Controlling Legionella in warm water systems 2010

Draft

Comments are invited until 1 June 2010. Please email to legionella@health.vic.gov.au

Department of Health

Victoria
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Published by the Victorian Government Department of Health
Melbourne, Victoria

This document may also be downloaded from the Department of Health web site at: www.health.vic.gov.au/environment/legionella

Authorised by the State Government of Victoria, 50 Lonsdale Street, Melbourne.

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1. Introduction

1.1 Purpose of this document

Legionella bacteria can grow in the warm water systems commonly found in our commercial and public buildings. In Victoria there have been no confirmed cases of Legionnaires' disease linked to a warm water system in a health or aged care facility. However in 2008 seven cases of Legionnaires' disease were linked to a warm water system operating in a commercial car wash.

On 1 January 2010 the Public Health & Wellbeing Act 2008 and the Public Health and Wellbeing Regulations 2009 commenced. The Health (Legionella) Regulations 2001 were repealed on the same day.

Sections 61 to 64 of the Public Health and Wellbeing Regulations 2009 contain the requirements for warm water systems.

The changes replace the prescriptive requirements of the 2001 with a requirement to manage the risk of *Legionella* associated with water delivery systems in certain places:

- premises supplying aged care
- premises supplying health services
- health service establishments
- registered funded agencies
- correctional services
- commercial vehicle washes.

Some facilities have found it difficult to manage the risks of *Legionella* growth in warm water systems in the past, due to the design, age or condition of their system. For example, some systems have difficulties introducing chlorine to disinfect the system following the detection of *Legionella*.

The original warm/hot water system may have been so altered over the years that it no longer bears any resemblance to the original design and is best described as a 'heavily modified' or even 'hybrid' system. This creates ongoing difficulties with maintenance and/or disinfection.

Following industry consultation and workshops, *Controlling Legionella in warm water systems* has been developed by the Department to:

- supplement the requirements of the Regulations
- assist industry to develop appropriate assessment and management methods for controlling *Legionella*
- provide references to other relevant documents and technical notes.

This guide should be read by:

- people responsible for warm water systems in correctional, health and aged care facilities – hospital engineers, facility managers, maintenance staff, consultants and water treatment contractors
- infection control practitioners and teams.

This guide recognises the weight of international evidence linking *Legionella* found in warm water systems to outbreaks of Legionnaires' disease, but balances this against the lack of comparable evidence in Victoria and Australia. A graduated process is therefore recommended. A better understanding of each system will assist in assessing the risks and establishing *Legionella* control.

Templates for basic assessment and review are provided in this guide and should enable most facilities to better meet regulatory requirements. An advanced template is also provided for complex systems in high risk settings or those having problems with *Legionella* control.

1.2 What is Legionnaires' disease?

Legionnaires' disease[1] is a serious form of pneumonia, caused by the bacteria *Legionella*. These bacteria occur naturally in lakes, rivers, creeks and soil, usually at low concentrations or below delectable levels. There are many species of *Legionella*, but the main source of Legionnaires' disease is *Legionella pneumophila serogroup 1* ('Lp 1').

Although not all cases of Legionnaires' disease are severe, up to ten per cent of cases may be fatal. Those with severe symptoms need to be treated in hospital with antibiotics. The earlier they are diagnosed and treated, the better the outcome.

1.2.1 Case definition

The case definition for Legionnaires' disease used by the Australian National Notifiable Diseases Surveillance Systems requires a confirmed case to have laboratory definitive evidence and clinical evidence. A probable case must have laboratory suggestive evidence and clinical evidence.

Whereby laboratory definitive evidence includes any one of the following:
- isolation of *Legionella*
- presence of *Legionella* urinary antigen
- seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to *Legionella*.

Whereby clinical evidence includes any one of the following:

- fever
- cough
- pneumonia.

Whereby laboratory suggestive evidence includes any one of the following:

- single high antibody titre to *Legionella*
- detection of *Legionella* by nucleic acid testing
- detection of *Legionella* by direct fluorescence assay.

1.2.2 Symptoms

Usually, symptoms are similar to a serious 'flu' infection – fever, headache (often severe), shortness of breath, muscle aches and pains and sometimes a dry cough – but may also include pneumonia.

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[1] For a copy of the department's brochure *Legionnaires' disease – the facts*, refer to www.health.vic.gov.au/ideas/diseases/leg_facts.htm

From the time of exposure to *Legionella* bacteria, it takes between two and ten days for onset of symptoms. In most cases, symptoms begin after five or six days.

1.2.3 Diagnosis

Once people show symptoms, there are three main tests for confirming Legionnaires' disease:

- sputum test (samples are cultured; takes up to ten days for results)
- blood tests (this requires two tests more than four weeks apart)
- urine test for *Legionella pneumophila* antigens (known as urinary antigen testing, usually done within a day).

1.2.4 People at highest risk

Most people exposed to *Legionella* do not become infected. Literature[2] indicates that those patients most at risk include those who:

- have a weakened immune system (includes organ-transplant patients), have HIV/AIDS, are receiving systemic steroids, or are undergoing treatment for cancer
- are over 50 years of age
- have chronic underlying disease such as diabetes, congestive heart failure, chronic lung disease or chronic renal disease
- smoke cigarettes (or who have until recently been heavy smokers)
- consume alcohol heavily.

Some hospital patients or aged care residents are at a higher risk, due to the nature of their illness. For example, heart transplant patients seem to be particularly susceptible (Chow and Yu 1998). Units that tend to have patients where *all are at higher risk* are oncology, haematology, organ transplant units, intensive care units, high dependency units and burns units.

Many people with Legionnaires' disease are admitted to hospital for long periods, spending some of this time in intensive care. A small percentage of people may suffer some permanent disablement. For a minority of sufferers, the disease proves fatal.

1.2.5 How *Legionella* is spread

Aerosols
The most likely pathway for Legionnaires' disease is breathing in *Legionella* bacteria in very fine droplets of water called aerosols. Artificial water systems, such as showers, spa pools and fountains are capable of forming such aerosols and may provide a favourable environment for *Legionella* bacteria to multiply into large numbers.

Aspiration
Contaminated potable water (with subsequent inhalation or aspiration of aerosols during drinking of the water) has been suggested as a possible source of Legionnaires' disease (Stout and Yu 1997), but not all researchers have been convinced of this theory (Bhopal 1995). Loeb *et al.* (1999) linked contaminated drinking water to two outbreaks of Legionnaires' disease in nursing homes. They suggested that the cause was aspiration due to swallowing difficulties.

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[2] Blatt *et al.* 1993; Carratala *et al.* 1994; CDC. 1997; Tablan *et al.* 1997; Loeb *et al.* 1999)

Environmental sources
The risk associated with *Legionella* is not confined solely to warm water or warm water systems. Other causes of Legionnaires' disease have included cooling tower systems (Dondero *et al.* 1980), spa pools (den Boer *et al.* 2002), misted food or refrigeration displays (Mahoney *et al.* 1992), ice machines (Bangsborg *et al.* 1995; Graman *et al.* 1997), fountains (Hlady *et al.* 1993), respiratory devices (Mastro *et al.* 1991; Mitchell *et al.* 1997) and humidifiers (Arnow *et al.* 1982; Woo *et al.* 1986).

1.3 What is a Water Delivery System?

The *Public Health and Wellbeing Regulations 2009* define a water delivery system as *"any shower plumbing, bath, pipes, water heaters, bathing facilities, water storage tanks or vehicle washing equipment used to store, deliver, transmit, treat or mix water".*

When assessing the risks associated with *Legionella* it is important to focus on two elements:

- Water being stored or supplied at a temperature of between 30°C and 60°C
- The potential for people to be exposed to respirable sized droplets produced by a water source.

If a water delivery system does not contain both of these elements the risks of Legionella growth are considered to be managed.

The regulations aim is to ensure that the risk of Legionella is managed in places such as showers designed to deliver water at temperatures that will not cause scalding as well as in other water systems in high risk premises that may incorporate the elements described above regardless of whether they have previously been recognised as a potential source of Legionnaires' disease.

1.4 What is a warm water system?

For the purposes of this guide, a warm water system is a piped water system, including any thermostatic mixing valve, which is designed to supply water to a shower outlet at a temperature between 30° and 60°C.

A distinction has been made between piped water systems – in which hot water is produced, but cooled before use – and tepid or warm water systems, in which the water is heated and recirculated at a temperature between 30°C and 60°C.

The department's sampling results over the past 7 years shows that all warm water systems are capable of growing *Legionella* and therefore they may potentially cause Legionnaires' disease.

For an overview of warm water systems and advice on their use, layout and installation, refer to Standards Australia handbook HB 263 – 2004 Heated water systems. Compiled by the Plumbing Industry Commission (Victoria), it is available as a hard copy or as a PDF file on the Standards Australia website (www.standards.com.au). The Plumbing Industry Commission's website (www.pic.vic.gov.au) also has a number of fact sheets (called Technical Solutions) on both hot and warm water systems.

2. Legionella and warm water systems

Much of the evidence linking *Legionella* found in shower warm water systems to outbreaks of Legionnaires' disease is from overseas. There is not yet any comparable evidence in Victoria and Australia. However, as discussed earlier, an outbreak of Legionnaires' disease in Victoria was linked to a warm water system used in a car wash facility.

The information in this chapter describes what is currently known, based on a literature review.

2.1 International experience

Detection of *Legionella* in warm water systems has been described by Laverdiere *et al.* (2002). Laverdiere refers to a Canadian study where 371 privately owned houses were sampled for *Legionella*. All had electric hot water heaters and 16 per cent had detectable *Legionella*. Stout and Yu (2002) also found that *Legionella pneumophila serogroup 1* had colonised a warm water system within one month of operation.

There are numerous reports in the literature of facilities with warm water systems being implicated in causing Legionnaires' disease in patients or residents. The European Working Group for *Legionella* Infections (www.ewgli.org) actually names accommodation sites recently associated with clusters of Legionnaires' disease, to warn intending visitors and advise those who visited during the exposure interval. Several of these sites had poorly designed and maintained warm water systems, often solar heated and not heat boosted.

2.2 Hospital-acquired (nosocomial) Legionnaires' disease

The incubation period for Legionnaires' disease is generally between two and ten days. A patient who has spent more than ten days continuously in hospital prior to the onset of Legionnaires' disease is considered to have nosocomial (hospital-acquired) Legionnaires' disease. Infection occurring two to nine days after hospitalisation is considered possibly nosocomial.

Overseas, cases of Legionnaires' disease have been sourced back to warm water systems of hospitals many times. Reviews of *Legionella* presence in hospital water systems and of nosocomial Legionnaires' disease are numerous (Hart and Makin 1991; Joseph *et al.* 1994; Chow and Yu 1998; Lin *et al.* 1998; Ruef 1998).

"Legionella are part of the 'normal' flora of water and only occasionally give rise to disease…There is no guarantee that Legionellae can be eradicated from [potable water systems]. There is extensive literature on nosocomial legionellosis and although some reports suggest that Legionellae have been eradicated from a hospital, most only show evidence of a reduction in the numbers of Legionellae in the water or a temporary fall below detectable numbers. The exercise of preventing nosocomial legionellosis is therefore one of containment and control….it is important to remember that Legionnaires' disease…is more severe in patients in hospital, and affects patients much more often than workers in the hospital." (Fallon 1994).

Hospital warm water systems are commonly contaminated with *Legionella* – more than two-thirds of institutions, in one study (Alary and Joly 1992). One NZ study showed *Legionella* to be the main microbial cause of nosocomial pneumonia (Everts *et al.* 2000).

For detailed studies of nosocomial cases in specific hospitals in different countries, refer to the following: Brazil (Levin *et al.* 1991); Quebec (Marrie *et al.* 1995); USA (Chang *et al.* 1996; Goetz *et al.* 1998), (Lepine *et al.* 1998), (Kool *et al.* 1999); Germany (Luck *et al.* 1998), (Kohler *et al.* 1999); UK (Tobin *et al.* 1980), (Patterson *et al.* 1994); Amsterdam (Zanen-Lim *et al.* 1984); France (Benz-Lemoine *et al.* 1991); Spain (Campins *et al.* 2000) and Austria (Prodinger *et al.* 1994).

Kool *et al.* (1998) describe a long-term outbreak of Legionnaires' disease in a hospital. Lepine *et al.* (1998) also describe long-term colonisation of a hospital plumbing system.

2.3 Australian and Victorian experience

Legionella has been reported in the warm water of a small number of metropolitan and country Victorian and NSW hospitals (Peel *et al.* 1985) (Broadbent 2003). Makela *et al.* (1981) described a case study involving five non-fatal cases of Legionnaires' disease, which occurred in 1979 and 1980 among patients living in Ballarat, Victoria. The investigation centred on a long term care institution and found that 'bathing water' reached a shower block from a holding tank designed to maintain the water at a constant temperature of 40°C. The shower was tested and found to be contaminated with Lp 1.

There has been a reported link between a domestic hot water system and a single case of Legionnaires' disease (Lp 8) in Queensland in 2003. The 50 L electric hot water system had the power turned off and low levels of *Legionella* (Lp 1 & 2-14) were detected in the water (Young *et al.* 2005).

In Victoria in 2008, seven cases of Legionnaires' disease (Lp1) were linked a warm water system at a self service car wash facility. Water was being stored at ~45°C before being supplied to a high pressure hose that generated a fine mist. Legionella (Lp1) was detected in samples collected from the outlet at 80 org/ml and from the storage tank at ~39,000 org/ml.

There is some anecdotal evidence of cases or outbreaks being linked to warm water systems in hospitals and aged care facilities. A definite link can generally only be established if the case(s) and the water sample from the warm water system have the same species of *Legionella*.

It is important to note that investigations may occur as late as about two to three weeks after exposure. This allows for incubation, onset of illness, diagnosis and notification to authorities. In this period, the system may have been treated prior to investigation, by routine maintenance or disinfection. As a result, it is unsurprising that the source is not always identified. Also, the patient may not remember all the sites they visited during the exposure interval.

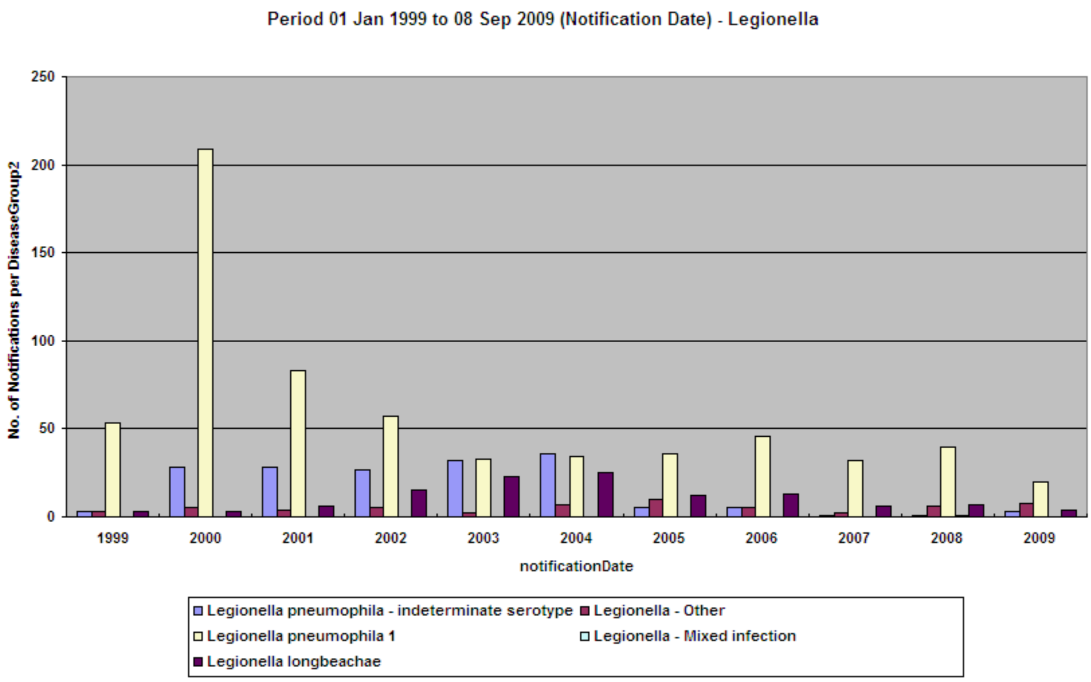
It is also possible that disease outbreak investigators may not have considered warm water systems in the past when attempting to identify a source, as the focus has been on cooling tower systems (Heath *et al.* 1998). In some outbreaks and most single cases of disease, the source is not identified (Li *et al.* 2002). *Legionella* in warm water systems may have contributed to some of these cases.

When investigating cases of any illness, it is always easier to identify the source of an outbreak, than a single case. From the mid 1990s, all cases of Legionnaires' disease in Victoria have been followed up by investigation. Also, anecdotal experience in Victoria is that while many facilities have detected *Legionella* in their warm water systems, there has been no link to a case of Legionnaires' disease within such a facility.

2.4 Notifying cases of Legionnaires' disease

The Victorian *Public Health & Wellbeing Regulations 2009* require the pathology laboratory and or the medical practitioner to notify the department immediately following confirmation of a case of Legionnaires' disease. The Department of Health investigates all cases, to determine the likely source.

The following graph shows the incidence of Legionnaires' disease in Victoria over the past decade. Most cases were attributed to cooling tower sources.



Since 2000, it is suspected that the testing of patients presenting with pneumonia-like symptoms for Legionnaires' disease has significantly increased due to increased awareness of Legionnaires' disease. Kool *et al.* (1999) showed that increased reporting of nosocomial Legionnaires' disease was attributable to urinary antigen tests – some cases went unnoticed before the test was introduced in 1999.

Most cases cannot be directly linked to a particular cooling tower or warm water system. However, it is possible that some of these unresolved cases are caused by warm water systems.

One problem with environmental investigations is that the notification of illness often occurs at least three weeks after exposure. It is possible that some changes to the system have occurred in that period and, as a result, the source may never be identified. These changes could relate to system maintenance, or the inadvertent flushing out of *Legionella*-infected biofilm.

This is particularly true of individual cases. It is often difficult to establish all sites visited during the incubation period, when interviewing a critically ill patient. For outbreaks, it is often easier to identify common places of exposure and hence identify the source.

2.5 The ecology of *Legionella* bacteria

There are over 43 species of *Legionella,* more than half of which have been linked to human disease. It has been reported 90 per cent of Legionnaires' disease cases are caused by *Legionella pneumophila* (AWT 2003).

Legionella pneumophila serogroup 1 (Lp 1) is the most common isolate recovered from environmental samples. Within Lp 1, there are more than 50 subtypes that can be identified by phenotypic or molecular typing methods. Different serogroups and subtypes vary in their degree of virulence (AWT 2003).

Legionella bacteria are difficult to culture from water at 15°C or less and the multiplication rate is slow between 20°C and 25°C. The optimum temperature for growth is around 37°C; at 46°C, the bacteria begin to die. As well as a favourable temperature, other growth factors include nutrient availability, presence of other bacteria/amoebae and biofilm on the wetted surfaces of pipes. It is also regarded as a slow growing bacteria (Broadbent 2003) and culturing in a laboratory can take up to ten days.

