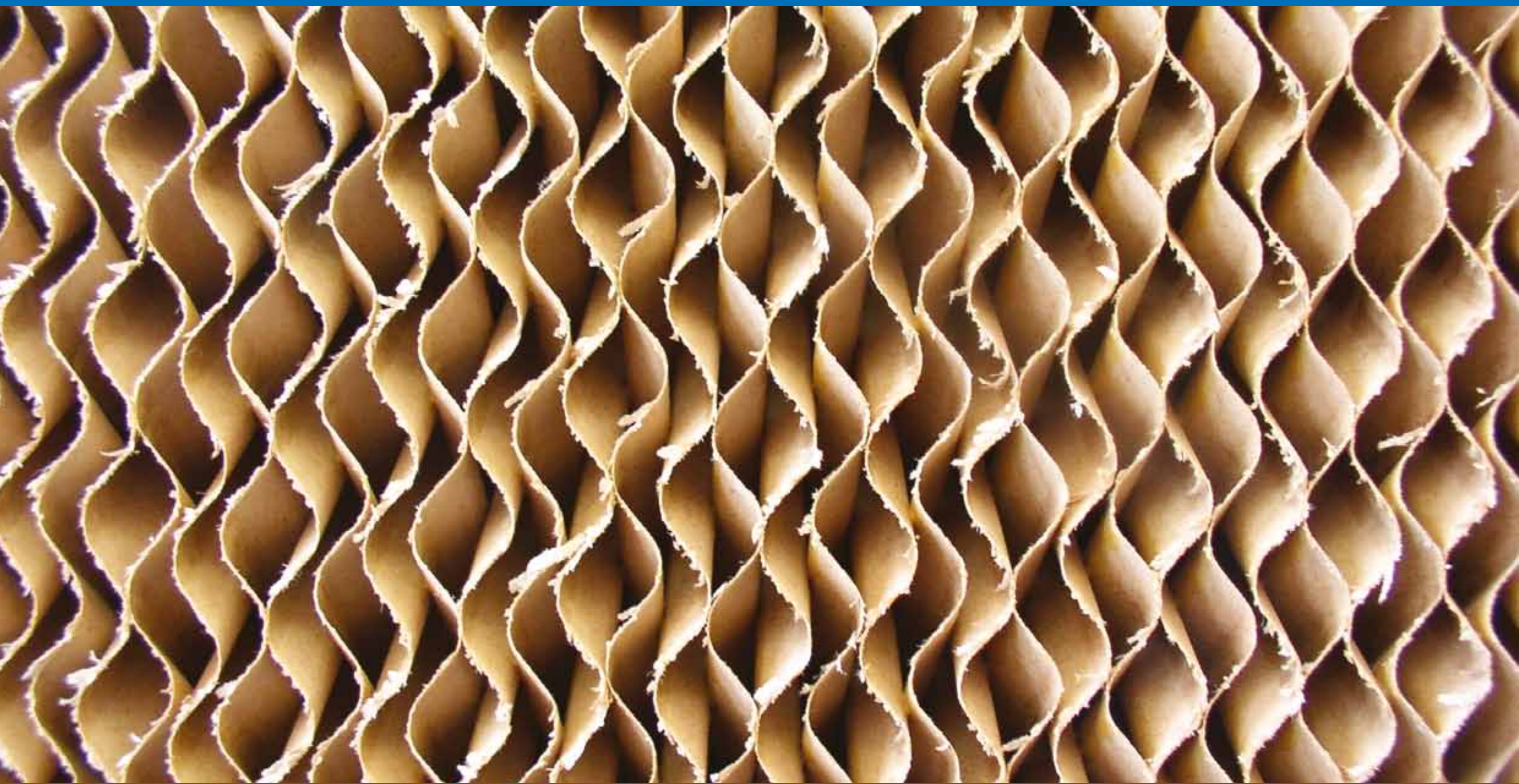
THE AUSTRALIAN INSTITUTE OF
REFRIGERATION, AIR CONDITIONING AND HEATING

BEST PRACTICE

GUIDELINES

Non-residential evaporative air cooling systems – Water efficiency and conservation



Smart Water Fund

AIRAH

BEST PRACTICE GUIDELINES

Non-residential evaporative air cooling systems – Water efficiency and conservation

Editor: **V J Aherne** BSc(Hons)Eng, MEnvMgt, Dip BSEng, Cert. Eng, M AIRAH

Review and Revision

To assist with the periodic review and revision of AIRAH Guidelines, users are encouraged to make known their experience in using this Guideline and to notify AIRAH of any additional information which they can provide or to which reference can be made. This information should be forwarded to the AIRAH national office.

Acknowledgements

These best practice guidelines are based on the contents of AIRAH DA29 Evaporative air cooling sytems. These guidelines have been reviewed by industry representatives and AIRAH wishes to acknowledge their contribution.

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The Australian Institute of Refrigeration, Air Conditioning and Heating (Inc.)
Level 3, 1 Elizabeth Street Melbourne Victoria Australia • Tel +61 3 8623 3000

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Contents

Non-residential evaporative air cooling systems – Water efficiency and conservation

1. Introduction

This Guide is provided to help owners and operators of evaporative air cooling systems to improve the water efficiency and reduce the water consumption of their systems. It covers recommendations for reviewing and improving existing systems and ongoing system maintenance and management for non-residential applications.

Water efficiency means getting more value or work out of the water that is consumed by the system. Water conservation means ensuring that water is not being wasted or lost by the system. The first step however, is to review some information about what evaporative air coolers are, how they work, and how water is used within these cooling systems.

2. What evaporative air cooling systems are

Evaporative air cooling systems draw air over wetted pads and surfaces. This results in the evaporation of the water into the air which reduces the air temperature and increases its moisture content. The cooled humidified air is distributed inside to the space, or process to be cooled, before leaving via natural relief or mechanical ventilation openings. Airflow rates are generally high and these systems are most effective in hot, dry, low humidity climates and where increased indoor humidity levels do not adversely affect comfort or processes.

Evaporative air and coolers can be classified as Direct, Indirect or Two stage systems can be further classified as ducted or non-ducted. All systems, regardless of their classification, use the same principles of forced water evaporation to reduce the temperature of the air.

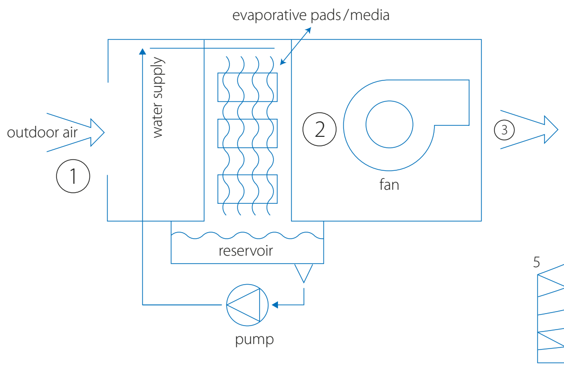
Some systems use the air to cool the water (e.g. cooling towers) but evaporative air coolers use the water to cool the air.

