capabilities to measure concentrations against guideline values are less readily available.

Criteria	Discussion of evidence to decision factors
Health equity impacts	While some guideline values are more conservative than others based on the point of departure determined from different animal studies, all of the proposed guideline options are intended to be protective of individuals and the general population with consideration for sensitive and vulnerable groups as they are derived based on worst-case assumptions for the most sensitive population group (children playing in recreational water and accidentally swallowing water). The proposed guideline values are based on ingestion and do not consider impacts on susceptible populations from inhalation or dermal exposure (which may be significant); however, these impacts can be considered as part of the alert level framework and broader risk management planning. Unnecessary site closures or restricted activities on water bodies may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Guideline values for cyanotoxins are intended to provide water managers with a more accurate assessment of the level of risk in their area if required as part of the alert level framework.
Resource impacts	All guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 13. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – cylindrospermopsins

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not selected as it was no longer considered appropriate given that sufficient evidence was available to set a guideline value for cyclindrospermopsin.
Option 2	Given the limited evidence base, Humpage and Falconer (2003) was considered to be the best available study on which to base a guideline value for cylindrospermopsin, as supported by both the US EPA (2019) and WHO (2021). Due to similar toxicity observed in cylindrospermopsin congeners (based on limited evidence), it was agreed that total cylindrospermopsins should be assessed as molar equivalents until further evidence is available.

Table 14. Candidate guideline options for cylindrospermopsins and supporting studies

Parameter	WHO (2021)/NZ 2024 & US EPA (2019)
Critical study	Humpage and Falconer (2003)
Study population	Mice (Male)
Form studied	Cylindrospermopsin
Exposure route	Trial 1: Oral (drinking water); Trial 2: Oral (gavage)
Study timeframe	Trial 1: 10 weeks; Trial 2: 11 weeks

Parameter	WHO (2021)/NZ 2024 & US EPA (2019)
Critical Effect	Kidney: dose-related increases in relative kidney weight, proximal renal tubular damage, decreased urinary protein Liver: necrosis, inflammatory foci, and bile duct changes Increased relative kidney weights was the critical effect selected by WHO (2021) and US EPA (2019) on which to base the point of departure.
Point of Departure (PoD)	30 µg/kg bw/day (NOAEL)
Uncertainty factors[1]	(used by both WHO (2021) and US EPA (2019)
UF_A	10
UF_H	10
UF_L	Nil
UF_D	3
UF_S	Nil
Total UF	300
Reference dose = PoD/Total UF	0.1 µg/kg bw/day
International guideline values [assumption values]	WHO: 6 µg/L (child) [250mL/day, 15 kg] US EPA: 15 µg/L (child) [210 mL/day, 31.8 kg]
Resulting adaption to Australian guideline value[2]	6 µg/L

NOAEL – no observable adverse effect level; LOAEL – lowest observable adverse effect level; UF – uncertainty factor.

1. Uncertainty factors: UF_A = Interspecies uncertainty factor - uncertainty factor for extrapolation from animals to humans; UF_H = Intraspecies uncertainty factor for human variability; UF_L = LOAEL uncertainty factor for use of LOAEL rather than a NOAEL; UF_D = Database deficiency factor - uncertainty factor to account for the limited database of toxicological studies; UF_S = Uncertainty factor for extrapolation from a subchronic to a chronic study.

2. Guideline values for cyanotoxins in recreational water were calculated using the equation below (based on WHO (2020)) using default assumption values for bodyweight and accidental ingestion for children (15 kg, 250 mL) as children are considered to be the most susceptible population group for accidental ingestion of recreational water (see Information Sheet - Exposure Assumptions). These calculations assume a relative source contribution of 100% for cyanotoxin exposure from recreational water bodies (i.e. other exposures such as drinking water/soil are considered negligible during an acute event) and daily accidental ingestion volume of 250 mL to account for the expected acute exposure scenarios for harmful algal and cyanobacterial blooms.

Guideline value (µg/L) = [NOAEL or LOAEL (µg/kg bw/day) x bodyweight (kg bw) x relative source contribution] ÷ [Accidental ingestion volume (L/day) x total UF].

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Evidence to decision – Anatoxins

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 15. Comparison of guideline options – anatoxins

Criteria	OPTION 1	OPTION 2
Decision?	Retain existing approach from NHMRC (2008), US EPA (2019) and Health Canada (2022)	Adapt Fawell et al. (1999), used by WHO 2021/NZ (2024)
Draft recommendation	No guideline value established for anatoxins.	Anatoxins in freshwater and brackish water bodies should not exceed a concentration of 20 µg/L (rounded).

Table 16. Discussion of evidence to decision factors for guideline options – anatoxins

Criteria	Discussion of evidence to decision factors:
Health evidence profile	WHO (2021) & NZ (2024): Based on Fawell et al. (1999) The study by Fawell et al. (1999) was selected as the best available information by WHO (2021) on which to derive a health-based reference value for anatoxin-a (WHO 2020). Since the study did not identify a nonlethal dose that caused lasting adverse effects, WHO determined that formal guideline values (provisional or otherwise) cannot be derived based on the available information (WHO 2020). Fawell et al. (1999) conducted a 5-day repeated gavage dosing trial in mice to determine a maximum tolerated dose for a 28-day study. The 28-day study used four dose groups of 10 mice of each sex dosed daily by gavage with (+)-ATX HCl at 0, 0.12, 0.6 or 3.0 mg/kg bw (equivalent to doses of pure (+)-ATX of 0, 0.098, 0.49 or 2.46 mg/kg). Body weight, food consumption and signs of illness were monitored in all mice through the trial, and detailed histopathology, haematology and serum biochemistry analyses were conducted for control and high-dose animals at the end of the study. One mouse in each of the highest two dose groups died within 2.5 hours of dosing. Necropsy did not show the cause, meaning that ATX toxicity could not be excluded. No other treatment-related effects were seen in any animal for any parameter examined. The authors therefore designated 0.098 mg/kg bw of pure (+)- ATX as the no-observed-adverse-effect level (NOAEL), but noted that the NOAEL could actually be 2.46 mg/kg bw.

Criteria	Discussion of evidence to decision factors:
	No long-term studies on the systemic effects of ATX were identified. No long-term studies on the systemic effects of ATX were identified. According to the WHO background document for anatoxin-a and analogues (WHO 2020), although ATX is the best studied analogue, limited evidence suggests that homoanatoxin-a (HTX) and the dihydro derivatives of ATX and HTX bind to the same receptor and may have similar potency to ATX when administered orally. Given the evidence that the analogues mentioned above are of similar toxicity to ATX, it is recommended that they be included in calculations of total ATXs as gravimetric or molar equivalents.
Exposure profile	In Australia, anatoxin producing cyanobacteria are not regularly tested for. A study in Victoria into the presence of anatoxin-a (ATX-a) producing cyanobacteria in surface water samples collected from 2010 and 2017 confirmed the presence of ATX-a producers (John et al. 2019). Globally, anatoxins have often been linked to deaths of dogs and wild animals (WHO 2020).
Health benefits vs harms	The proposed guideline values are concentrations that aim to manage risks before reaching higher levels where there is known harms to health. Lower guideline values are more conservative options compared to higher guideline values. However, the choice of guideline option should balance the need for conservatism against the highest quality evidence and whether the health endpoints under consideration (if using animal studies) are relevant and critical to humans and consider appropriate levels of uncertainty in their derivation. Lowering the guideline value may result in an increase of exceedances detected in water bodies and resulting site closure which can have broader impacts on communities.

Criteria	Discussion of evidence to decision factors:
Values and preferences (consumers, communities)	Human exposure to cyanotoxins is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. The visible presence of some algal blooms (such as mats, scums, discolouration of water) can be readily noticeable and have health effects from particles, even if cyanotoxins are not necessarily present. Increased water site closures as a result of implementing any of the guideline options while under investigation might have impacts on consumers and communities even from a perceived risk (e.g. economic, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress to communities if activities are restricted. All of the proposed guideline options could potentially result in restricted or lack of access to recreational water sites, which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or disasters. Consumption of cyanotoxins through food caught or collected from waters may be of particular concern in communities that rely on waters as a source of food. There could be a misconception that these guidelines are protective for the consumption of seafood or that the scope of these guidelines should include guideline values for the safe consumption of seafood. If risks do exist, some sites may already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. Given this complexity, and in line with the approach outlined in the Risk Management Framework, the proposed guideline values are intended to be included as part of an alert level framework that provides an option for everyone depending on the level of risk and the level of local resources and needs. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required.

Criteria	Discussion of evidence to decision factors:
Feasibility	All of the proposed guideline options are technically feasible as they are readily measurable using current commercial analytical techniques. However, the feasibility of implementing broader risk assessment and risk management processes as part of the proposed Risk Management Framework, particularly in the event of detected exceedances, will be resource dependent. Some water managers will find it unfeasible (or already find it challenging) to undertake some of the actions recommended as part of the broader risk management process, such as undertaking routine monitoring and implementing improvement programs to reduce point sources of pollution. However, the guidance provided regarding the alert level framework is intended to help provide options for water managers to assess the level of risk from cyanotoxins in their local area if analytical capabilities to measure concentrations against guideline values are less readily available.
Health equity impacts	While some guideline values are more conservative than others based on the point of departure determined from different animal studies, all of the proposed guideline options are intended to be protective of individuals and the general population with consideration for sensitive and vulnerable groups as they are derived based on worst-case assumptions for the most sensitive population group (children playing in recreational water and accidentally swallowing water). The proposed guideline values are based on ingestion and do not consider impacts on susceptible populations from inhalation or dermal exposure (which may be significant); however, these impacts can be considered as part of the alert level framework and broader risk management planning. Unnecessary site closures or restricted activities on water bodies may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Guideline values for cyanotoxins are intended to provide water managers with a more accurate assessment of the level of risk in their area if required as part of the alert level framework.
Resource impacts	All guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 17. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – anatoxins

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not selected as it was no longer considered appropriate given that sufficient evidence was available to set a guideline value for anatoxins.
Option 2	Given the limited evidence base, Fawell et al. (1999) was considered to be the best available study on which to base a guideline value for anatoxins, as supported by WHO (2021). It was agreed that given the evidence that ATX analogues mentioned above are of similar toxicity to ATX, it is recommended that they be included in calculations of total ATXs as gravimetric or molar equivalents.

Table 18. Candidate guideline options for anatoxins and supporting studies

Parameter	WHO (2021)/NZ (2024)
Critical study	Fawell et al. (1999)
Study population	Mice (Male)
Form studied	Anatoxin-a
Exposure route	Oral (gavage)
Study timeframe	28-day
Critical Effect	No treatment related effects observed during the study timeframe.

Point of Departure (PoD)	98 µg/kg bw/day (NOAEL) (conservative health-based reference value based on lowest dose tested due to lack of treatment-related effects in chronic studies).
Uncertainty factors[2]	
UF_A	10
UF_H	10
UF_L	N/A
UF_D	3
UF_S	Nil
Total UF	300
Reference dose = PoD/Total UF	0.33 µg/kg bw/day
International guideline values [assumption values]	WHO and NZ provisional guideline values: 59 µg/L (child) [250 mL/day, 15 kg]
Resulting adaption to Australian guideline value[2]	19.6 µg/L (child)

NOAEL – no observable adverse effect level; LOAEL – lowest observable adverse effect level; UF – uncertainty factor.

1. Uncertainty factors: UF_A = Interspecies uncertainty factor - uncertainty factor for extrapolation from animals to humans; UF_H = Intraspecies uncertainty factor for human variability; UF_L = LOAEL uncertainty factor for use of LOAEL rather than a NOAEL; UF_D = Database deficiency factor - uncertainty factor to account for the limited database of toxicological studies; UF_S = Uncertainty factor for extrapolation from a subchronic to a chronic study.

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2. Guideline values for cyanotoxins in recreational water were calculated using the equation below (based on WHO (2020)) using default assumption values for bodyweight and accidental ingestion for children (15 kg, 250 mL) as children are considered to be the most susceptible population group for accidental ingestion of recreational water (see Information sheet - Exposure assumptions). These calculations assume a relative source contribution of 100% for cyanotoxin exposure from recreational water bodies (i.e. other exposures such as drinking water/soil are considered negligible during an acute event) and daily accidental ingestion volume of 250 mL to account for the expected acute exposure scenarios for harmful algal and cyanobacterial blooms.

Guideline value (µg/L) = [NOAEL or LOAEL (µg/kg bw/day) x bodyweight (kg bw) x relative source contribution] ÷ [Accidental ingestion volume (L/day) x total UF].

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Evidence to decision - Saxitoxins

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 19. Comparison of guideline options – saxitoxins

Criteria	OPTION 1	OPTION 2
Decision?	Retain existing approach from NHMRC (2008), US EPA (2019) and Health Canada (2022)	Adapt EFSA (2009), used by WHO 2021/NZ (2024)
Draft recommendation	No guideline value established for saxitoxins.	Saxitoxins in freshwater and brackish water bodies should not exceed a concentration of 30 µg/L.

Table 20. Discussion of evidence to decision factors for guideline options – saxitoxins

Criteria	Discussion of evidence to decision factors:
Health evidence profile	The study by EFSA (2009) was selected as the best available information on which to derive a guideline value for saxitoxin (WHO 2020). EFSA (2009) reviewed about 500 cases of human PSP described in case reports that had estimated the consumption of saxitoxins (STXs) associated with a range of symptoms. In view of the acute toxicity the EFSA Panel decided to establish an acute reference dose (ARfD). The EFSA Panel concluded that the lowest-observed-adverse-effect level (LOAEL) for mild symptoms of PSP in humans was in the region of 1.5 µg STX equivalents/kg body weight. Since many individuals did not suffer adverse reactions at higher intakes, it is expected that this LOAEL is close to the threshold for effects in the most sensitive individuals. The Panel applied a factor of 3 to the LOAEL in order to estimate a no-observed-adverse-effect level (NOAEL). No additional factor for variation among humans was required because the data were from reports of a large number of affected consumers, including the most sensitive individuals. The Panel established an ARfD of 0.5 µg STX equivalents/kg bw.
Exposure profile	Saxitoxins (STXs) are naturally occurring alkaloids produced by some marine dinoflagellates and by strains of various species of freshwater cyanobacteria. Recreational water use may also cause intermittent exposure. Blooms of *A. circinalis (D. circinalis)* have been recorded in many rivers, lakes, reservoirs and dams throughout Australia, and *A. circinalis (D. circinalis)* is the most common organism in riverine blooms in the Murray-Darling Basin (Baker and Humpage 1994). The first reported neurotoxic bloom of *A. circinalis (D. circinalis)* in Australia occurred in 1972 (May and McBarron 1973). The most publicised blooms occurred in the Murray-Darling System in 1991, 2009 and 2010 (NSWBGATF 1992, NSW Office of Water 2009, MDBA 2010). The first bloom extended over 1,000 kilometres of the Darling-Barwon River system in New South Wales (NSWBGATF 1992). Stock deaths were associated with the occurrence of the bloom but there was little evidence of human health impacts. The blooms in 2009 and 2010 affected several hundred kilometres of the River Murray on the border between NSW and Victoria and included *Anabaena, Microcystis and Cylindrospermopsin*. Alerts were issued about risks to recreational use, primary contact by domestic users, livestock and domestic animals. A bloom of *A. circinalis (D. circinalis)* in a dam in New South Wales was shown to have caused sheep deaths (Negri et al. 1995). Marine shellfish are the most likely source of STXs that cause the severe illness known as paralytic shellfish poisoning (PSP).

Criteria	Discussion of evidence to decision factors:
Health benefits vs harms	Not all STX producers form surface scums or strong discolouration; those that do not may be overlooked by visual inspection. Therefore, if the presence of cyanobacteria is suspected, microscopic examination for the presence of cyanobacteria that could potentially produce STXs is important and where possible, toxin analysis should be performed because concentrations associated with cyanobacterial blooms can vary substantially (WHO 2021). The proposed guideline values are concentrations that aim to manage risks before reaching higher levels where there is known harms to health. Given the occurrence of cyanobacteria in Australia that produce STX, a guideline value provides a tool for managing and responding to harmful algal and cyanobacterial blooms that have the potential to produce STX. The data from toxin analyses may allow restrictions of site use to be avoided or lifted where these were based on biovolume or chlorophyll *a* concentrations.
Values and preferences (consumers, communities)	Human exposure to cyanotoxins is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. The visible presence of some algal blooms (such as mats, scums, discolouration of water) can be readily noticeable and have health effects from particles, even if cyanotoxins are not necessarily present. Increased water site closures as a result of implementing any of the guideline options while under investigation might have impacts on consumers and communities even from a perceived risk (e.g. economic, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress to communities if activities are restricted. All of the proposed guideline options could potentially result in restricted or lack of access to recreational water sites, which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or disasters. Consumption of cyanotoxins through food caught or collected from waters may be of particular concern in communities that rely on waters as a source of food. There could be a misconception that these guidelines are protective for the consumption of seafood or that the scope of these guidelines should include guideline values for the safe consumption of seafood. If risks do exist, some sites may already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.

Criteria	Discussion of evidence to decision factors:
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. Given this complexity, and in line with the approach outlined in the Risk Management Framework, the proposed guideline values are intended to be included as part of an alert level framework that provides an option for everyone depending on the level of risk and the level of local resources and needs. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required.
Feasibility	All of the proposed guideline options are technically feasible as they are readily measurable using current commercial analytical techniques. However, the feasibility of implementing broader risk assessment and risk management processes as part of the proposed Risk Management Framework, particularly in the event of detected exceedances, will be resource dependent. Some water managers will find it unfeasible (or already find it challenging) to undertake some of the actions recommended as part of the broader risk management process, such as undertaking routine monitoring and implementing improvement programs to reduce point sources of pollution. However, the guidance provided regarding the alert level framework is intended to help provide options for water managers to assess the level of risk from cyanotoxins in their local area if analytical capabilities to measure concentrations against guideline values are less readily available.
Health equity impacts	While some guideline values are more conservative than others based on the point of departure determined from different animal studies, all of the proposed guideline options are intended to be protective of individuals and the general population with consideration for sensitive and vulnerable groups as they are derived based on worst-case assumptions for the most sensitive population group (children playing in recreational water and accidentally swallowing water). The proposed guideline values are based on ingestion and do not consider impacts on susceptible populations from inhalation or dermal exposure (which may be significant); however, these impacts can be considered as part of the alert level framework and broader risk management planning. Unnecessary site closures or restricted activities on water bodies may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Guideline values for cyanotoxins are intended to provide water managers with a more accurate assessment of the level of risk in their area if required as part of the alert level framework.

Criteria	Discussion of evidence to decision factors:
Resource impacts	All guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 21. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – saxitoxins

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not selected as it was no longer considered appropriate given that sufficient evidence was available to set a guideline value for saxitoxin.
Option 2	Given the limited evidence base, EFSA (2009) was considered to be the best available study on which to base a guideline value for saxitoxin, as supported by WHO (2021). It was agreed that saxitoxin measurements in recreational freshwaters should also be assessed as STX-equivalents.

Table 22. Candidate guideline options for Saxitoxins and supporting studies

Parameter	WHO (2021)/NZ (2024)
Critical study	EFSA (2009)
Study population	Humans (500 cases of paralytic shellfish poisoning)
Form studied	Saxitoxins (STX) contained in shellfish
Exposure route	Oral (through diet, paralytic shellfish poisoning)
Study timeframe	NA
Critical Effect	Neurological effects
Point of Departure (PoD)	1.5 µg STX equivalents/kg bw/day (LOAEL)
Uncertainty factors[1]	
UF_A	Nil. Human population
UF_H	Nil. Wide spectrum of people (occupation, age, sex)
UF_L	3
UF_D	Nil
UF_S	Nil
Total UF	3

Parameter	WHO (2021)/NZ (2024)
Reference dose = PoD/Total UF	0.5 µg/kg bw/day
International guideline value	WHO & NZ: 30 µg/L (child) [250 mL/day, 15 kg]
Resulting adaption to Australian guideline value[2]	30 µg/L (child)

NOAEL – no observable adverse effect level; LOAEL – lowest observable adverse effect level; UF – uncertainty factor.

1. Uncertainty factors: UF_A = Interspecies uncertainty factor - uncertainty factor for extrapolation from animals to humans; UF_H = Intraspecies uncertainty factor for human variability; UF_L = LOAEL uncertainty factor for use of LOAEL rather than a NOAEL; UF_D = Database deficiency factor - uncertainty factor to account for the limited database of toxicological studies; UF_S = Uncertainty factor for extrapolation from a subchronic to a chronic study.

2. Guideline values for cyanotoxins in recreational water were calculated using the equation below (based on WHO (2020)) using default assumption values for bodyweight and accidental ingestion for children (15 kg, 250 mL) as children are considered to be the most susceptible population group for accidental ingestion of recreational water (see Information Sheet - Exposure Assumptions). These calculations assume a relative source contribution of 100% for cyanotoxin exposure from recreational water bodies (i.e. other exposures such as drinking water/soil are considered negligible during an acute event) and daily accidental ingestion volume of 250 mL to account for the expected acute exposure scenarios for harmful algal and cyanobacterial blooms.