Culturing *Legionella* requires a special, quite selective media. In water environments, *Legionella* must obtain all of the nine amino acids that it needs from other living organisms that produce them in excess and/or from the decomposition of organic matter. Evidence also exists that some species of *Legionella* are more virulent than others, like *Legionella pneumophila* is responsible for most cases of disease. Serogroups 1, 3, 4 and 6 were found to make up nearly 90 per cent of all American Legionnaires' disease cases. There have also been reports that algae and amoebae may enhance the number and virulence of the bacteria and promote the aerosol transmission of the bacteria, by protecting it from desiccation (Fliermans 1996).

The presence of nutrients in water causes a micro-layer to form on the inner surfaces of pipes that come in contact with the water. This layer acts as a food source for bacteria, including *Legionella*. Once *Legionella* become attached to the surface of this layer, a gelatinous polypeptide/polysaccharide matrix gathers nutrients and protects against superheating. This allows the bacteria to flourish and produce biofilm (Anon 1998) (Rogers *et al.* 1994).

The majority of *Legionella* do not exist as free-swimming bacteria – they reside, well-protected, inside protozoan/amoeba hosts and in the matrix of biofilm. Eventually, they are released from their hosts in the form of small vesicles, each containing hundreds of *Legionella* (EPA 1999).

Amoebae are motile protozoan cells thought by many to act as "trojan horses", by internally hosting *Legionella* bacteria. *Legionella* are known to survive and multiply inside the amoebae (Newsome *et al.* 1998). As amoebae are less sensitive to disinfectants, *Legionella* can survive in water, which has been disinfected. The *Legionella* later cause the amoebae to break open and are released into the immediate surroundings. This could be into water, or if the amoeba cells have been inhaled, into the lungs (Broadbent 2003). The amoebae associated with harbouring *Legionella* do not themselves cause disease in humans.

Amoebae are certainly often present in water systems, particularly growing in biofilm. However, treating for amoebae as a mechanism of controlling *Legionella* is not a well-developed concept as yet and will not be addressed in this guide. Authors such as Chang (1978) have shown that amoeba cysts can resist high temperatures and that hyperchlorination can be effective, given sufficient time and concentrations. Amoebae need to survive by consuming bacteria, so reducing their food supply will result in reduction of amoebae numbers. Such interactions support the need for controlling all microbial growth in the system.

Legionella pneumophila has been observed to multiply in hospital plumbing systems only when amoebae were also present, suggesting that protozoa are essential for providing the habitat in which *Legionella* can multiply (Atlas 1999) (Nahapetian *et al.* 1991). In terms of survival, the amoeba-grown bacteria are better able to withstand their aquatic environment and may be more virulent. After intracellular replication within protozoa, *Legionella pneumophila* shows resistance to high temperature, acidity and biocides (Atlas 1999).

Laboratory testing may also be influenced by the presence of *Legionella* inside amoebae. Hay and Seal (1994) describe a study by Nahapetian *et al.* (1991) which found that 11.8 per cent of water samples containing amoebae were negative for *Legionella,* but after prolonged incubation were found to contain *Legionella*.

Changes in water pressure and flow rates of water distribution systems may cause disruption of the biofilm, resulting in increased concentration of *Legionella* in water supplies (Kramer & Ford 1994).

2.6 Thermal sensitivity of *Legionella*

Legionella is susceptible to high temperatures. The following figures are a guide to temperatures that would encourage or discourage growth in a warm water system. However, it has been our experience that the use of heat as a disinfectant is impractical because it is unlikely that water temperatures mentioned below can be maintained for the required time and there is some evidence that raising the temperature of the system slightly for a short amount of time may favour the growth of Legionella (Mathys, W. 2008). We recommend that chlorine disinfection be used in response to a Legionella detection, section 4.1.2 describes disinfection methods using chlorine.

Optimum growth range
The optimum growth range is between approximately 35°C and 46°C (Anon 2001).

Active range
Legionella is active between 20°C and 50°C (Anon 2001).

Killing range
Legionella has a fast death rate above 60°C (Anon 2001) and a slow death rate between 50°C and 60°C (Anon 2001).

Temperature-time relationship
There are numerous reports on the temperature-time relationship required to kill *Legionella.* While there is no definitive study, the following figures are provided as background information:

- 71.7°C for 15 seconds causes 100 per cent kill (Birkbeck 1993)
- 70°C causes 100 per cent rapid kill (AWT 2003)
- 70°C for 10 minutes eliminates *Legionella* from water (EPA 1999)
- 61.7°C for at least 30 minutes causes 100 per cent kill (Birkbeck 1993)

- 60°C for 2 minutes causes 90 per cent kill (AWT 2003)
- 60°C for 2.7 minutes causes 90 per cent (Barbaree Unknown)
- 55°C for 27 minutes causes 90 per cent kill (Barbaree Unknown)
- 50°C for 2 hours causes 90 per cent kill (AWT 2003).

These varying reports show that relying purely on heat to disinfect a system colonised with *Legionella* may not always be successful.

2.7 Species of *Legionella* associated with warm water systems

Warm water system-associated outbreaks of disease include a more diverse range of *Legionella* species and serogroups than other sources. This includes Lp 1, 2, 5, 6 and 12 serogroups and other species such as *L. micdadei*, *L. bozemanii*, and *L. feeleii* (Bentham 2003).

Muder and Yu (2002) describe the relative risks of different *Legionella* species as follows:

"Although there is considerable evidence that the presence of L. pneumophila in a hospital water system is predictive of the occurrence of nosocomial legionellosis within the facility, the risk posed by the presence of other Legionella species is less well defined."

2.8 The role of aerosols

There is evidence that showers produce aerosols. For example, *Legionella pneumophila* has been isolated from air samples collected in a shower room; Dennis *et al.* (1984) and Kool *et al.* (1998) describe taking air samples in a hospital (with an, as then, undetected outbreak of Legionnaires' disease) and finding Lp 6 in the room after the showers had been turned on.

Aerosols containing *Legionella* are generated during normal operation of showerheads and hot water taps, but not in the same quantities as cooling tower systems. These aerosols are rarely transported over distances of more than a few metres (Bollin *et al.* 1985).

Dennis and Lee (1988) describe aerosols in detail. When released as a bolus (a single slug), aerosol survival of *Legionella* assumes even greater importance as a virulence factor, than if it were released continuously. The longer the cells remain viable in an aerosol, the greater the dose that susceptible individuals will accumulate over the time that they are exposed to the aerosol and therefore, the more likely they are to succumb to infection.

Colbourne *et al.* (1984) showed that turning on a tap released sufficient pressure to draw stagnant water containing the organism into the main water flow and then out of the tap to generate aerosols of less than 5 μm in diameter in showers.

Mechanical or thermal biofilm disruption may release amoebae and *Legionella* into domestic plumbing, where they are subsequently aerosolised (Straus *et al.* 1996).

3. Assessing and managing warm water shower systems

Given the lack of confirmed cases of Legionnaires' disease in Victoria (and Australia) attributable to aerosol exposure from warm water shower systems in hospitals and aged care facilities, the following graduated approach to assessment and management is recommended.

For all systems

Step 1: Conduct an audit to locate and gather basic information about each warm water system on your site.

Step 2: Conduct a basic assessment and review of management of the system, using the template provided.

Step 3: Keep accurate and detailed records of all maintenance performed on all systems on your site, on a system-by-system basis.

Step 4: Identify dead legs including those created by unused outlets and develop a management plan.

Step 5: Develop a clear plan on what you will do should *Legionella* be detected.

Step 6: Develop a water sampling strategy and start regular sampling for *Legionella.*

For systems that are of increased risk or have *Legionella* control difficulties

Step 7: Develop an advanced assessment of the warm water system:

- where *Legionella* is detected in a system on a regular basis, or
- where the action taken to disinfect the system is shown to be ineffective.

This advanced assessment is also advisable for sites of high risk or large health care facilities.

Step 8: Conduct an advanced review of the warm water system, using the template provided. This will lead to a more comprehensive understanding of the warm water system and identify any improvements required for better management.

The complexity of many systems does not allow for a comprehensive review of their design nevertheless, small modifications to the design can produce dramatic improvements in water quality, system performance and risk reduction.

Owners are encouraged to review the design of systems where possible. Where improvements have been identified, they should take steps to implement those improvements.

Information relating to assessing and managing the risks associated with water delivery systems used in commercial car wash premises is available at: www.health.vic.gov.au/environment/legionella/car_washes

3.1 Step 1: The site audit

A site audit should review the number, location and nature of all warm water systems present at the facility. In particular, document:

- the broad layout of the system: that is where is the water heater and what area does it serve? This is best done on a plan of the site.
- the type of warm water system installed, including the broad detail about components present in the system: for example calorifier/water heater connected to TMVs.

In older facilities, an accurate detailed plumbing layout may not be available. If a problem does arise, a response or treatment will be applied without a clear idea of whether the proposed cause of the problem was accurately diagnosed or appropriately treated. Misdiagnosing problems due to lack of information can delay resolving the problem and may lead to more serious flow-on effects.

Having a basic diagram or plan about every warm water system on the site is an important step toward being able to address such risks.

An up-to-date diagram of the piping system layout should:

- Detail the direction of water flow in pipework.
- Indicate whether the water is cold, warm or hot.
- Locate all outlets, identifying their type of fitting, dead legs and dead ends (where they are known), TMVs, other tempering devices, water heating and storage tanks and booster pumps or heaters. All components should be included, including smaller attachments and components such as stop taps, shock absorbers, line strainers, pressure limiting valves and non-return valves. Label heat-tracing cables, if present.
- Check whether heated water is recirculated back through the calorifiers and if so, label, which pipelines are circulated back.

The plan should be reviewed annually and updated as necessary with construction or remedial changes.

Plumbing diagrams tend to be drawn by plumbing consultants or architects, however it is permissible for anyone to edit existing diagrams. There are no standardised plumbing symbols, but a key to the symbols chosen needs to be included on the diagram. Examples of plumbing layouts can be found at the Plumbing Industry Commission website: www.pic.vic.gov.au

It is also common for hospitals adding new buildings to connect the plumbing to existing building systems. This can result in an overly complex piping network and a hybrid system, and unless maps are updated following changes to the plumbing, it can be difficult to obtain a pipe layout map retrospectively.

Guidance note: Perform a site audit and develop as detailed a system layout as is practical for the site.

3.2 Step 2: Do a basic assessment and review of the warm water system

It is recommended that all facilities with warm water systems conduct a basic assessment and review of the system's management. The information gathered in Step 1 (Site audit) will help in completing the basic assessment template.

It is again emphasised that the risk of Legionnaires' disease associated with warm water shower systems in Victoria is considered to be very low. It is therefore difficult to justify large expenditure on upgrades to warm water systems in any facility. In many circumstances, a basic risk assessment may note deficiencies that cannot or will not be fully addressed in the management plan, until such time as the risk is considered to have increased.

Guidance note: All premises supplying aged care, health services, health service establishments, registered funded agencies, correctional services and commercial vehicle washes should develop a basic assessment and management review.

Basic assessment and review does not need to be a highly complex task; the degree of complexity will often be dictated by the availability of information, budget and other resources. Assessment and review will lead to better defined management for each warm water system on the site.

Each management plan should be endorsed by the person responsible for:
- operation of the system
- operation of the site such as the chief executive officer or manager
- infection control (in the case of hospitals), or the Occupational Health & Safety committee for the site.

3.3 Step 3: Keep accurate maintenance records

Records of maintenance and testing assist the responsible person or contractors in finding the source of problems and in so doing, minimise costs in the long term.

All inspections, measurements, and modifications to the system design and water treatment need to be carefully recorded on a system-by-system basis.

The relevant Australian Standard is AS/NZS 3666.2:2002 *Air-handling and water systems of buildings-Microbial control. Part 2: Operation and maintenance.* Clause 2.6.1 Operating and Maintenance manuals specify these manuals shall be provided for all plant, equipment, water treatment and systems. A search should be made to locate these manuals and place them in a folder.

Maintenance manuals may give information on:

- physical details of the plant, equipment and systems and pre-treatment carried out
- recommendations on water treatment and management
- recommended cleaning, disinfection and emergency decontamination procedures
- start-up, operating and shut-down procedures
- particulars of the maintenance management program, including plant servicing and cleaning schedules.

Clause 2.6.2 Maintenance records of AS/NZS 3666.2:2002 requires up-to-date maintenance reports and log books. Maintenance records shall contain at least the following information:

- date, item of plant, equipment or system and nature of service performed
- details of defects found and rectification procedure undertaken
- name of the person and company performing the service.

Where appropriate, draw a diagram to identify the location of activities, for example, locating modifications to system layout, or which outlets were sampled.

You should note that an Authorised Officer of the Department who is investigating compliance with the Public Health and Wellbeing Regulations 2009 or investigating a case of Legionnaires' disease may request to see your records of maintenance and testing of the warm water system.

Guidance note: Detailed records should be kept of all works and maintenance on any part of the warm or cold water system.

3.4 Step 4: Removal of dead legs

Dead legs are a term given to pipes or fittings that have little or no flow through them. These sections of a system are believed to provide the most ideal conditions for *Legionella* to grow and multiply in the biofilm that adheres to the pipe.

A dead leg can be a branch in a water supply line that is branched off from the circulating system, but does not have an outlet or draw off point at its end. For example, a shower may have been removed in renovations, but the pipe leading to the shower has been left, providing a dead leg full of water. It can also arise where a pipe does have an outlet or draw off point at its end but is not in regular use, such as a disused staff shower or laundry sink. New buildings are not immune from these sections. For example, last minute changes may have been to the layout, creating a dead leg concealed by walls.

Water in dead legs can stagnate, permitting sufficient time for *Legionella* present to multiply and contaminate water circulating past the dead leg. As the water is not circulating, it can be difficult to disinfect these parts of a system. Dead legs that cannot be removed require passive diffusion of a biocide, which is not achievable for point-source forms of disinfection, such as UV light. Another difficulty with dead legs in old buildings is that they are often present, but concealed and unknown to those responsible for the system, particularly if accurate plumbing layouts are not kept up-to-date.

Risk reduction strategies include:

- Where dead legs are present in an existing system, seize opportunities that permit access to the dead legs, to drain and remove them. Remove the tee or branch fitting, or at the very least, cut and seal the pipe at the branch. It is usually not practical to locate all dead legs in a large, old and complex building, but it is strongly recommended that efforts be made to identify opportunities to locate and remove them during maintenance or renovation work on the site.
- Flow can be increased through use of booster pumps at distal sites to the calorifiers.
- Point-of-use instantaneous warm water heaters for specific parts of the system will circumvent stagnation in those parts.
- Direct pipework to recirculate water back through the calorifier where possible.

Another risk reduction strategy that has been widely used is the flushing of unused outlets.

Flushing all outlets of a warm water system not in use for seven days is no longer a mandatory requirement of the Regulations and it is now an issue where facilities are able to make a risk assessment and to then decide on whether outlets will be flushed.

Most public health guidelines around the world on this subject call for regular flushing of unused outlets in a warm water system. The aim of this process is to as far as possible drain off stagnant water within the system. The logic behind this action is that by flushing all outlets the likelihood of accumulation of free-floating *Legionella* in a system is reduced. In practice, this process may not drain out all of the stagnant water within a dead leg but most literature still recommends that this practice be undertaken regularly.

For example, UK Health & Safety Commission 'Approved Code of Practice & Guidance' 2000 (Health & Safety Commission 2000) advises that:

'The risk from legionella growing in peripheral parts of the domestic water system such as deadlegs off the recirculating hot water system may be minimised by regular use of these outlets. When outlets are not in regular use, weekly flushing of these devices for several minutes can significantly reduce the number of Legionella discharged from the outlet. Once started, this procedure has to be sustained and logged, as lapses can result in a critical increase in Legionella at the outlet. Risk assessment may indicate the need for more frequent flushing where there is a more susceptible population present, e.g. in hospitals, nursing homes etc.'

(Jacobs 2001) also describes the flushing process:

- All outlets must be flushed at full flow. Where outlets have the facility to mix warm and cold water, both warm and cold sections must be flushed.
- The period of flushing must be sufficient to remove all stagnant water leading to the outlet, and for the temperature of the system to be reached at the outlet.

While this process may not drain out all of the stagnant water within a dead leg, it should be undertaken weekly, with priority given to showers (as an aerosol forming outlet).

Weekly flushing of all outlets is not a trivial exercise:

- It can be difficult for staff to maintain awareness of usage patterns for all outlets and to identify which outlet has not been used in a week.
- It results in a significant loss of water.

3.5 Step 5: Develop a clear plan on what you will do should *Legionella* be detected

The Department's experience is that it is very important that you carefully consider what you will need to do if you do detect *Legionella* in your warm water system. If you do not plan ahead then you will find that there may be difficulties that you could have avoided. Once you detect *Legionella* you have legal obligations to take action to disinfect the system. In particular, the *Public Health and Wellbeing Regulations 2009* states that, within 24 hours of receiving a report that *Legionella* has been detected in a sample from a warm water system that the system must be disinfected.

A good plan would have the following elements:

- It should be written down
- It should be clear who is responsible for which elements in the plan
- It should describe exactly how you will disinfect the system as required by the Regulations
- It should describe who and how your stakeholders will be told of the detection

- Review how the system is operating.

3.5.1 Disinfecting the system

The plan must describe exactly how you will disinfect the system in a process called 'emergency disinfection'. You must disinfect the system within 24 hours of being notified of the detection. This aspect is described in detail in Chapter 4.

The plan should also detail who is responsible for authorising the disinfection so that no time is wasted if the action is indeed required.

3.5.2 Communication

It is important that you have thought about and documented your policy on communication of a Legionella detection before it happens. Section 8 of this document provides a model policy statement on communication of *Legionella* and Legionnaires' disease related issues whilst Section 8 contains a model communication plan.

3.5.3 Review how the system is operating

Immediately after the detection of *Legionella,* it is important to:

- Confirm equipment is operating effectively.
- Check maintenance records to find out if aberrances in procedures or faults with any components of the system have been reported.
- Actively review practices used in relation to the warm water system concerned.
- Review any existing documentation such as the risk management plan and consider whether changes need to be made to the plan or practices.

Guidance note Develop a clear plan of what you will do as soon as you receive advice that *Legionella* has been detected. This should involve:

- disinfecting the system immediately
- activating the communication protocol
- reviewing past practices
- implementing any changes necessary to correct faults.

3.6 Step 6: Sampling for *Legionella*

Whilst the regulations no longer mandate that you must test the water in the warm water system periodically for *Legionella*, it is recommended that all high risk premises undertake a water sampling program as part of a risk management approach.

3.6.1 Developing a sampling strategy

Sampling water in the warm water system at the point of the greatest likely exposure (like showers) is a worthwhile activity and can be a reasonably cost effective mechanism for monitoring a system. It is not a substitute for good maintenance and monitoring of the warm water system itself, but should be viewed as a performance indicator.

Sampling frequency should be based on the size and nature of the facility. Sampling from outlets should be taken from units housing patients at higher risk for acquiring Legionnaires' disease. If *Legionella* is detected, action must be taken to disinfect the system.

