Queensland Health

Water quality guidelines for public aquatic facilities

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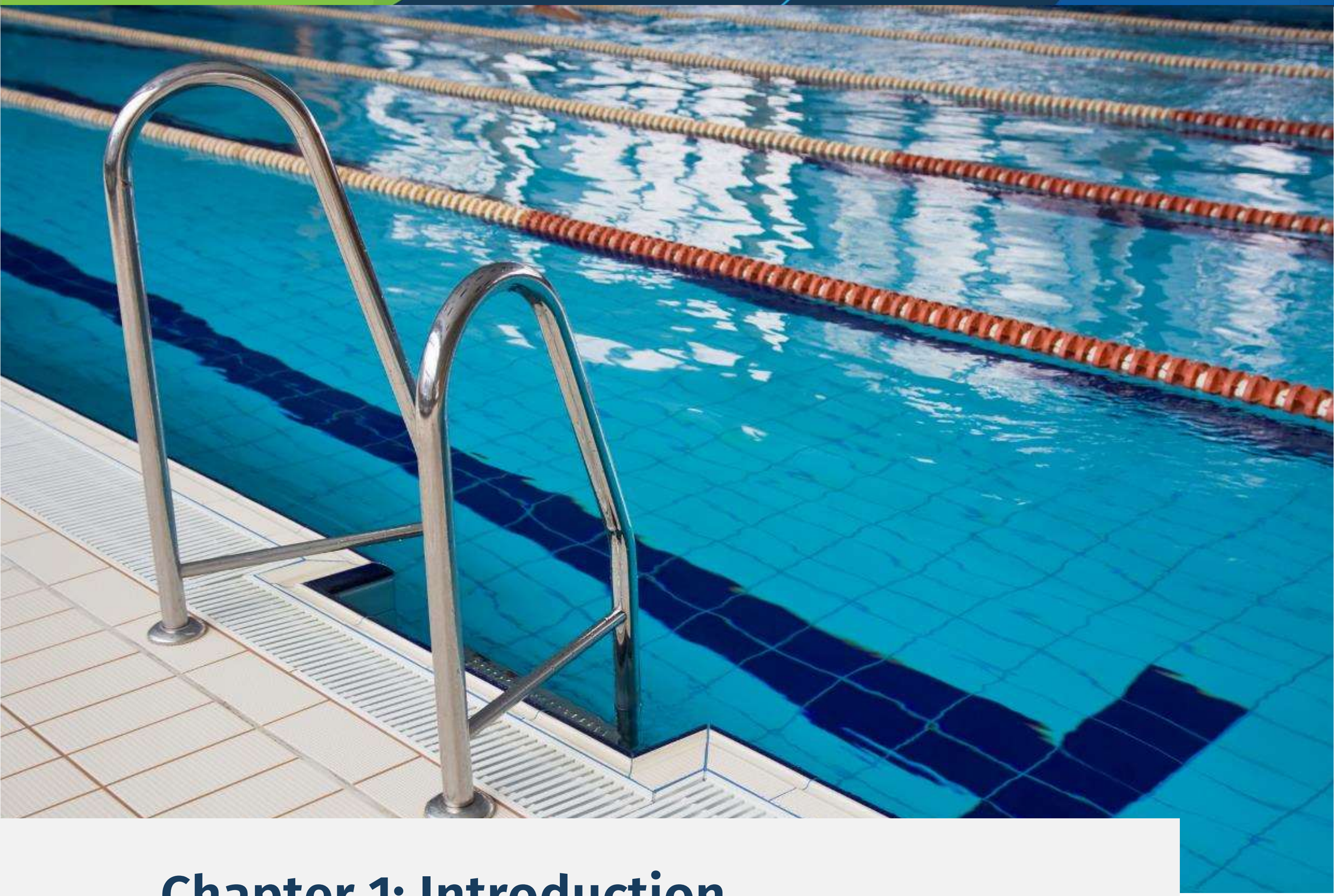


Chapter 1: Introduction

1.1 Purpose

While public aquatic facilities are vital for maintaining and promoting active lifestyles for improved health and wellbeing, these facilities have been associated with outbreaks of illness. Aquatic facility users, especially children, can be affected by disease-causing microorganisms that are passed through contaminated pool water, contaminated surfaces or through person-to-person contact.

This guideline assists organisations and people who operate public aquatic facilities to reduce risks to public health. The focus of the guideline is on water quality associated risks and does not consider risks related to pool design (e.g. hydraulics), physical safety (e.g. slips and falls), drowning or sun protection. It can also provide advice to local and state government environmental health officers to help fulfil their regulatory and advisory roles with respect to water quality.

1.2 Scope

The information and advice in this guideline apply to all public aquatic facilities. Public aquatic facilities are those that are commonly used by the public.

They include but are not limited to:

- public swimming pools and spa pools
- learn-to-swim pools
- school swimming pools
- aquatic facilities in gyms or fitness centres
- some aquatic facilities associated with apartment blocks, retirement complexes and strata title and body corporate developments
- aquatic facilities associated with holiday accommodation, including holiday parks, hotels, holiday apartment complexes and motels
- water theme parks, with installations such as water slides, wave simulators and 'lazy river' pools
- hydrotherapy pools
- domestic pools when used for commercial purposes (such as private learn-to-swim classes).

Specific information about interactive water features, also known as splash pads, spray parks and water play areas, is included in *Appendix 1*.

Although this guideline may be useful to domestic swimming and spa pool owners, questions about water quality or maintaining these pools are best directed to a pool shop or pool contractor.

Organisations that manage natural bodies of water for recreational use should refer to the latest edition of the National Health and Medical Research Council's *Guidelines for managing risks in recreational water* (refer to *Reference material*).

For operational matters not covered by this guideline, public aquatic facility operators should refer to the Royal Life Saving Society Australia *Guidelines for safe pool operations* (refer to *Reference material*). This is the recognised guidance document for pool managers to safely operate aquatic facilities and includes guidance for facility design, risk management, safety equipment, first aid, asset management, supervision and programs.

1.3 Site-specific risk management plans

Any public aquatic facility can use a site-specific risk management plan to help minimise potential public health risks. All public aquatic facilities are encouraged to have such a plan in place, however the use of risk management plans is particularly important for high-risk facilities (refer to *Table A2.4* Risk categories to inform monitoring frequencies *Risk Categories to inform monitoring frequencies* in *Appendix 2)*, where a facility cannot meet elements of this guideline, or where a facility falls outside the scope of this guideline.

A site-specific risk management plan may include:

- a description of the facility, its source water, and its treatment systems
- staff roles and responsibilities, competency or training requirements
- water quality targets and treatment objectives
- hazard identification
- risk assessment
- identification of control measures
- specific incident response procedures
- operational monitoring
- verification monitoring
- data recording and reporting
- stakeholder contact list.

Potential users of the aquatic facility, including any vulnerable groups such as children, immune compromised, pregnant or elderly bathers should be considered in the risk assessment. For example, an aged care or hospital aquatic facility may implement additional controls such as increased frequency of verification monitoring to verify water quality is within specification.

Chapter 2: Public health hazards associated with public aquatic facilities

Key points

- Poorly managed public aquatic facilities can create ideal conditions for spreading disease.
- In public aquatic facilities, microbiological hazards pose the greatest risk to health because they can cause outbreaks of disease.
- Chemicals can pose a risk to the health of bathers and staff.

Public aquatic facilities are important for maintaining and promoting active lifestyles. Although using public aquatic facilities provides many health benefits, if aquatic facilities are not properly managed, the health of bathers may be put at risk. This is particularly relevant for vulnerable groups such as young children, the elderly and people with low immunity.

Bathers can be affected by disease-causing microorganisms (pathogens) that are passed on through contaminated pool water, contaminated surfaces or person-to-person contact.

Similarly, certain chemicals can put the health of bathers at risk. This chapter provides general guidance on the types of public health hazards that bathers can be exposed to in public aquatic facilities.

2.1 Microbiological hazards

Microbiological hazards that can cause illness in humans include viruses, bacteria, protozoa and fungi. In public aquatic facilities, microbiological hazards pose the greatest risk to public health because they can cause outbreaks of illness.

Microbiological hazards are typically introduced into aquatic facilities through the following sources:

- faecal matter– for example, from a contaminated water source, through faecal accidents, or through shedding of faecal matter from bathers.
- other contaminants – for example, shedding from human skin, mucus, vomit or other secretions, from animals, windblown matter, stormwater runoff, or natural inhabitants of warm water environments (such as blue-green algae) that flourish if introduced into poorly disinfected aquatic facilities.

Table 1 lists common illnesses related to microbiological hazards in public aquatic facilities. Gastroenteritis and skin, wound and ear infections are the most common. Other conditions such as respiratory illnesses caused by *Legionella* are less common and are typically associated with poorly maintained spa pools. Illness caused by *Acanthamoeba*, atypical Mycobacterium, *Leptospira* and *Naegleria* from aquatic facilities are uncommon, with infrequent reports of illness in Australia or internationally.

Table 1: Illnesses associated with aquatic facilities

Type of illness	Group of causal microorganisms	Example of causal microorganism	Example source of causal microorganism
Gastroenteritis	**Virus**	*Norovirus* Hepatitis A	Faecal accidents Bather shedding Vomit accidents
		Adenovirus	
	Bacteria	*Escherichia coli (E. coli)*	
		Shigella	
		Campylobacter	
	Protozoan parasite	*Cryptosporidium*	
		Giardia	
Skin, wound and ear infections	**Bacteria**	*Pseudomonas aeruginosa*	Bather shedding in water or on wet surfaces
		Staphylococcus aureus	
	Virus	Molluscum contagiosum	Bather shedding in water, wet surfaces or swimming aids
		Papillomavirus (plantar wart)	Bather shedding in water or wet surfaces, in particular on changing room floors and in showers
		Varicella-zoster virus (chickenpox)	Direct contact with infectious fluid from an infectious person such as sharing a towel with an infectious person
	Fungi	Tinea pedis (athlete's foot)	Bather shedding on floors in changing rooms, showers and facility decks
Eye and nose infections Respiratory infections	**Virus**	Adenovirus	Faecal accidents (and nasal and eye secretions)
Swimming pool granuloma	**Bacteria**	Atypical mycobacterium	Bather shedding in water and on wet surfaces

Type of illness	Group of causal microorganisms	Example of causal microorganism	Example source of causal microorganism
Hypersensitivity Pneumonitis			Aerosols from spas and water sprays
Legionellosis (Pontiac fever and Legionnaires' disease)	**Bacteria**	*Legionella*	Aerosols from spas and water sprays Poorly maintained showers
Granulomatous amoebic encephalitis (GAE) Keratitis	**Protozoan amoeba**	*Acanthamoeba*	Aerosols from spas Bather shedding in water or on wet surfaces
Wide ranging from flu-like symptoms to severe organ disease	**Bacteria**	*Leptospira*	Urine from infected animals
Primary amoebic meningoencephalitis (PAM)	**Protozoan amoeba**	*Naegleria fowleri*	Warm water environments that are inadequately disinfected Biofilm in pipes and other components in inadequately disinfected waters

Adapted from: NSW Department of Health 2013-Public swimming pool and spa pool advisory document

The risk of passing on illness increases if the pool water is not properly managed. Of all the microbiological hazards listed in *Table 1*, *Cryptosporidium*, the cause of the illness cryptosporidiosis, is responsible for most outbreaks of illness associated with public aquatic facilities. *Cryptosporidium* causes diarrhoea that, in some cases, can last up to 30 days. *Cryptosporidium* is a problematic microbiological hazard in public aquatic facilities because *Cryptosporidium* oocysts are much more resistant to chlorine disinfection than other microbiological hazards. Also, a person affected by cryptosporidiosis can continue to have *Cryptosporidium* oocysts in their faeces for several weeks after the symptoms have gone. Therefore, an exclusion period of at least 14 days after all symptoms have ceased is recommended to prevent potential contamination of a public aquatic facility.

2.2 Chemical hazards

Chemical hazards can pose a risk to the health of bathers and staff. It is important that chemicals are used and stored according to the manufacturer's instructions. Personnel who handle chemicals should be appropriately trained and wear the correct personal protective equipment. Safety Data Sheets should be available onsite for all chemicals used by a public aquatic facility.

Disinfection by-products can also pose health risks. Disinfection by-products are chemical compounds that form when disinfection chemicals react with contaminants from the skin, hair, sweat, saliva, urine and other organic matter. The most common disinfection by-products associated with public aquatic facilities are chloramines and trihalomethanes.

Disinfection by-products pose a risk not only to water quality but also to air quality in indoor facilities. To help ensure the health and comfort of bathers and staff, ventilation rates detailed in the *Building Code of Australia* (Council of Australian Governments, 2016) and Australian Standard 1668.2 should be followed for all indoor facilities.

2.3 Environmental hazards

Although bathers are mostly responsible for introducing contamination, it can also be introduced from the surrounding environment and can vary seasonally. Environmental contamination can be a particular problem for outdoor aquatic facilities where matter such as dust, soil, sand, leaves and grass can easily enter the pool. Birds, bats and other animals can also contaminate the pool with their droppings.

2.4 Water supply

The best available water supply, ideally mains drinking water, should always be used to fill a pool. Roof-harvested rainwater could be used for pools provided it is introduced into the pool through the balance tank to allow sufficient treatment. Recycled water, including treated stormwater or sewage, is not suitable to use in swimming pools due to risks to human health from microbiological and chemical contaminants.

Chapter 3: Regulatory framework

Key points

- The *Public Health Act 2005* provides environmental health officers with powers to manage public health risks associated with public aquatic facilities.
- Local governments may enact local laws about public aquatic facilities.

3.1 Public Health Act 2005

In Queensland, public health risks associated with public aquatic facilities are overseen by local governments under the *Public Health Act 2005* (the Act). The Act provides local government environmental health officers with powers to help them determine whether there is a public health risk at a public aquatic facility. The Act also provides enforcement tools to address public health risks.

State Government environmental health officers may oversee the management of public health risks associated with the use of State Government-owned or operated public aquatic facilities. State Government environmental health officers may also provide advice in response to an outbreak of disease that has occurred at any public aquatic facility or on the remediation of a contaminated aquatic facility.

The Act does not require compliance with this guidance document. However, environmental health officers may use it to help determine whether a public health risk exists and whether public aquatic facilities are being appropriately managed.

3.2 Links to local laws and other local government permits and contracts

Some Queensland local governments have enacted local laws regarding public aquatic facilities under the *Local Government Act 2009*. These laws, in addition to conditions specified on permits or in operational contracts, may specifically require aquatic facility operators to comply with elements of this guideline that are suitable for compliance purposes. Public aquatic facility operators should check with their local council to find out if there are any relevant local laws in their local government area.