Guideline value (µg/L) = [NOAEL or LOAEL (µg/kg bw/day) x bodyweight (kg bw) x relative source contribution] ÷ [Accidental ingestion volume (L/day) x total UF].

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Evidence to decision tables – harmful algal and cyanobacterial blooms alert level framework and biomass triggers

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 23. Comparison of guideline options – harmful algal and cyanobacterial blooms alert level framework and biomass triggers

Criteria	OPTION 1	OPTION 2
Decision?	Retain NHMRC (2008) An alert level framework comprising surveillance, alert and action modes, biomass triggers based on cell count and biovolume to manage adverse health effects from ingestion of known toxins and nonspecific health outcomes from exposure to cyanobacterial material.	Adopt and adapt NHMRC (2008), WHO (2021), NZ (2024). Adapt alert level framework comprising surveillance, alert and action levels from NHMRC (2008). Adapt biomass triggers for biovolume and chlorophyll-a from WHO (2021). Adapt alert frameworks for benthic cyanobacteria and marine algae from NHMRC (2008) and NZ (2024).
Draft recommendation	Recreational water bodies should not contain: ≥ 50 000 cell/mL toxic *Microcystis aeruginosa* or Biovolume equivalent of ≥ 4 mm³/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume or ≥ 10 mm³/L for total biovolume of all cyanobacterial material where known toxins are not present or Cyanobacterial scums consistently present ≥ 10 m cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers.	Effective management oversight and public communication should be adopted to minimise exposure to harmful algal and cyanobacterial blooms in recreational water environments to reduce risks to public health. Consistent with the preventive risk management approach, a situation assessment and alert level framework should be implemented to facilitate a proactive and staged response to the presence and development of harmful algal and cyanobacterial blooms. As part of determining appropriate actions using an alert level framework, recreational water bodies should not contain: • ≥ 20 µg/L of anatoxins • ≥ 6 µg/L of cylindrospermopsins

Criteria	[OPTION 1]()	[OPTION 2]()
		• ≥ 8 µg/L of microcystin-LR* or other microcystins and nodularin toxins • ≥30 µg/L of saxitoxins • biovolume equivalent of ≥ 3 mm^3/L for the combined total of all cyanobacteria • chlorophyll *a* of ≥ 8 µg/L (with a dominance of cyanobacteria) • cyanobacterial or algal scum** or visible presence of cyanobacteria or algae with visibility <1 m • *Moorea producens* (formerly *Lyngbya majuscula*) and *Microcoleus* in high abundance *This guideline value represents the sum value of all microcystins and nodularin toxins present. A toxicity equivalence factor of one should be used for all microcystin and nodularin congeners. **Algal scum: dense accumulation of cyanobacterial or algal cells at or near the surface of the water forming a layer of distinct discolouration (green, blue, brown or red).

Table 24. Discussion of evidence to decision factors for guideline options – harmful algal and cyanobacterial blooms alert level framework and biomass triggers

Criteria	Discussion of evidence to decision factors
Health evidence profile	**NHMRC (2008) (Option 1):** The alert level framework comprises three levels, surveillance mode, alert mode and action mode. A two-level guideline for exposure to cyanobacteria: level 1 is based on the probability of adverse health effects for ingestion of known toxins, in this case based on microcystins, level 2 is based on the probability of increased likelihood of nonspecific adverse health outcomes, principally respiratory, irrigation and allergy systems, from exposure to very high cell densities of cyanobacterial material irrespective of the presence of toxicity or known toxins. Biomass triggers are based on cell counts for *M. aeruginosa* based on the microcystin guideline value and an epidemiological studies. The corresponding biovolume is calculated assuming a single cell of *Microcystis aeruginosa* with a volume of 87 μm^3. The surveillance mode threshold is based 500 cells/mL of toxic *Microcystis aeruginosa*, the approximate detection limit. The corresponding biovolume is 0.04 mm^3/L for the combined total of all cyanobacteria. The surveillance mode upper value and alert mode lower value of 5000 cells/mL is level at which skin irritation (Pilotto et al. 2004) and other health problems have been reported (Pilotto et al. 1997). The corresponding biovolume is 0.4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. The alert mode upper range and action mode are based on 50,000 cells/mL – corresponding to the health guideline value for microcystin of 10 µg/L (assuming a toxin cell quota of 2 x 10-7 µg total microcystins/cell based upon data from a toxic Australian bloom. The corresponding biovolume is 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. The action mode also specifies a limit of ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present. A biovolume of 10 mm^3/L for combined total of all cyanobacteria is based on a study showing increased likelihood of symptom reporting (primarily mild respiratory complaints) (Stewart et al. 2006).

Criteria	Discussion of evidence to decision factors
	Karenia brevis indicator values are as follows: Surveillance mode: ≤ 1 cell/mL; Alert mode: > 1 - < 10 cells/mL; Action mode ≥ 10 cells/mL. **Option 2 – adapt NHMRC (2008) and WHO (2021):** The proposed alert framework comprises three pathways for response: assessment by visual site inspection; assessment by visual site inspection and field measurements; and assessment supported by laboratory analysis. While the structure and nomenclature of the current NHMRC (2008) guidelines alert level framework remains suitable to retain given that it is already widely used across Australia, the biomass triggers that underpin the alert level framework require updating in light of more recent evidence and changes in practice. Option 2 proposes an alert level framework based on biomass triggers for biovolume and chlorophyll-a similar to that used by WHO (2021). This change in approach reflects experience that the use of cell number thresholds may lead to undue restrictions of recreational use if the dominant cyanobacteria are species with very small cells. This is because toxin concentrations relate more directly to cellular biomass rather than cell numbers. Cell counts can be used, as can any other locally convenient indicator of the presence and amount of potentially toxic cyanobacteria (e.g. *in situ* fluorescence, turbidity, satellite data), provided that such a parameter is calibrated with occasional toxin analyses. The biomass triggers supporting the alert level framework correspond to microcystins-LR but have been adapted to the Australian context. Similar to WHO (2021) the biovolume triggers are based on a ratio of 3 µg microcystins per mm^3 biovolume and a ratio of 1 µg microcystins per µg chlorophyll-a based on the work of Ibelings et al. (2021). Under Option 2, the proposed biomass values supporting the alert level framework are as follows: • the surveillance level and alert level (lower range) thresholds are based on the current Australian drinking water guideline value for microcystin-LR (1.3 µg/L) calculated using the same point of departure as the recreational water quality guideline value for Microcystin-LR (40 µg/kg bw/day). The resulting biomass trigger values are: - Biovolume equivalent of 0.4 mm^3/L for the total of all cyanobacteria (1.3 µg/L ÷ 3 µg microcystins per mm^3 biovolume)

Criteria	Discussion of evidence to decision factors
	- 1 µg/L chlorophyll-a with dominance of cyanobacteria (1.3 µg/L ÷ 1 µg microcystins per µg chlorophyll-a, rounded down) • The action level and alert level (upper range) thresholds are based on the recreational water guideline value for Microcystin-LR (8 µg/L) derived as part of this review (refer to the related Evidence-to-Decision table for cyanotoxins in the Administrative Report). The resulting biomass trigger values are: - Biovolume equivalent of 3 mm^3/L for the total of all cyanobacteria (8 µg/L ÷ 3 µg microcystins per mm^3 biovolume, rounded up) - 8 µg/L chlorophyll-a with dominance of cyanobacteria (8 µg/L ÷ 1 µg microcystins per µg chlorophyll-a) For *Moorea producens* (formerly *Lyngbya majuscula)* and *Pfiesteria* spp. the three-tier alert level framework in NHMRC (2008) is adopted. The biomass trigger for *Karenia brevis* was removed from option 2 as it was determined that further review for *Karenia* spp. in Australia was required in light of the recent South Australian algal bloom. New Zealand is the only country or jurisdiction to date that specifically considers guidance for the hazards posed by benthic cyanobacteria. Their Alert and Action levels are based upon a quantitative visual estimation of coverage of a substrate or production of scum by detachment of benthic cyanobacteria. In the absence of any other guidance available, it is proposed that the guidance for Microcoleus mats be adopted. It is noted that NZ (2024) adopts a three-tier alert level framework similar to NHMRC (2008) using cell counts and biovolumes developed specifically for toxin-producing cyanobacteria observed in Aotearoa. The toxin quota datasets were either based entirely on data from Aotearoa (microcystins and nodularins), based entirely on international data (cylindrospermopsins) or based on a mixture of data from national and international data (anatoxins). Similar to NHMRC (2008), NZ (2024) adopts an action level for the total biovolume of all cyanobacteria (10 mm^3/L) for such situations where high concentrations of 'non-toxigenic' cyanobacteria taxa are present to protect human health from the risks associated with other agents produced by or co-occurring with cyanobacteria. Option 2 expresses biomass triggers as 'total biovolume of all cyanobacteria' and therefore does not distinguish between known toxin producers or non-toxigenic cyanobacteria taxa.

Criteria	Discussion of evidence to decision factors
Exposure profile	Microcystins are the most significant water quality issue in relation to cyanobacterial blooms in south-eastern Australia. In Australia, they are produced predominantly by *Microcystis aeruginosa*, but can occasionally be produced by *Dolichospermum* spp. Globally, *Microcystis* strains and field samples dominated by *Microcystis* spp. are reported to contain predominantly microcystin-LR, -RR and -YR in varying proportions (TCiW 2021). Microcystin cells are reported to be smaller in cell sizes compared to other toxic cyanobacterial species. Microcystin toxin expression, according to available literature, is the most variable by cell count and has been documented to range up to 300 fold, which is significantly greater than other published toxic or potentially toxic cyanobacterial species. It is considered that the adoption for this ratio for the generation of guidance for other toxic or potentially toxic cyanobacterial species presents a conservative approach for the other toxic or potentially toxic cyanobacterial species. The exception is when cylindrospermopsin-producers are present; it should be noted that potentially high dissolved and cell-free fraction of cylindrospermopsin in the water cannot be accounted by cell biovolume measurements or chlorophyll-a. In such circumstances, toxin testing is warranted. There is limited information on other toxins, despite their occurrence in Australia.
Health benefits vs harms	It is important to choose parameters that indicate cyanotoxin occurrence and to define the levels at which they trigger specific actions. Such levels should be sufficiently protective but not set so low that they lead to undue restrictions on site use. The alert level framework enables a proactive response before reaching concentrations of cyanotoxins at levels where there is known harms to health. There are limitations with all alert level frameworks. The alert level framework using microcystins as the reference species may be limited in its application especially in relation to benthic cyanobacteria and for harmful blooms where cylindrospermopsin producers are dominant. Whilst the alert framework is suitable for most planktonic cyanobacteria, not all species of planktonic cyanobacteria form visible blooms, scums or strong discolouration (e.g. cylindrospermopsin producers). Those that do not may be overlooked by visual inspection. Furthermore, some toxins (e.g. cylindrospermopsin producers) dissolve in water and may persist after the toxin-producing cyanobacteria have disappeared. In the absence of further information on other species in Australia, the alert level framework should provide a conservative level of protection.

Criteria	Discussion of evidence to decision factors
Values and preferences (consumers, communities)	Human exposure to cyanotoxins is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. The visible presence of some algal blooms (such as mats, scums, discolouration of water) can be readily noticeable and have health effects from particles, even if cyanotoxins are not necessarily present. Increased water site closures as a result of implementing any of the guideline options while under investigation might have impacts on consumers and communities even from a perceived risk (e.g. economic, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress to communities if activities are restricted. All guideline options could potentially result in restricted or lack of access to recreational water sites, which may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or disasters. Consumption of cyanotoxins through food caught or collected from waters may be of particular concern in communities that rely on waters as a source of food. There could be a misconception that these guidelines are protective for the consumption of seafood or that the scope of these guidelines should include health-guideline values for the safe consumption of seafood. If risks do exist, some sites may already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.

Criteria	Discussion of evidence to decision factors
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. The alert level framework provides an option for everyone depending on the level of risk and the level of local resources and needs. However, the acceptability of these guideline options to stakeholders who implement the Guidelines will be affected by the certainty of the underpinning evidence. Stakeholders who have higher resource impacts if these guideline options are implemented may find them less acceptable to implement if the justification for a change in practice is based on a guideline option that has been found to have low certainty in the evidence base. Guideline options that are underpinned by high confidence evidence would be more acceptable to stakeholders. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required.
Feasibility	Given the remoteness of some water bodies in Australia an alert framework that enables a pragmatic, proactive response to potentially harmful algal and cyanobacterial blooms in areas that does not rely on analytical capability is needed. All of the proposed guideline options are technically feasible as they are readily measurable using current commercial analytical techniques. The alert level framework is intended to help provide options for water managers to assess the level of risk from cyanotoxins in their local area if analytical capabilities to measure concentrations against health-based guideline values are less readily available.

Criteria	Discussion of evidence to decision factors
Health equity impacts	The trigger values supporting the alert level frameworks are intended to enable a pragmatic, proactive response before guideline values are reached. This should be health protective for the general population, noting that there may be some populations that might be more sensitive to harmful algal and cyanobacterial blooms than others, particularly for allergies. Unnecessary site closures or restricted activities on water bodies may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Health-based guideline values for cyanotoxins are intended to provide water managers with a more accurate assessment of the level of risk in their area if required as part of the alert level framework.
Resource impacts	All guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 25. **Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – harmful algal and cyanobacterial blooms alert level framework and biomass triggers**

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	While this guideline option provides a precautionary level of protection from harmful algal and cyanobacterial blooms in recreational water, option 2 is considered a stronger guideline recommendation as it reflects current best practices for establishing biomass triggers.
Option 2	This guideline option was selected based on what is considered the best available evidence for harmful algal and cyanobacterial blooms in recreational water, with consideration of impacts resulting from unnecessary water site closures on communities and other stakeholders. This option also provides guidance on managing risks within a preventive risk management framework. Given the biovolumes (0.4 to 3 mm^3/L) are conservatively based on a dominance of cyanobacteria and don't distinguish between non-toxic and toxic species, it was considered that the previous threshold for non-specific adverse health outcomes (e.g. skin irritation) of 10 mm^3/L was no longer required. It was also determined that a biomass trigger for *Karenia brevis* was not supported without further review and could be considered following public consultation.

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Evidence to decision table – Chemical hazards in recreational water

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 26. Comparison of guideline options – chemical hazards

Criteria	OPTION 1	OPTION 2
Decision?	Maintain status quo in NHMRC (2008). Simple screening approach using default chemical screening values (10 times the drinking water guideline value) with further investigation in the event of exceedances. Separate health-based guideline values for PFOS+PFHxS and PFOA.	Adapt wording in current recommendation and adapt WHO (2021) advice for screening chemicals. Simple screening approach for all chemicals using default chemical screening values (20 times the Australian drinking water guideline value) with further risk assessment recommended in the event of exceedances. No separate health-based guideline values, but option to develop site specific screening values with local exposure data in consultation with relevant health authorities/ regulators.

Criteria	OPTION 1	OPTION 2
Draft recommendation	Current recommendations: Waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes. Recreational water should have a pH in the range 6.5–8.5 (a pH range of 5–9 is acceptable in recreational waters with a very low buffering capacity) and a dissolved oxygen content greater than 80%.	Suggested recommendations: Water contaminated with chemicals at concentrations that may cause harm to humans is unsuitable for recreation. Where default screening values (determined by multiplying the current Australian drinking water guideline value by 20) are exceeded, further risk assessment should be undertaken. Site specific screening values for chemicals of concern can be developed in consultation with the relevant health authority or regulator. Recreational water should have a pH in the range 6.5–8.5 (a pH range of 5–9 is acceptable in recreational water bodies with a very low buffering capacity) and a dissolved oxygen content greater than 80%.

Table 27. Discussion of evidence to decision factors for guideline options – chemical hazards

Criteria	Discussion of evidence to decision factors:
Health evidence profile	While the health effects of many chemical hazards are well known, in most cases the risks posed by chemical contaminants in recreational water bodies may be significantly reduced through dilution and dispersion through the water body. NHMRC (2008) and WHO (2021) both note that in most cases and depending on the circumstances, recreational water users are unlikely to come into contact with sufficiently high concentrations of most contaminants to suffer adverse effects from a single exposure. Even repeated exposure is unlikely to result in adverse effects at the concentrations of chemicals typically found in surface water. An evaluation of evidence (O'Connor 2022) indicated that the available evidence was inadequate to determine if exposure to listed chemical hazards (e.g. PFAS, pesticides, nanomaterials, hydrocarbons, metals, endocrine disrupting chemicals, surfactants, or combinations of these) could give rise to any significant human health risks in waters used for recreational and cultural purposes given that such exposures are generally low. There was low certainty in three included primary studies regarding the health effects of heavy metals and polycyclic aromatic hydrocarbons (PAHs) from exposures due to recreational water bodies, leading to limited confidence in the reported associations. The findings of the review also indicated that the evidence in the available guideline literature lacked sufficient detail to determine which chemicals harmful to human health might be present at elevated concentrations in Australian waters and their sources. Similarly, evidence for the physicochemical properties of chemical hazards that may enhance uptake via dermal, inhalation or ingestion exposure pathways was generally limited. Furthermore, there was no information in the guideline literature on methods for adjusting exposure assumptions for problematic chemicals. There was also little evidence found in the review for focusing on 'hot spots' (site specific vs chemical specific) or undertaking periodic toxicity testing as well as chemical testing. Both NHMRC (2008) and WHO (2021) recommend a default screening approach to monitoring chemical water quality in recreational water bodies and as a starting point for site specific investigations. NHMRC 2008 recommends monitoring for chemical concentrations using a simple screening approach using screening values based on 10 times the Australian drinking water guideline value (Option 1). The assumption of 10 times the drinking water guideline is based on Mance (1984) and potentially overestimates health risks because it is based on daily consumption of 10% of the amount of drinking water and assumes daily recreational activity where 200 mL is assumed to be ingested each day. In 2019 NHMRC also set health-based guideline values for PFOS+PFHxS and PFOA using an approach that aimed to more accurately estimate the annual accidental ingestion volume for these specific chemicals. The chemical screening approach outlined in the WHO (2021) Guidelines was found to be suitable for potential adoption/adaption in Australia in Option 2. WHO (2021) recommends an approach for investigating substances occurring in

Criteria	Discussion of evidence to decision factors:
	recreational water at a concentration 20 times higher than the guideline value in the *WHO Guidelines for drinking-water quality*. This was considered to provide a more realistic worst-case scenario (based on the upper limit accidental ingestion for a small child playing in water and upper limit of events of 150 times per year) on which to potentially base the default chemical screening values. Option 2 also allows for the derivation of more accurate site specific screening values based on local use of the water body if required.
Exposure profile	Monitoring programs for recreational water bodies are limited in Australia, mainly occurring in urban areas and with a focus on monitoring for microbial risks (e.g. enterococci) and not chemical hazards. NHMRC is aware that ongoing research and existing monitoring programs for environmental waters may be useful for recreational and cultural water purposes when the relevant data is peer-reviewed and made publicly available. There are many chemicals typically present at very low concentrations in natural water bodies; higher concentrations of some chemicals would reasonably be expected where there is ongoing point source pollution, and known contamination in and around the water site. Actual concentrations would vary over time and be highly dependent on factors relating to weather events and seasonality (e.g. water flow, rainfall levels). However, in general recreational water users are unlikely to come into contact with sufficiently high concentrations of most chemical hazards to suffer adverse effects from a single exposure. Even repeated (chronic) exposure is unlikely to result in adverse effects at the concentrations of chemical hazards typically found in natural water bodies (NHMRC 2008; WHO 2021)
Health benefits and harms	Screening values aim to monitor potential risks against default levels (that have some level of conservatism built into them) before reaching higher levels where there is known harms to health – the intent is then to investigate the source of the contamination. Lower screening values are more conservative compared to higher screening values. However, the choice of guideline option should balance the need for conservatism against the best available evidence and consider appropriate levels of uncertainty in their derivation. In addition, conservative screening values could potentially overestimate the health risks, especially if they assume daily swimming by the local population that doesn't accurately reflect the local use of the water body. Overestimation of health risks may result in unnecessary site closures or restricted activities which may disadvantage communities if there are limited recreational water sites available in the event of an increase of exceedance.