Sampling of water for *Legionella* in the warm water system should be part of a response to the risks of *Legionella* growth in warm water system.

Guidance note: A *Legionella* sampling strategy should be developed and implemented to maximise the impact of the expenditure and effort. This strategy needs to recognise the degree of complexity of the warm water system involved and identify:

- sampling frequency
- sampling locations
- sampling technique
- who will take the samples
- which laboratory will perform the analysis.

3.6.2 Sampling frequency

It is the Departments' position that sampling of the water in the warm water system at the point of the greatest likely exposure (i.e. showers) is a worthwhile activity and can be a reasonably cost effective mechanism for monitoring a system. It is not however a substitute for good treatment, maintenance and monitoring of the warm water system itself but should be viewed as a performance indicator.

There is no 'magic formula' for determining the ideal number of samples but the frequency should be determined based on factors such as:

- Your overall risk assessment of the risk that the warm water system might cause a residents, patients, workers or prisoner to contract Legionnaires' disease;
- The size and complexity of the system. This is supported by a study which suggested that larger water distribution systems are more susceptible to contamination than smaller ones because stagnation is more likely. The same study also suggested that larger hospitals (as measured by bed numbers) are more likely to be contaminated with *Legionella* than smaller hospitals (Alary and Joly 1992);
- The extent to which you are managing the risks by other means such as continuous treatment of the water as discussed in section 4;
- The implications of an outbreak of Legionnaires' disease on the organisation, residents, patients, workers or prisoners.

3.6.3 Sample numbers

The number of samples taken in a time period should depend on the number of people that are potentially exposed to the water via showers and other outlets – in general, the larger that number, the larger should be the sampling program.

As a guide, *it is recommended that at least 2 samples be taken for every 100 showers or beds* (whichever is the larger number) in every system each sampling period (such as monthly or quarterly depending on the risk assessment).

3.6.4 Identifying sampling locations

The focus should first be placed on outlets, which are more likely than others to contain *Legionella* contaminated aerosols:

- where current or recent construction or redevelopment is affecting the pipework
- where *Legionella* has been previously detected
- where there is low flow or low temperature
- where people, particularly high-risk patients/residents/prisoners, may become exposed to aerosols potentially containing *Legionella* such as showers rather than basin tap outlets.

The strategy will draw from your knowledge of the warm water system layout. Identifying all outlets is necessary to develop your sampling strategy. Water sampling should then ideally be rotated over time throughout all parts (and possibly all outlets) of the system, as well as the sampling from the circulating water and the calorifiers.

Construction and renovations
First, look for specific parts of the system that have either been involved in construction or redevelopment or *Legionella*-related remedial activity.

Some evidence exists that construction can be related to nosocomial Legionnaires' disease in warm water systems and that if there are concerns, consideration should be given to flushing and disinfecting the system. During construction and renovations, often both the ground and surrounding buildings are affected in some way. If the ground is disturbed, underground plumbing can be damaged and ingress of soil and other debris can occur. Connecting new plumbing onto existing structures or recommissioning plumbing that has been temporarily off-line can cause shocks or pressure changes that can burst the piping. This presents further risk of ingress of contaminants and can also disturb and mobilise settled reservoirs of *Legionella* and other microbes present in sludge, sediment and biofilm.

It is therefore recommended that there be increased sampling and surveillance of the system during these times. Sampling will need to be weighted toward these areas until the works are satisfactorily completed or the concentration of *Legionella* is undetectable.

Previous detection of *Legionella*
Extra attention ought to be given to outlets, which have previously tested positive, as it may indicate a problem in the vicinity of that outlet.

Areas of low flow or temperature
Extra attention should be given to areas known to be problematic in terms of low flows or temperatures as these conditions can be associated with increased risk of *Legionella* growth.

Next, consider your system's usage, temperature and flow profile. The sampling strategy needs to be weighted toward such areas.

Showers
Showers should be targeted for sampling before other outlets.

High-risk patients, residents or prisoners
Outlets that service areas where high-risk patients, residents or prisoners are located need additional focus. The sampling strategy suggested is weighted such that outlets in these areas will be rotated through slightly faster than other areas of the hospital.

3.6.5 Recommended sampling methodology

A plan of the site, which identifies all of the calorifiers/water heaters and warm water outlets, including showers, can be used as a starting point. A short process involving infection control/OH&S personnel and maintenance engineers/staff may be able to add notations to this plan which broadly categorises each outlet in each system into one of five categories.

This does not need to be a highly detailed and expensive process.

Suggested categories are:

a. calorifiers/water heaters
b. outlets in areas which are known to have low flow or low temperature
c. outlets which have been positive for *Legionella* in the last 12 months
d. outlets in areas currently involved in construction/renovation
e. outlets in areas which are commonly used by patients, residents or prisoners who can be characterised as being at 'high risk' of contracting Legionnaires' disease
f. all other outlets.

Of these, priority should be given to outlets in categories b. to e. In general, showers should be targeted.

The order in which outlets are to be sampled can be determined through randomising the outlet numbers within the categories.

3.6.6 Sampling technique

In accordance with AS/NZS 2031:2001, use sterile water sampling containers that contain sodium thiosulphate at a concentration of approximately 100 mg/L (when the sample is added). This additive serves to neutralise residual chlorine or other oxidising biocides. Prepared containers are usually available from NATA-accredited laboratories that culture water samples for *Legionella*. Confirm with the supplier that the containers *do* contain sodium thiosulphate, and at the recommended concentration such as 100 mg per litre. It does not matter if the container is not completely filled and the thiosulphate is in "excess."

Note that even though Melbourne metropolitan water supplies tend to have very low levels of chlorination, it is still recommended that all sampling bottles have sodium thiosulphate added, purely to ensure that there is a uniform and verifiable approach to sampling.

Guidance note: Sample bottles should contain sodium thiosulphate as per AS/NZS 2031:2001.

Given that patients come into contact with water from the outlets without flushing or disturbing the outlet, it is recommended that this first flush of water should be sampled and tested, without any prior cleaning, disturbance or disinfection of the outlet.

The outlets should be turned on with the same force that one would normally turn a tap or shower on, not just at a trickle. As most water sampling containers are small, turning on a tap with normal force may lead to splash and part of the sample being lost. To prevent splash, consider using a larger containers that have a wide mouth, ensuring that they are pre-prepared with sodium thiosulphate.

When sampling calorifiers, water samples are to be collected from the calorifier's drain valve after flushing for 30 seconds, or long enough to clear the outlet itself of any stagnant water.

A minimum of 100 mL is recommended by the standard AS/NZS 3896:2008 to be collected per sample, making sure that at least 2 cm of space is left above the water to enable sample mixing at the laboratory. Leaving a space in the top of the sample is important as it assists laboratory staff to process the sample efficiently.

Guidance note: A minimum of 100 mL is recommended to be collected.

3.6.7 Using swabs

Results from swabs cannot provide accurate concentrations of any bacterium at each site and are also likely to represent the inner surface of outlets, rather than the water that is delivered. For these reasons, the department does not take swabs of warm water systems.

Guidance note: The use of swabs to monitor the presence of *Legionella* is not recommended.

3.6.8 Sample transport and storage

In accordance with AS/NZS 3896: 2008 samples for testing for Legionella should be delivered to the laboratory in an insulated container to minimise significant variations in temperature.

ISO 11731: 1998 recommends that samples should be transported at 18°C but not less than 6°C and be protected from heat and sunlight. This standard recommends that samples should be delivered to the laboratory as soon as possible, preferably within 1 day but not more than 2 days.

Wherever possible, we believe that samples should arrive at the laboratory as soon as possible, ideally within six hours of collection but definitely within 24 hours.

Guidance note: Discuss the transport and timing of sampling and delivery with your laboratory.

3.6.9 Personal protective wear

While protective respiratory gear is not needed whilst collecting samples under normal circumstances, in the event of an outbreak, investigators collecting water samples do wear protective masks as a preventative measure. In routine sampling, where the risk of *Legionella* being present is expected to be very low, respirators should still be provided as an option to staff.

3.6.10 Who can collect the samples?

It is not necessary to have an independent party collect the samples, but detailed records need to be kept of this activity.

3.6.11 Choosing a laboratory

It is recommended that samples be tested by a NATA-accredited laboratory. To check if a particular laboratory is accredited or to find an accredited laboratory, go to the National Association of Testing Authorities (NATA) website at www.nata.asn.au

Guidance note: Use NATA-accredited laboratories to test water samples.

Laboratory methodology

Due to the nature of the culturing method in Australia, the minimum detectable concentration of *Legionella* is 10 colony forming units (CFU) per millilitre of water. While current technology permits the detection of lower concentrations of *Legionella*, a concentration of 10 CFU/mL is regarded as the minimum threshold that is associated with reasonable risk of causing disease.

Guidance Note: The department does not deem it necessary to detect concentrations below the current Australian threshold of detection (10 CFU/mL).

Presumptive culture results

Some laboratories offer early culture results, known as "presumptive" results. If the result is for samples taken from circulating water, calorifiers/water heaters or tanks, and given that critical event disinfection can be laborious and costly, it is reasonable to wait for the result to be confirmed before acting. However, it would be prudent to check that all equipment is working correctly in the period between receiving the presumptive and final results.

3.6.12 Interpreting the sample results

If *Legionella* is detected, then steps must be taken to disinfect the system. Disinfection methodologies are discussed in the next section of this guide.

3.7 Step 7: Advanced assessment of warm water systems

The template for advanced assessment of a warm water system provided in Section 8 will lead to a more detailed understanding of the risks present in an individual warm water system.

The regular detection of *Legionella* indicating that the system is colonised should send a signal to those responsible for the site that the risk of Legionnaires' disease in that site has increased. Also, the inability of a disinfection procedure to produce a negative result indicates that a review of systemic disinfection procedures is warranted.

Guidance note: It is recommended that the level of response be increased whenever *Legionella* is detected in the system on a regular basis. This should include ongoing monitoring of the water temperatures within the system and use of a systemic disinfection system, such as Copper-Silver or low level chlorination.

3.7.1 Heated water temperature and flow rates

The water temperatures of the system require regular monitoring and this is best done from designated or 'sentinel' outlets.

Sentinel outlets can be the first and last outlets on a recirculating system. For non-recirculating warm water systems, sentinel taps can be regarded as the nearest and furthest taps from the storage tank. Other outlets considered to represent a particular risk should also be included. For example, if an area is known to have a history of complaints about cool water temperatures, this should be targeted in a monitoring program. In general, temperature monitoring needs to be performed when the system is under heavy load and in the period immediately after peak load.

Ideally, automated temperature loggers can be permanently positioned in various locations of the system, such as on the piping leaving the calorifier/water heater. This would greatly simplify the task and provide real-time information. These devices can be linked to exception reporting that can alert staff in the event of failures as well as providing information when the system is under heavy demand and for determining recovery efficiency.

For those systems that are using TMVs, the check should ensure that the temperature of the water leading to the TMVs is above 60°C.

Table 1 presents a suggested protocol for measuring the temperature of the system.

Table 1: Monitoring regime for water temperature				
Frequency	Check	Standard to meet		Notes
		Cold Water	Warm/Hot Water	
Monthly	Sentinel water outlets	The water temperature should be below 20°C after running the water for up to two minutes.	For hot water outlets, the water temperature should be at least 50°C within a minute of running the water. For outlets with a tempering device supplying warm water, the temperature should that specified by the tempering device (maximum of 45°C) within a minute of running the water.	This check makes sure that the supply and return temperatures on each loop are relatively unchanged, like the loop is functioning as required
	How water feeds to TMV's on a sentinel basis	N/A	The water supply temperature to the TMV should be at least 50°C (as an absolute minimum) within a minute of running the water. Ideally, it should be above 60°C.	One way of measuring this is to use a surface temperature probe.
	Water leaving and returning to calorifier or water heater	N/A	Outgoing water temperature should be at least 60°C and return at least 50°C. Ideally, return water temperature should be above 60°C.	If fitted, the thermometer pocket at the top of the calorifier and on the return line are useful points for accurate temperature measurement. If installed, these measurements could be made automatically and logged by a building management system.
Six monthly	Incoming cold water inlet (at least once in the winter and once in the summer)	The water should preferably be below 20°C at all times.		The most convenient place to measure is usually at the ball valve outlet to the cold water storage tank
Annually	Representative number of outlets on a rotational basis	The water temperature should be below 20°C after running the water for two minutes.	The water supply temperature to the TMV should be at least 50°C (as an absolute minimum) within a minute of running the water. Ideally, it should be above 60°C.	This check makes sure that the whole system is reaching satisfactory temperatures for *Legionella* control.

Guidance note: It is recommended that the water temperatures of the system be monitored on a regular basis and this is best done from designated or 'sentinel' outlets.

Developing a water temperature profile

Developing a full water temperature profile is not a trivial exercise and is not recommended unless other indicators have pointed to significant problems such as regular detection of *Legionella* or complaints about water temperatures. However, the development of such a profile if performed thoroughly should provide highly valuable information. Collecting this information will indicate any areas that may not be achieving the correct temperature at the outlet and which would require further investigation. It can point to areas of stagnation or low flow and can highlight areas for remedial works or increased attention in terms of water sampling.

Ideally, the temperature profile would be established for both summer and winter to account for ambient temperature variations. It is important to note the time of the day that the testing was performed, to take into account demands on the system that may occur in a facility.

Where available, use a copy of the warm water system layout diagram to record your observations, so that any patterns of temperature variation can be seen. This may also include examining patterns of use that can explain such variations.

A recommended methodology is to:

- Measure the temperature of water from a drain point of the calorifiers after allowing water to run for 5–10 seconds, or long enough to remove any water settled in the drain outlet itself. The temperature should be greater than 60°C.
- Measure the temperature of the heated water at each set of taps and showers, after running the water for one minute. If you have any *hot* water outlets on the system (such as in staff rooms), these will be more informative than those that have been tempered. For hot water, the temperature should be at least 50°C (as an absolute minimum and ideally above 60°C) within a minute of running the water. For outlets with a tempering device (warm water), the temperature should be that specified by the tempering device (maximum of 45°C) within a minute of running the water.
- Check the temperature of the cold water at each set of taps and showers, after running the water for one minute. It should fall below 20°C. Flow and water temperature are integrally related.

Guidance note: Water temperature profiles should be developed over both summer and winter and at different times of the day to account for variations.

Boosting the system temperature

The most obvious solution is to turn up the calorifier temperature, so that circulating water is hotter for longer before reaching tempering devices. The extent of increase would depend on the capability of the calorifier, but more so on the nature of the problem associated with temperature. For example, where the problem is low flow rates in parts of the system, increasing the water temperature from the calorifier may not have a dramatic effect on those problem areas.

Other options to boost the water temperature include:

- adding booster heaters at points distal to the primary calorifier
- directing pipework to recirculate water back through the calorifier to reheat

- inspecting the insulation of parts of the system that do not hold the heat and adding or repairing insulation as necessary
- considering the use of point-of-use continuous flow hot water heaters for localised application to areas where it is difficult to control *Legionella* regularly, or where there is low demand
- adding heat-tracing elements to pipework that lose heat. Tracing is most commonly added when installing a new system, rather than retrofitting. Plumbers must ensure the heat trace electric supply is isolated, prior to undertaking any work that requires cutting through the pipe insulation to expose the copper pipe. These devices are discussed in more detail earlier in the guide.

Further reading
More information on heat tracing can be found at the Plumbing Industry Commission website: http://www.pic.vic.gov.au under water supply (hot water) on the 'Technical solution sheets' of the 'Technical assistance' page.

Guidance note: Where a water temperature profile shows low temperature areas, consideration should be given to boosting the water temperature in those areas.

Water flow and stagnation
For *Legionella* to multiply to levels that could lead to contamination and disease, the bacterium requires warm temperatures and sufficient time to multiply. If water flow is poor or infrequent, the water in any piping that is not part of a recirculating loop will stagnate. Based on current culturing methods, *Legionella* is not considered a particularly fast grower, and even at warm temperatures, it is likely to take up to a day to double in numbers. However, if stagnation does occur for hours or days, then *Legionella* may multiply and locally colonise the system, particularly if the disinfection used does not have a residual effect.

If the bacteria multiply and do not locally attach to the piping, the next time that water is drawn, a high concentration of *Legionella* could be delivered to a number of outlets. Local colonisation of the line could provide a further source of *Legionella* to that of the incoming cold water, and which could lead to serial seeding of the system.

Stagnant or poorly flowing water will also lose heat so even if the water is heated to high enough temperatures that do not suit *Legionella*. Stagnant parts may hold the water in the temperature range favoured by *Legionella*.

Identifying points of stagnation
Stagnation arises when water is not drawn through piping. As it loses heat whilst stagnant, the temperature of the piping is an ideal proxy for measuring stagnation. As some time may be involved before the temperature drops following stagnation, the temperature must be assessed over a period of time rather than at a single time point. Also, as usage patterns and air temperature fluctuate daily and seasonally, temperature monitoring needs to include night and day and different seasons.

One way of measuring temperature over time is to attach automated temperature loggers to the external surface of hot water piping and record temperature data over time. Representative line runs should be monitored over 3 to 7 days and in the middle of each season, so that a pattern of the day and night use and seasonal variation can be recorded. Examine any long dead legs or dead ends that are accessible. This information will be able to tell you both whether the temperature is maintained at the warm temperatures (assuming they follow a TMV) and for how long water stands at the warm temperatures.

If temperatures are shown to drop dramatically overnight or to fall into the temperatures between 20°C and 60°C, this may indicate poor insulation or stagnation. In the absence of residual disinfection products, this environment can be highly conducive to *Legionella* growth. If the system remains unmodified, one set of recordings from each of the four seasons from a representative range of pipelines should provide sufficient information regarding the performance of the system. Stagnation may also occur in part of a system when, for example, a ward is shut down for extended periods.

Dead legs
Dead legs are a term given to pipes or fittings that have little or no flow through them. These sections of a system are believed to provide the most ideal conditions for *Legionella* to grow and multiply in the biofilm that adheres to the pipe.

A dead leg can be a branch in a water supply line that is branched off from the circulating system, but does not have an outlet or draw off point at its end. For example, a shower may have been removed in renovations, but the pipe leading to the shower has been left, providing a dead leg full of water. It can also arise where a pipe does have an outlet or draw off point at its end but is not in regular use, such as a disused staff shower or laundry sink. New buildings are not immune from these sections. For example, last minute changes may have been to the layout, creating a dead leg concealed by walls.

Water in dead legs can stagnate, permitting sufficient time for *Legionella* present to multiply and contaminate water circulating past the dead leg. As the water is not circulating, it can be difficult to disinfect these parts of a system. Dead legs that cannot be removed require passive diffusion of a biocide, which is not achievable for point-source forms of disinfection, such as UV light. Another difficulty with dead legs in old buildings is that they are often present, but concealed and unknown to those responsible for the system, particularly if accurate plumbing layouts are not kept up-to-date.

Risk reduction strategies
Risk reduction strategies include:

- Where dead legs are present in an existing system, seize opportunities that permit access to the dead legs, to drain and remove them. Remove the tee or branch fitting, or at the very least, cut and seal the pipe at the branch. It is usually not practical to locate all dead legs in a large, old and complex building, but it is strongly recommended that efforts be made to identify opportunities to locate and remove them during maintenance or renovation work on the site.
- Flow can be increased through use of booster pumps at distal sites to the calorifiers.
- Point-of-use instantaneous warm water heaters for specific parts of the system will circumvent stagnation in those parts.
- Direct pipework to recirculate water back through the calorifier where possible.

Design considerations
Dead legs should not be designed or built into a new system. Pipework should be designed to be as direct as possible, avoiding stretches that do not recirculate. Dead legs, where they exist, are to be as short as practicable.

Further information:
The Plumbing Industry Commission have published a series of Technical Solutions including one on the topic of achieving hot water delivery temperatures/dead ends See http://www.pic.vic.gov.au/www/html/396-technical-solutions-sheets.asp?intSiteID=1

Guidance note: 'Dead legs' should be removed at every available opportunity, for example, when sites are undergoing renovations.

3.8 Step 8: Developing an advanced management plan

Further assessment of the system as already described in Step 7 will lead to the conduct of a more comprehensive review of management of the system to better address the risks of a warm water system which has had:

- *Legionella* detected on a regular basis, or
- where actions taken to disinfect the system have been shown to be ineffective.

An advanced review of management should also be conducted by facilities for each warm water system on site.

In the context of *Legionella* detection, you should consider that either:

- three consecutive detections of *Legionella* in the system; or
- the detection of *Legionella* in 30 per cent or more of the samples taken for analysis on any one occasion; or
- a recurring pattern of detection, emergency disinfection, followed by a period of non-detection and then detection etc.

should trigger this advanced assessment and development of a management plan.

Developing a more comprehensive management plan following further assessment and review of a warm water system is not a trivial task, but as discussed earlier the degree of complexity will be dictated by the availability of information, budget and other resources.

4. Systemic and localised disinfection

Disinfection methods discussed in this section have been divided into systemic and localised treatments.

Systemic disinfection treats all of the water in the system.

Localised treatments only treat water passing one or more points within a system. Specific issues and risks are associated with each.

All forms of treatment will require regular inspection and maintenance, varying in frequency with the type of treatment and associated risks.

There is no method of disinfection that will work for all sites and in all circumstances. This is because there are a multitude of combinations of situations between different sites, ranging from the incoming water quality to the design and maintenance of the system, the number of outlets and the number of staff available for maintenance.

Different facilities will need different solutions and it is up to the staff overseeing the warm water system to identify which method is most effective. This may involve trial and error, or even require different solutions for different parts of the system.

The following information is a guide to:

- some disinfection options that could be used to control *Legionella*
- some of the issues of application and maintenance involved with each method
- some examples of how they have been applied in particular settings.

A number of the treatments involve handling hazardous chemicals, which need to be treated with care, and handled by staff who are trained by experienced and suitably qualified people.[3] Similarly, some treatments require maintenance by skilled personnel and the proximity and availability of such personnel may be an issue for rural and regional sites. Where information is available at the time of writing, it has been provided in the relevant sections.

It must also be remembered that warm water must be of a potable quality. Therefore, treatments that can be applied to warm water systems are different to those applied to cooling towers.

The disinfection methods covered in this section are:

- heat disinfection
- chlorination (sodium hypochlorite)
- chlorine dioxide
- copper/silver ionisation
- chloramination (monochloramines)
- ultra-violet (UV) light
- ozonation.

The most effective treatments have proven to be a combination of systemic disinfection of entire water systems (including thermal disinfection, hyperchlorination, copper-silver ionisation) and local disinfection of specific

[3] For further information, refer to the Occupational Health and Safety Regulations 2007.

portions of those systems (including UV light disinfection, instantaneous heating systems, ozonation).

4.1 Systemic disinfection treatments

4.1.1 Heat disinfection

Heat disinfection (also known as 'thermal eradication' or 'super heat and flush') is probably the primary disinfection method in use around the world. The main advantage of heat disinfection and flushing is that it does not require the addition of chemicals.

The literature provides numerous examples of studies illustrating how heat disinfection was used to disinfect a system contaminated with *Legionella.* However, the literature also shows that heat disinfection or superheating is not generally a medium or long term solution.

Table 2: References describing hospitals that used superheating hot water tanks and flushing outlets to treat warm water systems

Reference	Temperature	Degree of effectiveness
(Mermel *et al.* 1995)	75°C for 72 hrs, also sterilised showerheads and taps. HWT raised from 43°C to 52°C	*Legionella* free for at least 6 months
(Prodinger *et al.* 1994)	HWTs at 54 - 60°C. Monthly superheats to 76°C	Unable to control *Legionella*
(Zacheus and Martikainen 1996)	HWT raised to 60 – 70°C for 2 to 4 weeks with twice daily outlet flushing for a few minutes then reduced the temperature	Unable to control *Legionella* when water below 60°C

The disadvantages of heat disinfection and flushing are that:

- It will not disinfect piping or fittings that are beyond a tempering device or thermostatic mixing valve, unless these are bypassed. This requires a skilled and appropriately licensed plumber
- It requires considerable hours of skilled labour
- It results in a high volume of wastewater
- It is difficult for most systems to either heat the tank water to 70°C, or be able to achieve similar temperatures right through to the non-tempered outlets
- It has poor long-term control. Recolonisation has been reported after superheat and flush procedures, followed by new cases of hospital-acquired Legionnaires' disease (reported in Lin *et al*. 1998)
- There are significant and potentially life threatening scalding hazards associated with this method – residents or patients may use the shower system during the heat disinfection and be scalded by the superheated water.

Routine heat disinfection
Routine disinfection involves periodic (usually monthly) heating of the calorifier/water heater to a temperature of at least 70°C for one hour, then systematically flushing all outlets for a short time. This is best performed during the afternoon or evening, when patients are less likely to be showering or

sleeping, or when they are absent from the facility. Building occupants need to be warned that the water from the hot outlets is not tempered.

It is important that the temperature during this procedure is measured, both as the water flows out of the tank and at remote outlets during flushing. This evaluates the system's ability to heat the water accurately, as settings on the calorifier/water heater may be unreliable. In many systems, as soon as hot water is flushed through an outlet the temperature in the calorifier/hot water unit drops significantly. The risk here is that as flushing proceeds, the temperature of the water coming through the outlet drops below the temperature needed to disinfect the water in the pipes and outlets.

There are numerous recommendations and reports of the temperature and time needed for heat disinfection, but no definitive study. A conservative approach needs to be taken and the department has adopted the Centers for Disease Control and Prevention (CDC) standard in that if heat disinfection is used the hot water temperature should be raised to 71°C and maintained at that level while each outlet around the system is progressively flushed for at least 5 minutes.

Guidance note: Heat disinfection is regarded as being of limited short-term effectiveness for disinfection of warm water systems. Where used, it is recommended that the temperature of the hot water tank be raised to at least 71°C and maintained at or above that level. After this has been completed, flush each outlet in turn for at least 5 minutes, with the water temperature of the water being monitored to ensure it does not drop below 71°C. Note: many systems would not be able to meet this standard.

4.1.2 Chlorination

Chlorine is usually added to the water in the form of sodium hypochlorite[4]. Sodium hypochlorite added to water forms hypochlorous acid, which is often referred to as 'chlorine disinfectant'. The actual amount of hypochlorous acid produced in this process depends on the pH of the water – the higher the pH, the less hypochlorous acid is produced. As a result, pH adjustment may be required to keep the pH between 7 and 8.

Chlorine may only suppress *Legionella,* rather than kill it. Inactivation and suppression of *Legionella* requires chlorine levels of greater than 3 mg/L (Lin *et al.* 1998).

The **advantages** of chlorination are that:

- It is relatively easy to implement and monitor
- Direct feedback controlled systems can be installed to automatically adjust doses
- It is relatively cheap
- It is easily installed in existing systems, without major modifications
- The efficacy is not affected by water turbidity

[4] It can also be added as chlorine gas or granular calcium hypochlorite. Chlorine in the form of liquid sodium hypochlorite is sometimes added manually to the system usually via the water tanks. It can also be injected under pressure into the recirculating line. For example, this is required in indirect systems where chlorine is required to be injected into a pressurised recirculation loop.

- Warm temperatures (45°C) enhance disinfectant activity compared to cold water
- There is a residual effect for downstream contamination.

The **disadvantages** of chlorination are that:

- Hyperchlorination may lead to corrosion of the pipes after 5 to 6 years of operation (EPA 1999).
- Chlorine decomposes at hot (> 60°C) water temperatures.
- It is less effective when pH is alkaline (>pH of 8) and therefore needs pH control.
- It produces by-products.
- It is a hazardous substance[5], in some circumstances.

A warm water system can either be routinely disinfected using chlorine via regular 'shock' additions of excess chlorine, or through routine application of lower levels of chlorine. These methods are described below.

Routine chlorination
CDC and HICPAC 2003 recommends that in facilities with solid organ transplant programs, heated water be chlorinated to achieve 1 to 2 mg/L free chlorine at the outlets.

Guidance note: Where routine chlorination is used, a level of 1- 2 mg/L of free residual chlorine (as measured at the outlets) should be maintained.

Shock chlorination
Shock chlorination means using chlorine at high levels following a critical event, or a single disinfection rather than a continuous one.

Adverse event chlorination
Adverse event chlorination is also known as 'hyperchlorination'. Lin *et al.* (1998) describe hyperchlorination as being a pulse injection of chlorine in water to achieve concentration of chlorine at 20 to 50 mg/L throughout the system. After a time (which is not described in the article), the water is drained and the system is mixed with incoming water.

Kool *et al.* (1998) describes a 5 minute flush with water with 10 to 20 mg/L as being effective in a hospital with long term colonisation.

The CDC recommends hyperchlorination of the system by:
- adding sufficient chlorine, preferably overnight, to achieve a free chlorine residual of at least 2 mg/L throughout the system, and
- flushing each outlet for at least 5 minutes with water containing at least 2 mg/L free residual chlorine.

Crosby quotes the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in recommending dosing with a chlorine source sufficient to hold a chlorine residual of at least 2 mg/L for a minimum of 2 hours. During this time, all outlets should be opened so that chlorine odour is detected at the outlet. This may require up to 20 to 50 mg/L chlorine in the hot water tank. (Crosby *et al.* 2003).

It is important to note that:

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[5] For further information, refer to the Occupational Health and Safety Regulations 2007.

- The maximum level of chlorine in drinking water as set in the Australian Drinking Water Guidelines (ADWG) is 5 mg/L.
- There are concerns associated with use of such high levels of chlorine and for corrosion of the warm water system.

Guidance note: Where hyperchlorination is used, either following a critical event or as a pulse type shock disinfection, the following procedure should be followed:

- Advise building occupants that the water is to be heavily chlorinated.
- Dose the warm water storage tank with sufficient sodium hypochlorite to maintain a free chlorine residual of at least 2 mg/L at pH 7.0 to 7.6 throughout the system. This procedure is ideally done overnight.
- Measure free residual chlorine at 15-minute intervals, to ensure that the concentration is at least 2 mg/L.
- Flush each outlet for at least 5 minutes with water containing at least 2 mg/L free residual chlorine.
- Drain the system and refill with water until the system has been thoroughly flushed of the chlorine, to reduce the likelihood of complaints about odours etc.

If the calorifier/water heater is found to be persistently contaminated, the water heater should be physically cleaned following disinfection. The procedure for cleaning follows that used during annual maintenance. It is recommended that staff cleaning out the contaminated water heater use respiratory breathing apparatus that exclude bacteria. In such circumstances, a full review of the system is also recommended to identify areas for improvement including additional or alternative disinfection methods.

Table 3: Further reading on hyperchlorination

Reference	Dose	Degree of effectiveness
Marrie *et al.* (1992)	3 monthly at 10 mg/L	Poor *Legionella* control, with damage to plumbing
Levin *et al.* (1991)	Shock chlorination of 6 mg/L free in tanks, then heated to 80°C, outlets flushed then circulating water maintained at 60°C	*Legionella* free for the 5 months studied
Heimberger *et al.* (1991)	Manual clean of a *Legionella* free for the 7.5 months studied hot water tank (HWT) then superheated to 85°C/1 hr, then flushing so that taps maintained at 70°C for 15 mins then 50 mg/L chlorine in HWT/ 3 min, then repeated the above with additional chlorine supplemented to water exiting HWT so that continual residual at 1.5 - 2.0 mg/L at outlets.	*Legionella* free for the 7.5 months studied
Patterson *et al.* (1994)	Continuous chlorine at 1- 2 mg/L at outlets with dead leg removal, reduction of total water volume and increased pumping.	*Legionella* free for the 7.5 months studied

4.1.3 Chlorine dioxide

This is regarded as a relatively stable and efficient biocide. Chlorine dioxide is a highly reactive gas that readily dissolves in water and remains a true gas in solution. Its primary mode of action is oxidation. Unlike chlorine it does not react to form hazardous by-products with naturally occurring organic compounds. It inactivates bacteria in the water, disrupting a number of different cell processes by oxidation. It shows superior bactericidal activity over chlorine at elevated pH levels.

It is non-reactive with ammonia and most nitrogen containing compounds and is less aggressive to copper and steel than chlorine.

Chlorine dioxide can be generated on-site by an electrolytic method from a sodium chlorite precursor, rather than chlorine gas or acid. The unit is either fitted just prior to the hot water tank or at the incoming supply mains. The water entering the unit must be between 5 and 40°C.

The **advantages** of chlorine dioxide are that it:

- can provide direct feedback of the levels of chlorine dioxide levels in a system
- is relatively easy to implement and monitor
- can be linked up to a building automation system to register faults
- remains effective at hot water temperatures
- is effective over the pH range of 6 to 10 (Crosby *et al.* 2003)
- can be applied to hot and cold water
- is considered to penetrate biofilm
- has no perceptible odour
- is regarded as minimally corrosive (Crosby *et al.* 2003)
- oxidises rather than chlorinates organic compounds, so it does not produce halogenated disinfection by-products such as trihalomethanes (Crosby *et al.* 2003)

The **disadvantages** of chlorine dioxide are that it:

- is degraded by UV light and so any combined application must have the UV treatment upstream, or in an area not reliant on the presence of ClO_2
- is regarded as a hazardous substance[6]
- may be more costly than chlorine or copper/silver treatments
- may be less effective than copper/silver
- may take many months to eradicate *Legionella* from distal sites
- produces chlorite as a product of decomposition.

Routine dosing

There is general consensus that a level of 0.5 mg/L is needed to control *Legionella.* For example, Hood (2004) describes the successful experience with chlorine dioxide at 0.5 mg/L and engineering interventions over a 10 year period at Scottish Royal Infirmary. This level is also reported to be effective against planktonic and sessile *Legionella* in hot water systems by the UK Health and Safety Commission (Health & Safety Commission 2000).

Sidari *et al.* (2004) reported a two-year study on a large hospital where ClO_2 was maintained between 0.5 to 0.8 mg/L on the potable water supply. Monthly monitoring showed a halving of *Legionella* positivity at hot water outlets and elimination at cold building source water areas; however the mean concentration

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[6] For further information, refer to the Occupational Health and Safety Regulations 2007.

of *Legionella* in positive samples was not changed. Further studies are continuing to evaluate the efficacy of long-term treatment with ClO_2.

Maximum levels in drinking water
Chlorine dioxide is regulated by US EPA at a level of 0.8 mg/L (AWT 2003), while the ADWG recommends the chlorine dioxide concentration should not exceed 0.4 mg/L in drinking water. ADWG also states that chlorine dioxide would not be a health consideration unless the concentration exceeded 1 mg/L. Chlorite is a dissociation product of chlorine dioxide and should not exceed 0.3mg/L in drinking water.

Monitoring
It is recommended that chlorine dioxide levels be checked at least monthly, to ensure that the concentration of chlorine dioxide at the sentinel taps is at least 0.1 mg/L (Health & Safety Commission 2000).

Adverse event dosing
The use of chlorine dioxide in adverse events (such as following the detection of *Legionella* or a case of Legionnaires' disease) requires levels of between 5 to 10 mg/L until flushed throughout the system, then reduced to 0.1 to 0.2 mg/L.

The water is non-potable during this disinfection and outlets cannot be used for the period when concentration is greater than 1 mg/L. Hood (2004) describes the use of 50 mg/L to deal with colonisation problems. Walker *et al.* (1995) describes the use of chlorine dioxide measured to deal with a critical incident. The chlorine dioxide levels in the hot water system were increased to between 50 and 80 mg/L and all taps were run for one hour whilst ensuring that the levels when measured at the outlets were between 50 and 80 mg/L. No *Legionella* were found in the water and the biofilm was reduced dramatically.

Maintenance
Generally, the supplier of the equipment used to generate the chlorine dioxide will be responsible for the maintenance of the equipment and dosing. Given that chlorine dioxide is not yet commonly used in Victoria, prospective users need to satisfy themselves of ongoing maintenance arrangements, particularly in rural locations. The following table describes the routine maintenance required.

Table 4: Routine maintenance of chlorine dioxide disinfection systems	
At least monthly	Annually
Diagnostic tests of unit	Replace fittings and rubber components
Check the quantity of chemical in the reservoir, replacing cartridges as necessary	
The rate of addition of chlorine dioxide to the water supply confirming with a wet test	
Refill brine tanks as required	
Check the concentration of chlorine dioxide at sentinel outlets. Concentrations should be at least 0.1 mg/L.	

Guidance note: Chlorine dioxide is regarded as an effective means of treating warm water systems.

4.1.4 Copper-silver ionisation

Disinfection using copper-silver ionisation involves electrolytic generation of positively charged copper and silver ions, which are released into the water. The silver ions inhibit bacterial growth by interfering with electron transport, binding to DNA and interacting with cell membranes. Copper on the other hand is required as a trace element for microbial growth, but in its free form is actually antimicrobial.

Copper ions function by enhancing displacement reactions, disrupting enzyme structure and binding thiol or other groups on protein molecules. The combination of the two metals provides a significant synergism of antimicrobial activity (Lin 1996 reported in Crosby *et al*. 2003). Copper-silver ionisation is not limited to hot water and is effective at all temperatures.

Electrodes are placed in the circulating water so that copper and silver ions are added to the system continuously, via an electrolysis process caused by applying a voltage across the electrodes. The dose can be manually adjusted by varying the applied voltage and the one concentration is circulated throughout the tanks and pipe network. Newer models are designed to inject ions in proportion to the water used, via a signal obtained from a flowmeter. The copper-silver generation device can be installed on the incoming raw cold water, the cold water storage tank or on the hot water line.

Most literature recommends installation on the hot water line to minimise the ingestion of the metals through drinking the water (Lin *et al.* 1998). However at the levels used, both copper and silver concentrations are well below the acceptable levels, rendering this process safe for use in drinking water. Some systems use a combined electrode with both metals present, whilst others use separate electrodes.

Copper-silver ionisation has gained popularity amongst facilities in Europe and the United States. Numerous journal articles have been written confirming the efficacy of this form of systemic disinfection (Lee 2004). Kusnetsov *et al.* (2001) found that it was more difficult to eradicate *Legionella* from taps and showers than in the circulating water, which would be true for any form of disinfection. However, regular use of the outlets eradicated *Legionella*. Recently, local distributors have entered the market with equipment suitable for warm and cold water installations.