3. How evaporative air cooling systems work

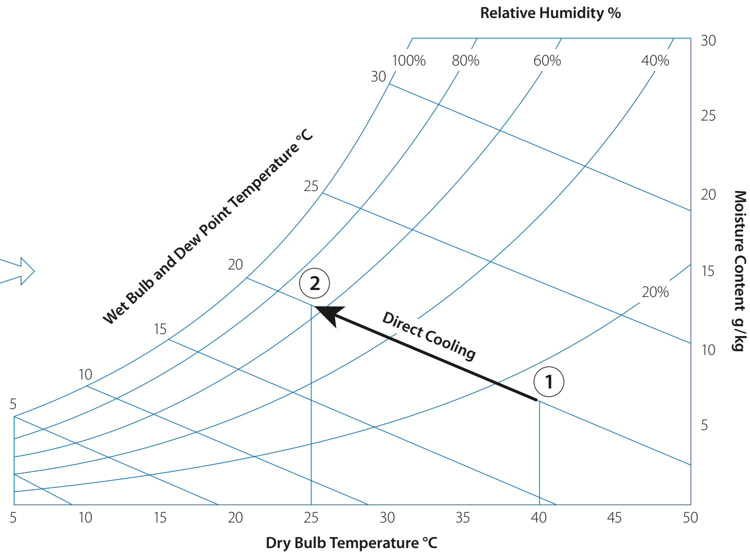
We have all noticed a marked air cooling effect after a light shower of rain or the sharp temperature drop when you arrive at the base of a waterfall. That is the evaporative cooling effect at play in nature. Perspiration or sweating is an example of a very effective evaporative cooling process adopted by the human body. Changing water from a

Direct evaporative air coolers

Typical arrangement



Psychrometrics



Air enters at condition 1.
Air leaves wet pads and is supplied to room at condition 2.
Air discharges from space at condition 3 and dissipates to atmosphere at condition 1.

liquid to a gaseous state requires energy and that energy is usually supplied from the air in the form of a heat flow resulting in a temperature drop of the air. In the case of sweat, that energy is supplied from the body in the form of a heat flow resulting in a temperature drop of the skin.

Evaporative air cooling systems use electrical energy to generate and distribute cooled air via their fans and pumps. Water is consumed by evaporation to produce the cooling effect and also by dilution based water quality management systems aimed at minimising salt build-up within the system water.

Evaporative air coolers rely on the difference between the wet bulb and the dry bulb temperatures for their cooling effect. The wet bulb temperature is different from the dry bulb temperature that we are used to considering. The wet bulb temperature is a function of the dry bulb temperature and the moisture content of the air. It is easily measured using an instrument such as a sling psychrometer; it can be calculated from air dry bulb temperature and relative humidity data or read directly off a psychrometric chart.

The difference between the wet bulb and the dry bulb temperatures of the outdoor air is called the Wet Bulb Depression (WBD). A properly designed and installed evaporative air cooling system can reduce the dry bulb temperature of the outdoor air by a factor equivalent to the rated evaporation efficiency of the evaporative air cooler, multiplied by the wet bulb depression of the outdoor air. For example, for a direct evaporative air cooler rated at 80% evaporative efficiency and with a wet bulb depression of 12°C, the evaporative air cooler should reduce a 34°C outdoor dry bulb temperature to:

34 – (0.80 x 12) = 34 – 9.60 = 24.4°C

That's a 9.6°C temperature reduction for a unit operating under these conditions.

4. The potential to waste water

Studies have shown that many evaporative air coolers in the non-residential sector are using excessive amounts of water unnecessarily. In many systems the unit is "dumping" or "bleeding" significant quantities of water to the drain for the full length of time that the system is turned on. This water consumption is often either excessive or not necessary and represents a significant waste of water and an increase in operating costs.

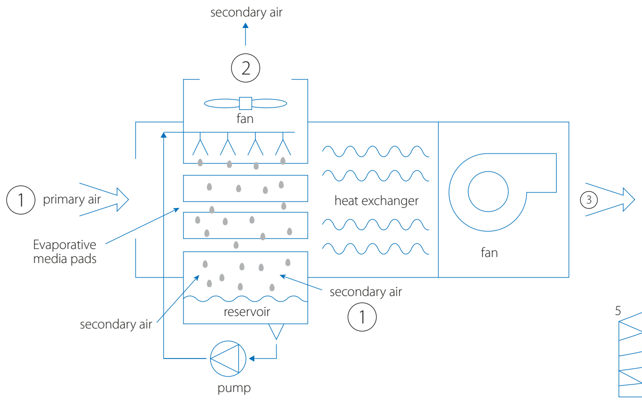
The results of a study initiated by the Department of Sustainability and Environment, and managed by AIRAH, indicated that potentially up to 1800 ML/year of water could be saved in Victoria by optimising the water consumption of evaporative air coolers in the non-residential sector. Some ways to make your evaporative air cooling system more water and energy efficient are listed in this guide.

5. How to apply this guide

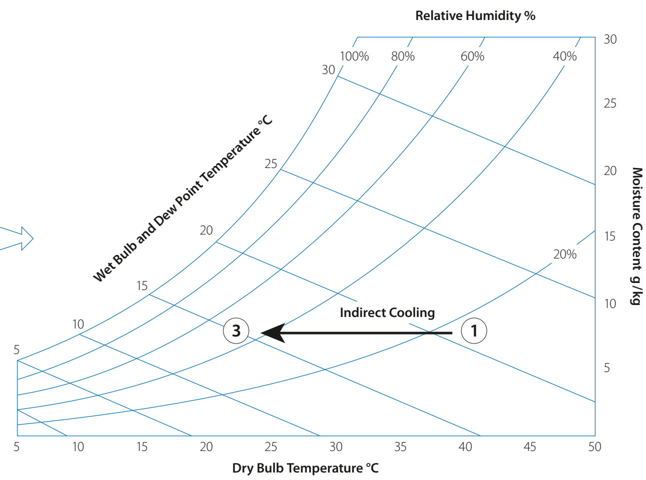
The water efficiency principles contained within this Guide apply to typical direct and indirect evaporative air cooling

Indirect evaporative air coolers

Typical arrangement



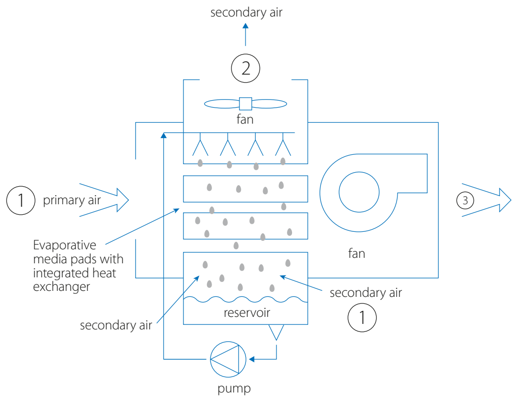
Psychrometrics



(A) Indirect evaporative air cooler (with separate heat exchange)

Secondary air enters at condition 1, and leaves wet pads at condition 2.
Primary air enters heat exchanger at condition 1 and is supplied to room at condition 3.
Air discharges from space at condition 4 and dissipates to atmosphere at condition 1.

