5 Guidelines for recreational water quality and aesthetics

Water-based recreational activities are popular with Australians and New Zealanders. Although each country has an extensive coastline, much of it is inaccessible for recreational purposes, resulting in highly localised pressures on accessible coastline. The same is true for estuarine and freshwater rivers and lakes, especially those close to urban centres. Therefore, water quality guidelines are necessary to protect these waters for recreational activities such as swimming and boating, and to preserve the aesthetic appeal of water bodies. Water quality guidelines are used in the monitoring and management of a range of microbiological, physical and chemical characteristics that determine the suitability of a water resource for recreational purposes.

5.1 Guidelines for users in New Zealand

In New Zealand, water managers should refer to *Recreational Water Quality Guidelines* (NZ Ministry for the Environment 1999). This document and the draft supporting manual can be downloaded from:

http://www.mfe.govt.nz/about/publications/water_quality/beaches-guidelines.htm

The revised New Zealand guidelines were trialed over the 1999/2000 bathing season. This trial period will be followed by a consultation round similar to that carried out for the 1998 *Bacteriological Water Quality Guidelines for Marine and Fresh Water*. The extent of further revisions, if any, will depend upon the response to the revised guidelines. Any recommendation to the Minister for the Environment regarding a National Environmental Standard will be made after the round of consultation.

5.2 Guidelines for users in Australia

The material for Australian users of *Guidelines for Recreational Water Quality and Aesthetics* is currently being prepared. When completed, it will replace this section, in accordance with NWQMS requirements and National Health and Medical Research Council (NHMRC) statutory procedures. The NHMRC, ANZECC and ARMCANZ all recognise the need for a single guideline document to supplant earlier sets of guidelines for recreational water quality, published separately by the NHMRC and NWQMS (*Australian Guidelines for Recreational Use of Water* (NHMRC 1990) and ANZECC (1992) respectively).

It is intended that the new guidelines should be largely based on recommendations from the World Health Organization (WHO) including draft WHO *Guidelines for Safe Recreational-water Environments: Coastal and Fresh-waters* (WHO 1998) and WHO *Health-based Monitoring of Recreational Waters: The Feasibility of a New Approach (The 'Annapolis' Protocol)* (WHO 1999). These documents will provide the impetus to develop a single Australian guideline document. It will be part of the revised NWQMS Guidelines and will also be available as a separate NHMRC/ARMCANZ/ANZECC publication. The basis of the proposed guidelines for recreational water quality and aesthetics in Australia is provided in Appendix 5.

Until these Guidelines are revised and endorsed, users should apply the guidelines from the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992). These guidelines are reproduced below. While these (1992) guidelines are interim, the eventual guidelines that result from the NHMRC's current revision will be the definitive guidelines.

5.2.1 Introduction

Recreational guidelines accommodate two categories of sporting activity:

- sports in which the user comes into frequent direct contact with water, either as part of the activity or accidently; for example, swimming or surfing (primary contact);
- sports that generally have less-frequent body contact with the water; for example, boating or fishing (secondary contact).

A third recreational category concerns the passive recreational use of waterbodies, mainly as pleasant places to be near or to look at (no body contact). The relevance of the different water quality guidelines to the three recreational categories is shown in table 5.2.1. The detailed water quality guidelines for recreational water are summarised in table 5.2.2.

Table 5.2.1. Water quality characteristics relevant to recreational use

Characteristics	Primary contact (e.g. swimming)	Secondary contact (e.g. boating)	Visual use (no contact)
Microbiological guidelines	x	x	
Nuisance organisms (e.g. algae)	x	x	x
Physical and chemical guidelines:			
Aesthetics	x	x	x
Clarity	x	x	x
Colour	x	x	x
pH	x		
Temperature	x		
Toxic chemicals	x	x	
Oil, debris	x	x	x

The first part of this section on Australian guidelines provides a brief summary of the most important aspects of the above categories, while the second section contains details on the specific guidelines. Many of the guidelines necessary for the maintenance of certain aspects of recreational water quality (e.g. preservation of aquatic life and wildlife) are discussed in other chapters and will only be briefly mentioned here. The recommended guidelines rely on the guidelines developed by NHMRC (1990), with additional indicators included where appropriate.