Criteria	Discussion of evidence to decision factors:
Values and preferences (consumers, communities)	Human exposure to chemical hazards is an ongoing concern to consumers and communities, including exposure from the environment through activities in and around natural water bodies. Community perceptions around the risks posed by chemicals in recreational water bodies may vary, and exposure to chemicals may be perceived by some to be a greater risk to health than other hazards that present a more serious, acute health risk to communities (such as health risks from faecal pollution, harmful algal blooms). Increased water site closures as a result of implementing either of the guideline options might have broad impacts on consumers and communities (e.g. economic, environmental, social and cultural impacts) and may potentially cause subsequent psychological and/or financial distress in communities, such as if recreational activities are restricted. Both guideline options could potentially result in restricted or lack of access to recreational water sites if screening values are exceeded. This may impinge on the universal right to freedom of movement. This is particularly important for Aboriginal and Torres Strait Islander people who have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. There are international human rights laws that allow governments to restrict freedoms during public health emergencies, such as catastrophic contamination events or natural disasters. If risks do exist, some sites will already be restricted (e.g. access or restricted activities), but water managers may need to consider if local communities are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication is required.
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational and cultural water use and the management and regulation of natural water bodies across Australia is broad and complex. Given this complexity, and in line with the approach outlined in the Risk Management Framework, a simple screening approach with the option to develop more appropriate, site specific guidance in Option 2 may be considered more acceptable as it provides an option for everyone depending on their resources and needs. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of screening values, or during investigations, might be unacceptable to some stakeholders. This may be due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) that may arise from actual or perceived health risks.. Known chemical hazards at existing sites may already be restricted (e.g. access or restricted activities) but managers will need to consider if this is still acceptable to local communities that are still using sites (e.g. important food source in remote areas) and if further risk management or risk communication with the community may be required.

Criteria	Discussion of evidence to decision factors:
Feasibility	Both guideline options are technically feasible as the proposed default chemical screening levels are readily measurable using current commercial analytical techniques. However, the feasibility of implementing broader risk assessment and risk management processes as part of the proposed Risk Management Framework, particularly in the event of detected exceedances, will be resource dependent. Some water managers will find it unfeasible to undertake some of the actions recommended as part of the broader risk management process, such as undertaking routine monitoring and implementing improvement programs to reduce point sources of pollution. Local recreational water managers may find it challenging to derive site specific screening values based on local data, due to resource or capability limitations. They may need to seek professional advice to derive site specific screening values; however, the proposed guideline options are intended to provide default screening values that can be used in the first instance to assess the level of risk if site managers are unable to derive site specific screening values.
Health equity impacts	Screening values based on the *Australian Drinking Water Guidelines* will be protective of individuals and the general population with consideration for sensitive and vulnerable groups as they are based on the most critical health effect for the most sensitive population group. Option 1 is a more conservative guideline option as it results in a lower chemical screening value; however, this could overestimate the health risk as it assumes daily swimming by the population. Overestimation of health risks may result in unnecessary site closures or restricted activities which may negatively impact health and wellbeing in communities where there are limited recreational water sites available. Option 2 provides a more realistic worst-case scenario on which to base the default screening values which may more accurately focus investigations on sites that need the most risk assessment.

Criteria	Discussion of evidence to decision factors:
Resource impacts	Both guideline options may have impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Increased interactions with health and/or water regulators and testing services (such as a resulting of increased monitoring requirements or site assessments) may result in increased regulatory burden and increased costs for testing. Testing might also be required as part of site specific assessment and ongoing monitoring requirements. Implementing prevention and control strategies (catchment protection), whilst resource intensive initially would likely lead to more sustainable outcomes. Management and regulation of water bodies across Australia is complex, ranging from local Councils, state/territory health/EPA agencies to Commonwealth. Information on legislative/regulatory impacts on any recommendations from these stakeholders will be collected during public and targeted consultation and considered before finalising the guidelines.

Table 28. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – chemical hazards

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not selected as the exposure assumptions based on Mance (1984) were considered overly conservative and assume that the population accidentally ingests 200m L of recreational water every day through recreational activities. While this guideline option may result in more conservative default screening values, Option 2 allows for the derivation of more accurate (and potentially more conservative) site specific screening values depending on local use of the water body in consultation with the relevant health authority or regulator.
Option 2	This guideline option was considered the most appropriate option for screening the vastly different recreational water environments across Australia while retaining a high level of conservatism that protects public health. The default screening values of 20 x the Australian drinking water guidelines are based on a more realistic estimate of worst-case exposure assumptions (using upper limits for event frequency (150 per year) and accidental ingestion per event (250mL)) similar to the approach recommended by the WHO. The option to derive site specific screening values in consultation with the relevant health authority or regulator allows for more conservatism to be incorporated if required based on local water use data. This guideline

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
	option was selected based on what is considered the best available evidence for exposure assumptions, with consideration of impacts resulting from unnecessary water site closures on communities and other stakeholders.

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Evidence to decision table – Exposure assumptions

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 29. Discussion of evidence to decision factors for guideline options – exposure assumptions

Criteria	Discussion of evidence to decision factors:		
Decision?	Retain existing approach NHMRC (2008)	Adapt combination of WHO (2021), enHealth (2021a), NHMRC (2008)	Adopt US EPA (2019) and Health Canada (2022)
Candidate exposure assumptions (volume and frequency)	*Microcystin guideline value*: For child (15 kg), 100 mL incidental ingestion over 14 days. *Chemical hazards*: Screening approach, 10 times Australian drinking water guideline value based on 200 mL per day for 365 days per year. Equates to 10% of volume of drinking water ingested per year, assuming 2 L per day. *Microbial pathogens*: Faecal indicators based on epidemiological studies.	*Cyanotoxins guideline/reference values**: For child: 250 mL per day, 15 kg (bodyweight adopted from WHO 2021 and in line with enHealth 2012a). *Chemical hazards*: Screening approach, 20 times Australian drinking water guideline value based on 250 mL per swimming event and estimated frequency of 150 events per year. This equates to about 37.5 litres per year, representing approximately 5% of the volume of drinking-water ingested per year (based on 730 litres assuming 2 litres per day ingested). Where there is evidence that dermal and inhalation are significant exposure routes for a specific hazard, refer to *Environmental Health Risk Assessment – Guidelines for assessing*	*Cyanotoxins:* For child: Health Canada (2022): 103 mL per day, 23 kg. US EPA (2019a): 210 mL per day, 31.8 kg. *Chemical hazards*: No guidelines or screening values provided. *Microbial pathogens*: Faecal indicators based on epidemiological studies (per 100 mL).

Criteria	Discussion of evidence to decision factors:		
		human health risks from environmental hazards (enHealth 2012b). *Microbial pathogens*: Faecal indicators based on epidemiological studies. Where a site-specific quantitative microbial risk assessment is conducted, adopt 250 mL per event. *Adopted by NZ 2024	
Exposure assumptions	*Microcystin* Guideline value based on risk of short-term (14-day) repeated exposure to microcystin toxins via ingestion. (Two weeks of continuous exposure for swimming and aquatic recreation in a summer holiday season). A conversion factor (0.32) is applied to convert the 44 days exposure in the pig study, to a recreational water exposure period of 14 days per year. Weight of child is determined by the assumed age. Vidal et al. (2017) describe a case of microcystin poisoning requiring a liver transplant from recreational exposure in a 20 month old.	Worst-case ingestion levels per swimming event is 250 mL (children) and estimated frequency of 150 events. *Exposure volume* The exposure volume of 250 mL is consistent with WHO (2021). This is the upper value for children's exposure to recreational water derived from Table 4 of DeFlorio-Barker et al. (2018). The calculation was based on averaging the upper 95th percentiles of the volumes swallowed by the groups of children 6-12yrs (220 mL for marine water and 184 mL for freshwater per event) and ages 13-18 yrs (280 mL for marine waters and 174.7 mL for freshwater per event). This produced figures of 250 mL for marine water and 179 mL for	*Cyanotoxins* US EPA (2019a): 0.21 L/day (90th percentile daily recreational water incidental ingestion rate for children aged six to 10 years); 31.8 kg (mean body weight of children six to 10 years). (US EPA 2011, 2019a) Health Canada (2022): 103 mL/day is the estimated amount accidentally ingested per day during recreational water activities by a child aged 6 to 10 years (38 mL/h x 2.7 h/day), Children aged 5-11 spend the most time in outdoor pools – hence

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Criteria	Discussion of evidence to decision factors:		
	Chemical hazards NHMRC (2008, p. 155) states that when applying drinking water quality guidelines to recreational water, consumption of 100-200 mL per day should be taken into consideration but provide no references for this range. A screening value is based on the suggestion from Mance et al. (1984) that recreational water makes a minor contribution to intake, equivalent to 10% of drinking water consumption. Given most authorities (including WHO) assume consumption of 2 L of drinking water per day, ingestion of 200 mL per day from recreational contact with water is assumed (WHO 2003). This value assumes a daily lifetime exposure and hence is conservative. Based on this assumption, a recreational water guideline value can be calculated by multiplying the Australian drinking water guideline value by a factor of 10.	freshwater. 250 mL was selected as the worst case scenario. *Exposure frequency* The event frequency of 150 days is consistent with WHO (2021) and enHealth (2012a). 150 events per year is suggested for use in Australian screening risk assessments (enHealth 2012a). *Body weight* Consistent with WHO (2021) and NHMRC (2008): Weight of child is determined by the assumed age. Vidal et al. (2017) describe a case of microcystin poisoning requiring a liver transplant from recreational exposure in a 20 month old.	considered to be protective for other age groups. The amount of water accidentally ingested per day uses ingestion rates based on Dufour et al. (2017). The average body weight for children in Canada corresponding to the greatest exposure duration is 23 kg (based on ages 4–8 years) (Health Canada, unpublished). water-quality-cyanobacteria-toxins-en.pdf

Criteria	[Discussion of evidence to decision factors:]()
Data on exposure variables	According to WHO (2021), there is limited data are available on volumes of water ingested during recreational activities. According to the *Australian Exposure Factor Guide* (enHealth 2012a): • Insufficient survey data exist to provide a robust estimate for frequency and time spent by Australians swimming in either swimming pools or natural bodies (e.g. beaches, lakes, creeks and reivers). • No Australian data for incidental ingestion of water while swimming were located. • Swimming activity will likely be dependent on the location in Australia; higher in tropical and sub-tropical regions compared with temperate or colder areas. • Event frequency: In the absence of Australian upper estimated data, the US EPA (1997), Table 15-18 upper estimate of 150 days per year for a person who swims regularly for exercise or competition is suggested for use in Australian screening risk assessments (refer to [Exposure Factors Handbook]()). • Time spent swimming: 0.5 h/day for general population, and 1.5 h/day for people who swim regularly. • The suggested values for incidental water ingesting while swimming are provided as text below from Table 4.6.3 of enHealth 2012a. **Table 4.6.3: Suggested values for incidental water ingestion rates while swimming** Adults (>15 yrs) Suggested incidental water ingestion rate • Approximate average of 25 mL/hr • Approximate upper estimate of 125 mL/hr Children (≤ 15 yrs) Suggested incidental water ingestion rate

Criteria	Discussion of evidence to decision factors:

- Approximate average of 50 mL/hr
- Approximate upper estimate of 150 mL/hr

Table 4.6.3: Suggested values for incidental water ingestion rates while swimming

		Suggested incidental water ingestion rate (mL/hr)
Adults (>15 yrs)	Approximate average	25
	Approximate upper estimate	125
Children (≤ 15 yrs)	Approximate average	50
	Approximate upper estimate	150

Note: Data based on studies in swimming pools. 50 mL/h is based on Dufour et al. (2006) (i.e. 49 mL/h) ingested for male and female children combined (Table 4.6.1), but slightly greater than the average ingestion rate (38 mL/h) for children (<15 years) in the Schets et al (2011) study (i.e. average ingestion volume of 51 mL per event*60 min/81 min average duration of swimming event). 150 mL/h is based on Schets et al. (2011) study (i.e. upper 95% CI of 200 mL per event x 60 min/81 min average duration of event).

Key findings of international studies on exposure assumptions for water ingested during recreational activities are as follows:

Dufour et al. (2006)

- A US pilot study involving 53 recreational swimmers, using a community swimming pool disinfected with cyanuric acid stabilised chlorine. Participants were instructed to swim for at least 45 minutes. ingested cyanuric acid was used to determine the amount of water swallowed during swimming activity.
- Results of the study indicate that non-adults (≤18 years) ingest about twice as much water as adults during swimming activity. The mean volume of water swallowed by non-adults was 37 mL over a 45 minute period (average for boys was 45 mL, *p*-value=0.1029). Adults swallowed an average of 16 mL per 45 minutes of swimming activity. The range of water

Criteria	Discussion of evidence to decision factors:

	volume ingested by non-adults was from 0 to 154 mL. Ninety-seven percent of the non-adults swallowed 90 mL or less. Adults swallowed between 0 and 53 mL of water.
	• Refers to a comparison of the water ingested by the non-adult recreational swimmers in the present study with the five young, competitive, long distance swimmers studied by Allen et al. (1982) indicates that competitive swimmers swallow significantly more water than recreational swimmers in a 45 minute interval. The competitive swimmers swallowed about three and one-half times more water than the young recreational swimmers in this study (37 mL vs. 128 mL).
	Schets et al. (2011)
	• Dutch study. Exposure data collected for swimmers in freshwater, seawater, and swimming pools in 2007 and 2009 in the Netherlands. Information on the frequency, duration, and amount of water swallowed were collected via questionnaires completed by 8000 adults of whom 1924 additionally answered questions for their eldest child (<15 years). Survey participants estimated the amount of water that they swallowed while swimming by responding in one of four ways: (1) none or only a few drops; (2) one or two mouthfuls; (3) three to five mouthfuls; or (4) six to eight mouthfuls.
	• Children swam more often, stayed in the water longer submerged their heads more often and swallowed more water, compared to adults.
	• Swimming pools were visited most frequently (on average 13-24 times/year) and fresh and seawater sites on average were visited 6-8 times/year. For children, 95%UCL: 91, 25, 24 frequency of swimming per year at swimming pool, freshwater and seawater, respectively.
	• For children <15 years, the exposure parameters in swimming pools, freshwater and seawater are as follows:
	  • Swimming pool: average volume of water swallowed: 51 mL (95%UCl:200), swimming duration: 81 minutes (95%UCL: 200).
	  • Freshwater: average volume of water swallowed: 37 mL (95%UCl:170), swimming duration: 79 minutes (95%UCL: 270)
	  • Seawater: average volume of water swallowed: 31 mL (95%UCl:140), swimming duration: 65 minutes (95%UCL: 240)
	Dorevitch et al. (2011)

Criteria	Discussion of evidence to decision factors:
	• US study: Chicago area surface waters, self-reported estimates of ingestion from individuals (2,705) after they engaged in recreational activities (i.e., canoeing, fishing, kayaking, motor boating, and rowing). Swimming pools, interviews and 24-hour urine samples for analysis of cyanuric acid involving 662 participants engaged in limited contact scenarios (i.e., canoeing, simulated fishing, kayaking, motor boating, rowing, wading/splashing, and walking), as well as full contact activities. The estimated volume of water ingested during both limited and full contact recreational activities is summarised in the US EPA *Exposure Factors Handbook* (US EPA 2019b). • Mean and upper confidence estimates of water ingestion are about 3–4 mL and 10–15 mL during limited-contact recreation at surface waters. • Mean and upper confidence estimates of water ingestion are about 10 mL and 35 mL during swimming at a pool. Dufour et al. (2017) • Second follow-up study from Dufour et al. (2006) with larger study population. US Study involving nine public swimming pools in Ohio. The study enrolled 549 participants, from the ages of 6 to adult, recreating in a disinfected pool setting (performed "normal swimming activities"). Researchers determined the amount of water ingested per participant by conducting a 24-hour urinalysis for cyanuric acid. Swimmers were directed to perform normal swimming activities for approximately 1 hour, however the self-reported duration ranged between 47 minutes and 104 minutes. Study population comprised: children aged 6-10, teens aged 11-15 and adults ≥16 years. • Data are logarithmically distributed, data statistics reported in terms of geometric means and confidence intervals, and overall mean as arithmetic mean to compare it to published data. For water ingested by all swimmers: arithmetic mean was 32 mL, and the ratio of water swallowed in children versus adults was 2.0 (47 mL versus 24 mL). • Swimmers on average ingest 32 mL/h (geometric mean 14 mL) of water while swimming, with a range of 0 to 280 mL per hour. Children swallowed almost four times as much water (38 mL/h) as adults (10 mL/h). Male children swallowed the most amount of water (geometric mean 43 mL). There is no ingestion data available for this study for children younger than 6 years.

Criteria	Discussion of evidence to decision factors:
	• Among the upper quartiles of their respective groups, children ingested almost twice as much as water as adults (16 and older) and 50% more than teens. Children, while comprising only 12% of the entire study population, made up 30% of those in the upper quartile, ingesting between 37 and 280 mL of water with an average of about 87 mL. • Summary of data statistics (mL/h), Geometric means (95% confidence intervals): Children 24 (17-33), Teens 24 (19-30), Adults 12 (11-14). The greatest amount of water ingested by children, teens, and adults, respectively, was 245 mL, 267 mL, and 279 mL. • The **US EPA *Exposure Factors Handbook* (updated 2019)** (source: About the Exposure Factors Handbook | US EPA), used data obtained from the authors (Dufour et al. 2017) and estimated arithmetic mean ingestion rates and additional percentiles of the distributions for additional age groups of children. The arithmetic mean ingestions rates were 38, 44, 33, and 28 mL/h for ages 6 to <11, 11 to <16, 16 to <21, and 21+years, respectively. The 95th percentile ingestion rates were 96, 152, 105, and 92 mL/h for ages 6 to <11, 11 to <16, 16 to <21, and 21+years, respectively. De-Florio-Barker et al. (2018) • Pooled analysis of 12 prospective cohorts of beachgoers (68,685 subjects) at freshwater and marine beaches (temperate climates) in the US. Self-reported estimates of time spent in the water were combined with estimates provided by Dufour et al. (2017) of the volume of water swallowed during 45-90 min of swimming. This information was used to conduct a simulation study to provide an estimate of the rate of water swallowed per minute for those aged ≥6 years. Estimate volume of water swallowed per swimming event: Volume (mL/min) x Time (min/event) = Volume (mL/event). Authors report that the results of the simulation, using self-reported time spent in the water (n=68,685) and estimated volume of water swallowed per minute from Dufour et al. (2017), present a refined estimate of the volume of water swallowed per swimming event and decrease the uncertainty associated with recreational water ingestion estimates, especially among children, compared to previous studies. • Those recreating in marine waters, typically spent more time in the water compared to freshwater swimmers. • Based on the simulation, the estimated volume (mL) of water swallowed per swimming event: - Children 6-12: Freshwater: 53 (mean), 184 (95th percentile), Marine: 67.7 (mean), 220 (95th percentile)

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Criteria	Discussion of evidence to decision factors:

- Ages 13-18 years: Freshwater: 45 (mean), 174.7 (95th percentile), Marine: 71.4 (mean), 280 (95th percentile)
- Adults 19-34 years: Freshwater: 21.9 (mean), 85.3 (95th percentile), Marine: 32.8 (mean), 126 (95th percentile)
- Ages ≥35 years: Freshwater: 22.6 (mean), 88 (95th percentile), Marine: 32.3 (mean), 121.3 (95th percentile)

Other studies

- Water ingestion among surfers on the Oregon coast was investigated by Stone et al. (2008). In that study participants were also asked to estimate the volume of water swallowed while surfing. Based on the self-reported estimates of ingestion volume and ingestion frequency, the authors estimated a median daily ingestion of 34.4 mL, and an arithmetic mean of 170.6 mL (upper value 665 mL).

US EPA (2019) *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*

Table 7-3 in US EPA (2019b) provided as text below gives calculated daily incidental ingestion rates based *Exposure Factor Handbook* and DeFlorio-Baker et al. (2017), adopts the 90th percentile daily ingestion rate in the derivation of the criteria and recreational swimming advisories.

Table 7-3. Calculated Daily Incidental Ingestion Rates Based on EFH and DFB Datasets

Volume per Hour Data Source	Event Duration Data Source	Age Group (years)	Events per Day (if assumed)	90th Percentile Daily Ingestion Rate (L/day)
Recreational AWQC Appendix E full dataset (L/hr)	EPA *Exposure Factors Handbook* (2011)[a] (hr/day)	5 to 11	not needed	0.21
	DeFlorio-Barker et al. (2017) (DFB) (hr/event)	4 to 7	1	0.11
			2	0.23
		8 to 12	1	0.12
			2	0.24

[a] This distribution was used in the derivation of the criteria and recreational swimming advisories.

Table 7-3. Calculated daily incidental ingestion rates based on EFH and DFB datasets

Volume per hour data source: Recreational AWQC Appendix full dataset (L/hr)

Criteria	Discussion of evidence to decision factors:

	Event duration data source:
	EPA Exposure Factors Handbook (2011)[a] (hr/day)
	• Age group: 5 to 11 years
	  ○ Events per day: Not needed
	  ○ 90th percentile daily ingestion rate: 0.21 L/day
	DeFlorio-Barker et al. (2017) (DFB) (hr/event)
	• Age Group: 4 to 7 years
	  ○ Events per Day: 1
	  ○ 90th Percentile Daily Ingestion Rate: 0.11 L/day
	• Age Group: 4 to 7 years
	  ○ Events per Day: 2
	  ○ 90th Percentile Daily Ingestion Rate: 0.23 L/day
	• Age Group: 8 to 12 years
	  ○ Events per Day: 1
	  ○ 90th Percentile Daily Ingestion Rate: 0.12 L/day
	• Age Group: 8 to 12 years
	  ○ Events per Day: 2
	  ○ 90th Percentile Daily Ingestion Rate: 0.24 L/day
	[a]This distribution was used in the derivation of the criteria and recreational swimming advisories.
	Considerations in deriving default exposure assumptions:
	• Studies suggest children ingest more water than adults during swimming. There are very few studies on ingested volumes for recreational activities involving limited contact with water.