Typical arrangement



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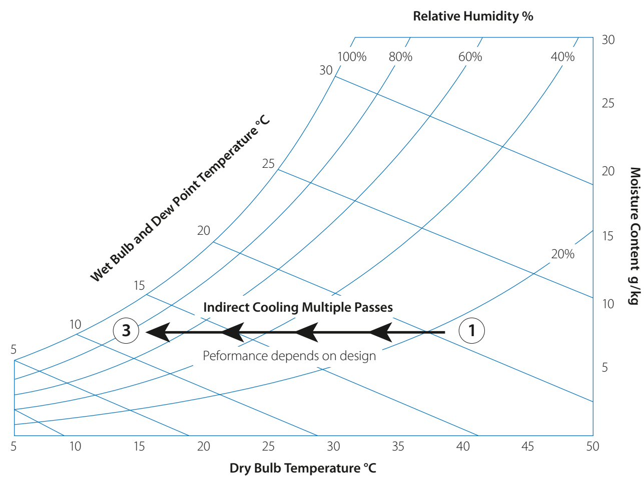


(B) Indirect evaporative air cooler (with integrated heat exchange)

Secondary air enters at condition 1, and leaves integrated heat exchanger at condition 2.
Primary air enters integrated heat exchanger at condition 1 and is supplied to room at condition 3.
Air discharges from space at condition 4 and dissipates to atmosphere at condition 1.

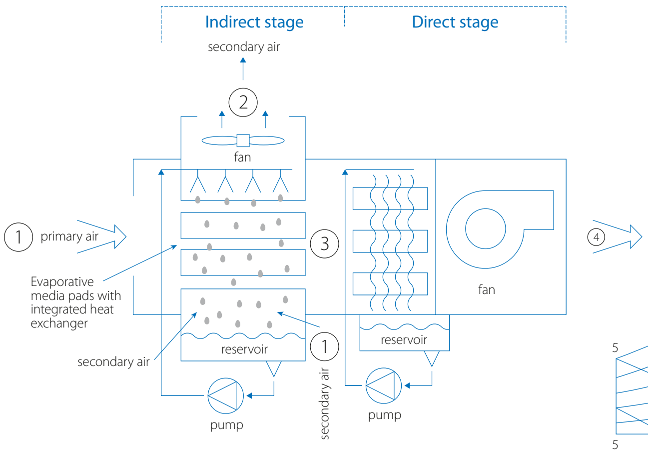
systems. The guide outlines a series of standardised steps to follow to optimise the system. The standardised steps will be particularly helpful to operators of evaporative air cooling systems associated with commercial, industrial, process and agricultural uses.

Operators should optimise the water use of evaporative air cooling systems by improving efficiency and reducing consumption to:

- Conserve water resources.
- Reduce waste, reduce costs and save money.
- Be environmentally responsible.
- Assist with environmental ratings or green lease commitments associated with a building.
- Help demonstrate corporate environmental credentials.

Two stage Indirect/Direct evaporative air cooler

Typical arrangement



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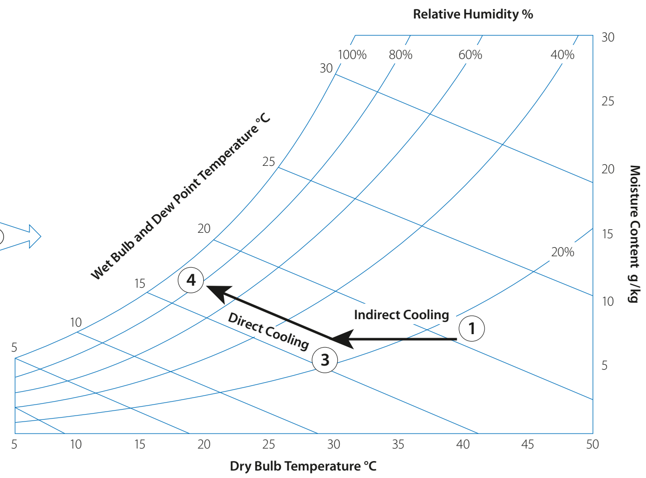


Secondary air enters indirect section at condition 1, and leaves wet pads at condition 2.
Primary air enters indirect section heat exchanger at condition 1 and is supplied to direct section at condition 3.
Primary air leaves direct section wet pads and is supplied to room at condition 4.
Air discharges from space at condition 5 and dissipates to atmosphere at condition 1.

This guide aims to identify the main ways in which an evaporative air cooling system consumes water and outlines a series of recommendations to assist the operator or maintenance service provider in the reduction of system water consumption.

Operators can reduce the water consumption of evaporative air cooling systems by:

- Reducing the cooling load.
- Improving the system control.
- Optimising the cycles of concentration and minimising bleed or dump volumes.
- Preventing any loss from carryover, windage or splash out.
- Maintaining valves, sensors and all equipment to prevent leaks.
- Maintaining system performance to optimise efficiency.

Evaporative air cooling systems in non-residential applications can range considerably in size and complexity. There are many systems that are small in water use and some that are large in water use. Many existing systems have not been optimised for water efficiency and conservation.

6. How water is used in systems

The water balance of an evaporative air cooling system refers to all of the water inflows and outflows associated with the operation of the system. Water outflows from an evaporative air cooling system include controlled losses such as evaporation, bleed and dump and uncontrolled losses such as leaks, splash out, overflows, carryover and windage. All of these water outflows are replaced by make-up water from the system water supply.