Table 5.2.2 Summary of water quality guidelines for recreational waters

Parameter	Guideline
Microbiological	
Primary contact*	The median bacterial content in fresh and marine waters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL or 35 enterococci organisms/100 mL. Pathogenic free-living protozoans should be absent from bodies of fresh water.**
Secondary contact*	The median value in fresh and marine waters should not exceed 1000 faecal coliform organisms/100 mL or 230 enterococci organisms/100 mL.**
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, sewage fungus, leeches, etc., should not be present in excessive amounts.* Direct contact activities should be discouraged if algal levels of 15 000–20 000 cells/mL are present, depending on the algal species. Large numbers of midges and aquatic worms should also be avoided.
Physical and chemical	
Visual clarity & colour	To protect the aesthetic quality of a waterbody: • the natural visual clarity should not be reduced by more than 20%; • the natural hue of the water should not be changed by more than 10 points on the Munsell Scale; • the natural reflectance of the water should not be changed by more than 50%. To protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m.
pH	The pH of the water should be within the range 5.0–9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.
Temperature	For prolonged exposure, temperatures should be in the range 15–35°C.
Toxic chemicals	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in tables 5.2.3 and 5.2.4.
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour.

* Refer to Section 3.3 of these revised Guidelines relating to nutrient concentrations necessary to limit excessive aquatic plant growth.

** Sampling frequency and maximum values are given in Section 5.2.3.1.

5.2.2 Recreational categories

5.2.2.1 Primary contact

Water used for primary contact activities, such as swimming, bathing and other direct water-contact sports, should be sufficiently free from faecal contamination, pathogenic organisms and other hazards (e.g. poor visibility or toxic chemicals) to protect the health and safety of the user. The general guidelines desirable for aquatic scenery are also applicable for water used for primary contact.

5.2.2.2 Secondary contact

Water used for secondary contact activities, such as boating and fishing, should also meet the guidelines suggested for aquatic scenery. Since there is less body contact with the water, the microbiological guidelines can generally be lower, although not in cases when shellfish might be taken from from the waterbody. To protect water-skiers from injury and boating vessels from damage, the water should be free from floating or submerged logs and stumps and excessive growth of algae and other aquatic plants. The quality of the water should be maintained so that there is minimal alteration of the fish habitat.[a]

a See Ch 3

5.2.2.3 Visual use

Surface waters used for visual recreational use (no-contact activity) should not be altered in any way that reduces their ability to support aesthetically valuable flora and fauna. Such alteration could be physical, such as dredging and dam construction, or could be due to the addition of wastes to the water. Visual impact of the surface waters is important; they should be free from:

- floating debris, oil, grease and other objectionable matter;
- substances that produce undesirable colour, odour, taste or foaming;
- undesirable aquatic life, such as algal blooms, or dense growths of attached plants or insects.

All these factors have to be considered in areas used for aquatic scenery.

5.2.3 Detailed water quality guidelines

5.2.3.1 Microbiological characteristics

Primary contact

The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed:

- ***150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL);***
- ***35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL).***

Pathogenic free-living protozoans should be absent from bodies of fresh water. (It is not necessary to analyse water for these pathogens unless the temperature is greater than 24°C.)

Secondary contact

The median bacterial content in fresh and marine waters should not exceed:

- ***1000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100 mL);***
- ***230 enterococci organisms/100 mL (maximum number in any one sample: 450–700 organisms/100 mL).***

There is a long international experience of disease outbreaks associated with contaminated water (McNeill 1985, Cabelli 1989). Disease-causing micro-organisms (pathogens) associated with bathing areas include salmonellae, shigellae, enteropathogenic *Escherichia coli,* cysts of *Entamoeba histolytica*, parasite ova, enteroviruses and infectious hepatitis (Hart 1974, McNeill 1985). Generally, the most common types of diseases that have been associated with swimming areas are eye, ear, nose and throat infections, skin diseases and gastrointestinal disorders. McNeill (1985) has reviewed epidemiological studies associated with recreational waters.

Direct detection of pathogens is not a feasible option for routine assessment, since they occur intermittently and are difficult to recover from water. For this reason, ‘indicator’ micro-organisms are generally used to assess the health risks associated

with pathogens in recreational waters (Elliot & Colwell 1985). A number of organisms have been considered as indicators of health risks for swimming areas (McNeill 1985, Daly 1991).