The **advantages** of copper-silver ionisation include:

- *Legionella* are killed, not just suppressed (Lin *et al*. 1998).
- At low levels of application, it does not corrode piping or plumbing fixtures and therefore it may be useful where age of the system, corrosion or deterioration is a major concern.
- It is suited to complex or hybrid systems.
- Reportedly, it is safer than other forms of biocide.
- It remains effective at all water temperatures.
- It is easily installed in existing systems without major modifications.
- Some distributors are now offering systems with automated dosing, based on flow rate meters.
- Modern constant current systems automatically maintain the current to maximum available voltage and reduce the amount of manual intervention.
- Modern cell design minimises the impact of scaling and high pH.

The **disadvantages** of copper-silver ionisation include:

- Silver is a toxic substance (though not at the levels used) and a heavy metal.
- At the time of writing, there are few Australian suppliers and manufacturers. It is therefore important to select a supplier who will provide the technical back-up and has the necessary experience with *Legionella* control in warm water systems.
- It can be difficult to optimise the correct dosing for each system if the installation of the unit is not set up appropriately. The calculations performed by the manufacturer/supplier require involvement by engineers and plumbers to gather and provide relevant information, to ensure optimisation of the process. From Victorian experience of units without flow meters, the dosing requires continual manipulation (largely attributed to variation in demand).
- Water hardness can affect the efficiency of the electrodes to release ions. In hard water, scale can build up on the electrodes, which can affect the concentration of silver ions being released. Modern cell design and constant current help reduce the effect of scale. Additionally, silver ions in solution can bind to any dissolved solids, which will reduce the concentration of silver ions available to react with bacterial and algal contaminants. However, this can be compensated for in the setting up of the equipment.
- In both hard and soft water, the process is pH sensitive and it is difficult to maintain silver ion concentrations above pH 7.6. Systems in which the water has scaling potential and/or pH levels above 8.0 are problematic due to scaling electrodes and precipitating copper – both of which lend to significantly reduced effectiveness (AWT 2003).
- Installation of units into sites with substantial colonisation may not immediately result in eradication of *Legionella*. Over 5 months using Cu/Ag, Biurrun *et al.* (1999) reduced the number of colonised sites in a hospital water system from approximately 60 per cent to 17 per cent.
- There is a suggestion that resistance to the heavy metals might occur over time (Meyer et al. reported in Crosby *et al*. 2003), but this was when the silver concentrations were used at 0.01 mg/L, well below the effective levels of 0.02 – 0.04 mg/L.

Routine dosing
Various dosing levels are reported in the literature:

- 0.2 to 0.4 mg/L copper and 0.02 to 0.04 mg /L silver (Lin *et al.* 1998) as per UK Health and Safety Executive L8, European Working Group for *Legionella* Infection & W.H.O.
- Copper and silver ion concentrations of 0.2 to 0.4 mg/L and 0.02 and 0.04 mg/L, respectively, are recommended for antimicrobial activity (Liu *et al.* 1994).
- 0.2 to 0.8 mg/L copper and 0.02 to 0.08 mg/L silver (AWT 2003).
- For soft water, a minimum concentration of 0.02 mg/L of silver (Health & Safety Commission 2000). This level of silver still requires copper ions to complete the synergy.

Acceptable levels for copper in drinking water (as set by the Australian Drinking Water Guidelines) are less than or equal to 2 mg/L, with 1 mg/L set as the aesthetic level. There is a 0.1 mg/L acceptable level for silver.

Adverse event dosing
To date, there is little information regarding the use of copper/silver for such incidents. However, some distributors have advised that chlorination can be used as a disinfectant in these incidents. Where chlorine is used, it is highly synergistic with copper-silver ionisation so a lower level than normal could be used.

Maintenance
States *et al.* (1998) found that these systems require regular maintenance and monitoring. Table 5 describes the routine maintenance that needs to be performed.

Table 5: Routine maintenance of copper-silver ionisation systems		
Weekly	At least monthly	Annually
Monitor the rate of silver ions being released into solution, as determined by measuring copper . This will reflect changes in treatment levels.	Measure the concentration of silver ions from sentinel outlets such as the first and last outlets after the electrode on a recirculating system, or closest and furthest outlets from the calorifier/water heater for non-recirculating systems. Concentrations should be at least 20 µg/L.	Check the concentration of silver ions from at least 10% of outlets chosen to represent the system complexity. Concentrations should be at least 20 µg/L. If concentrations are not 20 µg//L, the dosing should be reviewed.
	Measure the pH of water just prior to passing the electrode and the pH of the water supply. This could be measured from water stored in cold water storage tanks, or that entering the cold water supply. Waters with scaling potential and pH levels > 8 may be problematic. Liu *et al*. 1994 recommends electrodes need to be cleaned of scale every 4 to 8 weeks (Liu *et al*. 1994), but modern electrode cell design and constant current supplies help reduce the effect of scale and high pH. Examine the electrodes for scale. These will need to be cleaned when scale is observed or around **every 3 months.** Cleaning should follow the manufacturer's instructions. The frequency of cleaning will depend on manufacturer selected, softness/hardness of water and amount of water passed through the system	
	Monitor the concentration of dissolved solids and consider the concentration of silver ions detected in solution. If they are low, the dissolved solids will need to be addressed. This could involve filtering the water and cleaning areas where sludge or corrosion products may have settled, such as in the base of calorifiers/water heater and cold water tanks.	

Monitoring copper and silver concentrations
Operators will need to monitor silver and copper in water regularly. Sampling kits provided by the manufacturer can measure concentration of copper. Silver ions are measured by analytical techniques in a qualified laboratory. Results of water testing for silver from laboratories take approximately 5 working days (mainly due to batching of samples). On-site silver test kits are available and although not as accurate as laboratory tests, offer the capability of testing for changes in treatment level. In the UK, the practice is to monitor copper weekly using on-site testing and silver every six months.

References in the literature describing hospitals that used copper-silver ionisation to treat warm water systems show that it took from 12 months to four years to substantially or completely reduce *Legionella* appear in Table 6.

Table 6: References describing hospitals that used copper-silver ionisation to treat water systems	
Reference	Duration that *Legionella* was substantially or completely reduced following copper/silver addition
Colville *et al.* (1993)	12 months
Selenka *et al.* (1995)	18 months
Mietzner *et al.* (1997)	22 months
States *et al.* (1998)	24 months
Kusnetsov *et al.* (2001)	48 months

Note that the durations reflect the length of study and therefore the effectiveness may have lasted longer.

Guidance note: Copper-silver ionisation is regarded as an effective means of treating warm water systems. Where used, it is recommended that:

- It be placed on the hot or warm line rather than on the cold water line to minimise the volume of water ingested by patients, staff or residents.
- Copper concentrations of 0.2 to 0.4 mg/L and silver concentrations of 0.02 to 0.04 mg/L respectively be maintained and closely monitored.

4.1.5 Chloramination (Monochloramines)

Monochloramines are formed when ammonia and free chlorine are mixed in water. The mode of action is the same as that of chlorine. Chloramination has been used for drinking water disinfection for almost one hundred years, particularly in the United States. As monochloramine (NH_2Cl) takes longer to decay than chlorine, it is considered to diffuse into stagnant water and biofilms more effectively than chlorine (Kool *et al*. 1999)

Chloramine is produced by the reaction of a known ratio of chlorine and ammonia. At a pH between 7.0 and 8.0 and at a chlorine-to-ammonia weight ratio of less than 5:1, monochloramine will be the predominant species (Crosby *et al*. 2003). It requires longer contact time for adequate microbial kill, but may be more persistent in water systems because it does not react with organics to produce trihalomethanes. It may also penetrate biofilms better (LeChevallier *et al.* 1998 reported in Cunliffe 1990).

A study (Kool *et al.* 1999) supported the view that monochloramine-treated drinking water was less likely to be associated with cases of Legionnaires' disease.

For monochloramines, the Australian Drinking Water Guidelines have a health limit of 3 mg/L, and a 0.5 mg/L aesthetic limit.

The **advantages** of monochloramines are that it:

- is more effective than chlorine, particularly at high pH
- minimises the formation of disinfection by-products such as trihalomethanes and haloacetic acid (Kool *et al.* 1999)
- can be measured.

The **disadvantages** are that:

- Some systems may require a separate water tank in order to establish an appropriate treatment system.
- Monochloramines have not been as thoroughly investigated as other forms of disinfectants and so less is known about their efficacy.

For further reading, consult Kool (2000).

Guidance note: Monochloramine treatment is regarded as an effective means of disinfecting a warm water system on an ongoing basis, but is probably best suited to large facilities.

4.2 Localised treatments

Localised treatments may be usefully applied to incoming cold water supply to prevent *Legionella* entering the system, particularly where systems have a negative history of contamination. Alternatively, localised treatments can be used as point-source treatments to disinfect parts of a warm water system. These methods have either little or no residual effect.

Localised treatments are inappropriate for treating the entire system. If used for systemic disinfection, there is strong risk that they will not work and therefore that any *Legionella* present in the system will not be controlled.

4.2.1 Ultra-violet (UV) light

UV, particularly at a wavelength of 254 nm, interferes with DNA in organisms to the extent that they can no longer replicate and multiply. The 90 per cent lethal dose for *Legionella pneumophilia* is 2.04 $mW/s.cm^2$. Low-pressure mercury lamps are used to generate UV.

Light in the ultraviolet light spectrum (approx 250 to 280nm) is biocidal based upon its action upon the nucleic acid of the organism. Water is passed thru a UV lamp source, which must have a residence time and energy sufficient to adequately irradiate the water column to a sufficient kill level.

A flow through UV device is typically installed on a water line, to kill *Legionella* as water flows through the unit. UV light is most effective when it is localised to a specific area within a building like a high risk unit. The UV lamps are housed in quartz sleeves and the sleeves need to be kept clean to allow adequate light penetration. Scaling of the lens area of the UV source will interfere with light intensity and therefore UV energy in the water. Pre-filtration can assist in preventing scale and other deposit build-up (Allegheny 1997), as UV requires relatively clean water with less than 60 mg/L suspended solids (AWT 2003).

UV is a point source method and no chemical residual is carried through the system. The literature shows that UV should be applied as a point-source treatment (typically installed near outlets) as an adjunct to systemic treatments, because it cannot be expected to completely control *Legionella* in a large system of pipework.

This is because the *Legionella* must pass through the UV light – if the bacteria is present in outlets, biofilm, dead ends or dead legs, they will not be free moving in the water and so will not pass through the device to be exposed to the treatment. Recirculation of the water past a UV unit will assist greatly in control of microorganisms.

Quartz sleeves housing the UV lamps are susceptible to scale, slime and mineral deposits, and must be cleaned regularly. Pre-filtration is strongly recommended.

Table 7 contains references to journal articles describing hospitals that applied UV in a point-of-use application on the incoming hot and cold water. This usually followed localised hyperchlorination of fittings and pipework.

Table 7: References describing hospitals that applied UV in a point-of-use application on the incoming hot and cold water

References	Degree of effectiveness
Makin and Hart (1993)	Used on water supplying one shower - *Legionella* free during the 8 months examined. (Makin and Hart 1993) found that UV irradiation at 254nm was effective in controlling Lp in shower water. It prevented recolonisation after it was initially eradicated by chlorination and autoclaving. The study used a 10μm filter and UV on the incoming cold water and on the hot water**.**
Liu *et al.* (1995)	Used on water entering a wing - *Legionella* free for at least 4 months
Farr *et al.* (1988)	Used on water entering transplant patient rooms – *Legionella* free for up to 9 months. Reported success in a trial using 5 micrometre filters and UV light in a hospital water system contaminated with L.micdadei.
Hall *et al.* (2003)	One study found that in a new hospital, UV equipment was installed in the water mains. In the 13 year period since installation, none of 930 water samples detected *Legionella* (Hall *et al.* 2003).

This table reveals UV has been shown to be effective in some installations, but not in others. Consequently, it is important to receive professional advice as to whether UV treatment is appropriate for the condition and type of warm water system, the correct sizing of the UV to the system, the best location of the UV unit on the system and an appropriate maintenance schedule.

The **advantages** of UV disinfection are that it:

- is useful for small areas that may need additional or special attention. For example, if a hospital unit could not be cleared of *Legionella* contamination through other means of disinfection, a UV generator could be installed onto that section of the pipework.
- is relatively easy to install
- has no adverse effect on water or plumbing
- is tasteless
- has no disinfection by-products
- is particularly useful in warm water systems that have recirculation.

The **disadvantages** of UV disinfection are that it:

- has a relatively limited application (point use or supplementary disinfection tool)
- cannot measure the effect gained at outlets, other than to monitor bacterial presence
- is affected by turbidity and particulates. These 'shade' bacteria from the UV rendering it less effective. As a result, inspection and cleaning of tube sleeves is required to prevent build up of film.

- is affected by scale and mineral deposits which can develop on the UV lamp sleeves through which the light passes. As a result, this requires regular cleaning. Pre-filtration of water is also recommended, to reduce build up of scale or other deposits on the sleeves.
- has no residual effect
- needs a warning system to show that the unit is working.

Routine use
UV is suited to routine use in that it can be used continuously.

Adverse events
UV cannot be "boosted" or provide any downstream residual effect and so other forms of disinfection would be needed for such events. If heat disinfection is to be applied to the system, the flow through UV unit would need to be isolated.

Maintenance

Table 8: Routine maintenance of UV disinfection systems

Weekly	At least monthly	Annually
Inspect the UV device particularly for any scale or growth on the sleeves surrounding the UV tubes, cleaning as needed. Generally, in a recirculation system with good quality water and plumbing, the sleeves will need to be cleaned every 3–4 months.	Monitor the concentration of dissolved solids, as particulates in the water will impede the effect of the UV light. If they are high, the dissolved solids will need to be addressed. This could involve filtering the water and cleaning areas where sludge or corrosion products may settle, such as in the base of hot and cold water tanks. Ensure that all tanks are well sealed, in good structural order, and inaccessible to animals, airborne debris or decaying structural materials.	Replace UV tubes (generally annually or at a frequency recommended by the manufacturer)

Guidance note: Ultra-violet light (UV) is of use by providing point source disinfection of warm water systems in sites where there are outlets or sections regarded as being of particularly high risk. It is not regarded as being effective as a means of disinfecting water throughout a system unless the water is recirculated past the UV system.

4.2.2 Ozonation[7]

Ozone appears to act by damaging DNA. It is applied as either gas or dissolved in water. As with UV treatment, the lethal effects are at a single point in the system and require contaminants to be circulating past the point of treatment to be effective.

Ozone is dissolved into the point of use water system to achieve a dose of about 1 to 2 mg/L. Ideally, this is done with a generator that produces ozone in proportion to the water flow rather than a generator that produces ozone at a constant rate regardless of demand. Since ozone is a very strong oxidizer, it is an excellent biocide and has proven effective at low concentrations. However, it can damage piping and since it has an extremely short half-life, it is virtually

[7] An approval from the Secretary of the department may be necessary for some types of disinfection methods. For further information please contact the Legionella Section at 1800 248 898.

impossible to maintain any significant residual throughout a dynamic water system. It has significant equipment costs and disinfectant residuals are difficult to maintain and distribute throughout the system. It has minimal impact on biofilm on non-planktonic *Legionella* in dynamic or complex water systems.

The main **advantage** of ozonation is that it is not markedly affected by pH or temperature, working best at lower temperatures and higher pH.

The **disadvantage**s of ozonation are that:

- it is not regarded as effective for warm water systems
- it has no residual effects for *Legionella* downstream, as it needs to be removed from the water prior to the water being used
- high concentrations of ozone may damage piping
- it is a hazardous substance
- it has an acrid odour.

Routine dosing
Ozone is effective at concentrations of 1- 2 mg/L, but should be applied according to the manufacturer's instructions.

The ADWG do not give guidance for ozone, as it is stated that ozone leaves no residual. Treatment by ozone could result in bromate being generated as a disinfection by-product and there is a 0.02 mg/L health limit for bromate.

Adverse event dosing
No information has been found on this matter.

Guidance note: Ozone is not yet regarded as being effective as a means of disinfecting warm water systems.

4.2.3 Disinfecting thermostatic mixing valves

Routine processes
TMVs should be maintained on an annual basis. This includes a cleaning and disinfection process. The following is drawn from the *NSW Code of Practice for Thermostatic Mixing Valves in Healthcare Facilities* (Wesley, 2000). This process should be carried out following the removal and inspection of the valve and other fail-safe checks required for anti-scalding purposes:

Table 9: Cleaning and disinfecting a thermostatic mixing valve
Caution: Exercise special care in handling, cleaning and re-assembling the component parts of the mixing valve, otherwise any physical damage may result in incorrect operation of the mixing valve – with possible fatal results for the end user. It is recommended that the valve supplier be consulted to clarify any specific requirements of the equipment.
Sludge and any other sediment should be carefully removed with the aid of a brush with long, soft bristles and using a solution of manual dishwashing detergent. Follow by thorough rinsing with fresh, clean running water.
All scale which is strongly adhering to mating surfaces should be carefully removed with the aid of a wetted 400 to 600 grade, wet and dry type abrasive paper then rinsed well with fresh water.
Check and replace all seals at least every 12 months. Use only the 'O' rings, seals, gaskets and lubricant as supplied by the valve manufacturer/distributor, as alternative materials may not be suitable for the particular valve or its application. Check the old 'O' ring against the new one to verify that they are of the correct size. All 'O' ring seals and the related groove shall be carefully and completely smeared with lubricant.
Where practicable, clean the inside of the valve body using a clean rag or brush.
Concurrently with the routine work on servicing the mixing valve, the temperature regulating device or thermostat should be temporarily removed from the mixing valve. The mixing valve, the associated warm water lines and the respective outlet fittings should then be disinfected simultaneously with hot water at a temperature of at least 70°C for a period of not less than 5 minutes. This disinfection procedure must only be carried out with the prior knowledge of the manager/owner of the site and under close supervision so as to avoid scalding of the end user. The complete warm water system must then be flushed through with cold water so as to remove any traces of hot water followed by flushing with warm water after completion of the service work.

Adverse events
All parts of warm water system including the TMV's must be cleaned and disinfected when *Legionella* has been detected in the water. The method to be used is identical to that used for routine processes.

4.2.4 Disinfecting outlets

Routine disinfection
Although the NSW Code of Practice states that all showerhead rosettes and aerators, including hand showers, are to be disinfected every time a system is routinely disinfected, no specific work is required over and above the routine disinfection conducted.

Adverse events
If one outlet in a site produces a positive test result, either the outlet is locally contaminated, or there is greater contamination throughout the system. If other samples were taken concurrently, the presence of other positive samples would lend support to the possibility of systemic contamination. The concentration of the positive results may provide evidence toward the degree of contamination.

Guidance note: If one sample taken from any location in the warm water system is *Legionella* positive, then the entire system must be disinfected – the tanks, the pipework and any TMVs.

Note that if a tempering valve is used at the outlet (uncommon in hospital settings), they will not need to be removed and disinfected if the entire system is to be disinfected.

Where a sample has a been taken from a specific outlet and a *Legionella* positive result has been obtained, in addition to the disinfection of the system it is recommended that the specific outlet be disinfected in the following manner:

Table 10: Disinfecting an outlet
Caution: As the risk of the fitting being contaminated with *Legionella* is high, staff cleaning the components should wear protective respiratory gear as the process of removal and cleaning could possibly generate aerosol-containing *Legionella*.
If a sample from an outlet is positive, first perform the systemic critical event disinfection discussed elsewhere.
Remove the fitting and flush the piping for 5 minutes.
Note: When aerators are present on taps that have been associated with a positive water culture, consider removing them or replacing the fitting with a style that does not use an aerator.
Disassemble the fitting into its components. Inspect the components for integrity and presence of biofilm. Replace any rubber components such as seals and washers. Scrub all other components with a brush or pipe cleaner using a solution of manual dishwashing detergent, removing as much debris or growth as possible. Soak the non-rubber components in bleach for at least 1 hour then rinse thoroughly.
Reconnect the fitting and flush for 2 minutes. Collect a water sample from this site for *Legionella* culture.

4.2.5 Filtration

Microfiltration
Microfiltration filters bacteria out of water. Microfiltration units can be used for large volume or small volume demand flow. The units can be applied at the incoming cold water supply to the hospital or smaller units can be applied to treat a portion of a system in a localised manner. As the cartridges tend to be heat sensitive, cold water lines would need to be filtered prior to heating.

Water passing through small portions of the warm water systems that need additional or special attention could be filtered for *Legionella* in conjunction to other treatments. A pore size of 5μm is generally regarded as being needed.

Ultrafiltration
Ultrafiltration on outlets at 0.2 microns has been proposed by Sheffer *et al*. (2005) to exclude *Legionella* and other bacteria, using a targeted approach to prevention. The manufacturer recommended that the point-of-use filters used in this study had a useable life of only 7 days: the filters were easily fitted and removed by the use of a quick connect adaptor.

Side stream water filtration
This type of filtration is not actually a form of disinfection, but sometimes used to remove sediment, sludge and other debris in a water system, using sand, cartridges or centrifugal designs to filter the water. The removal of such organic matter permits biocides to work more effectively on *Legionella*. This may have a useful role for warm water systems where such debris is a problem, although flushing may also assist in such circumstances.

The main **advantage** of filtration is that it may assist where other methods are unable to control *Legionella.*

The main **disadvantages** of filtration is that:

- It has limited application.
- It can be expensive.

- The filters, if not properly, maintained with regular timed or pressure activated backwashing, can actually become contaminated and infect the passing water.
- Fibre components do not tolerate temperatures above 40°c.
- Devices that filter water by reverse osmosis (RO) can fail and permit *Legionella* to pass through.

Maintenance
Filtration either uses single-use or reusable cartridges. Reusable cartridges require regular backwashing or cleaning.

Guidance note: Filtration can be a useful supplement to another form of disinfection.

4.3 Using distilled, sterile water

Distilled, sterile water has been proposed as the sole source in areas where patients are not bathed, such as intensive care units and high dependency units. Clearly, this has extremely limited application and is only included here for completeness.

A situation is described in literature where a hospital resorted to sterile water for high-risk patient areas, with good results. Patients were also asked not to shower in areas linked to cases of Legionnaires' disease.

Table 11: Reference: hospital that resorted to sterile water for high-risk patient areas	
Reference	Degree of effectiveness
Marrie *et al.* (1991)	Following many cases, sterile water was introduced and patients were asked not to shower in areas where cases were linked.

5. Warm water system design

The information in this chapter describes what is currently known about designing warm water systems to prevent *Legionella* contamination, based on a wide-ranging literature review.

5.1 General considerations

Warm water systems have traditionally been designed to minimise heat losses and save on energy consumption. Designs tend toward cost effectiveness, ease of installation and the ability to supply warm water on demand. Microbiological safety or ease of cleaning have not been high on the list of important attributes.

The design stage must also allow for anticipated changes in demand, both seasonally (short term) and as the population increases (long term). If demand is not met on a day-to-day basis, water passing through the system will either be insufficiently heated, or water may stagnate in piping and storage vessels. Both of these situations are conducive to *Legionella* growth.

The design needs to facilitate access to points requiring regular maintenance or servicing, including easy access to the water lines for chemical disinfection. Some equipment, such as ozone generators, require an airing space, while others may need to lose heat. If these needs are not met, hazardous conditions could result in injury to staff.

Note: Minimum requirements in Victoria for installing and maintaining warm water systems in buildings other than single dwellings can be found at: http://www.pic.vic.gov.au

5.2 Heated water

Heated water is defined in AS/NZS 3500.0:2003 as:
'Water that has been intentionally heated. It is sometimes referred to as hot water or warm water.'

AS/NZS 3500.4:2003 requires that *'heated water shall be stored at a minimum temperature of 60°C, to inhibit the growth of Legionella bacteria'*.

5.3 Types of warm water systems

See Standards Australia handbook **HB 263 – 2004 Heated water systems** for information on typical system layouts, regarding:

- warm water systems
- tempering heated water
- achieving compliance
- tempering valves
- thermostatic mixing valves
- solar warm water systems
- typical warm water systems.

There are two main designs:

- Those that deliver hot water to thermostatic mixing valves, where it is cooled to the desired temperature by mixing with cold water
- Those that distribute warm water throughout ('tepid water systems').

Warm water provides the ideal temperature for *Legionella* growth. The more branches of a system that have warm water, the more branches there are to become contaminated.

Tepid systems have the highest potential for growing *Legionella,* as they have a significant proportion of water at a temperature ideal for *Legionella*. This requires a more concerted effort and ongoing vigilance to maintain the warm water free of bacterial contamination.

This contrasts with those systems that deliver hot water (above 60°C) to thermostatic mixing valves located close to the point of use. These systems are generally regarded as the preferred design for minimising the risk of *Legionella* growth, because the heat serves to disinfect portions of the system. However, the thermostatic mixing valve and the pipe downstream contain a mix of both hot water and cold water (which may contain *Legionella*) and can therefore become colonised with *Legionella*.

5.3.1 Hybrid systems

Some systems have a combination of the components described above, or have various types of sub-systems.

5.3.2 Recirculating and non-recirculating systems

In larger buildings, most hot and warm water systems are of the recirculating type, to conserve energy. This means that water is heated to the target temperature and sent around the building and ***returns to the heating point for re-heating***, if needed, back to the target temperature.

The alternative is a simple non-recirculating (direct delivery) system, where water is heated and sent via pipework to the points of use. If not used, the water gradually cools down. When the outlet is required to deliver hot water, the cool water needs to be exhausted from the outlet before hot water starts to be delivered. The exception to this is where devices are used to maintain the temperature of the water at around 50°C.

5.3.3 Indirect warm water systems

In this type of system, the water to be supplied to outlets is contained within a piping system, as distinct from a large storage tank. Part of the piping system (a heating coil) is located within a hot water storage vessel. Heat is transferred through the walls of the heating coil to heat the water in the pipe, which is then supplied to the outlets. A common example is the 'Edwards' System. A relatively small volume of water is stored within this piped system, compared to systems with a large capacity storage tank. This is not considered to be 'stored water', which would require heating it to at least 60°C.

Water is circulated through the pipework by a pump, and a thermostat (usually located on the storage vessel) controls the heat source (usually a gas burner), to ensure that the water in the pipe is supplied to outlets at the correct target temperature.

The advantage of an indirect warm water system is that the water in the pipe is maintained in constant circulation.

The disadvantage of an indirect warm water system is that in the event that the water becomes contaminated with *Legionella*, heat disinfection may not be a feasible option. This is because the hot water storage vessel needs to be able to heat the water in the circulating pipe to a hot temperature for a large amount of time, to enable all outlets in the system to be flushed for the times recommended in this guide. In some systems, this is also not feasible because the temperature of recirculating water drops below the temperature needed for heat disinfection when an outlet is flushed. In one extreme case, several days were required in order to complete the heat disinfection process because of this problem.

5.4 Components of warm water systems

5.4.1 Materials

Materials such as natural rubber, hemp, linseed-oil based jointing compounds and fibre washers should not be used in domestic water systems (Health & Safety Commission 2000) because of their ability to support *Legionella* growth.

5.4.2 Water heaters

Calorifiers
Calorifiers are defined in AS/NZS 3500.0:2003 as an *'apparatus for indirect heating of water in a vessel, the source of heat being a separate coil of heated pipes immersed in the water.'*

In a hospital setting, calorifiers may have a capacity as great as 8,000L. Calorifiers tend to be of a vertical or horizontal cylindrical design. Vertical calorifiers are at higher risk of being infected with *Legionella* than horizontal calorifiers.

Sludge and sediment can accumulate at the base of the calorifier. If the temperature of the calorifier is not above 60°C, or the temperature within is cooler at the bottom, *Legionella* may grow using the sediment as nutrients. Heavy contamination has been associated with large volume hot water heaters (Alary and Joly 1992).

The location of the heating element in the calorifier is also important. If the element is not located at the bottom of the tank, (for example, located at the side as with electric hot water heaters) water below the heated element may not be heated as well other parts, particularly if there is sediment that can serve to insulate the water.

If calorifiers are taken off-line, because for example, a number are in use and demand decreases, *Legionella* can grow in the cooler stagnant water. Cases of disease have resulted from reintroducing a stagnant calorifier that had not been drained or disinfected (Fisher-Hoch *et al*. 1982).

There is also evidence that as calorifiers age, they become more susceptible to *Legionella* contamination:

- The age of the oldest hot water heater was greater in hospitals with contaminated water, compared to those free of *Legionella* (26 vs. 20 years) (Alary and Joly 1992).
- Hot water tanks that were contaminated tended to be older (median age of 16 vs. 11 years). Those less than 5 years old were generally free of *L. pneumophila* (Vickers *et al.* 1987).

Design considerations:

- Calorifiers and their drain points should be readily accessible for cleaning and disinfection
- Calorifiers need to be capable of heating the *entire volume* of water to the set temperature
- Vertical tanks can suffer stratification of heat and may require destratification systems to be integrated. Horizontal tanks are therefore preferable to vertical tanks
- The calorifier should be well insulated, to reduce heat losses
- The thermometer should be located distal to the heating elements, when possible
- Hot and cold water storage systems in commercial buildings are often oversized relative to actual usage, because of uncertainties in occupation at the design stage. This leads to excessive safety margins. If the design needs to allow for future growth in demand, then this should be organised in a modular fashion. This enables additional plant to be added at a later stage, as required. (EPA 1999).

Table 12: Routine maintenance of calorifiers	
At least monthly	Annually
If the temperature of the water in the calorifier is not automatically monitored, monitor it manually.	Drain the heated tanks and clear out any sediment or sludge. It is critical that the tanks be ventilated before staff enter and that all relevant occupational health and safety procedures are followed. Maintenance workers overseas have reportedly contracted *Legionella* infections during physical cleaning of tanks with high-pressure water or other means. The use of personal protective equipment, including facemasks, is therefore recommended.
If the parts have not been used for more than 4 weeks or are to be brought back on line after being isolated, thorough cleaning and disinfection of all such parts must be performed.	Physically check that the water circuitry plans for the calorifier match what is actually present and update the plans as necessary.

Guidance note: Calorifiers and hot water services should be monitored to ensure that the temperature has not dropped below the desired level.

Continuous flow hot water heaters
These are also known as 'instantaneous hot water systems'. The water is heated on demand, without storage, usually to provide warm water instantaneously. These heaters can be used to heat water for the entire system, or used in a localised application (for example, individual showers in a ward).

These types of heaters have been used both for large scale and isolated parts of hospitals, to manage *Legionella.* However, large hospitals with extensive systems may have heaters that are unable to meet greatest demand, leading to distribution of warm water, rather than hot. As they have no storage capacity, the heaters should not pose a risk of *Legionella* multiplication within the heater. They often have the capacity to be adjusted by a suitably trained operator, to raise the temperature above 60°C and provide downstream heat disinfection when required.

Heat trace cabling
Heat tracing is electrically heated cabling laid along the length of piping, to maintain a set temperature of the piping and the water. The cables are approximately one centimetre in width and are run lengthwise. Multiple lines can be attached to the piping, side by side. The cables and piping are then insulated together, with specialised labelling of the insulation to alert plumbers and others that electrical cabling is within.

Relatively few facilities have installed heat trace cables in Victoria, but the use of this technology is likely to increase, as it guarantees the temperature at the point of delivery. For example, in a high-rise apartment building, recirculated water at 50°C may be supplied on riser mains to each level, with branch supplies to each apartment. Heat trace cables could be used to maintain the water at 50°C to each apartment. Attaching heat tracing to piping in which the target temperature is difficult to maintain may prove useful in lowering the risk of *Legionella* multiplication.

5.4.3 Cold water storage tanks

Cold water is often stored in water tanks. It should be assumed that very low levels[8] of *Legionella* may enter the system through the incoming potable/cold water. These few *Legionella* entering the system are probably insufficient to cause disease. It is when they pass into conditions that permit them to multiply that the concentration may be increased sufficiently to reach an infective dose. If water in these tanks is kept below 20°C (NHMRC 1996), these tanks are not regarded as a risk for *Legionella* multiplication. However, if tanks are located where they are exposed to full sun or other hot plant equipment, or water delivered to the tank is above 20°C, *Legionella* may multiply in the cold water storage.

If tanks are not sealed or are in a state of deterioration, they may become polluted by vermin, or release corrosive products into the potable water. Either provides a nutrient source that *Legionella* and other microbes could later use in warmer parts of the system. Water tanks can also accumulate sediment from the incoming water, leading to similar risks.

Large facilities may also have large water storage tanks on site for emergency uses or pressure purposes and can be a potential growth area for *Legionella* if linked into the potable water system on the site. In such cases, it is recommended that the water in the tank be disinfected, prior to being discharged into the potable water system. The same technique could be used to reduce *Legionella* numbers from potable supply before entering the warm water system.

Design considerations
- Water storage and their drain points should be readily accessible for cleaning and disinfection
- Cold water tanks should be completely covered and possess a well-fitted lid
- Tanks should be well insulated
- Tanks should have a storage volume that matches demand.

Routine maintenance
The cold water storage tank should be cleaned and disinfected in accordance with the Australian Standard AS/NZS 3500.1:2003, which specifies that all water storage tanks for drinking water should be cleaned and disinfected:
- prior to initial use

[8] Possibly below detectable levels.

- whenever the tank is taken out of service for inspection, repairs, painting or other activity that might lead to contamination of the water.

Table 13: Routine annual maintenance of cold water storage tanks
Visually inspect all cold water storage tanks, including those storing water for emergency purposes, checking the following: • the integrity of the materials for deterioration, corrosion, microbiological contamination • the water should be clear and free of surface debris • evidence of insects or birds and the integrity of any insect screens or bird netting • the lid which should be well fitted and in good condition • the integrity and appropriateness of the type and amount of insulation.
Measure the amount of water that passes through the tank over 24 hours, to determine if the water is likely to stagnate. The measurement can be made by either using a water flow meter at the outlet pipe, or by closing off the supply water and measuring the rate of water used calculated from the drop in the level of the water surface, over a given time.
Physically check that the plans of the water circuitry match what is present and update the plans as necessary.
As necessary, the tank should be emptied, cleaned, disinfected and faults repaired. More frequent inspections may be needed if the tanks are deteriorated or contaminated.

Cleaning the tanks
AS/NZS 3500.1:2003 requires that the tank be drained and all debris and sludge removed. The surfaces of the tank are to be thoroughly cleaned, using either a high pressure water jet or by sweeping or scrubbing. All water, dirt, and other material accumulated in this cleaning process are to be flushed or removed from the tank.

Disinfection
AS/NZS 3500.1:2003 also requires that after cleaning, the tank should be disinfected by one of the following means:

(a) **Chlorination.** Fill the entire tank to overflow level with chlorinated water with a free chlorine residual of not less than 10 mg/L at the end of the retention time. The chlorine needs to remain at this level for either 6 or 24 hours, depending on how it is delivered into the water. If the water entering the tank has been chlorinated uniformly by gas-feed equipment or chemical pump, then the retention period is at least 6 hours. However, if the storage tank has been filled with water that has been mixed with sodium hypochlorite or calcium hypochlorite within the storage facility, then the retention period is to be at least 24 hours. In either case, the tank must be drained after disinfection and flushed out with potable water prior to being put back into service.

(b) **Contact cleaning/disinfection.** Here a much more concentrated solution (200 mg/L available chlorine) must be applied to all surfaces of the storage tank, for at least 30 minutes. The tank surfaces must then be hosed down and flushed with drinking water, prior to being put back into service.

The choice of method needs to be based on consideration of the size of the tank to be disinfected, training of the personnel involved, occupational health and safety and the method of disposal of the chlorinated water, which may require neutralisation prior to discharge.

Guidance note: Cold water tanks should be cleaned and disinfected in accordance with AS/NZS 3500.1:2003

5.4.4 Mixing valves

Thermostatic mixing valves

Thermostatic mixing valves (TMVs) are defined in AS/NZS 4032.1:2005 'Water supply - valves for the control of heated water supply temperatures - Thermostatic mixing valves - Materials design and performance requirements' as being a:

'mixing valve in which the temperature of the water from the mixed water outlet is automatically controlled by a thermostatic element/sensor to a pre-selected temperature that is suitable for direct contact with the skin'.

This standard deals with the TMV's mechanics and construction. Approved valves are labelled with a product approval mark. AS/NZS 3500.4:2003 details requirements for installation of TMVs.

The components, lubricants and 'waterways' within the TMV are in contact with potable water are therefore required to comply with AS/NZS 4020:2005.

TMVs are often installed in the piping to reduce the temperature of hot water to warm water, so that water delivered to outlets is less likely to scald the user. A TMV typically services water to multiple outlets.

If any of outlets served by the TMV are not used frequently, the combination of time and the ideal temperature for *Legionella* growth could lead to a localised 'slug' of *Legionella* that would be delivered to the next end user.

TMVs pose further risk in that they can have rubber components that reportedly can become colonised with *Legionella*, thereby providing a continual inoculation of water passing through.

Further information relating to the installation and commissioning of TMVs can be obtained from the Standards Australia handbook "Heated water systems" HB 263 – 2004 produced by the Plumbing Industry Commission.

From a perspective of minimising the risk of *Legionella* growth, the objective would be to reduce the distance from the TMV to the outlet, as a way of reducing the volume of water that could become colonised by *Legionella*. It is therefore recommended that the total length of piping from a thermostatic mixing valve to all outlets that it supplies should be less than 10 metres (Standards Australia HB 263-2004).

Maintenance procedures

Thermostatic mixing valves are required to undergo annual maintenance checks to minimise the risks of failure and hence scalding. The following table describes the routine maintenance required to also deal with the risk of *Legionella* growth within the TMV.

Table 14: Routine maintenance of thermostatic mixing valves
Maintenance must be performed by licensed plumbers.
For contact details of plumbers trained in TMV servicing, contact the Building Services and Special Trades Department at Victoria University on (03) 9919 7302
Use only tools, spare parts, lubricants, materials and maintenance/service procedures recommended in the valve manufacturers'/suppliers' published service instructions, or as appropriate to the particular task. Materials in contact with potable water shall comply with AS/NZS 4020:2005.
Servicing and maintenance should be conducted in accordance with the manufacturer's instructions. This should first be performed within 3–6 months of commissioning, then every 12 months thereafter. This should include a physical clean and disinfection of the TMV.