6.1 Evaporation

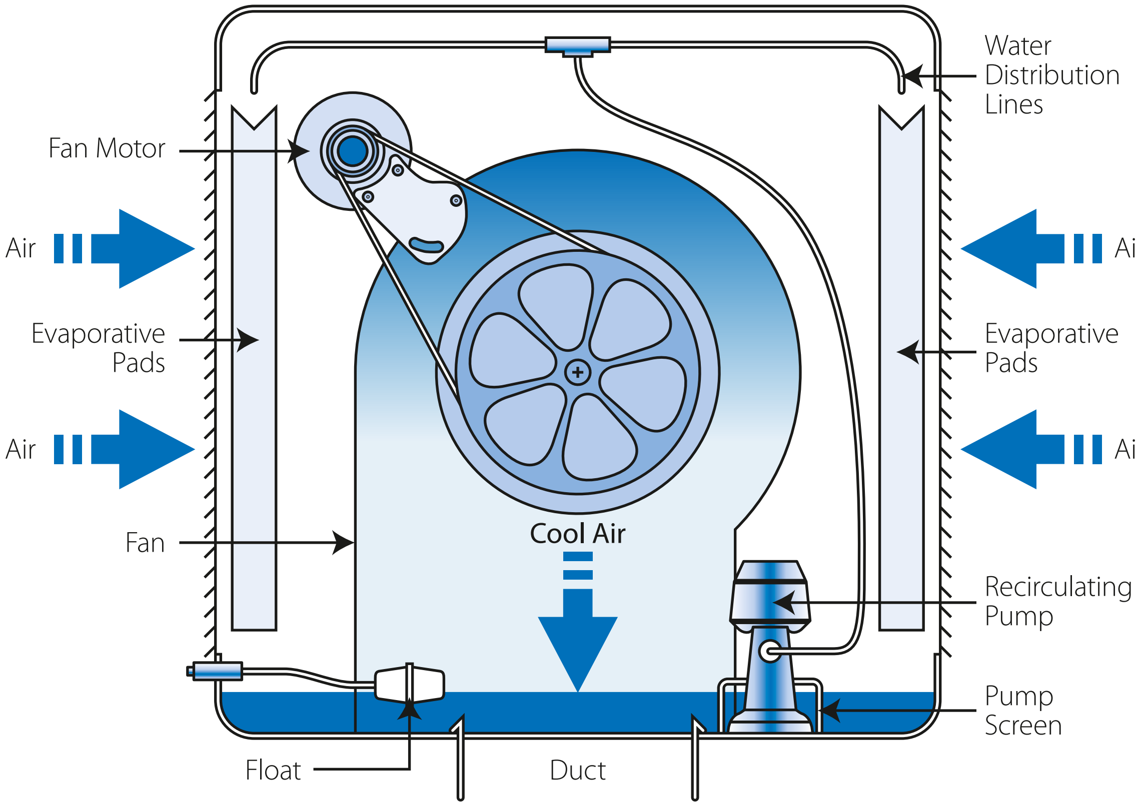
Evaporation is a necessary part of the system operation and can only be reduced by a reduction in the cooling load, or by improving the automatic control of the system so that the system only operates when cooling is required. A simple assessment of the system evaporation rate under defined operating conditions can be made by the operator or maintenance service provider (refer to AIRAH DA29).

6.2 Total Dissolved Solids (TDS)

As the evaporative air cooler evaporates water from the system any impurities or dissolved solids within the water get left behind while the evaporated water is replaced from the make-up supply. As the cycle of make-up and evaporation continues these impurities or total dissolved solids (TDS) become concentrated within the evaporative air cooler reservoir. When TDS levels become highly concentrated they can affect evaporative air cooler performance (pads and pumps) and component corrosion.

TDS cannot be measured directly but it does affect the conductivity of the water. The conductivity of the water is readily measured and is therefore used as a good indicator of water TDS levels. The rate of rise of TDS within the water is a function of the rate of evaporation and the quality of the make-up water.

Typical direct evaporative air cooler



The term cycles of concentration (C) or concentration ratio refers to the ratio of impurities or the total dissolved solids (TDS) in the reservoir water to the TDS in the make-up water.

C = TDS reservoir water / TDS make-up water

C = conductivity of reservoir water / conductivity of make-up water

\As water contaminants build up the concentration level of impurities, or total dissolved solids (TDS) in the system water, should be controlled by draining off a portion of the circulating water from the system and replacing it with clean make-up water. This drained water is called bleed or dump. The volume of bleed water is an operational issue. Modern evaporative air coolers made of corrosion resistant plastic materials, and using robust modern materials for evaporative media, fans and pumps can operate effectively at a higher TDS level than in the past.

6.3. Bleed

Bleed water is drained from a system so that clean make-up water can replace it and reduce the overall system TDS level by dilution. Bleed can be achieved in a system in a number of different ways and will vary depending on the brand and system design.

- **Automatic bleed** – These bleed systems respond to preset system key performance indicators (KPI) and bleed off water until the KPI has returned to the setpoint or allowed range. Automatic bleed is usually achieved by the application of a conductivity sensor (used to estimate TDS) whose signal will operate a solenoid valve or drain valve on the bleed system.
- **Continuous bleed** – This is a common form of bleed where water is continuously removed from the system and make-up water constantly supplied. Although inexpensive and easy to set this form of bleed as a water quality management system is very wasteful of water. Particularly in applications where drinking quality water is being supplied to the air cooler.
- **Periodic bleed** – These systems operate either on a time clock so that the bleed occurs at a particular time interval or on a flow meter so that bleed occurs after a preset volume of make-up water has flowed through the system. Again this form of bleed has been shown to be relatively wasteful of water.

A bleed valve, automatically controlled by a conductivity sensor, is the method of bleed control recommended in AIRAH DA29 to optimise system water use. Bleed is drained from the system and automatically replaced by make-up water, but only when it is required.

6.4. Dumping

Dumping refers to the draining of the water reservoir and entire water content of the evaporative air cooler.

Dumping water from an evaporative air cooler was primarily developed as a microbial control strategy. Water should never be allowed to stagnate in the reservoir of an evaporative air cooler. Temperature and the presence of nutrients and microorganisms can all combine to introduce microbial issues. Best practice microbial control suggests that an evaporative air cooler should dump all of its reservoir water at least once every 72 hours, and that this should be the overriding requirement in any dumping strategy. In practice, dumping once every 24 hours is the recommended minimum frequency.

Evaporative air coolers should always be stored drained and dried when not in operation for an extended period of time and during the off-season. This is particularly important for direct and two stage systems where the supply air and circulating water systems come into direct contact, but is also relevant for indirect systems.

Dumping cycles may also include a pad "drying" time. Some evaporative air coolers only dump a portion of their water reservoir.

Dumping can be achieved by the system in a number of different ways depending on the brand and system design.

- **Automatic dump** – Dumping systems can be conductivity controlled. Similar to automatic bleed, a conductivity sensor controls a dump valve which opens when a preset conductivity level (indicating TDS level) is reached. The dump system permits only sufficient water to be dumped to restore the conductivity to a safe operating level. This minimises water wastage and salt build-up on the pads.
- **Measured dump** – The reservoir will be dumped after a preset volume of make-up water has entered the evaporative air cooler. In evaporative air coolers without bleed, the make-up water volume directly relates to the volume of evaporated water (assuming no leaks and carryover) and should therefore directly relate to the level of TDS or quality of the reservoir water. This form of bleed has been shown to be wasteful of water.
- **Timed dump** – The reservoir will be dumped at a preset time interval after the cooler has been shut down. Again, this form of bleed has been shown to be wasteful of water.

Dump is sometimes used as a substitute for bleed, i.e. as the method applied to control the TDS level of water within the system reservoir.