3.3 Australian Pesticides and Veterinary Medicines Authority registered products

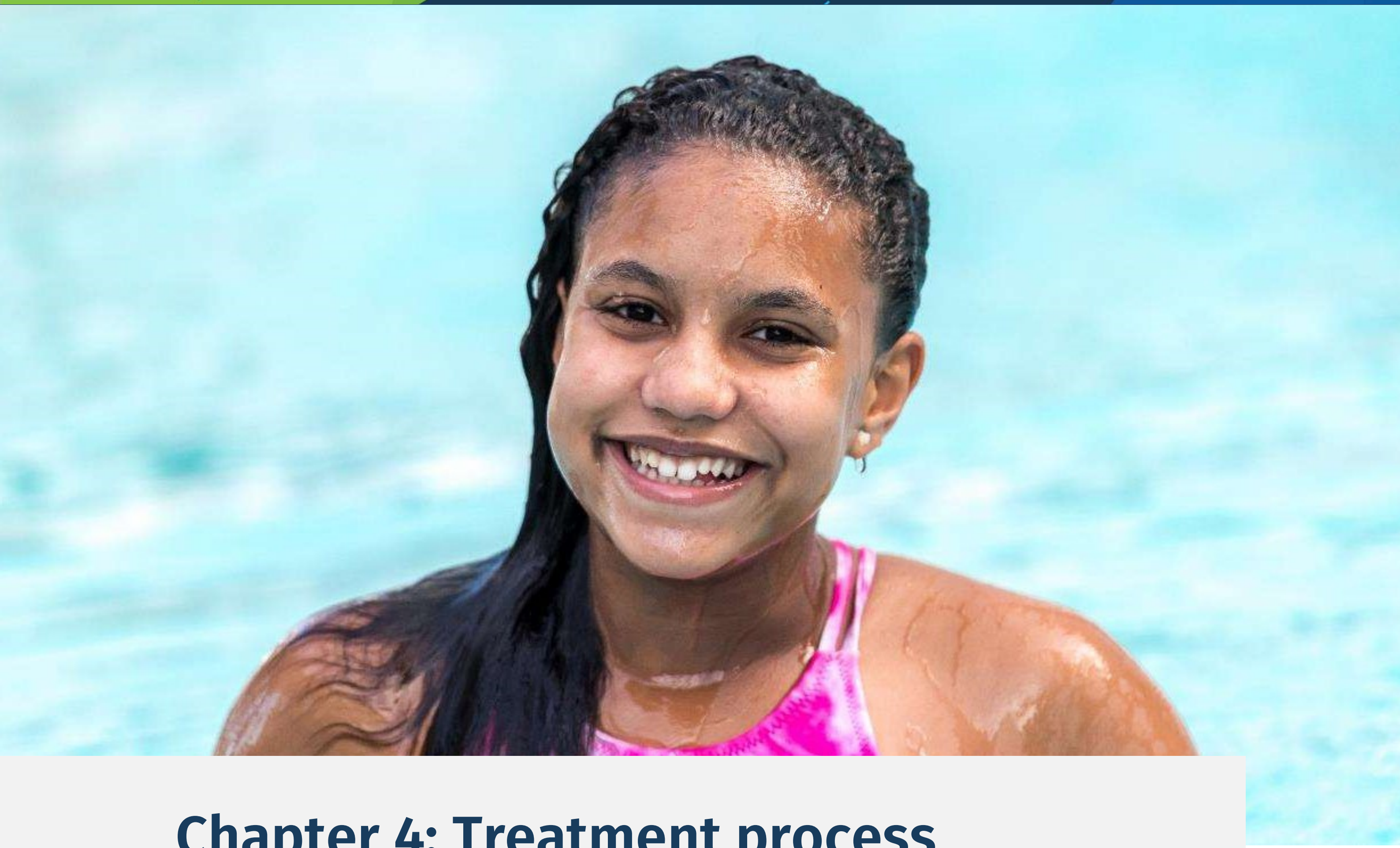
Swimming pool and spa chemicals sold in Australia are regulated under the Australian Government's *Agricultural and Veterinary Chemicals Code Act 1994*. The Australian Pesticides and Veterinary Medicines Authority (APVMA) operates the Australian system that evaluates, registers and regulates agricultural, veterinary and swimming pool chemicals. This means that swimming pool and spa chemical products must be registered with the APVMA before they can be sold to the leisure industry or to the general public.

The APVMA requires that spa and pool chemical suppliers and manufacturers show they have followed a rigorous process before the product can be registered for use in Australia. This process is described on the link to the APVMA website shown in the *Reference material* section of this guideline.

Queensland Health only supports using primary disinfectants (as discussed in *section 4.2.2*) that have been registered with the APVMA or have undergone independent testing against the APVMA's guidelines. The APVMA's database of registered products can be searched via the link to the APVMA website shown in the 'Reference material' section of this guideline.

3.4 Australian Standards

There are a number of Australian Standards that apply to public aquatic facilities. Where they are relevant for a particular facility, the most recently published Australian Standards should be complied with. A list of Australian Standards that apply to public aquatic facilities is provided in the *Reference material* section of this guideline.



Chapter 4: Treatment process

Key points

- Aquatic facilities should adopt a multi-barrier approach to protect water quality; this means there should be two or more types of treatment processes to reduce pathogen risk.
- At a minimum, treatment processes must include filtration combined with primary (chlorine- or bromine-based) disinfection.
- Secondary disinfection is recommended for all public aquatic facilities, particularly for high-risk facilities where there is a need for extra protection against *Cryptosporidium*.

Public aquatic facilities must maintain suitable water quality to prevent the spread of illness. Facilities are expected to have effective treatment barriers in place to reduce harmful microorganisms including viruses, bacteria and protozoan parasites. All public aquatic facilities should adopt a multi-barrier approach which involves two or more types of treatment processes to address pathogen risk. Each barrier (treatment process) on its own may not be able to completely remove or prevent contamination, but together, the barriers work to provide greater assurance that the water will be safe for use. Treatment processes need to be operated, monitored and maintained in accordance with manufacturer's instructions to minimise variability in performance.

At a minimum, treatment processes should include filtration combined with primary (chlorine- or bromine-based) disinfection. For facilities categorised as high-risk, additional secondary disinfection such as ultraviolet (UV) disinfection or ozone is recommended to reduce *Cryptosporidium* risk.

4.1 Filtration

Key points

- Effective filtration improves the efficacy of disinfection and is an essential treatment step for protecting the health of public aquatic facility users.
- Filters capable of removing *Cryptosporidium* oocysts (4 microns in diameter) reduce the risk of cryptosporidiosis in bathers.
- New filtration systems should be designed to maximise the removal of *Cryptosporidium*.

In basic terms, filtration is a process of separating solids from liquids. In a public aquatic facility, filtration is a treatment process that physically removes suspended particles from the water. Effective filtration is an essential pre-treatment to effective disinfection.

Filters are often categorised according to their allowable operating flow rates. The flow rate is a measure of how much water flows through each square metre of the filter medium's surface area per hour and is expressed as cubic metres per hour per square metre ($m^3/hr/m^2$), also described as the filtration flux (flowrate per unit area). Generally, the slower the flow of water through the filter, the more efficiently it removes particles. Filters installed at an aquatic facility will have a maximum operational flowrate, based on the flux suitable for effective filtration.

New filtration systems should be designed to maximise the removal of *Cryptosporidium*. Filters capable of removing particles 4 microns in diameter (refer to National Health and Medical Research Council's *Australian Drinking Water Guidelines* in *Reference material*) and achieving a filtrate turbidity of 0.2 NTU consistently will provide additional protection against *Cryptosporidium*, noting that new aquatic facilities should also employ a secondary disinfection system (see *4.2.3*).

> *'With chlorine-tolerant human pathogens like Cryptosporidium becoming increasingly common in aquatic venues, effective filtration is a crucial process in controlling waterborne disease transmission and protecting public health.'*
>
> **World Health Organization 2006**

Where a public aquatic facility has a number of different pools or water attractions, each water body should ideally have its own filtration system. Independent filtration systems for each water body provides the potential to isolate water bodies at higher risk of contamination from lower risk pools, thereby allowing for some parts of the facility to remain open if only one water body becomes contaminated. This is particularly important if pools are used by young children who have not been toilet-trained.

Each filtration system should ideally have multiple filter units to allow backwashing of one filter whilst maintaining filtration of the recirculating pool water. This flexibility also enables a planned inspection and maintenance program, which is essential for filter efficiency.

Filtration types differ markedly in terms of the media, coagulant, process configuration and the operational conditions applied. Each filter type should be operated in accordance with the manufacturer's specified operating parameters including filtration rates and run times, head loss and backwash rates. The filter should be based on maximum bather numbers, operating 24 hours per day.

The following processes make filtration more effective:

- Coagulation. Where the filtration system incorporates coagulation, the use of coagulants and flocculants, when used in accordance with manufacturer's instructions, can assist with the removal of fine, dissolved, colloidal or suspended material, and pathogens.
- Backwashing. Backwashing is the process of reversing the flow of water back through the filters to flush trapped material to waste. Backwashing should take place whenever the difference between the filter inlet pressure and the filter outlet pressure (differential pressure, or pressure drop) reaches a level identified by the manufacturer or based on a maximum filtration timeframe. Backwash water should always be sent to waste; the concentration of contaminants in backwash water makes it unsuitable for re-use (without advanced treatment).
- For media filters discard filtrate immediately following backwashing until the filtrate runs clear. This will help minimise breakthrough of particulates following backwashing.

Cartridge filters must be removed and cleaned according to manufacturer's instructions.

To monitor the efficacy of the filtration system, the operational monitoring program should include monitoring of the coagulation dosing process, flowrate, filtration cycle including filter-to-waste times, triggers for backwashing and turbidity.

Turbidity should be monitored immediately post filtration. The recommended limits for turbidity are listed in *Table A2.1* and *Table A2.2* in *Appendix 2.*

4.2 Disinfection

Key points

- Chlorine- and bromine-based disinfectants are the only chemical-based disinfectants acceptable for use in public aquatic facilities for primary disinfection.
- Recommended disinfectant residuals (concentrations) should be maintained at all times.
- Automatic dosing is recommended for all facilities for consistent and reliable dosing.
- Automatic dosing enables the operator to respond to variables, such as bather numbers and weather conditions, that can modify dosing requirements.
- Secondary disinfection is recommended for all public aquatic facilities, particularly for high-risk facilities where there is a need for extra protection against *Cryptosporidium*.
- Secondary disinfection should be designed to achieve a minimum 99.9% inactivation of *Cryptosporidium* oocysts as water passes through the disinfection system.
- Pool circulation systems should have adequate water turnover to ensure disinfected water is present in all parts of the aquatic facility.
- Operators of public aquatic facilities should implement proactive strategies to manage disinfection by-products.

Effectively disinfecting the water in a public aquatic facility is the best way to protect the health of bathers. Disinfection is the process of inactivating disease-causing microorganisms through either physical destruction (e.g. by ultraviolet light) or by adding specific disinfectant chemicals (e.g. ozone). Filtration of pool water is required to remove particles and allow chemicals to directly contact microorganisms; therefore, disinfection systems should be located post filtration and treat 100% of the filtration flow.

Not all disinfectants available on the market are fit for use in a public aquatic facility. Ideally a disinfectant should:

- be able to inactivate all disease-causing microorganisms
- be fast-acting
- maintain lasting residual effectiveness
- be dosed easily, accurately and safely
- be non-toxic to humans at levels required for effective disinfection
- not cause damage to infrastructure
- be able to be measured accurately and simply on site.

In practice, no single disinfectant is able to meet all of these criteria completely.

The most suitable type of disinfectant will depend on a range of factors including:

- indoor or outdoor situation
- the type of aquatic facility – such as general pool or specialised hydrotherapy
- the chemical characteristics of the water supply
- the number of people who use the facility
- circulation capacity and pool design
- chemical handling and safety issues
- supervision and maintenance requirements
- pool water temperatures.

4.2.1 Types of disinfectants

In this guideline, disinfectants are categorised as either ‘primary’ or ‘secondary’ disinfectants. Primary disinfectants must not only be capable of killing hazardous microorganisms, but they must also persist in the water to provide ongoing disinfection. They provide the greatest overall level of disinfection and should therefore be used at all public aquatic facilities. As mentioned in Chapter 3, in Australia the APVMA assesses primary disinfectants for their effectiveness and safety.

At the time of publication, the only primary disinfectants registered by the APVMA and acceptable to use in public aquatic facilities, are specific compounds that are chlorine- or bromine-based. These disinfectants are generally effective at inactivating viruses and bacteria that can cause disease. However, neither chlorine nor bromine is effective against *Cryptosporidium* at levels that are acceptable for general use when the pool is operational.

Secondary disinfectants generally boost or support primary disinfection and are recommended for all facilities, particularly for high risk facilities (refer to *Table A2.4* in *Appendix 2*) where there is a need for extra protection against *Cryptosporidium*. Commonly accepted secondary disinfection systems include ozone and UV disinfection systems.

4.2.2 Primary disinfectants

4.2.2.1 Chlorine-based disinfectants

[Refer to *Table A2.1* in *Appendix 2* for the chemical criteria for facilities using chlorine-based disinfectants.]

Chlorine is the most common primary disinfectant and is generally effective at inactivating viruses and bacteria that can cause disease. Chlorine is not effective against certain protozoa such as *Cryptosporidium* at levels that are acceptable for regular use.

Approved chlorine-based chemicals include:

- elemental chlorine gas
- liquid chlorine (sodium hypochlorite)
- granular chlorine (calcium and lithium hypochlorite)
- electrolytic generation of chlorine from salt (salt chlorination)
- stabilised chlorine granules/tablets (dichloroisocyanurate and trichloroisocyanurate).

The concentration of stock chlorine solutions can degrade quickly with improper storage. As with all chemicals, chlorine should be stored in accordance with the label instructions.

When chlorine is added to water it forms a mixture of hypochlorous acid (a strong disinfectant) and hypochlorite ions (a weaker disinfectant). Together, hypochlorous acid and hypochlorite ion make up what is known as ‘free chlorine’.

The pH of the water will affect how much of the stronger disinfectant (hypochlorous acid) is formed. To ensure free chlorine remains effective, pH is recommended to be maintained within the range listed in *Table A2.1* in *Appendix 2*. If the pH drops too low, it may affect bather comfort; if it becomes too high the free chlorine will lose most of its disinfection power.

Free chlorine can react with nitrogen-containing contaminants in the water, such as ammonia, to form ‘combined chlorine’ or ‘chloramine’. Combined chlorine is unwanted because it is not only a poor disinfectant, but it can also cause skin irritation, eye irritation, corrosion and a strong and offensive ‘chlorine smell’.

When added together, free and combined chlorine is called ‘total chlorine’. When evaluating total chlorine values, the combined chlorine value should not exceed the level stated in *Table A2.1* in *Appendix 2*.

Chlorine demand

Chlorine demand reflects the amount of free chlorine that is lost or used up through reactions with microorganisms and other contaminants in the water; it is the difference between the amount of chlorine added to the water and the amount of free available chlorine or combined chlorine remaining at the end of a specified time period. Chlorine demand is often relative to the number of bathers but is ultimately related to the total amount of contaminants in the water (leaves, dirt, cosmetics, sunscreen etc.). The greater the chlorine demand, the greater the amount of chlorine that will need to be added to the water to ensure the minimum recommended free chlorine level is maintained at all times. Chlorine demand can be reduced by encouraging bathers to shower before they enter the water and designing public aquatic facilities such that environmental contamination is minimised.

Stabilised chlorine

In outdoor facilities sunlight breaks down chlorine, which can lead to significant loses of free chlorine. Stabilised chlorine (chlorine with cyanuric acid added to it) can be used to address this issue because cyanuric acid bonds loosely to the free chlorine to minimise the impact of UV light. It can be purchased as granules/tablets or can be formed by adding cyanuric acid to water containing free chlorine.

The decision to use stabilised chlorine in an outdoor aquatic facility and the level at which it is added should be balanced against the need for immediate remediation in the event of a diarrhoeal incident or *Cryptosporidium* contamination incident (refer to *Appendix 6*). Use of stabilised chlorine can affect the effectiveness of hyperchlorination procedures. For hyperchlorination to be undertaken, cyanuric acid concentration levels need to be dropped below 15 mg/L. This may involve partially draining the pool and adding fresh water.

The maximum level of cyanuric acid that is recommended to be added to an outdoor pool is detailed in *Table A2.1* in *Appendix 2*. Cyanuric acid reduces the disinfection power of hypochlorous acid, therefore the minimum free chlorine level should be maintained at the level listed in *Table A2.1* in *Appendix 2*. Cyanuric acid should not be used in indoor pools.

4.2.2.2 Bromine-based disinfectants

[Refer to *Table A2.2* in *Appendix 2* for the chemical criteria for facilities using bromine-based primary disinfectants.]

Bromine is another primary disinfectant that works in a similar way to chlorine. Bromine-based chemicals include:

- bromo-chloro-dimethylhydantoin (BCDMH) tablets
- sodium bromide with an activator (hypochlorite or ozone).

Bromine is more stable at higher temperatures than chlorine but slightly less effective as a disinfectant, therefore the minimum concentrations must be higher. Bromine is commonly used in spa pools but, because it will decay in sunlight and cannot be stabilised, is rarely used in larger outdoor aquatic facilities.

The effectiveness of bromine is also affected by pH but to a lesser extent than for chlorine. To ensure bromine remains effective, pH should be maintained within the range detailed in *Table A2.2* in *Appendix 2.*

Bather contact with brominated pool water can lead to skin issues such as itching and rashes. However, skin irritation is less likely to occur in properly maintained facilities where the right water balance is maintained and where regularly exchanging water prevents a build-up of disinfection by-products and other chemicals.

4.2.3 Secondary disinfectants

Secondary disinfection is recommended for all public aquatic facilities, particularly for high risk-facilities (refer to *Table A2.4* in *Appendix 2*) where there is a need for extra protection against *Cryptosporidium*.

4.2.3.1 Ultraviolet disinfection

UV disinfection has a higher energy than visible light but, because it has a shorter wavelength, it is invisible to the human eye. UV light is a powerful secondary disinfectant, particularly against bacteria and protozoa such as *Cryptosporidium*. The germicidal wavelength of UV light kills or inactivates these microorganisms by destroying the nucleic acid inside them. However, because no lasting disinfection residual can be provided, UV light is not considered a primary disinfectant.

UV disinfection systems should be designed for full flow (not side stream) to achieve a minimum 99.9%, inactivation of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 99%, reduction for all other types of facility (Centers for Disease Control and Prevention, 2018).

UV disinfection systems typically have one or more UV lamps installed in the pipework where the pool water circulates. The 'sleeves' that protect the UV lamps must be cleaned regularly so the lamps continue to emit the correct dose. The clarity and flow rate of the water can also impact the effectiveness of UV lamps, therefore the operational limits set by the manufacturer should be complied with. Some UV disinfection systems have self-cleaning lamp sleeves and provide for real-time monitoring of the dose rate.

The maximum and minimum levels required for chlorine and bromine remain the same when using UV disinfection. UV disinfection systems should be positioned before any chlorine or bromine dosing points because the UV light can reduce the concentration of disinfectant residual in the water.

4.2.3.2 Ozone

Ozone is a highly reactive gas that can be dissolved in water. When dissolved in water, it acts as a powerful disinfectant that can inactivate a wide range of disease-causing microorganisms. Ozone is not considered a primary disinfectant because no lasting residual can be provided.

Ozone is typically used with chlorine as a secondary disinfectant. It provides greater disinfection power and can inactivate *Cryptosporidium* oocysts. Ozone systems should be designed to achieve a 99.9%, reduction of *Cryptosporidium* for interactive water features (splash pads, spray parks and water play areas) and a minimum 99%, reduction for all other types of facility (Centers for Disease Control and Prevention, 2018).

When ozone returns to its gaseous form, it can cause respiratory irritation. Therefore, where ozone is used as part of the water treatment system it must be removed from the water ('quenched') before the water is returned to the part of the facility where bathers are exposed. The treatment systems should include an activated carbon bed or ozone destructor for quenching ozone before the treated water is returned to the area where people are using the water.

The maximum and minimum levels required for chlorine should be maintained when using ozone. Ozone systems should be located before any chlorine dosing points because the activated carbon bed or ozone destructor will also remove any chlorine in the water.

> Avoid the use of ozone with BCDMH because it may produce bromate, a harmful disinfection by-product.

4.2.3.3 Chlorine dioxide

Unlike chlorine-based disinfectants, chlorine dioxide is not a form of primary disinfection because it does not produce free chlorine. Chlorine dioxide is a powerful disinfectant; however, it is more complex to dose consistently compared with chlorine and bromine. Some public aquatic facilities may use chlorine dioxide as a supplementary 'shock treatment' to manage health risks associated with *Cryptosporidium* and *Giardia* or the build-up of biofilm. If the chlorine dioxide manufacturer has validated the treatment efficacy, some facilities may choose to use chlorine dioxide for managing chloramine concentrations or in response to faecal contamination incidents.

4.3 Automatic chemical dosing

Automatic dosing of primary disinfectants is recommended for all public aquatic facilities. Automatic dosing systems can be programmed with a set range of values that ensure optimal disinfection. Automatic dosing systems will range in complexity but, at a minimum, all dosing systems should be operated to ensure chemicals are dosed within the operational set point range to ensure the appropriate disinfectant residual is maintained at all times More advanced automatic dosing systems allow for 'proportional dosing' whereby the dose rate varies according to the magnitude of the deviation from the set point.

4.4 Disinfection by-products

Disinfection by-products are unwanted chemical compounds that form when disinfection chemicals react with organic matter in the water, including contaminants from skin, hair, sweat, saliva and urine. The most common disinfection by-products associated with public aquatic facilities are chloramines and trihalomethanes. Public health risks from disinfection by-products in aquatic facilities are likely to be low. By contrast, microbiological risks are significant if disinfection is inadequate. At no time should disinfection be compromised or reduced over concerns relating to disinfection by-products.

4.4.1 Chloramines

Chlorine reacts with certain nitrogen-containing compounds introduced by bathers (mostly urine and sweat) to form chloramines (also known as 'combined chlorine'). Chloramines can cause skin and eye irritation and have a strong smell that bathers often incorrectly associate with high levels of chlorine.

Chloramines can also affect air quality in indoor venues. As such, adequate ventilation is essential. Specific advice on controlling the air quality impacts of chloramines in indoor facilities is contained in the NSW Department of Health's (2013) fact sheet *Controlling chloramines in indoor swimming pools* (refer to *Reference material*).

Reducing the amount of nitrogen-containing compounds introduced into the water will help to reduce the rate at which chloramines are produced. Requiring bathers to shower with soap and rinse well before swimming or entering the water, and strongly encouraging regular toilet breaks, can help achieve this.

Chloramines can be controlled with secondary disinfection systems such as UV disinfection and ozone. Alternatively, breakpoint chlorination or oxidisers - such as hydrogen peroxide, chlorine dioxide and potassium monopersulphate - can be used. Breakpoint chlorination is a process where enough chlorine is added to a pool to oxidise chloramines in the water to ensure an effective free chlorine residual is produced.

Chloramines can also be controlled in public aquatic facilities by regular shock dosing of chlorine to a concentration of at least 10 times the combined chlorine concentration. To prevent harm, shock dosing must only occur when the facility is closed. The facility should not be reopened until the total chlorine level is less than 10 mg/L. In instances where shock dosing does not remove or reduce chloramines, replacing a proportion of the facility's water with fresh water can reduce the level of chloramines present.

4.4.2 Brominated disinfection by-product

Bromine can react with certain organic chemicals to form brominated disinfection by-products. Reducing the amount of organic chemicals introduced into the water will help to reduce the rate at which brominated disinfection by-products are produced. Requiring bathers to shower with soap and rinse well before swimming or entering the water, and strongly encouraging regular toilet breaks, can help achieve this.

4.4.3 Trihalomethanes

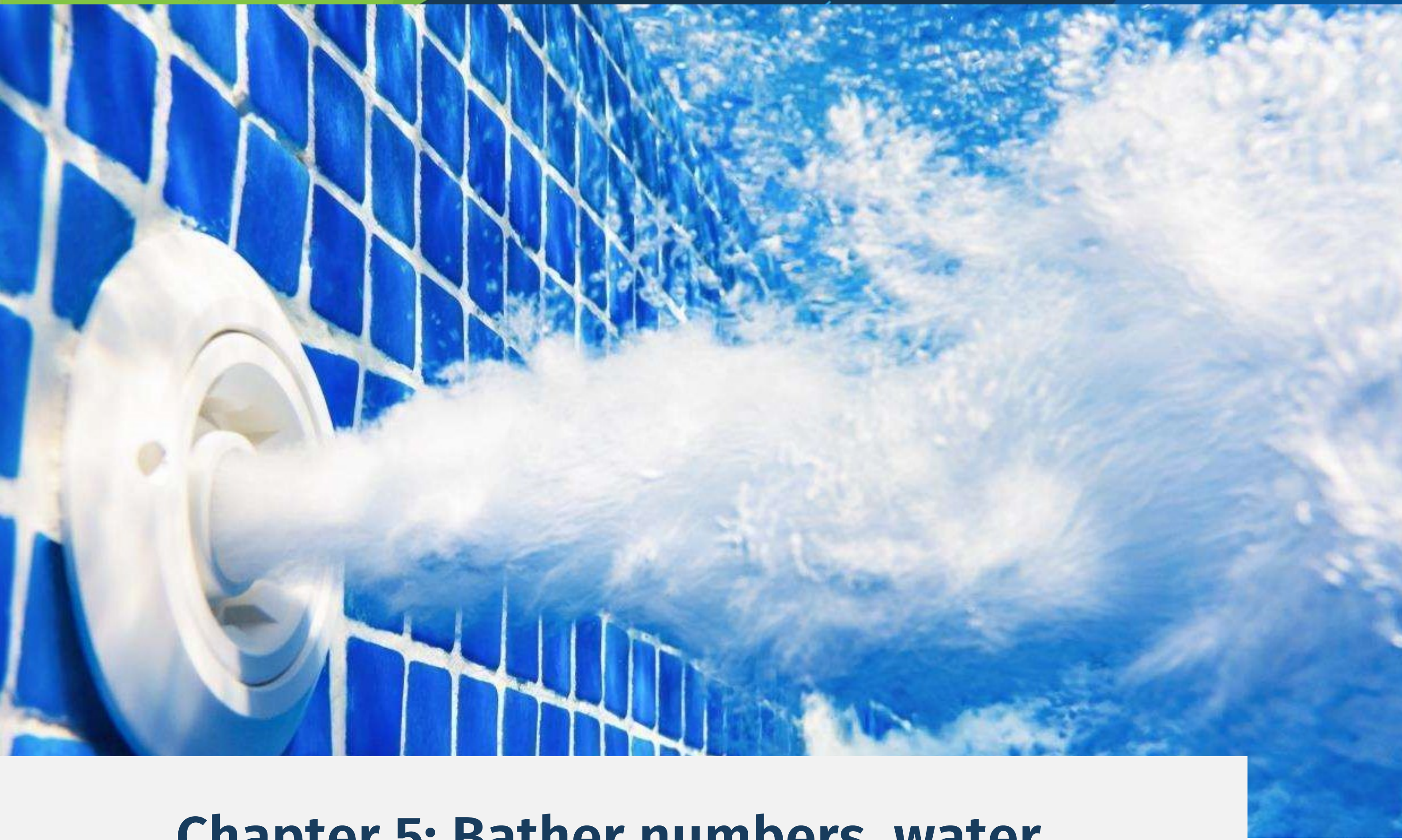
Trihalomethanes are produced when chlorine- and bromine-based disinfectants react with organic matter that is introduced by bathers, the surrounding environment, or is present in source water. While long term exposure to elevated levels of trihalomethanes may be hazardous to human health, in a well-managed aquatic facility they are unlikely to be a significant health risk.

> ‘The risks from exposure to chlorination by-products in reasonably well managed swimming pools would be considered to be small and must be set against the benefits of aerobic exercise and the risks of infectious disease in the absence of disinfection.’
>
> **– World Health Organization 2006**

Like chloramines and brominated disinfection by-products, the level of trihalomethanes can be minimised by getting bathers to shower using soap and rinse thoroughly before they enter the water.

4.5 Troubleshooting guide

Many variables can affect public aquatic facility treatment systems. Common issues have been summarised in the troubleshooting guide in *Appendix 3*. The information provided should be used as a guide only. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff is at risk. Only suitably qualified or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to seek professional advice.



Chapter 5: Bather numbers, water circulation and turnover times

Key points

- A facility should strike a realistic balance between the number of bathers it allows and the capacity of the facility and treatment plant.
- Effective water circulation ensures treated water reaches all areas of the facility and that polluted water is removed efficiently.
- Short turnover times, in combination with filters that are capable of removing *Cryptosporidium* and/or secondary disinfection systems that are capable of inactivating *Cryptosporidium*, provide the highest level of protection.

5.1 Bather numbers

Working out the maximum number of bathers that a facility can accommodate should take into account a number of factors including the surface area of water in the facility, the water depth, the type of activity and the capability of the water treatment plant.

The maximum bather numbers for a facility should be recorded and pool managers should ensure systems are in place so the maximum bather number is not exceeded.

Where entrance to the facility cannot be controlled, the issue of bather numbers should be addressed in a facility risk management plan.

The maximum bather numbers should be reviewed regularly to determine whether the treatment system is capable of maintaining the water quality. If the maximum bather number is approached or exceeded, then operators may need to:

- implement strategies to reduce bather numbers (e.g. by sectioning off parts of the pool)
- increase the treatment plant capability
- further dilute the pool water with fresh water
- use additional treatment such as ozone or UV disinfection.

5.2 Water circulation

Efficient water circulation in a public aquatic facility is very important because it ensures pollutants are adequately removed as quickly as practicable and that treated water reaches all areas of the facility.