NHMRC (1990) favours the use of faecal coliform bacteria, a sub-group of the total coliform population that are easy to measure and are present in virtually all warm-blooded animals. Faecal coliform bacteria in human faeces comprise about 97% *E. coli*, around 2% *Klebsiella*, and a further 2% *Enterobacter* and *Citrobacter* together. However, McBride et al. (1991) have documented a number of deficiencies with the use of faecal coliforms as indicator organisms of health risks in recreational waters and waters used for shellfish growing. Recent epidemiological studies have shown poorer relationships between faecal coliform densities and illness rates in bathers than are obtained using enterococci (marine waters: Cabelli 1983a,b, Cabelli et al. 1982, 1983) and using either enterococci or *E. coli* (fresh waters: Dufour 1984). Further, there is now considerable evidence that faecal coliforms die off faster than pathogens under certain circumstances; therefore, they may go undetected during beach monitoring programs, resulting in the disease risks being underestimated.

New Zealand (McBride et al. 1991), Canada (CCREM 1991) and the United States (USEPA 1986) now recommend guidelines for recreational waters in terms of either enterococci or *E. coli* (or the non-faecal indicator *Pseudomonas aeruginosa*). For example, the New Zealand guidelines recommend that the median bacterial content of samples taken over the bathing season should not exceed 33 enterococci/100 mL (or 126 *E. coli*/10 mL) for fresh waters, and 35 enterococci/100 mL for marine waters (McBride et al. 1991). The guidelines recommended here are based on the levels recommended by NHMRC (1990) in terms of faecal coliforms, and those recommended by McBride et al. (1991) in terms of enterococci.

5.2.3.2 Nuisance organisms

Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in excessive amounts. Guidelines relating to nutrient concentrations necessary to limit excessive aquatic plant growth are given in Section 3.3 of these revised Guidelines.

Direct contact activities should be discouraged if algal levels of 15 000–20 000 cells/mL are present, depending upon the algal species. Large numbers of midges and aquatic worms should be avoided.

Biological factors that influence the recreational value of surface waters include those that endanger the health or physical comfort of people and animals, and those that render water aesthetically objectionable. In the first category are non-biting midges, phantom midges, caddis flies and mayflies, which can emerge in large numbers and cause serious nuisance to people picnicking, camping or living near the shoreline. More serious are biting insects that can cause irritation from their bites, respiratory allergic reactions or quite serious diseases. Common diseases transmitted by aquatic invertebrates are encephalitis, malaria and schistosome dermatitis (swimmer's itch).

Excessive growths of aquatic plants can also cause problems in recreational areas. Rooted and non-rooted macrophytes may obstruct the view of swimmers and

obscure underwater hazards. They can also entangle swimmers and induce panic if encountered unexpectedly. If the growth is very dense, boating and fishing may also be restricted. Dislodged or free-floating plants may also drift on to beaches, decay and cause objectionable odours as well as provide breeding areas for nuisance organisms.

Algal blooms, particularly if dominated by blue-green algae (cyanobacteria), can impair the recreational values of a waterbody by reducing the clarity and by accumulating along shorelines with effects similar to those cited for macrophytes. In addition, several species of blue-green algae can produce toxic substances that may kill fish, birds and domestic animals (Shilo 1981, Codd 1990, Falconer 1990). Species of blue-green algae have also been responsible for contact dermatitis in humans and influenza-like symptoms in swimmers (Codd 1990). Primary contact activities in waters containing high levels of cyanobacteria should be discouraged. Ingestion of cyanobacterial-infested water has been associated with gastrointestinal disorders in swimmers, and lipopolysaccharides found in certain cyanobacteria have been identified as causing skin irritations, dermatitis and allergy reactions observed in swimmers using cyanobacterial-infested waters (A McNeill, Victorian Rural Water Corporation, pers. comm., June 1992). As an interim guide, direct contact should be avoided when 15 000–20 000 cells/mL are present, depending on the algal species.

Periphyton growing on the bed of rivers and streams can also reduce the usefulness of these systems for contact recreation. Quinn (1991) recommended that to protect contact recreational areas:

> … the seasonal maximum cover of stream or river bed by periphyton as filamentous growths or mats (greater than about 3 mm thick) should not exceed 40%, and/or biomass should not exceed 100 mg chlorophyll *a*/m^2.

Quinn also called for additional research to define the level of periphyton that constitutes a nuisance.

Excessive aquatic plant growth is most often caused by high nutrient concentrations (mostly phosphorus and nitrogen) entering the waterbody. Guidelines for limitations on nutrients can be found in Section 3.3.

5.2.3.3 Physical and chemical characteristics

Visual clarity and colour

To protect the aesthetic quality of a waterbody:

- ***the natural visual clarity should not be reduced by more than 20%;***
- ***the natural hue of the water should not be changed by more than 10 points on the Munsell Scale;***
- ***the natural reflectance of the water should not be changed by more than 50%.***

To protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc (Secchi disc) should exceed 1.6 m.

Guidelines relating to visual clarity and colour are required for two reasons: first, to ensure that the aesthetic quality of the waterbody is maintained and that there is no

obvious change in the colour or visual clarity; and second, that the visual clarity of the water is not so low that it is unsuitable for swimming.

As discussed in Section 8.2.3 (Vol. 2), the optical quality of water, primarily its colour and clarity, is determined by the attenuation of light, particularly by SPM but also by dissolved matter (Kirk 1983, 1988). Visual clarity, defined in Section 8.2.3, is of considerable importance because it affects the recreational and aesthetic quality of water.

Panel studies undertaken by Davies-Colley and Smith (1990) in New Zealand showed that almost all people can detect a change of 30% in visual clarity. Davies-Colley (1991) used these results to recommend that reduction in visual clarity should be limited to less than 20%. This value is also used here.

In addition to aesthetic values, visual clarity of water is also important so that swimmers can estimate depth and see subsurface hazards easily (Thornton & McMillon 1989, Smith et al. 1991). Most guidelines require that the substrate should be visible in areas that are of wadeable depth, the water clarity usually being specified in terms of Secchi depth (NHMRC 1990, CCREM 1991). However, as Davies-Colley (1991) points out, a just-visible Secchi disc on the bottom means that potential hazards, such as snags and broken bottles, will not be visible because the Secchi disc has a higher contrast than the hazards. Davies-Colley (1991) recommended that a better guideline for the visual clarity relevant to swimmer safety in wadeable areas would be to require that the black disc visibility should be not less than 1.6 m, which is equivalent to the bottom of the waterbody being visible at an adult chest height of around 1.2 m. For diving areas, the water clarity would need to be considerably greater than this.

Water colour is the perception of light backscattered from within the waterbody as observed when viewed downwards at a near-vertical angle. Typically, about 3% of the incident light will re-emerge from the waterbody as backscattered light, although this ratio can vary widely. Colour of water has three aspects: hue, brightness and saturation or colour purity (Davies-Colley 1991). New Zealand research has shown that people value blue and green hues in water, but not yellows and reds (Smith & Davies-Colley 1992). Davies-Colley (1991) recommended that the natural hue of a waterbody should not be changed by more than 10 points on the Munsell Scale. Further, he recommended that the natural reflectance should not be changed by more than 50% to protect the brightness of the waterbody. New Zealand studies have shown that people are not particularly sensitive to water brightness.

pH

The pH of the water should be within the range 5.0–9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.

Ideally, the pH of the water for swimming purposes should be approximately the same as the lacrimal fluid of the eyes, which is about pH 7.4. However, lacrimal fluids have a high buffering capacity when in contact with solutions of different pH levels. They are able to maintain their pH within limits until their buffering capacity is exhausted. A deviation as small as 0.1 unit of the normal pH of the lacrimal fluid causes irritation of the eyes (Mood 1968).

Temperature

For human survival in cold water, the critical problem is to maintain body temperature. There is considerable variation from one individual to another in the rate of body cooling; it is primarily a function of body size, fat content, prior acclimatisation and overall physical fitness. Body heat is lost primarily by conduction from the inner organs through the trunk. Water cooler than 15°C is extremely stressful to swimmers not wearing appropriate protective clothing. Extended periods of continuous immersion at these temperatures may cause death. Thermal stress can be induced by temperatures exceeding the normal skin temperature of 33°C, and there is a risk of injury with prolonged exposure to temperatures above 34–35°C (Health & Welfare Canada 1983).

Toxic chemicals

Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. In general, toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4.

In general, there are two kinds of human exposure in swimming areas: contact with the waterbody and ingestion of the water. Recreational water should contain no chemicals that can irritate the skin of the human body. To protect swimmers from harmful effects through ingestion, the guidelines from tables 5.2.3 and 5.2.4 should be applied for other toxicants. Special care must be taken to check for substances that can enter the body by absorption through the skin. Higher concentrations of toxicants may be tolerated occasionally if it is assumed that no person will ingest more than a maximum of 100 mL water during a normal swimming session (NHMRC 1990) compared with 2 L/d for potable water.

Surface films

Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour.

The presence of oil and petrochemicals makes water aesthetically unattractive. They can form deposits on shorelines, and bottom sediments that are detectable by sight and odour. Some organic compounds can be absorbed directly from the water through the skin (CCREM 1991), making these substances even more undesirable in recreational areas.

Table 5.2.3 Summary of water quality guidelines for recreational purposes: general chemicals

Parameter	Guideline values (µg/L, unless otherwise stated)
Inorganic:	
Arsenic	50
Asbestos	NR
Barium	1000
Boron	1000
Cadmium	5
Chromium	50
Cyanide	100
Lead	50
Mercury	1
Nickel	100
Nitrate-N	10 000
Nitrite-N	1000
Selenium	10
Silver	50
Organic:	
Benzene	10
Benzo(*a*)pyrene	0.01
Carbon tetrachloride	3
1,1-Dichloroethene	0.3
1,2-Dichloroethane	10
Pentachlorophenol	10
Polychlorinated biphenyls	0.1
Tetrachloroethene	10
2,3,4,6-Tetrachlorophenol	1
Trichloroethene	30
2,4,5-Trichlorophenol	1
2,4,6-Trichlorophenol	10
Radiological:	
Gross alpha activity	0.1 Bq/L
Gross beta activity (excluding activity of ^{40}K)	0.1 Bq/L
Other chemicals:	
Aluminium	200
Ammonia (as N)	10
Chloride	400 000
Copper	1000
Oxygen	>6.5 (>80% saturation)
Hardness (as $CaCO_3$)	500 000
Iron	300
Manganese	100
Organics (CCE & CAE)	200
pH	6.5–8.5
Phenolics	2
Sodium	300 000
Sulfate	400 000
Sulfide	50
Surfactant (MBAS)	200
Total dissolved solids	1 000 000
Zinc	5000

NR = No guideline recommended at this time; MBAS Methylene blue active substances

Table 5.2.4 Summary of water quality guidelines for recreational purposes: pesticides

Compound	Maximum concentration (µg/L)	Compound	Maximum concentration (µg/L)
Acephate	20	Fenvalerate	40
Alachlor	3	Flamprop-methyl	6
Aldrin	1	Fluometuron	100
Amitrol	1	Formothion	100
Asulam	100	Fosamine (ammonium salt)	3000
Azinphos-methyl	10	Glyphosate	200
Barban	300	Heptachlor	3
Benomyl	200	Hexaflurate	60
Bentazone	400	Hexazinone	600
Bioresmethrin	60	Lindane	10
Bromazil	600	Maldison	100
Bromophos-ethyl	20	Methidathion	60
Bromoxynil	30	Methomyl	60
Carbaryl	60	Metolachlor	800
Carbendazim	200	Metribuzin	5
Carbofuran	30	Mevinphos	6
Carbophenothion	1	Molinate	1
Chlordane	6	Monocrotophos	2
Chlordimeform	20	Nabam	30
Chlorfenvinphos	10	Nitralin	1000
Chloroxuron	30	Omethoate	0.4
Chlorpyrifos	2	Oryzalin	60
Clopzralid	1000	Paraquat	40
Cyhexatin	200	Parathion	30
2,4-D	100	Parathion-methyl	6
DDT	3	Pendimethalin	600
Demeton	30	Perfluidone	20
Diazinon	10	Permethrin	300
Dicamba	300	Picloram	30
Dichlobenil	20	Piperonyl butoxide	200
3,6-Dichloropicolinic acid	1000	Pirimicarb	100
Dichlorvos	20	Pirimiphos-ethyl	1
Diclofop-methyl	3	Pirimiphos-methyl	60
Dicofol	100	Profenofos	0.6
Dieldrin	1	Promecarb	60
Difenzoquat	200	Propanil	1000
Dimethoate	100	Propargite	1000
Diquat	10	Propoxur	1000
Disulfoton	6	Pyrazophos	1000
Diuron	40	Quintozene	6
DPA	500	Sulprofos	20
Endosulfan	40	2,4,5-T	2
Endothal	600	Temephos	30
Endrin	1	Thiobencarb	40
EPTC	60	Thiometon	20
Ethion	6	Thiophanate	100
Ethoprophos	1	Thiram	30
Fenchlorphos	60	Trichlorofon	10
Fenitrothion	20	Triclopyr	20
Fenoprop	20	Trifluralin	500
Fensulfothion	20		

Sources: NHMRC & AWRC (1987), NHMRC (1989)