6.5. Other water losses

Other system water losses can include carryover, splash out and windage. Carryover refers to small water droplets that leave the system entrained in the system supply air. Splash out refers to water leaving the system via the air intakes and other openings in the system casing. Windage refers to the effect of prevailing winds blowing water droplets out of an evaporative air cooling system air inlets. Windage should not be confused with carryover or splash out, both of which can occur without the presence of wind.

6.6. Leaks

Leaks, even small ones, can result in significant water wastage over time. This water loss is minimised by periodically reviewing the evaporative air cooling system and associated pipework for leaks. An overflow caused by a faulty make-up water float valve is a relatively common form of leak.

6.7. Make-up water

Make-up water has to be added to the system to replace all of the water lost from or consumed by the unit, including evaporated water and bleed or dump water. Ultimately, it is the volume of make-up water that is being reduced in any successful water conservation effort.

6.8. Cleaning water

Other system water losses include any water used for system or component cleaning during routine maintenance activities.

7. Water efficiency and conservation

Recommendations to improve the water efficiency of the evaporative air cooler, or to reduce system water consumption, are listed under the following headings:

- Address system water balance and consumption.
- Improve the system control.
- Improve the system operation.
- Ensure regular maintenance.
- Initiate system retrocommissioning.

Any Plumbing or electrical work must be carried out by appropriately qualified practitioners.

7.1. Address system water balance and consumption

To optimise the water efficiency of an evaporative air cooling system the entire water balance of the system should be addressed. Water outflows (losses) include evaporation, bleed, dump, carryover, splash-out, windage and system leaks. Some water outflows are controlled (evaporation and bleed or dump) and are essential to the correct operation of the system. These controlled outflows need to be optimised. Some water outflows are uncontrolled (overflows, carryover, splash out, windage and leaks). Uncontrolled water outflows need to be minimised or removed. See 8 for full details of optimising water use in systems.

7.2. Improve the system control

The operation characteristics or profile of evaporative air cooling systems needs to be optimised. Improving system operating efficiency is equivalent to reducing water consumption. The evaporative air cooling system design condition is generally specified for the highest (or near highest) outdoor air wet bulb temperature of the year. The rest of the time the system has the potential to be controlled to minimise water and energy use. The system should not run if cooling is not needed.

Many systems operate with a very low level of control with some systems only providing an on/off control function. The provision of automatic controls, to ensure the unit only operates when cooling is required, can significantly improve the water efficiency of the system. Automatic controls can be based on the internal temperature of the space or can be linked to the process being cooled.

Systems with automatic control will ensure that the system only operates when cooling is required. Systems with programmable controls help to ensure that systems do not operate out of hours or when the building is unoccupied. Systems may also incorporate ventilation only modes and unit dry out modes which can be incorporated into the control system.

7.3. Improve the system operation

Understanding how systems work and understanding how best to operate the system will help to optimise performance and water efficiency. System operators need to have a good understanding of operational issues including how to use the system, when to use the system, using ventilation only modes and the like. Operators should consult the system operating and maintenance manuals and their maintenance service provider for further information.

Regular monitoring of the normal water usage pattern of an evaporative air cooling system will identify any peaks or irregularities in water consumption. Water meters can be placed on the make-up water line and, where practical and economically feasible, the bleed water line to effectively understand the system water consumption pattern. Systems also need to be regularly maintained and their performance and condition monitored, see 10.

7.4. Ensure regular maintenance

The operating efficiency of an evaporative air cooler can decrease over time due to aging components, drift in tolerances, dirt build-up on pads reducing evaporation efficiency and out of balance fans reducing airflows. Regular maintenance will reduce these problems and help the evaporative air cooler maintain high efficiency and optimum performance.

Evaporative air cooling systems require regular maintenance and need to be periodically fine tuned to ensure that they continue to match operational loads and are providing optimal performance. Water and energy use should be continually reviewed to ensure that the benefits of any system improvements or refinements are achieved. A well managed system, whether it is in an industrial, agricultural or HVAC&R application, will generally reject more heat, use less power, consume less water, and produce less risk than a poorly managed system.

AIRAH Application Manual DA19 on HVAC&R Maintenance provides a series of schedules listing the maintenance tasks associated with evaporative air coolers. These maintenance schedules have been reproduced in Appendix A of this guide for information.

Operators should ensure that maintenance service providers are aware that water efficiency and conservation is a significant aim of the maintenance program. Maintenance providers can be incentivised for water conservation by setting system water use targets as part of a performance based maintenance contract.

7.5. Initiate system retrocommissioning

Initiating a retrocommissioning process for existing (older) systems provides an opportunity to improve their performance and sustainability and reduce their water consumption. Retrocommissioning evaporative air cooling systems covers all of the issues listed above, see 9.

8. Optimising water use

The water efficiency of a system needs to be optimised and the first step is to conduct a system water audit. The audit helps to identify areas of water use and areas of potential water savings. The next step is to implement the changes identified during the audit and the final step is to audit the new modified system/operation. Any Plumbing or electrical work must be carried out by appropriately qualified practitioners.

Water efficiency audits should be carried out periodically to ensure that the system continues to perform at the required level. Prior to auditing a system for the first time the following assessment areas should be given particular attention:

- The system used to control the evaporative air cooling system bleed or dump rate.
- The control system applied for capacity control of the evaporative air cooling system.

- The placement and operation of suitable water meters on the evaporative air cooling system make-up and bleed lines.
- The maximum cycles of concentration at which the system can operate efficiently.

The following headings outline the potential improvements that could be implemented to reduce water consumption and increase system water efficiency.

8.1. Evaporation

Evaporation is a major and legitimate water use of the system. Evaporating the water cools the air and without evaporation these cooling system would not work. Evaporation rates within a system can only be reduced by:

- Reducing the cooling load (refer to AIRAH DA29).
- Upgrading or redesigning the system to improve water efficiency (see 8.3).
- Optimising the system operation to improve water conservation (see 7).

Where the cooling load served by the system can be reduced the system will be required to operate less frequently and hence improve water efficiency. Methods to reduce the cooling load include:

- Addition of roof, ceiling and wall insulation.
- Addition of shading, internal and external.
- Improvements to the building such as new glazing.
- Colour of structure and surrounds.
- Alteration to processes being served.
- Increased use of natural ventilation or passive cooling.

Where cooling loads can be significantly reduced, there is an opportunity to reduce the size of the evaporative air cooler which would further reduce system water consumption.

8.2. Bleed

Bleed volumes can be reduced by:

- Optimising the cycles of concentration (see 6.3).
- Introducing conductivity control of the bleed system (see 6.2).
- Maintaining and protecting the bleed valve.
- Regularly maintaining and calibrating the conductivity sensor.

Some evaporative air cooler bleed control systems are continuous, are based on timers or water meters, or are manually operated. These systems benefit greatly from being upgraded to an automatic conductivity controlled bleed system to improve water quality control and reduce water consumption.