Ideally the majority of pool water should be taken from the surface of the pool because it contains the highest concentration of pollutants. The remainder should be drawn from the bottom to remove grit and other matter that accumulates on the floor. Undertaking a dye test is a reliable way of assessing water circulation and should be conducted during commissioning of a new facility and repeated following any changes to the filtration or hydraulic system as well as routinely to ensure water circulation remains effective. A procedure for undertaking dye tests is detailed in the Water Circulation Dye Test (Centers for Disease Control and Prevention, 2016).

5.3 Turnover times

Turnover time is the time taken for a quantity of water that is equal to the volume of water in the aquatic facility to pass through the filtration system.

Facilities with high bather numbers and low volumes of water (such as shallow wading pools and spas) require short turnover times, so that water is circulated through the treatment process more frequently. This is due to the potential for higher contaminant loads in the water. Facilities with low bather numbers and high volumes of water (such as diving pools) can use longer turnover times.

A shorter turnover time means there is less time between when contaminants are introduced into the water and when that water passes through the facility's water treatment plant. Using a secondary disinfection system, or a filter that is capable of removing *Cryptosporidium*, means the risk to bathers is reduced. This is the basis of the worldwide trend to decrease the turnover time for public aquatic facilities.

A public aquatic facility operator may have limited control over the turnover time for an existing water treatment system. However, when retrofitting or upgrading an existing pool, or constructing a new public aquatic facility, best practice turnover times should be adopted, and the inlets and outlets should be positioned so they provide the best water circulation and contaminant removal.

Recommended turnover times for different types of public aquatic facilities are detailed in *Table A4.1* in *Appendix 4*.

Chapter 6: Managing water balance

Key points

- Appropriately balanced water is essential for effective disinfection, bather comfort and protecting the aquatic facility's infrastructure.
- The most common method for checking the water balance is to use the Langelier Saturation Index, which takes account of the water's pH, total alkalinity, calcium hardness, total dissolved solids and temperature.

Water balance is about pool water chemistry and how different physicochemical parameters interact. These parameters include pH, total alkalinity, calcium hardness, total dissolved solids and temperature. Water that is not well balanced can affect disinfection, can be uncomfortable for bathers and can result in scale forming or fittings corroding.

6.1 Langelier Saturation Index

The most common method for checking the balance of water is the Langelier Saturation Index (LSI). The LSI is a mathematical equation that relates to each of the parameters described below. This equation is described in detail in Appendix 5. The LSI should always be within the acceptable range (refer to *Table A5. 1* in *Appendix 5*).

6.1.1 pH

The pH of water is a measure of how acidic or alkaline the water is. The pH of water in all aquatic facilities should be maintained within the recommended range (refer to *Table A2.1* (chlorinated facilities) and *Table A2.2* (brominated facilities) in *Appendix 2*) to ensure effective disinfection and bather comfort.

If the pH is too high, it can be reduced by adding strong acids such as hydrochloric (muriatic) acid or sodium bisulphate (dry acid). Acid should always be diluted into water before being added slowly to the balance tank. Lowering the pH also lowers total alkalinity, so take care when adding acid to ensure the water stays in balance. Carbon dioxide can also be used to lower pH but, because it is a weak acid, the pH change will be slower than when using strong acids.

If the pH is too low, sodium carbonate (soda ash) can be used to raise it quickly. Sodium bicarbonate (bicarb soda) can be used to raise pH more slowly. Increasing the pH in this way also increases total alkalinity.

Automatic pH control is recommended for all public aquatic facilities and strongly recommended for high-risk facilities (refer to *Table A2.4* in *Appendix 2* for further information on aquatic facility risk categories).

6.1.2 Total alkalinity

Total alkalinity is a measure of the ability of water to withstand changes to pH (also referred to as its buffering capacity). Total alkalinity should be maintained within the recommended range (refer to *Table A2.1* (chlorinated facilities) and *Table A2.2* (brominated facilities) in *Appendix 2*).

If the total alkalinity is too low, the pH can change rapidly. If the total alkalinity is too high, it will be difficult to adjust the pH. Total alkalinity can be reduced by adding strong acids or raised by adding chemicals such as bicarb soda, though adding these chemicals will also affect pH.

6.1.3 Calcium hardness

Calcium hardness is the amount of calcium dissolved in the water. Balanced water should contain enough calcium so the water does not damage concrete surfaces or tile grout but not so much that it causes scale to form.

If calcium hardness needs to be raised, it can be increased by adding calcium chloride. If it needs to be reduced, it can be reduced by draining some water from the aquatic facility and introducing make-up water containing lower levels of calcium hardness.

6.1.4 Total dissolved solids

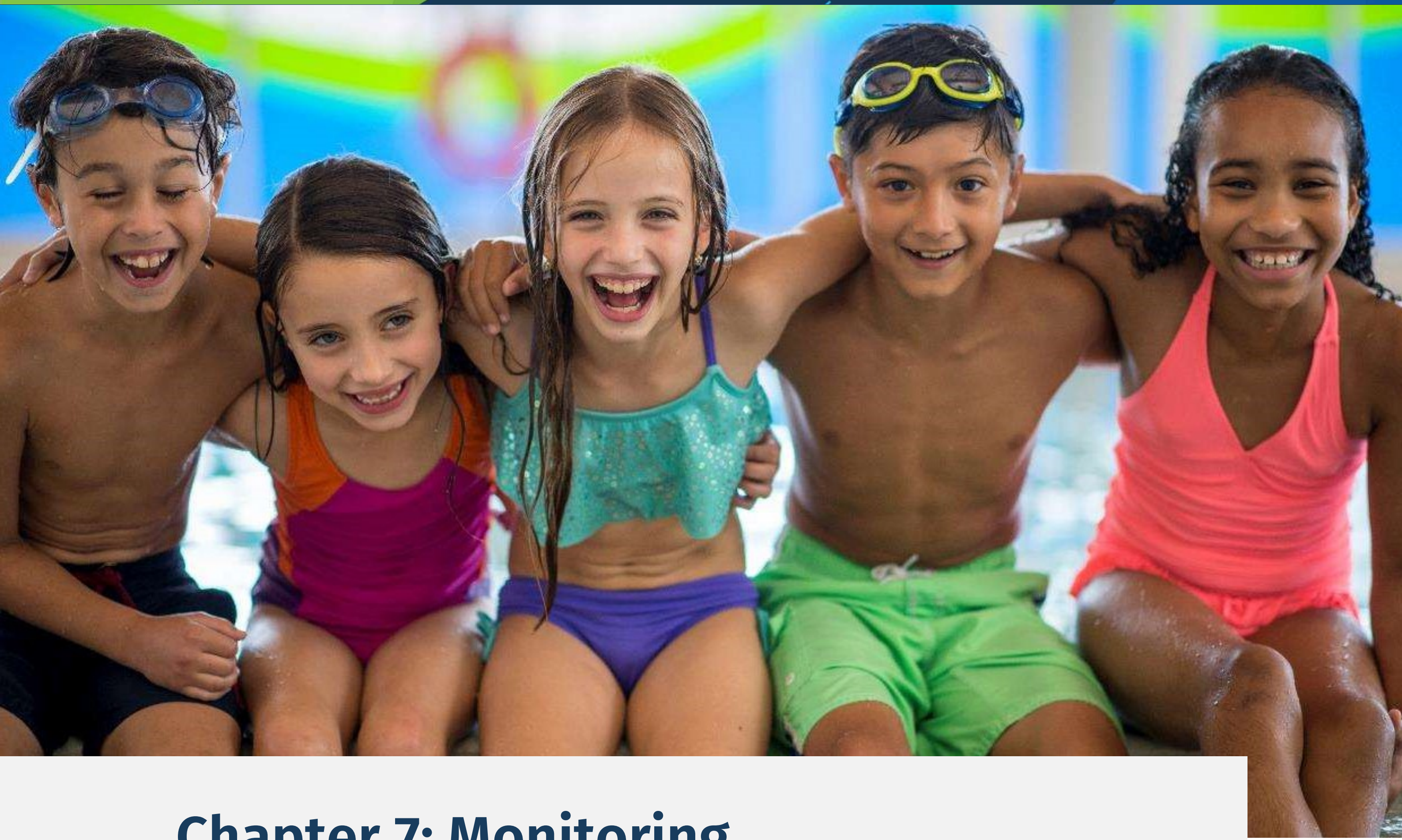
Total dissolved solids (TDS) describes the amount of salts and the small amounts of organic matter dissolved in water.

The level of TDS in water increases over time as bathers introduce contaminants or when water treatment chemicals are added. In general, TDS is managed by exchanging facility water with fresh make-up water. In a well-designed and well-operated aquatic facility, with regular backwash and routine exchange of water, TDS should not be a significant problem.

6.1.5 Temperature

The temperature of the water will affect its balance, although it is the least important of the water balance factors. Higher water temperatures can increase bacterial growth in the water, increase scaling and also affect the comfort of bathers. The temperature of any swimming or spa pool should not exceed 40°C.

It is important to consider how temperature may vary throughout the diurnal period and within the swimming or spa pool. Consideration should be given to when and where temperature is measured to ensure representative results. Locally warmer or cooler parts of the pool (e.g. near lamps or heaters or after cooler water has topped up the pool or heaters have been off for some time) should be considered when measuring water temperature. Samples should be taken, or temperature monitoring devices installed and monitored, to capture the warmest temperatures experienced in the pool during its use.



Chapter 7: Monitoring

Key points

- Operational monitoring should be the main focus for monitoring activities.
- Automated operational monitoring is recommended for all public aquatic facilities and strongly recommended for high-risk facilities.

Monitoring public aquatic facilities helps ensure the water quality is maintained. There are two types of monitoring: operational and verification.

Operational monitoring involves monitoring the performance of treatment processes or physical variables like water temperature. This could involve manual or automated operational monitoring to ensure that they are operating within the operational limits. Operational monitoring provides pool operators with an opportunity to address water quality immediately. It should be the focus of monitoring activities.

Alternatively, verification monitoring usually involves sending a water sample to a laboratory to verify that the water quality criteria have been met.

7.1 Operational monitoring

Operational monitoring includes any automated or manual monitoring of chemical and physicochemical parameters (for example, concentration of primary disinfectant, pH and temperature) and is essential for all public aquatic facilities.

Facility operators need to test the water regularly to check that the water treatment systems are operating as expected. Automated operational monitoring provides for more frequent or even 'real time' monitoring and is therefore the better option for operational monitoring. Manual operational monitoring provides the next best method for determining whether the treatment systems are operating as they should.

7.1.1 Automated operational monitoring

Automated operational monitoring (sometimes called 'online monitoring') usually involves use of monitoring probes or instruments to provide real-time information about water quality parameters. These probes require periodic calibration against standard solutions or 'calibration standards'. Automated operational monitoring is needed when automatic dosing systems are used (such as automatic chlorine dosing) but may also be used to monitor other water quality parameters or treatment steps. Where possible, treatment processes should have on-line instrumentation to monitor their performance and trigger alarms and corrective actions to ensure that they are operating within specification and in accordance with the manufacturer's recommendations.

Online instrumentation for filtration systems may include coagulant dosing control, online filtrate turbidity, pressure differential and flowrate; for ultraviolet disinfection systems, ultraviolet transmissivity, flowrate, UV lamp age, UV lamp sensor; and for chlorination systems chlorine setpoint dose, chlorine residual monitoring, pH and temperature. Where automated operational monitoring is used, the results should be recorded electronically. The automated monitoring system should be configured to alert facility operators whenever operational parameters are not within acceptable limits.

Where automated operational monitoring is used, regular manual operational monitoring should also be used to confirm that the results from the automated systems are accurate. These samples should be taken from a location just before the monitoring probes.

7.1.2 Manual operational monitoring

Manual operational monitoring provides spot checks of chemical and physicochemical parameters. Manual samples should be taken from a location furthest from the inlets where bathers have not been present for the previous 60 seconds. Taking samples for ozone is an exception; these samples should be taken close to an inlet to confirm ozone is being removed or 'quenched'.

7.1.3 Test kits

All aquatic facilities should use appropriately calibrated photometers for manual operational monitoring. Domestic pool kits and test strips are not recommended for public aquatic facilities because they are not accurate.

7.1.4 Frequency of operational monitoring

All aquatic facilities should ensure disinfectant residual, pH and water balance (alkalinity, calcium hardness and TDS) are monitored regularly. Higher risk facilities should be monitored more frequently than lower risk facilities. *Table A2.4* in *Appendix 2* provides guidance on risk categories for public aquatic facilities. *Table A2.5* in *Appendix 2* provides recommended operational monitoring frequencies for each risk category.

7.2 Verification monitoring

Verification monitoring checks that the required water quality criteria have been met. Verification monitoring typically involves taking a water sample and sending it to an external laboratory for analysis.

Verification monitoring usually focuses on microbiological parameters but can also include certain chemical criteria that cannot be easily analysed by pool operators.

7.2.1 Microbiological parameters

Microbiological parameters that should be included in a verification monitoring program for aquatic facilities include heterotrophic colony count (HCC), *Escherichia coli* and *Pseudomonas aeruginosa*. Guideline values for each of these parameters are provided in *Table A2.3* in *Appendix 2*.

7.2.1.1 Heterotrophic colony count

HCC, sometimes referred to as 'heterotrophic plate count' or 'total plate count', provides a basic indication of the microbiological quality of a water sample. HCC does not differentiate between harmless and potentially harmful bacteria; it provides a simple indication of the number of bacteria present in the water. However, it can also provide important information that can help determine whether the filtration and disinfection processes are operating effectively.

Elevated HCC results suggest disinfection systems are not operating as required and so the performance of the treatment processes should be checked. If a treatment deficiency is found, actions should be taken to correct it (refer to *Appendix 6*). If no treatment deficiencies are found, a resample should be taken to verify there are no ongoing issues. If ongoing issues are found, the treatment process and/or management of the aquatic facility may need to be improved, e.g. through enhancing cleaning, water chemistry, water turnover, reducing bather numbers or treatment upgrades.

7.2.1.2 Escherichia coli

E. coli is a bacterium found in large numbers in the faeces of warm-blooded mammals. Most strains of *E. coli* are harmless, but some can cause serious illness in humans. *E. coli* is typically used as an indicator of faecal contamination and its presence in water suggests that filtration and disinfection may not have been effective and therefore disease-causing microorganisms may also be present.

Where a laboratory does not analyse for *E. coli*, samples may be submitted for thermotolerant coliform analysis because these are the next best indicator of faecal contamination. A noncompliant *E. coli* or thermotolerant coliforms result indicates deficiencies in disinfection and this should trigger an investigation into the performance of the treatment process. If a treatment deficiency is found, appropriate remedial action will need to be taken (refer to *Appendix 6*) and a resample taken to verify the effectiveness of the remedial action. If no treatment deficiencies are found, a resample should be taken anyway to verify there are no ongoing issues.

7.2.1.3 Pseudomonas aeruginosa

Pseudomonas aeruginosa is a bacterium that can cause a range of infections in humans. It can be introduced to the water from bathers or from the surrounding environment. *Pseudomonas* in the water can mean that disinfection systems are not operating as they should, and appropriate remedial actions will need to be taken (refer to *Appendix 6*).

7.2.2 Chemical parameters

Chemical parameters that should be included in a verification monitoring program for aquatic facilities include chloramines and ozone, if used. Guideline values for each of these parameters are provided in *Table A2.1* in *Appendix 2.*

7.2.3 Frequency of verification monitoring

Verification monitoring should never be used as a substitute for operational monitoring. Higher risk facilities should undertake more frequent verification monitoring than lower risk facilities. *Table A2.4* in *Appendix 2* provides guidance on risk categories for public aquatic facilities. *Table A2.6* provides recommended verification monitoring frequencies for microbiological parameters for each risk category and *Table A2.7* provides recommended verification monitoring frequencies for chemical parameters for each risk category.

The frequency of verification monitoring may be reduced via a risk assessment process. For example, where long-term monitoring (for example, monthly over a full calendar year of operation) shows a chemical parameter to be consistently compliant with the guideline level, frequency can be reduced to quarterly.

The frequency of verification monitoring may also have to be increased in some circumstances. For example, following any significant change in pool operations or treatment, during high use periods or following a change in chemical used, verification frequency for relevant parameters should be increased until evidence of a return to stable values is shown.

Frequent verification monitoring should also be undertaken at all public aquatic facilities when commissioning new water treatment equipment, or when there is some uncertainty about the effectiveness of the water treatment processes in place.

7.2.4 Taking a verification sample

Verification samples should be taken from a location furthest from the water inlets where bathers have not been present for the previous 60 seconds. When taking verification samples always take the following steps:

- remove the cap from the sample bottle
- Immerse the bottle, neck down in the water to a depth of about 300 mm. At this point the container should be tilted to face horizontally away from the hand and then be moved horizontally until the container is full
- Remove the sample container, replace the bottle lid and label before storing in an appropriate container (such as an esky or cooler). Ensure samples are maintained in the conditions and sample submission timeframes specified by the laboratory. Freezer bricks can be used to ensure the samples stay cool during transport and kept within the correct temperature range and the required holding period
- Verification samples should be submitted to a laboratory that the National Association of Testing Authorities (NATA) has accredited to perform the requested analysis
- Samples must be analysed within 24 hours of collection.

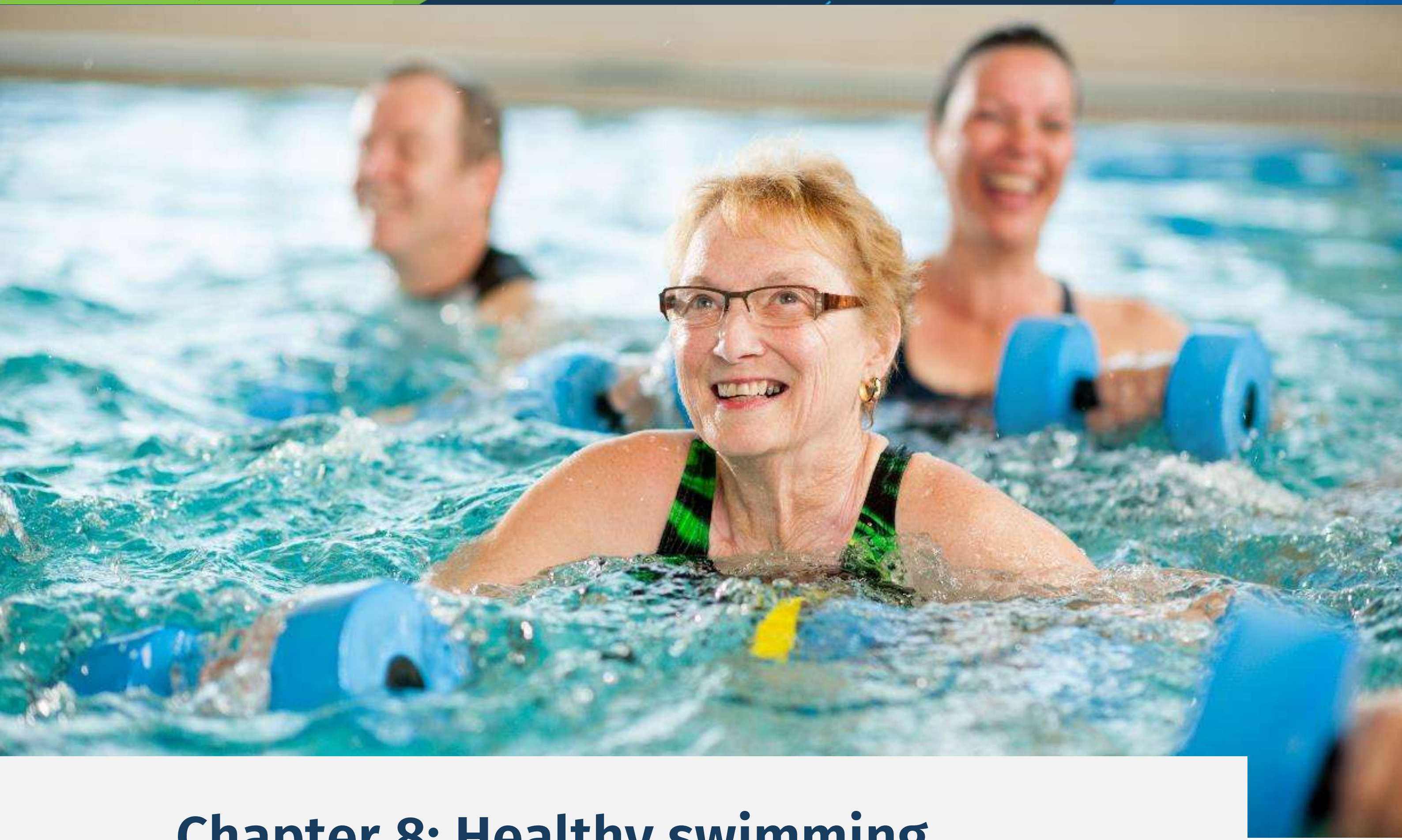
7.2.4.1 Microbiological sampling

Microbiological samples should only be taken using a sample container provided by the analytical laboratory. It is important that the analytical laboratory is aware that the sample is to be taken from an aquatic facility with disinfected water and provide the appropriate neutralising agent in the sample container. Neutralising agent in the sample bottles helps to ensure that the results of microbiological sampling are representative of the water quality. Samples should be maintained in the conditions and sample submission timeframes specified by the laboratory. Samples must be analysed within 24 hours of collection.

7.3 Record keeping

All aquatic facilities should maintain a record of operational and verification monitoring results for at least 12 months. Monitoring logs should be filled out when samples are analysed and then retained on site. An example of a monitoring log template is provided in *Appendix 7.*

Aquatic facilities should have arrangements in place to ensure that the laboratory undertaking the analysis immediately reports the results to the person(s) responsible for managing and maintaining water quality. Results should be reviewed on receipt for compliance with the appropriate water quality criteria (refer to *Appendix 2*). Appropriate corrective actions should be undertaken in instances where non-compliant results are observed.



Chapter 8: Healthy swimming

Key points

- Do not swim if you have diarrhoea and do not swim for 14 days after symptoms have stopped.
- Shower and wash with soap, especially your bottom, before swimming.
- Wash your hands with soap after going to the toilet or changing a nappy.
- Change nappies in nappy change areas only.
- Avoid swallowing pool water.

Bather hygiene and aquatic facility design are important factors in keeping swimming pools clean and to prevent disease-causing microorganisms and environmental contaminants being introduced.

8.1 Exclusion periods following illness

Bathers can introduce large numbers of disease-causing microorganisms into the water. Disease-causing microorganisms come from the faeces of infected bathers. The period during which disease-causing microorganisms are excreted varies from person to person however, once pool water is contaminated with these microorganisms, disease can spread to other people, even when only small amounts of water are swallowed.

In the case of an infection with *Cryptosporidium*, an infected person will excrete *Cryptosporidium* during the illness and up to 14 days after symptoms have resolved (two weeks after the diarrhoea has stopped). This is particularly concerning because sufferers, even those who are no longer symptomatic and have showered, may introduce a small amount of faecal matter into the water, causing contamination. Furthermore, *Cryptosporidium* is resistant to the levels of chlorine or bromine typically used for pool disinfection. This means it can survive in the water for long periods and potentially make others sick.

Signage should be displayed at every public access point advising bathers who have recently had a diarrhoeal illness to not swim for 14 days after symptoms stop. The signage should also advise parents to exclude their children for 14 days if their children have had a diarrhoeal illness. Staff who use a public aquatic facility as part of their job should also adhere to these exclusion periods, although these staff may still undertake tasks that don't involve being in the water.

Public aquatic facilities can encourage parents to prevent ill children from attending swim lessons by promoting exclusion periods and providing 'catch-up' swim lessons for children who have recently had a diarrhoeal illness. All facilities should offer learn-to-swim class structure fees to allow refunds or 'catch-up' lessons if a child is sick with diarrhoea (and for 14 days after symptoms resolve) during the enrolment period.

8.2 Showering

Some people can become infected with disease-causing microorganisms without becoming ill; these are known as 'asymptomatic' infections. Although these people might not become ill, they will still have disease-causing microorganisms in their faeces. These people, like all other bathers, may have small amounts of faecal material on their bottom, which can transfer disease-causing microorganisms into the water. For this reason, it is important that all bathers shower and wash with soap before entering the water.

Pre-swim showering is a difficult requirement to enforce for many existing aquatic facilities. Bathers can be prompted to shower before using the facility via strategically placed signage at public access points, by providing soap dispensers in the shower facilities and ensuring change rooms are kept hygienic and pleasant to use. Visual and verbal reminders to encourage bathers to shower before using a public aquatic facility can help to change behaviour, reduce chlorine demand and reduce the rate at which disinfection by-products are created.

In the design of new aquatic facilities, showers should be easily accessible and strategically located. Consider designs that require bathers to enter the change rooms before they can enter the aquatic facility itself because this will encourage bathers to shower before entering the water.

8.3 Toileting and handwashing

To help minimise public health risks, it is important to encourage proper toileting behaviour among bathers. Parents and the guardians of children should be encouraged to ensure their young children use the toilet before entering a public aquatic facility as well as regularly while at the facility. Toilets should include signs to encourage bathers to wash their hands with soap before returning to the water. Always provide enough soap for handwashing. In the design of new aquatic facilities, toilets should be easily accessible and positioned close to the swimming area(s).

8.4 Changing nappies

Nappy change areas should be provided in an easily-accessible location, kept clean, sanitised regularly, and always be supplied with soap for handwashing. Wash-down water from nappy change areas should not be allowed to flow to the pool or stormwater. Bins should be provided for used disposable nappies and these should be emptied regularly.

Infant 'aqua nappies' and swim pants are commonly used but can give a false sense of security regarding faecal contamination. There is no evidence to suggest that they can prevent faecal material from leaking into the pool.

Regular nappy changing and frequent trips to the toilet can reduce the chance of a faecal accident. Staff should let patrons know that nappies can only be changed in nappy change areas rather than near the water's edge.

8.5 Avoid swallowing pool water

Many illnesses associated with public aquatic facilities occur after swallowing contaminated water, so all bathers should be discouraged from drinking pool water. Children should also be supervised and discouraged from 'whale spitting' because this can often lead to accidently swallowing water. If possible, locate drinking fountains at convenient locations within the aquatic facility, particularly near areas used for exercise.

8.6 Assistance animals

Assistance animals (such as guide dogs) can be permitted to enter a public aquatic facility but should not be permitted to enter the water.

8.7 Signage

Appropriate signage can help ensure bathers practise good hygiene. It is best to display signage at each public access point that says:

- If you currently have, or have had, diarrhoea you should not enter the water. You should not swim for 14 days after symptoms have stopped.
- Parents/guardians of children who have had diarrhoea in the past 14 days should ensure their children do not enter the water.
- Please shower, with your bathers removed, using soap and rinsing thoroughly before entering the water.
- Avoid swallowing the pool water.
- Parents/guardians should ensure young children use the toilet before entering the water and regularly while at this facility.
- Do not change nappies beside the pool or rinse off your child in the pool. Use the change room provided.
- Wash your hands thoroughly after using the toilet or changing nappies. Please use the soap provided.
- Do not urinate in the pool. This contaminates the pool water.
- Faecal accidents can happen. If you or your child doesn't quite make it to the toilet, please tell our staff immediately. Confidentiality will be respected.

8.8 Minimising the likelihood of environmental contamination

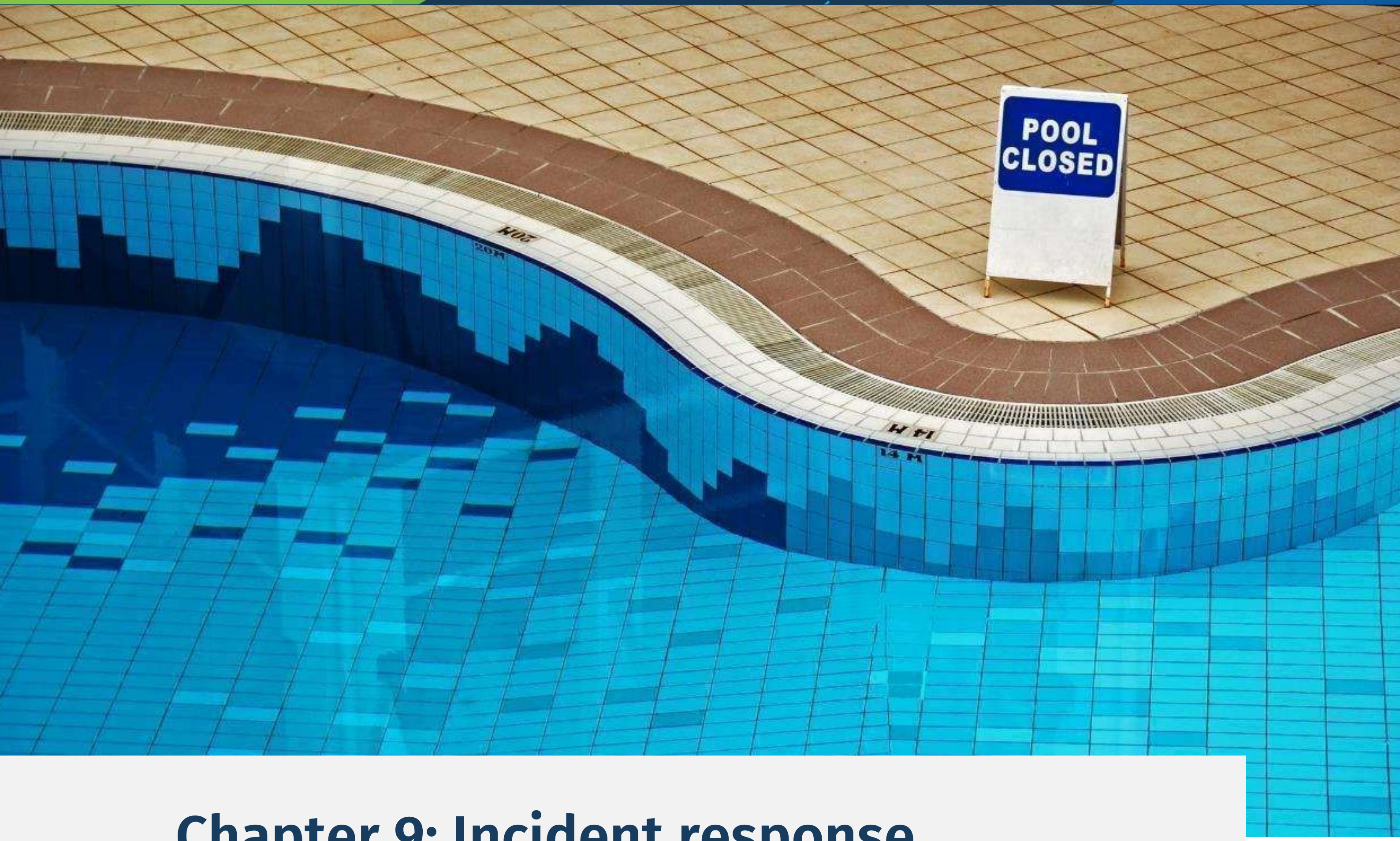
Environmental contamination can affect water quality in many ways. Public aquatic facilities should be designed to reduce the likelihood of environmental contaminants being introduced into the water.

For outdoor facilities, the surfaces around the facility should be sloped to direct stormwater away from the water body. Nearby trees should have overhanging branches removed. Any play equipment should be designed to discourage birds from roosting on it, and barriers (fences) are recommended to exclude animals.

For indoor aquatic facilities, environmental contamination is also a concern and is predominantly caused by bathers carrying microorganisms and organic matter into poolside wet areas.

For a proactive approach to minimise environmental contamination, consider the following:

- Dirt traps – Matting should be placed at the entry and exit points to aquatic facilities to capture dirt and additional environmental contaminants carried in on footwear.
- Shoe removal points – Appropriately signed areas for shoe removal, on entry to pool change areas and poolside wet areas, can reduce contamination from the external environment. Providing free storage lockers (with a key deposit) for patron's shoes and bags can also help to facilitate this change.



Chapter 9: Incident response

Key points

- Incidents that adversely affect water quality can occur at any public aquatic facility.
- Operators should have documented procedures for responding to incidents.
- Staff should be trained to respond to incidents appropriately.

9.1 Response procedures

Despite the best efforts of public aquatic facility operators, the water in an aquatic facility may become contaminated or a water treatment failure may occur. These incidents often present a real risk to the health of bathers and it is therefore necessary for the operator(s) to respond appropriately.

Operators should have documented and readily accessible procedures for responding to incidents and be trained to carry out these procedures.

Appendix 6 provides guidance on responding to water quality incidents or treatment failures that may affect public health. These incident response procedures are primarily for larger aquatic facilities with large volumes of water. For smaller aquatic facilities, it may be easier to empty the affected water body, remove any accumulated contaminants retained in the filter, refill and re-establish the necessary water balance and disinfectant residual.

9.2 CT value

In incident response, it is important that all public aquatic facility operators are familiar with the concept of disinfection CT; a measure of disinfection effectiveness. CT is the concentration of the disinfectant residual multiplied by the contact time at the point of residual measurement. It is expressed as milligrams (mg) of chlorine per litre (L) times the number of minutes for which this concentration of chlorine is maintained (e.g. 15 mg.min/L). CT values are used to determine what concentration of disinfectant residual and what length of time is required to inactivate a certain type of disease-causing microorganism. Variations in disinfection time for a range of pathogenic organisms are shown in Table 2.

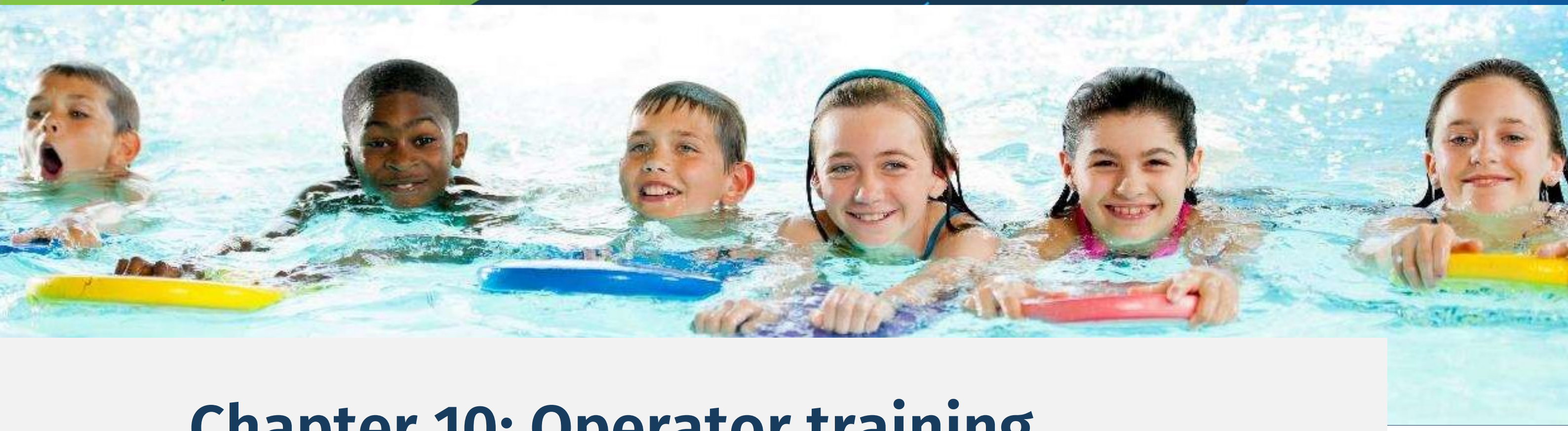
Table 2: Disinfection times for selected pathogens in pools

Contaminant[1]	Disinfection time[2] (1 mg/L chlorine at pH 7.5 and 25°C)
E. coli bacteria	< 1 minute
Hepatitis A virus	16 minutes
Giardia parasite	45 minutes
Cryptosporidium parasite	15,300 minutes (10.6 days)[3]

[1] Note that in practice only the *Cryptosporidium* value is relevant to most circumstances since that is the most resistant pathogen.

[2] Note that these disinfection times relate to the given pH, temperature and disinfectant concentration ranges, and are influenced by other factors such as turbidity and cyanuric acid. For instance, required contact times will increase as pH rises and decrease as temperature rises, and vice versa.

[3] During an incident response, as summarised in *Appendix 6*, for water without cyanuric acid, a CT of 15,300 mg.min/L is required to inactivate the infectious *Cryptosporidium*. This can be achieved by maintaining a free chlorine concentration of 20 mg/L for 13 hours (15,300 ÷ 20 = 765 minutes or ~13 hours), or 10 mg/L for 26 hours (15,300 ÷ 10 = 1,530 minutes or ~26 hours), or via alternative combinations of chlorine concentration and time that achieve the required CT. A higher value applies to water with cyanuric acid, as noted in *Appendix 6*. This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk (for example, UV disinfection) and can be proven to have been operating within the validated parameters during and since the contamination event.



Chapter 10: Operator training

Key points

- All staff involved in operating a public aquatic facility should undertake appropriate training for their role.
- Staff who operate high-risk facilities should undertake more extensive training.
- Managers of larger public aquatic facilities should consider obtaining industry accreditation.

Operators of public aquatic facilities should be committed to training and continuous professional development. Membership with a recognised industry body is strongly encouraged.

The level of operator training should be proportionate to the risk of the facility. Operators of high-risk aquatic facilities should undertake more extensive training than those who operate lower risk facilities. It is strongly recommended that operators of high-risk facilities complete the relevant competency of either a Certificate III (course code CPP31218) or Certificate IV (course code CPP41312) in Swimming Pool and Spa Service, as offered by a registered training organisation.

The minimum standard for aquatic facilities would be for staff to undertake a short course offered by an industry body or registered training organisation. These typically cover the key water quality-oriented competencies of the Certificate III or IV.

Facility managers should ensure they have adequately trained staff who understand the treatment processes and know how to maintain water quality. Managers of public aquatic facilities, particularly managers of larger facilities such as aquatic centres and water parks, should also consider self-accrediting or obtaining formal accreditation under an industry-led accreditation framework for facility managers. This may involve completing qualifications specific to the role of managing a public aquatic facility and undertaking continuous professional development.

Appendices

Appendix 1: Interactive water features (splash pads, spray parks and water play areas)

The information provided below will help operators of IWFs to minimise the risk to public health.

Risk management

Interactive water features are considered high risk facilities and it is therefore strongly recommended that all IWFs have site-specific risk management plans.

Location

IWFs are often located within public open spaces such as parks, so it is important to consider surrounding land uses and how other activities in the neighbouring area may affect the water quality of an IWF. For example, sand pits, garden beds and trees can increase the volume of physical contaminants (such as sand, dirt and leaf litter) entering the IWF. This may compromise the effectiveness of filtration and disinfection systems.

General site sanitation, including the availability of public infrastructure (such as toilet and shower facilities) may reduce physical and microbiological contamination of the IWF water system. Access to showers, toilets and baby change facilities encourages good hygiene practices among IWF users.

Where IWFs are located in areas where animals may be present (for example, near dog parks), providing bag dispensers can prompt owners to collect and dispose of animal faeces.

System design

Full system design plans (as installed) and operating manuals should be maintained so they can be reviewed by an environmental health officer as required.

The following factors should be considered when designing an IWF:

- the quality and availability of the source water
- containment structures and drainage including upstream interceptor drains to prevent stormwater runoff entering the IWF
- water circulation – recirculating water (subject to treatment and re-use) versus non-recirculating water (passes through the IWF only once)
- infrastructure – appropriately sized to achieve effective water circulation, turnover, filtration and disinfection targets
- materials and system components – fit for purpose (slip resistant, anti-entrapment) and able to withstand ongoing exposure to the surrounding environment including varying disinfection concentration levels (such as during periodic shock dosing)
- water flow – engineered to prevent both water stagnation and water pooling

- spray plume height and velocity – high spray plumes may expose more people due to the drift of water particles, including people who may not be directly using the facility; low spray plumes may be more appealing to young children, resulting in accidental or intentional water consumption
- backflow prevention – this ensures water supply lines are protected from contamination. Any backflow device should be installed and commissioned to comply with the relevant plumbing and drainage legislation.

Recirculating systems

Water storage and circulation

Water should be stored and circulated to allow adequate water turnover and distribution of disinfectant throughout all parts of the system. Water tanks should be accessible for cleaning and inspection and be capable of complete draining. Storage capacity, including both the size and number of tanks required, must be sufficient to ensure an adequate residual level of disinfectant is maintained within the system.

Water temperature is an important consideration when sizing water storage tanks. Small volumes of water will heat rapidly when exposed to external surfaces during IWF operation increasing the risk of microbiological growth. A water turnover rate of 30 minutes is recommended due to the relatively small volumes of water and high pollutant load associated with IWFs. A flow gauge should be fitted to the system to demonstrate an adequate flow rate within the IWF.

Treatment

Filtration: Filtration systems should be fitted to remove particulate matter (soils, leaves etc.) and potential disease-causing microorganisms. The filtration system should run constantly while the IWF is open to users.

New filtration systems should be designed to maximise the removal of *Cryptosporidium*. Filters capable of removing particles 4 microns in diameter (Health Canada, 2019) and achieving a filtrate turbidity of 0.2 NTU consistently will provide additional protection against *Cryptosporidium*.

Disinfection: Automatic dosing equipment and ongoing monitoring equipment should be fitted to control the level of disinfectant in the water. Refer to *Table A2.1* in *Appendix 2* for water quality parameters and targets. Using cyanuric acid is unlikely to be beneficial where the majority of the water is contained in a balance tank. In addition, using cyanuric acid in such instances may reduce the effectiveness of chlorine disinfection.

Secondary disinfection: Secondary disinfection is recommended, usually in the form of UV disinfection, for all IWFs. UV disinfection can inactivate *Cryptosporidium* oocysts and control combined chlorine while improving the water quality (including the odour from combined chlorine). A UV disinfection system should be installed in a location prior to the chlorine dosing point and run constantly while the IWF is open to effectively control the combined chlorine levels. Prioritise using validated equipment that is capable of delivering a UV dose required to achieve a minimum 99.9% inactivation of *Cryptosporidium* (Centers for Disease Control and Prevention, 2018).

On-site monitoring

Daily on-site monitoring is essential for all IWFs and should include physically inspecting the site. This is important to maintain an understanding of water quality and to verify the accuracy and reliability of any remote monitoring. The frequency of monitoring should be determined as part of the site-specific risk management plan. Routine operational monitoring should include free chlorine, total chlorine, pH, alkalinity, cyanuric acid (if used) and water temperature. Refer to *Table A2.1* in *Appendix 2* for water quality parameter targets.

Records of physical inspection and on-site operational monitoring should be maintained and made available for compliance inspection.

Remote monitoring

To enable real-time, remote monitoring of free chlorine levels, pH and water temperature, IWF operators should install probes for free chlorine, pH and temperature.

The probes should be configured to allow automatic shutoff of the IWF when the free chlorine levels, pH levels or water temperature are out of specification.

If remote monitoring is used, the results should be reliable and accessible during operating hours and made available during compliance inspections.

Signage

Safety signage should be provided in a conspicuous location(s) and include:

- contact details for reporting issues/faults with the IWF
- advice to not swallow the water
- advice not to use the IWF if someone has diarrhoea, and for 14 days after symptoms have stopped
- advice for babies and toddlers to wear tight-fitting swim nappies
- the location of the nearest public toilets/change rooms
- advice that animals are prohibited from accessing the IWF.

Assistance animals

Assistance animals (such as guide dogs) can be permitted to enter an area with an IWF but should not be permitted to enter the IWF or drink the water.

Seasonal operation

For any IWF that are operated seasonally, to minimise water quality risks the IWF should be drained to remove any stagnant water prior to closing for the season. Prior to re-opening, the system should be cleaned and disinfected.

Operator skills and knowledge

The owner or operator of an IWF should take reasonable care to ensure the person(s) responsible for managing the IWF has the appropriate skills, knowledge and experience. Further information on operator training is provided in Chapter 10.

Non-recirculating systems

These systems present a lower public health risk and therefore may not require treatment as they:

- use mains drinking water supply; and
- do not recirculate water.

Appendix 2: Water quality criteria and monitoring frequencies

Table A2.1 Chemical criteria for facilities using chlorine-based primary disinfectants

Parameter	Situation	Criteria[1]
Free chlorine[2]	Any pool without cyanuric acid, other than a spa pool	Min. 1.0 mg/L
	Outdoor pool with cyanuric acid	Min. 2.0 mg/L
	Spa pool	Min. 3.0 mg/L
	Interactive water feature	Min. 1.0 mg/L
Combined chlorine (chloramines)	Any pool or interactive water feature	Max. 1.0 mg/L, ideally < 0.2 mg/L
Total chlorine	Any pool or interactive water feature	Max. 10 mg/L
Turbidity (pool water)[3]	Any pool or interactive water feature	Max. 1 NTU[4], ideally < 0.5 NTU
pH	Any pool or interactive water feature	7.2–7.8
Total alkalinity	Any pool or interactive water feature	80–200 mg/L
Cyanuric acid	Outdoor pool only	Max. 50 mg/L, ideally ≤ 30 mg/L
Ozone[5]	Any pool or interactive water feature	Not detectable

[1] mg/L is equivalent to parts per million or ppm

[2] Free chlorine concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.

[3] If turbidity is measured immediately post filtration, it should not exceed 0.2 NTU (DIN 19643 (2012-11)).

[4] **NTU** - Nephelometric Turbidity Unit.

[5] Residual excess ozone is to be quenched before circulated water is returned to the pool.

Table A2.2 Chemical criteria for facilities using bromine-based primary disinfectants

Parameter	Situation	Criteria[1]
Bromine[2]	Any pool, other than a spa pool	Min. 2.0 mg/L
	Spa pool	Min. 6.0 mg/L
	Any pool	Max. 8.0 mg/L
pH	Any pool	7.2–8.0
Sodium bromide	Bromine bank system	Max. 8.0 mg/L
	Ozone[3]/bromide system	Max. 15 mg/L
Turbidity (pool water)[4]	Any pool	Max. 1 NTU[5], ideally <0.5 NTU
Total alkalinity	Any pool	80–200 mg/L
Cyanuric acid	Any pool	None – no benefit

Table A2.3 Microbiological criteria for all facilities

Parameter	Guidelines value
Escherichia coli (or thermotolerant coliforms)	0 CFU[6]/100 mL or 0 MPN[7]/100 mL
Pseudomonas aeruginosa	0 CFU/100 mL or 0 MPN/100 mL
Heterotrophic colony count (HCC)	Less than 100 CFU/mL

[1] mg/L is equivalent to parts per million or ppm

[2] Bromine concentration should be increased when high bather numbers are anticipated to ensure concentrations are never less than the minimum.

[3] Ozone quenching is not required in an ozone/bromide system.

[4] If turbidity is measured immediately post filtration, it should not exceed 0.2 NTU (DIN 19643 (2012-11)).

[5] **NTU** - Nephelometric Turbidity Unit.

[6] **CFU** - colony forming units

[7] **MPN** - most probable number

Table A2.4 Risk categories to inform monitoring frequencies

Low risk facilities	Medium risk facilities	High risk facilities
• Retirement village pools (not used for organised exercise activities e.g. private learn to swim classes) • Residential apartment pools • Diving pools	• 25 m and 50 m pools • Hydrotherapy pools • School pools • Gym pools • Resort pools • Holiday park pools • Motel pools • Theme park wave pools	• Spas • Interactive water features • Wading pools • Learn-to-swim pools • Program pools • Water slides • Shallow-depth interactive play pools • Pools used by incontinent people • Artificial lagoons with unrestricted access

Adapted from: NSW Department of Health 2013 - Public swimming pool and spa pool advisory document

In instances where a facility manager is operating a type of facility that is not included in *Table A2.4*, the manager should identify the type of facility that is most similar and monitor accordingly.

If a facility falls into multiple risk categories, the facility should be monitored as if it were the type of facility in the highest risk category. For example, if a gym pool is used for learn-to-swim classes, the facility should be categorised as high-risk.

Table A2.5 Recommended minimum operational monitoring frequency

Parameter	Low-risk facilities	Medium-risk facilities	High-risk facilities
Free chlorine and combined chlorine; or bromine	**1 daily sample,** if automated monitoring is in place	**1 daily sample,** if automated monitoring is in place	**1 daily sample,** if automated monitoring is in place
	1 daily sample, if no automated monitoring is in place	**3 daily samples,** if no automated monitoring is in place	**5 daily samples,** if no automated monitoring is in place
pH	Tested at the same time as for disinfectant residual (all facilities)		
Water balance (includes calcium hardness, total alkalinity TDS and temperature)	Weekly (all facilities)		
Turbidity	Daily (all facilities)		
Cyanuric acid (if used)	Weekly (all facilities)		

Table A2.6 Recommended microbiological verification monitoring frequency

Parameter	Low-risk facilities	Medium-risk facilities	High-risk facilities
Escherichia coli (or thermotolerant coliforms)	Quarterly	Quarterly	Monthly
Pseudomonas aeruginosa	Quarterly	Quarterly	Monthly
Heterotrophic colony count (HCC)	Quarterly	Quarterly	Monthly

Note that the frequency of monitoring should be increased if the bather numbers increase significantly. For example, during school holidays when bather numbers at public facilities increase significantly, medium-risk aquatic facilities should be monitored as if they were high-risk facilities.

Table A2.7 Recommended chemical verification monitoring frequency

Parameter	Low-risk facilities	Medium-risk facilities	High-risk facilities
Chloramines (combined chlorine)	Quarterly	Quarterly	Monthly
Ozone (if used)	Quarterly	Quarterly	Monthly

Note that the frequency of monitoring should be increased if the bather numbers increase significantly. For example, during school holidays when bather numbers at public facilities increase significantly, medium-risk aquatic facilities should be monitored as if they were high-risk facilities.

Appendix 3: Troubleshooting guide

The information in the following table should be used as a guide only.

Where available, the troubleshooting guide provided by the manufacturer of pool equipment should be preferentially used. There may be other causes that are not listed. Misdiagnosis or inappropriate action can worsen some problems to a point where the safety of bathers and staff may be at risk. Only suitably qualified or experienced staff should diagnose or undertake corrective actions. If you are unsure, it is best to get professional advice.

Table A3.1 Troubleshooting guide

Problem	Possible reasons	Action
pH too high	Mains water is alkaline (and hard)	Add more acid
	Alkaline disinfectant used	Consider changing to less alkaline disinfectant
		Adjust regularly/frequently/automatically by acid dosing
pH too low	Mains water is acidic	Add more alkali (for example, sodium bicarbonate/ soda ash)
	Acidic disinfectant used	Check pH probe and control settings
		Adjust regularly/frequently/automatically by alkali dosing
pH fluctuations	Water is not buffered – alkalinity is too low	Check and raise alkalinity
	Dosing erratic	Check dosing accuracy and frequency
pH difficult to change	Water too buffered – alkalinity too high	Check and lower alkalinity

Problem	Possible reasons	Action
Cloudy, dirty water	Bathing load too high	Reduce bathing load
	Filtration inadequate	Check filter, coagulant dosing, filtration rate, backwash
Cloudy, clean water	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
	Air introduced when dosing coagulant	Check on coagulant dosing; check air release on filters and for air leaks on the suction side of the pump
Cloudy, coloured water (outdoor pools mainly)	Algae – sunlight, poor hydraulics	Increase residual level and backwash; consider using algicide as directed by the label when the pool is not in use
Slimy, coloured growth on pool walls, floor, black on grouting	Algae – sunlight, poor hydraulics	Without bathers, brush or vacuum off algae, increase disinfectant level, backwash, consider using algicide
Water has bad taste or smell – irritates eyes and throat	High combined chlorine	Check combined chlorine levels and type; be prepared to dilute or correct free chlorine level
	pH wrong	Check and correct if necessary
Chlorine level difficult to maintain	Sunlight	Consider a stabiliser (cyanuric acid)
	Chlorine product has deteriorated and lost strength	Check storage condition of chlorine, shelf life, and test strength of chlorine
	Bather pollution	Reduce bathing load
	Filter blocked, turnover reduced, hydraulics poor	Check filter, strainer, flow rate and valves

Problem	Possible reasons	Action
Filter blocked (pressure across the filter is too high)	Backwashing/ cleaning too frequent – or scale blocking the filter	Check and improve backwash effectiveness; consider replacing filter media
	Incorrect coagulant dosing	Check coagulant dosing; inspect filter
Water clarity generally poor	Wrong filter or incorrect use	Check filtration media (backwashing, etc.)
	Insufficient chlorine	Check and correct free chlorine residual
	Incorrect or no coagulant	Check coagulant use
Hard scale on surfaces, fittings, pipes, etc.; water may feel harsh	Hardness salts coming out of solution	Check and where necessary correct pH, alkalinity, hardness
Cannot get test kit readings for free chlorine residual	Chlorine levels too high	Test a 5:1 diluted water sample
	Chlorine levels too low	Check chlorine dosing
Poor air quality (indoor pools)	Air circulation poor	Check air handling – introduce more fresh air
	Combined chlorine too high	Restore recommended chlorine levels by achieving breakpoint to oxidise chloramines
	Temperature too high	Reduce to recommended levels
Water has a salty taste	Dissolved solids too high	Dilute with mains water
Staining at water inlet	Irons salts coming out of solution	Check pH, water balance, coagulation

Adapted from: Pool Water Treatment Advisory Group 2017

Appendix 4: Recommended turnover times

Table A4.1 Recommended maximum turnover times for different types of public aquatic facilities

Maximum turnover time	Pool type
30 min	Interactive water features, spas and hydrotherapy
1 hour	Waterslide, wading, spas and hydrotherapy
2 hours	Learn-to-swim, lazy river, program, wave, artificial lagoons with unrestricted access, pools used by incontinent people, spas and hydrotherapy
4 hours	School, 25 m and 50 m pools, spas and hydrotherapy
6 hours	Retirement village pools (not used for organised exercise activities), residential apartment, gym, resort, holiday park and motel
8 hours	Diving

Adapted from: Pool Water Treatment Advisory Group 2017 - Swimming pool water – treatment and quality standards for pools and spas and the Centers for Disease Control and Prevention 2018 - The Model Aquatic Health Code

Appendix 5: Langelier Saturation Index

The most common method for determining the balance of water in a public aquatic facility is the Langelier Saturation Index (LSI).

The LSI should be between −0.5 and 0.5, with an ideal value of 0.

The LSI is calculated using the following equation:
LSI = pH + AF + CF + TF – 12.1

Where:

- pH is the measured pH of the pool water
- AF is a factor related to the total alkalinity of the water
- CF is a factor related to the calcium hardness of the water
- TF is a factor related to the water temperature
- 12.1 is an average correction factor for total dissolved solids (TDS).

The values for each of the factors above can be obtained from Table A5.1.

Table A5. 1 Table of values for Langelier Saturation Index calculation

Measured value for total alkalinity (mg/L)	Value to use for the AF	Measured value for calcium hardness (mg/L)	Value to use for the CF	Measured value for temperature (°C)	Value to use for the TF
5	0.7	5	0.3	*Plunge pools are typically > 10°C*	
25	1.4	25	1		
50	1.7	50	1.3	8	0.2
75	**1.9**	75	1.5	12	0.3
100	**2.0**	100	1.6	16	0.4
150	**2.2**	150	1.8	19	0.5
200	**2.3**	200	1.9	24	0.6
300	2.5	300	2.1	29	0.7
400	2.6	400	2.2	34	0.8
800	2.9	800	2.5	40	0.9
1,000	3.0	1,000	2.6	*40°C is the maximum allowable spa temperature*	

Bold text indicates ideal operational ranges. Where the LSI is negative, the water is corrosive and may damage pool fixtures and fittings. Where the LSI is positive, scale can form and interfere with normal operation.

Example calculation

Consider a pool with a pH of 7.4, total alkalinity of 100 mg/L, calcium hardness of 250 mg/L, at 29°C.

Reading from the table, the alkalinity factor is 2.0, the calcium hardness factor is 2.0, and the temperature factor is 0.7.

LSI = pH + AF + CF + TF – 12.1

LSI = 7.4 + 2.0 + 2.0 + 0.7 – 12.1

LSI = 0

This pool water is ideally balanced.

If the calcium hardness of the same pool was 1,000 mg/L, then the calcium hardness factor would increase to 2.6. In this case, the LSI would be +0.6 and scale is likely to form. If scale forms on heater elements and filter components, the pool will not operate efficiently.

Corrections to the Langelier Saturation Index

The LSI described above is applicable to most aquatic facilities. However, there are exceptions related to facilities with high TDS water and for operators of outdoor pools using cyanuric acid. These exceptions are discussed in detail in the *American National Standard for Water Quality in Public Pools and Spas* (American National Standards Institutes, 2019). If the TDS of the water in an aquatic facility is greater than 1,500 mg/L, the factors in the American Standard should be used. Where outdoor aquatic facilities use cyanuric acid to stabilise chlorine, this will affect the alkalinity, and the correction factors stated in that document should be applied.

Appendix 6: Incident response

Diarrhoeal incident – public aquatic facilities that use chlorine *without cyanuric acid* *(Remedial steps for spas - see page 61)*

Diarrhoeal incidents pose a particularly high risk to the health of bathers. Immediately closing the affected water body(ies) and undertaking appropriate remediation is the only way to prevent the spread of disease.

Recommended remedial steps

1. Immediately close the affected water body and any other connected water body(ies) within the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove as much of the faecal material as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the faecal material to the sewer. Do not use aquatic vacuum cleaners for removing faecal material unless the vacuum waste can be discharged directly to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Hyperchlorinate the affected water body(ies) by dosing the water to achieve a free chlorine contact time (CT) inactivation value of 15,300 mg.min/L (for example, free chlorine of 20 mg/L for 13 hours or 10 mg/L for 26 hours, or via alternative combinations of chlorine concentration and time that achieve the required CT).
5. Ensure filtration and any secondary disinfection systems operate for the entire decontamination process.
6. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
7. After the required CT has been achieved, reduce total chlorine to below 10 mg/L. Sodium thiosulphate can be added to neutralise excess chlorine.
8. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
9. Ensure the water is balanced.
10. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
11. Record the incident and remedial action taken.
12. Reopen the water body(ies).

***Cryptosporidium* and/or general suspected illness or possible outbreak**

Where a state or local government environmental health officer suspects or confirms a public aquatic facility has been linked to illness, or an outbreak of illness (including *Cryptosporidium*), all water bodies in the facility should be disinfected as per the recommended remedial steps above. This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk and it can be demonstrated to have been operating within the validated parameters during and since the contamination event. Note that *Cryptosporidium* has been singled out since it is the most common reported source of illness or outbreak associated with aquatic facilities in Australia.

Diarrhoeal incident – public aquatic facilities that use chlorine *with cyanuric acid* *(Remedial steps for spas - see page 61)*

Diarrhoeal incidents pose a particularly high risk to the health of pool bathers. Immediately closing the affected water body(ies) and undertaking appropriate remediation is the only way to prevent the spread of disease. Chlorine stabiliser (cyanuric acid) significantly slows the rate at which free chlorine inactivates or kills contaminants such as *Cryptosporidium*. It is therefore necessary to achieve a much higher free chlorine contact time (CT) than is necessary in water bodies that do not use cyanuric acid.

Recommended remedial steps

1. Immediately close the affected water body and any other connected water body(ies) in the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove as much of the faecal material as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the faecal material to the sewer. Do not use aquatic vacuum cleaners for removing faecal material unless the vacuum waste can be discharged directly to the sewer and the vacuum equipment can be adequately cleaned and disinfected.
3. Adjust the pH to 7.5 or lower.
4. Ensure cyanuric acid concentration is 15 mg/L or less (this can be achieved by partially draining and adding fresh water without chlorine stabiliser to the affected water body).
5. Once the cyanuric acid concentration is 15 mg/L or less, use unstabilised chlorine to hyperchlorinate the affected water body(ies) by dosing the water to achieve a free chlorine CT inactivation value of 31,500 mg.min/L (for example, free chlorine of 20 mg/L for 28 hours or via alternative combinations of chlorine concentration and time that achieve the required CT).
6. Ensure filtration and any secondary disinfection systems operate for the entire decontamination process.
7. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
8. After the required CT has been achieved, reduce total chlorine to below 10 mg/L. Sodium thiosulphate can be added to neutralise excess chlorine.
9. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
10. Ensure the water is balanced.
11. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
12. Record the incident and remedial action taken.
13. Reopen the water body(ies).

***Cryptosporidium* and/or general suspected illness or possible outbreak**

Where a state or local government environmental health officer suspects or confirms a public aquatic facility has been linked to illness, or an outbreak of illness (including *Cryptosporidium*), all water bodies in the facility should be disinfected as per the recommended remedial steps above. This requirement may not apply if a facility has a system that is validated to treat *Cryptosporidium* risk and it can be demonstrated to have been operating within the validated parameters during and since the contamination event. Note that *Cryptosporidium* has been singled out since it is the most common reported source of illness or outbreak associated with aquatic facilities in Australia.

Formed stool and vomit contamination – public aquatic facilities that use chlorine with or without cyanuric acid

(Remedial steps for spas - see page 61)

Formed stool (faeces) and vomit contamination incidents pose a risk to the health of bathers. The only way to prevent the spread of disease is to immediately close the affected water body(ies) and undertake appropriate remediation.

Recommended remedial steps

1. Immediately close the water body and any other connected water body within the aquatic facility and ensure staff involved in the response have appropriate personal protective equipment.
2. Remove the stool or as much of the vomit as possible using a bucket, scoop or another container that can be discarded or easily cleaned and disinfected. Dispose of the waste to the sewer. Do not use aquatic vacuum cleaners for removing the stool or vomit unless vacuum waste can be discharged to the sewer and the vacuum equipment can be adequately cleaned and disinfected. Ensure filtration and any secondary disinfection systems run until the end of the decontamination process.
3. For facilities that do not use *chlorine stabiliser* (cyanuric acid), raise the free chlorine concentration to a minimum of 2 mg/L and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.

   or

   For facilities that use *chlorine stabiliser* (cyanuric acid), maintain the free chlorine concentration at a minimum of 2 mg/L and maintain that concentration for 50 minutes, making sure not to exceed a pH of 7.5.
4. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
5. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
6. Ensure the water is balanced.
7. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
8. Record the incident and remedial action taken.
9. Reopen the water body(ies).

Note that no remedial action is required for blood in the water provided an appropriate primary disinfectant residual is present.

Failure to meet microbiological parameters

If, during verification monitoring, there is a failure to meet microbiological parameters (for example, exceedances of the *Escherichia coli* or *Pseudomonas* guideline values) remediation of the affected water body(ies) should be undertaken.

Recommended remedial steps (other than for spas)

1. Immediately close the affected water body and any other connected water body within the aquatic facility.
2. For facilities *with or without cyanuric acid*, raise the free chlorine concentration to a minimum of 2 mg/L (if not already at 2 mg/L) and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.
3. If the filtration system incorporates a coagulation step, ensure coagulant concentration is correct to enhance the filtration process.
4. Backwash filter media or replace the filter element as appropriate. Precoat filter media should be replaced.
5. Ensure the water is balanced.
6. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
7. Record the incident and remedial action taken.
8. Reopen the water body(ies).

Recommended remedial steps for spas

1. Empty all water from the spa (including balance tanks).
2. Scrub and rinse all surfaces with tap water known to have an acceptable water quality.
3. Spray all surfaces with a chlorine solution of one part bleach to 10 parts water. Note that the dilution factor is based on a bleach product containing 10–12.5% sodium hypochlorite. Apply liberally and leave to soak for 10 minutes.
4. Rinse with tap water known to have an acceptable water quality.
5. Refill the spa.
6. Raise the primary disinfectant level to that recommended in *Appendix 2* (3 mg/L for chlorine or 6 mg/L bromine) and maintain that concentration for 25–30 minutes, making sure not to exceed a pH of 7.5.
7. Backwash filter media, or replace the filter element as appropriate. Precoat filter media should be replaced.
8. Ensure the water is balanced and the concentration of disinfectant is acceptable.
9. Hygienically clean, disinfect or dispose of materials, tools, equipment or surfaces that have come into contact with contaminated water.
10. Record the incident and remedial action taken.
11. Reopen the spa.

In major contamination events it may be necessary to submit a sample of the water to show it is free of microbiological contamination before reopening. Public aquatic facility operators should contact a local government environmental health officer for advice.

Contamination of surfaces

Hard surfaces within a public aquatic facility may become contaminated with faeces, vomit or blood, or with water of poor quality that has been contaminated by such substances. In these instances, operators should follow the remediation measures below.

1. Restrict access to the affected area.
2. Remove all visible contamination with disposable cleaning products and dispose of appropriately.
3. Disinfect the affected area using a chlorine solution of one-part household bleach to 10 parts water. Note that the mentioned dilution factor is based on a bleach product containing 10–12.5% sodium hypochlorite. Apply liberally and leave to soak for 10 minutes.
4. Hose the affected area, directing the water to a stormwater drainage point.
5. Log the incident and remedial action taken.
6. Reopen the affected area.

Appendix 7: Example monitoring log

<Name of your pool> **Week beginning / /**

Day	Time	Temperature °C	pH	Free chlorine DPD 1 mg/L	Total chlorine DPD 1+3 mg/L	Combined chlorine (total- free) mg/L	Total alkalinity mg/L	Calcium hardness mg/L	Total dissolved solids (TDS) mg/L	Number of bathers	Tester Initials	Corrective actions / reason
Monday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Tuesday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Wednesday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Thursday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Friday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Saturday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											
Sunday	6.00 am											
	10.00 am											
	12.00 pm											
	2.00 pm											
	6.00 pm											

Glossary

Term	Definition
Acid	A liquid or dry chemical used to lower the pH of pool water.
Acidic	Having a pH below 7.0.
Alkaline	Having a pH above 7.0.
Alkalinity	Refer to *Total alkalinity.*
Alkalinity factor	(AF) Used to calculate the Langelier Saturation Index of water.
Ammonia	A nitrogen-containing compound that combines with free chlorine to form chloramines or combined chlorine.
Backwash	The process of removing debris accumulated in a filter by reversing the flow of water through the filter.
Bather number	A measure of the number of bathers in an aquatic facility over a set time. This should be linked to the capacity of the treatment system and pool safety.
BCDMH	Bromo-chloro-dimethylhydantoin. A common bromine-based disinfectant.
Biofilm	Slime-like community of microorganisms usually attached to wet surfaces.
Breakpoint chlorination	The addition of sufficient chlorine to oxidise combined chlorine to the point where free chlorine makes up the total chlorine and chloramines are oxidised to below detectable levels.
Buffering capacity	The capacity of water to resist pH change, e.g. when adding strong acids or bases.
Calcium hardness	A measure of calcium salts dissolved in pool water. Calcium hardness factor (CF) is used to calculate Langelier Saturation Index.
Carbon dioxide	A common gas found in air at trace levels. When injected into pool water it forms mild carbonic acid to lower pH.
CFU	Colony-forming units. A measure of microorganisms per unit volume of water.

Chloramines	A group of disinfection by-products formed when free chlorine reacts with urine, sweat or other nitrogen-containing compounds in water.
Chlorination	The application of chlorine products for disinfection.
Chlorine demand	The amount of chlorine that will be consumed by readily oxidisable impurities in pool water.
Chlorine dioxide	A secondary disinfectant. Chlorine dioxide is generally generated on site and then added to the water or generated in the water itself by adding specially formulated tablets to the water.
Chlorine gas	Gaseous form of chlorine containing 100% available chlorine.
Clarity	Degree of transparency with which an object can be seen through a given depth of pool water.
Coagulants	Chemicals, sometimes referred to as flocculants, that help clump suspended particles together into a filterable size.
Colloids	Items of small size that are floating in solid, liquid or gas.
Combined chlorine	A measure of the chloramines in water.
Cryptosporidium	A protozoan parasite that causes cryptosporidiosis. This is a diarrhoeal disease in healthy persons that can last one to two weeks. For those with some underlying health conditions it can result in severe dehydration, and in some cases death.
CT	Disinfection residual concentration (C, in mg/L), multiplied by contact time (T, in minutes) at the point of residual measurement; a measure of disinfection effectiveness.
Cyanuric acid	A stabiliser that can be added to an outdoor aquatic facility to reduce chlorine loss due to ultraviolet light from the sun.
Disinfectant	An oxidising agent that is added to water and is intended to inactivate disease-causing microorganisms.
Disinfectant residual	The measurable disinfectant present in water.
Filter	A vessel or device that removes suspended particles.
Flocculant	A substance used in treating water that promotes clumping of particles.

Flow rate	Rate of movement of water typically stated as litres/second (L/s) or cubic metres per hour (m^3/hr). A cubic metre is 1,000 litres.
Free chlorine	A measure of the chlorine that is available as hypochlorous acid and chlorite ion.
Hyperchlorination	The practice of dosing high amounts of chlorine-containing chemical to achieve a specific CT to inactivate disease-causing microorganisms.
Hypochlorous acid	Formed when any chlorine-containing product is dissolved in water. The most active oxidising form of chlorine.
Inlets	Points at which water from the aquatic facility's water treatment is reintroduced to the water body.
Isocyanuric acid	Refer to Cyanuric acid.
Langelier Saturation Index	Calculation based on various factors to determine the corrosive or scale-formation nature of water. Used to determine appropriate water balance.
Make-up water	Water used to replace water lost from an aquatic facility including backwash water, evaporation, splashing, water exchange and the water bathers carry out on their bodies. Make-up water is typically introduced from municipal mains via an auto-level valve.
Micron	A micrometre – one millionth of a metre. Used to describe particle size.
Microorganism	Microscopic organism such as a virus, bacterium or protozoan.
NATA	National Association of Testing Authorities – the national accreditation body for Australian testing laboratories.
Nitrogen	An element present in ammonia, sweat, urine, fertilisers and a variety of personal care products. When introduced to pools, it readily reacts with chlorine to form chloramines.
Oocyst	A hardy, thick-walled spore. The infective stage in the life cycle of *Cryptosporidium.*
Outbreak	Two or more human cases of a communicable (infectious) disease related to a common exposure.
Outlets	Points at which water exits the water body for treatment by the facility's water treatment plant.

Oxidation	The process by which disinfectants destroy contaminants and inactivate disease-causing microorganisms.
Ozone	A relatively unstable molecule containing three oxygen atoms. Ozone is created on site by passing oxygen across a corona discharge (in the same manner as lightning creates ozone in a thunderstorm). It is one of the most powerful oxidants known. It has a very short life wanting to revert to atmospheric oxygen, hence it cannot be stored for later use. It is a light blue gas and can also be created using ultraviolet light. It is very hazardous, especially in poorly ventilated spaces.
Pathogens	Disease-causing microorganisms.
pH	A scale used to express the acidity or alkalinity of a solution on a scale of 0–14, with 7.0 being neutral. Values less than 7.0 are acidic and values greater than 7.0 are alkaline.
Photometer	An analytical tool that uses light intensity measurements to determine the concentration of a particular chemical.
Physicochemical	Relating to both physical and chemical properties of a substance.
Program pool	A pool set aside at certain times for specific programmed activities like swim school or lap swimming
Residual	Refer to *Disinfectant residual*.
Scale	The precipitate or deposit that forms on surfaces in contact with water when calcium hardness, pH or total alkalinity levels are too high.
Shock dosing	The practice of dosing high amounts of chlorine (sometimes in excess of 10 mg/L) into a public aquatic facility to reduce chloramines or to remove confirmed or suspected microbial contamination.
Sodium bicarbonate	A white powder used to raise total alkalinity in pool water. Also known as bicarb soda.
Sodium bisulphate	A granular material used to lower pH and/or total alkalinity in water. Also known as dry acid.
Sodium carbonate	A white powder used to raise pH in water. Also known as soda ash.
Sodium hypochlorite	A clear liquid form of chlorine. Commercially available in bulk delivered strengths of 10–12.5% available chlorine. Also called liquid chlorine or bleach.

Source water	Water used to fill the aquatic facility and used as make-up water. Usually town water but could also include rainwater (provided it is introduced into the balance tank first).
Stabiliser	Refer to *Cyanuric acid*.
Test kit	Equipment used to determine specific chemical residual and physical properties of water.
Total alkalinity	A measure of the pH buffering capacity of water.
Total chlorine	The sum of both free and combined chlorines.
Total dissolved solids	TDS A measure of the salts and small amounts of organic matter dissolved in water.
Trihalomethanes	Compounds formed by reaction between chlorine or bromine and certain organic compounds.
Turbidity	The cloudiness of water due to the presence of extremely fine particulate matter in suspension that interferes with light transmission.
Turnover time	The period of time required to circulate a volume of water, equal to the aquatic facility's capacity, through the treatment plant.
UV light	Ultraviolet light. Wavelengths of light shorter than visible light.
Water slide	A feature at an amusement park consisting of a large slippery slide, often with many curves and twists, leading to a pool, with water running along the slide into the pool.

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Australian Standards

SAI Global has compiled a comprehensive list of Australian Standards that may be relevant to public aquatic facilities in its *Guide to Standards – pools and spas* <https://infostore.saiglobal.com/uploadedFiles/Content/Standards/Guide_to_Standards-Pools_and_Spas.pdf>.

Key Standards include:

HB 241-2002 Water management for public swimming pools and spas

AS 1668.2-2012 The use of ventilation and airconditioning in buildings

AS 1926.1-2012 Swimming pool safety – safety barriers for swimming pools

AS 1926.2-2007 (R2016) Swimming pool safety – location of safety barriers for swimming pools

AS 1926.3-2010 (R2016) Swimming pool safety – water recirculation systems

AS 2560.2.5-2007 Sports lighting – specific applications – swimming pools

AS 2610.1-2007 (R2016) Public spas

AS 2865-2009 Confined spaces

AS 3136-2001 Approval and test specification – Electrical equipment for spa and swimming pools

AS 3636-1989 (R2013) Solar heating systems for swimming pools

AS 3780-2008 The storage and handling of corrosive substances

AS 3979-2006 Hydrotherapy pools

AS/NZS 2416.1:2010 Water safety signs and beach safety flags: Specifications for water safety signs used in workplaces and public areas (ISO 20712-12008, MOD).

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