Criteria	Discussion of evidence to decision factors:
	• Ingestion volumes in fresh and marine waters are inferred from self-reported data. Data derived from swimming pools where urinalysis for cyanuric acid is conducted are not subject to the same reporting biases, with Dufour et al. (2017) providing the most robust dataset. However, ingestion in swimming pools may under-represent ingestion rates in fresh and marine water environments due to deterrence to consume highly chlorinated water. • Duration of swimming event relies on self-reported estimates and data from fresh and marine waters will vary according to climatic conditions, and for this reason time spent swimming as reported by Schets et al. (2011) may not be applicable to the Australian context. Deflorio-Baker et al. (2017) report that the results of the simulation, using self-reported time spent in the water (n=68,685) and estimated volume of water swallowed per minute from Dufour et al. (2017), present a refined estimate of the volume of water swallowed per swimming event and decrease the uncertainty associated with recreational water ingestion estimates, especially among children, compared to previous studies. • In summary, data from Deflorio-Baker et al. (2017) provides the best available data for underpinning exposure assumptions. A summary of values for exposure variables from key studies is at Table 31.
Health benefits vs harms	Ingestion is considered the primary route of exposure for all hazards. Current methods make no allowance for other exposure routes, such as inhalation and dermal absorption, which may be significant for some chemicals. Skin absorption can be a route of update for some heavy metals and organic chemicals. Inhalation can be an important exposure route for highly volatile chemicals, microbial hazards and algal toxins. Even so, there is considerable uncertainty associated with the quantification of unintentional ingestion volume, and it is relevant to consider the context and methods applied in the study before directly applying reported statistics. At best they should be considered 'indicative estimates', and protective estimates for the specific location should be selected as part of the risk assessment process. Therefore, in deriving default exposure assumptions underpinning these guidelines, where available in the literature, conservative estimates (upper 95th percentile estimates) based on children ingesting water via swimming have been adopted.

Criteria	Discussion of evidence to decision factors:
Values and preferences (consumers, communities)	It is reasonable to assume that the community would expect that default exposure assumptions underpinning guidelines and risk assessments are protective and err on the side of caution. The default exposure assumptions are not representative of all recreational and cultural uses such as activities involving limited water contact, or potentially higher exposure scenarios relevant to cultural practices. Aboriginal and Torres Strait Islander people have strong cultural and spiritual connections to Country and waters and a strong responsibility to care and maintain these lands and waters. The guideline emphasises the importance of engaging with First Nations communities to incorporate knowledge on cultural practices and understanding of exposure pathways and assumptions in assessing and managing risks.
Acceptability (other key stakeholders)	The acceptability of the default exposure assumptions is likely to be varied amongst stakeholders. In this regard, where there is site-specific data available, its application in the risk assessment for a given water site should be undertaken in consultation with the relevant health authority or regulator.
Feasibility	Local recreational water managers may find it challenging with their local resources/capabilities to undertaken surveys and studies to inform site specific exposure values as described in the above studies. Given there is no Australian data for incidental ingestion of water while swimming, providing default exposure assumptions makes it feasible for water managers to assess risk.
Health equity impacts	Since exposure durations and frequencies may vary significantly among people, representative estimations must be made. The selection of representative estimations must account for people who have greater than 'typical' exposure to ensure broad protection across a population which may exhibit highly variable exposure patterns. The literature suggests that children are a sensitive sub-population with regard to recreational exposure, are likely to spend more time in direct contact with waters and ingest more water than adults. It is therefore appropriate that the default exposure assumptions are based on water ingestion in children.
Resource impacts	Where exposure volumes and frequency are expected to be greater, specialist expertise will be required to conduct a site-specific risk assessment. Deriving site-specific exposure estimates is likely to be cost-prohibitive in most cases.

Table 30. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – exposure assumptions

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	This guideline option was not selected as the exposure assumptions were not considered to be based on the best available methods or evidence. For chemical hazards, the exposure assumptions based on Mance (1984) were considered to be overly conservative and assume that the population accidentally ingests 200 mL of recreational water every day through recreational activities. For cyanotoxins, there was some uncertainty about the approach taken in NHMRC (2008) to derive a health-based guideline value for microcystins (i.e. estimating exposure over a 14-day period using 100 mL/day and a conversion factor of 0.32 to adjust a 44-day study to a 14-day study). In light of this, the approach adapted for microcystins in Option 2 is considered to be a more robust approach to developing short-term guideline values for cyanotoxins as they are based on the best available evidence for accidental ingestion volumes and retain a high level of conservatism through the application of safety factors.
Option 2	This guideline option was considered the most appropriate option for screening the vastly different recreational water environments across Australia for chemicals and cyanotoxins while retaining a high level of conservatism that protects public health. This option reflects a more realistic estimate of worst-case exposure assumptions (using upper limits for event frequency (150 per year) and accidental ingestion per event (250 mL)) similar to the approach recommended by WHO (2021). The option to derive site-specific exposure values in consultation with the relevant health authority or regulator allows for more conservatism to be incorporated if required based on local water use data. This guideline option was selected based on what is considered the best available evidence for exposure assumptions.
Option 3	The exposure assumptions are based on similar literature to Option 2 but are not worst-case estimates from these studies.

Table 31. Summary of values for exposure variables from key studies – exposure assumptions

Citation	Context	Reported values for exposure variables	Study characteristics	Limitations
Dufour et al. (2006)[a]	US swimming pool.	Ingestion rate: • Average of 16 mL per 45 minutes (21 mL/h) • Range: 0 and 53 mL per 45 minutes	Ingestion rate (≤18 years) • Average 37 mL over a 45 min period (49 mL/h) • Average for boys was 45 mL over 45 minutes period, *p*-value=0.1029. • Range 0 to 154 mL over 45 min period. • 97% swallowed 90 mL or less over 45 min period.	Amount ingested based on analytical method. Study population small. Ingestion rate can only be inferred, not duration as swimmers instructed to swim for 45 minutes.
Schets et al. (2011)[b]	The Netherlands. Swimming pools, fresh and seawater sites. Swallowed per event	Volume ingested (mL): • Swimming pools: 34 (95%UCI: 170) • Freshwater: 27 (95% UCI: 40) • Seawater: 27 (95% UCI: 140) (Reported values for men, noting values are greater than women) Duration (min): • Swimming pools: Men: 68 (95%UCI:180), Women: 67 (95%UCI:170) • Freshwater: Men: 54 (95%UCI:200), Women: 54 (95%UCI: 220)	Volume ingested (mL) for children (<15 years) • Swimming pools: 51 (95%UCI: 200) • Freshwater: 37 (95%UCI: 170) • Seawater: 31 (95%UCI: 140) Duration (min): • Swimming pools: 81 (95%UCI:200) • Freshwater: 79 (95%UCI:270) • Seawater: 65 (95%UCI: 8-240) Frequency (per year): • Swimming pools: 24 (95%UCI:91) • Freshwater: 8 (95%UCI:25) • Seawater: 7 (95%UCI: 4)	Data are based on self-reporting. Frequency for freshwater and seawater unlikely to be representative of Australian conditions.

Citation	Context	Reported values for exposure variables	Study characteristics	Limitations
		• Seawater: Men: 45 (95%UCI:160), Women: 41 (95%UCI: 180) Frequency (per year): • Swimming pools: Men: 13 (95%UCI:54),Women: 16 (95%UCI:65) • Freshwater: Men: 7 (95%UCI:25), Women: 7 (U95%UCI: 23) • Seawater: Men: 6 (95%UCI:22), Women: Seawater: 6 (95%UCI:19)		
Dorevitch et al. (2011)[c]	US swimming pools and surface waters in Chicago	• Mean and upper confidence estimates of water ingestion are about 3–4 mL and 10–15 mL respectively during limited-contact recreation (rowing, canoeing/kayaking, boating without capsizing, fishing) at surface waters. • Mean and upper confidence estimates of water ingestion are about 10 mL and 35 mL during swimming at a pool.		With the exception of volume ingested in swimming pools, data are based on self-reporting, and data are not provided for individual age groups of the population
Dufour et al. (2017)[b] (& US EPA (2019b) estimated arithmetic mean ingestion	US swimming pools	Ingestion rate (mL/h) for adults ≥16 years: • 10 (average) • 12 (geometric mean), 95%CI:11-14 • 105 (95^{th} percentile)	Ingestion rate (mL/h) for children (6-10 yrs): • 38 (average) • 24 (geometric mean), 95%CI:17-33 • 96 (95^{th} percentile) Ingestion rate (mL/h) for teens (11-15yrs)	Follow-up study of Dufour et al. (2006), with larger population size. Swimmers directed to swim for approximately 1 hour, actual time spent was self-reported and varied between 47-104 minutes.

Citation	Context	Reported values for exposure variables	Study characteristics	Limitations
rates and 95th percentiles)			• 24 (geometric mean), 95%CI 19-30 • 152 (95th percentile)	
Deflorio-Baker et al. (2017)	Pooled data. Freshwater and Marine beaches.	Estimate volume (mL) of water swallowed per swimming event: • 19-34 years: Freshwater: 21.9 (mean), 85.3 (95th percentile), Marine: 32.8 (mean), 126 (95th percentile) • Ages ≥35 years: Freshwater: 22.6 (mean), 88 (95th percentile), Marine: 32.3 (mean), 121.3 (95th percentile	Estimate volume (mL) of water swallowed per swimming event: • 6-12 years: Freshwater: 53 (mean), 184 (95th percentile), Marine: 67.7 (mean), 220 (95th percentile) • 13-18 years: Freshwater: 45 (mean), 174.7 (95th percentile), Marine: 71.4 (mean), 280 (95th percentile)	Simulated study combining ingestion volumes in swimming pool (Dufour et al. 2017), and self-reported data on swimming duration at swimming pools, marine and freshwater beaches. Sensitivity analysis conducted.

a. Cyanuric acid. Cyanuric acid is a breakdown product of chloroisocyanurates, which are commonly used as disinfectant stabilisers in swimming pool water. In these studies, the duration of participants engaged in swimming is controlled, and then all urine of each participant is collected for 24 hours following the swimming event. The total amount of Cyanuric acid excreted in urine is used to retrospectively estimate the volume of water ingested.
b. Self-reported questionnaire. The second approach is to ask participants how much water they think they consumed while swimming using categories such as 'none or only a few drops', "one or two mouthfuls", "three to five mouthfuls" or "six to eight mouthfuls"
c. Limited-contact recreation. Refer to Dorevitch et al. (2011) or US EPA Chapter 3 of the Exposure Factors Handbook (updated 2019) (USEPA 2019b) for exposure data on 'limited-contact recreation' activities.

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WHO 2021. Guidelines on Recreational Water Quality: Volume 1 Coastal and Fresh Waters. World Health Organization (2021). Geneva.

Evidence to decision table – Aesthetic aspects of recreational water

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 32. Discussion of evidence to decision factors for proposed guideline recommendation – aesthetic aspects of recreational water

Criteria	Proposed guideline recommendation
Decision?	Maintain status quo in NHMRC (2008) and WHO (2021). No guideline values established, general description of good aesthetic water quality.
Draft recommendation	Recreational water bodies should be aesthetically acceptable to recreational water users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity, and; substances and conditions that produce undesirable aquatic life.
Health evidence profile	The current recommendation aligns with NHMRC (2008) and WHO (2021) guidance and reflects consensus on the importance of aesthetic quality in recreational water management. There is no compelling evidence to suggest that aesthetic hazards alone cause direct health harm, or that the current recommendation is insufficient.
Exposure profile	The aesthetic aspects of a recreational water body may infer potential pollution and the need for further investigation to determine the presence of chemical and microbial hazards. In such cases, exposure to these hazards via ingestion, dermal contact, or inhalation of water droplets may occur during recreational activities involving full or partial immersion.
Health benefits and harms	Aesthetic factors in recreational water include visible pollutants (e.g. litter, scum, oil), discolouration, unpleasant odours, and turbidity. While these do not typically pose direct health risks, they are strongly associated with public perceptions of water safety and cleanliness.

Criteria	Proposed guideline recommendation
	The presence of aesthetic hazards may indicate underlying contamination (e.g. faecal pollution, chemical spills) and can deter use of recreational sites. While this may serve a protective function by deterring use of potentially contaminated sites, it may also reduce access to the health and wellbeing benefits of water-based recreation. Therefore, maintaining aesthetic standards supports public health by encouraging and maximising the benefits of safe recreational and cultural use.
Values and preferences (consumers, communities)	Aesthetic indicators are often the most visible and immediate cues for the public. WHO (2021) notes that aesthetic acceptability is a key determinant of public confidence and use as it influences risk perception. Maintaining clear, odour-free, and visually clean water supports effective risk communication and aligns with community expectations and satisfaction. Aesthetic factors can have a significant economic impact on coastal communities. Large-scale or widespread environmental issues may deter tourists or visitors to an area.
Acceptability (other key stakeholders)	The recommendation aligns with public expectations and current operational practices. Consultation with Aboriginal and Torres Strait Islander communities highlighted the importance of sensory indicators—such as changes in water colour and odour— for evaluating water quality. The inclusion of First Nations' knowledge and sensory observations, informed by long-standing relationships with Country, provide valuable complementary insights of risks to water quality, and strengthens community trust and engagement in water quality monitoring.
Feasibility	There is no proposed change to the existing guidance. Aesthetic monitoring is already part of water quality management (e.g. visual inspections, public health messaging and community feedback mechanisms).
Health equity impacts	Maintaining aesthetically acceptable water supports equitable access to safe and enjoyable recreational environments, particularly for communities with limited alternatives.
Resource impacts	Aesthetic monitoring is already integrated into routine visual inspections and community reporting. There is no evidence to suggest that continuing with this guidance would impose additional workload on site managers, health authorities, or monitoring agencies.

Table 33. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – aesthetic aspects of recreational water

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
	The proposed recommendation—to maintain alignment with NHMRC (2008) and WHO (2021) guidelines—reflects the importance of aesthetic quality for public confidence and recreational and cultural use, even though aesthetic hazards alone do not pose direct health risks. This approach supports consistent public health messaging and recognises the role of aesthetic factors in influencing exposure behaviour and risk perception.

References:

NHMRC 2008. National Health and Medical Research Council (Australia). 2008, *Guidelines for managing risks in recreational water Australian Government National Health and Medical Research Council*. National Health and Medical Research Council Canberra, A.C.T.

WHO 2021. World Health Organization (2021). Guidelines on Recreational Water Quality: Volume 1 Coastal and Fresh Waters. Geneva:WHO.

Evidence to decision table – Radiological hazards

The Evidence to Decision (EtD) table below is intended to capture key factors and considerations when comparing and deciding on guideline options. This is in alignment with NHMRC Standards for Guidelines. Note this table can be updated or amended to capture additional criteria and factors once stakeholder feedback from targeted/public consultation has been received and considered by NHMRC and the Recreational Water Quality Advisory Committee.

Table 34. Discussion of evidence to decision factors for guideline options – radiological hazards

Criteria	OPTION 1	OPTION 2	OPTION 3
Decision?	Retain existing approach in NHMRC (2008) and reference ARPANSA (2017)	Set reference level at 10 mSv/year	Set reference level at 1 mSv/year
Draft recommendation	No reference level set (status quo). Regular monitoring for radiological hazards is not recommended for all recreational water bodies; however, monitoring for radiological hazards should be considered on a case-by-case basis if a recreational water body may be of concern (i.e. based on legacy or	Regular monitoring for radiological hazards is not recommended for all recreational water bodies; however, monitoring for radiological hazards should be considered on a case-by-case basis if a recreational water body may be of concern (i.e. based on legacy or planned exposures, past activities). For protection of people against radiation exposure from recreational and cultural water use, the recommended reference level is 10 millisievert per year (10 mSv/year.) Where default radiological screening values are exceeded, further risk assessment should be undertaken.	Regular monitoring for radiological hazards is not recommended for all recreational water bodies; however, monitoring for radiological hazards should be considered on a case-by-case basis if a recreational water body may be of concern (i.e. based on legacy or planned exposures, past activities). For protection of people against radiation exposure from recreational water use, the recommended reference level is 1 millisievert per year (1 mSv/year.) Where default radiological screening values are exceeded, further risk assessment should be undertaken.

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Criteria	OPTION 1	OPTION 2	OPTION 3
	planned exposures, past activities).		

Table 35. **Discussion of evidence to decision factors for proposed guideline recommendation – radiological hazards**

Criteria	Discussion of evidence to decision factors
Health evidence profile	The recommended approaches to managing radiation risks in Australia are outlined by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) in the *Guide for Radiation Protection in Existing Exposure Situations* (ARPANSA 2017). In line with ARPANSA (2017) and as part of a preventive risk management approach, the proposed guideline options all outline a risk-based approach to deciding (using a default reference level) whether further measures are needed to manage radiation risk. The reference level is a benchmark for judging whether further protective actions are necessary and, if so, in prioritising their application. Note as part of the approach outlined in ARPANSA (2017), water quality assessment is coupled with assessment of radiation from other sources (e.g. soil/rocks/sediment) in the surrounding area to determine the overall radiation risk. • Option 1 does not set a reference level but requires consideration of radiological water quality during an initial risk assessment. If there are any concerns, ARPANSA (2017) recommends site specific investigation and risk mitigation using an intermediate reference level of 10 mSv/yr as a starting point. • Option 2 adopts the recommended starting point of 10 mSv/year for site specific investigations as outlined in ARPANSA (2017). • Option 3 represents the most conservative option and requires site specific investigation at lower levels (i.e. 1 mSv/year) similar to those used to monitor drinking water (NHMRC 2011). All of the proposed guideline options are considered protective of public health, as the proposed guideline options sit within the recommended range of reference levels for existing exposure situations (i.e. between 1 and 20 mSv/year) as per ARPANSA (2017).

Criteria	Discussion of evidence to decision factors
Exposure profile	Elevated levels of radioactivity in recreational water bodies can result from naturally occurring concentrations of radioactive material in source waters (e.g. groundwater, mineral/thermal springs) or through human activities where radioactive materials may come into contact with water supplies (e.g. historical or current mining practices, nuclear testing). Many sites where radiation is present are already restricted (e.g. Montebello Islands, Western Australia). The available evidence suggests that the risk to human health from exposure to radiological contaminants in recreational water bodies in Australia is very low (ARPANSA 2024). In most cases, radiation exposures from immersion in recreational water or accidental ingestion of recreational water are not as high as the exposures from pathways that are out of scope of the updated Guidelines (e.g. external exposure from soil, rock and sediment, deliberate ingestion of seafoods, mineral waters and bush foods, inhalation of dust or radon).
Health benefits vs harms	The proposed guideline options are considered protective of individuals and the general population. They aim to manage risks before reaching higher levels of radiation where there are known harms to health. Lower reference values (such as Option 3) might be considered more conservative compared to higher reference values. However, the choice of guideline option should balance conservatism against the likelihood of exposure through water, and the feasibility of implementation, particularly in settings with less resources. The option of deriving site specific reference levels will provide flexibility for water managers based on their local circumstances, recreational water use patterns and community preferences. Lowering the guideline value may result in an increase of exceedances detected in water bodies, potentially resulting site closures during investigations which can have broader impacts on communities.
Values and preferences (consumers, communities)	Radiation might be perceived to be higher risk to human health by the public compared to other risks in recreational water (e.g. harmful algal blooms, chemicals, drowning, crocodile attacks). Information on values and preferences (recreational water users, communities) will be collected and included following targeted/public consultation. Increased recreational water site closures as a result of implementing any of the options while under investigation might have impacts on local economy even from a perceived risk (e.g. tourism, fishing). If risks do exist, many sites will already be restricted

Criteria	Discussion of evidence to decision factors
	but will need to consider if (and how) local communities are still using sites (e.g. these sites may be an important food source in remote areas) and if further risk management or risk communication is required.
Acceptability (other key stakeholders)	Acceptability of the proposed guideline options may vary across different stakeholder groups, given that the types of recreational water use and the management and regulation of natural water bodies across Australia is broad and complex. Increased water site closures as a result of implementing any of the options in the event of ongoing exceedances of reference values, or during investigations, might be unacceptable to some stakeholders due to various short- or long-term impacts on the local economy (e.g. tourism, fishing) even from a perceived health risks during the investigation process. In the event of site closures, water managers will also need to consider if risks are acceptable to local communities that are still using water sites (e.g. if there is an important food source accessed by the community) and if further risk management or risk communication with the community is required. Option 3 will likely be seen as overly restrictive by water managers as it would create a large regulatory burden to demonstrate that a site is below 1 mSv/year, which is the same level used to monitor risks in drinking water.
Feasibility	Implementation of these guideline options may be difficult for some site managers, particularly in remote areas away from analytical facilities and relevant expertise for risk assessments. Option 3 in particular would create a large regulatory burden for site managers to demonstrate that a site is below 1 mSv/year, which will be challenging depending on resources (e.g. proximity to analytical laboratories).
Health equity impacts	Some of the guideline options under consideration are more conservative than others, and as a result would be considered more protective of public health. Option 2 provides a more realistic worst-case scenario on which to base the default reference value which may more accurately focus investigations on sites that need the most risk assessment.

Criteria	Discussion of evidence to decision factors
Resource impacts	All of the proposed guideline options may have resource impacts on water managers if they represent a change to current practice, particularly if no monitoring is currently undertaken at recreational water sites. Analytical services will be required for any monitoring programs, with associated costs for site managers.

Table 36. Summary of Recreational Water Quality Advisory Committee decision regarding guideline options – radiological hazards

Decision	Decisions regarding the following guideline options by the Recreational Water Quality Advisory Committee are outlined below:
Option 1	While this guideline option may have the least amount of impacts on water managers as it maintains the status quo, it was agreed that providing a default reference level (such as in the other proposed guideline options) would be more helpful for water managers to assess the risk from radiation at their water sites.
Option 2	This guideline option was considered to be most appropriate reference level for assessing radiation risks in recreational water. The reference level is considered to be sufficiently health protective without being overly conservative (such as Option 3) and being unduly resource intensive for some stakeholder groups. Following risk assessment, a different, site specific reference level may be selected.
Option 3	This guideline option is considered to be overly conservative for recreational water exposure (given that 1 mSv/year is the reference level for daily drinking water exposure). This guideline option may also be the least feasible to achieve given the likely resource impacts on water managers.

References:

ARPANSA (2017). Guide for Radiation Protection in Existing Exposure Situations Radiation Protection Series G-2. Australian Radiation Protection and Nuclear Safety Agency. Available at https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series/guides-and-recommendations/rpsg-2, accessed 6 September 2023.

ARPANSA (2024). Report on the evaluation of the evidence on radiological water quality to inform the update to the 2008 NHMRC Guidelines for Managing Risks in Recreational Water. Australian Radiation Protection and Nuclear Safety Agency. October 2024.

NHMRC (2008). Guidelines for managing risks in recreational water. National Health and Medical Research Council Australian G.overnment. Canberra, ACT.

NHMRC (2011). Australian Drinking Water Guidelines 6 version 4.0 (published June 2025). National Health and Medical Research Council. Australian Government, Canberra.

Appendix B – Survey on community water use and risk awareness

In 2022, NHMRC surveyed Aboriginal and Torres Strait Islander stakeholders and representatives to ensure the updated Guidelines reflect the values, knowledge systems, and lived experiences of First Nations communities. This process aimed to:

- seek First Nations perspectives on water quality risks, risk management, and risk communication
- consider ways to incorporate traditional knowledge and scientific evidence to improve national guidance
- establish and maintain respectful relationships with First Nations stakeholders throughout the guideline development process.

NHMRC sought initial feedback on the appropriateness of the survey format and consultation questions from several advisors that helped refine the survey.

NHMRC used Survey Monkey to conduct the online survey, receiving seven consultation submissions from various individuals and organisations including health departments, local councils and Aboriginal health services and corporations.

NHMRC also surveyed attendees in person at the National Aboriginal and Torres Strait Islander Environmental Health (NATSIEH) conference held in Darwin September 2022. Conference attendees included:

- Environmental and Public Health Officers
- Rangers
- Local Aboriginal and Torres Strait Islander Land Council Delegates
- Local, State and Federal Government Delegates
- Academics/Research Institutes.

Feedback provided by survey respondents and responses has been deidentified and summarised in the table below.

Table 37. Summary of early feedback from advisors regarding the survey format and proposed consultation questions

Feedback	NHMRC and Committee Response
The term 'recreational water' is not inclusive of the typical use of water bodies on Country and may cause confusion, which might lead to a lack of engagement.	Noted. NHMRC is committed to ensuring national guidelines are inclusive of all Australians, including First Nations communities. NHMRC will continue to learn from consultation experiences to improve the inclusiveness of advice provided. Edits made throughout draft guidance to acknowledge that the term 'recreational water' does not reflect the ways that First Nations communities use water on Country. Further examples to be considered pending public consultation feedback.
The challenge of building rapport through email and gauge enough interest in consultation through virtual methods.	Noted. NHMRC is committed to improving the way that First Nations communities are consulted in the development of national guidelines and will continue to learn from consultation experiences to improve processes. Edits made to risk management framework to embed involving First Nations communities in consultation and planning processes.

Table 38. Summary of stakeholder feedback about community water use and risk communication on Country

Question	Answers	NHMRC and Committee Response
Question 1: What do you use the water on your Country for?	Stakeholders reported using water for fishing, food gathering, swimming, bathing, paddling, boating, cultural activities, and spiritual ceremonies. Other uses mentioned included drinking, washing, and economic activities such as business or work.	Noted. NHMRC recognises the importance of water on Country and its use for a wide range of purposes. Information on community water use considered in drafting relevant sections of draft Guidelines (e.g. risk management framework, evidence to decision process).
Question 2: Who looks after the water and lets you know if it is unsafe to use?	Stakeholders commonly identified community leaders, Elders, local councils and state governments as sponsible for looking after and communicating when it is unsafe to use. Some stakeholders identified rangers and other organisations (such as BHP).	Noted. Coordination and site management may be undertaken by a range of organisations, committees or groups depending on the local context. Suggestions incorporated into relevant sections of risk management framework.
Question 3: What type/s of water do you have on your Country?	Stakeholders reported a variety of water sources, including rivers, creeks, waterholes, billabongs, lakes, dams, bores, coastal beaches, and groundwater springs or soaks. This diversity highlights the range of environments and water types.	Noted. Suggestions incorporated into relevant sections of Guidelines (e.g. introduction, scope of Guidelines).

Question	Answers	NHMRC and Committee Response
Question 4: Is there any information that you can share about how you can tell if water is not safe to use (e.g. smell, sight, sound, taste, animal behaviour, other)?	Responses to this question were mixed. Several stakeholders indicated they could share information about assessing water safety (n=3), some were unsure (n=2), and others reported they could not provide such information (n=2). One respondent did not provide an answer.	Noted.
Question 5: Are there any traditional management ways to keep water safe that you can share?	Responses to this question were mixed. Several stakeholders indicated they could share information about traditional management methods (n=2), some were unsure (n=1), and others reported they could not provide such information (n=3). One respondent did not provide an answer.	Noted.

Question	Answers	NHMRC and Committee Response
Question 6: If you answered yes to any of the questions above and are happy to share, please provide more information:	Practical indicators mentioned for assessing water quality included observing the colour, smell, and presence of debris, as well as using local knowledge such as water hardness in the Pilbara region. One stakeholder highlighted the importance of culturally appropriate, in-person engagement for sharing knowledge about water safety. For example, "*come on-Country sit at our fires and listen to the stories, not on the web, very inappropriate*."	Noted. NHMRC acknowledges the preferred method for consultation with stakeholders is through face-to-face engagement and is committed to improving the way that First Nations communities are consulted in the development of national guidelines. Due to the pandemic and limited resource constraints when undertaking targeted consultation (time, budget, travel restrictions) stakeholder engagement was largely undertaken remotely other than the face to face NATSIEH conference in Darwin. NHMRC will continue to learn from consultation experiences to improve processes and incorporate learnings into guidelines (for example, by developing useful advice for state/territory or local level water site managers about best practice methods of engaging with First Nations communities). Suggestions about practical indicators incorporated into relevant chapters in draft Guidelines.
Question 7: Is your community involved in decision making about water on your Country and managing safety?	Stakeholders indicated that their communities were either not involved or were unsure about their involvement in decision-making and safety management regarding water on their Country.	Noted.

Question	Answers	NHMRC and Committee Response
Question 8: If yes, can you give us an example of anything that worked well or didn't work well?	Most stakeholders did not provide a response to this question. One stakeholder stated that governments fail to engage and include Aboriginal people and their knowledge in water management, let alone enabling Aboriginal people to be decision makers about water on-Country.	Noted. NHMRC recognises First Nations communities have had little involvement in state, territory and national government processes about water management. NHMRC is committed to improving the way that consult with First Nations communities are consulted in the development of national guidelines. Guidance supporting consultation and involvement of First Nations communities about risk management of water on Country has been incorporated into the risk management framework. NHMRC will consider additional information about traditional knowledge and approaches to managing water quality that can be incorporated into the draft Guidelines pending further feedback from public consultation.
Question 9: If no or unsure, would you like to be more involved in any water safety planning in your community?	Responses were mixed: some stakeholders expressed interest or potential interest in being more involved in water management, while others indicated they would not like to be more involved.	Noted.

Question	Answers	NHMRC and Committee Response
Question 10: What is the most important thing/s to you about water on your Country?	Stakeholders consistently emphasised that the most important aspects of water on their Country are its safety for use, health for animals and the environment, and ongoing accessibility for all community needs. Many also highlighted the value of traditional knowledge in decision-making, the importance of local community consultation about water issues, and the need for transparent communication regarding water testing results. Although stakeholders considered it important for traditional knowledge to inform decision-making, for local communities to be consulted about water issues, and for communities to receive information about water testing results, these were reported as not occurring.	Noted. Suggestions considered in drafting guidance in relevant sections of the risk management framework and in evidence to decision processes.

Question	Answers	NHMRC and Committee Response
Question 11: Are you aware of any health risks in your water, particularly those you can't see? (e.g. germs, parasites, chemicals or radiation)	Most stakeholders answered yes. One answered no, one did not provide a response.	Noted.

Question	Answers	NHMRC and Committee Response
Question 12: What do you think is the biggest danger to your community from water on your Country?	Stakeholders identified a range of dangers associated with water on their Country. The most mentioned risks included: • drowning and other accidents • infections from germs (such as bacteria and blue-green algae) and parasites • illnesses caused by both natural and man-made chemicals in the water. Some respondents also highlighted concerns about government decisions being made without adequate community consultation, as well as other hazards like pesticides, herbicides, endocrine disruptors, nutrients, and, in some cases, radiation.	Noted. NHMRC recognises that different communities will have different concerns, awareness and priorities that should be taken into consideration when risk management planning. NHMRC is developing updated guidance to support best practice water quality risk management approaches that can be used to help keep communities safe and involved. This advice will be provided in the risk management framework and supporting documents.

Question	Answers	NHMRC and Committee Response
Question 13: How does your community share news about any health risks in your water?	Stakeholders reported that information about health risks in water is shared through both informal and formal channels. Most commonly information is shared through word of mouth and community meetings. Other methods included communication by community rangers, use of social media, signage at water sites, local clinics, posters around the community, and, in some cases, websites and local news outlets.	Noted. Guidance about risk communication and community involvement on will be provided in the Framework. It is noted that most communication about the risks to community happens at the local level through different information sources, and the needs and resources of communities will vary around Australia. Suggestions considered during drafting of risk communication guidance.
Question 14: How do you like to be told if there is something wrong with the water?	Stakeholders expressed a preference for receiving information about water issues through direct and accessible channels, such as word of mouth, community meetings, local clinics, community rangers, and signage at water sites. Other methods included social media, local news, websites, and posters on community boards.	Noted. Guidance about risk communication and community involvement has been incorporated into the risk management framework. It is noted that most communication about the risks to community happens at the local level through different information sources, and the needs and resources of communities will vary around Australia. Suggestions considered during drafting of risk communication guidance.

Question	Answers	NHMRC and Committee Response
Question 15: Do you have any suggestions about what would help raise awareness of health risks from water in your community?	Stakeholders suggested a range of approaches to raise awareness about water-related health risks, including: • school education programmes • local meetings and workshops • involvement of community rangers • social media campaigns, local news and radio • posters and signage around the community • information provided through local clinics. Storytelling and the use of both traditional and contemporary communication methods were also highlighted as effective ways to engage the community and improve risk awareness.	Noted. Guidance supporting improved risk communication methods and community involvement will be provided in the Framework. It is noted that the dissemination of health advice at a local level is highly dependent on factors such as local requirements, resources and training. Suggestions considered during drafting of risk communication guidance.

Question	Answers	NHMRC and Committee Response
Question 16: Case studies/ further information	There is limited engagement and opportunities to have input on-Country about water, states and federal fail Aboriginal people constantly. We are an after thought or out of scope for projects. Commit governments (all levels) to do better.	Noted. NHMRC recognises that First Nations communities have had little involvement in state, territory and national government processes about water management. NHMRC is committed to improving the way that First Nations communities are consulted in the development of national guidelines and will continue to learn from consultation experiences to improve processes. Guidance supporting consultation and involvement with First Nations communities about ongoing planning and engagement about risk management of water on Country has been incorporated into the risk management framework.
Question 16: Case studies/ further information	There is a lack of community consultation, involvement and communication when it comes to water. Community is rarely advised why the water turns yellow/brown (which has happened numerous times) or if it is unhealthy to drink.	Noted. NHMRC recognises that First Nations communities have had little involvement in state, territory and national government processes about water management. Guidance supporting improved risk communication methods and community involvement has been incorporated into the Framework. It is noted that the implementation of this at a local level is dependent on factors such as local requirements, resources and training.

Question	Answers	NHMRC and Committee Response
Question 16: Case studies/ further information	Would like to share: community involvement in decision making or planning for water safety, Communication of the risks to keep people safe, water safe problems and how these are managed or prevented Human relationship towards water, air, fire, earth and water = me = you	Guidance supporting improved risk communication methods and community involvement has been incorporated into the Framework. It is noted that the implementation of this at a local level is dependent on factors such as local requirements, resources and training.
Question 16: Case studies/ further information	Communication of the risks to keep people safe	Noted. The updated Guidelines include advice on risk communication and suggestions from this survey have been considered in drafting the guidance.

Table 39. Summary of feedback from NATSIEH conference attendees

Feedback	NHMRC and Committee response
More photos, visuals, diagrams in the guidelines	Noted. Where possible and within publication requirements, resources and permissions the Guidelines will be incorporating relevant visual aids to support guidance and assist in implementation (e.g. figures, diagrams, photos). Further visual tools or guidance to assist in implementation to be considered following public consultation.

Feedback	NHMRC and Committee response
Consultation needs to take place from the beginning of research/guideline development and co-designed with Aboriginal and Torres Strait Islander peoples	Noted. NHMRC is committed to improving the way that First Nations communities are consulted in the development of national guidelines and will continue to learn from consultation experiences to improve processes.
Improved data collection from Environmental Health Officers (EHOs)	Noted. While some guidance on sample collection, frequency and suggestions on capacity building will be provided in the Framework and supporting information sheets, it is noted that the implementation of this advice by EHOs at a local level are dependent on factors such as local requirements, regulations, resources and training. Additional guidance that could further support EHOs (or local agencies who are responsible for managing EHOs) will be considered following public consultation.
Have we considered Indigenous Data Sovereignty Principles	Noted. Indigenous Data Sovereignty Principles have been and will be applied to the best of our availability within organisational standards and processes during this targeted consultation and in future consultations. Guidance supporting the application of these principles at the local level during risk management planning and local data collection to be considered for inclusion in the Framework pending public consultation.

Appendix C – Targeted consultation summary

Targeted consultation on the draft Guidelines was undertaken between August and November 2025 prior to public consultation. The Environmental Health Standing Committee (enHealth) Water Quality Expert Reference Panel and the NHMRC Water Quality Advisory Committee were invited to provide feedback.

A summary of key issues raised during the targeted consultation process is captured in the table below as well as NHMRC responses and actions taken to address them. A number of typographical and minor edits were also suggested to improve the clarity of the guidance or provide further references – these are not listed below and were actioned where accepted or deferred until after public consultation.

Table 40. Targeted consultation feedback on draft *Chapter 1 - Introduction*

Feedback received	Response
Consider "temperature" as a hazard in water (e.g., hot springs).	Noted. Suggestion to be considered by Committee following public consultation. Resources for management of hypothermia included in *Information Sheet - Resources on water quality and other hazards*.
Tourists and visitors may be at higher risk due to language barriers and different cultural expectations about safe swimming locations.	Accepted. Suggested edits made.

Table 41. Targeted consultation feedback on draft *Chapter 2 – Framework for the management of recreational water quality* and supporting information

Feedback received	Response
Communications planning should address mis/disinformation.	Accepted. Suggested edits made.
A brief reference should be included to highlight the extra risks if drinking water bodies are used for recreation. Safeguarding catchments and applying a multibarrier approach are increasingly important due to population growth, greater recreational use, and climate change impacts like severe storms and bushfires.	Accepted. Suggested edits made to Introduction and Framework.

Feedback received	Response
The Risk Management Framework explores the cultural significance of water, but the importance of water contact and engagement for First Nations communities should be considered with greater understanding and appropriate sensitivity.	Noted. Further feedback will be sought during public consultation to improve this section.
Clarify the distinction between physical safety around water and water quality risk management. The term "water safety" is used in various contexts, so suggest clearer terminology is used to avoid any confusion.	Noted. The terminology used throughout the Guidelines may be reconsidered following feedback from public consultation.
Amend the *Principles for implementation* to ensure First Nations communities are partners; emphasise full participation and inclusivity, and that resources need to be developed in partnership with traditional owner groups to reflect local governance and cultural needs.	Accepted. Suggested edits made.
Defining consequence using illness in the Water Quality Risk Management Plan Template may underestimate risk; suggest "potential for illness" is more appropriate.	Accepted. Suggested edits made and footnote added.
In the *Information Sheet – Monitoring Programs*, remove reference to water treatment processes (UV/chlorine) - as they are excluded from the Guidelines.	Accepted. Suggested edits made.

Table 42. Targeted consultation feedback on draft *Chapter 3 - Microbial pathogens from faecal sources* and supporting information

Feedback received	Response
Consider discussing differences in virus concentration results obtained from culture methods vs. polymerase chain reaction (PCR) tests, as this may affect interpretation of raw sewage data.	Noted. Suggestion to be considered by Committee following public consultation.

Feedback received	Response
Suggest providing a reference for statements on pathogen evolution and clarifying that the species barrier becomes increasingly important from bacteria to protozoa to viruses.	Noted. Suggestion to be considered by Committee following public consultation.
Limit unnecessary management actions to avoid overestimating public health risk.	Accepted. Suggested edits made.
Add cautionary notes about interpreting low numbers of results, especially single results.	Noted. Minor edits made to clarify. Suggestion to be further considered by the Committee following public consultation.
Simplify *Information sheet – Faecal indicator organisms*, provide a short introduction to indicator organisms for context, and mention National Association of Testing Authorities (NATA) accreditation.	Noted. Copyediting will be undertaken following public consultation.

Table 43. Targeted consultation feedback on draft *Chapter 4 - Other microbial hazards* and supporting information

Feedback received	Response
Clarify that most melioidosis cases are not associated with recreational water activities.	Accepted. Minor edits made to clarify.
Note case of Shewanella infection associated with River Murray.	Accepted. Edits made to note infection case in Shewanella section.
Highlight recent surge in *Naegleria fowleri* cases in Kerala and link to higher survival rate and rapid intervention.	Accepted. Minor edits made to highlight this example.
Clarify age distribution differences in *Naegleria fowleri* cases from exposure from recreational water versus sinus irrigation.	Accepted. Minor edits made to clarify.
Consider mentioning avian influenza.	Noted. Suggestion to be considered by Committee following public consultation.

Feedback received	Response
Suggestion that Table 4.1 specify the use of waterproof dressings in addition to covers, and that the section on non-cholera vibrio should include advice to wash cuts thoroughly with clean water if sustained while swimming in contaminated seawater, as wounds are unlikely to be covered before submersion.	Accepted. Suggested edits made to Table 4.1.

Table 44. Targeted consultation feedback on draft *Chapter 5 - Harmful algal and cyanobacterial blooms* and supporting information

Feedback received	Response
Detection of single toxin genes can be misleading as some toxins require multiple genes to function; gold standard should be toxin detection, especially when making decisions with major social and economic impact.	Accepted. Amendments made to clarify.
Consider discussing non-specific responses to marine blooms (i.e. skin rashes), which are rarely investigated scientifically.	Noted. Suggestion to be considered by Committee following public consultation.
Section on *Karenia mikimotoi* needs updating; now thought to be a mixture of species, including one producing brevetoxins.	Noted. Minor edits made and Committee to review further following public consultation.
Stronger rationale needed for variation from World Health Organization (WHO) guideline value of 24 µg/L in Table 5.4 - Cyanotoxin guideline values to support an alert level framework.	Noted. Rationale for guideline values provided in *Information sheet – Derivation of guideline values for cyanotoxins in recreational water* and related Evidence to Decision table.
The values in the Framework (5.4.2) differ from quoted sources and WHO guidelines; reliance on ELISA testing to define toxicity may lead to overconservative action/alert levels. Suggestion that toxin testing should be considered the gold standard, and that action and alert levels should be based on evidence of toxicity wherever possible.	Accepted. Suggested edits made.

Feedback received	Response
Review section on *Karenia brevis* (Table 5.5) and where mentioned in supporting information. While the stated levels are used in the shellfish industry, recent developments in South Australia indicate that *Karenia brevis* has not been detected in Australia, but other species have. Support further research and advise that, based on current information, an alert level for *Karenia brevis* should not be set.	Noted. Suggestion to be considered by Committee following public consultation.
Consider adding β-N-methylamino-L-alanine (BMAA) to Table 5.1, noting this may be more relevant to the *Australian Drinking Water Guidelines*.	Noted. BMAA not included in Table 5.1 but discussed later in the chapter.
Consider the role of skin irritation assays, including effect-based and in vitro bioassay methods, for both exposure and hazard assessment of cyanotoxins in recreational water. Applying effect-based methods to inform risk assessment and response would be novel, as other jurisdictions are not currently doing this, but it is becoming possible and may be worth exploring. Consider mentioning effect-based methods for both neurotoxicity and skin irritation assessment, and if not included in the main text, at least referencing them in the research section (5.5).	Noted. Suggested edits made to research and development section. Committee to consider further following public consultation.
Weekly sampling for surveillance is challenging in regions with vast distances and limited resources. Recommends monthly/ fortnightly sampling depending on season and alert level.	Noted. Minor edits made to clarify that actions within the Alert Level Framework can be adapted if required.
Include possible use of drones or satellite data for surveillance and assessment.	Accepted. Suggested edits made.
Suggested amendments to simplify and clarify text, such as restructuring and condensing sections, rewording academic language for accessibility, and avoiding terms that may become outdated.	Accepted. Suggested edits made where possible. Further copyediting to be undertaken following public consultation.

Table 45. Targeted consultation feedback on draft *Chapter 6 - Chemical hazards* and supporting information

Feedback received	Response
Add 'duration and volume' as factors in pollution event management.	Accepted. Text amended.
The screening values are currently based on adult body weight rather than the 13 kg child body weight specified in the *Australian Drinking Water Guidelines* (ADWG) s6.3.3. This approach may overestimate acceptable levels for children, as using a lower body weight would result in more conservative (lower) guideline values. Suggestion to clarify the rationale for this approach and consider whether screening values should be adjusted to better protect children.	Noted. Text added to clarify that ADWG health-based guideline values are conservative and health protective for the general population. Default screening values are intended to provide general advice for investigations, but if more targeted screening values are required there is advice on how to derive these.
Expand section on health effects to include human health impacts.	Noted. Content kept it general given the lack of evidence. Additional text added to clarify.
Reposition paragraphs to justify why it is important to consider chemical hazards.	Accepted. Suggested edits made.
Consider whether chemicals could act as skin irritants at concentrations lower than "20x ADWG drinking water guideline," although this is considered unlikely; further review may be warranted.	Noted. A review (O'Connor 2022) found that ingestion is considered the primary pathway of exposure and that risks due to dermal exposure are not likely to be significant due to the low concentrations of chemicals and expected exposure scenarios during recreational water activities. Reference to enHealth guidance added if dermal exposure is identified as a possible concern.
Consider whether bioassay methods, such as skin sensitisation assays used in personal care product testing, could now be applied to detect skin irritation from water samples, as this may be a useful area for further investigation	Noted. The review did not identify the use of bioassays in diagnosing dermal effects from exposure to recreational water. If this approach becomes viable in the future it can be considered for inclusion in the Guidelines in the future.

Feedback received	Response
Address natural toxins like cane toad toxins and algal toxins.	Noted. Cane toad toxins not specifically reviewed. The risk assessment process should identify if this may be a concern for further investigations. Algal toxins were reviewed for the cyanobacteria and algae review (Burch 2021).
Address NHMRC's current guidance on PFAS in recreational water.	Noted. The NHMRC document: *Guidance on Per and Polyfluoroalkyl substances (PFAS) in Recreational Water* is not mentioned as it will be rescinded upon publication of the updated Guidelines. The current PFAS guideline values for drinking water are not specifically mentioned in the draft chapter for public consultation; however, it is noted that screening values should always be calculated using the most current version of the *Australian Drinking Water Guidelines* available on the NHMRC website.
Consider adding a survey template as an appendix to support chemical hazard identification in recreational water.	Noted. No changes made. The *Information sheet - Sanitary inspections* will be available in the draft Guidelines and cross-referenced where possible.
Clarify monitoring requirements for chemical analytes. Routine (e.g. quarterly) monitoring for chemical indicators in Table 6.4 may be impractical for many local government authorities due to cost, resource, and skill constraints; even basic microbial sampling is currently challenging for many local government authorities.	Noted. No changes made. The Guidelines do not recommend specific monitoring requirements (e.g. quarterly) as monitoring programs should be site-specific based on an initial risk assessment.
Revise and/or simplify technical content in Information sheets for accessibility.	Noted and not accepted. The Information sheets are intended to provide more technical guidance to help guide responsible entities and responsible authorities derive site specific guideline values and therefore technical content is considered appropriate.

Feedback received	Response
Given the technical complexity of the calculations, suggest local councils to consult with health regulators or subject matter experts initially.	Accepted. Suggested edits made.
A working party is updating the Environmental Health Risk Assessment guidelines (enHealth 2012b); the citation may need to be revised once the new version is published.	Noted. Citation and other information will be updated as required pending publication of updated enHealth guidance.
The ADWG s6.3.3 uses a child body weight of 13kg; clarification may be needed if a different value is used.	Noted. Bodyweight aligns with *enHealth Australian Exposure Factor Guide* (2012). Reference added to clarify.
The draft Evidence-to-Decision tables present clear arguments, advantages and disadvantages of each approach highlighting health evidence, benefits, and harms. The inclusion of *Information sheet – Deriving site specific screening values* - including those for chemicals, will facilitate consistency in the development of health-based site-specific screening values. The recommendation to consult health authorities and regulators in the development of health-based site-specific screening values provides added opportunity for public health risks to be considered when assessing the suitability of recreational swimming sites.	Noted.
The explanation and scenario for the PFAS example in the *Information sheet – Deriving site specific screening values* is clear and helpful, though consideration should be given to whether the PFAS scenario will remain relevant in the long term (10-15 years).	Noted. Examples used in theoretical calculations can be updated in future as required.

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Table 46. Targeted consultation on draft *Chapter 7 - Aesthetic aspects of recreational water* and supporting information

Feedback received	Response
Use inclusive terminology and examples that apply to all recreational water sites, not just coastal environments (e.g. replace 'beach' with 'shoreline' or 'water body'); revise examples such as 'seaside resort' to ensure broader applicability.	Accepted. Suggested edits made to terminology and examples for broader application of all recreational water sites.
Broaden the scope of preventive and control measures to address aesthetic impacts beyond plastic and litter, and ensure the section includes local strategies.	Accepted. Preventive and control measures expanded to address a wider range of aesthetic issues and local strategies.
Include reference to rainfall causing litter in the litter and debris section.	Accepted. Reference to rainfall added to highlight its role in litter transport.

Table 47. Targeted consultation on draft *Chapter 8 - Radiological hazards* and supporting information

Feedback received	Response
Volumes of inadvertent ingestion of water (Table 8.1) should align with ingestion assumptions in Table 8.2 and other chapters.	Accepted. Suggested edits made.

Appendix D – Expert review summary

Expert review on the draft Guidelines was undertaken between in October and November 2025 before public consultation. Several experts were nominated by the Recreational Water Quality Advisory Committee based on their recognised expertise in relevant fields.

To be eligible for undertaking expert review, reviewers were required to complete a Disclosure of Interest prior to receiving any documents. Disclosed interests of independent expert reviewers are listed in **Appendix E**.

A summary of key issues raised during the expert review process is captured in the tables below as well as NHMRC responses and actions taken to address them. Several typographical and minor edits were also suggested to improve the clarity of the guidance or provide further references – these are not listed below and were actioned where accepted or deferred until after public consultation.

Summary of expert review feedback and responses for the draft *Chapter 5 - Harmful algal and cyanobacterial blooms* and supporting information

Table 48. Summary of Question 1 feedback

Question 1: Please comment on the appropriateness of the draft harmful algal and cyanobacterial blooms chapter regarding its readability and usefulness, given the target audience of the Guidelines e.g. is the draft guidance relevant, accurate and easy to understand?

Feedback	Response
The draft guidance is well written, concise, and appropriate for agencies and the public. The draft guidance is relevant, accurate, and easy to understand. Reviewers were supportive of the proposed risk management approach. Reviewers recommend including more Australia-specific context and examples, rather than relying heavily on international sources.	Noted. Australian examples have been provided where available. Additional examples may be added pending any additional information shared during public consultation.
The guideline recommendation section is appropriate and informative. Minor edits to terms and definitions are suggested. • Dominance is a relative term. Consider defining to avoid confusion. • Possibly consider the term “visible” rather than “observable”. Either is suitable.	Noted. Suggested edits made where accepted. Noted. No changes made, will consider changing after public consultation if further specificity can be provided. Accepted. Suggested edit made.

Feedback	Response
The overview section is comprehensive and concise. It contains the right amount of information, and the definitions are provided at the appropriate level.	Noted.
Reviewers made editorial corrections to taxonomy, updated genus names, and terminology (e.g., “phosphorus” vs. “phosphorous”). Review for consistency. Also suggest including a brief explanation about evolving cyanobacteria taxonomy.	Accepted. Suggested edits made. Copyediting to be undertaken following public consultation. Suggestion to add explanation about taxonomy to be considered by Committee following public consultation.
Table 5.1 may be misleading/unhelpful as it is not clear these are toxic genera found world-wide. Highlighting toxic genera found in Australia would be helpful.	Noted. Minor edits made. Table is intended to provide general information: non-Australian species retained for information and additional Australian examples included where available. Suggestion to be considered further by Committee following public consultation.
More detail and context are needed for fresh and brackish waters, including ecosystem-specific subsections (lakes, rivers, brackish waters). Suggestions to improve clarity and usefulness include adding subsections for lakes, rivers, and brackish waters with issues that have occurred in the past as well as emerging issues.	Noted. Suggestion to be considered by Committee following public consultation.
The chapter tends towards cyanobacteria, neglecting eukaryotes and generalisations that don’t apply to them. Although there is more information available on freshwater cyanobacteria, the text needs careful proofreading to clearly indicate when the discussion is limited to cyanobacteria.	Noted. Suggestion to be considered by Committee following public consultation.

Feedback	Response
Suggest including a section on the mismatch between toxin levels and cell biovolumes (and densities) based on strain variability. This is a rapidly growing area of research, and it is often a greater source of variability in population-level toxin quotas than changes within cells in response to growth status or environmental conditions.	Noted. Suggestion to be considered by Committee following public consultation.
Given recent events in South Australia and previous blooms in Tasmanian estuaries, suggest that dinoflagellates should be included in the most common toxin producer list.	Noted. Suggestion to be considered by Committee following public consultation.
Given evolving state of knowledge of species involved in the South Australian bloom, text/box should be revised to remove reference to *K. mikimotoi* until more information becomes available. Including text which broadly discusses *Karenia* spp. would be more appropriate.	Noted. Section has been updated and will be further reviewed following public consultation.
Clarification needed relating to testing methods (ELISA vs. PCR/qPCR), particularly description of ELISA test. The paragraph and related framework should be revised by an expert to accurately distinguish between toxin detection and gene analysis methods. ELISA detects toxins, not toxin genes	Noted. Paragraph revised.
Clarification of toxin production and gene expression in cyanobacteria (refer to edits and comment in chapter). Toxin genes are always present in toxic strains and not switched on or off; toxin production varies between strains, but more research is needed to understand changes in toxin yield during blooms.	Accepted. Committee to consider rewording following public consultation if required.

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Feedback	Response
Suggested corrections to clarify that, while phosphorus is an important macronutrient, not all cyanobacteria are nitrogen fixers. Nitrogen should also be included, as many freshwater systems are co-limited by nitrogen, and the addition of both nitrogen and phosphorus is more likely to stimulate blooms.	Noted. Corrections made. Suggestion to be considered by Committee following public consultation.
Guidance should reflect that toxin production in cyanobacteria varies along a spectrum between strains and is influenced more by phosphorus than nitrogen availability. Correction to Burford reference. This paper did not find higher toxin cell quotas with higher nitrogen availability. Instead, it says that toxin cell quotas were higher with higher phosphorus availability.	Noted. Reference removed. Committee to review further following public consultation.
Management interventions should also include sewerage treatment plant upgrades, construction/remediation of wetlands, and treatment of urban stormwater discharge. More explanation is needed for the identified conditions that may promote harmful algal blooms, e.g. drought. What are the characteristics of drought that promote harmful algal blooms?	Noted. Minor edits made. Suggestion to be considered by Committee following public consultation.
Suggested corrections to clarify that dinoflagellates can utilise both organic and inorganic nutrients. It should not be assumed that only inorganic nutrients promote blooms. Additionally, some dinoflagellates are mixotrophic, so organic carbon concentrations can also play an important role in bloom development.	Noted. Suggestion to be considered by the Committee following public consultation.
Table 5.4 (note a) should account for cases where specific toxin congeners have higher oral toxicity, and guideline values should be adjusted accordingly using toxicity equivalence factors when robust data is available. Suggested wording provided.	Noted. Suggestion to be considered by Committee following public consultation.

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Feedback	Response
Support for the risk management approach and alert level framework. Reviewers suggested edits to allow public reports of blooms in pre-screening, clarify terminology, ensure ELISA is described as a toxin test, and consider the inclusion of microscopy and molecular analysis for detecting toxic species.	Noted. Minor edits made.
Suggest acknowledging change to the Australian recreational cyanobacteria guidelines moving away from including a threshold for non-specific adverse health outcomes (e.g., respiratory, irritation and allergy symptoms).	Noted. This is noted in the relevant Evidence to Decision table.
Descriptions of Surveillance, Alert and Action Levels should be better adapted to provide the Australian context, ensuring all relevant toxin-producing species are included and accurately described.	Noted. Suggestion to be considered by the Committee following public consultation.
The Action Level definition should specify guideline values for cyanotoxins, not cyanobacteria, to accurately reflect the content of Table 5.4.	Accepted. Minor edits made.
Restructure sections for clarity (e.g., separate freshwater and marine benthic cyanobacteria, add context for different waterbody types). More detail is needed for marine ecosystems, and structure should reflect which is more relevant in Australia.	Draft Guidelines may be revised to improve clarity following public consultation. Noted. Suggestion to be considered by Committee following public consultation.
Table 5.5 and related text should refer to *Karenia* species (*Karenia* spp.) rather than just *Karenia brevis*, to address uncertainty about which species are toxin-producing. Update the table to include recommended actions for agencies at each alert level for greater clarity and convenience.	Noted. Suggestion to be considered by Committee following public consultation.

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Feedback	Response
Sections 5.4.6 and 5.4.7 contain overlapping content, suggest re-structuring guidance.	Noted. Suggestion to be considered by the Committee following public consultation.
The monitoring procedure gives prominence and weight to the use of Secchi disc transparency. While Secchi disc transparency is a useful indicator for algal presence, its reliability is reduced by non-biological particles. Recommend noting these limitations.	Accepted. Suggested edits made.
Suggest adding a reference for pigment fluorescence monitoring of cyanobacteria hazards to section 5.4.5.3, such as work by Zamyadi on in situ fluoroprobes.	Accepted. Citations added.
Consider whether public health advisories and warnings should be communicated by other commonly used and accepted means of advice such as websites and social media.	Accepted. Minor edits to clarify. Additional guidance on risk communication provided elsewhere in the Guidelines.
Reviewers were supportive of the Research and Development section and recommendations. The topics suggested for further research are all appropriate and important.	Noted
In-text references missing from the references section.	Accepted. References added.

Table 49. Summary of Question 2 feedback

Question 2: Please comment on the appropriateness of the draft information sheets regarding readability and usefulness, given the target audience of the Guidelines e.g. is the draft guidance relevant, accurate and easy to understand?

Feedback	Response
The draft information sheets are relevant, and easy to follow. The information sheets provide a good summary of triggers, indicators, and derivation of guideline values.	Noted.
Where calculations depart from WHO guidelines, it is recommended to clearly note these differences in the *Information sheet - Derivation of guideline values for cyanotoxins*.	Noted. Minor edits made

Feedback	Response
Due to contrary evidence regarding oral toxicity of dihydroanatoxin-a in comparison to anatoxin-a, statements regarding similar toxicity should be avoided. Suggestions to add reference to recent studies.	Noted. Suggestion regarding higher oral toxicity to be considered by the Committee following public consultation.
Suggest including information about the role of strain variation within and between waterbodies, impacting the mismatch between cell biovolumes or densities and toxin concentrations in the *Information sheet – Cyanobacterial biomass triggers supporting the alert level framework*.	Noted. Suggestion to be considered by Committee following public consultation.
Suggested reformatting of tables in the *Information sheet - Cyanobacterial biomass triggers supporting the alert level framework* so that associated content isn't split over pages.	Noted.

Table 50. Summary of Question 3 feedback

Question 3: Do you support the approaches taken to review the evidence and derive guideline recommendations and supporting information? e.g.

- whether the evidence has been appropriately considered, interpreted and translated, using the Evidence-to-Decision Framework to derive the relevant guideline recommendations?
- is the approach used to derive cyanotoxin guideline values and biomass triggers scientifically justified?
- is the alert level framework appropriately protective of public health?
- whether any other information is required to support the recommendations, and if the approach has been adequately and transparently communicated?

Feedback	Response
Expert reviewers were generally supportive of the evidence review process and derivation of cyanotoxin guideline values and recommendations. The information is generally thought to be well set out and explained. The approach to deriving guideline values and biomass triggers is scientifically justified and based on best available evidence. The alert level framework is appropriately protective of public health, practical, and consistent with international best practice.	Noted.

Feedback	Response
The Evidence to Decision Framework is logical and provides a suitable format to appropriate consider, interpret and translate the evidence. Different pieces of evidence and the Australian context were clearly framed and resulting consequences for adopting more conservative guideline values was presented. The reasoning for moving forward to the adopted approach was presented at the end. Consider targeted communications with technical end users and responsibility agencies to enhance their understanding.	Noted.
The process and rationale for decisions are generally well communicated, though further articulation of Australia-specific context and rationale for certain thresholds is suggested.	Noted.
The selection of Option 2 for cyanobacterial biomass triggers is reasonable and pragmatic. For mat-forming species such as *Moorea producens* and *Microcoleus*, the term ‘high numbers’ should be replaced with ‘high biomass’ or ‘significant biomass’, as this more accurately describes their ecological impact.	Noted. Some minor edits actioned.
Suggest clarifications to text confusion regarding the use of chlorophyll *a* as a biomass trigger to ensure consistency and understanding. Correlating biomass triggers with toxin risk is challenging due to strain variability within populations, but the proposed triggers are cautious and should help to minimise risk.	Noted. Suggestion to be considered by Committee following public consultation.
Selection of cyanotoxin guideline values as presented in the Evidence to Decision table are reasonable and pragmatic. Suggest review of references to ensure consistency.	Noted. Minor edits made.

Feedback	Response
From the perspective of human health protection, guideline values are more conservative than the WHO guideline values by introducing an uncertainty factor for database deficiencies. This can have additional impacts through more frequent and widespread closures of water bodies – but because this decision was based on the practice adopted in other parts of the world, I imagine that it will be accepted by the community.	Noted.
The calculation of the Surveillance to Alert Level threshold, based on the drinking-water guideline value allows sufficient time to gather better data on potential risks. Some concern around the rationale for using microcystin data to set cyanobacterial biomass thresholds, given the superior data available for microcystins compared to cylindrospermopsins it is considered appropriate. Consider how clearly the guidelines acknowledge the need for regions affected by cylindrospermopsin-producing cyanobacteria to potentially deviate from the standard approach.	Noted.

Table 51. Summary of Question 4 feedback - General/ overall comments on the draft chapter.

Feedback	Response
Expert reviewers found the draft chapter and information sheets to be well written, easy to follow, and provide a good level of information for both technical and non-technical audiences.	Noted.
Suggestion to consider the use of 'algae' and 'cyanobacteria'. These are currently used independently which may be confusing for readers as cyanobacteria are often referred to as algae. It would be more helpful to refer to 'eukaryotic algae' and 'cyanobacteria'.	Noted. Suggestion to be considered by Committee following public consultation.

Feedback	Response
Key suggestions include incorporating more Australia specific context setting. After reviewing Evidence to Decision tables I wondered if some of the Australia-specific context provided in these would be good to also include in the guidelines chapter.	Noted. Additional examples will be considered pending public consultation feedback.

Summary of expert review feedback and responses to draft *Chapter 4 - Other microbial hazards* and supporting information

Table 52. Summary of Question 1 feedback

Question 1: Please comment on the appropriateness of the draft harmful algal and cyanobacterial blooms chapter (Attachment A) regarding its readability and usefulness, given the target audience of the Guidelines e.g. is the draft guidance relevant, accurate and easy to understand?

Feedback	Response
Lack of scope in the chapter to frame the rationale for what microbial risks have been included here or not.	Noted. Links to other relevant chapters are provided in the overview. Suggestion to be considered by Committee following public consultation.
In Section 4.2, there is variable detail given for different organisms – some organisms have a lot of detail (each case described) but this is not consistent. Suggest standardising presentation and formatting for the microbial specific information for clarity.	Noted. Suggestion to be considered by Committee following public consultation. Copyediting to be undertaken prior to final publication.