In automatic bleed systems a conductivity meter or probe is used to control bleed volume in response to a predetermined setting. The setting of the conductivity meter will depend on the cycles of concentration being applied to the system and the TDS limits for the equipment set by the manufacturer.

Manufacturers will generally nominate a maximum operating TDS level or an operating range for their equipment. This value is used to determine a system conductivity setpoint. As the conductivity sensor registers levels approaching the setpoint the bleed (or dump valve) is opened to drain off some reservoir water which is then automatically replaced by clean water from the make-up system. This clean make-up water dilutes the TDS level within the reservoir which reduces the conductivity allowing the bleed or dump valve to close until TDS level reaches the setpoint again.

Regularly cleaning and calibrating the conductivity sensor will assist with accurate bleed control. Dirty sensors, or sensors that are out of calibration may lead to faulty readings, excessive bleed and hence excessive water use.

8.3. Dump

Dump volumes can be reduced by:

- Optimising the cycles of concentration (see 6.3).
- Introducing conductivity control of the dump system (see 6.4).
- Regularly maintaining and calibrating the conductivity sensor.
- Maintaining and protecting the dump valve.

Some evaporative air cooler dump control systems are continuous, are based on timers or water meters, or are manually operated to also control the TDS level within the water reservoir. These systems benefit greatly from being upgraded to an automatic conductivity controlled dump system to improve water quality control and reduce water consumption.

In automatic dump systems, a conductivity meter or probe is used to control the dump cycle in response to a predetermined setting. The setting of the conductivity meter will depend on the cycles of concentration being applied to the system and the TDS limits for the equipment set by the manufacturer.

8.4. Carryover

Droplets of water should never be entrained in the air stream as only water vapour contributes to the evaporative air cooling effect. Carryover is controlled largely by the systems' design and operation and is not normally an operational issue in a correctly designed and operated system, refer DA29.

Carryover should never occur within a system and can be eliminated by:

- Checking that the air flow rates are within acceptable manufacturer limits.
- Checking that the water pressure and flow rate is not too high.
- Checking that eliminators (where fitted) are of correct design, are installed correctly and are not damaged, fouled or blocked.
- Providing appropriate fan speed control.
- Protecting the evaporative air cooler from excessive ambient winds.

Check that prevailing winds and unit orientation cannot act to increase the carryover characteristics of the system. Units can be protected by screens. Any screening should not adversely affect the system air intake or airflow. Screens can be used to direct airflows to the system air intake.

8.5. Splash out

Splash out is rare in systems that use pads as the evaporative media but can occur in units that use sprays and nozzles. It is more likely to occur when the fans have cycled off (or to a low speed) for control purposes. Splash out can be reduced by:

- Installing anti splash louvres on the system air intakes.
- Checking that anti splash louvres are installed correctly and are not damaged
- Ensuring the water supply pressure is not too high or outside of the manufacturer's limits.
- Ensuring that the fan speed and airflow rates are not too high or outside of the limits.

8.6. Windage

Windage can be reduced by protecting the system from excessive ambient wind. Care should be taken that any screening does not adversely affect the system air intake or discharge airflows.

8.7. Leaks

The best way to check for water leaks is a visual survey of the plant. Water leaks may be intermittent and physical evidence of previous leaks (stains etc.) should be investigated. Water meters and system consumption levels should be checked and recorded to detect changes in usage patterns. A sharp increase in water use could indicate a leak in the system. For large or multi-unit systems, the use of water sub meters in this application is particularly useful. The presence of less obvious water leaks will be confirmed if the meter continues to tick over when all water using devices are turned off on a particular circuit. Any leaks discovered should be repaired by a licensed practitioner.

8.8. Make-up water

The quality of the make-up water being used in the evaporative air cooling system needs to be established.

Where the quality of supplied make-up water varies over time (there are often seasonal variations) it may need to be monitored so that appropriate changes to system management can be applied. Where make-up water quality is known to be variable or subject to temporary spikes in contaminant levels, alternative water sources and an automatic switch over to the alternative supply system could be considered.

Make-up water of poor or inadequate quality can be treated prior to being added to the evaporative air cooling system. Pre-treatment can include filtration and water chemistry manipulation. Alternatively, a portion of the make-up water can be pre-conditioned and then blended with the rest of the untreated make-up water prior to entering the cooling water system. Improving make-up water quality can assist in increasing the system cycles of concentration number. This reduces bleed volumes which ultimately reduces the make-up water quantity required by the system.

Utilising alternative water sources can significantly reduce the drinking water consumption of the system. Bleed water and any water used for system cleaning and maintenance can be captured and reused or recycled to improve the overall water consumption of the facility. See Appendix B.

8.9. Cleaning water

The volume of cleaning water used in maintenance can be reduced by increasing the cleanability of the system (improve access/upgrade components) or using recycled or reused water for cleaning purposes.

Specific system management activities that consume water such as cleaning protocols or periodic drain downs should be recorded and the consumption event noted. System operators need to be aware of how much water is being used by cleaning and maintenance practices.

8.10. Water pressure

Excessive pipe pressures can cause increased carryover loss, incorrect operation of nozzles and possible overflowing of the water reservoir. Excessive flows reduce performance, can damage components and are usually evidenced by excessive splash out.

Under pressure can also affect system effectiveness. Air will naturally take the "dry" path (i.e. the path of least resistance) through the system, with poor water distribution further derating performance. Uniform air/water distribution over and through the pads is essential for correct system performance.

Excessive pressure from a water supply system can be corrected by the application of pressure reducing devices at the system inlet.

9. Retrocommissioning

9.1. Why retrocommission?

The results of a study initiated by the Department of Sustainability and Environment, and managed by AIRAH, into the water use of evaporative air cooling systems in non-residential applications has shown that the biggest issue with regard to excessive water use is the constant bleed system applied in many evaporative air coolers. Continuous bleed is a system whereby a small amount of water is continuously removed from the system and replaced by clean makeup water. This process is intended to dilute the circulating water and reduce the TDS level. The problem is that continuous bleed dilutes the water whether the dilution is required or not. The continuous bleed rate is adjustable and often factory preset to a default rate which is often relatively conservative.

Investigation has shown that evaporative air cooler bleed rates are often excessive in practice, particularly in applications where units are supplied with drinking quality water from a distributed water supply. Periodic dumping is another method used to control water quality. Again investigation has shown that in many systems dumping is too frequent leading to elevated and unnecessary water consumption. The study concluded that if all non-residential evaporative air coolers were operated at best practice for water efficiency, a staggering 1800 ML of water could be saver per year.

Existing systems that incorporate a continuous bleed or periodic dumping can only be made more water efficient by undertaking a retrocommissioning process.

Retrocommissioning provides an opportunity to improve the performance and sustainability of existing evaporative air cooling systems. Any improvement in operating performance will reduce system water consumption. Retrocommissioning is all about reviewing the existing system, in particular the water quality management system (bleed/dump) employed, and identifying practical improvements that can be made to improve system performance. Retrocommissioning can be carried out by licensed plumbers, maintenance service providers or water treatment service providers. Any plumbing or electrical work must be carried out by appropriately qualified practitioners.