Guidance Note: Thermostatic mixing valves (TMVs) should be cleaned and maintained in accordance with manufacturer's specifications and an annual physical clean and disinfection conducted by a licensed plumber.

Guidance Note: Thermostatic mixing valves (TMVs) should be installed with short runs to all outlets served by the TMV. The distance of piping from a TMV to an outlet should be less than 10 metres.

Three-way modulating valves

Three-way modulating valves are used for mixing very large volumes of hot and cold water and are usually installed close after the calorifier.

Maintenance of three-way modulating valves is required as per manufacturer's instructions.

Tempering valves

Tempering valves are small valves, mixing hot and cold water at the point of use, sited behind the fitting. Tempering valves need to comply with AS/NZS 4032.2:2005. These valves are usually used in domestic settings to reduce the water temperature from 60°C to supply 45°C water at sanitary outlets. Further information regarding installation, commissioning and maintenance of tempering valves can be obtained from the Standards Australia handbook HB 263 - 2004 "Heated water systems" produced by the Plumbing Industry Commission of Victoria.

5.4.5 Pipework

In most hospitals, pipe work for potable water is made of copper. However, the trend in construction is toward plastic piping due to its ease of installation, lower cost and not being subjected to corrosion. There is evidence to suggest that microbes, including *Legionella*, will both grow on the surface of the plastic piping such as PVC and polyethylene more readily than on copper or steel (Schofield & Locci, 1985; Rogers *et al*., 1994), and chemicals that leach from the materials can be used by microbes as a nutrient source. Plastic piping may therefore present a greater risk than standard copper piping.

Design considerations:

- All pipework for potable water should ideally be copper, to minimise the growth of *Legionella*. Where this is not the case, this factor should be considered in the development of a water sampling program and in any risk management plan that is developed for the site or system
- If a biocide is part of either the routine or the adverse-event disinfection protocol, it is critical that the necessary equipment and injection point is plumbed in, to minimise delays in adding the biocide
- If hot and cold pipe work is to be installed alongside each other, the cold water pipes should be installed below hot/warm water piping, to reduce heat transfer
- Scale, corrosion, sludge and biofilm need to be controlled
- The integrity of warm water piping insulation needs to be in good working order
- Eliminate 'dead legs' in the pipe work.

5.4.6 Water hammer arrestors

Water hammer arrestors (shock absorbers) are used to reduce hammering in pipes. Typically, they sit at right angles to the pipe and have an internal cavity that expands as the pressure of water in the pipe increases, such as when taps are opened or closed quickly. These arrestors are made of stainless steel and are designed to absorb noise, primarily caused by valves opening and closing in the hot and cold water systems. There are many types and some have a pocket that allows the natural collection of water and sediment. This becomes a natural reservoir for *Legionella*.

In one hospital overseas, the decision was made to remove all 125 arrestors from the system, as some were contaminated. This did not eliminate all *Legionella* from the system, however it did serve to substantially reduce the concentration.

Memish *et al.* (1992) described an outbreak of 10 cases in a hospital. After superheating of the water to 80°C, hyperchlorination to 2ppm and flushing of the system, no new cases were observed for 5 years, before 3 new cases were observed. Hammer arrestors were then removed and cultured, with 10 per cent yielding heavy growth of Lp 1. Since their removal, no new cases were identified.

Removing the hammer arrestors could be considered in the instance where *Legionella* is cultured from the sediment collected in them and when *Legionella* is unable to be controlled by other means. There are no stated maintenance requirements for these devices.

5.4.7 Outlets

For warm water systems, the main route of transmission of *Legionella* from a contaminated system to a susceptible patient is probably through inhaling aerosols containing the bacteria. These aerosols can arise from hand basins, spas, baths and showers. Fittings are important, as they are the main route of aerosolising any *Legionella* that may be present in the heated water, and can become locally contaminated, particularly if the outlet is not used often.

Backflow prevention devices and aerators
Backflow prevention devices (vacuum breakers) are either testable or non-testable, depending on the level of hazard identified. Maintenance procedures are not listed in AS 3500.1:2003, but testable devices should be checked for effective operation at intervals not exceeding 12 months; at least every two years for non-testable devices.

Aerators contain a disc of mesh that is typically screwed onto the end of a fitting to reduce the flow of water and splash when the tap is turned on fast. They also serve to greatly reduce the amount of water used.

Backflow prevention devices and aerators can be contaminated with *Legionella* and so add further points in the system that can become contaminated; some hospitals have chosen to remove aerators from taps, particularly as they can become recolonised within a month of sterilisation (Wadowsky *et al.* 1982; Ciesielski *et al.* 1984). However, other authors have found that aerators not regarded as being a risk factor for contamination by *Legionella*e (Alary and Joly 1992).

Taps

Legionella has also been isolated by swabbing or scraping the inside of taps, (Arnow *et al.* 1982; Wadowsky *et al.* 1982; Ciesielski *et al.* 1984) including non-touch tap fittings (Halabi *et al.* 2001), and from tap water (Arnow *et al*. 1982; Wadowsky *et al.* 1982; Levin *et al.* 1995). *Legionella* has also been isolated from the aerosol generated by taps (Bollin *et al.* 1985).

One study found that non-touch fittings in hospitals were much more likely to be contaminated with *Legionella* than conventional taps, possibly due the low volume of water that flows through the outlet and warm temperature. (Halabi *et al*. 2001)

Showers

Legionella has been isolated from showerheads in numerous studies, both from swabbing or scraping the inside of the device (Arnow *et al.* 1982; Wadowsky *et al.* 1982; Ciesielski *et al.* 1984) and the rubber fittings (Colbourne *et al.* 1984) from water coming from showers and shower baths (Tobin *et al*. 1980) and from the aerosol generated from showers and shower baths (Dennis *et al.* 1984; Bollin 1985; Mastro, 1991; Colville *et al.* 1993).

As *Legionella* is transmitted by aerosols small enough to be inhaled, fittings that do not generate inhalable aerosol have reduced risk. There is currently no information on differences in aerosol production between different fitting types, so the risk associated with different types of fittings is unknown.

Maintenance procedures for showerheads

It has been suggested that showerheads should be periodically removed, flushed and the inside surface manually scrubbed to remove any loose debris. The department has not been able to find sufficient supporting evidence for this practice to justify the cost of the process.

Guidance note: Removing and cleaning showerheads is not recommended as a method of reducing the risk of *Legionella* growth.

Flexible shower hoses

These have been shown to become colonised with *Legionella* (Walker *et al*. 1995).

6. Templates

6.1 Basic assessment and review

Person completing template	Date of completion

Common name of warm water system *e.g. "Block Z system"*	

1. Site details

Item	Details
Site location *e.g. 50 Lonsdale Street, Melbourne*	
Site owner's name (if government owned, write name of the facility)	
Contact details for site owner/manager	Name: Work Ph: Mobile:

2. System details

Item	Details
Name (and contact details) of person responsible for the day-to-day management of the system	Name: Position: Work Ph: Mobile:
Describe the system e.g. *calorifier/heater set at 65°C leading to TMVs*	
No. of calorifiers/water heaters and their volume	
Number of warm water outlets	
Number of hot water outlets	
System layout[9]	
Has the system been modified since installation?	
If yes, describe how?	
Age of the system?	
Age of the pipework?	
Age of other key components of the system?	
Is it a recirculating or non-recirculating system?	
Is there a cold water storage tank?	
Are there TMVs on premises?	
If yes, how many?	
Are outlets served by TMVs located less than 1m or greater than 6m after TMV?	
Are 3-way modulating valves fitted?	
If yes, how many?	
Approx. turnover volume of system per day	

[9] Attach as detailed a plan of the system as can be practically obtained.

3. Patient/resident profile

Item	Details
Broadly describe the health-risk status of the residents or patients served by the system being assessed	

4. Record keeping

Accurate and updated records of each system are essential; these records include details of installation, maintenance, sampling and results, flushing and disinfection.

Item	Details
Person responsible for the upkeep of these records	
Location of the records	
Location of maintenance manual/service manuals available on-site for inspection	
Insertion of recommended cleaning methods and dismantling instructions in manual	
Insertion of procedures for maintenance and management in manual	
Insertion of physical details, including drawings of the equipment and systems, in manual	
Insertion of operating and shut-down procedures in manual	
Inclusion of detailed maintenance schedule in manual	
Inclusion of material safety data sheets for any hazardous water treatment chemicals	
Inclusion of equipment safety data sheets	
Ensure that the maintenance log book is readily available at any time for inspection on site	

5. Hot water heaters

Item	Details
Describe the plan for regular cleaning and disinfection of the hot water storage in the water heaters	
State the plan for regular measurement of the temperature of the hot water	

6. Cold water tanks

Item	Details
If system has cold water storage tanks, state the plan for regular cleaning and disinfection of the tank/s	

7. Disinfection of the system

Item	Details
Describe the method and frequency of routine disinfection	
Is a heat/chlorination disinfection procedure in place if the system is shut down for a period of greater than a month?	

8. Continuous disinfection of the system by UV

Item	Details
If the system has continuous UV treatment, detail the program for lamp replacement, checking of operation of lamps and cleaning of sleeves around the lamps	

9. Thermostatic Mixing Valves (TMVs)

Item	Details
Describe the program to annually service TMVs and 3-way modulating valves by a licensed plumber	
Details of organisation/plumber/contact for this service and maintenance work	

10. Weekly flushing of unused outlets

Item	Details
Describe the program to flush unused showers on a weekly basis	
Describe the program to flush unused outlets (other than showers) on a weekly basis	

11. Sampling for *Legionella*

Item	Details
Describe your sampling regime for *Legionella* testing	
Is this regime within the Regulations for your method of disinfection? • At least two samples for 100 showers or beds	
Do you have a disinfection method available if *Legionella* is detected?	

12. Communication plan

Item	Details
Briefly outline the communication plan in place following detection of *Legionella* in the warm water system	

6.2 Advanced assessment and review

Complete the *Basic assessment and review* template before commencing this advanced assessment and review template.

Replies to details requested on the template should be as complete as possible.

Person completing template	Date of completion

Common name of warm water system *e.g."Block Z system"*	

1. Water quality

Item	Details
Describe the water supply quality	
Describe the water delivery quality (at outlets)	

2. Temperature/flow profile

Item	Details
Have you monitored the temperature of the water in key parts of the system?	
When was this last monitored?	
Has the system since been modified?	
Are you aware of low temperature areas?	
If yes, where?	
Are you aware of low flow areas?	
If yes, where?	
What is temperature of cold water delivery into the system?	

3. Water heaters

Item	Details
Describe water heating device	
Location of the heating device	
How is water heated like gas, electricity, solar?	
If solar heated, what is final temperature of the boosted hot water?	
What is storage volume of each heater?	
Age of the water heaters?	

4. Cold water tanks

Item	Details
Is there a cold water storage tank?	
If yes, what is the age of the tank(s)?	
What is the tank made of?	
Does the tank(s) show any sign of deterioration?	
Are any of the water tanks exposed to contamination such as dust, vermin etc?	
Is there a stand-by alternative tank that creates dead legs?	
How accessible is the tank for maintenance?	

5. Pipe work

Item	Details
What are the pipes made of?	
Approximate percentage of pipe work of system that is easily accessible.	
Does the system have a continuous flow or recirculation loop?	

6. Dead legs

Item	Details
Are there obvious known dead legs?	
If yes, describe their location	
Are there unused outlets?	
If yes, describe their location	

7. Water sampling

Item	Details
Are water samples taken from the warm water system tested for *Legionella* on a regular basis?	
If yes, describe the frequency?	
How are sites for sampling selected?	
Has *Legionella* has been detected in the system as in previous 12 months, assuming water sampling has been regular for that period?	
If yes, from what sites, what species, how often and at what concentration?	
How do the sites from which *Legionella* has been found relate to the temperature profile?	
Describe the sample collection protocol	
Person responsible for taking the samples	
Details of testing laboratory	Laboratory name: Laboratory address: Laboratory ph:

8. Routine disinfection

Item	Details
Is there any ongoing routine disinfection of the water?	
If yes, describe the method and frequency	
If no, when is this going to be introduced?	
How effective has your routine disinfection method been (ie determined by control of *Legionella*)?	
If the disinfection method involves chemicals, are the staff who apply the disinfection appropriately trained, particularly in handling of hazardous chemicals and critical events?	

9. Improvements to water quality

Item	Details & proposed timelines
If water quality incoming to the system is poor (ie discoloured or dirty), detail what can be done to improve it	
If water quality at outlets is poor, detail a plan for improvements to the system	

10. Improvements to temperature/flow profile

Item	Details & proposed timelines
Describe the plan to address areas of low temperature or flow	
If the system is a recirculation type, what is the flow rate in the ring main?	
Do you have a temperature/flow profile? If yes, attach a copy.	

11. Improvements to reduce system stagnancy

Item	Details & proposed timelines
If outlets served by TMVs are greater than 10m after the TMV, describe a program to shorten these lengths of pipework.	
If the system can be improved by increasing the flow in low flow areas, describe a program to increase the flow in these areas.	
If there are outlets identified as no longer being necessary, describe a program for their removal.	
Describe the program to remove identified dead legs in the system.	
Describe a program for weekly flushing of unused outlets.	
Describe the strategy to ensure that the correct unused outlets are flushed.	

12. Improvements to water heater

Item	Details & proposed timelines
What actions are to be taken to address water heater deterioration, if detected?	

13. Improvements to cold water storage

Item	Details & proposed timelines
If the tanks show signs of deterioration, describe the plan to address the deterioration	
Describe how the tanks are or will be protected from external contamination	
If there is a stand-by water tank that creates a potential dead-leg, describe how the risks to the system that this tank presents will be addressed	

14. Improvements to disinfection of warm or cold water

Item	Details & proposed timelines
If *Legionella* has been detected in a system, even though improvements have been made to the system's temperature or flow, can an improvement be made to the disinfection of a system?	
If yes, state an improvement that can be made to the disinfection of the warm water	

15. Improvements to sampling for *Legionella*

Item	Details & proposed timelines
If frequency for testing for *Legionella* is not consistent with the Regulations, can such a frequency be put in place?	
If the number of outlets sampled is not consistent with the department's recommendations, can the appropriate number be put in place?	
Can an improvement be made in the selection of appropriate sites/locations for sampling? If so describe the new arrangements	
If outlets other than showers have been selected for sampling, can improvements be made by sampling from showers in preference to sampling from taps?	

16. Adverse event disinfection protocol

Item	Details & proposed timelines
What adverse event disinfection methods would be used following *Legionella* detection?	
If chemicals are to be used in an adverse event disinfection, are the injection points in place for this procedure?	
Is the injection point downstream of the circulation pump?	
How effective has your disinfection method been where *Legionella* has been detected in the past?	
If an adverse event disinfection was ineffective, what improvements or changes can be made to the disinfection method?	

17. Communication plan

Item	Details
Attach the developed communication plan to this template	

7. Model policy statement on communication of *Legionella* and Legionnaires' disease related issues

Scope

This policy describes the way in which the facility will deal with the detection or non-detection of *Legionella*, as well as any information about an association of the facility with cases of Legionnaires' disease relating to a warm water system.

Context

***Legionella* bacteria and Legionnaires' disease**
Legionella bacteria are relatively common in the natural environment, but when they find a mechanism for growth and transmission to the lungs of susceptible people and cause Legionnaires' disease, the bacteria then becomes a serious public health issue.

Showers (or potentially any other warm water outlet) can discharge very fine aerosols that may contain *Legionella*. There is international evidence that if aerosols containing *Legionella* bacteria are inhaled by susceptible people, those aerosols may cause Legionnaires' disease. The evidence in Australia (where few, if any, cases of Legionnaires' disease have been associated with shower warm water systems) suggests that this risk is very low. It is believed that the most likely source of aerosols in warm water systems, which could contain *Legionella,* is from showers.

The risk is likely to be greatest in a hospital environment, due to the compromised health status of many of our patients that places them at higher risk of contracting Legionnaires' disease than most other individuals.

The incubation period for Legionnaires' disease is between two and ten days. This means that cases of Legionnaires' disease may occur from two to ten days after exposure to the *Legionella*-contaminated aerosols.

Detection of *Legionella* at any level in a warm water system
Despite the overall risk being considered low, detecting *Legionella* in a warm water system could have significant public health implications if it results in a case of Legionnaires' disease. An immediate response is required to disinfect the system. Re-sampling and testing for *Legionella* two to seven days following the detection of Legionella in a sample is recommended. Due to the complexity of the laboratory test involved, there is up to a ten-day interval between collecting a water sample and receiving results.

If *Legionella* is detected in a warm water system, there is a low chance of susceptible people being exposed to *Legionella*-contaminated aerosols from a shower, until the source has been identified and treated. This means that any related cases of Legionnaires' disease may be confirmed either before or after the *Legionella* testing has occurred.

Early advice that *Legionella* has been detected in a warm water system could alert individuals suffering from flu-like symptoms to consult a medical practitioner and discuss their exposure and symptoms. Early diagnosis can result in less severe illness. Early advice can also inform clinical staff and health care workers to include Legionnaires' disease in differential diagnosis of cases of nosocomial pneumonia, leading to the provision of the most appropriate antibiotic treatment.

It is important that Visiting Medical Officers (such as visiting clinicians and visiting general practitioners) be included in this information process.

Policy statement

Principle 1: Education

We will commence an awareness-raising program (coordinated by the Occupational Health and Safety Committee) to make information available to all staff and contractors who use our facility. It will cover:

- location and management of warm water systems on the site
- this policy
- Legionnaires' disease.

Principle 2: Risk management

The facility will develop risk management plans for warm water systems on its property. The development of the plans will be the responsibility of the Chief Executive Officer and overseen by the Occupational Health and Safety Committee *and Infection Control Team*[10]. The plans, when developed, will be presented to the Board of Management for endorsement.

The plans will include a detailed Communication Plan outlining the response to all reasonably foreseeable scenarios. The Chief Executive Officer is delegated the authority to update the plan as required.

The facility will ensure that it adopts a continuous improvement approach to warm water systems and will review the warm water system(s) management plans annually. Reviews will also be conducted before the commencement of any major construction on the hospital site, to take into account any potential change in risk as a result of such construction and to seize any opportunities for improving existing systems during re-development.

Principle 3: Transparency

Legionella

The detection of *Legionella* will trigger an open communication process. This will extend to the adoption of a transparent approach for handling information concerning *Legionella* as it relates to the warm water system(s) operated by the facility.

This means that the facility will work cooperatively within existing structures (such as the Occupational Health and Safety Committee, facility management and Infection Control teams), to develop a process that ensures all *Legionella* test results from warm water systems are made accessible to staff, together with information explaining the significance of the results.

Confirmed cases of Legionnaires' disease

In the event that confirmed case(s) of Legionnaires' disease are linked by the Department of Health to our facility, we will release the maximum information available that respects the rights of the person(s) concerned to privacy. This information is likely to consist of the basic facts - that a case or cases has been confirmed and that the department has advised that our facility is implicated as a

[10] Infection control teams are likely to be only relevant to hospitals and large aged care facilities.

possible source. Patient/resident details will not be released. The release of information would be performed jointly by the department and the facility.

Media
A decision on whether to brief the media about the detection of *Legionella* will be made by the Chief Executive Officer, after discussion with the Department of Health. The decision will be based on risks to public health and on the usefulness of such information in minimising the impact (through early diagnosis) of any cases of Legionnaires' disease that may have resulted from exposure of individuals to *Legionella* from the system concerned.

Principle 4: Management reporting

Reports consisting of the following information will be prepared and submitted to the Board of Management.

Quarterly:

- A chart showing the results of all *Legionella* sampling results. The chart will be in the form of a rolling 18-month time series, to allow comparison with the same period in the previous year.

- Reporting against implementation objectives contained in the facility's warm water management plans, such as the installation of equipment or other improvements.

- A summary of the key issues for each system.

Exceptions/variances

Presence of *Legionella* in a warm water system must be reported by telephone to the facility's Chief Executive Officer on the day of detection.

A report on the action taken following that detection is to be incorporated into the report to the next scheduled meeting of the Board of Management.

A copy of these management reports will be circulated to both the Occupational Health and Safety Committee and the Infection Control Committee.

8. Model communication plan – Legionella and Legionnaires' disease

The warm water system (insert name of system and building which it serves) in the showers is sampled at …[11] intervals and tested at an independent laboratory for *Legionella*[12]*.* The Department of Health may also detect *Legionella* through their sampling program. It is possible that Legionella could be detected in any sample taken from the water in the system.

Legionella is reported as the number of Colony Forming Units per millilitre (CFU/mL) of sample. The level of detection for the sample taken from (insert location of outlet) on (insert date of sampling) is above 10 CFU/mL.

The independent testing laboratory reports sample results directly to the:

- **[insert name of position e.g. Hospital Engineer[13]]** by mail, where the water has been tested for *Legionella* but not detected.
- **[insert name of position e.g. Hospital Engineer** and **Infection Control Practitioner]** by telephone, with confirmatory fax or email where *Legionella* has been detected.

Note that there is up to ten-day time lag between sampling for *Legionella* and obtaining results from the laboratory.

The agreed plan for each potential outcome is detailed below. It includes a series of flow charts and templates[14].

The plan includes elements which deal with both the detection and the non-detection of Legionella in the system.

A plan to deal with a confirmed case of nosocomial (hospital/institution-acquired) Legionnaires' disease is also included.

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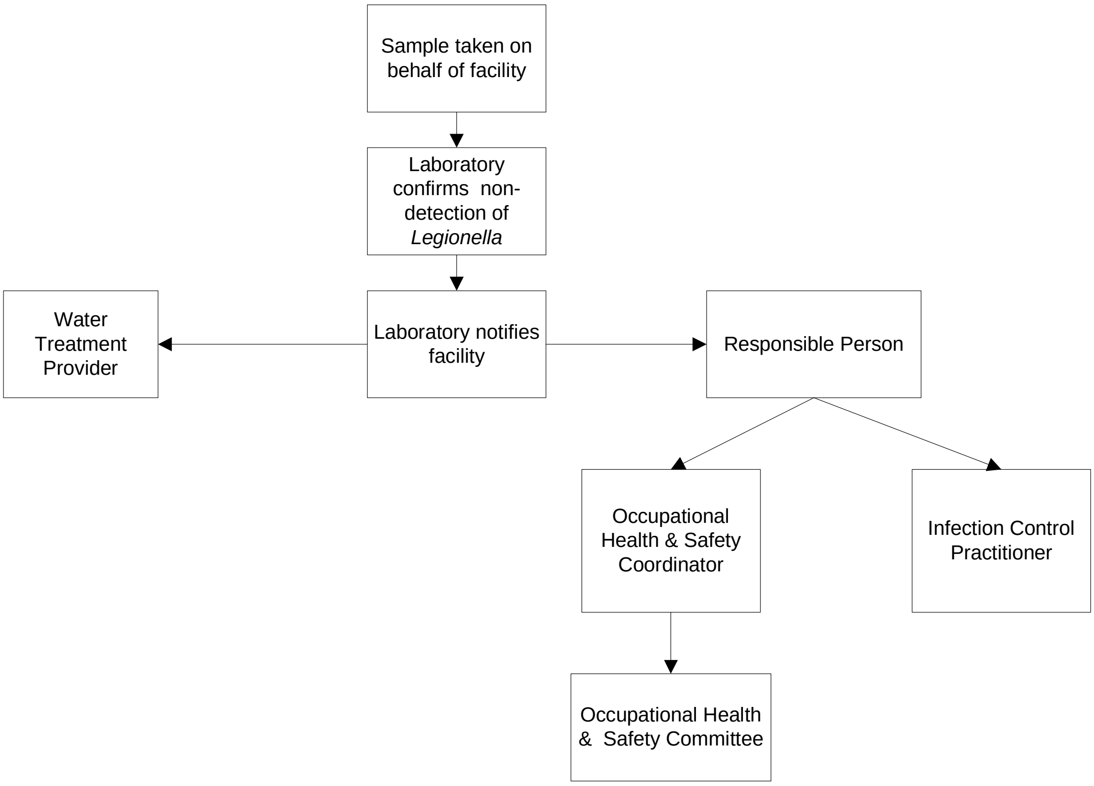
[11] Insert frequency and summary of sampling protocol.

[12] Delete if no routine sampling performed and rewrite to cater for this scenario. For example, 'The warm water system is not tested routinely for *Legionella,* but could possibly be tested either by the hospital or the Department of Health in the course of an investigation of a case of Legionnaires' disease, or during a random test. If it is detected by the department, the hospital engineer will normally be contacted by the department. In this case, the Hospital Engineer will need to activate the appropriate section of the communication plan'.

[13] The water treatment provider will need to be notified where chlorination is used.

[14] The examples given are based on a hospital but they can be adapted for any type of facility

Attachment 1: Warm Water System tested and no *Legionella* detected

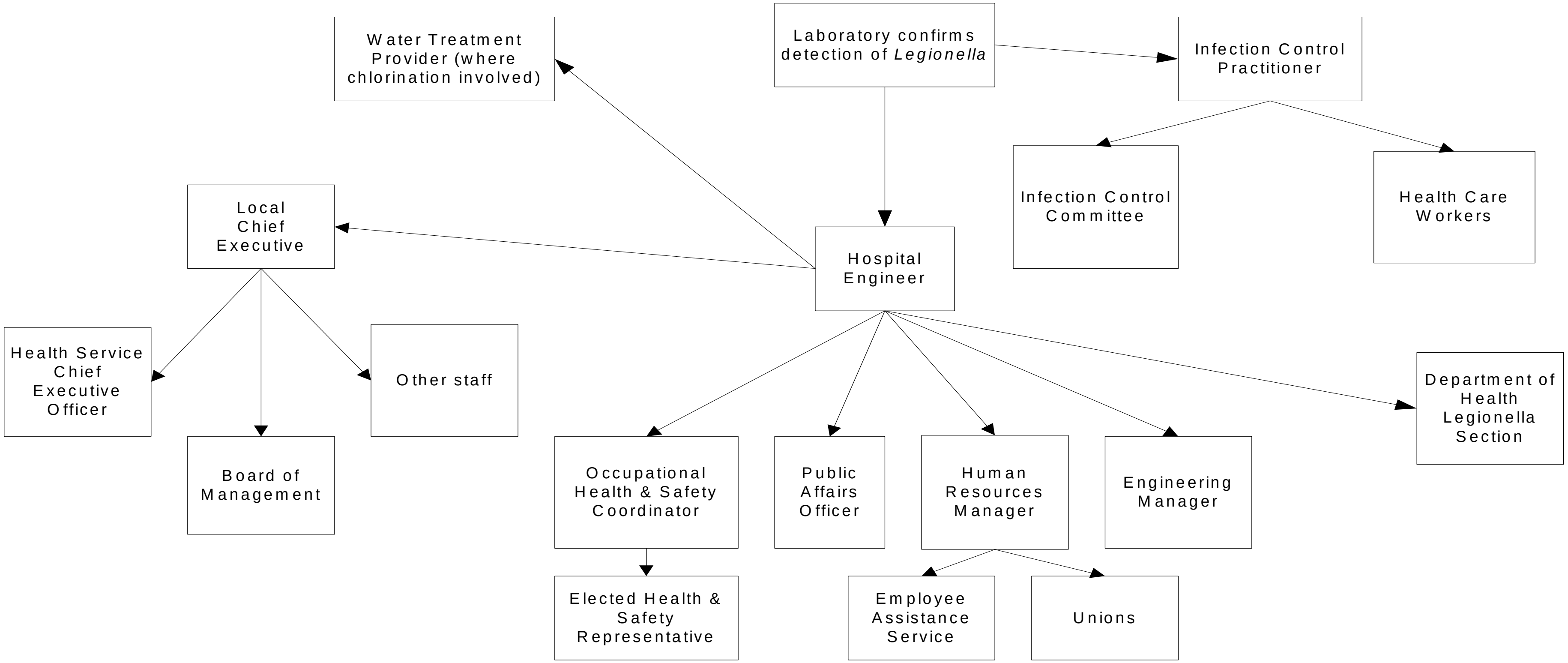


The ……………………………………… [insert name of position e.g. facility manager] will advise the following by email:

Title	Name	Action required
OH & S Coordinator		Tabling at next Occupational Health & Safety Committee meeting
Infection Control Practitioner		Tabling at next Infection Control Committee meeting

Attachment 2: Legionella detected in Warm Water System

Summary of Communication Plan for a Hospital



Attachment 3: Model statement about the detection of Legionella in a hospital

The Hospital Engineer and Infection Control Practitioner will be contacted directly by the laboratory. The following table describes the communication process.[15]

With warm water systems, the risk of contracting Legionnaires' disease is associated with inhaling *Legionella*-contaminated aerosols from a water outlet. Showers linked to contaminated warm water systems have been most commonly implicated in cases of Legionnaires' disease. Where *Legionella* is detected in a warm water system, all patients and staff will be excluded from using the showers in the affected areas linked to the warm water system, until such time as the system has been disinfected.

The Department of Health may also sample the water in the warm water system. In the event *Legionella* is detected, the department will normally contact the Hospital Engineer directly. They will in turn contact the infection control practitioner and the water treatment provider. The process is otherwise the same as where *Legionella* is detected by the hospital.

[15] Actions may vary, depending on warm water system and patient groups involved. Where the water is chlorinated on a routine basis, the water treatment provider will need to be contacted immediately, to arrange emergency chlorination.

Attachment 4: Model statement about the detection of Legionella in a hospital

The Hospital Engineer and Infection Control Practitioner will be contacted directly by the laboratory. The following table describes the communication process.[16]

With warm water systems, the risk of contracting Legionnaires' disease is associated with inhaling *Legionella*-contaminated aerosols from a water outlet. Showers linked to contaminated warm water systems have been most commonly implicated in cases of Legionnaires' disease. Where *Legionella* is detected in a warm water system, all patients and staff will be excluded from using the showers in the affected areas linked to the warm water system, until such time as the system has been disinfected.

The Department of Health may also sample the water in the warm water system. In the event *Legionella* is detected, the department will normally contact the Hospital Engineer directly. They will in turn contact the infection control practitioner and the water treatment provider. The process is otherwise the same as where *Legionella* is detected by the hospital.

[16] Actions may vary, depending on warm water system and patient groups involved. Where the water is chlorinated on a routine basis, the water treatment provider will need to be contacted immediately, to arrange emergency chlorination.

Attachment 5: Template for communication with hospital staff

Title	Name	Telephone	Email	Who will make contact?	Method of contact?	What information will be provided?	Action required
Local Chief Executive				Hospital Engineer	Phone and email	Attachment 3	Implement plan
Occupational Health & Safety Coordinator				Hospital Engineer	Phone and email	Attachment 3	Noting
Infection Control Team members				Infection Control Practitioner	Phone and email	Attachment 3 Attachment7	Implement agreed patient surveillance pro
					Phone		
					Phone and email		
					Phone and email		
Public Affairs Officer				Hospital Engineer	Phone and email		Noting
Human Resources Manager				Hospital Engineer	Phone and email		Implement agreed staff surveillance proce monitor any staff absent from work for mo ....[17]with flu-like illnesses. In such cases, th will be personally contacted by the Human Resources Manager (or their representativ given the information in Attachment 3. Oth stakeholders to be notified as per the rema the plan.
Health Care Workers				Infection Control Practitioner	Hard copy memo & email		Implement agreed patient surveill protocol
Other staff				Local Chief Executive's Office	Hard copy memo & email		Noting

[17] Normally 2 to 3 days

Elected Health & Safety Representative				Occupational Health & Safety Coordinator	Phone & email		Noting

NOTE: References to Attachments 3 and 7 in the column "What information will be provided?" appear in *Model Communication Plans for Hospitals – Legionella and Legionnaires' Disease* (Department of Human Services, Nov 2001). This document can be found on the *Legionella* website: www.health.vic.gov.au/environment/*Legionella*/industry. Attachment 3 refers to pro forma email: *Legionella* Detection in Warm Water System. Attachment 7 refers to pro forma: Patient Surveillance Protocol – Legionnaires' disease

Attachment 6 Pro forma email - *Legionella* Detection in Warm Water System

Legionella Bacteria Detected in Routine Sampling of Warm Water System
Legionella spp ……. have been detected in a sample of the warm water system … at …….CFU/mL. The sample was taken from the water ……. on the …..

Only the warm water system in the ……. Building is affected[18].

Critical Incident Plan Implemented
The Hospital's Communication and Response Plan has been activated and you have been notified as part of that plan.

Legionnaires' disease
Legionnaires' disease is an extremely rare form of pneumonia. In Victoria, it is most commonly caused by *Legionella pneumophila* bacteria.

Early symptoms of the disease resemble those of flu: headache, fever, chills, muscle aches and pains and generally a dry cough followed by shortness of breath. Other systems in the body can sometimes be affected resulting in diarrhoea, confusion and kidney failure. Antibiotics are used to treat Legionnaires' disease.

Legionella are a common bacteria usually associated with water. The risk of *Legionella* growing within a warm water system cannot be eliminated. Warm water systems are common in hospitals to reduce the likelihood of scalding to patients and others. Susceptible people who inhale *Legionella* contaminated aerosols from outlets connected to the warm water system, are at greatest risk of contracting Legionnaires' disease.

Those most at risk are those:

- Who smoke
- Over 55
- Who have chronic lung disease
- Who are immunocompromised.

Treatment of Warm Water System
The warm water system concerned is to be disinfected at ….[19] by …..[20] Re-sampling of the water will be performed on ….

Patients will be excluded from the shower area in the areas of the hospital affected until confirmation has been received that the disinfection has been completed.

Increased Surveillance
It is unlikely that any people who may have been exposed to the *Legionella* bacteria from the warm water system will go on to develop Legionnaires' disease. We have nevertheless taken the precaution of increasing the health surveillance of patients.

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[18] Add in additional information where available, for example, "other hospital systems were tested at the same time but *Legionella* was not detected".
[19] Time and date.
[20] Describe the method to be used.

Patient Surveillance
Medical staff at the hospital have been asked to increase the level of surveillance for cases of Legionnaires' disease which may have been acquired while a patient has been staying at the hospital.

Media Enquiries
The Hospital spokesperson in relation to this matter is ……

Initially, though all enquiries from the media are to be directed to our Public Affairs Manager …………. on …….

You will be advised of the issue of any media release.

Internal Enquiries
Internal enquiries about the warm water system can be directed to …..[21] on ……..

More Information
More information about Legionnaires' disease is available from the Department of Health's Web site at http://www.health.vic.gov.au/ideas/bluebook/legionellosis

[21] Normally, this will be the Hospital Engineer.

Attachment 7 Pro forma email - *Legionnaires' Disease* Linked to Hospital Warm Water System

Legionnaires' Disease Confirmed
Legionnaires' disease has been confirmed in ……[22]. The Department of Health has advised that they believe that the warm water system in the ……[23] of the hospital is the ……[24] source of the *Legionella* bacteria responsible for the disease. The warm water system concerned supplies warm water to showers and other outlets within the ….. building.

Critical Incident Plan Implemented
The warm water system concerned has been disinfected at ….[25] by …..[26] This is an approved method of disinfection under the Health *(Legionella)* Regulations 2001. The Department of Human Services Public Health Division has confirmed that this action should have significantly reduced the risk of *Legionella* being present in the system at the moment. The system will be re-tested for *Legionella* bacteria on …...

Results of the re-sampling will be available on ……… and will be made available to all staff.

Legionnaires' Disease
Legionnaires' disease is an extremely rare form of pneumonia. In Victoria, is most commonly caused by *Legionella pneumophila* bacteria.

Early symptoms of the disease resemble those of flu: headache, fever, chills, muscle aches and pains and generally a dry cough followed by shortness of breath. Other systems in the body can sometimes be affected resulting in diarrhoea, confusion and kidney failure. Antibiotics are used to treat Legionnaires' disease.

Legionella are a common bacteria usually associated with water. The risk of *Legionella* growing within a warm water system cannot be eliminated. Susceptible people who inhale *Legionella* contaminated aerosols, which leave the shower, are at greatest risk of contracting Legionnaires' disease. Those most susceptible are those who:

- Smoke
- Are over 55 years of age
- Have chronic lung disease
- Are immunocompromised.

Staff with Health Concerns
The Department of Human Services advise that cases of Legionnaires' disease have only rarely been associated with warm water systems.

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[22] Insert as much of the non-confidential aspects that explain the situation as you can and answer the most common questions. Was the person(s) a patient or staff member? How might they have been exposed? And so on.
[23] Describe the building implicated
[24] Content will depend on the advice from the Department of Human Services. For example, it may refer to a possible linkage.
[25] Time and date.
[26] Describe the method to be used.

Staff who have not used a shower connected to the affected system are not considered to be at risk. Similarly, there is no evidence that staff who have assisted a patient in showering are likely to be at risk.

The Department of Health do not recommend routine screening of staff for Legionnaires' disease in such circumstances.

Staff with general concerns about the issue are advised to discuss the matter with their supervisor.

Patient Surveillance
Medical staff at the hospital have been asked to increase the level of surveillance for cases of Legionnaires' disease which may have been acquired while a patient has been staying at the hospital. This will mean that patients with flu-like symptoms or pneumonia may be tested for Legionnaires' disease.

Media Enquiries
The Hospital spokesperson in relation to this matter is ……

Initially though, all enquiries from the media are to be directed to our Public Affairs Manager …………. on …….

You will be advised of the issue of any media releases.

Internal Enquiries
Internal inquiries about the warm water system can be directed to …..[27] on ……..

More Information
More information is available from the Department of Human Services Web site at http://www.health.vic.gov.au/ideas/bluebook/legionellosis

[27] Normally, this will be the Hospital Engineer.

Attachment 8 Pro forma - Patient Surveillance Protocol Legionnaires' Disease

In the event of confirmed cases of nosocomial Legionnaires' disease at the hospital the following protocol will be implemented[28].

[28] This should describe the process that has been agreed for use in such situations and should describe any additional testing that is recommended in such situations.

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