Feedback	Response
There is not specific guidance on the management of antimicrobial resistance within water contexts, so reference to it within the guidelines may suggest this is something to be managed by those applying this document. Suggest providing clarity around current knowledge or expectation of management responsibilities should be considered. If retained, the significance of AMR for each organism should be highlighted (e.g. limited impact to *Leptospira*, but significant in pseudomonads)	Noted. Suggestion to be considered by Committee following public consultation.
Suggested corrections to the section on *Burkholderia* e.g. while the organism is generally associated with soil, global cases in recreational waters are often linked to high turbidity in impacted regions. This important association is not currently emphasised in the chapter.	Noted. Suggestion to be considered by the Committee following public consultation.
Suggested corrections to the section on *Leptospira* include tightening the content for consistency with other microbial sections. Consider including recommendations for individual protective measures for other organisms, especially where personal strategies have proven effective. Currently only presented for *Leptospira*.	Noted. Suggestion to be considered by Committee following public consultation.
Suggested edits to the section on *Pseudomonas* including the introduction of animal-derived sources, the potential for prolonged survival, and survival within free-living amoeba.	Noted. Suggestion to be considered by the Committee following public consultation.
Reconsider the inclusion of very rare organisms such as *Chrombacterium violaceum* and *Shewanella* spp., given their low case numbers globally and minor clinical significance.	Noted. Suggestion to be considered by the Committee following public consultation.

Feedback	Response
Suggested addressing inconsistencies in Table 4.2 relating to source information provided across the listed organisms, particularly regarding animal carriage and its inclusion for marine species,	Noted. Suggestion to be considered by Committee following public consultation.
Suggested edits to the climate change section include broadening the focus beyond temperature to also consider the role of soils as reservoirs for many organisms, as well as the impact of flooding on water quality degradation and the resuspension of solids.	Noted. Suggestion to be considered by the Committee following public consultation.
The guidance on mismanagement is very generic and doesn't provide particularly actionable advice or a sense of prioritisation of risks. If there's no good date to base advice on, then at least perhaps explicitly state this and say that the general principles represent current best practice (or not).	Noted. Suggestion to be considered by the Committee following public consultation.

Table 53. Summary of Question 2 feedback

Question 2. Do you support the approaches taken to review the evidence and derive guideline recommendations and supporting information? e.g.

- *whether the evidence has been appropriately considered, interpreted and translated, using the Evidence-to-Decision Framework to derive the relevant guideline recommendations?*
- *whether any other information is required to support the recommendations, and if the approach has been adequately and transparently communicated?*

Feedback	Response
The PRISMA review approach undertaken was appropriate to review the evidence for *N. fowleri* and *B. pseudomallei*. However, while it is clearly articulated within the guideline document that there are no health-based targets available for these organisms, consider including other findings. In particular, the lack of consistency in the technical data, low overall study numbers and study associated bias limits comparability, and generalisability of the reviewed studies. Therefore, the preference for application of Option 2, with recommendations for site-specific evaluations, is appropriate given the information available.	Noted.

Table 54. Summary of Question 3 feedback – General /overall comments on the draft chapter.

Feedback	Response
While the focus of this chapter is on the potential health impacts of exposure to waterborne, non-faecal derived pathogens, some of the organisms presented have both faecal/urine (as part of zoonotic carriage) and environmental exposure pathways (e.g. *Pseudomonas*, *Leptospira*). This is not clearly presented, or defined, in the current documentation. However, this information is an important consideration to the end user and how they operationalise mitigation/prevention strategies.	Noted. Suggestion to be considered by the Committee following public consultation.
Suggest grouping organisms that have zoonotic and environmental reservoirs, and those that are exclusively associated with environmental exposure. This could then align with source information presented in Table 4.2, and risk management discussions.	Noted. Suggestion to be considered by the Committee following public consultation.

Appendix E – Disclosure of interests

The declarations of interest of Committee and Subgroup Members at the time of their involvement in the development of the Guidelines are listed in the table below. Consideration of the declarations of interests of Committee Members during the period 2018-2025 were undertaken according to NHMRC committee policy at the time.

Declaration of interest of the Recreational Water Quality Advisory Committee

Professor Stuart Khan (Chair) - Professor and Head of School of Civil Engineering, University of Sydney

- **Area of expertise:** Trace Chemical Contaminants in Water; Risk Assessment and Risk Management; Environmental Engineer
- **Interest details:**
    - In March 2025, I was appointed Chair of the Wastewater Expert Panel for NSW Environmental Protection Authority (NSW EPA).
    - As an academic employee of the University of New South Wales, I regularly applied for research funding grants from government and non-government agencies. These include but are not limited to The Australian Research Council (ARC) and Water Research Australia (WRA). Applications to NHMRC funding schemes were less frequent, but not excluded.
    - I have an honorary (unpaid) role as an adviser to the Parramatta River Catchment Group, specifically in regard to the Group's Our Living River Campaign. The objective of this campaign is to facilitate the reopening of sites on the Parramatta River, which could be safely reopened for recreational swimming.
    - I was previously an employee of the University of New South Wales (UNSW). UNSW has a strong interest and considerable activity in water quality research. In this role, I worked closely with many Australian and international water industry participants including water utilities, health regulators, environment regulators and private consultants.
    - I have provided expert opinion to Water Research Australia on PFAS chemicals. This includes contribution to a current water industry factsheet on these chemicals and their relevance to the water industry. I have, in the past, made comments to the media regarding the safety and risks associated with PFAS in drinking water.
    - As an Academic at the University of New South Wales, I participated in national and international academic and industry conferences. In some cases, I attended these as an invited speaker, occasionally with costs such as conference registration, travel and/or accommodation provided by the conference organisers.
    - As an academic researcher at the University of New South Wales, I published academic research papers in academic research journals. In some cases, these papers addressed the contents or trends of Australian water quality guidelines.

- As an Academic at the University of New South Wales, I taught undergraduate and postgraduate classes which cover topics closely related to the activities of the Water Quality Advisory Committee and the Recreational Water Quality Advisory Committee. These included details and interpretation of the Australian Drinking Water Guidelines and Recreational Water Quality Guidelines.
- I have been appointed as a member of the NSW Independent Metropolitan Water Advisory Panel (IMWAP). This is a panel of about 6 people who will provide advice on future water planning for the Sydney (Sydney, Blue Mountains and Illawarra) and Lower Hunter (Newcastle) regions. The appointment is for 2 years (to 31 March 2023). The appointment is made by the NSW Minister for Water (The Hon Melinda Pavey MP). The Panel will report to the NSW Government Water Sector Leadership Group and the Department of Planning, Industry and Environment (DPIE).
- I occasionally undertake work for members of the Australian Water Industry as a consultant. I do this both through the University of New South Wales and as a private consultant. My private consultancy work is related to water quality assessment.
- I am a member of the National Water Grid Advisory Body. The Advisory Body provides independent expert advice to the Australian Government via the Deputy Prime Minister on specific water infrastructure policy, projects and investment priorities. While it does not have a decision-making role, the Advisory Body's advice will inform the Australian Government's decisions and policy and in turn help deliver the National Water Grid.
- I am a Committee/Advisory member of: WHO – Water Quality and Technical Advisory Group 2015 – present; Water Quality Research Australia – Project Quality Review Team 2012 – present; U.S. WateReuse
- I was a past Committee/Advisory member of: U.S. WateReuse Foundation – Project Advisory Committee 2010 – 2014; Australian Water Recycling Centre of Excellence – Project Advisory Committee 2011 – 2014; CSIRO and NSW Environmental Trust – Project Advisory Committee 2010 – 2013; South East Queensland Urban Water Security Research Alliance – Project Advisory Committee – Purified Recycled Water Project 2008 – 2012
- I previously lectured at the University of New South Wales on water and wastewater quality and analysis.
- I have Journal Editorships: Associate Editor – Environmental Science – Water Research and Technology; Journal of Water Supply – Research Technology
- I have published numerous journal articles, reports and book chapters; also presentations at international and national conferences, seminars and workshops
- I am a recipient of research grants from government and non-government agencies – including Australian Research Council and Water Research Australia
- I am a Member of: Australian Water Association; International Water Association; Engineers Australia

- I am the Director of the Australian Graduate School of Engineering (AGSE) at UNSW

Dr Ben van den Akker - Senior Research Fellow, University of South Australia, SA

- **Area of expertise**: Areas of expertise: urban water systems (waste/recycled water), microbiology, quantitative microbial risk assessments
- **Interest details:**
  - Senior Research Fellow at the University of South Australia, conducting research related to health aspects of water quality
  - Former Lead Scientist, Wastewater Research SA Water. SA Water or its activities could reasonably be perceived to be an influence due to a competing interest either for or against the issues being considered by the committee
  - SA Water utilises ocean outfalls to discharge treated effluent into recreational waters and have guidelines/requirements on how to manage access to recreational waters during events associated with spills/overflow
  - Received grant for: Applying quantitative microbial risk assessment, epidemiological modelling, and Bayesian Network models to facilitate AMR management in wastewater services, water reuse and biosolids/composts usage
  - Associate Editor Water Conservation Science and Engineering, Springer Nature.
  - Publication of numerous journal articles and book chapters as well as presentations at international and national conferences and seminars
  - Adjunct positions at Flinders University and University of South Australia
  - Conduct consultancy for and provides technical advice to Australian Water utilities
  - Seconded to the University of South Australia 2 days per week (2019 to Dec 2020) on research related to recreational waters, antibiotic resistance, and risk assessment of water reuse schemes
  - Previous professional working relationship with Dr Mike Burch, the cyanobacteria and algae reviewer, at SA Water,

Dr Meredith Campey - Manager Beachwatch Programs, Department of Planning and Environment, NSW

- **Area of expertise:** Marine science and recreational water quality
- **Interest details:**
  - Manager of Beachwatch Programs with NSW Department of Climate Change, Energy, the Environment and Water, involved in the implementation of statewide recreational water quality monitoring programs.
  - Publication of annual NSW State of the Beaches report, and co-author on peer-reviewed papers on recreational water quality at swim sites.

  - Provides advice for microbial pollution events, including daily beach pollution forecasts for swim sites in NSW.
  - Involved in research projects related to recreational waters in partnership with universities.
  - Developed a range of documents including protocols, fact sheets and guides including Protocol for the assessment and management of microbial risks in recreational waters for implementing chapter 5 of the NHMRC (2008) guidelines for managing risks in recreational waters.

Dr Christine Cowie - Senior Research Fellow, Woolcock Institute of Medical Research, Macquarie University

- **Area of expertise:** Environmental epidemiology – currently air pollution epidemiology
- **Interest details:**
  - Guest lecturer at UNSW for Env Health unit, predominantly on-air pollution issues, occasionally discuss water related issues in more general EH lectures.
  - Co-ordinated and lectured in the EH subject in the Master of Public Health at the University of Sydney from 2003-2008, including lectures on water related issues.
  - Previously conducted joint research and published a paper on the health effects of recreational water exposure to cyanobacteria. Michael Birch was also an author on this paper, published in 1997.
  - Conducted consultancy for Sydney Water Corporation (SWC) Sewer Workers Health Study which consisted of field work, a literature review and biological and chemical risk assessment of the health risks posed to Sydney Water (SWC) sewage workers. Many of the recommendations were implemented by SWC.
  - Former member of the Australian Water Association.
  - Former Manager, Water Unit, NSW Health Ministry
  - Publication of papers in peer reviewed journals, submissions to government, and reports. Presentations at local and international conferences, seminars and workshops
  - Former member of various interdepartmental committees specific to water issues including
    - Former member of NHMRC Committee for the Rolling Revision of the Australian Drinking Water Guidelines
    - Former member of NHMRC Committee for development of the Recycled Water Quality Guidelines
    - Strategic Liaison Group/ Joint Operational Groups with SWC and SCA
    - Beachwatch Advisory Committee
    - NSW Drought Committee
    - Rural Water Supply Advisory Committee.

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Dr Dan Deere - Freelance water, sanitation and hygiene (WASH) Consultant, Sole trader under the company Water Futures Pty Ltd.

- **Area of expertise:** Water quality and risk management, water and recycled water auditing.
- **Interest details:**
    - Current funded projects for: European Commission and Global Water Research Coalition: 2021 - present; World Health Organization: 2003 - present; Water Research Australia: 2012 - present; University of Newcastle: 2021 – present; University of Bristol, Kathmandu University and Haramaya University (funded by UK Aid): 2020-present; University of Adelaide, (for Seqwater): 2019 – present; New Zealand Ministry of Health and Department of Internal Affairs: 2019 – present; Hong Kong Water Supplies Department: 2017 – present; NT Government (Power Water with Department of Local Government, Housing and Community and Department of Health): 2018 – present; NSW Health: 2019 – present; VicWater, EPA and Department of Environment, Land, Water and Planning: 2019 – present; University of Queensland: 2009 – present.
    - Current unfunded projects/activities or partially funded but largely unfunded project for: World Health Organization; Asian Development Bank; Water Research Australia; National Health and Medical Research Council: Guidelines for Managing Risks in Recreational Water, Water Quality Advisory Committee; COVID-19 technical support for multiple agencies in Australia and internationally on an as needs basis relating to general microbiology and WASH aspects. This to date has been in the US, UK, China, HK, Australia, Vietnam, Lao, Fiji, Thailand, Cambodia and NZ.
    - Additional minor funded activities past and present include peer reviews, training, workshop facilitation, regulatory audits of water suppliers for health departments, contributions to research projects and specific technical assessments and validation, with the work mostly related to microbial pathogens.
    - Publications include numerous journals and technical reports and presented at international and national conferences, seminars, webinars and workshops. Focus is on providing practical guidance founded in objective, best available evidence. These can be found in Research Gate and PubMed.
    - I regularly co-author publications, such as scientific papers, technical reports or guidelines, for the water industry, health departments and development agencies, such as development banks and WHO. I sometimes receive partial payment from the agencies towards my contribution for the preparation of the documents and the review, presentation and training associated with those documents. The work relates to aspects of water quality management.
    - Occasionally I provide expert witness statements in court. On approximately half-a-dozen occasions this has related to the interpretation of the Australian Drinking Water Guidelines or Guidelines for Managing Risks in Recreational Waters where I have been called by water utilities or health authorities in NSW and Victoria to advise the court on their correct interpretation in matters relating to water quality protection. This included the New Zealand Government Havelock North Inquiry at where I spent two weeks in the Inquiry hearings as an Expert Witness.
    - As a consultant, I regularly participate in national and international academic and industry conferences. In some cases, I attend these as an invited speaker, occasionally with costs such as conference registration, travel and/or accommodation provided by the conference organisers. The invitations relate to aspects of water quality management. Current presentations are: - Water Research

Australia: Drinking water catchment source assessment tool training program scheduled for Brisbane in 2021; University of Queensland: Drinking Water Quality Management training programs scheduled twice per year.

- I am a member of various groups that are involved in water quality management. This includes the Seqwater Water Security Program - Independent Review Panel as a water quality expert, the NSW Health Cryptosporidium and Giardia Expert Panel as a water microbiologist. In addition I am a member of the Australian Water Association (including the Rural, Regional and Remote and the International Water Association specialist networks), the International Water Association, International Water Resources Association and Water Research Australia.
- I occasionally undertake work for members of the Australian Water Industry as a consultant. This includes Health Departments, Water Agencies and Water Utilities. Almost all of the work is for state government departments or stated-owned corporations. I do this as a private consultant. My private consultancy work is related to water quality risk assessment and management and other aspects of water quality science. Much of this work is information and involves answering ad hoc telephone calls or emails, particularly during water contamination incidents. Such work is largely unpaid and undertaken on a voluntary basis. Sometimes the work involves contractual engagements for project work such as peer review, risk assessments, management plan developments or training. Current projects are: Water Research Australia: Risks to drinking water from recreational water activity as well as the ColoSSoS SARS-CoV-2 sewage surveillance program; Hong Kong Government: assessment of risks from using seawater for potable uses. NSW Health: support for councils to implement the ADWG Framework. Power Water (Northern Territory): Catchment source water assessments to identify pollution sources. Vic DH: Drinking water supply risk management plan regulatory audits for water utilities (funded by the utility but undertaken for DHHS). Queensland Health: Advising Qld councils on implementing Health-based Targets; Vic EPA: QMRA relating to recreational water guidelines. IPART: Drinking water supply risk management plan regulatory audits for water utilities (funded by the utility or IPART but undertaken for IPART). WHO: Western Pacific Regional Office Water Safety Plan Training of Trainers Program for AusAID (DFAT) and UK AID.
- I periodically take part in training and lecture work for universities and agencies relating to water and health. I usually get paid something towards that work. This includes Australian and international institutions. The training relates to aspects of water quality management. Current projects are: - University of Queensland: IWES training courses (Feb and July each year) in drinking water and recycled water quality management; Various water utilities engaged via universities or directly: training in developing drinking water safety plans; Assisting RMIT and SCU update and offer the Exemplar Global DWQMS and RWQMS exam.Specialist support for COVID has been provided at no charge for WSAA, AWA, WIOA, Qld Water Directorate, NSW Water Directorate, WaterRA and GWRC. This has included workplace/occupational health and safety webinars and Q&A sessions, factsheets and guidance and fielding calls ad hoc from workplace/occupational health and safety professionals in the sector. In addition extensive funded and unfunded activity is ongoing in relation to sewage surveillance for SARS-CoV-2 across the global WASH sector.

Ms Sarah Holland-Clift - General Manager Community and Catchment Services, Corangamite Catchment Management Authority, VIC

- **Area of expertise:** Former community group representative
- **Interest details:**
    - Statutory responsibilities of this role include management of the Barwon River through Geelong (including recreational water quality monitoring) and rural drainage schemes, education and information provision and implementation of the Corangamite Waterways Strategy.
    - Previously managed the development of the Parramatta River Masterplan, which included commissioning a strategic analysis of water quality monitoring in the Parramatta River catchment and development of a framework for river swimming site activation. This work worked within existing NHMRC Guidelines but also proposed potential new directions that would provide more tailored monitoring and management solutions for the Parramatta River.

Dr Andrew Humpage - Affiliate Senior Lecturer at the University of Adelaide, South Australia

- **Area of expertise:** Clinical biochemistry, histopathology, in vivo and in vitro toxicology, and genotoxicity, particularly in cyanobacterial toxins
- **Interest details:**
    - Received travel and accommodation support from WHO and Singapore Utilities Board to attend meetings in relation to my membership of the WHO Guidelines for Drinking Water Quality Chemicals Committee 2016-2018.
    - Provided expert advice to WHO Drinking Water Quality Chemicals Committee in relation to my expertise in cyanobacteria and their toxins.
    - Drafted the WHO Background Documents in support of Guideline Values for four cyanobacterial toxins in drinking water and recreational water.
    - Co-authored 4 chapters in the WHO publication Toxic Cyanobacteria in Water
    - Associate editorship of the Journal of Toxicology and Regulatory Policy
    - Dr Humpage had a previous professional working relationship with Dr Mike Burch, the cyanobacteria and algae reviewer, at SA Water

Dr Greg Jackson - Director, Water Unit, Prevention Division Department of Health, Queensland

- **Area of expertise:** Environmental Science
- **Interest details:**
    - Permanent employee of the Queensland Department of Health, as Director of the Water Unit, within the Health Protection Branch. In this role I have some regulatory responsibilities under the Public Health Act 2005 (Qld).
    - Appointment as Adjunct Associate Professor in the Queensland Alliance for Environmental Health Sciences at the University of Queensland. This appointment involves the development of applications for research funding under the Alliance.

- Member of the enHealth Water Quality Expert Reference Panel, as the Queensland jurisdictional representative. This is an advisory role, with no regulatory or funding responsibilities.
- Designated representative of Queensland Health as a General Member of Water Research Australia and also serve on the Strategic Advisory Committee for WaterRA.
- With respect to the engagement of CSIRO to draft the narrative review for free-living organisms, I declare that I am managing a project with University of Queensland, which is sub-contracting analytical services to CSIRO Brisbane. Queensland Department of Health has no direct contractual arrangement with CSIRO.

Dr Muriel Lepesteur-Thompson - Senior Health Risk Advisor – Microbial, EPA Victoria and Adjunct Associate Professor, RMIT University

- Area of expertise: Microbial risk assessment (including QMRA) and risk management
- Interest details:
  - Senior Health Risk Advisor with EPA Victoria, involved in the development of environmental policies and guidelines. Provides advices for microbial pollution events, future developments and may assist the Court as an Expert Witness. Involved in research projects related to recreational waters in partnership with universities.
  - Member of the Working Group for the development of the Victorian antimicrobial resistance strategy and the Chairman of the Environment & Waste Technical Advisory Group.
  - Senior Health Risk Advisor – Microbial at EPA Victoria. Contributes to the development of future environmental public health policies and guidelines such as: SEPP Waters of Victoria, Guidelines for managing human health risks in recreational waters, Guidelines for assessing human health risks for wastewater discharge into waterways, Guidelines for composting facilities, Waste to land regulations.
  - Provides advice in relation to emergency and pollution events, development proposals and prosecution (expert witness statements for VCAT or Supreme Court).
  - Member of the Project Steering Committee for the RMIT-ECP-SEW/MW joint project "Managing Microorganisms in Victoria's recycled water assets" and partnered with various research organisations in projects related to public health and waters: Quantitative Microbial Risk Assessment for recreational users of Port Phillip Bay, Source Tracking in Port Phillip Bay, Significance of the environment as a reservoir for Antimicrobial Resistance (proposal submitted), A national approach to tackling antimicrobial resistance in the water cycle (proposal submitted for ARC funding), Modelling Risks to Recreational Users of Port Phillip Bay (proposal submitted), Development of a rapid, low-cost, portable detection method for E. coli and enterococci (proposal submitted).
  - Appointed as Adjunct Associate Professor at RMIT.

Dr Richard Lugg - Independent Consultant, WA

- **Area of expertise:** Water quality and human health
- **Interest details:**
    - Involved in the administration of recreational water matters in the WA Department of Health until 2015.
    - Previously worked on quantitative modelling of free-living organisms in recreational water. The review and guidelines update may propose something that conflicts this previous work.
    - Various publications on topics including methods for Faecal Indicator Bacteria enumeration and thermophilic Naegleria.
    - Attended the WHO 2001 consultation workshop.

Professor Susan Petterson - Professor, School of Medicine, Griffith University; Director, Water & Health Pty Ltd; Editor, Journal of Water and Health (IWA Publishing)

- **Area of Expertise:** Quantitative Microbial Risk Assessment Specialist, risk assessment software tool development
- **Declaration of interest:**
    - Appointed as a non-executive director for Sydney Water in 2022
    - Consultant in application of QMRA for vulnerability mapping of Cryptosporidium risks associated with NSW drinking water supplies for NSW Health.
    - Member of the independent peer review panel (human health) for Sydney Water looking at public health components of the wet weather overflow program.
    - Ongoing advice and research assistance related to pathogens associated with in-premise plumbing for Viega GmbH & Co. KG Plumbing and Heating Systems Attendorn, Germany.
    - I serve as an advisor for WHO Water Sanitation Hygiene and Health on risk assessment and microbial aspects in water. Past participant in the WHO Guidelines Development Group for Sanitation Guidelines Participant in the Microbial Aspects Advisory of the Guidelines for Drinking Water Quality Member of the JEMRA (Joint FAO/WHO Expert Meetings on Microbial Risk Assessment) roster of experts.
    - Teaching and course presentation for IWES industry training courses
    - Affiliated with Griffith University - Associate Professor at School of Medicine
    - Peer Review of QMRA undertaken for recreational water quality at Hunter Beaches for Hunter Water looking at health risk assessment of sewage discharges
    - Member of the Independent Metropolitan Water Advisory Panel for NSW Department of Planning Industry and Environment
    - Consultant to: Viega Plumbing on opportunistic pathogens; the City of Edmonton, Canada – on recreational water; expert testimony for AGL Macquarie on opportunistic pathogens.
    - Current projects for: Global Water Pathogens Project; Public Health Agency of Sweden 2012 – present; Sydney Water Corporation 2012 – present; NSW Health 2012 – present; WHO 2009 – present

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- Past projects for: Government of Alberta, Canada 2013 – 2014; INTARES EU 2011 – 2014; Water Research Australia 2011 – 2013; Swedish Water and Wastewater Association – Stockholm Water Ltd 2011
- Publications in numerous journals and reports; also presentations at international and national conferences, seminars and workshops
- Microbial Risk Assessment for Comparison of Sewer Overflow Management Options: Consulting work for Queensland Urban Utilities applying QMRA to assess overflow impacts on recreational sites.

Ms Rachael Poon - Senior Policy Officer Food, Chemicals and Biosecurity Regulatory Policy, Department of Energy, Environment and Climate Action, Victoria

- **Area of Expertise:** Water regulator with expertise in microbiology and biotechnology
- **Declaration of Interest:**
  - Currently work as Senior Policy Officer, Food, Chemicals and Biosecurity Regulatory Policy, Department of Energy, Environment and Climate Action - Victoria
  - Member of EPA State Environment Protection Policy Recreational Water Technical Reference Group, Victorian Pool operator handbook steering committee, Aquatic facility regulators working group
  - Published numerous journal articles from 2005-2013 when researching bacterial toxins and pathogenesis at Monash University (2003-2008).
  - Developed a range of documents including guidelines, fact sheets and educational materials for the department relating to private drinking water supplies, flood waters, recreational water and harmful algae.
  - Presented at a range of national and international conferences, workshops and seminars.
  - Partner works at Yarra Valley Water in asset planning and maintenance.
  - Project Lead, Wastewater Surveillance for SARS-CoV-2 in Wastewater
  - Published journal articles, and developed guidelines, factsheets and guidance material for DHHS

Professor Anne Roiko – Professor School of Medicine and Dentistry Griffith University; Adjunct Professor Australian Rivers Institute, Griffith University; Adjunct Professor, University of the Sunshine Coast; Research Advisor, WaterNSW

- **Area of Expertise:** Environmental epidemiology, quantitative microbial risk assessment and risk management
- **Declaration of Interest:**
  - Member of special interest groups of AMR (Antimicrobial resistance) and wastewater surveillance within QAEHS (Qld Alliance for environmental Health Sciences) at the University of Queensland.
  - Member of the Scientific Advisory Committee of IBEC (Integrated Bioscience and Built Environment Consortium) for which I have delivered a webinar on climate change impacts on zoonotic diseases

- Member of several professional associations that include environmental health risks in their scope including the International Water Association, the Australian Water Association, the Australasian College of Toxicology and Risk Assessment, Environmental Health Australia
- Supervising a doctoral candidate working on Recreational water health risks
- Named CI on a successful ARC grant 'Climate Resilient Water Training Centre'
- Chair of the Public Health Scientific Expert Panel for Healthy Land and Water and have been involved in the development of related guidelines, standards, education materials or fact sheets, writing of publications, delivering speeches, or engagement in public debate on advice regarding Recreational Water Safety.
- Member an international advisory board for an EU funded project on horizontal transfer genes of AMR genes in the environment
- Member of an advisory committee for Victorian EPA to discuss site-specific health risk assessments for recreational water.
- Board member of the Health-related Water Microbiology (HRWM) Special Interest Group, of the International Water Association (IWA). The work of this group included:
    - scientific review of abstracts submitted to the 2019 IWA Symposium of the Healthrelated Water Microbiology Special Interest Group – some of which is related to recreational water quality.
    - activities around wastewater-based epidemiology and scientific review of papers for a conference in Netherlands in 2025.
- Have applied for and received funding for research projects related to recreational water management.
- Have responded to requests and received funding for consultancies that could be perceived to have a bearing on recreational water management.
- Appointed to the Commonwealth Games Water Working Group and was responsible for providing advice regarding water-related risk registers for use during the Commonwealth Games on the Gold Coast.
- Published peer-reviewed material that relate to recreational water management.
- Theme leader for Urban Water and Waste Management within the Cities Research Institute, Griffith University.
- Griffith University's representative for Water Research Australia.

Dr Jenny Stauber - Ecotoxicologist, Self employed

- **Area of Expertise:** Microbiology, environmental contamination and risk assessments
- **Declaration of Interest:**
    - I am a fellow of Australian Academy of Technological Sciences and Engineering (ATSE) and Australian Academy of Science (AAS).
    - I have been involved in the development of toxicant guidelines for aquatic ecosystem protection for the Australian government, and am a member of several government and metals industry advisory committees, both nationally and

internationally. This previously included chairing the SEPP waters and groundwaters of Victoria science advisory panel, which concluded in Dec 2016.

- Currently chair the Management Committee for the Queensland Alliance for Environmental Health Science, a joint UQ and Qld Health centre. I am a member of the Independent Expert Committee on CSG and Large Coal Mining Development and a member of the Alligator Rivers Region Technical Committee (both for DAWE).
- Member of the Reef Water Quality Independent Science Panel (ISP) and the Gladstone Healthy Harbour Partnership ISP.
- Member of the global metals associations Ecotoxicity Advisory Panel.
- Research funding received includes from the international nickel association (NiPERA), the International Zinc Association and the Metals Environment Research Association, not for profit associations, to develop Ni and Zn bioavailability-based water quality guidelines for aquatic ecosystem environmental protection and to develop implementation guidelines and training material for ANZG water quality.
- Currently supervise PhD and Honours students through UTS and Latrobe University on topics unrelated to recreational water quality.
- Joint holder in shares in BHP Billiton, South32, Wesfarmers and CSL.

Dr Cameron Veal - Principal of Scientific Services, Seqwater, QLD

- Area of Expertise: Water quality and public health.
- Declaration of Interest:
  - Development of Seqwater's Cyanotoxin Based Recreational Water Quality Management Response including the Publication of 1 Peer Review Paper, 2 Conference Presentations, Development of Cyanotoxin guidelines for recreation and fact sheets for Seqwater’s recreational users including educational material and/or fact sheets. My previous role (paid employment as Technical Coordinator - Catchment Water Quality) at Seqwater includes development and overseeing Seqwater's Recreational Water Quality Management Plan, which has seen us develop and implement a cyanotoxin based recreational water quality management plan to better characterise the public health risk and move away from proxi indicators for risk (Cell counts and Biovolume Measures), which due to the nature of local conditions were not adequately representing the public health risks.
  - Current role as Principal of Scientific Services involves the utilisation of the NHMRC Guidelines for Managing Risks in Recreational Waters as the backbone of our Recreational Water Quality Management Plan.
  - Employment with a Bulk Drinking Water Supply Authority which permits a range of primary and secondary recreational opportunities and follows the NHMRC’s Guidelines for Managing Risks in Recreational Waters. Seqwater utilise the NHMRC’s Guidelines for Managing Risks in Recreational Waters as the backbone for our Recreational Water Quality Management Plan and any changes to the Guidelines would then be updated and reflected in our management plans. Changes in suggested monitoring activities, parameters or frequency of monitoring could have

additional or reduced financial cost on Seqwater's sampling and monitoring program.

- Involvement with three committees run by Healthy Land and Water (Scientific Expert Panel, Monitoring and Evaluation Steering Committee and Healthy Waterplay Committee). The Scientific Expert Panel, Monitoring and Evaluation Steering Committee focussed on water quality monitoring, recreation, public health, management and science in South East Queensland. I am an invited member of the Scientific Expert Panel and Ex Chairperson of the Monitoring and Evaluation Steering Committee for which I receive no additional monetary remuneration apart from standard pay from Seqwater for my substantive role as Technical Coordinator – Catchment Water Quality. In these committees we represent the local councils, utilities and regulators discussing common recreational management activities and current research and development.
- Water Industry PhD Supervisor of a Griffith University PhD Student who is "Evaluating the application microbial source tracking with quantitative microbial risk assessment to characterise health risks in recreational waters." Seqwater sponsors and funds several small research projects investigating microbial and chemical risks associated with different recreational activities on its drinking water storages to ensure risks to recreational users associated with recreating in open multi use catchments are appropriately managed.
- Individual Member of the Australian (AWA) and International Water Associations (IWA) and institutional member (through Seqwater) of Water Research Australia. Has been involved in and attended several conferences run in Australia by the Australian and International Water Association and been on Water Research Australia Industry research programs and PAC's
- Publications in several journals and reports; also presentations at international and national conferences, seminars and workshops. I have published 9 peer review papers (5 as lead author), written several reports and presented multiple conference talks on a range of optical physics, biology, cyanobacteria, water monitoring and coral reef topics.
- Recipient of research grants from government and non-government agencies, as well as named industry partners on several current Australian Research Council Linkage Grant Applications (none currently funded). During my PhD Studies I received grant funding from multiple organisations including: The Great Barrier Reef Foundation, The United States of America's National Oceanic and Atmospheric Organisation, Australian Coral Reef Society, The Australian Israeli Scientific Exchange Foundation, PADI Aware foundation and Australian Geographic. In my water utility role, I am listed on several Australian Research Council Industry Linkage Grants.
- Honorary Research Fellow at the School of Civil Engineering (The University of Queensland) and Cities Research Institute (Griffith University). I hold two honorary positions where I supervise post graduate students and guest lecture when required

on topics revolving around water management, monitoring and water utility operations.

- Due to the inclusion of CSIRO staff in the undertaking of expert reviews, I need to declare that in my role at Seqwater we have several active programs with CSIRO researcher in the microbial spaces, principally Dr Warish Armed and Dr Simon Toze.

Declarations of interest of contracted evidence reviewers

Dr Michael Burch - Visiting Associate Professor in the School of Biological Sciences in the Faculty of Sciences at the University of Adelaide; Director, Australis Water Consulting Pty Ltd.

- The reviewer was involved in the development of the previous version of the NHMRC guidelines (The Guidelines for Managing Risks in Recreational Water. 2008). This was initially as a volunteer member of the steering Committee and subsequently as chair of the Committee (2004-2006).
- The reviewer participates in research projects with university staff and students; publishes journal articles with University affiliation. This includes publications on cyanobacteria and algae.
- The reviewer is the Director and Principal of an Australian water consulting company that provides advice on water management and research management to a range of Australian and international clients, including government agencies, water authorities, research Institutions, Universities and local government organisations.
- The reviewer is the Director and Principal of an Australian water consulting company that provides advice on water management and research management to a range of Australian and international clients, including government agencies, water authorities, research Institutions, Universities and local government organisations.
- Professional association with members of the NHMRC Recreational Water Quality Advisory Committee (RWQAC) (the Committee). The reviewer has professional scientific relationships with several members (three members) of the Committee which has included joint research and producing joint publications at different times over the last 30 years.
- Member of Water Research Australia through affiliation with the University of Adelaide, and as a consultant. The reviewer provides professional and scientific advice to Water RA staff on research project design and management. This may be as a consultancy on a normal commercial basis. The reviewer is a joint author on the following paper which was included in the review.
- The study by Pilotto *et al.*, (1997) was included in the review although it was outside the date range specified (2006-2021). This was because it was a highly relevant Australian epidemiological study designed at the time to gather information to inform exposure to toxic cyanobacteria in recreational water environments.

Dr Nick O'Connor - Principal Consultant, Ecos Environmental Consulting Pty Ltd.

- As principal consultant at Ecos Environmental Consulting, I am involved in many consulting projects for clients in the public and private sectors. However, the majority of my clients are regional and metropolitan water corporations for whom I provide consultancy advice in the areas of water-related human health and ecological risk assessment.

- As a consultant to Melbourne Water, I provide consultancy advice in the areas of water-related human health and ecological risk assessment.
- As a consultant to VicWater (Victorian Water Industry Association), I provide consultancy advice about chemicals of concern in recycled water.
- As a Member of Scientific Services Consultancy Panel for South East Water, I provide consultancy advice in the areas of water-related human health and ecological risk assessment.
- As a consultant to the Victorian Department of Environment, Land, Water and Planning and Victorian Department of Health and Human Services and Victorian Environment Protection Authority. I recently undertook a project in conjunction with Atura P/L and Water Futures P/L to develop the 2020 version of the Victorian Recycled Water Guidelines.

Dr Yufei Wang - Ecos Environmental Consulting Pty Ltd.

- As a researcher at RMIT in chemical and environmental engineering, I am involved in several water research projects, performing analysis and providing consultancy advice to our industrial partners.
- Photolysis of emerging contaminants, R&D project for Melbourne Water: I perform research activities and report findings assessing the environmental impact on the attenuation of chemicals of concern and provide consultancy advice on their associated risks in recycled water.
- Validation framework review and drinking water supply system performance assessment, R&D project for Water Source Australia. I provide consultancy advice about assessment of disinfection performance of a Point of Entry drinking water supply system.
- Publication of journal articles: I report my research on behaviour and risk assessment of chemicals of concern in recycled water.

Dr Geoffrey Puzon - Senior Research Scientist, CSIRO

- CSIRO is a member of Water Research Australian. In my current role, I am expected to have an active scientific career and publish scientific journal articles and other publications.

Dr Guobin Fu - Senior Research Scientist, CSIRO

- CSIRO is a member of Water Research Australian. In my current role, I am expected to have an active scientific career and publish scientific journal/ conference articles, as well as lecture graduate students.

Dr Anna Kaksonen - Senior Research Scientist, CSIRO

- CSIRO is a member of Water Research Australian. In my current role, I am expected to have an active science career and publish scientific journal articles and other publications.

Declarations of interest of expert reviewers

Dr Jonathan Puddick - Team Leader, Aquatic Molecular Ecology, Cawthron Institute

- In my current role at the Cawthron Institute, I provide consultancy advice to water managers and government agencies regarding risks related to toxin-producing cyanobacteria, as well as undertaking scientific research on the topic.
- I am a member of the Water Technical Expert Panel for Taumata Arowai (New Zealand's drinking water regulator). I provide expert advice regarding cyanotoxin risk management.
- I am the subject lead for the harmful algal blooms topic on the Environmental (Public) Health science programme funded by Health NZ, Te Whatu Ora.
- I am project lead for an Fisheries Research and Development Corporation (FRDC) funded project investigating the toxicity of nodularin, a cyanotoxin, and its accumulation in seafood.
- I am project lead for an MBIE-funded project investigating the potential to produce nitrogen fertilisers from nitrogen-fixing cyanobacteria.
- I am a standard member of the professional body that advocates for freshwater sciences in New Zealand (NZ Freshwater Sciences Society)
- I am a standard member of the professional body that advocates for science in New Zealand (Royal Society NZ)

Dr Anusuya Willis - Director, Australian National Algae Culture Collection, CSIRO

- In my primary role at CSIRO and occasional consultancy work: providing information on cyanobacteria for mitigation and management of blooms.
- Associate Editor overseeing peer-review and publication of articles in the journal Harmful Algae.
- As a Member of Water Research Australia, I contributed to the fact-sheet “potentially toxic cyanobacteria of Australia” and received funding for project “review of cyanobacteria risks in source waters”
- In 2025, I was the Chair of the 9th Australia and New Zealand Cyanobacteria Workshop (Sept 23 – 25th), hosting 1030 water researchers and industry participants at CSIRO.

Dr Michael Burch - Affiliate Associate Professor at The University of Adelaide; Director, Australis Water Consulting

- In this Adjunct/Affiliate position I participate in research projects with university staff and students; publish journal articles with University affiliation. This includes publications on cyanobacteria
- I have a professional association with Dr Daniel Deere, Water Futures (member of the RWQAC). Worked jointly on one short term consulting project with Water Futures.
- I have a professional scientific relationship with Dr Andrew Humpage (member of the RWQAC) who was a former long-term colleague while working at the South Australian Water Corporation over approximately 30 years. This has included producing joint publications.

- As a Member of Water Research Australia through affiliation with the University of Adelaide, I provide professional and scientific advice to Water RA staff on research project design.
- In my role as Director of Australis Water Consulting, I provide consultancy advice on a commercial basis to Water RA on research project management.
- In 2020, as part of my role as Director of Australis Water Consulting, I was commissioned by NHMRC to undertake a narrative review to inform the update to the guidance on harmful algae and cyanobacteria and recreational water.

Dr Michele Burford - Professor, Australian Rivers Institute, Griffith University

- Griffith University is a member of Water Research Australia. I periodically bid for projects, and undertake reviews of projects.
- As a member of the Steering committee for Griffith Uni/Seqwater collaboration, I participate in reviewing new and existing projects.
- As a member of the scientific expert advisory group for EcoMarkets Australia, I participate in reviewing documents relating to water quality improvements to ensure they are based on best practice.
- I am reviewing a report submitted to WaterRA on potable recycled water.
- As an Australian representative on UNESCOE-FAO Intergovernmental Panel on Harmful Algal Blooms, I provide information about Australia's marine and freshwater harmful algal blooms and facilitate collaboration and coordination internationally.
- Australian Research Council linkage project with Sydney Water, Resilient Rivers partnership, Healthy Land and Water, Qld Dept Environment, Tourism, Science and Innovation, UQA and SCU on river health. I am the chief investigator for the research project collaborating with partners which is focussed on river health and nutrient biogeochemistry
- I attend meetings of the Healthy Land and Water Ecological Health Monitoring Program scientific advisory committee to provide advice on the health monitoring program in southeast Queensland.

Professor Karin Leder - Infectious Diseases Epidemiology Unit, Monash University

- Chief Investigator on grant funded by MRFF. The grant funds infrastructure to perform laboratory work on samples collected by water industry partners.

Dr Rebekah Henry - Senior Associate, Planetary Health, Monash University

- Chief Investigator on grant funded by MRFF. The grant funds infrastructure to perform laboratory work on samples collected by water industry partners.
- As the Monash University Representative for Water Research Australia, I provide a conduit for researchers to interact with the larger water industry.
- Chief Investigator on research funded by Melbourne Water. The grant funds analytical and staff expenses to conduct research on waterbodies and treatment systems within Victoria

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- Chief Investigator on research funded by EPA Victoria. The grant funds analytical and staff expenses to conduct research on hazard assessment of recreational beaches in Port Phillip Bay