The retrocommissioning process for a system includes investigating whether the evaporative air cooler is suitable for conversion from a continuous bleed to an automatic bleed or dump system. Conversion is by the installation of additional sensors and controls on the system or by adjusting the systems existing sensors and controls.

Existing systems and components may have been in place for some time and it may be possible to either upgrade system performance with simple repairs and component upgrades or to replace the system with the latest technology.

The retrocommissioning process offers the following potential benefits:

- Reduce system water consumption.
- Optimise the evaporative air cooling system water consumption, most cooling for least water use.
- Review and reduce the load on the system.
- Improve the control of the system.
- Reduce system energy consumption.
- Perform maintenance for performance and efficiency.
- Perform maintenance of water management system.
- Improve owner or operator understanding of system operation and maintenance.

9.2. The retrocommissioning process

The retrocommissioning process consists of the following 10 steps:

1. System survey.
2. System evaluation.
3. System inspection and maintenance.
4. Identification of upgrades.
5. Evaluation of upgrades, including an evaluation report.
6. Selection of upgrades.
7. Implementation of selected upgrades.
8. Commissioning of modified system.
9. Handover.
10. Recheck (seasonal or 6 months).

As part of the retrocommissioning process an evaluation report is presented to the owner outlining the potential system improvements and their associated costs and listing specific recommendations for the system under consideration. Implementation is up to the owner who should consider the evaluation report and nominate the improvements or upgrades that should be implemented.

9.3. Upgrades and improvements

Energy efficient alternatives can be adopted and improved control or operating regimes applied. Similarly, water efficient alternatives or design strategies can be adopted to improve overall system sustainability outcomes.

Common improvements identified by the retrocommissioning process include:

- **Access platforms** – Can be added to facilitate maintenance and improve safety.
- **Bleed/Dump system** – Can be automated by the addition of a conductivity sensor and valve actuator.

- **Controls** – Adding thermostatic or programmable controls to an uncontrolled unit will ensure that the system only operates when cooling is required. Controls can be retrofitted onto existing systems including the fitting of required sensors and controllers.
- **Air intakes** – Modern air intake louvres can exclude direct sunlight, reduce splash out and windage to zero while still showing less air resistance to the evaporative air cooling system fan.
- **Air filters** – Can be fitted onto or integrated with air intake louvres to reduce incoming airborne contaminants.
- **Pads** – New designs can promote better water coverage and better air/water contact improving evaporation efficiency. Pad designs and materials more suitable for contaminated water are also available.
- **Fans and pumps** – Modern fans and pumps operate more efficiently and can be manufactured from more corrosion resistant materials.
- **Fan and pump drives** – Variable speed drives are now available in a wider range and at less cost than may have previously been the case.
- **Ductwork** – Ducts can be sealed to prevent leakage, their insulation can be increased and shut-off dampers can be installed to seal the system when it is not in use.
- **Wind screens and baffles** – Can be applied to minimise system derating due to ambient wind effects and to minimise or reduce uncontrolled water losses due to windage.
- **Installation of ember protection screens** – In locations that may be subject to a potential bush fire hazard it is recommended that ember protection screens are installed on the unit, to protect from burning embers entering the cooler, and possibly causing a fire.

System improvements should be carried out in accordance with the advice and recommendations of the original equipment manufacturer. Retrocommissioning procedures should ensure that any new plant or operating protocols do not adversely affect the performance of existing systems. Recommissioning of other existing systems may be required to ensure proper integration of the upgraded plant.

10. Managing system operation

10.1. Metering

In order to effectively manage the operation and performance of an evaporative air cooling system, the inputs to the system and the outputs from the system need to be known and quantified. The best way to capture this information is by the installation of meters.

Owners and operators should ensure the provision of ample meters, and other instruments, of correct range and accuracy, to allow system performance monitoring. Operators should know how meters can be used to monitor water and energy consumption and system performance.

Monitoring provides system performance data which can be compared against historic or benchmark data. Monitoring can provide valuable information on patterns of consumption and plant loading.

The following items should be measured and monitored for an evaporative air cooling system:

- Make-up water flow rates and quantities.
- Bleed or dump water flow rate and quantities.
- Unit (fan and pump) power and energy consumption.
- System water conductivity (indicates TDS).

In larger systems, the bleed take-off point should be metered, if practical and economically feasible. A significant factor determining the water efficiency of a cooling water system is the cycles of concentration at which the system is operated. Raising cycles of concentration can significantly reduce bleed and hence overall water use. While cycles of concentration can be calculated (estimated), the direct reading of make-up and bleed water meters will provide a far more accurate assessment as it is based on measurements, not estimates.

Bleed water tends to be the most contaminated water in the system and suspended solids within the water can cause operational difficulties for some meters. It is good practice to protect the meter with a strainer or filter installed upstream of the solenoid valve on the bleed line.

10.2. Monitoring

In order for a meter to be useful in system management, it should be monitored. The data should be logged at regular intervals and periodically assessed by a competent person. Operators and maintainers should learn or be instructed on how to use meters and monitors, log and record system data, and assess the performance of the evaporative air cooling system.

For larger systems, conductivity and flow meters should be read regularly to quickly identify operational problems. A log of make-up, bleed, conductivity, and energy consumption should be maintained and trends monitored to identify deteriorations in performance.

Ideally, meters, sensors and controls should, where applicable, interface with any Building Management and Control System (BMCS) to facilitate continuous monitoring and control. Automatic data logging systems can be retrofitted to system meters and sensors to provide integration with the BMCS.

10.3. Maintenance

Routine or scheduled maintenance minimises operational risks and provides assurance that system performance is optimised. Well maintained optimised systems use less water and energy and provide better control. Maintenance of evaporative air cooling systems should be in accordance with the recommendations of AIRAH DA19 HVAC&R maintenance, see Appendix A.

10.4. Recommissioning and system tuning

Evaporative air cooling systems should be periodically recommissioned to provide assurance that they are operating as intended. In particular, system set points and control settings may need to be reset following any unauthorised changes. Depending on the precise requirements of the building operation or process the initial commissioning and system settings may need to be readdressed if the current operational requirements differ significantly from the original design requirements.

Systems that are characterised by poor performance should be totally retrocommissioned, see 9. Plant sizes should be checked and plant performance should be tested. System control protocols and control equipment deserve particular attention. Even systems that are performing well should be periodically tuned, including a review of system control settings and loads.

11. Further information

Further information on evaporative cooling systems and cooling water system design is provided in the following documents:

- **AIRAH**

  DA19 HVAC&R Maintenance

  DA 29 Evaporative air cooling systems

- **DHS (Victoria)**

  Evaporative coolers – An operation and maintenance guide for owners (2001)

- **Standards Australia**

  AS 2913 Evaporative air conditioning systems

  AS/NZS 3666.1 Air-handling and water systems of buildings – Microbial control – Part 1: Design, installation and commissioning

  AS/NZS 3666.2 Air-handling and water systems of buildings – Microbial control – Part 2: Operation and maintenance

Notes:

Appendix A

Evaporative air cooler maintenance schedule

Evaporative air coolers should be maintained in accordance with AS/NZS 3666.2.

Action	Interval (Months)	Explanation
1. Check and adjust bleed rate.	3	The appropriate bleed rate will depend on the water quality being supplied to the unit. It may be necessary to increase the bleed rate if it is found that there is an excessive build up of salts or suspended matter. It may be necessary to reduce the bleed rate or convert to an automatic conductivity controlled system if bleed rates are excessive (See retrocommissioning)
2. Check operation of float valve and dump valve.	3	This should be done by manually operating each valve and observing the water level and bleed rate.
3. Check that pads are uniformly wet, adjust if necessary.	3	Uneven water distribution over the pads will significantly reduce the efficiency and capacity of the unit.
4. Inspect pads for cleanliness, remove and hose down as necessary. Record and report if pads need replacing.	3	In particularly dusty areas this inspection may be necessary on a weekly basis. The client or service technician should be aware of the local requirements.
5. Remove inspection panel, check belts.	3	This requires a visual inspection of the belts and a physical check to ensure that the belt tension is correct and belts are sound.
6. Switch on, check pump operation.	3	A visual inspection of the water flow in the distribution tray is usually sufficient.
7. Report if air filter (where fitted) requires replacing.	3	
8. Flush drainage system with clean fresh water.	3	
9. Drain and clean sump.	3	Draining and cleaning sumps is an effective method of reducing microbial population multiplication.
10. Inspect water strainer and clean where necessary.	3	

Pre Season

Action	Interval (Months)	Explanation
1. Adjust for even water distribution over filter pads.	12	Uneven water distribution over the pads will significantly reduce the efficiency and capacity of the unit.
2. Check water bleed rate complies with manufacturer recommendations.	12	This may need to be adjusted to a different rate from the above recommendations. It may be necessary to increase the bleed rate if it is found that there is an excessive build up of salts.
3. Inspect filter pads and record/ report if new pads are required.	12	Pads should be inspected regularly: AS/NZS 3666.2 requires inspection every three months, and replacement as necessary.
4. Reinstall drain plug in reservoir, fill reservoir and check ball valve setting, clean line strainer.	12	It is often wise to disinfect the cooler before placing back in service. With the fan isolated and the pump operating add a small quantity of household bleach and allow water to circulate for about 30 minutes. Run water to waste and flush with fresh water for 5 minutes, repeat this fresh water flush and then refill the unit and place in service.

End of Season

Action	Interval (Months)	Explanation
1. Apply grease film to blower shaft and bearings.	12	
2. Check belts for wear and adjust.	12	
3. Check pulley alignment.	12	
4. Clean water distribution channels.	12	
5. Empty and clean water reservoir, leave drain plug out.	12	
6. Examine for corrosion, repair as necessary and report if painting is required.	12	Paint should be selected as appropriate for the location of the cooler and the conditions of operation.
7. Lightly lubricate motor bearings to the manufacturers' recommendation where possible.	12	
8. Remove, hose down and reinstall filter panels.	12	
9. Switch off pump, inside unit, if switch is fitted.	12	
10. Turn off water supply.	12	In areas subject to frost, isolate the water supply and drain pipework to avoid burst pipes due to freezing.

Appendix B

Alternative water sources and uses

B1 Water sources

Drinking water has traditionally been the most common water source used in evaporative air cooling systems. Water is supplied to the site from the local water authority reticulation system and is used directly in the system. This water is fit to drink and water quality is generally high and causes few operational problems. However water usage rates for evaporative air cooling system s can be high and water authorities are now encouraging system owners, designers and operators to investigate alternative sources for system water.

There are several options available to the operator depending on the application and location of the system. Alternative water sources for evaporative air cooling systems include:

- Rainwater and stormwater,
- Condensate from air conditioning or refrigeration systems,
- River, lake or seawater,
- Bore water or groundwater,
- Recycled or reused water.

Recycled water should never be used for direct evaporative systems.

The essential aspects of any water source selected are the water quality, the availability and its cost.

Any water reuse, rainwater, stormwater, surface water or bore water applications need to be discussed with the government authorities with jurisdiction (health, water and environmental) so that the appropriate licences and approvals are obtained to ensure that there are no public health, OH&S or environmental risks. Operators should ensure that the appropriate licences and the like have been obtained for their particular application and circumstances.

Computer software can be used to model the operational impact of using alternate water sources and mixtures as make-up water based on the chemical analysis of the proposed water sources. This process is valuable in determining the feasibility of alternative make-up water sources for the evaporative air cooling system.

In many cases alternative water sources are backed up by traditional sources to provide for continuity of operation. Multiple sources provide some operational security and can improve system reliability and availability factors.

Pipes and tanks containing alternative non-drinking water sources should be clearly labelled and identified to avoid potential cross connections with drinking water or unintentional use as drinking water. Back-flow prevention devices should also be fitted to prevent any contamination of drinking water with non-drinking water.

B2 Water quality

An important aspect to consider when assessing the viability of alternative water sources for evaporative air cooling systems is the consistency of the water quality and the potential for variations or departures from the expected quality. The quality of the water available for use may have an impact on the evaporative air cooling system materials or operation. Evaporative air cooling system manufacturers will have a standard specification defining the water quality application limits for their equipment. This will depend on the system materials and design and will vary between different manufacturers and system types.

The quality of recycled or reclaimed water may vary depending on variations in the alternative water source. Cooling water systems are very susceptible to reductions in water quality or contamination and even a short-term reduction or variation can cause significant and on-going problems in the system. For example a short-term increase of oil or hydrocarbons in the make-up water may provide an ongoing supply of nutrients within the system. Some contaminants may be very difficult and expensive to remove from the system.

Any alternative water source needs to be discussed with the installer, manufacturer or water treatment service provider as different make-up water chemistries may have implications for the equipment being utilised.

B3 Onsite reuse of water

Even when cycles of concentrations have been maximised and bleed minimised the volumes of water drained from an evaporative air cooling system can still be relatively high, particularly on sites with multiple units. Consideration should be given to the re-use of this water elsewhere on site.

Water drained from units due to bleed or dump has been successfully reused in toilet flushing, landscape irrigation and maintenance cleaning applications. Bleed or dump water can be stored and then reused when required. This water may have high salt concentrations and may contain treatment chemicals so care should be taken that any reuse application is suitable.

Because evaporative air coolers tend to wash the air of dirt and dust, the drain water can contain nutrients and microbes as well as elevated salt levels. Storage of this water can encounter microbial growth problems and instantaneous use (without storage) is recommended, unless the water is treated.

Notes: