# Technical information for the Victorian guideline for water recycling

Publication 1911.2 March 2021

EPA acknowledges Aboriginal people as the first peoples and Traditional custodians of the land and water on which we live, work and depend. We pay respect to Aboriginal Elders, past and present.

As Victoria's environmental regulator, we pay respect to how Country has been protected and cared for by Aboriginal people over many tens of thousands of years.

We acknowledge the unique spiritual and cultural significance of land, water and all that is in the environment to Traditional Owners, and recognise their continuing connection to, and aspirations for Country.

**Disclaimer**

The information in this publication is for general guidance only. It does not constitute legal or other professional advice and should not be relied on as a statement of the law. Because it is intended only as a general guide, it may contain generalisations.

You should obtain professional advice if you have any specific concern. EPA has made every reasonable effort to provide current and accurate information, but does not make any guarantees regarding the accuracy, currency or completeness of the information.



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# Acronyms and abbreviations

| ACRONYM/ABBREVIATION | FULL TITLE |
|---|---|
| **AQI** | Air quality index |
| **ABN** | Australian business number |
| **ABS** | Australian Bureau of Statistics |
| **ADI** | Acceptable daily intake |
| **ADWG** | *Australian Drinking Water Guidelines* |
| **AGWR** | Australian Guidelines for Water Recycling |
| **AICS** | Australian Inventory of Chemical Substances |
| **ANZECC** | Australian and New Zealand Environment and Conservation Council |
| **ANZFA** | Australian and New Zealand Food Authority |
| **ANZG** | *Australian and New Zealand Guidelines [for Fresh and Marine Water Quality. (2018)]* |
| **ARMCANZ** | Agriculture and Resource Management Council of Australia and New Zealand |
| **BGA** | Blue-green algae |
| **BOD** | Biochemical oxygen demand |
| **CAS** | Chemical Abstracts Service |
| **CCP** | Critical control point |
| **CEC** | Cation exchange capacity |
| **CF** | Crop factor |
| **CFU** | Colony forming unit |
| **CVO** | Chief Veterinary Officer |
| **DALY** | Disability adjusted life years. One DALY is equivalent to one lost year of healthy life. |
| **DELWP** | Department of Environment, Water, Land and Planning |
| **DFSV** | Dairy Food Safety Victoria |
| **DHHS** | Department of Health and Human Services |
| **DoH** | Department of Health (see also DHHS) |
| **DPI** | Department of Primary Industry |
| **EC** | Electrical conductivity |
| **ECP** | Environmental control point |
| **EMP** | Environmental management plan |
| **EPA** | Environment Protection Authority |
| **EPI** | Estimation programs interface |
| **ERF** | Rainfall efficiency factor |

| ACRONYM/ABBREVIATION | FULL TITLE |
|---|---|
| **ESC** | Essential Service Commission |
| **ESP** | Exchangeable sodium percentage |
| **GED** | General environmental duty |
| **GEM** | Guideline for environmental management |
| **GL** | Guideline |
| **GMP** | Good manufacturing practices |
| **GST** | Goods and services tax |
| **HACCP** | Hazard analysis and critical control point |
| **HBT** | Health-based targets |
| **HDPE** | High density polyethylene |
| **HEMP** | Health and environment management plan |
| **HH** | Human health |
| **HMP** | Human health management plan |
| **HQ** | Hazard quotient |
| **IDEA** | Intermittently decanted extended aeration |
| **IEF** | Irrigation efficiency factor |
| **IR** | Irrigation requirement |
| **LCA** | Land capability assessment |
| **LF** | Leaching fraction |
| **LR** | Leaching requirement |
| **LRV** | Log reduction values |
| **MID** | Minimum infective doses |
| **MPN** | Most probable number |
| **NATA** | National Association of Testing Authorities |
| **NLDR** | Nutrient load to demand ratio |
| **NTU** | Nephelometric turbidity units |
| **PBT** | Persistent bio accumulative and toxic |
| **PC** | Protective concentrations |
| **PE** | Pan evaporation |
| **PFU** | Plaque forming unit |
| **PIC** | Plumbing Industry Commission |
| **PIW** | Prescribed industrial waste |
| **QA** | Quality assurance |

| ACRONYM/ABBREVIATION | FULL TITLE |
|---|---|
| **QMRA** | Quantitative microbial risk assessment |
| **RF** | Rainfall |
| **RWQMP** | Recycled water quality management plan |
| **SAR** | Sodium adsorption ratio |
| **SEPP** | State environment protection policy |
| **SOP** | Standard operating procedures |
| **STP** | Sewage treatment plant |
| **TDS** | Total dissolved solids |
| **TOC** | Table of contents |
| **TPU** | Treatment process units |
| **UV** | Ultraviolet |
| **UVT** | UV transmissivity |
| **VBA** | Victorian Building Authority |
| **WHO** | World Health Organization |
| **WSAA** | Water Services Association of Australia |
| **WSUD** | Water sensitive urban design |
| **YVW** | Yarra Valley Water |
| | |

# Glossary of terms

| TERM | DESCRIPTION |
|---|---|
| **Beneficial use** | The use of the environment or any element or segment of the environment prescribed in Schedule 2 of SEPP Waters (Government of Victoria, 2018a) to be a beneficial use to be protected in accordance with SEPP Waters. |
| **Class of recycled water** | Recycled water classes (A, B and C) that include health-related microbiological and process performance requirements but not environmental quality parameters such as salinity or nutrient limits. |
| **Cross-connection** | A physical connection between the recycled water and drinking water supply systems. |
| **Drinking water** | Water suitable for human consumption and other household uses as defined in the *Australian Drinking Water Guidelines*. Also known as potable water. |
| **Dual pipe scheme** | An urban water recycling scheme where recycled water is provided to householders for certain uses via a reticulation system that is separate from the drinking water supply. Sometimes referred to as a third pipe scheme. |
| ***E. coli*** | *Escherichia coli*. A bacterium found in the gut of warm-blooded animals that is used as an indicator of faecal contamination. |
| **Hazard analysis and critical control point (HACCP)** | An industry-recognised preventive risk management system that identifies, evaluates and controls hazards associated with the production of safe food or water. |
| **Hazard** | A biological, chemical, physical or radiological agent that has the potential to cause harm. |
| **Hazardous event** | An incident or situation that can lead to the presence of a hazard. |
| **Health and environmental management plan (HEMP)** | A plan covering the use of recycled water that details the management of health and environmental risks. |
| **Industrial wastewater** | Industrial wastewater produced from processes at industrial or commercial premises, including all waterborne waste from these facilities except sewage and prescribed industrial waste. |
| **Log reduction value** | Removal/inactivation for a target organism. The reduction in pathogen concentrations across a process or step measured in logs to the base 10 (log10). Calculated as log10 [feed water concentration] minus log10 [product water concentration]. |
| **Manager (scheme manager)** | The body (or bodies) identified as being responsible for the management of recycled water and for engagement with recycled water users. The responsibilities are defined within the HEMP. This is the same as the supplier in most cases. |
| **Pathogen** | Organism capable of causing disease. In untreated wastewater, the key pathogen groups are bacteria, viruses, protozoa and helminths. |
| **Preventive risk management** | A philosophy that focuses on the systematic evaluation of processes to identify hazards, assess risks and implement preventive strategies to manage risks. |
| **Proponent (scheme proponent)** | The body (or bodies) facilitating the development of a recycled water scheme, but which may not have responsibility for managing the scheme once recycled water is supplied. This may be a developer for instance. |
| **Quantitative microbial risk assessment (QMRA)** | A tool that uses quantitative data to mathematically assess the health risk from exposure to pathogens. |

| TERM | DESCRIPTION |
|---|---|
| **Recycled water** | The scope and use of the term recycled water in this guideline includes water that has been derived from sewerage systems or industry processes and treated to a standard that is appropriate for its intended use. More broadly than within this guideline, the term also refers to water derived from stormwater or greywater. |
| **Recycled water system** | The infrastructure that supplies and conveys recycled water from its source to its point of use and which may include a water recycling plant and other infrastructure. |
| **Recycled water quality management plan (RWQMP)** | A section of the HEMP that covers the production of Class A recycled water at a treatment plant. |
| **Risk** | The likelihood of identified hazards causing harm in exposed populations (over a specified time frame) and including the severity of consequences. |
| **Risk assessment** | The overall process of using available information to predict how often hazards or specified events may occur (likelihood) and the magnitude of their consequences. |
| **Salinity** | The content of salt in soil or water. Generally expressed in units of electrical conductivity (EC), although total dissolved solids (TDS) is also used to indicate salinity. |
| **Scheme** | A recycled water scheme can be discrete or can be interconnected and can consist of treatment plants, distribution systems, reticulation networks and users. |
| **Sewage** | Water that has been used by households, commercial premises or industry and discharged to the sewerage system for treatment at a sewage treatment plant (STP). |
| **Sewage treatment plant** | A treatment plant that treats sewage. |
| **Sodicity** | A chemical imbalance that occurs in soil when an excess of sodium (a monovalent ion) is present in the soil relative to divalent ions such as calcium and magnesium which results in clay particles being held together more loosely, and if this occurs when there is a low ionic concentration in the soil water, dispersion of the clay particles occurs. |
| **Supplier (of recycled water)** | The body responsible for the supplying recycled water. This body may be responsible for producing a Recycled Water Quality Management Plan (RWQMP) if not produced by the scheme proponent or scheme manager. Often the scheme manager is the supplier. The supplier treats wastewater and provides recycled water for someone else to use (user) or use themselves. This is often a water corporation that might supply to a third party (market gardeners, residential premises) or using recycled water themselves. The supplier is the proponent when seeking approval. |
| **User (of recycled water)** | The body responsible for using recycled water. This body may be responsible for producing a user site management plan (SMP) if not produced by the proponent, manager or supplier. The user receives recycled water from the supplier and uses it. This may include residential premises, market gardeners and councils (parks and gardens). |
| **Water sensitive urban design (WSUD)** | The integration of water cycle management into urban planning and design. Key principles are: protect natural systems; integrate stormwater treatment into the landscape; protect water quality; reduce run-off and peak flows; and add value while minimising development costs. |
| **Water recycling plant** | A treatment plant that treats sewage from domestic and industrial sewer |

| TERM | DESCRIPTION |
|---|---|
| | catchments and treats it for recycling; or treats industrial wastewater and treats it for recycling. |

# 1 About this publication

This publication should be read in conjunction with *Victorian Guideline for Water Recycling* (publication number 1910).

The publication *Technical information for Victorian Guideline for Water Recycling* (publication 1911) provides information to assist recycled water scheme managers and users implement aspects of these guidelines, such as:

- information on how to complete health and environment management plans (HEMPs)
- guidance on how to classify risk
- suggestions on how to approach community consultation
- information on preparation of user site management plans
- useful checklists for things such as preparation of the RWQMP and special considerations for plumbing.
- description of Class A reuse scheme endorsement process
- information on how to prepare human health and environmental risk assessments.

The information in this publication suggests some best-practice technical approaches and methods that can be used to comply with EPA Publication 1910 *Victorian Guideline for Water Recycling*. The information in this technical publication should therefore be used as a resource, rather than a set of regulatory requirements. Recycled water scheme managers and users can use the information in this publication if and when they need it and are free to explore or use other best practice management options, as required by each individual scheme.

EPA will update the technical information in this publication over time. Additional resources will be added to the supporting documentation package over time, beginning with a detailed guide for class B and C scheme HEMPs, Irrigation guidelines and the audit scope/guide.

# 2 Assessment of the recycled water system

Recycled water systems must be assessed before strategies to prevent and control hazards are planned and implemented. The aim of an assessment is to provide a detailed understanding of:

- entire recycled water supply system, from source to end use or receiving environment
- hazards, sources and events (including treatment failure) that can compromise recycled water quality
- preventive measures needed to effectively control hazards and prevent adverse impacts on humans and the environment.

## 2.1 Factors to consider in risk assessment

This section provides information recycled water scheme managers should consider when undertaking an assessment. Detailed information on identifying hazards and conducting risk assessments is provided in Section 4.

### 2.1.1 Sewage

Sewage from domestic and industrial catchments can be accessed for reuse from a sewage treatment plant, or by extracting it at a specific location within the sewer catchment (sewer mining). For the purpose of this publication, any untreated wastewater source containing human faecal material is referred to as sewage. Additional risk assessment may be required when there are certain industries or activities in the sewer catchment such as highly toxic waste generating industries or illegal sewer connections.

### 2.1.2 Industrial water

Industrial water is wastewater produced from processes at industrial or commercial premises. It includes all waterborne waste from these facilities except sewage. The quality and quantity of industrial water produced is highly variable depending upon a range of factors, including:

- the raw process material
- the industrial process that generates wastewater, such as raw material washing, finished goods wash water, process filtrates, centrifugations and pressings, and boiler and cooling tower blow down
- the number of times the water has been recycled – potentially increasing or decreasing the concentration or levels of contaminants
- the characteristics of the products and surfaces the water contacts
- chemicals added in the industrial process
- reactions that occur during the industrial process

- additives such as biocides, anti-scalants and pH adjusters
- the temperature of the water.

Trade waste accepted within a sewerage system is considered part of sewage (see Section 2.1.1. Under the Environment Protection (Industrial Waste Resource) Regulations 2009, all liquid industrial waste (including industrial wastewater) not used in accordance with these guidelines, or discharged to sewer under a trade waste agreement, is a category A prescribed industrial waste (PIW) and should be managed as per *Managing prescribed industrial waste: Industrial Waste Management Policy (Prescribed Industrial Waste) and policy impact assessment* (publication 734*)*

### 2.1.3 Intended use for recycled water

With appropriate management, treated sewage or industrial wastewater can be used for a wide range of residential, commercial, industrial, agricultural and amenity purposes.

Industrial uses include:

- material washing (for example coal and sand)
- dust suppression
- process rinse water
- crate and pallet washing
- hardstand and vehicle washing
- fire protection
- cooling
- in production line
- boiler or cooling tower feed water supplement.

Agricultural and horticultural uses include:

- livestock fodder and drinking (excluding pigs)
- crop irrigation (surface and subsurface)
- landscape irrigation (surface and subsurface), including irrigation of municipal parks and gardens, sports grounds and urban cooling.

Commercial uses include:

- construction (for example road compaction)
- dust suppression
- fire protection
- commercial car washing facilities or depots
- commercial laundries or washing machines at non-residential facilities
- toilet flushing at non-residential facilities
- heating/cooling (air-conditioning) systems.

Residential uses include:

- washing machines
- car washing
- external cleaning
- toilet flushing
- garden watering.

Drought relief uses include:

- livestock
- crop irrigation
- dust suppression
- municipal gardens and landscapes (amenity horticulture).

Novel reuses, not previously considered and captured in established guidance or precedent, may require a thorough first principles risk assessment. Novel and high human exposure reuses require specific human health and environmental risk assessments to determine recycled water quality and control measures, and the relevant supporting evidence must be provided with the application.

### 2.1.4 Inadvertent or unauthorised uses of recycled water

It is important that all parties assessing recycled water schemes should consider inadvertent or unauthorised use of recycled water. This is because it may result in higher than intended exposure to humans and the environment.

For example, in dual-reticulation systems, a cross-connection may result in recycled water being supplied to taps used to supply water for drinking, or recycled water may be used to fill a domestic swimming pool. Some households may deliberately and knowingly use recycled water for an unauthorised purpose, despite advice to the contrary. In addition, overapplication of recycled water in domestic gardens or public parks may result in run-off or seepage to adjacent ecosystems (for example bushlands, wetlands).

### 2.1.5 Cross-connections and misuse of recycled water

The supplier of recycled water is responsible for inspecting recycled water connections to ensure drinking water supply is protected and recycled water is not consumed.

This includes developing and implementing a risk-based approach that adequately manages health risks to individual property occupants by preventing internal plumbing cross-connections between drinking water and recycled water systems. Additional preventative measures are required for premises supplied with recycled water which have higher risk users, such as schools and aged care homes.

The *Australian Guidelines for Water Recycling* (AGWR) contain additional information and guidance on inspection, monitoring and auditing. The Victorian Building Authority (VBA) undertakes some risk-based audits of domestic recycled water connections. However, this only covers a portion of recycled water plumbing works.

A list of preventative measures recommended to control plumbing related risks is provided in Section 22.2.2.

## 2.2 Recycled water system analysis

### 2.2.1 System analysis

Hazard identification and risk assessment requires a documented detailed description of the recycled water system. The recycled water system is defined as the collection or catchment of untreated wastewater through to the end-user or receiving environment. This system analysis should include:

- The catchment for the sewage treatment plant, including an overview of the domestic industrial or commercial trade waste inputs and groundwater/stormwater infiltrations and the volumes, quality, controls and monitoring.
- The sewage treatment plant, including the design and operation of the treatment process; the efficiency of the processes for removal of organic matter, pathogens, nutrients and parameters such as organic contaminants (if applicable); monitoring equipment; process inputs such as coagulants and disinfectants; and processes for dealing with failure and emergencies.
- The quality of the source water and the recycled water for physicochemical and microbial parameters. This should note whether historical data and specific monitoring is required, including from events such as wet weather or low flows.
- Storages, including the size, configuration and location of the storages; potential seasonal impacts on the storages; and intake or offtake locations.
- The supply system (distribution, reticulation and plumbing) including the pipeline specifications; plumbing installation controls (pipe coding, installation audits); control valves; and maintenance regimes.
- The end uses, including the intended uses for recycled water and demand profile; the lot sizes; expected irrigation methods; stormwater treatment processes; the nature of properties (single/multi/high-density, industrial developments); and soil, surface water and groundwater characteristics.

A process flow diagram (Figure 1) should also be developed to schematically illustrate the system capturing all the relevant characteristics of the recycled water scheme (Table 1). In situations where multiple organisations are involved in different parts of the system, administrative arrangements should be documented to ensure an integrated overview of the system is established.

The following resources and information are needed to understand a recycled water system and its associated risks:

- a team of experts who understand each part of the entire recycled water scheme (source to use)
- information and documentation on key characteristics of the recycled water system to be considered
- a flow diagram of the recycled water system from the source to the application or receiving environments.

The system analysis should be reviewed periodically or when major changes occur in the process and risk management system.

**Figure 1 – Generic flow diagram of a range of possible exposure pathways for water recycling schemes. For specific schemes, inputs from livestock, abattoir, chemical and industrial wastes may need to be shown as may pipe maintenance/flushing operations. Unintended uses and intentional misuses may need to be shown. For agriculture food uses, such as meat and plants, need to be specified**

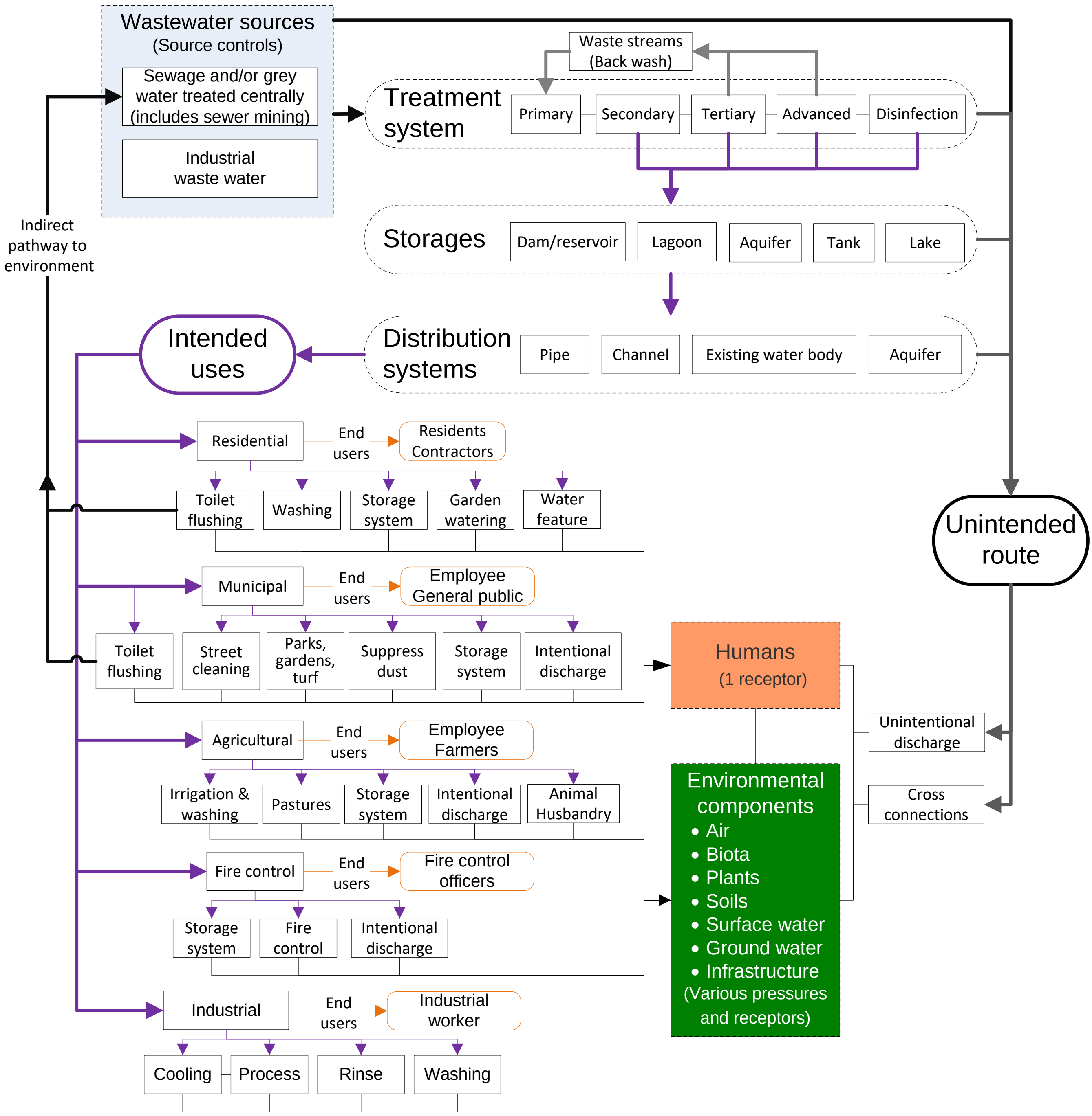


**Table 1 – Example characteristics of recycled water schemes (as a guiding set of examples)**

| Recycled water sources (catchment and collection systems) | |
|---|---|
| • Influence of land use and government policies, such as:<br>▫ development and planning restrictions<br>▫ future planning activities<br>▫ industrial developments.<br>• Input controls, such as:<br>▫ household chemical regulation, labelling and education<br>▫ livestock yards and abattoirs, food processing plants<br>▫ trade waste programs (for sewerage systems) | ▫ management of contaminated sites (for stormwater systems)<br>▫ regulation of household plumbing configuration (for greywater systems).<br>• Meteorology and weather patterns (climatic and seasonal variations).<br>• Residential developments.<br>• Topography and drainage patterns (hydrology). |
| **Source water characteristics** | |
| • Flow and reliability of source water.<br>• General and unique properties (physical, chemical, microbial):<br>▫ bacteria, viruses, protozoa and helminths relevant to human, animal and plant transmission pathways<br>▫ detergents (greywater)<br>▫ industrial chemicals<br>▫ major ions, salinity, hardness and pH<br>▫ metals and radionuclides | ▫ nutrients (nitrogen and phosphorus)<br>▫ organic chemicals<br>▫ disinfection by-products<br>▫ biologically active compounds including endocrine disruptors, pharmaceuticals.<br>• Seasonal and event changes (including droughts or floods).<br>• Spatial variations. |
| **Treatment systems** | |
| • Disinfection residual and contact period.<br>• Equipment design:<br>▫ size<br>▫ materials<br>▫ peak flow rates<br>▫ process change control<br>▫ backup systems<br>▫ bypass provisions<br>• Monitoring equipment and automation | • Nature of treatment processes including primary, secondary and tertiary treatment, on-site treatment, nutrient reduction and disinfection.<br>• Recycled water treatment chemicals used:<br>▫ coagulant<br>▫ filtration aids<br>▫ disinfectant<br>• Stability and reliability of processes.<br>• Treatment configuration and efficiencies. |
| **Storages (including lagoons and wetlands)** | |
| • Algae, macrophytes, zooplankton–plant dynamics.<br>• Biofilms and opportunistic pathogens.<br>• Aquatic community characteristics and any protection status.<br>• Detention times.<br>• Protection (e.g. covers, enclosures, access)<br>• Recreational or human activity.<br>• Seasonal variations:<br>▫ stratification<br>▫ algal blooms | • Storage design:<br>▫ depth<br>▫ materials<br>▫ size<br>▫ storage capacity.<br>• Intake location and operation.<br>• Treatment efficiencies (microbial removal).<br>• Use of the site by birds.<br>• Vectors and vector-borne diseases. |
| **Distribution systems, application and receiving environments** | |
| • Access controls (e.g. fencing).<br>• Application controls including methods (e.g. spray, drip, subsurface irrigation), design of irrigation system and scheduling (e.g. night-time only).<br>• Application rates.<br>• Conservation status/protected areas.<br>• Cross-connection controls and audit systems.<br>• Groundwater characteristics including nature of existing aquifers, current uses, depth and quality. | • Local vegetation (on-site and off-site).<br>• Biofilms and opportunistic pathogens.<br>• Physical barriers (e.g. buffer zones, trees and shrubs).<br>• Plumbing standards and requirements (e.g. location of piping, colour coding, labelling).<br>• Permitted uses.<br>• Receiving water characteristics including their nature (marine or freshwater, flows, volume, tidal movement, current uses and environmental values). |

| | |
|---|---|
| | • Recreational or human activity in receiving environment.<br>• Soil characteristics. |
| **Uses of recycled water** | |
| • Irrigation.<br>• Stock watering.<br>• Residential and commercial use of water for toilet flushing, car washing, garden watering, clothes washing.<br>• Environmental flow (intentional discharge) and activities downstream.<br>• Fire control. | • Water features (e.g. ponds, fountains).<br>• Agriculture and horticulture.<br>• Industrial uses.<br>• Irrigation of urban recreational areas, open spaces, parks and gardens. |
| **End users of recycled water** | |
| • Communities in vicinity of application sites (permanent or visitors).<br>• Communities that may use products or facilities irrigated with recycled water or that receive recycled water.<br>• Agricultural, horticultural, commercial and industrial users of recycled water. | • Communities in vicinity of application sites (permanent or visitors).<br>• Communities that may use products or facilities irrigated with recycled water or that receive recycled water.<br>• Agricultural, horticultural, commercial and industrial users of recycled water. |
| **Receiving environments components** | |
| • Air.<br>• Biota.<br>• Groundwater.<br>• Humans. | • Infrastructure.<br>• Plants.<br>• Soils.<br>• Surface water.<br>• Marine water. |
| **Pressures** | |
| • Urbanisation (spills to sewers, changing nature of sewage, water efficiency and reduced water, changing chemical usage, climate change, travel and connected communities for spread of pathogens).<br>• Extreme and infrequent events (for example droughts or floods). | • Seasonal characteristics.<br>• Climatic conditions.<br>• Soils.<br>• Topography.<br>• Geology. |

### 2.2.2 Supplementing recycled water supply

Supplementing recycled water quantities with other primary water sources (such as potable, bore water, irrigation channel water, stormwater, stream or drainage channel water) is an acceptable practice to manage salinity and nutrients or to supplement volumes.

However, supplementing recycled water with other water sources in order to meet the minimum treatment standards (such as levels for biological oxygen demand (BOD), suspended solids (SS), *E. coli* and pH) is not an acceptable practice as recycled water must meet the required criteria **prior** to dilution with other sources.

If supplementation of the recycled water supply is undertaken, the user should evaluate the quality of the other water sources (chemicals, nutrients and particularly microbiological quality) and the associated safety and sustainability risks. Appropriate water quality monitoring is necessary to verify final quality following supplementation.

### 2.2.3 Transport of recycled water

Road transport of recycled water is not subject to EPA's prescribed waste Regulations or waste transport controls. However, where recycled water is to be tankered (for instance, for drought relief or dust suppression), procedures must ensure that this does not result in spillage, odours or the contamination of the water being transported. In addition, consideration should be given to potentially unknown users of recycled water that might draw from water tankers to use that water. Suggested best practice measures include:

- ensuring the full quantity of water supplied to the transporter is delivered to the recycling site
- transporting recycled water in a watertight and enclosed tanker
- ensuring the tanker or pipeline is not contaminated with other sources of waste that will in turn contaminate the recycled water and cause public health, food produce or environmental problems on the recycling site
- ensuring recycled water is not transported in tankers used for transporting potable water for human drinking (refer *Guideline for drinking (potable) water transport in Victoria 2008*, available from www.foodsafety.vic.gov.au).

## 2.3 Assessment of water quality data

In many cases, recycled water schemes are developed from existing wastewater treatment systems. A review of historical water quality data can help to understand source water characteristics and system performance. A review can also help to identify hazards and aspects of the system that require improvement. Parameters that can provide useful information include:

- suspended solids or turbidity
- biochemical oxygen demand
- microbial quality, including faecal pathogens and indicators
- chemical quality, including salinity — for example, total dissolved salts (TDS) or electrical conductivity (EC), sodium adsorption ratio (SAR), nutrients (macro and micro), heavy metals and metalloids, pesticides and other organics
- algal counts
- organic matter
- colour
- pH
- disinfectant residuals and by-products.

Data should be reviewed over time and after specific events, such as heavy rainfall, which can lead to poor water quality. Although historical data can be useful, there may be substantial gaps that should be identified. Therefore, such data should only be used as one component of the assessment. Generic data (for example, relating to sewage) can sometimes be useful, but such data should be used with care. Variability should also be considered, particularly for smaller systems.

Water quality data obtained from monitoring source waters, the operation and stability of treatment processes, and recycled water as supplied to users should be assessed before it is used. The reliability of the available data should be considered in the assessment.

Data analytic methods may be useful in assessing data include control charts and temporal analysis of water quality records. Records should be analysed for short-term or seasonal spikes which can be caused by trade-waste discharges, seasonal occurrence of illnesses, or storm events. Sometimes it may be difficult to be aware of potential problems or hazards because events occur gradually or result from cumulative effects. Trends analysis can be a valuable tool for recognising such effects.

# 3 Assessing environmental risk

Environmental risks posed by recycled water schemes will vary, depending upon:

- the location (for example, relative to houses or watercourses)
- land capability (pressures such as climate, soil types, slopes, salinity and depth to water table)
- size of the scheme (volume of recycled water used)
- application techniques
- the end-use (such as irrigation of golf courses or growing food crops).

For recycled water use, details of risk identification and assessment should be provided in the EMP, thus providing an effective mechanism for third party review.

Recycled water use schemes must meet the following environment protection objectives:

- protect the beneficial uses of groundwater and surface waters as defined in the relevant SEPP including considering toxicity, eutrophication and algae

- avoid structural changes to the soil or contamination (for example, soil salinity, waterlogging or sodicity) that may reduce the (short or long term) productivity of the land
- avoid visual or productive impacts to plants
- avoid contamination of the air environment by the production of offensive odours, spray drift and aerosols
- minimise any unwanted infrastructure impacts.

To evaluate whether these objectives can be met, the following risks need to be assessed:

- groundwater: impacts on the beneficial uses of groundwater particularly from salts, nitrogen (nitrate) and pathogens that may be present in recycled water
- surface waters: impacts on the beneficial uses of surface waters from contaminated run-off containing nutrients, salts, metals and pathogens from recycled water
- air: risk of air pollution problems from aerosols generated by the spray application of recycled water or odours from inadequate treatment. Avoid production of offensive odour by using appropriate treatment and storage facilities for recycled water. Manage the storage and use of recycled water to ensure aerosol and spray drift are minimised
- soils: impacts on soils from nutrients, salts, organic and inorganic contaminants that may be present in recycled water including:
    - soil salinity
    - SAR
    - erosion of saline or nutrient-rich (especially phosphorus) soils
    - waterlogging effects of over-irrigation, poor drainage and high-water tables
- plants: minimise plant toxicity and nutrient imbalance to acceptable levels
- infrastructure: minimise staining, blocking and corrosion
- biota: soil and aquatic
- livestock and food safety.

The receiving land (particularly agricultural land) should not be utilised as an extension of the treatment process for pathogen control, nor chemical contamination dispersal and dilution. These circumstances would be considered as disposal and therefore be subject to works approval and licensing.

## 3.1 Environment management plan, risk assessment

The environmental management plan (EMP) requires understanding the whole recycled water scheme. This includes identifying hazards and the likely environmental components and pressures that will influence how likely a specific receptor (specific plant, biota or animal species) is to be impacted. The exposure could be from the end-use or via the treatment, storage or distribution system.

The risk assessment section of the EMP uses likelihood and impact to determine the risk posed by specific hazards. Understanding the land system where recycled water will be used is crucial for a scheme where water is applied directly to the land and re-enters the environmental segments. The land capability assessment (LCA) provides valuable information on the pressures in the environmental components to inform the risk assessment and should be a part of recycled water schemes where recycled water is applied to the land and an EMP is required.

The EMP should consider (Table 2):

- environmental components – general descriptors of entry points into the environment
- pressures – environmental conditions and resource uses that influence the exposure or impact to the receptor
- hazards – chemical (nutrients, toxicants and staining) and physical (temperature)
- receptors within the ecosystem − specific species and materials that could be impacted within environmental component
- recycled water uses (intentional and unintentional)
- possible impacts from the recycled water quality and uses, considering environmental components, hazard and receptors.

The risk to environmental segments and receptors from release of recycled water into the environment (by intentional and unintentional uses) should be minimised to acceptable levels. The risk assessment should consider the pressures and hazards that might influence the likelihood and impact on the most sensitive receptors relevant to the recycled water scheme, within the context of the whole environmental system.

For example, if recycled water reuse has the potential to result in nutrient enrichment of water (environmental component), then measurement of nutrients (chemical hazards) and plants (ecosystem receptors) will be a pathway of exposure to consider. Several other pathways for hazard exposure to receptors of concern also need to be considered. Each pathway should reach acceptable levels of risk. If the risks are determined to be unacceptable, then appropriate preventive measures should be identified to minimise the risk to acceptable levels.

**Table 2 – Factors to consider for the EMP when using recycled water**

| Environmental components | Pressures | Hazards | Receptors | Recycled water uses | Impacts from hazards |
|---|---|---|---|---|---|
| **Air** | Soil type and depth | Chemical | Water bodies | Intentional | Contamination |
| **Infrastructure** [A] | Land and catchment topography | Toxicants – inorganic and organic | Soils types | Fire fighting | Odour |
| **Soils** | Climatic conditions – e.g. rainfall, evaporation | Metabolites | Plant species | Storage | Eutrophication – algal blooms |
| **Water body (ground or surface water)** | Lakes and water bodies nearby | Salinity and sodicity | Biota – e.g. soil microbe, animal or fish species | Discharge | Aesthetic – colour |
| **Plants** | Hydrogeological conditions – e.g. depth to ground water | pH | Infrastructure – e.g. spray drift from irrigation staining a fence | Washing | Toxicity |
| **Biota** | Other users of resources | Nutrients | Humans | Irrigation | Nutrient imbalances and fertility |
| | | Physical | | Dust suppression | Water logging |
| | | Temperature | | Unintentional | Structure and permeability |
| | | Hydraulic load | | Cross connection | |
| | | | | Discharge | |

Notes:

[A] (pipes, drippers, ornamental water features, toilets, septic tank). This table lists those commonly considered factors and is not a complete list.

## 3.2 Environmental risk assessment framework

The risk level for each hazard or hazardous event can be estimated:

- qualitatively, by identifying the likelihood that it will happen and the severity of the impact (if it does happen) and using a risk matrix to combine the likelihood and impact to provide a qualitative estimation of risk, or
- quantitatively, by providing a numerical estimate of the risks. This method is rarely used as the amount of data required is rarely available, except where this is a published guideline (for example the quantitative risk assessment has already been completed to derive a guideline).

These two methods and how they might be used together as a semi-quantitative assessment are outlined in Section 3.2.1 and Section 3.2.2.

The general principal of the environmental risk assessment outlined in this publication is that the controlled (residual) risk should be low (acceptable) after assessing the maximal risk and applying preventive measures (if required). However, in some cases a controlled, moderate risk may be acceptable or manageable This will require rigorous monitoring and corrective actions in place to ensure no negative environmental impact in the medium to long-term (20 to 100 years).

### 3.2.1 Qualitative

For qualitative assessment of risk, Table 3 and Table 4 should be used:

- where there are insufficient data to use a quantitative approach, or
- by estimating the impact quantitatively Table 5 and likelihood qualitatively; a semi-quantitative approach.

The likelihood should be based on historical experience and the understanding of the recycled water scheme proposed, site characteristics, and pressures identified in the LCA.

**Table 3 – Qualitative risk matrix for estimating environmental risks based on the likelihood of exposure or an event and the consequence.**

| | | Impact descriptors [A] | | | | |
|---|---|---|---|---|---|---|
| | | No negative impact | Harmful to local ecosystem with local impacts contained to site | Harmful to regional ecosystem with local impacts primarily contained to on-site | Lethal to local ecosystem; pre-dominantly local, but potential for off-site impacts | Lethal to regional ecosystem or threatened species; wide-spread on-site and off-site impacts |
| **Likelihood** | | **Impact levels** | | | | |
| Descriptor | Level | 1 Insignificant | 2 Minor | 3 Moderate | 4 Major | 5 Catastrophic |
| 1:100 years | A Rare | Low | Low | Low | Moderate | High |
| 1:20 years | B Unlikely | Low | Low | Moderate | High | High |
| 1:5 to 10 years | C Possible | Low | Moderate | High | High | Extreme |
| 1:1 to 4 years | D Likely | Low | Moderate | High | Extreme | Extreme |
| >1:1 year | E Almost certain | Low | Moderate | High | Extreme | Extreme |

Notes:

[A] (pipes, drippers, ornamental water features, toilets, septic tank). This table lists those commonly considered factors and is not a complete list.

**Table 4 – Qualitative measures of consequence or impact**

| Level | Descriptor | Example of description |
|---|---|---|
| 1 | Insignificant | Insignificant impact or not detectable. |
| 2 | Minor | Minor impact for small population. |
| | | Potentially harmful to local ecosystem with local impacts contained to site. Short-term reversible environmental impacts. No detectable change to ecosystem. Can be readily managed but requires immediate action to minimise impacts. For example, a minor leakage of recycled water overland into a nearby creek causing some nuisance impacts (e.g. odour) or some stress to native plants (e.g. phosphorus-sensitive natives). |
| | | Some manageable disruption to normal use or discharge. |
| 3 | Moderate | Minor impact for large population. |
| | | Potentially harmful to regional ecosystem with local impacts primarily contained to on-site. Possible minor impacts on adjacent areas. Medium-term, generally reversible environmental impacts. Environmental impacts should be readily contained or mitigated (e.g. eutrophication of waterway from run-off when irrigated with recycled water). |
| | | Significant disruption, affecting normal use or discharge, increased monitoring. |
| 4 | Major | Major impact for small population. |
| | | Potentially lethal to local ecosystem. Predominantly local, but potential for offsite impacts. Medium- to long-term environmental impacts. Potentially reversible over a duration of several years. Significant impact on ecosystems. Environmental impacts difficult to contain or mitigate (e.g. major fish kills, widespread death of flora and fauna). |
| | | Significant disruption, affecting normal use or discharge. Possible cessation of use. High level of monitoring required. |
| 5 | Catastrophic | Major impact for large population. |
| | | Potentially lethal to regional ecosystem or threatened species. |
| | | Widespread, on and offsite impacts. Catastrophic harm, with environmental impacts extremely difficult, if not impossible, to contain or mitigate (e.g. catastrophic impacts on World Heritage areas, or species, populations or ecological communities identified as threatened). |
| | | Major failure of system leading to cessation of use. |

Note:

This table expands on Table 17 the *AGWR* 2006.

### 3.2.2 Quantitative

Hazard quotients (HQs) can be used to assess the relationship between the concentration of a hazard in recycled water and a guideline value (Equation 3). The HQ can then be used to:

- quantitatively determine the risk directly (assuming the likelihood = likely to almost certain), or
- inform the impact level for the qualitative risk assessment (making it semi-quantitative).

**Equation 1 – Hazard Quotient (HQ) calculation**

$$HQ = \frac{Concentration}{\text{Guideline}} \, or \, \frac{Concentratioin}{PC}$$

Where: HQ = Hazard quotient for the specific chemical or pollutant of interest. PC = Protective concentration (Section below)

**Table 5 – Hazard quotient conversion to environment impact or risk using guideline values**

| Hazard quotient (HQ) | Consequence for risk matrix (Table 59) (semi quantitative) | HQ description for risk directly[A] (quantitative) |
|---|---|---|
| <0.5 | Insignificant | Low (L) |
| 0.5 to <1.0 | Minor | Moderate (M) |
| 1.0 to <2 | Moderate | High (H) |
| 2 to <10 | Major | Extreme (E) |
| 10 or greater | Catastrophic | |

[A] Assumes a likely or almost certain likelihood. However, should be considered with duration of exposure also for short term events and the short or long-term guidelines (for example acute or chronic impacts). Note this relationship has been derived for environmental risk and should not be used for assessing human health.

HQs can also be used with derived protective concentrations (PC) (Equation 1) where a guideline does not exist for a hazard of concern. In these cases, the quality of the data and confidence in the PC should be reflected by multiplying the derived PC with a safety factor. Additionally, it should be stated why a specific safety factor has been used in deriving a PC. This work should be undertaken and scientifically justified by an experienced toxicologist. There are many scientific methods for deriving a PC for a specific hazard with an environmental component. For example, the ANZG describes a methodology to determine PCs in aquatic systems (ANZG, 2018; Warne et al., 2017).

## 3.3 Hazardous events

### 3.3.1 Emergency discharge

Section 30A of the *Environment Protection Act 1970* provides powers to EPA to approve emergency discharges of waste. If an emergency discharge of recycled water is anticipated, approval for the discharge must be sought from EPA. Situations that may require emergency discharges (for example, to surface waters) are plant malfunction, or impending spillage from storage facilities as a result of very high rainfall (greater than one-in-ten wet year). Routine flushing and minor bursts and leaks are not considered to be emergency discharge.

### 3.3.2 Incidental events

Even with best practice design and management, unexpected and unintended incidental events of recycled water discharge or disposal into the environment could happen. Environmental impacts from incidental events depend on the contaminant levels in recycled water. The greatest risk posed by nutrients is when high nutrient recycled water enters waters during dry periods when natural flows are low. The risk assessment should consider the impact of incidental events on the environment. Events that should be considered include:

- bursts and leaks, likely to result in relatively large pollutant loads. These are more common during summer months
- flushing, which is a planned, usually infrequent event that is typically avoided during dry periods due to the limited availability of water. However, for some new recycled water schemes it may be necessary to maintain quality in slow-to-build residential developments through more frequent flushing.

### 3.3.3 Run-off

Increased run-off can occur from washing down hard surfaces, washing cars on hard surfaces and over-watering gardens and crops. The risks of such uses should be considered as part of the environmental risk assessment.

### 3.3.4 Ornamental water features

The use of recycled water in ornamental water features should ensure:

- features are not directly connected to waterways and/or groundwater (for example, ponds may require a liner)
- algal blooms, odour and other nuisances are controlled
- vector risks are considered and controlled
- biofilm formation is controlled, to reduce fungal and bacterial growth and aerosolisation
- Legionella risks considered and controlled
- any nutrients and other contaminants (such as disinfection by-products, salt and heavy metals) are not toxic to aquatic life.

## 3.4 Hazard identification and potential impacts

Substances present in recycled water may adversely affect soils, water and produce safety, particularly if it contains industrial waste inputs. Environmental hazards that need to be assessed and managed are listed below. However, the type and quality of recycled water will vary significantly, depending on local factors, source water and regulatory controls. Therefore, a wide range of hazards may be found in recycled water at varying concentrations. Due to this, an initial screening-level risk assessment of all hazards (for all intended uses of the recycled water) may be needed. This is particularly the case when there is a known risk of hazards being present (for example, the presence of a specific industry in the sewage catchment).

The key environmental hazards found in water recycled from sewage may include:

- nitrogen and phosphorus
- salinity and sodicity
- sodium and chloride toxicity
- pharmaceuticals
- chemicals including heavy metals
- chlorine disinfection residuals (from the treatment process)
- hydraulic loading (water)
- pathogens – animal health and produce quality
- boron
- cadmium.

Industrial wastewater can present a wide array of hazards due to the presence of microbiological, physical and chemical agents. Without adequate protection, people or the environment can be exposed to these hazards when industrial water is recycled. Potential common hazards found in industrial wastewater may include:

- nutrients (nitrogen and phosphorus)
- biodegradable organics (composed principally of proteins, carbohydrates and fats)
- persistent chemicals
- organic and inorganic compounds with toxicity
- refractory organics which tend to resist conventional methods of wastewater treatment (for example, phenols and agricultural pesticides)
- dissolved inorganics (for example, calcium and sodium)
- metals (for example, arsenic, barium, cadmium, chromium, lead, mercury and silver)
- suspended solids
- non-pathogenic organisms that may cause odour, or corrosion and scaling of equipment. Some of these organisms may be opportunistic pathogens that only cause disease in people with a weakened immune system.

Hazards that may develop in recycled water post treatment include phytoplankton, which may proliferate due to the relatively high level of nutrients.

### 3.4.1 Protecting environmental waters

The State Environment Protection Policy (Waters) provides guidance on water quality criteria for the protection of beneficial uses and generally refers to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018). The ANZG provides criteria for the quality of recycled water to protect agricultural land, farm produce quality, groundwater and surface waters.

Algal blooms can affect the treatment reliability of recycled water supplies. For systems subject to algal blooms, a blue-green algal emergency response plan should be developed. The emergency response plan should detail:

- allowance for alternative supply systems
- measures to screen or filter recycled water before supply or application
- suitable mechanisms to clean and flush the distribution system
- a blue-green algal monitoring program
- threshold blue-green algal cell numbers that trigger actions, such as cessation of supply for stock drinking.

The Department of Environment, Land, Water and Planning (DELWP) publishes an annual blue-green algae circular (for example, see the *Victorian blue-green algae circular. algal management framework* DELWP, 2018) which informs local water managers about algal bloom coordination within Victoria. The circular has a bio-volume calculator to determine the level of cell count at which a response may be required. The circular also has a blue-green algae notification form.

### 3.4.2 New hazards and those requiring a watching brief

For some hazards, little information is available, making risk assessment problematic. In addition, a watching brief is required for new or suspected contaminants of concern. If any part of a recycled water system changes, or new hazards are identified through the recycled water quality monitoring program, then a full risk assessment may need to be completed for that hazard to:

- ensure the hazard is not a significant environmental risk
- confirm that the modification to the recycled water system has not introduced new specific ecosystem receptors and associated environmental risks.

### 3.4.3 Nitrogen, phosphorus and potassium

Phosphorus and nitrogen are the most common nutrients in recycled water to pose an environmental risk. Elevated nutrient concentrations are key contributors to loads applied to the soil with irrigation. They are also cause algal blooms and lead to associated water quality problems. Potassium can also be high in some industrial wastewater. Nutrients are beneficial for plant growth, but an excess build-up of some nutrients in soil and migration to surface water and groundwater can cause:

- health issue if ingested
- toxicity to some plants (including phytotoxicity to native plants sensitive to high nutrient levels)
- loss of soil productivity
- toxicity to aquatic life
- nuisance growths of aquatic plants, algal blooms and associated water quality problems.

The performance objective for nutrient management is to ensure:

- total applied nutrients (from recycled water and from any additional fertiliser application) are utilised for plant growth or remain stored within the soil for future uptake by plants
- applied nutrients do not build up in the soil to a level where they cause an adverse impact on beneficial use of the environment (in surface waters, groundwater and soil).

Recycled water contains sufficient potassium to replenish uptake by most crops. Potassium is most likely to become deficient if annual crops are harvested and removed. Potassium concentration in some industrial waste are high, which could be beneficial in some cases but potassium at high concentrations can also contribute to the sodicity of a soil (Equation 2).

**Table 6 – Indicative nutrient uptake rates for selected crops**

| Plant species | Nitrogen uptake (kg/ha/year) | Phosphorus uptake (kg/ha/year) | Potassium uptake (kg/ha/year |
|---|---|---|---|
| Bent grass | 170 | - | - |
| Bermuda grass | 280 | 30– 50 | 220 |
| Clover | 180 | 20 | 100 |
| Eucalypts | 90 | 15 | 60 |
| Grapes | 20 | - | - |
| Lemons | 60 | - | - |
| Lucerne | 220–540 | 20–30 | 170–220 |
| Oats | 60 | 50 | 130 |
| Oranges | 40 | - | - |
| Poplars | 115 | 25 | 75 |
| Radiata pine | 95 | 10 | 70 |
| River Sheoak | 140 | 20 | 80 |
| Ryegrass | 200–280 | 60–80 | 270–330 |
| Rye/clover (2:1) | 220 | 50 | 230 |
| Sorghum | 90 | 15 | - |
| Tall fescue | 150–320 | 30 | 300 |

Source: *Guidelines for wastewater Irrigation* (publication 168), (EPA Victoria, 1991). Additional data is available from the AGWR (NRMMC et al., 2006)

## 3.4.4 Salinity and sodicity

The presence of soluble salts within recycled water in some areas of Victoria can result in:

- impact to plant growth or plant death. The problem is more severe in hot and dry climatic conditions
- toxicity due to specific ions (for example, chloride and sodium), which could be displayed as foliar damage from sodium and/or chloride ions
- impacts to groundwater and surface water quality through salt migration
- impacts on soil structure due to the application of excessive sodium in irrigation water. This can make the soil more dispersible and erodible, leading to the restricted hydraulic conductivity. This may also lead to waterlogging or build-up of salinity.

Further complications of salinity problems can occur in geographic locations where the water table is high (within two metres of the ground surface).

Salinity and sodicity management aim to ensure:

- salt or sodicity levels in the water or soil do not impact on plant health, surface waters, groundwater or surrounding land
- stored salt in the subsoil and groundwater is not mobilised by irrigation.

Irrigation water salinity can impact plants depending on their sensitivity (Table 7). Salinity can also build up in the soil over time if not managed correctly (see preventive measures Section 3.7). The salinity of the recycled water will lead to changes in soil salinity. The relationship between the leaching fraction used for irrigation and rainfall should be used to manage this.

The risk (and occurrence) of soil sodicity in sandy soils is much lower than for clay soils. Sandy soils usually have only small amounts of clay and readily leach sodium ions. This is due to greater hydraulic conductivity and a low capacity to hold on to ions in the soil (low cation exchange capacity (CEC)). Conversely, clay soils tend to hold on to sodium ions on clay particles (Table 8). Most soils will not have any impact if the sodium absorption ratio (SAR) of the irrigation water is <5 (Table 8).

**Table 7 – Irrigation water salinity impacts to plants based on the electrical conductivity**

| EC (dS/m)b | TDS (mg/L) [B] | Water salinity rating | Plant suitability | Default impact [A] |
|---|---|---|---|---|
| <0.65 | 0 to <390 | Very low | Sensitive crops | Insignificant |
| 0.65 to <1.3 | 390 to <780 | Low | Moderately sensitive crops | Minor |
| 1.3 to <2.9 | 780 to <1740 | Medium | Moderately tolerant crops | Moderate |
| 2.9 to <5.2 | 1740 to <3120 | High | Tolerant crops | Major |
| 5.2 to <8.1 | 3120 to <4860 | Very high | Very tolerant crops | Catastrophic |
| ≥8.1 | ≥4860 | Extreme | Generally too saline | |

Source: ANZECC and ARMCANZ, 2000a). 1 dS/m = 1000 µS/cm.
[A] Default impacts are relevant to all plants. For example, if the plant species relevant to the scheme are all very tolerant grasses, insignificant impacts could span 0 to <2.9 dS/m, pushing the other impact descriptors higher.
[B] Based on a conversion factor of 600 to represent an indicative TDS, this varies considerably for deferent sources of wastewater and recycled water and EC should be used.

**Table 8 – Relationship between acceptable sodium adsorption ratio (SAR) of irrigation water and soil texture**

| Soil texture | Acceptable irrigation water SAR | |
|---|---|---|
| | Median (Default impact = Insignificant) | Range[A] |
| Sand, sandy loam | 20 | >20 |
| Loam silty loam | 10 | 8–20 |
| Clay loam | 8 | 5–13 |
| Light clay | 6 | 5–11 |
| Medium to heavy clay | 4 | 4–5 |

[A] Related to charge of clay
Source: modified from (ANZECC and ARMCANZ, 2000a)
Note: soil texture should consider top and subsoil to ensure that deep leaching is possible if required.

Sodicity in water or soil extracts is measured as SAR (Equation 2) and in soil as the exchangeable sodium percentage (ESP) (Equation 3) as follows:

**Equation 2 – Sodium adsorption ratio (SAR) calculated using sodium (Na), calcium (Ca) and magnesium (Mg) concentrations (mg/L)**

$$SAR\ (meq/L)^{0.5} = \frac{\frac{Na}{23}}{\sqrt{\frac{\frac{Ca}{20} + \frac{Mg}{12.2}}{2}}}$$

**Equation 3 – Exchangeable sodium percentage**

$$ESP = 100 \times \frac{ExchNa}{CEC}$$

*Where Exch.Na = Exchangeable sodium and CEC = cation exchange capacity (the sum of exchangeable cations (Ca+Mg+Na+K as cmol/kg)*

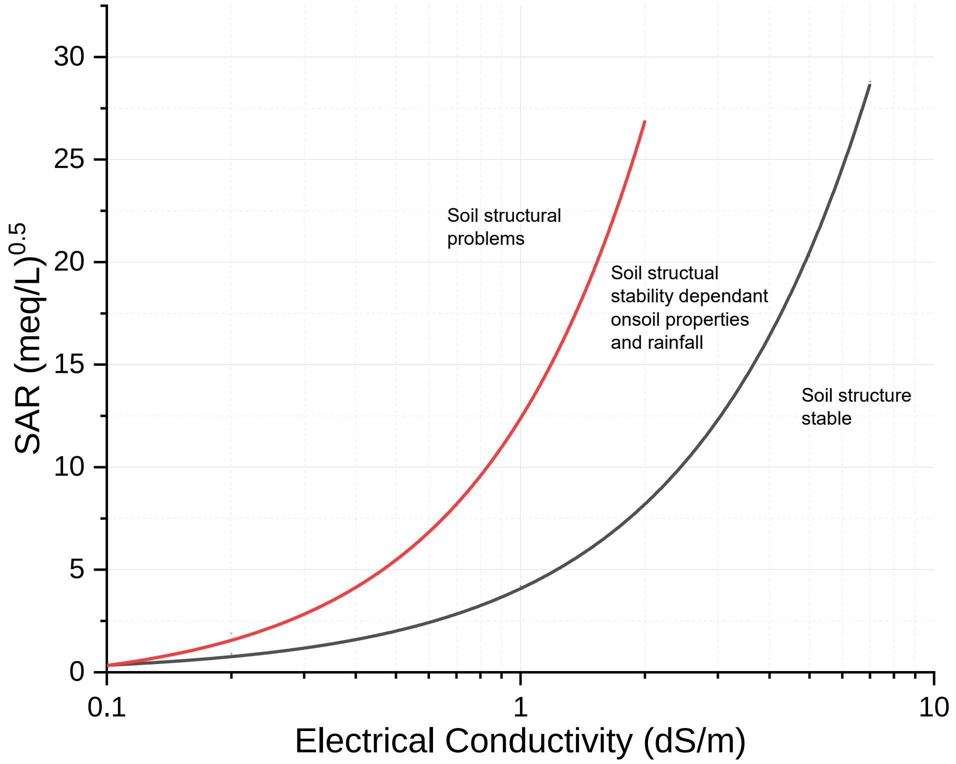
**Table 9 – Potential impacts to soil due to the relationship of irrigation water sodium adsorption ratio (SAR) and electrical conductivity (EC)**

| SAR/EC | Default impact [A] | Potential impact |
|---|---|---|
| 0 to <4.1 | Insignificant | Soil structural stable |
| 4.1 to <13 | Minor | Stability depends on soil properties and rainfall, there could be structural problems |
| ≥ 13 | Moderate | Soil structural problems |

Notes:

[A] Default impacts assume a loamy to clay soil.

**Figure 2 – Relationship between SAR and EC of irrigation water for prediction of soil structural stability (adapted from (ANZECC and ARMCANZ, 2000a), 1 dS/m = 1000 µS/cm)**




## 3.4.5 Sodium and chloride

Sodium and chloride can be directly toxic to some plants (Table 10). Chloride can also increase plant uptake of cadmium already present in the soil, and this can impact food quality. If chloride concentrations are higher than 350 mg/L, this impact should be considered further (ANZECC and ARMCANZ, 2000a).

**Table 10 – Sodium and chloride concentration (mg/L) causing foliar injury in crops of varying sensitivity when water is applied by sprinklers (directly to plant leaves)**

| Sodium (mg/L) | Chloride (mg/L) | Sensitivity rating | Default impact[A] | Plants |
|---|---|---|---|---|
| 0 to <115 | 175 | Sensitive | Insignificant | Almond, apricot, citrus, plum, grape |
| 115 to <230 | 350 | Moderately sensitive | Minor | Pepper, potato, tomato |
| 230 to <460 | 700 | Moderately tolerant | Moderate | Barley, maize, cucumber, lucerne, safflower, sesame, sorghum |
| ≥460 | >700 | Tolerant | Major | Cauliflower, cotton, sugar beet, sunflower |

Source: (ANZECC and ARMCANZ, 2000a).
[A] Default impacts are relevant to all plants. For example, if the plant species relevant to the scheme are all tolerant sunflowers, insignificant impacts could span 0 to <460 mg/L, pushing the other impact descriptors higher.

## 3.4.6 Chlorine residual

Recycled water is often chlorinated as a disinfection treatment to minimise pathogens. However, high concentrations of residual chlorine in recycled water can have a negative impact on plants irrigated with recycled water. Usually residual chlorine in recycled water is less than 1 mg/L and the impact is insignificant (Table 11). In distribution systems for class A recycled water, a target disinfectant residual of 0.2 to 0.5 mg/L is desirable to maintain quality and control biofilms.

**Table 11 – Effect of residual chlorine in recycled water on plants sprinkler irrigated with recycled water**

| Hazards | Unit | Default impacts[A] on plants from sprinkler irrigation | | | |
|---|---|---|---|---|---|
| | | Insignificant | Minor | Moderate | Major |
| Residual chlorine | mg/L | 0 to <1 | 1 to <5 | 5 to ≤ 10 | ≥10 |

Source: Modified from Pettygrove and Asano 1985, p 3–11, Asano et al. 2007 p 956, (ANZECC and ARMCANZ, 2000a). Note: Plants have varied sensitivity based on their species, stage of growth and other stresses.
[A]Default impacts are relevant to all plants. For example, if the plant species relevant to the scheme are known to be tolerant grasses, insignificant impact could span 0 to <5.0 mg/L, pushing the other impact descriptor higher.

Chlorine can also react with ammonia in recycled water to form chloramines or chloramines can be used directly to disinfect water. Monochloramine (generally the dominant form of chloramine) is usually considered less toxic than chlorine. However, there is limited data available for most plants and some may be more sensitive than others.

The aquatic toxicity of chlorine residuals should also be considered in assessing the management of bursts, flushing events and inappropriate uses. Less than 3 µg/L is recommended as a default value to afford 95 per cent protection of freshwater systems in ANZECC (ANZECC and ARMCANZ, 2000b).

### 3.4.7 Hydraulic load

Understanding irrigation requirements and managing irrigation rates is one of the most important components of irrigating with recycled water as it allows management of:

- water supply and minimising plant water stress
- soil salinity
- nutrients applied with recycled water
- water to remain on site.

A simple definition of irrigation requirement is that it is equal to the difference between the plant water requirement and the depth of rainfall at a location. Rainfall can be measured using standard meteorological equipment. However, to measure an accurate hydraulic load, measuring the effective rainfall and plant water requirement is more complex (Section 3.7.4).

### 3.4.8 Boron

Concentrations of boron in recycled water are unlikely to be high enough to cause direct toxicity to plants through foliar application. However, boron from recycled water irrigation can accumulate in the root zone and if it is not leached down through soil, it may lead to plant toxicity problems (Table 12).

**Table 12 – Maximum boron concentrations in irrigation or soil water tolerated by a variety of plants, without reduction in yields**

| Default[A] Impacts | Tolerance | Boron in irrigation or soil water (mg/L) | Plant |
|---|---|---|---|
| Insignificant | Very intolerant | < 0.5 | Blackberry, lemon, avocado, grapefruit |
| Minor | Intolerant | 0.5–1.0 | Peach, cherry, plum, grape, onion, garlic, sweet potato, sunflower, mung bean, sesame, lupin, strawberry, Jerusalem artichoke, kidney bean, lima bean, snap bean, peanut |
| Moderate | Moderately intolerant | 1.0–2.0 | Broccoli, capsicum, pea, carrot, radish, potato, cucumber, lettuce, olive, pumpkin, radish |
| Major | Moderately tolerant | 2.0–4.0 | Kentucky blue grass, cabbage, turnip, corn, artichoke, mustard, sweet clover, squash, musk melon, cauliflower |
| Catastrophic | Tolerant | 4.0–6.0 | Tomato, alfalfa, parsley, red beet, sugar-beet |
| | Very tolerant | 6.0–15.0 | Most grasses, asparagus, celery |

Source ANZECC and ARMCANZ 2000; Keren and Bingham 1985; Carrow and Duncan 1998. [A]Default impacts are relevant to all plants. For example, if the plant species relevant to the scheme are all very tolerant grasses, insignificant impacts could span 0 to <6.0 mg/L, pushing the other impact descriptors higher.

### 3.4.9 Metals, metalloids and organic chemicals

Cadmium can impact food quality and should be assessed as per other metals. Chloride concentration in recycled water (Section 3.4.5) should also be considered if growing food crops.

The *Australia and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) give a range of short and long-term trigger values for irrigation water. These, or other guidelines, should be referred to for any other hazards relevant to the recycled water schemes.

### 3.4.10 Algae

Algal blooms can affect the treatment reliability of recycled water supplies and potentially produce toxins. Algal blooms can appear during storage of recycled water as dense congregations of algae that form over dams and other storage facilities.

Due to the higher nutrient loads in many recycled waters, there is a greater likelihood of a blue-green algae (BGA) bloom during storage. Generally, algae applied to pasture via recycled water will not affect stock health provided the appropriate withholding periods are implemented and stock are grazed on dry land. There is, however, a greater risk to stock health associated with drinking recycled water containing BGA. It is the responsibility of water corporations to manage algal blooms and warn downstream users of any risks.

Livestock producer management strategies for BGA have been developed by Agriculture Victoria[1]. Livestock should not drink BGA contaminated water, as it can kill livestock very quickly, and sub-clinically affected or recovered animals may continue to die or demonstrate decreased production over several months.

See Section 3.4.10 for further discussion of algae relating to protecting environmental waters, and Section 3.7.9 in relation to algae control.

### 3.4.11 pH

Most soils are buffered and resist pH change. However, toxicity to plants, nutrient deficiency and soil structure problems may be caused by strongly acidic or alkaline irrigation waters. Therefore, the pH of irrigation wastewater should be in the range 6.5–8.4, although seasonal fluctuations can be expected, particularly if the wastewater is stored prior to irrigation (as noted in *Guidelines for Wastewater Irrigation*, (publication 168)).

A soil pH range of 5.5 to 8.0 is favourable to plant growth. pH strongly influences many soil characteristics including the plant-availability of nutrients, the solubility of potentially toxic elements, and microbial activity. On mineral soils, most agricultural crops do best in slightly acid soils (pH 6.5). In organic soils, crops do best with soil pH of approximately 5.5. Soil ameliorants can also be used to manage soil pH.

### 3.4.12 Suspended solids

Excessive amounts of suspended solids in irrigation water may clog the soil surface, depending on the nature of the solids and the soil. This reduces the infiltration rate of the soil and makes irrigation less effective (publication 168). The problem can be rectified to some extent by regular light cultivation. However, it is preferable to control suspended matter within the treatment process, so that is suitable for the irrigation system used and prevent clogging the soil surface.

### 3.4.13 Occupational health and safety

Best practice measures should be implemented to reduce potential occupational health and safety risks for onsite workers exposed to recycled water. Employers should make themselves aware of their associated responsibilities and duties under the *Occupational Health and Safety Act 2004.* Onsite workers who come into direct contact with recycled water containing high numbers of pathogens could become infected. Cyanobacteria in recycled water may also present a risk of developing skin and eye irritations or gastric upsets. The following best practice measures should be implemented to minimise the exposure of onsite workers to risks associated with recycled water use:

- education of onsite workers about risks associated with recycled water exposure (ingestion and inhalation of recycled water droplets and mist)
- appropriate immunisations (immunisations are not considered necessary for any class A schemes, due to the high microbiological water quality)
- installation of wash basin connected to potable water supply

[1] https://agriculture.vic.gov.au/farm-management/water/blue-green-algae-in-water

- no consumption of food or drink while working directly with recycled water and the washing of hands with soap before eating, drinking or smoking, and at the end of the working day
- using protective equipment appropriate to the tasks being undertaken and the quality of recycled water being used
- avoiding high exposure to, and inhalation of, recycled water spray by limiting access to irrigation areas to a minimum during irrigation periods.

### 3.4.14 Produce (food safety) risks

Water recycling schemes must not result in the unacceptable microbial or chemical contamination of produce or food, or otherwise adversely affect animal health and farm produce quality. Exposure routes need to be carefully managed to prevent contamination of produce via:

i. direct routes (for example, contact between food crops and pathogens/contaminants in recycled water and/or receiving soils), or

ii. indirect routes (for example, chemical bioaccumulation in animal meat/fat, helminth cysts in meat, microbiological contamination of milk via exposure of cow teats and udders or pasture irrigated with recycled water).

Victoria has a comprehensive food safety regulatory system based on the *Food Act 1984* and the *Food Standards Code* developed by FASANZ. This framework is supported by Codes of Practice and other Acts specific to particular industries, such as livestock disease control and dairy industry legislation.

A number of industries (for example, dairy, meat and horticulture) have adopted accreditation programs, such as FlockCare, and quality assurance (QA) systems under the HACCP (Hazard Analysis and Critical Control Point) framework to manage animal health and produce safety risks. The management controls needed for food and produce safety associated with recycled water use must be addressed as part of these QA management systems.

Domestic and international markets for some agricultural produce may perceive recycled water use negatively, and therefore not wish to source produce that has been grown with it. Potential users of recycled water in agricultural applications should use strategies to ensure consumer and market acceptance. The acceptance of recycled water use in food production may be influenced through education programs. However, situations may exist where recycled water use is potentially unacceptable to consumers. Detailed advice regarding produce (food safety) risk management associated with recycled water use, and the relevant regulations, industry codes and approved QA systems can be obtained by contacting the appropriate government agencies as summarised in Section 11.2.3.

### 3.4.15 Infrastructure impacts

Infrastructure impacts include salt damp or rusting (for example, buildings and fences), build-up of deposits on piping, staining and clogging of irrigation emitters (Table 13).

**Table 13 – Water quality parameter relative to the potential for drip emitter clogging**

| Water quality parameter | Symbol | Unit | Default impact rating for risk of clogging emitters | | |
|---|---|---|---|---|---|
| | | | Insignificant | Minor | Moderate to high |
| Total suspended solids (include algae) | TSS | mg/L | <50 | 50-100 | >100 |
| pH | pH | | <7 | 7-8 | >8 |
| TDS | TDS | mg/L | <500 | 500-2000 | >2000 |
| Manganese | Mn | mg/L | <0.1 | 0.1–0.5 | >1.5 |
| Total iron | Fe | mg/L | <0.2 | 0.2–1.5 | >1.5 |
| Hydrogen sulphide | $H_2S$ | mg/L | <0.2 | 0.2–1.5 | >1.5 |
| Bacterial number | n/a | Count/100ml | <10,000 | 10,000-50,000 | >50,000 |

Source: Asano et al. 2007, p 1068. Default impact assumes no maintenance and emitters are not self-cleaning.

## 3.5 Levels of risk assessment

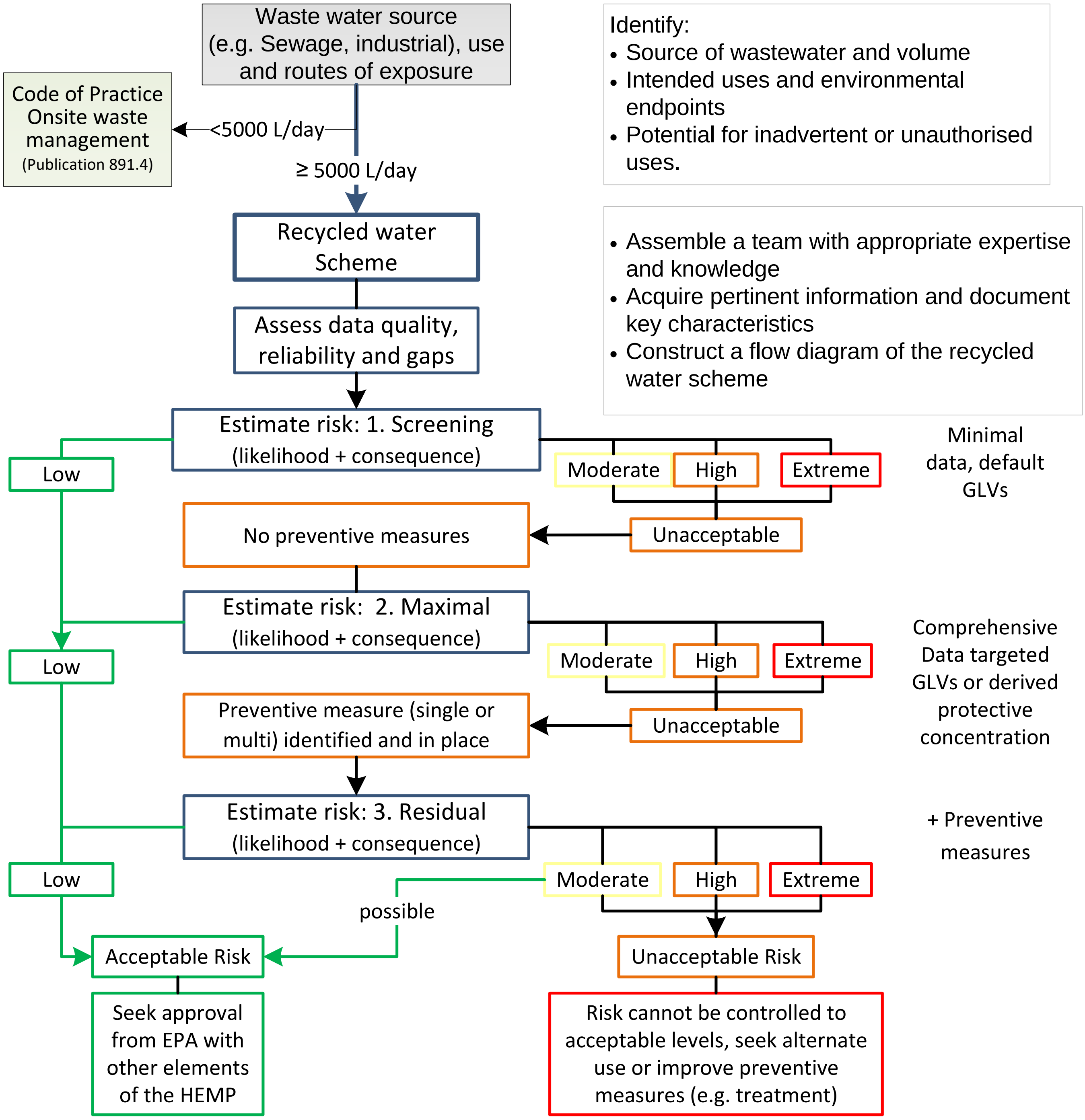
The risk assessment is mainly based on source water quality and proposed end uses. However, it also needs to consider all aspects of the recycled water scheme including collection, supply and storage (Figure 3). There are three stages of risk assessment:

1. screening, with minimal data
2. maximal, with more detailed data and no preventive measures
3. residual, with preventive measures considered.

The screening risk assessment establishes if applicable standards exist for the end use in relation to the recycled water. These may include state, national or international standards, or knowledge gained from similar risk assessments. Sometimes the appropriate standards may not have been developed for the specific end use. Some standards may have been developed to manage a similar risk profile. For example, standards for heavy metal levels may be based on threshold limits for contaminated soils. Where applicable end-use standards exist, the recycled water user or manager need to determine if the source water meets these standards.

The risk assessment should be used to identify the significance of a control measure and identify the environmental control points (ECP) Figure 3. Identifying the ECPs help ascertain the most important preventive measures to manage the environmental risks identified. The risk assessment approach depends on the existence of recognised guidelines for a hazard. The approach used also depends on if the control measure can be implemented and managed to reduce risks to an acceptable level (low or possibly moderate). Site specific guidelines or protective concentrations (PCs) can be derived, where appropriate. They should be supported with accepted scientific data and logic for the derivation (for example, Warne et al.; 2017). An appropriately qualified person should be engaged to undertake this assessment. An assessment is also required to determine how risks can be reduced to a low (or moderate, if acceptable) residual level.

**Figure 3 – Typical risk assessment process indicating the screening, maximal and residual risk assessment using the risk matrix (Table 3)**



## 3.6 Land capability assessments

The land capability assessment (LCA) should characterise the environmental pressures in the context of the recycled water scheme. The LCA should provide the basis for the environmental risk assessment which underpins the EMP. The objective of the EMP is to understand the condition and sensitivity of the environment (plants, soils, groundwater and surface water).

The LCA should include relevant parts of the environmental components for the recycled water uses, including:

- Soil, land and environment assessment (pressures):
  - location and site description
  - soils (CEC, phosphorus buffer capacity, texture, permeability, fertility, sodicity, salinity)
  - vegetation
  - topography
  - surface drainage
  - surface water – nearby
  - ground water – depth to ground water, groundwater quality and use
  - climate data.

And relate these pressures to:

- Plants (receptors):
  - species to be grown
  - tolerance and suitability to the pressures
  - evapotranspiration and crop factors
  - nutrient requirements.
- Water budget and nutrient loads (hazards):
  - water and nutrient budgets
  - irrigation methods
  - nutrient budget and hydraulic loads
  - phosphorus and nitrogen movement overland and deep drainage.
- Salinity and sodicity (hazards related to pressures and water budgets):
  - salinity
  - sodicity.
- Recycled water use – total requirements and volumes:
  - based on the intended uses.
- Environmental fate of hazards:
  - nutrient, metals, inorganic, organics
  - solubility, mobility and persistence.

Documents to assist with the LCA include the *Guidelines for Wastewater Irrigation,* (publication 168) (EPA Victoria, 1991) using updated climatic data.

## 3.7 Preventive measures and multiple barriers

Preventive measures should focus on preventing and managing the risk to acceptable levels by reducing the likelihood or impact. Preventive measures include:

- Exclusion barriers:
  - source controls
  - treatment levels.
- Onsite end-use restrictions:
  - site selection
  - buffer distances
  - crop and plant selected and grown
  - irrigation design, methods, scheduling and management
  - nutrients and salts budgeting
  - sodium applied (sodicity)

- application of soil ameliorants
- drainage and stormwater management (interception of movement offsite)
- public and stock access allowed
- withholding periods
- signage
- stock use restrictions
- time of use restrictions
- light control (algae control)
- storage design construction and use
- occupation health and safety requirements
- emergency discharges
- washing
- maintenance
- odour control
- shandying.

Many of the control measure are outlined below and further detail can be found in the AGWR (NRMMC et al., 2006).

### 3.7.1 Site selection

*Guidelines for wastewater irrigation* (publication 168) provides guidance on selecting appropriate irrigation sites. Site selection should consider soil, slope, surface water, groundwater, climate drainage and stormwater.

Soil profile and hydraulic conductivity should be determined for irrigation areas. Soil types least suitable for irrigation include highly permeable (for example, high sand and/or gravel content), or those with a low infiltration rate (heavy clay soils). While these soil types make a site less suitable, recycled water can still be applied providing associated risks are managed.

Sites with a slope of less than 10 per cent are preferred for irrigation, as this reduces the risk of run-off and erosion. The greater the slope, the more restraints on the design of the irrigation system and the more site management controls are required.

Nearby surface water should be assessed and protected to avoid impacts from surface run-off from or into stormwater systems.

Any surface drainage from the site irrigation should be retained on site. Movement offsite should consider impacts to other relevant environmental segments such as surface and ground waters.

A hydrogeological assessment of the proposed irrigation scheme should be undertaken. This will determine possible impacts on the groundwater, particularly for schemes that pose a significant risk. The assessment should be completed in accordance with the principles outlined in *Hydrogeological assessment (groundwater quality) guidelines* (publication 668).This assessment should consider the effect of the plant/crop production system and the effects of climate and recycled water on groundwater quality. Where an assessment indicates that irrigation is likely to result in surface waterlogging, root zone salinity and/or groundwater contamination, advice should be sought from an agronomist to determine if these risks can be managed adequately through site-specific controls.

The average annual evapotranspiration rates should substantially exceed rainfall to maximise recycled water reuse. Drier climates, such as those in the northwest of Victoria, are the most suitable. In areas with high rainfall, irrigation with recycled water is possible provided there is a distinct prolonged dry season, together with adequate available land for storage and irrigation.

### 3.7.2 Buffer distances

Buffer distances between recycled water application sites and surface waters or sensitive developments are influenced by:

- the class of recycled water used (controlling pathogen exposure)
- the irrigation methodology (control spray drift and application efficiency)
- site-specific parameters (such as the land slope, controlling erosion and run-off)
- the type of surface waters involved (controlling movement off-site to sensitive water ways).

There is a specific need to determine buffer distances where there is potential impact on drinking water sources from recycled water schemes. Drinking water sources include underground rainwater tanks, bore water supplies, waterways and reservoirs used for potable supply. Buffer distances may need to be agreed with the drinking water supplier.

The following table provides recommended buffer distances from the edge of the wetted area to surface waters for the use of class C recycled water. Buffer distances can be varied while still achieving the required objectives of providing environmental protection.

**Table 14: Recommended buffer distances from the edge of the wetted area to surface waters**

| Irrigation type | Surface waters |
|---|---|
| Flood/high pressure spray | 100 metres |
| Low pressure spray | 50 metres |
| Trickle or subsurface | 30 metres |

Recommended buffer distances could be reduced where:

- a class A or B recycled water is used instead of class C
- the surface waters are seasonal or a drainage channel
- best practice measures are implemented to prevent contaminated run-off leaving the site
- the site is particularly favourable, such as an elevated or well vegetated area between the recycling site and the surface water.

Buffer distances may need to be increased where:

- the surface water is highly sensitive (for example, heritage rivers and Ramsar sites)
- the surface water is used for potable water supplies
- the site is unfavourable, such as steep slopes and/or impermeable soils.

Spray drift of recycled water should not occur beyond the boundaries of reuse area as it may result in contamination of non-target produce and ingestion or inhalation of aerosols by the public. The following buffer distances (boundary of the irrigation area to the nearest sensitive development, such as residential areas, public parks, schools and shops) are suggested for spray irrigation applications:

- class A recycled water quality – no buffer distances are prescribed due to best microbiological water quality. However, irrigation should ensure no spray drift or water movement off-site to avoid nuisance aspects
- class B recycled water quality – at least 50 m from the edge of the wetted area to the nearest sensitive development
- class C recycled water quality – at least 100 m from the edge of the wetted area to the nearest sensitive development.

These buffer distances may need to be increased if high pressure spraying is conducted. Alternatively, the buffer distances may be reduced if suggested best practice preventive measures are implemented to reduce spray drift. These measures may include one or many of the following, depending upon the sensitivities of the area:

- tree screens
- anemometer switching systems
- restricted times of watering
- irrigation systems that prevent the generation of fine mist, such as low-rise sprinklers, small throw or micro sprinklers, and part circle sprinklers.

Other measures may be approved if the management plan demonstrates that they significantly reduce the risk to public health and amenity associated with spray drift.

### 3.7.3 Crop or plant selection

Impacts from several hazards are subject to the type of plants grown, as some plant species are more sensitive to specific hazard concentrations in the recycled water (for example, nutrients, salinity, boron, chloride and sodium) (Sections 3.4.3, 3.4.4, 3.4.8, and 3.4.5). Other plants are more sensitive to residual chlorine added to the recycled water (Section 3.4.6). If concentrations of the hazards are above the default impact of insignificant, plant selection could be used as a control measure to manage associated risk.

### 3.7.4 Irrigation

Performance objectives for site selection, design and operation of an irrigation scheme include:

- optimising water and nutrient uptake by plants (crops)
- preventing adverse environmental impacts on environmental values of surface waters and groundwater (as specified in the relevant SEPP)
- preventing adverse changes to soil structure, chemistry and therefore productivity for growing plants
- protecting human and stock health, and food or produce quality.

The irrigation system can have many features that can be effective as preventive measures for a range of hazards. Controls need to be considered in the context of the land capabilities and informed by the LCA completed as part of the HEMP. It is important for scheme sustainability that the loading rates of water, nutrients and salts are balanced with the site's ability to safely convert, absorb, use or store the nutrients and salts over the long term (nominally 100 years).

This can be achieved by modelling a water balance and irrigation budget for the site. The water balance spreadsheet contained in *Guidelines for wastewater irrigation* (publication 168) may be used to determine the size of an irrigation area and wet weather storage capacity based on calculated irrigation application rates over the proposed season. Alternate water balance modelling may be used to undertake water balance calculations (Allen et al., 1998) if those models provide better or equivalent solution.

Alternative methods should result in better or equivalent environmental outcomes and factors of safety as those outlined in *Guidelines for wastewater irrigation* (publication 168). An EPA agreement should be sought for usage of alternative water balance models that vary significantly from the one recommended in *Guidelines for wastewater irrigation* (publication 168), or that are not widely used by irrigation practitioners.

Climate, irrigation area, and crop water and nutrient requirements will determine how much recycled water is needed in a typical year. Seasonal conditions, weather, and both soil physical characteristics and moisture levels will determine the application rate.

An irrigation scheme should be designed to supply recycled water to the crop at a level determined by that crop's requirements. This may be achieved by designing the system so that it meets irrigation needs in a 90$^{th}$ percentile wet year so that the application rate can be varied during dry years and alternative water sources could be used.

The maximum hydraulic loading rate and the crop factor for a specific volume of recycled water will determine the minimum possible irrigation area in terms of water use. However, a larger area than the one calculated will generally be required to cope with variable factors, such as lower water uptake due to young or ageing crops.

Directly monitoring soil moisture levels is the preferred method for determining actual water application rates throughout the irrigation season. Alternatively, pan evaporation readings and the appropriate crop factor, or meteorological data and standard evapotranspiration models can be used. During the irrigation season, the crop's capacity to take water needs to be monitored regularly (daily, weekly to fortnightly) to determine when watering should occur.

#### 3.7.4.1 Irrigation method

It is important to match plants, soils, recycled water quality and irrigation methods and then use an irrigation system which is most suitable for the recycled water and the many site-specific variables (environmental pressures).

The main areas of assessment for irrigation systems are usually against water quality parameters, minimising environmental exposure (including efficiency of water use) and appropriateness for efficient and economic plant production. For example, Table 15 indicates the likelihood of surface run-off relative to the irrigation method and soil texture.

**Table 15 – Likelihood of surface run-off with recycled water irrigation system and soil type**

| Soil texture | Likelihood of surface run-off risk | | |
|---|---|---|---|
| | **Drip** | **Sprinkler/ Spray** | **Furrow** |
| Sand | Rare | Rare | Unlikely |
| Loam | Rare | Unlikely | Possible |
| Clay | Unlikely | Possible | Likely |

Source: modified from Stevens et al. 2006. Assumes good irrigation practise.

### 3.7.4.2 Irrigation requirements

For plant requirements to be met, additional water is required to overcome inefficiencies in irrigation method (effective irrigation is different to actual) and to leach salt down the soil profile.

Irrigation requirements (IR) can be calculated from pan evaporations and a crop factor (CF). Rainfall (RF) should also consider RF that:

- runs off and leaches through the root zone of the soil causing deeper percolation and RF that does reach the soil or plant
- evaporates before it can be used by the plant (for example lands on leaf area and evaporates).

To consider these losses of rainfall, a RF efficiency factor (ERF) is used. This is usually a percentage of RF. The IR should also consider any requirements for leaching (leaching requirement; LR) and the efficiency of the irrigation system using the irrigation efficiency factor (EIR).

The efficiency of applying water when irrigating (EIR)) can be calculated using Equation 4(Asano et al. 2007).

**Equation 4 – Irrigation efficiency factor**

$$E_{IR} = \frac{I_{BEN}(mm)}{I_{APP}(mm)}$$

Where:
$E_{IR}$ = Irrigation efficiency (See *Table 15* for typical values)
$I_{BEN}$ = Water used beneficially (for example not lost in wind drift, run-off, or excess application leading to deep percolation in excess of LF due to low distribution uniformity, but accessible to the crop for evapotranspiration, plant cooling and leaching of salts)
$I_{APP}$ = Water applied to field (for example irrigation water applied)

The IR can be calculated using Equation 5.

**Equation 5 – Irrigation Requirement**

$$\mathbf{IR} = \frac{(PE \times CF) + LR}{E_{IR}} - (RF \times E_{RF})$$

Where units are:
IR (Irrigation requirement) = mm
$E_{IR}$ (Irrigation efficiency factor) = unitless
PE (Pan evaporation) = mm; or Reference evaporation (ETo)
CF (Crop factor) = unitless; or Crop Coefficient (Kc), if ETo is used.
RF (Rainfall) = mm
$E_{RF}$ (Rainfall efficiency factor) = unitless
LR (Leaching requirement) = mm
Note the time unit for mm should be kept constant (for example mm/month, mm/year)

For a recycled water scheme, initial application of the IR should be completed on a monthly basis with the associate nutrient balance related to the load applied through recycled water. Climatic data should be from a local weather station accessed through the Australian Bureau of Meteorology for the area of interest or another weather station close to site. If this is not available, estimates from equivalent sources (for example, Australian Gridded Climate Data and Agriculture Victoria) could be suitable. This should give a good indication of recycled water requirements, which will then be modified for day to day operations and actual requirements.

Estimates for crop factors (CF), to use with PE, are available from EPA Publication 168: *Guidelines for wastewater irrigation* where the monthly growth stage and climatic conditions are considered. Alternative estimates for crop coefficients (Kc), to use with ETo (instead of PE) are shown in Publication 168 which need to be considered with the growth stage of a crop for each month. Rainfall efficiency can vary based on the amount rainfall and evaporation rates. Default estimates for $E_{RF}$ are presented in *Guidelines for wastewater irrigation* (publication 168) (EPA Victoria, 1991) are:

1. 0.70, for a PE of 0-125 mm/month
2. 0.84, for a PE of >125 to 200 mm/month
3. 0.95, for a PE of >200 mm/month.

Irrigation efficiency depends predominantly on the irrigation method. Typical in the field values for $E_{IR}$ range from 0.65 to 0.875

**Table 16 – Typical irrigation efficiency factors (Allen et al., 1998)**

| General irrigation type | Typical in the field | Range[A] |
|---|---|---|
| Surface | 0.65 | 0.40 to 0.80 |
| Sprinkler irrigation | 0.75 | 0.60 to 0.90 |
| Micro irrigation | 0.85 | 0.70 to 0.95 |
| Centre pivot or lateral move | 0.875 | 0.75 to 0.98 |

[A] Range depends on the specific irrigation system with the general irrigation type (Howell, 2003) Scheduling

Irrigation scheduling encompasses estimated water use (irrigation requirement, or IR), timing of application and quantity of recycled water to apply. Irrigation scheduling ensures that the correct amount of water is applied when required. There are a range of methods for irrigation scheduling that are typical for any irrigation system.

Ultimately, the texture and structure of the soil dictates the water holding capacity and the water available to the plant grown in the soil. Water should be applied to suit the root depth of the plants irrigated. For example, with turf, the top 20 cm of the soil is the predominant root mass. Therefore, any water passing this point will not be available to the plant and will contribute to leaching of water and potential nutrient losses.

For example, if the plants root depth is 20 cm, there is 20 cm of soil available to hold water. If the soil is a sandy loam texture, for every 1 cm of soil it will hold 1 mm of water (Table 17). That is, approximately 20 mm of water is held by the soil which is available to the plant. Therefore, when plant has used 20 mm of water (PE × CF or Kc × ETo per day, across a number of days, Equation 7), then irrigation is required. For example, at Bendigo in January 2019 the ETo averaged 8.7 mm/day (www.bom.gov.au/watl/eto/) and the Kc for warm season turf grass is 0.85 (Allen et al., 1998). Therefore, the average water use per day would be 0.85 × 8.7 = 7.4 mm/day, meaning irrigation would be required every 2.7 days (20/7.4), assuming there was no rainfall. The average daily water usage could be calculated to inform irrigation scheduling or soil moisture sensors used.

**Table 17 – Water removal from soil, starting at field capacity, if plants are maintained as indicated.**

| Soil Texture | Level of growth/appearance | | | | |
|---|---|---|---|---|---|
| | Excellent (Premium) | Great (Strong) | OK (Medium) | Just OK (Low) | Surviving (minimal) |
| | mm of water extractable/cm depth of soil | | | | |
| Sand | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 |
| Loamy sand | 0.4 | 0.6 | 0.7 | 0.8 | 0.9 |
| Sandy loam | 0.6 | 1.0 | 1.1 | 1.2 | 1.3 |
| Loam | 0.9 | 1.5 | 1.7 | 1.8 | 2.0 |
| Clay poor structure | 0.5 | 0.8 | 1.0 | 1.1 | 1.3 |
| Clay good structure | 0.7 | 1.1 | 1.3 | 1.6 | 1.9 |

Source: Handreck and Black 2002. Note excellent growth is usually requited for agricultural production systems were lower levels of growth may be acceptable for amenity horticulture (Landscape, gardens and turf).

An irrigation consultant with suitable expertise should be part of the team to develop the irrigation system and methods for scheduling.

### 3.7.4.3 Leaching

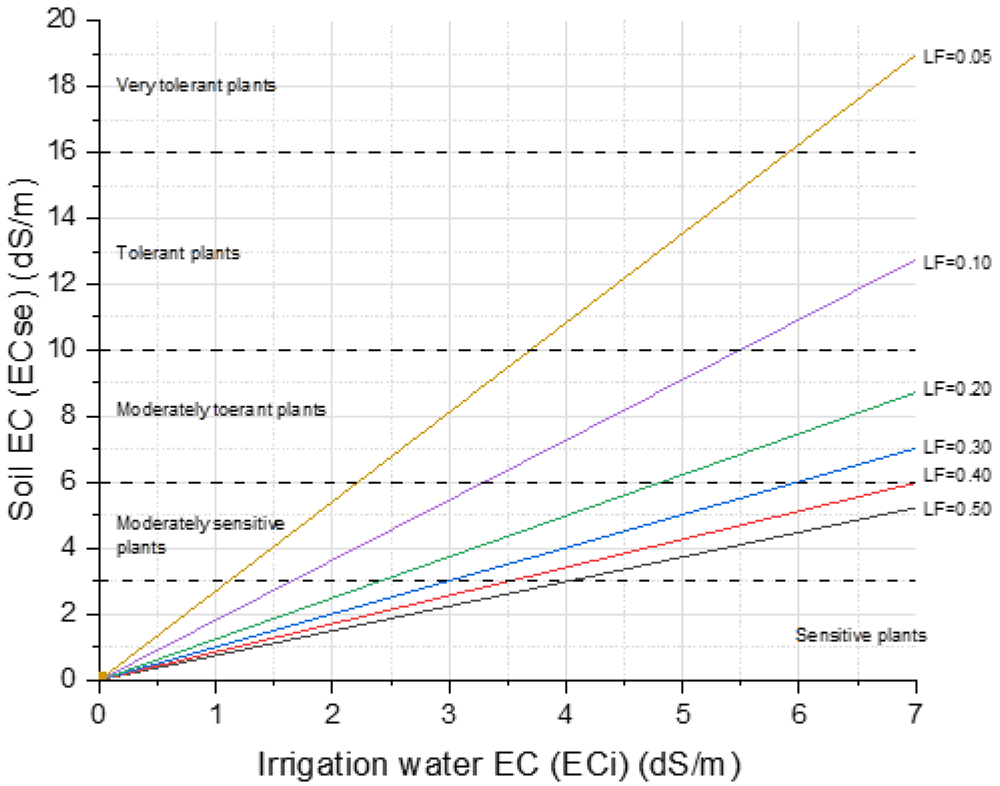
For steady state conditions, the leaching fraction (LF) is defined as the volume of drainage water (passing the root depth) divided by the volume of infiltrating irrigation water. The leaching requirement (LR) is an estimate of what the LF must be to ensure soil salinity remains within tolerable limits for the specific plants grown (given the irrigation water salinity) (Figure 4). These estimates depend on the soil type, whether deep percolation is possible and rainfall, as in some cases the winter rainfall may provide sufficient LF.

This steady state approach is usually a good estimate for long term changes in soil salinity. However, it assumes uniform application and does not consider:

- salt precipitation or dissolution
- irrigation frequency effects
- preferential flow
- upward water flow
- water chemical composition
- salt removal in surface run-off.

There are several transient models available to estimate short-term soil salinity changes from irrigation. However, these are not discussed here, as good soil monitoring, as part of the verification process, will generally provide direct feedback on the appropriateness of scheduling and application of recycled water.

**Figure 4 – Relationship between average root zone salinity (ECe) and electrical conductivity of irrigation water (ECi), as a function of leaching fraction (LF) and plant salt tolerance. Modified from (NRMMC et al., 2006).**




## 3.7.5 Nutrient and salt

### 3.7.5.1 Nutrient loading rates

In addition to a water balance, a nutrient balance must be completed during the design stages of an irrigation scheme. The nutrient balance needs to ensure that nutrients are applied at an optimal rate and load for the specific crop.

The nitrogen content of secondary treated sewage is normally between 10 and 30 mg/L, while tertiary plants configured for nutrient removal typically have a maximum of 5 mg/L nitrogen. This loading (the amount of nitrogen applied by the recycled water application and through any other means, such as fertiliser) should be balanced annually with the crop requirement. This is to prevent excessive nitrogen leaching to groundwater. Typical nitrogen uptake rates are approximately 40 to 540 kg/ha/year (Table 6). These figures can vary according to site conditions.

Comparison of applied nitrogen load to those removed by harvest will indicate the likely magnitude of nitrogen leaching into groundwater. If excessive nitrate leaching is likely, it is essential that steps are taken to combat this problem. Such measures include removing biomass regularly through thinning or harvesting the crop, reducing the nutrient loading rate by using a less concentrated source of recycled water, removing nutrients from the recycled water, or applying less recycled water to a larger area.

The phosphorus content of secondary treated sewage is normally between 6 and 10 mg/L, while tertiary STPs configured for nutrient removal typically have a maximum level of 1 to 2 mg/L phosphorous. Phosphorus uptake rates for a broad variety of crops are typically around 20 kg/ha/year, but can range from 20 to 80 kg/ha/year (Table 6). These figures can vary depending on site conditions. Information on soil's phosphorus retention capacity should be obtained and assessed for all irrigation sites. Phosphorus can leach into the groundwater or accumulate in the surface layers of some soils, depending on the type soil type If the surface layer is prone to erosion, phosphorus rich topsoils will erode, potentially ending up in surface waters and increasing nutrient levels. High phosphorus levels in soil can also affect soil productivity. As such, it is important for some schemes to have erosion and drainage controls for phosphorus management of irrigated land.

A nutrient load to demand ratio (NLDR) should be used to assess the possible impact of nutrient loads applied to the site from recycled water (Equation 6).

**Equation 6 – Nutrient load to demand ratio (NLDR)**

$$NLDR = \frac{Concentration\ in\ recycled\ water\ (mg/L)\ \times irrigation\ rate\ (IR)}{Nutrient\ demand\ for\ the\ plant\ or\ crop\ (kg/ha/year) \times AF}$$

Where IR is calculated as per Equation 7 in mm/year and nutrient demand can be estimated considering nutrient removal from the site. AF = assessment factor which should consider nutrient availability based on chemical forms available or adsorption to soil.

For example

$$NLDR = \frac{5\ (mg/L)\ \times 5\ (ML/year)}{20\ kg/ha/year\ \times 1} = \frac{25\ (kg/ha/year)}{20\ (kg/ha/year)} = 1.25 = Minor\ impact)$$

**Table 18 – Nutrient load to demand ratios and related default impacts.**

| Nutrient load demand ratio (NLDR) | Default impact |
|---|---|
| 0.0 to <1.0 | Insignificant |
| 1.0 to <1.5 | Minor |
| 1.5 to <2.0 | Moderate |
| 2.0 to <4.0 | Major |
| ≥ 4.0 | Catastrophic |

Potassium removal may also need to be considered (Section 3.4.3. *Guidelines for Wastewater Irrigation*, (publication 168) (EPA Victoria, 1991) provide guidance on calculating and determining appropriate nutrient loadings for irrigation schemes.

### 3.7.5.2 Salt loading rates

A salt balance should be undertaken for recycling schemes to limit the potential for groundwater contamination and reduced soil productivity. Salinity and sodicity management are critical for recycled water irrigation schemes. Salts in recycled water in some areas of Victoria limit the volume of water that can be applied to land.

If salt builds up in the root zone, the crop's growth rate and its capacity to take up water and nutrients will be reduced. Leaching of salt from the root zone is required to prevent salt build up. In most locations, rainfall will provide enough leaching to protect the root zone. Where this does not occur, extra irrigation is needed. This requires careful management to ensure excessive nitrate is not leached to groundwater.

Recycled water with a salinity of up to 500 mg/L can generally be used without significant risk to the environment and/or the crop, provided an appropriate amount of leaching occurs. Recycled water with TDS levels over 500 mg/L poses a risk to groundwater and soil, and crop and salinity controls will usually be needed.

*Guidelines for wastewater irrigation* (publication 168) provides guidance on appropriate site controls to manage and monitor the risks posed to groundwater, soils and crops.

## 3.7.6 Sodicity and soil ameliorants

There are several preventive measures for managing the SAR of irrigation water:

- decrease the sodium concentration in wastewater by source control or treatment, site selection (sandy soils tolerate higher SARs, ensure subsoil are managed also)
- soil ameliorants
- shandying with other water sources (NRMMC et al., 2006).

The application of gypsum is the most cost-effective method of ameliorating sodic soil (Table 19). It is important to note that another source of calcium is lime. Lime has very sparing solubility and should only be used in situations where:

- the soil pH is less than 6
- the desired effect is to supply both calcium for sodicity and carbonate for pH amelioration.

In these cases, combinations of both lime and gypsum are most effective.

**Table 19 – Soil dispersion and pH estimates for correction of sodicity related to gypsum and lime application rates**

| Dispersion | pH >6<br>Gypsum (t/ha) | pH <6<br>Gypsum + lime (t/ha) |
|---|---|---|
| None | 0 | 0 |
| Low | 2.5 | 1.25 + 1.25 |
| Medium | 5.0 | 2.5 + 2.5 |
| High | 10.0 | 5.0 + 5.0 |

Source: (Rengasamy et al., 2010) Note: t/ha × 0.1 = $kg/m^2$, gypsum and lime suppliers or suitably qualified persons should be consulted to determine precise gypsum and lime requirements. This table provides an indication of typical application rates.

Soil organic matter can also improve soil structural stability. Organic matter also benefits the soil by:

- increasing water holding capacity
- decreasing erosion losses
- supplying nutrients for plants and food for microorganisms
- increase nutrient holding capacity.

Developing and maintaining sufficient organic matter in the soil should be an essential part of any integrated approach to managing sodicity and associated structural problems.

There are generally two recognised methods for building soil organic matter:

- growing and incorporation of plants (green manure)
- addition of organic amendments like animal manures and composts.

Care should be taken when applying manures as they may contain significant amounts of salt and the nutrients they contain need to be considered in nutrient budgets.

### 3.7.7 Surface drainage and stormwater

All schemes should provide effective run-off controls including:

- efficient application methods
- proper irrigation scheduling such as water budgets
- tail water collection and recycling facilities for any excess run-off.

Onsite surface drainage controls are important to prevent waterlogging, particularly if the site has poor drainage due to fine textured soils or an insufficient slope. *Guidelines for Wastewater Irrigation,* (publication 168) (EPA Victoria, 1991) provides information on appropriate drainage controls for irrigation sites.

External surface water (stormwater run-on) should be prevented from flowing onto the irrigation site, as this may result in reduced IR and soil waterlogging. Suggested measures to control run-on include the placement of diversion banks and/or cut off drains around the irrigation site, where practicable. Drip, sub-surface, spray irrigation and low-head pressure sprinkler systems are suggested as best irrigation practices to prevent contaminated run-off leaving the boundaries of the irrigation area. If managed correctly, catch and return sumps may not be necessary with these types of irrigation systems.

Methods such as flood or furrow irrigation generally result in over irrigation and therefore require greater site management controls to minimise run-off, seepage, waterlogging and salinity problems. If flood irrigation is used, catch and return sumps are generally recommended. These will collect and recycle all irrigation run-off during the irrigation season as well as the first flush of contaminated stormwater (for example, the first 10 millimetres) during and after an irrigation event.

Generally, stormwater will only be contaminated with recycled water when rain occurs during or immediately following irrigation. The storage system should always be operated so that it is almost empty following irrigation.

This enables the collection of the first flush of contaminated rainfall run-off following irrigation. Recycled water irrigation should not occur during rain. The need for stormwater run-off and collection controls and design will be site-specific for irrigation methods other than flood. *Guidelines for Wastewater Irrigation* (publication 168) (EPA Victoria, 1991) provides further information on suggested stormwater controls for irrigation sites.

Regardless of site use, class A or B recycled water and nutrient reduction should be considered where there is high potential for recycled water run-off offsite. This would apply to schemes without run-off collection or recycling systems, and/or where there are high quality surface waters adjacent to the scheme, unconfined high quality groundwater/aquifers at the site, or sensitive neighbouring land uses (for example, protected flora and fauna sites). Nutrient reduction may also be necessary for recycling schemes having potential for run-off and off-site adverse impacts.

### 3.7.8 Public and stock access

Public and stock access controls for specific recycling schemes are outlined in Table 26. No specific public or stock access restrictions (other than pig prohibition) are recommended when a class A microbiological quality water is used if 4 LRV of helminths is achieved.

Sensible stock restriction controls should be employed to protect soils from stock traffic and compaction when wet. For lower quality recycled water (class B and C), restrictions on public and stock access, and limits on irrigation times are necessary. These limitations will depend on human and stock exposure potential and the quality of recycled water used.

### 3.7.9 Algae controls

For systems subject to algal blooms, a blue-green algal emergency response plan should be developed to cover nuisance and harmful algae. The emergency response plan should detail:

- allowance for alternative supply systems
- measures to allow the screening or filtering of recycled water before supply or application
- suitable mechanisms to clean and flush the distribution system
- a blue-green algal monitoring program
- threshold blue-green algal cell numbers that trigger actions, such as cessation of supply for stock drinking.

Factors that foster algal bloom formation and growth include:

- temperature
- light
- pH
- the availability of nutrients
- lack of competition from other micro-organisms
- the absence of predators.

Any water containing sufficient nutrients (nitrogen and phosphorous particularly) can form algal blooms if other conditions are conducive. Recycled water often has elevated levels of nitrogen and phosphorus. Long periods of dry warm weather provide favourable conditions for algal growth.

The best method for managing algae is to manipulate the factors discussed above that influence their growth. For example, restrict light, introduce predators or minimise storage time. Different algae may also live in different depths of the water storage. Adjusting water intake can minimise algae going into the irrigation system.

### 3.7.10 Storage

#### 3.7.10.1 Storage design and construction

Recycled water storage and irrigation system should be designed and constructed to contain all wastes up to the 90th percentile wet year.

*Guidelines for wastewater irrigation* (publication 168) provide guidance to determine the size of irrigation area and wet weather storage capacity for irrigation schemes. Appropriate base and embankment liners for wet weather storages should be designed to minimise seepage and protect groundwater, as well as prevent excessive water table rise. The appropriate technology and design of wet weather storage liners will vary, based on an assessment of:

- storage capacity
- water depth (head over the liner)
- recycled water quality (salinity and nutrient concentrations)
- underlying geology
- groundwater quality and uses
- vulnerability of groundwater.

The pondage liner design should be an integral part of the overall site selection and should be undertaken in accordance with the principles outlined in *Hydrogeological assessments (groundwater quality* (publication 668) (EPA Victoria, 2006).

Clay liners would be suitable in most circumstances. However, a high-density polyethylene (HDPE) liner or composite liner may be more appropriate if the storage is proposed for an area with sandy soils, and/or shallow (unconfined) aquifer and good quality groundwater. Also, if the groundwater is shallow and saline, then a vital liner design consideration is the need to prevent saline groundwater intrusion into recycled water storages.

Storages posing a moderate risk to groundwater should be provided with compacted clay liners of permeability less than $1 \times 10^{-9}$ metres per second, with suggested thicknesses relevant to storage capacities and water depths as follows:

**Table 20 – Recommended clay liner thickness**

| Storage capacity (ML) | Water depth (M) | Filling frequency | Liner thickness (mm) |
|---|---|---|---|
| < 3 | < 1.5 | Intermittently | Compacted surface clay soils |
| ≥ 3 | < 1.5 | Permanently | 300 |
| ≥ 3 | ~ 3 | Permanently | 600 |
| ≥ 3 | > 5 | Permanently | 1,000 |

The use of 300 mm liners requires special care during the construction phase to avoid cracking and to ensure an even thickness and compaction.

### 3.7.10.2 Use of storages as part of the treatment process

The recycled water being discharged to storage facilities should already be treated to a class suitable for its intended use. Storage facilities that are needed to make recycled water suitable for a particular use will be considered part of the treatment process and therefore subject to EPA works approval processes. Storage lagoons which are part of a reuse scheme do not require works approval but should be designed together with the reuse scheme.

The storage will need to achieve required quality criteria given a worst-case scenario (for example, to achieve 25 day storage for helminth control, the detention time needs to be based on the lowest storage volumes towards the end of summer irrigation). Care needs to be taken to avoid short-circuiting within storage lagoons. Managing any risks, such as the resuspension of settled helminths, should be detailed in the HEMP.

## 3.7.11 Maintenance

Maintenance of equipment can:

- minimise blocking of irrigation emitters and build-up of deposits in pipes
- ensure monitoring is accurate and irrigation rates and scheduling are sufficient.

Operators should understand the operation of monitoring equipment, so that causes of erroneous results can be recognised and rectified. Regular inspection and maintenance of all equipment, from source to point of use, ensures continuing process capability. A maintenance program should be established and document:

- operational procedures and records for the maintenance of equipment, including the calibration of monitoring equipment
- schedules and timelines

- responsibilities
- resource requirements.

### 3.7.12 Misuse by end user

#### 3.7.12.1 Residential use

Information on appropriate uses and the risks to the environment and human health if recycled water is not used accordingly should be provided to residents.

Suggested key messages should include:

- optimise garden watering so that waterlogging and run-off do not occur
- limit watering to sensitive plants such as natives
- wash cars and boats on grassed areas to minimise run-off to the stormwater system
- avoid run-off of recycled water during construction and renovation activities.

Influencing customer behaviour through messages about conservation and demand management will play an important role in risk management. While residents should not be responsible for complex management regimes such as leaching, they should be expected to use recycled water appropriately.

Metering and appropriate pricing of recycled water are also important mechanisms to encourage the responsible use of recycled water, as they impose a user-pays system. Individual meters must be installed at each property to monitor recycled water use. A single meter may be sufficient at multi-dwelling residential premises, such as apartment blocks, or where garden watering systems are managed by a single entity such as a body corporate.

### 3.7.13 Emergency discharge

If EPA cannot be notified prior to emergency discharge, notification must be as soon as practicable (with 24 hours) of the emergency discharge occurring. If storage lagoons contain toxic blue green algae, permission from EPA and the relevant rural water corporation must be obtained prior to discharge.

These discharges must not cause adverse health and environmental impacts. The site EMP and HEMP should address:

- the contingencies for when a discharge may be required
- summarise how the discharge will occur
- management practices that will be implemented to minimise health and environmental impact
- consider any requirement to inform the CVO (Section 22.1).

#### 3.7.13.1 Exclusion barriers

Exclusion barriers consist of collection controls, storage controls and treatment controls.

Collection controls include:

- managing or cleaning the catchment area
- using less chemicals in the industrial process
- diverting some streams and only collecting from lower risk parts of the industrial process
- diverting off-specification quality water to sewer (with appropriate agreements)
- bunding chemical storage area in accordance with EPA guidelines
- staff awareness and training.

Storage controls include:

- ensuring the storage is suitably designed to relevant engineering standards
- preventing contamination with covering
- diverting excess or overflow to sewer
- diverting off- specification quality water to sewer
- bunding chemical storage area in accordance with EPA guidelines
- signage
- staff awareness and training.

#### 3.7.13.2 Treatment controls

Treatment controls ensure appropriate treatment standards for end use. The type and level of treatment required will depend on specific risk factors. For example:

- chlorination to manage health risks
- simple triple interceptor to remove oils and fats
- filter to remove suspended solids
- monitoring and verification
- staff awareness and training.

#### 3.7.13.3 Preventative end controls

Preventative end-use controls include

- supply controls – for example, plumbing standards and fixtures such as backflow prevention, air pressure gaps between taps, appropriate transport vehicles and cleaning of them, signage, staff awareness and training
- application rates/volumes/times to ensure water remains on recycling site
- monitoring to ensure no long-term impact, dual-pipe supply for toilet flushing
- plumbing standards such as backflow prevention, air pressure gaps between taps, signage
- staff and user awareness and training.

#### 3.7.13.4 Managing workplace risk

Workplace risk is the primary exposure for many industrial water recycling schemes will be to employees and visitors to the workplace. This workplace risk is managed by WorkSafe Victoria’s occupational health and safety framework. Best practice measures should be implemented to reduce potential occupational health and safety risks for on-site workers exposed to reclaimed water. Employers should make themselves aware of their associated responsibilities and duties under the *Occupational Health and Safety Act 2004*.

The WorkSafe Victoria website (www.worksafe.vic.gov.au) has guidance on how to comply with these duties, including on controlling occupational health and safety hazards and risks. The following best practice measures should be implemented to minimise the exposure of on-site workers to risks associated with recycled water use:

- education of onsite workers about the risks associated with exposure to recycled water (ingestion and inhalation of reclaimed water droplets and mist)
- appropriate immunisations (immunisations are not considered necessary for any class A schemes, due to the high microbiological water quality)
- installation of wash basin
- no consumption of food or drink while working directly with recycled water and the washing of hands with soap before eating, drinking or smoking, and at the end of the working day
- using protective equipment appropriate to the tasks being undertaken and the quality of recycled water being used
- avoiding high exposure to, and inhalation of, recycled water spray by limiting access to irrigation areas to a minimum during irrigation periods.

#### 3.7.13.5 Managing business and consumer risk

The suitability of the water for the particular end use is also a business risk and should be managed via existing business risk management systems. For example, some management controls may need to be included in internal business management systems, such as an EMP.

Specific regulatory frameworks control the risks to consumers in relation to product safety and quality. For example, food safety is regulated by the *Food Act 1984*, and the *Fair Trading Act 2012* provides a framework for the safety of goods that are intended to be used, or are of a kind ordinarily used for personal, household or domestic purposes.

These management controls should be set out in a HEMP or similar management document that describes the proposed end use(s), source water quality, supply and management of the recycling scheme.

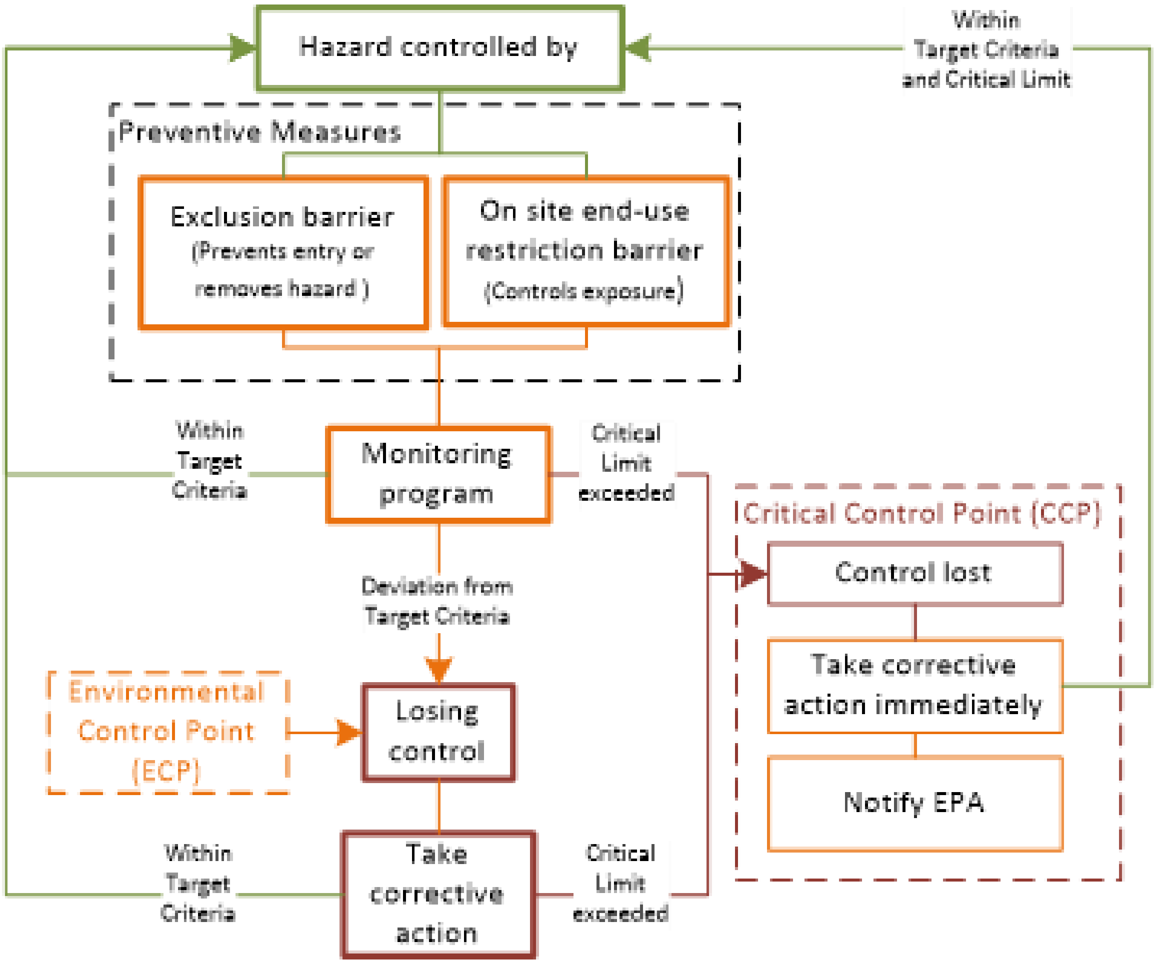
## 3.8 Critical control points and environmental control points

The critical control point (CCPs) and environmental control point (ECPs) identified in the risk assessment process are used to manage the associated risks using target criteria and an appropriate monitoring program (Figure 5). If other terms are used, such as 'quality control points', it is important to ensure the difference between CCPs, ECPs and other terms are explained.

For environmental risk management, the ECPs are used primarily for long-term changes in environmental risk indicators monitored and related chronic impacts. The CCP are more relevant for acute environmental impacts that can have immediate impacts. For example, an increase in salinity or exceeding a salinity CCP could impact sensitive plants within days after spray irrigation. However, the soil salinity may not be impacted for several years and should relate to an ECP for a specific recycled water scheme. The risk assessment process should:

- assess preventive measures throughout the recycled water system to identify CCPs or ECPs
- establish mechanisms for operational control
- document the CCPs/ECPs, critical limits and target criteria.

**Figure 5 – Relationship of preventive measures (On-site and exclusion barriers) with the monitoring program, environmental control points (ECP) and critical control points (CCP).**




## 3.9 Operational controls

Operational procedures and process controls need to incorporate the relevant preventive measures that have been identified for managing ECPs. For example, industrial process controls and operational procedures may include protective clothing, safety equipment and application rates. The relevant HEMP or agreement should include or refer to the document(s) that set out the operational procedures and process controls.

The operation controls should address the control measure and use the ECPs and CCPs to manage the day-to-day operation of the recycled water scheme.

# 4 Risk assessment

Hazard identification is just the first step in understanding the risk a hazard could pose to the environment and human health. To fully assess risk, the likelihood of a hazard occurring and its potential for impact both need to be considered.

## 4.1 Hazard identification

Identification of hazards should consider the risk they potentially pose to both human health and the environment.

Direct hazardous substances, such as toxins, as well indirect hazardous substances, such as nutrients that could lead to the proliferation of problem phytoplankton, should be considered.

Environmental hazards include those that could impact both aquatic and terrestrial systems. Examples include those that could impact adversely on freshwater quality, animal health, amenity horticulture, infrastructure and agriculture (food and product quality and safety). Note that these beneficial uses are broadly consistent with the Community Values defined in the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG, 2018).

The recycled water system analysis provides the basis for hazard identification, followed by risk assessment and control. In this context:

- a hazard or stressor is a biological, chemical, physical or radiological agent that has the potential to cause harm. Examples of potential hazards are pathogens, salinity and chemical contaminants
- a hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how). Examples of hazardous events are sewer spills, treatment plant failures or cross-connections between recycled water and drinking water supplies
- a risk is the likelihood of identified hazards causing harm in exposed populations in a specified time frame together with the potential for severe consequences (impact).

It is important to ensure that actions and resources are directed to manage the highest risks, rather than just the existence of a hazard. To assess risks, the framework provided by AGWR (or an alternative risk assessment framework) can be used.

Typical risks to human health, the environment and food safety are summarised below in the following sections (Sections 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6). The AGWR has a summary of potential hazards found in sewage (AGWR Table 2.2), their potential sources (AGWR Table A3.2) and hazardous events that could present risks (AGWR Table A3.3).

## 4.2 Determining the level of risk

Once potential hazards, hazardous events and their sources have been identified, the level of risk associated with each should be determined so that priorities for risk management can be established and documented. Not all hazards will require the same degree of attention. A risk assessment helps to direct attention and resources to those hazards that are most threatening.

**Screening-level risk assessment**

An initial, screening-level risk assessment may be useful to identify broad issues and show where to focus efforts for a more detailed assessment. The aim should be to distinguish between very high and low risks and focus resources on the management of high risks that require further consideration.

**Qualitative and quantitative risk estimation**

The level of risk for each hazard or hazardous event can be estimated by identifying the likelihood that it will occur and the severity of the impact if it does. A risk matrix can be used to combine the likelihood and impact to provide a qualitative estimation of risk. An example of this type of matrix is in Table 21.

For some contaminants, it is recommended to carry out a quantitative risk assessment, to provide a numerical estimate of risks (for example, the annual impact of illness in a population caused by a specific pathogen under a particular exposure scenario). Typically, quantitative risk assessment uses a four-step process that includes hazard identification, dose response, exposure assessment and risk assessment (for example, pathogens).

**Limitations**

Realistic expectations for hazard identification and risk assessment are important. For example, for any recycled water scheme, a detailed quantitative risk assessment will be possible only for a limited range of contaminants.

Hazard identification and risk assessment are predictive activities that will often include expert opinion that may be subjective, and thus involve uncertainty. These inherent limitations must be recognised during the risk assessment process. A possible outcome of risk assessment is the identification of specific areas where further information and research is required to fill knowledge gaps and improve confidence to manage higher unacceptable risks.

**Table 21 – Qualitative risk matrix for estimating human health and environmental risks based on the likelihood of exposure or an event and the impact**

| | | Impact descriptors | | | | |
|---|---|---|---|---|---|---|
| **Health** | | No negative impact | Minor impact for small population | Minor impact for large population | Major impact for small population | Major impact for large population |
| **Environment [A]** | | No negative impact | Harmful to local ecosystem with local impacts contained to site | Harmful to regional ecosystem with local impacts primarily contained to on-site | Lethal to local ecosystem; pre-dominantly local, but potential for off-site impacts | Lethal to regional ecosystem or threatened species; wide-spread on-site and off-site impacts |
| Likelihood | | Impact level | | | | |
| **Descriptor** | **Level** | **1 Insignificant** | **2 Minor** | **3 Moderate** | **4 Major** | **5 Catastrophic** |
| 1:100 years | A Rare | Low | Low | Low | Moderate | High |
| 1:20 years | B Unlikely | Low | Low | Moderate | High | High |
| 1:5 to 10 years | C Possible | Low | Moderate | High | High | Very high |
| 1:1 to 4 years | D Likely | Low | Moderate | High | Very high | Very high |
| >1:1 year | E Almost certain | Low | Moderate | High | Very high | Very high |

## 4.3 Assessing human health risk

Human exposure to recycled water must not pose an unacceptable risk to human health. Exposure can occur indirectly, such as via ingesting food produce irrigated or grown with recycled water (such as fruit, vegetables, milk and meat) and directly through unintentionally drinking from a recycled water tap or via a recycled water cross connection with the drinking water supply.

To manage human health risks, treatment processes should ensure appropriate levels of pathogen and contaminant removal before recycling. Appropriate restrictions should be placed on both human and produce exposure to recycled water based upon the reductions in pathogen levels achieved by the treatment process and other hazards of concern. In general, as the extent of treatment increases and the level of human or produce exposure decreases, the potential human health risks decreases.

Hazards to human health include:

- physical
- microbial
- chemical (discussed further in Section 4.6.2), including inorganic chemicals; organic compounds; pesticides
- radiological.

Pathogens in recycled water that need to be considered for health risk assessment include:

- bacteria (such as those causing cholera, typhoid, and shigellosis)
- protozoa (causing amoebiasis, giardiasis)
- viruses (such as those causing viral gastroenteritis or infectious hepatitis)

- helminths (such as *Taenia* which include tapeworm in humans and cysticercosis in cattle and pigs, and *Ascaris* which includes roundworms in humans).

The degree of risk from each of the above pathogen groups will depend upon the class of recycled water and the recycling application. Potential impacts both to and from recycled water of pathogen regrowth and disease transmission need to be assessed and appropriately controlled. This is particularly relevant where contamination via vectors, such as birds (that could be attracted to recycled water ponds) is concerned. If not controlled, pathogens have the potential to be transmitted to humans by:

- direct routes (that is through skin contact, ingestion or inhalation)
- indirect contact (that is, consumption of contaminated produce).

Recycled water schemes that require particular attention for health risk assessment include:

- irrigation of readily accessible public areas with potential for direct exposure to recycled water (for example, via spray drift or drinking or playing in water from sprays)
- consumption of produce that has come into direct contact with recycled water and is not cooked or processed prior to eating
- discharging recycled water to surface waters that are used for fishing, water contact sports or other recreational activities
- industrial recycling uses where workers may either come into direct contact with recycled water or ingest aerosols.

Phytoplankton that flourish in secondary treatment lagoons and winter storages may pose a risk to the adequate treatment and distribution of recycled water during bloom events. Cyanobacteria may also pose a risk to human and stock health through the production of toxins if the site is not appropriately managed.

Some bacterial pathogens (such as *Salmonella*, *Campylobacter* and *Legionella*) may also regrow in storage tank if biofilms develop.

## 4.4 Risk management principles

Recycled water sources can contain a wide range of contaminants that pose risks to human health, including disease-causing microorganisms (pathogens) and chemical substances. Concentrations of these contaminants need to be reduced to levels that are considered acceptable for human and animal health protection. Defining the acceptable, or tolerable level of risk is the first step in a recycled water risk assessment. The tolerable level of risk can then be used to set health-based targets for individual hazards.

## 4.5 Tolerable risk

The World Health Organization uses a metric known as the disability adjusted life year or DALY to quantify and compare the burden of disease associated with different water-related hazards. One DALY is equivalent to one lost year of ‘healthy’ life. The DALY takes into account the varying probabilities, severities and duration of effects and can, in principal, be applied regardless of the type of hazard (microbial, chemical or radiological) thus enabling a consistent approach across different hazards. This limit is also adopted by the AGWR (NRMMC et al., 2006) and is recommended in these guidelines for Victorian recycled water schemes. The AGWR also state that a chemical guideline value is the concentration or measure of a water quality characteristic that, over a lifetime of consumption, will not lead to more than 1 µDALY per person per year. WHO (2017) advises that expressing health-based targets for chemical hazards in DALYs enables comparisons with microbial risks. However, use of the DALY approach for chemicals has been limited in practice due to gaps in knowledge. Instead, chemical hazards are typically managed with reference to health-based guidelines (Section 10).

## 4.6 Quantitative risk assessment

### 4.6.1 Quantification of microbial risk

For predicting and managing recycled water quality, quantitative risk assessment has historically been focussed on microbial risk (commonly termed quantitative microbial risk assessment or QMRA) since the most significant human health hazards in recycled water are microorganisms capable of causing enteric illness. This is covered in the AGWR (NRMMC et al. 2006). However, more recently there has been an increasing awareness among water industry professionals of the issue of antimicrobial resistance strains and genes. There is little data on their removal through the wastewater treatment system and on their fate in the receiving environment.

### 4.6.2 Quantification of chemical risk

In contrast to microbial risk, chemical risk in recycled water has largely been assumed, until recently, to be negligible, as analysis of a wide range of persistent, bioaccumulative and toxic (PBT) organic compounds and heavy metals from wastewater treatment plants around Australia had shown that recycled water typically complied with drinking water guidelines, notwithstanding the reduced exposure to recycled water compared with drinking water (NRMMC et al., 2006).

However, more recently there has been an increasing awareness among water industry professionals of the issue of emerging chemicals of concern such as:

- pharmaceuticals and personal care products (PPCPs)
- endocrine disrupting compounds (EDCs)
- new disinfection by-products (for example brominated and iodinated organics)
- nanoparticles and microplastics
- flame retardants
- domestic chemicals used for cleaning, such as anti-scalants, disinfectants and polishes
- PFAS (per-and poly-fluoroalkyl substances)
- complex mixtures.

New chemical compounds are being identified at a rapid rate. Currently 144 million substances are listed on the *American Chemical Society's Chemical Abstracts Service (CAS)* and around 15,000 new substances are added daily. While not all known substances are in use commercially, it is likely that the number used is in the hundreds of thousands. The *Australian Inventory of Chemical Substances (AICS)* 6 contains over 40,000 substances (NICNAS, 2019) and does not include all substances likely to be used commercially in Australia. These observations can be tempered by the fact that only a small proportion of the substances used commercially are used in high enough volumes to be detectable in source waters or persist through water treatment processes at concentrations close to or above guideline values. Trade waste controls, dilution in the sewer network with other wastewater, and removal through the treatment process via such mechanisms as hydrolysis, biodegradation, partitioning to solids, oxidation, photolysis and volatilisation, act to contain the risk from persistent chemicals in recycled water.

A risk-based approach is required to deal with the numerous substances that could be present. Since the issue of CECs is a water industry-wide issue, there is a need for an industry-wide approach. EPA guidance in the form of acceptable risk assessment methodologies and recommended lists of parameters for monitoring is a helpful starting point (see EPA Publication 1287: *Guidelines for Risk Assessment of Wastewater Discharges to Waterways* Victoria, 2009).

There is a need to assess the variability of the source and treated water quality to determine risks posed by chemicals. For some very low risks schemes which receive largely domestic wastewater and low risk chemical inputs, default approaches to chemical risk monitoring and management may be appropriate. However, for schemes where trade waste inputs are a significant proportion of influent, site-specific assessment will be required.

#### 4.6.2.1 Risk-based approaches

Quantification of chemical risk requires a knowledge of the chemicals of concern, information on their concentration in source waters, particularly raw sewage, an understanding of their removal through the treatment process, end uses of the recycled water, and a tolerable concentration target such as a guideline. The guideline could be a drinking water guideline dose-adjusted to the highest expected exposure among all recycled water end uses (for example firefighting, Table 25.

**Table 22 – Steps in chemical risk quantification and supporting comments**

| Chemical risk quantification step | Comments |
|---|---|
| A list of chemicals of concern (priority chemicals) | Priority compound lists for monitoring can be based on information from trade-waste programs, review of the scientific literature or guidance produced by industry bodies or regulators. |
| Measured or predicted concentrations of priority chemicals in source waters and recycled waters | Information on concentrations of priority compounds in source waters and recycled waters can be obtained from direct monitoring or from the above sources. |
| Removal rate through treatment | Where monitoring is not feasible (for example no satisfactory analytical method is available or the cost is prohibitive) removal rates through treatment can be modelled using specialist tools. For example, a sewage treatment plant (STP) removal estimate can be obtained from the STP module of EPI Suite™ (US EPA, 2012). |
| Tolerable concentration target for limiting end use | A methodology is given in this document for determining dose-adjusted tolerable concentration targets from existing drinking water guidelines. Where no Australian guideline is available, Section 6.5 of ADWG provides a hierarchy of acceptable international guidelines (NHMRC and NRMMC, 2017). Where no Australian or international guideline is available, AGWR Phase 2 (NRMMC et al., 2008) provides methods for derivation of screening values based on available toxicological data. In the absence of high-quality toxicological data, or any toxicological data, conservative low-quality default values are given (for example thresholds of toxicological concern [TTCs]). |

Where low-quality screening values are used to determine tolerable concentration targets, the derivation methodology may contain multiple safety factors (for example see Equation 7 in Section 10.2.1.1) to account for the uncertainty. Such conservative screening values are generally very low and thus easily exceeded. In such cases, an appropriate response is to seek better quality toxicological data.

# 5 Managing the supply system

## 5.1 Distribution, reticulation and plumbing

Water quality must be maintained when storing and distributing recycled water after it has been treated. Recycled water must also be prevented from being used for a purpose for which it is not fit.

Class A schemes require a higher level of risk management compared to traditional agricultural recycling schemes. This is primarily due to the reduced ability of the supplier to tightly control residential behaviour in using the recycled water and greater exposure to a large population. The management aim is to prevent cross-connections and non-compliant uses and include surveillance systems to identify issues promptly.

Risks include, but are not limited to:

- using recycled water for a purpose for which it is not fit due to inadequate identification of the recycled water or failure to implement the required end use controls
- contamination of higher-grade recycled water supply systems, taps or fittings with lower grade recycled water due to cross-connections between the two supplies or misconnections
- pathogen contamination from the use of sewer repair equipment during mains alteration and repair
- pathogen contamination from the environment during mains alteration and repair
- opportunistic pathogen proliferation within recycled water during storage and/or distribution
- environmental impact due to burst mains and flushing events.

Methods to help mitigate these risks include design, construction and installation, and system operation.

Design, construction and installation methods include:

- adoption of suitable codes, such as the *Water Supply Code of Australia* (as amended from time to time, and noting utilities often have their own editions and supplemental codes). This code recommends against retaining permanent cross-connections between the recycled water and drinking water systems within the network downstream of storages
- use an approved and registered air-gap at the inlet to the recycled water storage if drinking water or higher-grade recycled water supply back-up is provided to a recycled water system, Alternative means of backflow prevention may be appropriate but these would need to be justified in HEMP on a case-by-case basis

- develop a process to ensure pipes and meters are only connected to the appropriate pipes that match their designation as being drinking water or a particular class of recycled water
- include a process to inspect new connections in areas that include multiple reticulation lines of recycled water of higher and lower class and/or drinking water, this can be 100 per cent or some other proportion determined based on a risk
- engage design, construction and installation contractors with appropriate accreditation and experience
- conduct regular auditing of contractors' work
- fire hydrants carrying recycled water should be clearly marked (for example, through labelling hydrants and fire plug covers with 'recycled water' and purple-coloured hydrant covers or plug/valve surrounds) and be identified in accordance with the current fire services' guidelines for identifying street hydrants for firefighting purposes.

System operation methods include:

- implement standard operating procedures for managing and maintaining the recycled water system
- devise and implement an appropriate scheduled maintenance program
- ensure that sewer or lower grade recycled water repair tools are not used to repair the higher-grade recycled water mains
- flush higher-grade recycled water systems after recharge if they are potentially contaminated during repair and maintenance work
- manage environmental impacts due to burst mains and flushing events
- assist in the control of biofilm, fouling, sloughing and odour formation, maintaining a disinfectant residual (for example, free chlorine above 0.2 mg/L or combined chlorine above 0.5 mg/L) during recycled water storage and distribution is often helpful. The maintenance of such a disinfectant residual may also be required in some recycled water schemes for public health reasons to control opportunistic pathogens if relevant exposures (for example, small size-class aerosol exposures to at risk groups) are considered likely
- scheme audits should take place periodically to confirm operation is in alignment with the operating procedures.

## 5.2 Special considerations for plumbing

Distributing and storing recycled water continues beyond water supply points to users. The supplier is responsible for inspecting recycled water connections to protect drinking water supply and prevent recycled water consumption.

This includes developing and implementing a risk-based approach that adequately manages health risks to individual property occupants by preventing internal plumbing cross-connections between drinking water and recycled water systems.

A list of preventative measures is provided in Section 22.2.2 Special considerations for plumbing.

While individual approvals from the Victorian Building Authority (VBA) are not required for each household, the VBA conducts audits of plumbing work to ensure work complies with relevant legislation. All plumbing work in Victoria must be carried out by an appropriately qualified and licensed plumber. Plumbing in this context includes but is not limited to: drainage, fire protection, irrigation, mechanical services (including cooling towers), roofing, sanitary, water supply, fire sprinkler systems and backflow prevention.

Contact the VBA on 1300 815 127 or visit www.vba.vic.gov.au for more information.

# 6 Preventative measures for recycled water management

## 6.1 Preventative measures and multiple barriers

Preventive measures are the actions, activities and processes used to prevent significant hazards in recycled water or to reduce the hazards to acceptable levels.

### 6.1.1 Identify existing preventive measures and estimate residual risk

After completing the hazard identification and risk assessment, the compiled risk register can be used to identify preventative measures (existing or new) against each identified risk. This approach ensures that the level of protection to control a hazard is proportional to the associated risk. When identifying existing preventive measures, or developing new measures, the following aspects should be considered:

- the entire recycled water system, including the water source, its characteristics and proposed end uses

- existing preventive measures, from the source/s to the recycled water user, for each significant hazard or hazardous event
- increased risk due to inadvertent or unauthorised actions
- spatial aspects when identifying preventive measures for environmental risks, because the sensitivity of receiving environments can vary over space
- areas where recycled water use or discharge is not appropriate. For example, due to environmental sensitivity or soil type topography.

The AGWR lists examples of preventive measures for recycled water systems in the main body of the text and in Appendix 3. End-use controls do not physically prevent the entry or removal of hazards. Rather, these controls reduce risk by controlling exposure. For example, high-quality recycled water might be used for residential and commercial property for non-drinking uses (high potential for human exposure), whereas lower quality recycled water might be restricted to drip irrigation of fruit trees (less potential for human exposure). Although hazards may be present in higher concentrations in the lower quality water, the application of end-use controls ensures that both types of use have a similar level of risk.

End-use restriction relies on user compliance. Experience indicates that monitoring and auditing are required to ensure compliance and should be considered when implementing such measures.

Preventive measures should be applied as close as possible to the source of the hazard, and the focus should be on prevention rather than the sole reliance on downstream treatment or control.

Residual risk is the risk that remains in the presence of preventive measures. Once existing preventive measures have been identified, the risk assessment process outlined above can be used to estimate the residual risk, which indicates if alternative or additional preventive measures are needed to reduce risks further.

### 6.1.2 Multiple barriers

The multiple barrier approach, used to manage drinking water quality, should also be adopted in managing recycled water schemes. In this approach, multiple preventive measures or barriers are used to manage hazards, meaning that reduced performance of one barrier does not result in total loss of management. Importantly, it may be possible to temporarily increase the performance of the remaining barriers while remedial action is taken to restore function of the faulty barrier. In addition, as a combination, multiple barriers produce less variability in performance than single barriers.

### 6.1.3 Identify alternative or additional preventive measures

If the assessment of residual risk indicates that existing measures do not reduce risk to an appropriate level, then alternative or additional preventive measures should be identified. The types and range of preventive measures employed will depend on the source water quality and the end use. The process of selecting these measures will be informed by the hazard identification and risk assessment outlined in Section 4).

## 6.2 Critical control points

Critical control points are preventive measures that are amenable to operational control and are essential for preventing or reducing hazards representing high risks to acceptable levels. Critical control points are particularly important for assuring water quality in centralised schemes.

In the early stages of a recycled water scheme development, the process flow diagram and risk register help to identify important control points, some of which may ultimately be deemed as critical control points.

Identification of critical control points is system specific, based on knowledge of potential hazards and associated risks, and preventive measures. Where possible, each identified hazard should have a critical control point. More than one critical control point may be associated with a single hazard, and a single critical control point may prevent or reduce more than one hazard.

Critical control points should be selected appropriately because they will be the focus of operational control. Too many critical control points can make the system unwieldy, whereas too few can fail to provide adequate assurance of recycled water quality.

Critical control points require:

- operational parameters that can be measured
- operational parameters that have critical limits (see section 6.2.1) which can be set to define effectiveness (for example, chlorine residuals for disinfection)
- operational parameters that can be monitored often enough to reveal any failures in a timely manner (for example, online and continuous monitoring of key treatment processes). In some cases, ‘timely’ may mean monitoring regularly rather than frequently (for example, backflow prevention audits)
- procedures for corrective action that can be implemented in response to deviation from critical limits.

The decision tree shown in Figure 8 can be used to identify critical control points. How a critical control point can be implemented is detailed in Table 30.

### 6.2.1 Critical limits

When critical control points are being used as a preventive measure, critical limits (which can be quantitative or qualitative) must also be defined and validated. A critical limit is a prescribed tolerance that distinguishes acceptable from unacceptable performance. When a critical control point process is operating within critical limits, hazard removal performance is regarded as acceptable. However, deviation from a critical limit represents loss of control of a process and indicates there may be an unacceptable health or environmental risk. Corrective actions should be undertaken immediately to control the process.

### 6.2.2 Alert levels (target criteria)

Suppliers may establish alert levels (also known as target criteria or performance goals) to provide early warning that a critical limit is being approached. Alert levels must be more stringent than critical limits, so that corrective actions can be before an unacceptable health or environmental risk occurs.

For example, where filtration is used, the critical limit might be set at 0.15 nephelometric turbidity units (NTU) and the alert level at 0.1 NTU. Similarly, in setting a minimum lagoon detention time to achieve pathogen or nutrient reduction, a critical limit might be 30 days and an alert level might be 35 days.

Any deviation from established targets should be regarded as a step closer towards loss of control of the process and must result in appropriate actions being taken.

# 7 Verification of recycled water quality and environmental performance

Verification includes monitoring recycled water quality for compliance with the risk assessment. This can include water quality criteria (both environmental and human health protection), soils, plants, terrestrial and aquatic biota, ground and surface water, the infrastructure associated with application or receiving environments, and the assessment of satisfaction of recycled water users.

Verification and validation are independent processes often used together as part of a quality control system. Verification involves testing of a system to prove it meets all its specified requirements (such as regulatory compliance) at a particular stage of development. Validation is often an internal process and by contrast involves testing to ensure the end product meets stakeholders needs and expectations. Validation therefore has a greater focus on external stakeholders.

## 7.1 Aims of verification

Verification of recycled water quality assesses the overall performance of the treatment system, the ultimate quality of recycled water being supplied or discharged, and the quality of the receiving environment. Verification provides:

- confidence for all recycled water stakeholders, including managers, suppliers, users and regulators, in the quality of the water supplied and the functionality of the system as a whole
- confidence that environmental and human health targets are being achieved
- an indication of problems and a trigger for any immediate short-term corrective actions, or incident and emergency responses.

## 7.2 Verification monitoring

Verification monitoring is often combined with a degree of validation (see Section 8) during the initial operation of recycled water schemes. At this stage, verification assesses if a scheme is performing and validation assesses whether a scheme will perform. Verification monitoring is conducted more frequently during the first weeks and months of operation to demonstrate that water quality and receiving environment targets are being achieved. Verification monitoring also provides confidence that the target criteria for water quality will be reliably achieved in the future. For many environmental target criteria, the ultimate verification of a sustainable system may require years of annual monitoring data.

Verification should be regarded as the final overall check that preventive measures are working effectively and that the target criteria or critical limits set from relevant guidelines are appropriate.

Sections 7.2.1 to 7.2.8 provide guidance on how to plan, conduct and assess verification monitoring for recycled water schemes.

### 7.2.1 Characteristics to be monitored

As it is neither physically nor economically feasible to test for all parameters equally, monitoring effort and resources should be carefully planned and directed at key characteristics and hazards identified for the recycled water system. Consideration should be given to the needs of the user, contract requirements, product disclosure and annual reporting requirements to EPA.

Key characteristics that supplier/manager should consider for verification include:

- microbial indicator organisms
- the parameters: salinity, sodicity, sodium, chloride, boron, chlorine disinfection residuals, nitrogen and phosphorus
- any health or environment-related characteristic that can be reasonably expected to exceed relevant guideline values (even if occasionally)
- any relevant characteristic related to the end use or discharge of the recycled water which can be reasonably expected to exceed the guideline value (even if occasionally).

### 7.2.2 Monitoring points

Verification includes regular monitoring to assess if recycled water quality and receiving environments (such as soil, groundwater and surface water) are meeting guideline values, regulatory requirements or agreed levels of service. Assessment of public health requirements is generally undertaken at the entry point of distribution systems. However, in the case of recycled water supplied for domestic non-drinking uses, some monitoring at point of supply to users may be required, particularly for indicators of microbiological quality.

### 7.2.3 Frequency of monitoring

Frequency of monitoring for individual characteristics will depend on variability. Monitoring needs to be frequent enough to obtain data that is meaningful and statistically valid. From a public health perspective, monitoring is required most frequently for microbial constituents, and less often for organic and inorganic compounds. Exposure to microbial pathogens can lead to immediate illness, whereas episodes of chemical contamination leading to acute health concerns are rare, except in the case of a specific event, such as chemical overdosing at a treatment plant. Human health guideline values for most parameters are based on impacts of chronic exposure.

From an environmental perspective, the focus is on chemical rather than microbial monitoring. This is because:

- chemical properties of recycled water are a much greater risk to environmental receptors than pathogens
- human-health requirements far exceed environmental requirements in relation to pathogens.

Some environmental risks are immediate. In these cases, there are usually established target criteria or critical limit values for common species (plants, terrestrial or aquatic biota), particularly if they have agronomic importance. In these cases, monitoring can be less frequent. However, if species do not have known target criteria or critical limit values, more frequent monitoring is required. Many environmental impacts from chemical hazards are based on chronic exposure. To reflect this, monitoring frequency is often monthly or yearly, rather than daily or continuous monitoring. Monitoring frequency will also depend on the level of risk and confidence in preventive measures in place.

### 7.2.4 Monitoring plan

Once parameters and monitoring locations have been identified, these should be documented in a consolidated monitoring plan. Monitoring data should be representative, reliable and fully validated as described in the AGWR (NRMMC et al., 2006). Procedures for monitoring and analysis should be documented in the monitoring plan.

### 7.2.5 Verification monitoring for class A recycled water schemes

Routine assessment should be used to verify whether monitoring for a treatment process performance has worked. Specifically, routine assessments should ascertain the performance of the treatment process and the plant's control approach. Verification monitoring **is not** to be relied upon for system control.

The requirements specified for verification monitoring of class A recycled water are consistent with the requirements of the AGWR. Additional monitoring may be included for:

- source water quality verification
- verification of distribution system operation
- assessment of chemical quality of water, typically monthly for the first 12 months and then quarterly thereafter.

Detection of pathogens or indicators is likely to indicate system failure or contamination. In the event an organism is detected in the class A recycled water, the responsible party must follow the notification procedure in Table 4 of Victorian Guidelines for Water Recycling (publication 1910) and carry out actions:

- notify EPA immediately
- investigate the cause of pathogens or indicators
- implement corrective actions.

**Table 23 – Verification monitoring for class A recycled water1**

| Organism | Frequency | Water quality objective | Limit of detection |
|---|---|---|---|
| *E. coli* | Weekly | No detection | 1CFU or MPN per 100 mL |
| Somatic (or FRNA) bacteriophage | Weekly | No detection | 1PFU per 100 mL |
| Cryptosporidium oocysts | Quarterly | No detection | 1oocyst per 1 L |

[1] The analysis must be undertaken by a laboratory that is accredited by the National Association of Testing Authorities (NATA) to conduct analysis for the specific organism. Where there is no NATA accredited method, the most current version of the American Public Health Association Standard methods for the examination of water and wastewater (Bridgewater et al., 2017) should be adopted.

Source: *Guidelines for validating treatment processes for pathogen reduction. Supporting class A recycled water schemes in Victoria (*DHHS Victoria, 2013*)*

### 7.2.6 Verification monitoring for health-related parameters

Monitoring programs and monitoring frequencies for different types of recycled water schemes (for both operational monitoring of health protection barriers and the verification of health water quality targets) are given in Table 5.6 of the AGWR 2006.

While recycled water quality objectives must be met through treatment, the protection of water quality must extend throughout the recycled water system to the end user. Controls should be in place to manage any downstream risks to water quality. Generic health risks for recycled water storages should be assessed. Table 24 provides some examples of management controls. It should be noted that this list is not exhaustive and additional risks or alternative management controls may be identified in the risk assessment for a specific recycled water system. The management controls in Table 24 relate only to the protection of human health. Aesthetic water quality issues (such as odour due to stagnant water) can also arise in storages and may require management for community acceptance of recycled water schemes.

**Table 24 – Suggested generic management controls to protect water quality in storages**

| Hazardous event | Control measure | Monitoring | Critical limit | Corrective action |
|---|---|---|---|---|
| Blue-green algae growth in uncovered storages | Monitoring | Blue-green algae:<br>• every two weeks in summer<br>• every two months in winter | As per BGA Circular alert levels[1] | Bypass storage and act to reduce algal numbers if possible |
| Miscellaneous hazards | Monitoring/ maintenance | Reservoir inspection:<br>• weekly (uncovered)<br>• monthly (covered) | – | As required to address any identified hazard to water |

[1] Refer to *Victorian Blue-Green Algae Circular* (DELWP, 2018)

### 7.2.7 Verification monitoring for environmental aspects

Environmental monitoring should be risk-based and reflect the risks identified in the risk assessment and the ECPs.

*Sampling and analysis of waters, wastewaters, soils and wastes* (publication IWRG701) (EPA Victoria 2009) can be used to inform an environmental monitoring program.

#### 7.2.7.1 Characteristics to be monitored and monitoring points

Recycled water is commonly applied to land, so there is potential for inadvertent (or intentional) discharge to groundwaters and surface waters. The range of monitoring parameters selected will depend on the impacts, prevention measures and the related target criteria or critical limits determined when assessing the impacts of specific hazards with specific environmental endpoints. Areas requiring monitoring could include:

- soil chemistry and physical properties (for example salinisation, dispersion, structural stability)
- plants, terrestrial and aquatic biota
- groundwater and surface water quality and quantity (levels)
- infrastructure
- air emissions.

Environmental monitoring can include testing for macroinvertebrates and examination of vegetation characteristics, as well as analyses for physical and chemical parameters.

All sites that could be affected by the use or discharge of recycled water may need to be monitored. Regular verification monitoring can, in some cases, be as simple as visual assessment (for example, looking for yellowing or browning of leaves, or ponding), with follow-up action if there are concerns.

Such visual inspection may be a very important part of verification for small scale or on-site stems.

#### 7.2.7.2 Groundwater

A groundwater monitoring program is suggested best practice where the supplier has determined that recycled water use poses significant risks. Such a program may not be needed if an impact assessment demonstrates that there is no significant risk to the groundwater in the short and long term.

The objectives of a groundwater monitoring program are to provide early warning of changes in groundwater quality and to measure the effectiveness of site controls in minimising groundwater impacts. The SEPP (Waters) specifies the beneficial uses of groundwater that require protection and the quality of groundwater that must be maintained to ensure their protection. Monitoring programs should report against the SEPP's recommended objectives.

A groundwater monitoring program typically:

- specifies the parameters to be monitored, noting that standard groundwater parameters include static water level, salinity (electrical conductivity) and nitrogen parameters ($NO_3$ and $NH_3$)
- defines appropriate monitoring locations, noting that bores are typically located up gradient and downgradient of the irrigation area and the storage lagoon
- monitors for parameters that would indicate risks to identified end-users of groundwater (for example, agriculture, recreation, irrigation or residential users)
- specifies monitoring frequencies.

Groundwater is typically monitored for the standard parameters at least every four months for the first 12 months of a recycled water scheme's operation. After that, monitoring is required every six months (winter/summer season). The frequency of monitoring be modified later, based on the results/trends obtained.

Personnel with hydrogeological expertise can be consulted to help develop a program appropriate to the identified risks.

#### 7.2.7.3 Soil

A soil-monitoring program for major water recycling schemes typically:

- specifies which parameters are to be monitored and would generally include (as a minimum) pH, electrical conductivity, exchangeable cations, total nitrogen, phosphorus, potassium, total cation concentration and SAR
- specifies the frequency of monitoring. Soil is typically analysed at least every two to three years (including initial baseline monitoring) to determine trends
- specifies monitoring locations. The number and location of monitoring points depend on the distribution of soil types. If there is little variation, three to five sites (which can be composites) may be sufficient for five to ten hectares. More sites are required for complex land systems.

The properties of the recycled water, and the characteristics of the soil should also be considered in the monitoring program and influence the range of parameters tested. For example:

- if the recycled water contains significant heavy metals and organic or inorganic contaminants, these compounds would typically be searched for in the soil
- standard soil fertility parameters are typically be monitored according to the crop or pasture's specific fertiliser management approach and sustainable yield
- major soil layers should be identified for each sampling pit detailing soil texture, structure, cracking, colour, moisture, rocks and stones, and other biological features
- soil moisture is usually monitored regularly to determine irrigation scheduling rates.

The parameters tested in the soil may vary from what's listed above, based on the advice from an appropriately qualified agricultural consultant or soil scientist.

Personnel with expertise in soil science may be consulted to help develop a soil-monitoring program.

#### 7.2.7.4 Stock and produce monitoring

Stock grazed on pasture irrigated with recycled water should be inspected and monitored in accordance with the *Livestock Diseases Control Act 1994*. Monitoring for produce is typically described as part of the farm's food safety QA plan.

The development of the monitoring program may consider guidance material such as the alert level of 10 *E. coli* CFU per gram of produce described in the *Guidelines for Fresh Produce Food Safety (FPSC, 2015)*.

#### 7.2.7.5 Baseline and validation monitoring data for environmental assessment

Baseline monitoring is an important component of establishing a recycled water scheme. Risks to the environment are often calculated and managed relative to the baseline, rather than using absolute guideline values. Environmental data is often highly variable because of natural annual and seasonal climatic variability. The more comprehensive the understanding of this variability, the easier it is to monitor and assess specific environmental changes introduced in the future through the use of recycled water.

In many cases, the baseline information underpins the risk assessment process. Comprehensive baseline data enables a better estimate of actual risk levels, since it allows changes in the environment to be assessed relative to the baseline. It also allows for an interpretation of guideline values for site-specific exceedances of relevant target criteria or critical limits for environmental protection.

Short-term environmental validation monitoring can be used for specific restrictive barriers, to determine if treatment processes or source control programs are meeting environmental target values or critical limits. Short- or long-term experiments and trials can be used to validate target values and critical limits for specific environmental endpoints or end-use restrictions.

Validation is particularly important for innovative preventive measures. For example, it may be necessary to validate a new irrigation method (such as subsurface drip irrigation) if it is being used on plants that have not been grown using this method before. When growing a plant that has no known salinity sensitivities, the tolerance of the plant to the salinity of the recycled water may need to be validated.

Due to the diverse nature of environmental monitoring, and the complexities of how target criteria and critical limits relate to specific environmental endpoints, it is often important to determine baseline values for specific endpoints. These baseline values can be used to determine any changes in environmental endpoints due to the recycled water use, as measured by the verification monitoring program (discussed below). The baseline monitoring is intended to reflect the specific environmental endpoints and be related directly to the verification monitoring program.

### 7.2.8 Verification of industrial water quality

Industrial water quality needs to be continuously verified, both at the source and end use. This will involve monitoring, but only as appropriate (not necessarily continuous online monitoring). Verification monitoring programs can be developed based on the risk assessment and can be reflected in the appropriate document (for example, by either suppliers as part of their supply agreement, or end users as part of their user site management plan and risk management).

It is important to identify what parameters and characteristics need to be monitored, at what point in the process, and how often they need to be monitored. For example, visual monitoring at source and/or end use may be sufficient if the main parameter of concern can be visually identified, while in other cases, testing may be required at source and/or end use to ensure certain quality levels are appropriate.

The user site management plan can set out the verification program including monitoring and analysis, and responsibilities. In many cases, monitoring and QA of industrial water quality will be the supplier’s responsibility as part of their supply agreement. In other cases, it may be the end user’s role to verify water quality immediately prior to use. This will depend upon appropriate expertise, resources and the contents of the contract.

# 8 Validation, research and development

Validation involves evaluating available scientific and technical information (including historical data and operational experience) and, where necessary, undertaking investigations to validate system-specific operational procedures, critical limits and target criteria.

Research and development have an important role to play in the recycled water management. Undertaking and participating in research allows for the continuous improvement of the recycled water scheme in terms of environment and health risk management.

## 8.1 Validation of processes

The aim of process validation is to ensure effective operation and control of the recycled water system. Validation is particularly important for innovative hazard-control processes and for schemes involving relatively high exposures (for example, residential use). In these cases, validation may be divided into stages, starting with evaluation of existing information. This is then followed by pilot trials and pre-commissioning testing of full-scale plants. Pilot trials and pre-commissioning normally incorporate water quality monitoring. In some cases, validation may include evaluation of specific end-use restrictions for human health or environmental protection. Seasonal variations should be considered in designing validation programs.

Validation monitoring can also be combined with verification monitoring (Section 7.2) in initial periods of post-commissioning testing of new recycled water schemes.

Processes should be revalidated when variations occur that may affect performance of processes (for example, impacts of changes to primary or secondary treatment processes on downstream filtration or disinfection). Any new processes should be tested using bench-top, pilot-scale or full-scale experimental studies to confirm that the required results are produced under conditions specific to the individual water supply system.

## 8.2 Validation monitoring

Validation monitoring is used to determine if preventive measures are capable of adequately controlling recycled water quality and exposure levels within the bounds required to achieve health and environmental target criteria. As far as practicable, validation monitoring should be completed before recycled water is supplied for its ultimate intended uses, although it may continue into a pilot-testing period.

As full validation is usually only performed once for each system configuration, it should be thorough. For example, full validation might involve checking that every recycled water pipe, connection, tap and irrigation system is properly marked, and that fittings and labelling methods for controlling uses are as intended. Although this initial activity is extensive and time consuming, it can be delegated to appropriately skilled professionals.

### 8.2.1 Validation monitoring for health risks

Due to potential health risks from use of recycled water, log reductions assured by designers and manufacturers of treatment systems, or by user group representatives, cannot be assumed to be valid. This means that some objective empirical evidence of the log reductions is required. The precise nature of this evidence depends on the nature of the barriers. The AGWR (NRMMC et al., 2006) gives examples of validation monitoring for health risks.

For validation monitoring for class A recycled water schemes, suppliers and managers of recycled water should refer to the following sections for validating treatment processes for pathogen reduction. The guidelines focus on managing the acute health risks posed by pathogens in recycled water, and therefore only address the validation of treatment processes to meet microbial water quality objectives.

### 8.2.2 Treatment validation monitoring of class A recycled water schemes

For class A recycled water schemes, the *Guidelines for validating treatment processes for pathogen reduction: supporting class A recycled water schemes in Victoria* (DoH Victoria, 2013) distinguish treatment validation from other forms of validation. The guidelines describe treatment validation as the process for demonstrating that:

- a treatment system can produce water of the required microbial quality under a defined range of operating conditions
- the system can be monitored in real time to provide assurance that the water quality objectives are being continuously met.

The process of treatment validation correlates the direct evidence of a treatment process' ability to remove the target pathogens of concern (for example, through one-off challenge tests) with data from operational monitoring (for example, through disinfectant residual monitoring or membrane integrity testing).

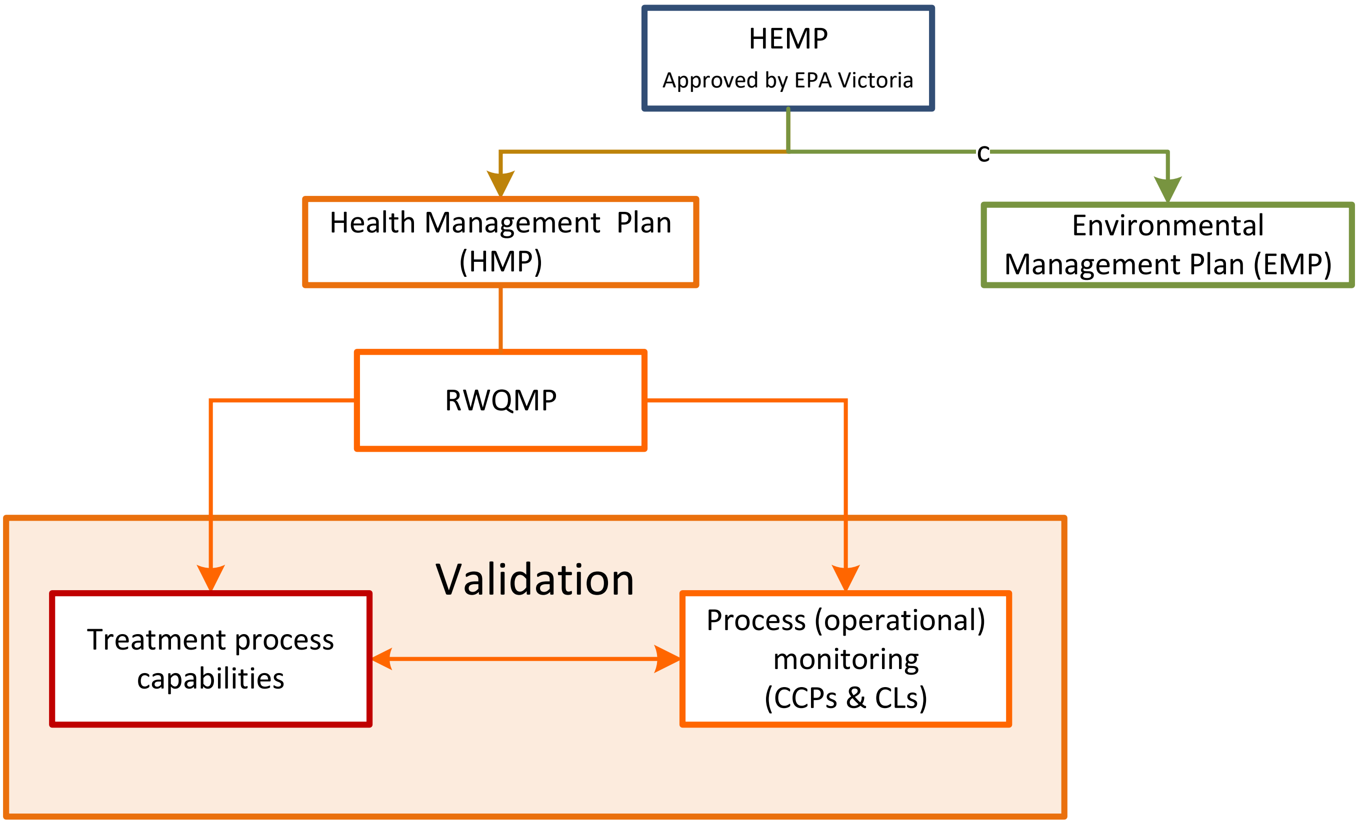
The operational monitoring parameters are used to demonstrate that the system is performing reliably and that any events or conditions that could lead to system failure are rapidly detected. This allows for immediate corrective action to prevent the supply of unacceptable quality water.

### 8.2.3 Validation and the approval process for class A recycled water schemes

The validation of treatment processes to produce class A recycled water quality is a key component of the approval process for class A recycled water schemes. The evidence of validation is provided through the RWQMP. Treatment validation can be undertaken by a scheme manager, a manufacturer or a research body. The scheme manager is required to provide evidence and interpret it for the specific application of treatment validation. This evidence needs to demonstrate that the treatment objectives will be met by the equipment and will be assessed by EPA as part of the review of the RWQMP for the supply of class A recycled water.

Typically, treatment validation is undertaken once, unless the system or its operating conditions are modified. However, some treatment process units (for example, membranes that are relied upon for virus reduction) may require ongoing periodic validation where performance degradation is known to occur over time.

**Figure 6 - Validation in the context of the approval process of class A recycled water schemes in Victoria**




### 8.2.4 The relationship of validation for class A water recycling schemes to AGWR monitoring categories

Treatment validation as described above encompasses the activities described in the AGWR as 'validation monitoring' and 'operational monitoring'.

For class A water recycling schemes, the validation process encompasses both validation monitoring and operational monitoring. This is to ensure the system's capability to reduce pathogens is quantified within a defined operational monitoring regime. The sensitivity of operational monitoring parameters to measure the efficacy of the treatment process for pathogen reduction is also determined. Validation monitoring is undertaken as part of the initial validation process. Operational monitoring is undertaken concurrently with validation monitoring. However, operational monitoring continues as part of routine operation, providing evidence of control.

Baseline and verification monitoring (see Section 7.2), support the validation monitoring framework. Baseline monitoring provides useful data to inform operational critical limits at the plant. For example, baseline monitoring can provide information on temperature, pH ranges and ammonia levels for chlorine disinfection and ultraviolet transmissivity.

Verification monitoring confirms that the control philosophy has been effective, and that microbial risk has been reduced to an appropriate level. However, verification monitoring is not to be relied upon for system control.

## 8.3 Design of equipment

Research and development should be undertaken when designing new equipment and infrastructure, or when implementing design changes to improve plant performance and control systems. New technologies require pilot-scale research and evaluation before full-scale implementation. Design specifications should be established to ensure that new equipment is able to meet the intended requirements and provide necessary process flexibility and controllability.

Other considerations for ensuring the reliability of water treatment systems include designing equipment and facilities to withstand natural disasters (for example, earthquakes and flooding) and also providing backup systems for emergencies (for example, alternative power generation). Appropriate consideration of these factors during the design phase will reduce the risk of equipment failures which could cause major disruptions in service or pose risks to human health or the environment.

## 8.4 Research and development

As part of the recycled water management process, there is value in undertaking and participating in research that allows for the continuous improvement of the recycled water scheme in terms of environment and health risk management.

Increased knowledge of potential hazards, (in particular, chemical hazards, antimicrobial resistance and emerging pathogens), and how these issues can be managed, are vital to the successful and safe uptake of industrial water and trade wastewater as an alternative water source.

To increase the efficiency and effectiveness of research and development activities, recycled water scheme managers and suppliers may seek to work collaboratively with other businesses within their industry sector, or those facing similar issues. If research and development opportunities are being explored, the HEMP may include or refer to the relevant document/s that describe/s the research and development. This can include who is responsible for the associated tasks, such as exploring research opportunities, conducting literature reviews, developing research programs, reporting and sharing of outcomes.

Ongoing review and improvement are essential to ensure that the HEMP remains relevant and new information is used to revise and improve the HEMP. Local research increases the understanding of specific characteristics of individual water supply systems. It may range from investigating mechanisms to optimise treatment plant performance, to analysing variation in recycled water quality parameters and their relationship with soil changes in residential areas.

Applied research and development may be directed towards:

- increasing the understanding of potential hazards within the specific catchment – for example, through:
  - examining the chemical quality of sewage to identify potential sources of industrial discharges
  - assessing trade waste agreements to identify chemical contaminants or antimicrobial resistance genes that may be discharged into source waters
  - examining seasonal or outbreak impacts on the microbial quality of sewage and recycled water
  - monitoring source water to understand the temporal and spatial variability of water quality parameters
- investigating improvements, new processes, emerging water quality issues and new analytical methods
- validating the operational effectiveness of new products and processes
- improving assessments of potential impacts of recycled water on human health, soils and other receiving environments
- improving measurements of potential exposures to recycled water (for example through aerosols, consumption of irrigated crops and irrigation of household gardens)
- assessing epidemiological effects of recycled water schemes
- assessing quality of products grown using recycled water, in comparison with similar products grown using alternative sources of water
- mechanisms to improve and optimise plant performance and evaluate treatment processes (including the validation of critical limits and target criteria) and the design of new equipment
- improving assessments of potential impacts of recycled water on soils and other receiving environments
- detailed analysis of temporal and spatial variations in source water quality parameters, and their relationship to soil and groundwater changes at receiving sites
- community attitudes, behaviours and effectiveness of education programs on recycled water.

Research activities should be carried out under controlled conditions by qualified staff. All protocols and results should be documented and recorded. Participation in research and development activities through partnerships and industry-wide cooperation can be a cost-effective way to address broader issues associated with recycled water quality and treatment.

## 8.5 Understanding of programs to improve management

Investigative studies and research monitoring include strategic programs designed to:

- increase understanding of a water supply system
- to identify and characterise potential hazards
- to fill gaps in knowledge.

For example, recycled water quality can vary over a wide range. An improved understanding of factors that affect water quality can lead to a better understanding of preventive measures required to improve management of recycled water systems. Improved understanding could enable operators and suppliers to anticipate periods of poor source water quality and develop responses.

Other examples of strategic programs include:

- baseline monitoring of parameters or contaminants, or testing of potential new water sources to identify water quality problems
- source water monitoring to understand the temporal and spatial variability of water quality parameters
- developing early-warning systems to improve the management of poor water quality
- event-based monitoring to determine the magnitude of impacts (duration and maximum concentrations)
- examining chemical quality of sewage to identify potential sources of industrial discharges
- assessing trade-waste agreements to identify chemical contaminants that may be discharged into source waters
- studying the movement of water within storages, including lagoons and wetlands, to determine real detention times and to identify short-circuiting effects
- examining seasonal or outbreak impacts on microbiological quality of sewage and treated recycled water.

# 9 Employee, operator, contractor and end user awareness and training

It is important to ensure that employees (including operators and contractors) and end users are adequately trained in the operational aspects of their work and understand the potential impact of their actions on the safety of a recycled water scheme. Awareness and training are important, because the knowledge, skills, motivation and commitment of operators, contractors and end users ultimately determine:

- a recycled water supplier's ability to successfully operate a water supply system and maintain the exclusion barriers used for preventive measures
- the effectiveness of end-use restriction barriers used as preventive measures.

Employees and end users need to be aware of the potential consequences of system failure, and of how decisions can affect public and environmental health. The recycled water supplier or end user, as applicable, should ensure that training needs are identified, that adequate resources are available for training, and that they document and maintain records of all employee training.

## 9.1 Employee awareness and training

For the successful operation of the recycled water scheme, it is essential that employees' training needs are identified, and that they are adequately trained. This requires training in the methods and skills needed to perform their tasks efficiently and competently. Ideally, employees should be trained to national water industry operator certification level. Depending on the role of the employee, training may need to cover:

- the principles of risk management
- knowledge and awareness of the HEMP, including roles, responsibilities and liabilities
- the recycled water system, including its operation and the preventive measures that are in place to ensure public and environmental health protection
- safe work practices to control the risk of employee exposure to hazards
- the organisation's protocols and policies for the system, such as system management and maintenance, monitoring and analysis of water, consumer complaints, or incident and emergency plans
- statutory requirements relating to the recycled water system
- the roles and responsibilities of individuals and agencies that relate to the recycled water system, both internal and external to the organisation
- how their actions can affect water quality, and public and environmental health
- the documentation, reporting and auditing of the system.

Training can take place in several forms. It may include formal induction or training sessions (in-house or external), seminars, courses, manuals, newsletters, briefings and meetings, and should encourage employees to communicate and think critically about the operational aspects of their work.

### 9.1.1 Identify training needs and resources

Specific training needs of employees should be identified. The degree of training required by an employee, or employees, will depend on their role. For some employees, their actions will have potential to impact on the health and environmental safety of the scheme. Treatment process operators in particular are critical in the production of safe water, and must have a sound understanding of the HEMP, and if operating a class A recycled water scheme, the RWQMP. They should have detailed knowledge of the purpose of the CCPs in a treatment process and the significance if critical limits for these are not met.

As a minimum, all operators and contractors should be aware of:

- general water quality
- water microbiology and water chemistry
- soil and groundwater chemistry.

Specific training to optimise recycled water system performance, such as principles of:

- recycled water treatment, including primary, secondary and tertiary treatment
- trade-waste control
- irrigation management (for agricultural, municipal and urban uses)
- hydraulic, nutrient and contaminant balances at sites of use or discharge
- application of plumbing codes relating to recycled water and dual water supply systems
- operation of filtration plants
- disinfection system operation
- distribution management
- monitoring and analysis of recycled water, soils, groundwater and surface water
- interpretation and recording of results
- maintenance of equipment.

Employees of water suppliers and contractors should also be trained in other aspects of recycled water quality management, including incident and emergency response, documentation, record keeping and reporting. The below highlights some of the issues to be considered when using contractors.

**Contractors**

In many cases, water suppliers rely on contractors to provide services in support of recycled water schemes. In some cases, more than one contractor might be involved in a scheme. For example, separate contractors might be involved in construction, operation of treatment processes, operation of distribution systems, and monitoring and analytical work.

Contractors need to have the same level of awareness, training and skills as the organisation's employees in relation to the tasks being performed. Requirements for contractor acceptability should be established, and contractors should be evaluated and selected on the basis of their ability to meet the specified requirements.

A recycled water supplier should ensure that contractors are qualified and have undergone appropriate training related directly to their task or role. When contracting labour, the organisation should ensure that contractors are educated and trained as necessary on the requirements for adherence to the organisation's policy and protocols.

Conditions under which the contractor operates should be clear, accurate and achievable, with scope for ongoing review and improvement. Contractor's quality management systems should be considered among the prerequisite programs for HEMPs and RWQMPs. Partnerships will be more successful where the recycled water supplier retains sufficient knowledge and technical expertise to manage the contract efficiently.

Revised from the AGWR (NRMMC et al., 2006).

Training programs should be adequately resourced, as sound training is fundamental to the operation of the recycled water system. Where possible, accredited training programs and certification of operators should be used.

### 9.1.2 Documentation

The HEMP should include or refer to the document(s) that describe(s) the employee awareness and training program, including who is responsible for the associated tasks (for example, conducting training, developing awareness materials and signage and ensuring all staff have attended training).

All training activities should be documented, and the records of employees who have participated in training maintained. Auditors will seek such information as evidence of employee competence. Mechanisms for evaluating the effectiveness of training should also be established and documented.

## 9.2 End user awareness and training

End users should be made aware of the importance of end use restriction and barriers. Awareness is required to support compliance with end use controls and best management practice. It is important to ensure that end users understand why restrictions and management requirements are necessary, and the implications to human health and the environment of not complying with them.

In practice, the level of awareness required, and the way that it is delivered, will be very different depending upon the nature of the end user, use and context. For instance, for high quality recycled water in a residential or commercial property setting, the focus will be on preventing cross-connections and understanding limitations on permitted uses. In contrast, much more extensive awareness and training may be required for users such as irrigators who may use class B or C water and are relied upon to follow restrictions.

Employees and staff working with industrial water need to be aware and appropriately trained in any relevant procedures and processes, and their responsibilities (for example, trained in monitoring processes and aware of incident and emergency management procedures). Relevant employees need to be aware and competently trained to ensure the necessary risk management controls are effective.

As a minimum, all end users should be aware of:

- restrictions on recycled water use
- self-testing of cross connections
- plumbing modifications and cross connection testing
- management requirements that are essential to ensure sustainable recycled water use
- any practice that will threaten human or environmental health.

Specific areas of training for particular end users might include:

- appropriate use of recycled water
- storage of recycled water
- algae control and identification
- environmental risks
- nutrient, fertiliser and soil conditioner management
- managing salinity and sodicity
- irrigation scheduling and performance
- drainage and run-off controls
- signage and pipe identification
- good practice, health and safety
- incident and emergency response
- monitoring
- documentation, record keeping and reporting
- new end users (capturing the change in ownership of properties and licences for recycled water use).

# 10 Health-based targets

## 10.1 Microbial risk

Once tolerable risks are established (see Section 4.5), health-based targets (HBT) can be set. HBTs are benchmarks that each recycled water scheme must meet to ensure the risk (measured in µDALYs per person per year) is not exceeded.

Performance targets are compulsory reductions in hazard concentrations. Performance targets can be:

- measures such as treatment processes which aim to reduce hazards
- onsite controls which aim to reduce both hazards and exposure.

There are many hundreds of microbial waterborne pathogen species in raw sewage, the total risk is dominated by a smaller number of species. WHO (WHO, 2017) advocates a practical approach to microbial risk assessment. This approach involves selecting reference pathogens for each group of pathogens (for example, bacteria, viruses, protozoa and helminths) based on their level of risk then deriving a target for each of these pathogens. The use of reference pathogens accounts for variations in:

- susceptibility to treatment
- prevalence of waterborne transmission
- source water characteristics.

The most common application of performance targets is to identify the most appropriate combinations of treatment processes that reduce pathogen concentrations so that HBT are met. Performance targets are normally expressed as log reductions.

Treatment processes must be selected based on evidence that they will meet required performance targets (see validation Section 8).

Performance targets are dependent on the hazard concentrations of the source water. Therefore, targets for sewage will generally be less conservative than for other types of wastewater.

## 10.2 Chemical risk

Tolerable risk is defined in terms of guideline values. This is the approach taken in the AGWR (NRMMC et al., 2008) and the ADWG (NHMRC and NRMMC, 2017). For chemicals with threshold effects, guideline values are typically based on the highest dose that causes no adverse effects (also known as 'no observed effect level', or NOEL) multiplied by safety factors. For chemicals with no demonstrated threshold, such as carcinogens, the guideline values are based on concentrations that would result in one additional cancer per one million people following a lifetime of consumption.

Suppliers should have a risk-based monitoring program, including periodic monitoring for the presence of toxicants such as heavy metals and organic chemicals in recycled water. The monitoring program should be reviewed when:

- modification to a treatment plant process commences operation
- significant changes occur within the sewerage catchment (such as new or modified trade and/or industrial waste connections).

Reviews should also be undertaken periodically according to the size of the treatment facility and potential risks of the associated recycled water schemes.

### 10.2.1 Chemical guideline derivation

Although recycled water is not approved for drinking in Victoria, drinking water guidelines can be used to determine health-based guidelines for recycled water. This can be achieved by adjusting for the lower dose involved in recycled water exposures. The formula used to derive drinking water guidelines includes a factor for exposure volume (the amount of water ingested). For drinking water, this volume is 2 L/day. In contrast, exposure volumes for standard recycled water exposures described in the AGWR are much less, with the maximum non-drinking exposure (such as firefighting) is 2.74 mL/day.

#### 10.2.1.1 Threshold and non-threshold chemicals

For threshold chemicals, the guideline development methodology is described in the ADWG (NHMRC and NRMMC, 2017) and AGWR (NRMMC et al., 2008). There are several versions of the derivation equations that consider if a substance is a threshold or non-threshold chemical; a pharmaceutical; or has published values for Acceptable Daily Intake (ADI).

The equations all have a similar form; a detailed methodology is given in the *AGWR Phase 2 Guidelines* (NRMMC et al., 2008). The following examples are for (i) a threshold chemical for which the available toxicity data is limited to animal studies and (ii) a non-threshold chemical with a slope factor published by a reputable source.

**Equation 7 – Threshold chemical**

$$GL\ (mg/L) = \frac{NOEL\ (mg/kg/day) \times bw(kg) \times P}{SaF\ \times V\ (L/Day)}$$

Where:
GL = guideline value
NOEL = no observed effect level from chronic animal study
bw = assumed average Australian adult (70 kg) or 2-year-old child (13 kg)
V = volume of water consumed – for firefighting this is 0.00274 $L.day^{-1}$
P = proportion from water, default value is 10% (so P=0.1)
SaF = a safety factor of up to 10,000, allocated according to advice in ADWG, defaults are

x 10 for interspecies variation (animal to human)
x 10 for intraspecies variation (human variation)

The carcinogenicity of non-threshold chemicals is characterised by experimental determination of potency (by derivation of a 'slope factor'). Using the slope factor, combined with a target risk of one in one million ($1 \times 10^{-6}$), the resulting guideline would mean that one additional cancer per one million people following a lifetime of water consumption could be expected at the guideline concentration.

**Equation 8 – Non-threshold chemical**

$$DW\ GL\ (mg/L) = \frac{Risk\ (1\ \times\ 10^{-6}) \times P\ (0.1) \times bw\ (70\ kg)}{SF\ (slope\ factor\ (mg/kg\ /day)^{-1}) \times V\ (L/day)}$$

Where:
DW GL = Drinking Water Guideline
Risk is the target tolerable cancer risk
bw = assumed average Australian adult (70 kg) or 2-year-old child (13 kg)
V = volume of water consumed – for firefighting this is 0.00274 $L.day^{-1}$
SF = slope factor $(mg/kg/day)^{-1}$; a cancer potency factor derived from a reputable scientific source, for example peer reviewed scientific literature, US EPA IRIS data (US EPA, 2018)

### 10.2.2 Guideline performance targets

To carry out a chemical risk assessment, use the recycled water guideline for each default exposure scenario listed in Table 25 which are determined by  recalculating the drinking water guideline values. This is based on the proportional reduction in dose (see item "V" for daily volume consumed in Equation 7 and Equation 8 in Section 10.2.1.1), compared to the recalculated guideline value, using the recycled water for an exposure equivalent to drinking water.

**Table 25 – Recycled water intended uses and exposure grouped by major exposure categories**

| Use | L/event | Events/year | L/year | L/day | mL/day |
|---|---|---|---|---|---|
| Drinking water | 2 | 365 | 730 | 2 | 2000 |
| | | | | | |
| Commercial lettuce | 0.005 | 70 | 0.35 | $9.59 \times 10^{-4}$ | 0.96 |
| Commercial other | 0.001 | 140 | 0.14 | $3.84 \times 10^{-4}$ | 0.38 |
| Total commercial | | | 0.49 | $1.34 \times 10^{-3}$ | 1.34 |
| | | | | | |
| Garden sprays | 0.0001 | 90 | 0.009 | $2.47 \times 10^{-5}$ | 0.02 |
| Garden ingest | 0.001 | 90 | 0.09 | $2.47 \times 10^{-4}$ | 0.25 |
| Garden accident | 0.1 | 1 | 0.1 | $2.74 \times 10^{-4}$ | 0.27 |
| Home lettuce | 0.005 | 7 | 0.035 | $9.59 \times 10^{-5}$ | 0.1 |
| Home other | 0.001 | 50 | 0.05 | $1.37 \times 10^{-4}$ | 0.14 |
| Total garden | | | 0.284 | $7.78 \times 10^{-4}$ | 0.78 |
| | | | | | |
| Toilet flushing | 0.00001 | 1100 | 0.011 | $3.01 \times 10^{-5}$ | 0.03 |
| Washing machine | 0.00001 | 100 | 0.001 | $2.74 \times 10^{-6}$ | 0 |
| Cross connection | 1 | 0.365 | 0.365 | $1.00 \times 10^{-3}$ | 1 |
| Total internal | | | 0.377 | $1.03 \times 10^{-3}$ | 1.03 |
| | | | | | |
| Total residential (garden + internal) | | | 0.661 | $1.81 \times 10^{-3}$ | 1.81 |
| | | | | | |
| Municipal irrigation | 0.001 | 50 | 0.05 | $1.37 \times 10^{-4}$ | 0.14 |
| | | | | | |
| Total residential + municipal | | | 0.711 | $1.95 \times 10^{-3}$ | 1.95 |
| | | | | | |
| Fire fighting | 0.02 | 50 | 1 | $2.74 \times 10^{-3}$ | 2.74 |

Source: Derived from Table 3.7 of AGWR, Phase 1, page 100; NRMMC et al. 2006).

## 10.3 Preventive measures to achieve HBT

Unrestricted exposure to hazards in inadequately treated recycled water can lead to unacceptable risks (above 1 µDALY per person per year). Consequently, the safe use of recycled water requires strategies (preventive measures) to reduce exposure to hazards by:

- preventing hazards from entering recycled water (Section 10.3.1)
- removing them using treatment processes (Section 10.3.2)
- reducing exposure, either by using preventive measures at the site of use or by restricting uses (Section 10.3.3).

### 10.3.1 Preventing entry of hazards into recycled water

While some hazards are an intrinsic property of source waters (for example, pathogens in sewage), others may potentially be controlled at source by restricting their discharge into the source collection system. For example, trade waste management can be used by water companies to manage chemical hazards discharged to sewer (see Section 12.2 ), setting acceptance limits for tankered waste received at the treatment plant, community awareness to prevent illegal input into sewer etc.

### 10.3.2 Removing or reducing hazards using treatment processes

Hazard concentrations can be reduced using various treatment processes. These can be used on their own or in combination with other controls. Reduction levels are determined by key design features of treatment system and by the intrinsic properties of the hazard. For example, different chemical hazards resist biodegradation and oxidation through treatment processes to varying degrees. Similarly, different pathogen groups respond differently to treatment processes, depending on their capacity for physical removal or inactivation.

The AGWR7 (NRMMC et al., 2006) summarises indicative removal rates of microbial hazards that can be achieved using identified treatment processes.

### 10.3.3 Reducing exposure through site controls

There are a range of preventive measures that reduce risk by lowering exposure to recycled water. These preventive measures can include:

- restricting uses of recycled water
- controlling methods of application
- setting withholding periods between the application of recycled water and use of irrigated areas or harvesting of produce
- cross-connection controls
- controlling public access during application or use of recycled water
- using signage, labelling and communication to minimise accidental exposure.

Each of these approaches is discussed in more detail in Section 11.

Estimates of microbial hazard exposure reductions provided by onsite preventive measures are given in the AGWR. However, the effectiveness of these measures requires further research. As such, the AGWR notes that this type of control measure should be applied in conjunction with education of users and monitored using surveillance and auditing.

# 11 Preventative measures to manage risks

## 11.1 Site control measure for restrictions for pathogen management

There are several site controls to manage pathogen risks which focus on minimising people's exposure to recycled water. Exposure reductions provided by on-site preventive measures are given in the AGWR (NRMMC et al., 2006) and examples are shown in Table 26. Such controls require reducing exposure to the pathogen or selecting appropriately treated recycled water (class A, B or C) and using it appropriately (Table 26).

For all residential and industrial recycling schemes where there is a risk of cross-connections with potable water systems, cross-connection controls are required. These include ongoing education of customers and plumbers, as discussed in Section 5.

**Table 26 – Acceptable uses and irrigation methods to use as preventive measures**

| Recycled water use category or exposure | Acceptable Classes | | | Irrigation controls | Withholding period controls | | Helminth controls |
|---|---|---|---|---|---|---|---|
| | A | B | C | B and C | 4 hrs | 5 days | |
| **Urban and industrial uses** | | | | | | | |
| Residential, unrestricted public access, open industrial systems | Y | N | N | None | None | None | Y |
| Restricted public access, closed industrial systems | Y | Y | Y | Withholding periods | Y | None | N |
| **Agricultural uses (non-livestock)** | | | | | | | |
| Raw human food crops exposed to recycled water | Y | N | N | None | None | None | Y |
| Crops grown over 1 metre above the ground and eaten raw (for example apples, pears, apricots, table grapes, olives) | Y | Y | Y | No food contact with recycled water via irrigation method[C], dropped product not to be harvested | None | None | N |
| Crops which are skinned, | Y | Y | Y | As above, and not to be wet from | None | None | N |

| Recycled water use category or exposure | Acceptable Classes | | | Irrigation controls | Withholding period controls | | Helminth controls |
|---|---|---|---|---|---|---|---|
| | A | B | C | B and C | 4 hrs | 5 days | |
| peeled or shelled before consumption (for example lemons, limes, nuts, watermelons, rockmelons) | | | | recycled water when harvested. | | | |
| Crops to be cooked (>70°C for 2 minutes) or processed before sale to consumers[A] (for example wheat, wine grapes) | Y | Y | Y | None | None | None | N |
| Cooked or processed human food crops not directly exposed to recycled water[E] | Y | Y | Y | None | None | None | N |
| Non-food crops, woodlots, turf, flowers | Y | Y | Y | None | None | None | N |
| **Livestock uses and exposure (pasture use refers to dry or ensile fodder)** | | | | | **Pasture use (Class B and C)** | | **Helminth controls** |
| Livestock (drinking) water[B] | Y | Y | N | None | N | N | Y |
| Washdown water for dairy sheds (NOT milking machinery) | Y | Y | N | None | N | N | Y |
| Irrigation of pasture and fodder for dairy animals (to minimise udder and milk exposure) | Y | Y | N | Withholding periods | Y | N | Y |
| | Y | Y | Y | Withholding periods | N | Y | Y |
| Irrigation of pasture and fodder for beef cattle | Y | Y | Y | Withholding periods | Y | N | Y |
| Irrigation of pasture and fodder for sheep, goats, horses | Y | Y | Y | None | N | N | N |
| **Change in land use post recycled water use without helminth controls** | | | | | | | |
| Exposure of cattle or pigs to grazing area where helminth reduction not implemented | Y | Y | Y | None | 2 years | | Based on above uses post 2 years, no pig exposure[D] |

[A] Crops that are cooked prior to consumption can be sold uncooked to consumers provided the safety of the practice (such as considering the irrigation steps, preparation prior to sale and domestic cooking) can be demonstrated to the satisfaction of EPA.

[B] Includes sheep, goats, cattle, horses, and poultry. Excludes pigs.

[C] Flood, furrow, drip, sub-surface.

[D] If wastewater source contains human faecal material.

[E] For example, crops irrigated via subsurface irrigation only where only the above ground portion is harvested.

Note that using recycled water for livestock water could potentially increase livestock exposure to pathogens and other contaminants. If there are sources of livestock pathogens (greater than an arbitrary 1 per cent of the flow) in the wastewater resource used to produce the recycled water, monitor stock health closely. Preventative measures to lower this risk are to not use recycled water for livestock or use class A recycled water.

Y = yes, N = no. Y indicates that recycled water of this quality is generally acceptable for the corresponding uses, however, additional preventive measures may be required.

## 11.2 Agricultural on-site preventive measures

### 11.2.1 Horticultural on-site preventive measures

The required recycled water treatment levels for irrigation of human food crops depend upon:

- the potential for the edible portion of the crop to come into direct contact with the recycled water. This reflects both the irrigation method (such as spray, drip, flood, subsurface, or hydroponic systems) and the crop involved (for example, if produce is grown in contact with the soil or if the produce has a protective and inedible covering)
- the level of processing or cooking of the food prior to consumption.

Crops that are potentially consumed raw and may come in direct contact with the recycled water require the highest treatment standards. Lower risk scenarios can use lower recycled water classes.

Only class A recycled water should be used on human food crops (both surface and root crops) that are consumed raw and are likely to be exposed to recycled water.

Class C recycled water may be used on crops or produce that will be either cooked at temperatures greater than 70° Celsius for two minutes, or processed prior to sale to the domestic market (for example, cereals, wheat and grapes for wine production). Class C recycled water may also be used on crops not in direct contact with recycled water, such as fruit trees. Use of class C recycled water on crops that will be cooked after sale to the domestic market may be acceptable. However, the safety of the practice (such as considering the irrigation steps, preparation prior to sale and domestic cooking) needs to satisfy the relevant government agencies such as EPA and CVO, where relevant.

### 11.2.2 Aquaculture

There is significant interest in using recycled water for aquaculture. While this guideline provides guidance on using recycled water for non-food chain scenarios, it does not provide water quality criteria for aquaculture involving human food chain applications. The guidelines also do not provide criteria on the water quality requirements relevant to environmental discharges from aquaculture facilities. There is research being undertaken to answer technical, environmental, food safety and economic questions on these topics. However, until this research is available, proposed schemes will need to be assessed by EPA on a case-by-case basis, and this guideline does not cover recycling of water for aquaculture.

### 11.2.3 Produce safety – quality assurance systems

Agricultural uses of recycled water need to address the associated produce safety issues through the use of quality assurance (QA) systems.

Several agricultural industries (such as dairy, meat and horticulture) have adopted food QA systems to manage produce safety. This means controlling risks, including microbiological, chemical and physical. Many QA programs are based on HACCP. Where required to assess the HEMP, auditors need to be satisfied that an appropriate QA system is being implemented. Implementing a HACCP plan approved by a certified HACCP auditor may be one way to demonstrate an appropriate QA system. There may be industry-specific issues not fully addressed by the *Victorian Guideline for Water Recycling*. Advice in relation to produce safety regulations, codes, issues, risks and quality systems associated with the use of recycled water can be obtained from various sources including:

- food safety regulators
- industry associations
- accredited QA consultants
- produce buyers (for example, supermarket chains).

Further advice can be obtained from the relevant authority or industry association. Some relevant government agency and industry contacts include:

- human food crops: Institute for Horticultural Development and the Vegetable Growers Association
- cattle and dairy animals: CVO and Dairy Food Safety Victoria (DFSV).

## 11.3 OHS preventive measures

As an additional food safety measure and for protection of workers, harvesting should not start until the produce is dry, unless recycled water is class A quality.

Class A recycled water is acceptable for produce washing for packaging of food. However, growers must have industry specific HACCP processes in place.

## 11.4 Urban on-site preventive measures

Recycled water is suitable for application under a wide range of urban non-potable uses. The potential exposure level to recycled water determines the class that is suitable for both urban and municipal recycling schemes. The potential exposure level is influenced by several factors including:

- acceptable uses of the recycled water within the scheme
- distance from residential or public assess areas
- use of signage and/or fencing to restrict site access
- irrigation method used
- use of restricted watering times (for example, night- time watering).

### 11.4.1 Residential and municipal with uncontrolled public access

Only class A recycled water may be used for residential or municipal recycling schemes where there is high potential for human exposure due to limited controls on public access.

Uses such as toilet flushing or where there is a risk of offsite movement may require additional nutrient removal.

Examples of relevant residential uses include:

- garden watering
- toilet flushing
- laundry
- hosing down hard surfaces

Examples of municipal use include irrigation of

  - open spaces, parks, sportsgrounds and golf courses (including those incorporating residential developments)
  - median strips with uncontrolled public access.

### 11.4.2 Municipal with controlled public access

Class B and C recycled water may be used for municipal schemes provided public access can be controlled by measures such as: irrigation practices; restricted watering times (for example, night-time watering, signage); fencing; and withholding periods (minimum of four hours) to ensure the areas are dry before public access. Table 26 provides further site controls and guidance for these controlled public access schemes

### 11.4.3 Irrigation methods for urban (non-potable)

The type of irrigation method can influence the appropriate recycled water class used and the extent of public access control required. The irrigation method can also influence the design of the run-off controls that may be needed.

The recycled water quality limits required for municipal irrigation are based on spray irrigation. EPA may approve recycled water quality of a lesser class if application methods such as sub- surface, trickle or micro- irrigation systems are used. Users of recycled water will need to demonstrate that public health will be adequately protected, and no contaminated run-off occurs.

# 12 Management of sewage quality

## 12.1 Domestic sewage

Domestic sewage is classified as wastewater from residential developments and commercial precincts, arising mostly from showers, vanities, baths, toilets, kitchens and laundries. It is the most common form of sewage and has predictable physical, chemical and microbiological properties. Hazardous events that can pose a challenge to the quality of domestic wastewater include:

- illegal connection of stormwater drainage to sewer causing hydraulic overload at the sewage treatment plant (STP), leading to inadequate treatment
- illegal dumping of chemicals via domestic sewers
- the use of persistent, toxic chemicals in pharmaceutical and personal care products or other household products (for example, anti-corrosion substances in dishwasher detergents). Due to their persistence through the sewage treatment process, these types of compounds can threaten the quality of recycled water products.

## 12.2 Industrial sources and trade waste controls

Trade waste can pose a challenge to producing consistent, safe, fit-for-purpose recycled water. This is due to greater temporal variability in flow rates and greater variability in its constituents compared to domestic sewage. The impact of trade waste on wastewater quality is generally managed through trade waste agreements which specify acceptable quality and quantity of trade waste received as part of a trade waste management program.

## 12.3 WSAA Sewage Quality Management Guidelines

The Water Services Association of Australia (WSAA) has developed the *Australian Sewage Quality Management Guidelines* (WSAA, 2012) as a resource for Australian water businesses to help them manage the quality of wastewater from their sewerage catchments. The WSAA Guidelines describe a 12-part framework for the management of sewage quality (including domestic and industrial wastewater). The framework is similar to the AGWR framework for managing recycled water quality and use (NRMMC et al., 2006) and the ADWG framework for managing drinking water quality (NHMRC and NRMMC, 2017).

The WSAA Sewage Quality Management Framework is flexible and can be used as a stand-alone system for managing sewage quality input or integrated with an existing management system. It includes principles of systems such as HACCP and ISO, and can build on programs and systems already in place (WSAA, 2012).

# 13 Recycled water treatment and quality

## 13.1 Treatment processes

Secondary treatment is the minimum standard of treatment needed for most agricultural and municipal recycled water use schemes.

Secondary treatment is typically regarded as either:

i. low rate stabilisation process such as stabilisation lagoons, aerated lagoons and facultative lagoons designed to achieve median concentrations for BOD of 20 mg/L and SS of 30 mg/L. This level of performance may be difficult for lagoon-based systems to achieve over summer due to algal productivity. Therefore, in times of algal blooms, it is appropriate to also monitor filtered BOD to establish a correlation between the BOD levels for the treatment process under normal conditions with BOD levels due to algal growth. For low rate processes, SS is used as a design criteria and is not used for ongoing confirmation of process efficiency, or
ii. primary sedimentation or an equivalent process for removal of solids, followed by organic matter and solids reduction via biological/mechanical treatment processes (for example, biofiltration, trickling filter, intermittently decanted extended aeration (IDEA), or activated sludge plants). This process aims to achieve median BOD of 20 mg/L and SS of 30 mg/L.

Tertiary or other advanced treatments that produce very low pathogen levels are required for schemes that have the high potential for exposure to humans, livestock and agricultural produce. Recycled water discharges to waterways or to groundwater also require advanced treatment levels.

Tertiary treatment to reduce nutrient concentrations are also be required for schemes that pose a risk of off-site movement of recycled water.

For all classes of recycled water, the treatment process must also include a pathogen-reducing disinfection step, such as chlorination or detention lagoons. However, systems using only detention lagoons do not typically provide class A recycled water and this process is unsuitable as the sole means of pathogen reduction for high contact uses. Detention lagoons are also not best practice for reliably producing Class B recycled water. More detailed guidance on disinfection is provided in *Disinfection of recycled water. Guidelines for environmental management* (publication 730) (EPA Victoria, 2002).

Primary treatment of sewage is not an acceptable treatment to produce recycled water for recycling schemes under this guideline. Minimum level of treatment is secondary treatment.

### 13.2 Class A recycled water

Uses that require class A recycled water will potentially not include 'barriers' between the water and direct human contact. These uses include recreational watering without restrictions on public access, or direct irrigation of food crops that may be consumed raw. Therefore, it is critical that treatment processes for class A uses are demonstrated to reliably provide the required pathogen reduction levels.

Given the importance of demonstrating treatment performance, the objectives in Section 1.4.2 *Victorian Guideline for Water Recycling* (publication 1910) for class A recycled water should be considered as indicative limits (for example, turbidity is less than 0.15 NTU). The principal focus for schemes requiring class A recycled water is to demonstrate that the treatment train process can achieve sufficient log removal of pathogens from raw sewage to final product water to achieve these objectives.

## 14 Supply of recycled water for drought relief

### 14.1 Key aspects of a drought relief scheme

Drought relief involves the access of water from standpipes for temporary uses such as:

- livestock
- crop irrigation
- dust suppression
- municipal gardens and landscapes (amenity horticulture).

Although Victoria's regulatory framework for recycled water is well established, drought relief schemes requires some variations to the 'default' recycled water controls. These variations reflect that drought relief end-uses are expected to involve the temporary application of small volumes of water and are likely to be managed by people with limited recycled water experience. Such uses may qualify for fast-tracked HEMP approval.

In developing drought relief schemes and tailored protocols, recycled water users and managers should consider any specific issues associated with their recycled water. If necessary, additional management controls should be included in the end-use protocols. Such issues could include recycled water with elevated salinity or significant trade waste inputs from, for example, an abattoir or saleyard (potentially requiring additional livestock controls). Prospective recycled water users must liaise with the regional EPA office and obtain EPA approval prior to commencing recycled water supply for a drought relief scheme.

Where class A recycled water is available, it can be used for the potential drought relief uses outlined in Table 27, below. Less stringent management control requirements will be needed for class A use (as opposed to class B or C). Where a water corporation has endorsed class A water for drought relief use, it should:

1. discuss the appropriate management controls for specific end uses with EPA prior to supplying customers
2. articulate these agreed management controls in their management framework for EPA approval.

Whilst acceptable uses for drought relief are detailed below (Table 27), additional uses will be considered as the need arises.

**Table 27 – Drought relief recycled water uses and treatment levels**

| Key end uses | Recycled water treatment level |
|---|---|
| Irrigation of crops not supplied to consumers 'raw' for example barley, wheat and wine grapes | Class C, B, or A |
| Irrigation of crops potentially supplied to consumers 'raw' for example carrots, strawberries, apples | Class A<br>Class C or B requires case-by-case assessment and site-specific management. |
| Irrigation of pasture for beef cattle grazing or dry dairy cattle | Class C, B or A with helminth control as defined in Table 57 |
| Irrigation of pasture for dairy cattle grazing or livestock drinking water | Class B or A with helminth control |
| Irrigation of pasture for other livestock grazing | Class C, B, or A |
| Irrigation of municipal gardens and parks | Class C, B, or A |
| Dust suppression and road works | Class C, B, or A |

## 14.2 Key recycling site management controls

Recycled water suppliers that provide recycled water for drought relief must have an EPA-approved HEMP which should include:

1. Screening of applicants – a mechanism for suppliers to screen potential users and confirm the recycled water quality and intended uses (consistent with Table 27). The screening process must also identify if there are site constraints that would make it difficult for the user to comply with these guideline's' requirements (refer to Section 3.7.1, 10.3.3 11.1). This could be approached by a direct meeting, telephone interview or written questionnaire.
2. Provision of information – users who pass the screening stage need to be provided with information describing the necessary management controls for safe recycled water use. The information can be tailored to specific use categories and issues associated with the local area and recycled water quality or it can be relatively generic, as necessary.
3. Ensuring compliance – a mechanism to ensure users are aware of the necessary controls, such as signing an undertaking to comply with the listed requirements. For some users, this may also involve the integration of additional controls into their operational procedures
4. Ongoing oversight – suppliers need to control access to the water, record tanker details, monitor water quality and record the volumes supplied to end-users. A program of random inspections of end-users needs to be included.
5. Review – the drought relief framework is only appropriate for temporary schemes to supply recycled water to deal with prolonged drought. A process should be included to review the effectiveness of the drought management framework and the associated documentation, such as via an annual review with EPA and key customers Schemes that involve ongoing use (greater than one year) must develop a management plan tailored to the scheme.
6. Standpipes and supply by tanker management - suppliers should ensure standpipes are appropriately designed and managed to avoid spills to the environment. Mechanisms must be in place to ensure tankers are not subsequently used for transport of potable water for human consumption (refer DHHS publication *Guide for water carting businesses* April 2018). Suppliers must control access to the water, record tanker details, monitor water quality and record the volumes supplied to end users. Where access to a standpipe is in a location owned by a third party, such as a standpipe located at a golf course, additional arrangements for control of access and recording of details may need to be established.

# 15 Guide for completion of Recycled Water Quality Management Plan (RWQMP) for class A water recycling schemes

## 15.1 Introduction

### 15.1.1 Purpose of the RWQMP

This section needs to make a statement that describes the purpose and scope of the RWQMP.

Typically, a RWQMP:

- addresses the responsibilities of the recycled water supplier
- covers the production and supply of recycled water that is fit-for-purpose. At a minimum it extends from the catchment of the system (including system inputs), through to the end of the treatment process
- includes detailed information on the validation of treatment processes
- identifies process control and monitoring that is necessary to produce water of an appropriate quality for the proposed end-uses.

### 15.1.2 Description of the scheme

This section needs to provide a brief description of the water recycling scheme.

It must include:

- the location of the scheme
- the size of the scheme (design capacity, expected minimum and maximum flows and flux)
- a description of the catchment, describing system inputs
- the proposed end-uses of recycled water
- a site plan showing the general arrangement of the treatment facility, a process flow diagram, and process instrumentation diagram
- a schematic of the scheme – including location of treatment processes, storages, pipelines and end-uses.

### 15.1.3 Management commitment

This section needs to provide a statement of management commitment to health and safety.

It should describe how the organisation responsible for the recycled water scheme has demonstrated that they are committed to the responsible use and management of recycled water through the implementation of preventive risk management.

## 15.2 Roles and responsibilities

This section describes the responsibilities of each stakeholder involved in the recycled water scheme.

### 15.2.1 Supplier

The supplier is the body responsible for the RWQMP and the producer of recycled water for a scheme. This may be achieved via the nominated supplier sub-contracting components of the design and operation of the system. However, one entity should be identified as the recycled water supplier (in most cases this will be a water corporation).

Describe the specific responsibilities of the supplier. These should include:

- developing, implementing and reviewing the RWQMP that underpins the production of recycled water that is safe for use
- supplying recycled water to one or more users and possibly other scheme managers
- ensuring any users or other scheme managers of class A recycled water from the supplier have an EPA approved environment management plan (EMP) or health and environmental management plan (HEMP).

Identify sub-contractors and their responsibilities. This should include communication arrangements in the event of system failure – refer to Section 15.11 of this template.

### 15.2.2 Scheme manager

The scheme manager is usually the supplier but, in some cases, may be distinct from the supplier. The manager is the body responsible for engagement with recycled water users. If separate to the supplier, the scheme manager is also typically responsible for the management of the recycled water delivery system, although the delineation of responsibility between scheme managers and suppliers may vary on a scheme-to-scheme basis. The responsibilities of the scheme manager are predominantly addressed in the scheme EMP or HEMP. However, any specific responsibilities that involve interaction with the recycled water supplier should be identified in the RWQMP.

Identify the scheme manager(s) (if any) who receive recycled water from the supplier and detail their specific responsibilities in relation to the RWQMP.

### 15.2.3 Users

A recycled water user is a person, organisation or community group that uses recycled water. Recycled water users will typically interact with the supplier (or scheme manager if distinct from the supplier), and therefore their responsibilities will be detailed in the HEMP or EMP for the scheme.

List responsibilities of end users if water is supplied directly to end users. The supplier must ensure that these users have an approved EIP or HEMP.

## 15.3 Water quality objectives

This section describes the water quality objectives needed to protect human health.

### 15.3.1 Microbial

Treatment processes must have measurable removal efficiency for target organisms that can be verified through operational monitoring. The LRV attributed to each TPU will be limited by the sensitivity of operational monitoring, as demonstrated through validation.

Describe how water quality objectives have been derived and how they are appropriate for the intended reuse (provide reference to relevant guidelines or specific risk assessment that has been undertaken to determine water quality objectives.

It is recommended to tabulate treatment plant performance objectives, expressed in log reduction values (LRV) attributed to specific treatment units (TPU). An example of a table is provided below.

**Table 28 – Log reduction values**

| Pathogen group | Target LRV | TPU 1 | TPU 2 | TPU 3 |
|---|---|---|---|---|
| Virus | a+b+c | a | b | c |
| Protozoa | p+q+r | p | q | r |
| Bacteria | x+y+z | x | y | z |

For further assistance refer to AGWR Section 3

### 15.3.2 Chemical

Chemicals are generally envisaged to be a low risk to human health where:

- wastewater is derived from largely domestic catchments
- recycled water is not used for drinking.

However, for schemes where chemical inputs from the catchment are considered to be significant, then specific water quality objectives should be identified through a risk assessment.

Describe the likely significance of chemical contaminants for the recycled water scheme.

For further assistance refer to AGWR Sections 3.5.4 and 3.5.5.

## 15.4 System assessment

This section needs to outline instructions for system assessment. It should include an overview of the recycled water system, identifying potential sources of risk that will require control.

Describe the approach taken to assess and identify management controls for these risks. Note that a preventive risk management system such as Hazard Analysis and Critical Control Point (HACCP) should be used for undertaking this assessment. The HACCP plan for the treatment process should be referred to.

For further assistance refer to AGWR Section 2.2 and 2.3.

## 15.5 Validation of treatment processes

Validation is a critical component of treatment process management. Validation ensures that the required water quality objectives will be achieved. As such, it is essential that individual processes within the treatment train (that will be relied upon to provide pathogen reduction) are validated. Each process unit should be addressed separately, and validation studies should be undertaken according to best practice. For further reference see: *Guidelines for validating treatment processes for pathogen reduction: Supporting class A recycled water schemes in Victoria* (DoH, 2013).

Include an analysis of the validation reports for each treatment process unit, and the conclusions that relate to the log reductions of viruses and protozoan parasites achieved by each treatment process unit.

Include analysis and conclusions from validation reports that relate to the operational monitoring that must be undertaken in order to confirm the required log removal is being achieved. This will need to relate to Section 15.6 of this template, where monitoring activities, critical limits and corrective actions are addressed.

Attach validation reports as an appendix to the RWQMP.

## 15.6 Operational monitoring and process control

### 15.6.1 Monitoring and corrective actions

This section needs to refer to the HACCP plan, and must identify the following information:

- critical control points (CCPs) (treatment process units that are relied upon to provide pathogen reduction)
- parameters monitored at each CCP to demonstrate process efficacy (operational monitoring)
- critical limits for each operational monitoring parameter that have been established during the validation activities
- corrective actions that will be taken if a critical limit is breached
- verification records to confirm that monitoring and corrective actions have been undertaken.

This information is best presented in a table format – see the example below.

**Table 29 – Example CCP template summary table.**

| **CCP x** | **Treatment process unit (for example UV disinfection)** | | | | |
|---|---|---|---|---|---|
| | **Parameter a** | **Parameter b** | **Parameter c** | **Parameter d** | **Parameter e** |
| **Critical limits/alert limits** | | | | | |
| Alert | | | | | |
| Critical | | | | | |
| **Monitoring procedures** | | | | | |
| What | | | | | |
| How | | | | | |
| When | | | | | |
| Where | | | | | |
| Who | | | | | |
| **Verification records** | | | | | |
| **Corrective actions**[1] | | | | | |
| What | | | | | |
| How | | | | | |
| When | | | | | |
| Where | | | | | |
| Who | | | | | |
| **Verification records** | | | | | |

[1] Refer to relevant standard operating procedures

For further assistance refer to AGWR Section 2.4

#### 15.6.1.1 Standard operating procedures

Standard operating procedures (SOPs) must be developed for all monitoring at CCPs. These must include the critical limits and corrective actions described in the RWQMP. Information on when the system can be brought back online after a shut-down must be included. These SOPs, or the operations manual in which they reside, must be referenced for each CCP. SOPs do not need to be attached to the plan.

List SOPs (or the operation manual in which they reside) for each CCP treatment process unit.

### 15.6.2 Verification monitoring

Verification monitoring assesses the overall performance of the system and compliance with the overall water quality objectives. It is independent of the routine operational monitoring of the system.

The specific parameters monitored should relate to the water quality objectives for the system and should be developed in consultation with EPA.

For further assistance refer to AGWR Section 2.5.

## 15.7 Prerequisite programs

Prerequisite programs are systems and procedures that should be in place to ensure optimal process operations underpin the effectiveness of the preventive risk management system. They may include:

- trade waste management
- operation and maintenance procedures
- quality assurance for installation of treatment components (for example, configuration of UV reactors, factory pressure tests for membrane systems, product specifications for replacement parts)
- calibration of monitoring instrumentation
- chemical quality assurance
- overarching organisational quality management systems that the RWQMP will be linked to.

Include a summary of prerequisite programs.

## 15.8 Incidents and emergencies

Detail incident and emergency protocols specific to the production and supply of recycled water including response actions, roles and responsibilities and communication arrangements.

Refer to AGWR Section 2.6.

## 15.9 Employee awareness and training

Employees including plant operators and contractors should have a sound knowledge base from which to make effective operational decisions. This requires training in the methods and skills required to perform their tasks efficiently and competently. Employees need to be aware of the potential consequences of system failures, and of how their decisions can affect the safety of the scheme.

Detail employee training needs and programs.

Refer to AGWR Section 2.7.

## 15.10 Documentation and reporting

### 15.10.1 Documentation

Records should be kept for:

- CCP monitoring results and analyses
- breaches of critical limits and corrective actions taken
- verification monitoring
- incidents and emergencies and corrective actions taken
- inspection and maintenance activities relevant to water quality.

Detail how where and by whom these records are kept.

Refer to AGWR Section 2.10.

### 15.10.2 Reporting

An annual report must be prepared and submitted to EPA.

Detail when this report will be prepared and who is responsible for its development and submission.

Refer to AGWR Section 2.10.

## 15.11 Notifications

If the supplier sub-contracts any aspects of recycled water production to other entities, then arrangements need to be in place for the notification of any incidents that may affect the safety of the scheme. The supplier must immediately notify all scheme manager/users (where applicable) of any incident that potentially places public health at risk. The following must be immediately notified to EPA (tel: 1300 372 842) and Environmental Health Unit of DHHS (tel: 1300 761 874):

- a system failure that may potentially impact on the health of users of the recycled water
- an emergency or incident that otherwise potentially places public health at risk.

Detail the arrangements and procedures for notification of incidents.

Refer to AGWR Section 2.10.

## 15.12 Auditing

Periodic auditing of compliance with the RWQMP (as part of the HEMP auditing process) is essential for ensuring that the supplier meets their obligations under the RWQMP.

Describe the audit process and frequency.

Refer to AGWR Section 2.11.2.

## 15.13 Review and improvement

Detail the process for reviewing and updating the RWQMP. Refer to AGWR Section 2.12.

## 15.14 Commissioning the RWQMP

The supplier should provide written confirmation that all operational monitoring, critical limit alarms and corrective actions within the RWQMP have been tested and verified, by an independent third party.

This written confirmation should be included with the final RWQMP that is submitted to EPA for approval.

# 16 HACCP framework

The production of safe and sustainable recycled water can be secured by the application of a water quality management system. This system focuses on the preventing the delivery of substandard recycled water, by ensuring that appropriate treatment steps, controls, monitoring and verification processes are in place.

This approach has been used by the food industry for many years through the application of the Hazard Analysis and Critical Control Point (HACCP) system. The water industry is increasingly adopting similar principles, as demonstrated in the *Safe Drinking Water Act 2003*, the *Australian Drinking Water Guidelines (2011)* and the *WHO Guidelines for Drinking-Water Quality (2017)*.

This section describes the application of HACCP to analyse and control a wastewater treatment plant to ensure the removal of pathogens and achieve the required microbial criteria These principles can be equally applied to other aspects of the recycled water scheme, including the supply system, end uses, and management of environmental risks.

HACCP comprises 12 steps – five preliminary steps and seven principles, as shown in Figure 7. These are discussed in detail below.

## 16.1 Preliminary steps

### 16.1.1 Assemble team

The HACCP team should be multidisciplinary, encompassing a broad range of expertise and skill in all aspects of the recycled water system.

Management within the organisation producing recycled water should also be represented to ensure organisational support for the HACCP process.

**i. Describe product**

The HACCP plan should specify that the product is class A recycled water, including the specific microbial criteria and other any water quality objectives that are applicable.

### 16.1.2 Identify intended use

The intended uses of class A recycled water within the recycled water scheme should be specifically described.

### 16.1.3 Construct flow diagram

The recycled water system should be mapped, from the catchment of wastewater to the delivery of water to the customer property. The flow diagram should include all transfer, treatment, input and monitoring steps, and is integral to a comprehensive system assessment.

### 16.1.4 Confirm flow diagram

The flow diagram should be confirmed with any detailed design specifications or functional design reports that have been developed for the scheme. If the scheme is utilising any existing treatment processes or infrastructure, the flow diagram should be confirmed with an on-site inspection.

## 16.2 Principles

### 16.2.1 Identify hazards and assess risk

A significant hazard is one that must be prevented, eliminated or reduced to an acceptable level to produce safe recycled water. Hazards may be biological, chemical or physical. Generally, the hazards of greatest concern for the recycled water plant are those that are biological (pathogens).

However, it may also be appropriate to consider chemical and physical hazards, such as those that may result in chemical contamination of the recycled water or physical damage to the recycled water plant.

The hazard analysis consists of four steps, which should be documented:

1. Identify hazardous events at each step in the process that may impact on water quality. These, for example, are initial pathogen loads and its risk profile, and events that may result in ineffective pathogen removal or recontamination of treated water with pathogens.
2. Determine the risk and significance of each hazardous event. This is the product of how frequently the hazardous event is expected to occur and what the consequences of that event occurring are. The framework provided in the *Australian Drinking Water Guidelines* (NHMRC 2004) or alternative risk assessment framework can be used for this assessment.
3. The HACCP team needs to identify at what point a hazardous event is considered to be significant. A rule of thumb for a risk assessment model that results in risk scores ranging from 1 to 25 (with 1 representing low risk and 25 representing extreme risk) is to consider that all events with a risk score of 5 or greater as significant.
4. Identify preventive measures for each hazardous event. These include system input management, physical barriers (such as treatment steps), monitoring, standard operating procedures and personnel training. More than one control measure may be required to control a particular hazard, and more than one hazard may be controlled by a particular control measure.

## 16.3 Determine critical control points (CCPs)

Hazardous events assessed as significant must be further assessed to identify whether they fall at a CCP. A CCP is essentially a step in the process that is critical for achieving or maintaining the required water quality. The decision tree in Figure 8 can be used to determine if a hazardous event happens at a CCP.

CCPs must meet at least the following criteria:

- they must have preventive measures with operational parameters that can be measured and for which critical limits can be set to define the operational effectiveness of the activity (for example, chlorine residual for chlorination or integrity tests for membrane filtration processes)
- they must have preventive measures with operational parameters that can be monitored at a frequency that will reveal any failures in a timely manner
- there must be corrective actions that can be implemented in response to deviation from critical limits.

Appropriate selection of CCPs is essential because the focus of operational control will be directed towards these processes and activities.

## 16.4 Establish critical limits

All CCPs must have critical limits for their operational parameters that are defined and validated. A critical limit distinguishes between acceptable and unacceptable performance. When a critical limit is not met, corrective actions should be immediately instituted to resume control of the process.

For treatment processes, critical limits must indicate a decline in performance that equates to at least a 6-log removal of viruses and a 5-log removal of protozoan parasites. The derivation of these limits is discussed in the document *Health Risk Management in Urban Recycling Schemes: Technical Background Paper* (DHS, 2005).

Many processes operational parameters can be closely linked to performance and tightly controlled (for example, CTs for disinfection indicate the log removal of specific pathogens). However, for processes where operational parameters cannot be as definitively linked to performance (for example, secondary treatment processes) a 5th percentile of performance, in terms of log removal, can be adopted. This value should be derived using a rigorous data set for pathogen removal and linked to a specific range of operating parameters. The upper and lower range of these operating parameters then form the critical limits for this step, and upstream or downstream processes in the treatment train must be tightly managed to ensure that, at this 5th percentile of performance, the total train will still provide at least 6-log removal of viruses and 5-log removal of protozoans which is required for typical dual pipe use by the current version of the Australian Guidelines for Water Recycling.

The information used to determine critical limits for monitoring of a particular CCP may include experimental studies, scientific literature and supplier specifications.

Critical limits must be validated to confirm they are accurate. Validation of critical limits forms part of the verification of the water quality management system and is discussed in Section 16.7.

## 16.5 Determine monitoring requirements

Monitoring provides assurance that the treatment process is under control. All CCPs must have an associated monitoring activity to ensure that critical limits are met. A monitoring regime that identifies the location and frequency of monitoring, and a description of the method or procedure of monitoring must be established.

## 16.6 Establish corrective actions

Corrective actions are taken when a critical limit is not met. If a critical limit is indicative of the treatment process providing sufficient pathogen removal, then the corrective action for not meeting that limit might be to stop water delivery to end users, or to increase treatment downstream to adequately compensate for the loss in performance. The documentation of corrective actions must include what immediate action is required to resolve the problem, who is responsible for undertaking the corrective action, and who must be notified.

## 16.7 Establish verification procedures

Verification procedures are used to determine whether the preventive measures are effective and whether the water quality management plan is being implemented appropriately.

Verification includes:

- monitoring and procedures identified in the HACCP plan during commissioning of the treatment process
- validation of critical limits (Section 16.7.2)
- equipment calibration
- cleaning and maintenance programs
- HACCP plan reviews and internal/external audits
- ongoing evaluation of monitoring data to assess the overall performance of the treatment process and HACCP plan.

### 16.7.1 Establish documentation and record keeping

Appropriate documentation provides the foundation for establishing and maintaining an effective HACCP plan. Documentation should include:

- information used to develop the HACCP plan
- CCPs, critical limits, monitoring and corrective actions
- standard operating procedures relied upon or specifically developed for the HACCP plan
- verification activities, including the validation of critical limits
- records generated as a result of monitoring
- reviews and modifications to the HACCP plan.

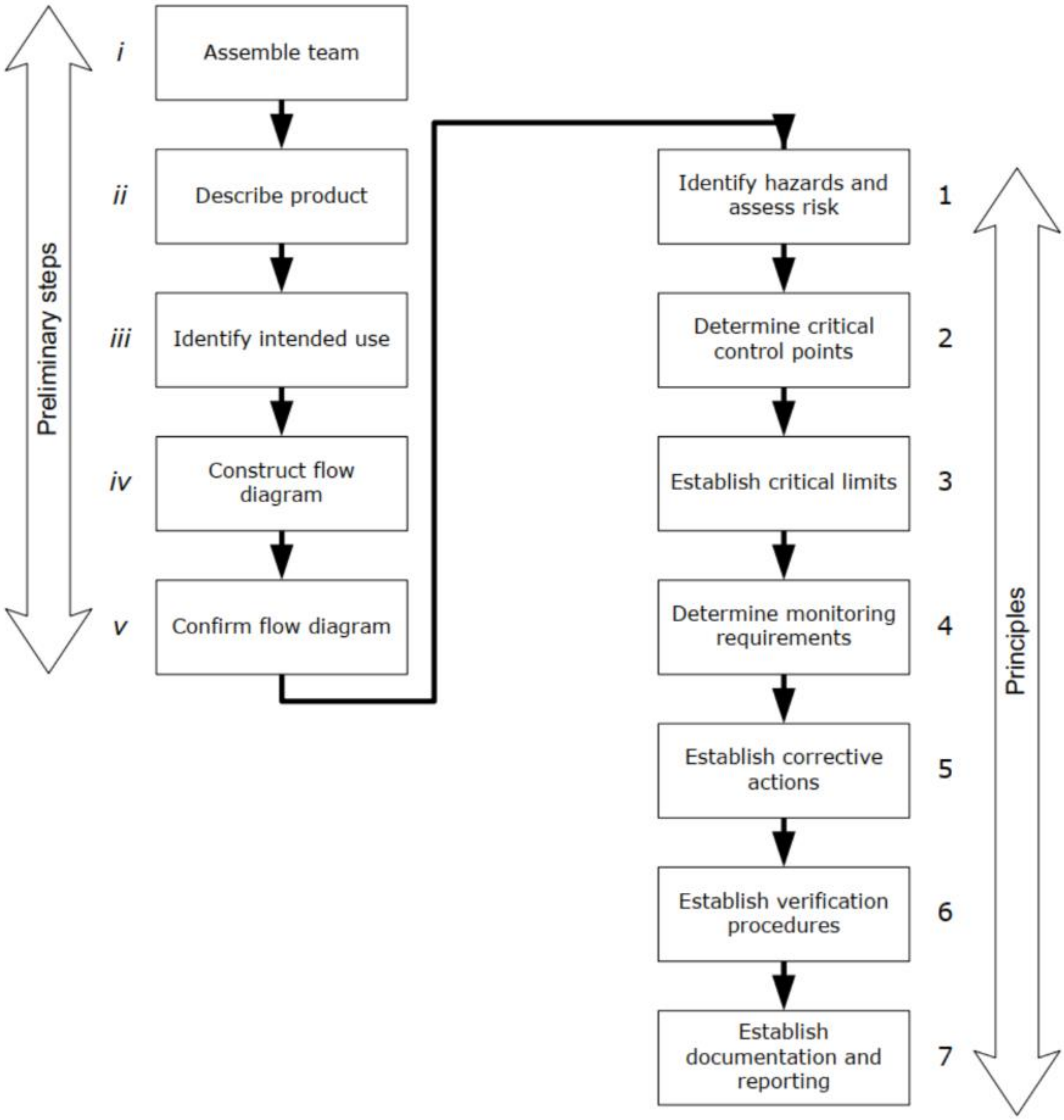
### 16.7.2 Validation

The validation of critical limits is essential for substantiating that the system can be controlled to meet the water quality objectives and the associated monitoring activities will be able to effectively indicate this. Validation must occur before supply of recycled water can commence.

The first stage of validation is to consider data that already exist. This can include data from the scientific literature, existing guidance, historical data (for example, from other schemes) and supplier knowledge.

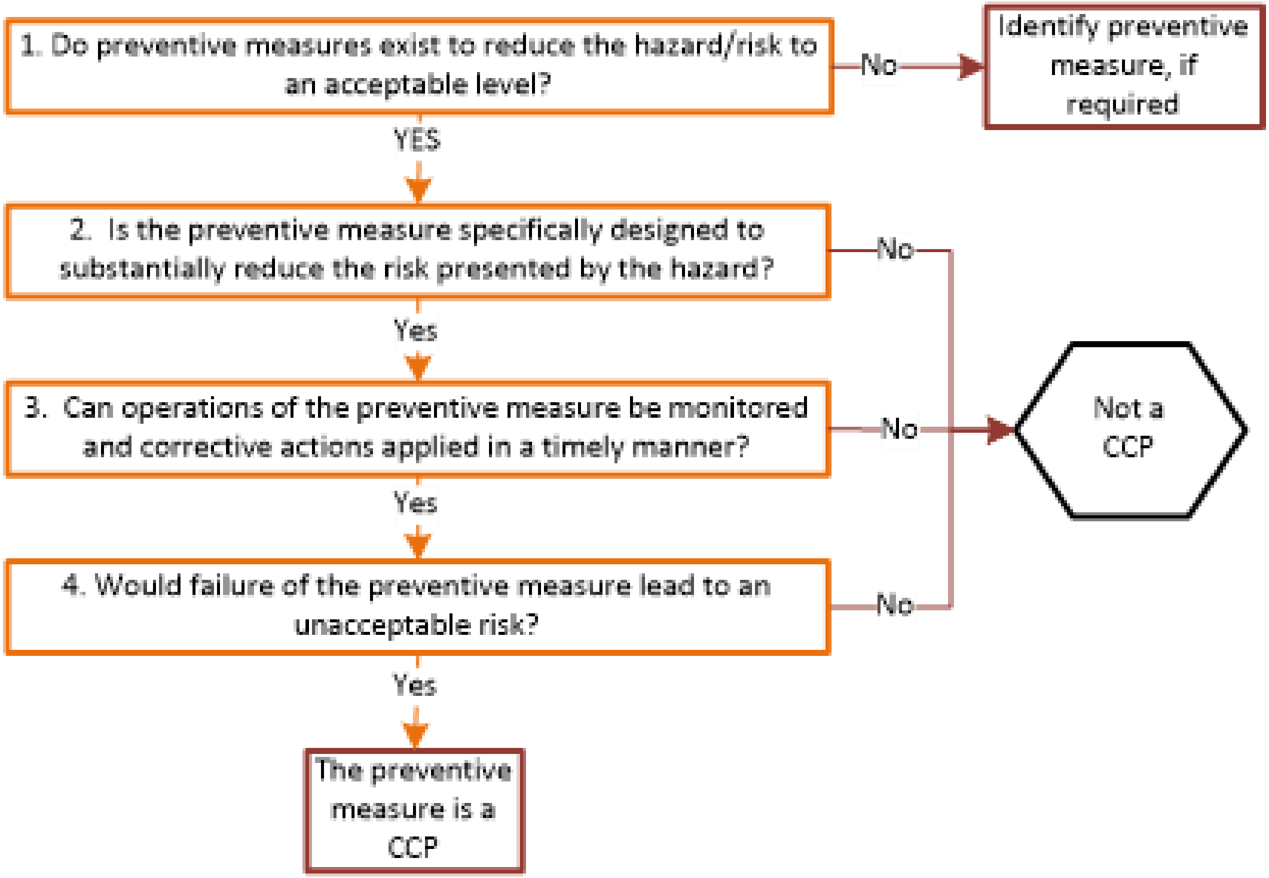
The second stage of validation is to determine whether additional monitoring is required (for example, whether specific on-site studies are necessary) and to collect and analyse the appropriate data. As validation is not used for the day-to-day management of the system, parameters that may be inappropriate for operational monitoring can be used. These may include microorganisms or tracer studies.

**Figure 7 – HACCP process**




Adapted from Codex Alimentarius, WHO

**Figure 8 – Decision tree to identify CCPs**



# 16.8 Example HACCP process control plan and CCP summary

## 16.8.1 Example CCP Table for UV disinfection

**Table 30 – Example CCP Table for UV disinfection**

<table>
<tr><th colspan="5">CCP3 – Ultraviolet Disinfection</th></tr>
<tr><td colspan="2">Process inputs</td><td colspan="3">• UF permeate water (in this example, the prior upstream process is ultrafiltration)</td></tr>
<tr><td colspan="2">Hazards<br>(biological, physical, chemical or radiological)</td><td colspan="3">• Inadequate disinfection<br>▫ poor feed water quality<br>▫ dirty lamps<br>▫ warm up period too short<br>▫ flow rate too low/high<br>• general malfunction (component failure, power failure)</td></tr>
<tr><td colspan="2">Control measures</td><td colspan="3">• Online monitoring for flow, ultraviolet transmissivity (UVT), and UV dose (Reduction Equivalent Dose)<br>• maintenance carried out as per manufacturers specifications.</td></tr>
<tr><td colspan="2">Key control measure(s)</td><td colspan="3">• Online monitoring for flow, ultraviolet transmissivity (UVT), and UV dose (Reduction Equivalent Dose or RED).</td></tr>
<tr><td colspan="2">Process control limits</td><td>Flow<br>($m^3$/hr)</td><td>UVT<br>(%)</td><td>UV Intensity<br>($W/m^2$)</td></tr>
<tr><td colspan="2">Alert</td><td>< 70<br>> 151</td><td>< 67</td><td>< 76</td></tr>
<tr><td colspan="2">Critical</td><td>< 65<br>> 168.8</td><td>< 65</td><td>< 73.5</td></tr>
<tr><td colspan="2">Typical operational value</td><td>75</td><td>69–75</td><td>80</td></tr>
<tr><td rowspan="5">Monitoring procedures</td><td>What</td><td>UF flow</td><td>Permeate UVT</td><td>UV intensity</td></tr>
<tr><td>How</td><td>Online</td><td>Online</td><td>Online</td></tr>
<tr><td>When</td><td>Ongoing</td><td>Ongoing</td><td>Ongoing</td></tr>
<tr><td>Where</td><td>UF feed</td><td>UF permeate</td><td>UV system</td></tr>
<tr><td>Who</td><td>Plant operations</td><td>Plant operations</td><td>Plant operations</td></tr>
<tr><td rowspan="2">Corrective action</td><td>What</td><td colspan="3">• UF flow<br>▫ Should the flow be outside the high/low flow alert limit for 60sec, a high/low alert alarm is generated on SCADA.<br>▫ Should the flow be outside the high/low flow critical limit for 60sec, a high/low CCP alarm is generated on SCADA and plant shutdown occurs.<br>• UVT<br>▫ < 67% – A low UVT alarm is generated.<br>▫ < 65% – Should the UVT be below the low critical limit for 30sec, off-spec diversion is initiated. Shutdown occurs after 30 minutes of off-spec diversion should the UVT not return to acceptable limits. A low CCP alarm is generated<br>• UV intensity<br>▫ < 76 $W/m^2$ – A low UV RED alarm is generated.<br>▫ < 73.5 $W/m^2$ – Should the UV RED be below the low critical limit for 30 sec, off-spec diversion is initiated. Shutdown occurs after 30 minutes of off-spec diversion should the UV intensity not return to acceptable limits. A low CCP alarm is generated.</td></tr>
<tr><td>Records</td><td colspan="3">• All CCP breaches should be recorded on the SCADA system.</td></tr>
</table>

# 17 User site management plan

The development of the user site management plan is a key component of sustainable recycled water use. A user site management plan is required to guide the management of the site-specific operations to comply with the HEMP. The user site management plan should combine important business planning and everyday site management practices, utilising the risk assessments and management strategy completed in the HEMP, to ensure a safe, sustainable and compliant) recycled water use scheme.

The user site management plan document should address recycling environmental risks posed. The prime objectives of a user site management plan should be to:

- demonstrate that the performance objectives of this guideline can be complied with by detailing the procedures and practices that will be implemented to manage risk (as defined in the HEMP)
- address all aspects of the HEMP which could pose a risk to the environment, human and stock health, and food safety
- provide the framework to assess the long-term performance of the recycled water scheme and thereby ensure sustainability.

To meet these objectives, the user site management plan should address any relevant components identified in the HEMP.

Commonly the HEMP will incorporate the user site management plan, particularly where there are multiple users. In other cases, a separate HEMP is prepared by the supplier and one or more user site management plans by the recycled water users. A single HEMP may be sufficient with no additional user site management plan being required in the case of a single user and supplier, or a well-managed scheme with low residual risks and good risk management practices with a combined single use (for example class A scheme for domestic irrigation only). The user site management plan must be endorsed by the supplier.

Recycled water use schemes should include a regular audit and user site management plan review program. For larger schemes (those with greater than 1 ML/d), the auditor should be independent and have experience with irrigation or other recycling schemes.

The user site management plan can be integrated with QA systems (such as food safety), or whole farm management plans for the recycling scheme. If a QA system such as HACCP has been adopted by a premises or industry (for example, dairy, meat or horticultural), then it can be integrated with the user site management plan, and implemented to ensure the relevant food/produce safety issues are covered and that guidelines are met.

The supplier and/or the user may develop the user site management plan. A regional user site management plan may be prepared by the supplier to cover all the recycling sites served by the supply scheme. Individual irrigation or whole farm management plans can be prepared for each recycling site but must be intimately linked to the regional user site management plan.

A supplier's responsibility is to ensure that required copies of any user site management plans are duly submitted. Users must also fulfil this requirement along with the correct implementation of the user site management plan.

EPA will periodically produce updated information bulletins and guidelines relating to user site management plans. Preparation of user site management plans should also consider the additional guidance provided by such publications.

Copies of the user site management plan for any recycling scheme must be made available for EPA inspection and auditing purposes upon request.

# 18 Supply of recycled water to Victorian schools

## 18.1 Preventive measures for use of recycled water

If a school is supplied with recycled water, it should implement these preventive measures to minimise risk from cross connections:

- If any plumbing work is performed on drinking and recycled water networks within schools supplied with recycled water the Victorian Building Authority (VBA) and the relevant water corporation should be notified.
- Plumbers are also required to provide notification via a statutory compliance certificate. The school's notification will occur in addition to the plumber submitting a compliance certificate in order to provide an extra level of assurance.
- The water corporation may inspect the school's drinking and recycled water networks, after receiving notification of the plumbing work. The water corporation will advise you if an inspection is required. This inspection may involve a cross-connection check.

## 18.2 Information to be supplied to the VBA and relevant water corporation

The following information must be supplied to the VBA and the relevant water corporation in relation to any plumbing work conducted on drinking or recycled water networks on a school's premises:

- the name of the plumber
- the plumber's licence/registration number and Australian Business Number (ABN). This information will be provided on the invoice the plumber provides for the plumbing work undertaken
- the nature, location and date of the plumbing work undertaken
- a copy of the compliance certificate. Compliance certificates are issued for plumbing work which has a total value of $750 or more (including materials and any appliances, labour and GST) and are required to be provided to the person(s) contracting the plumbing practitioner. Plumbers are also required to submit the compliance certificate to the VBA.

## 18.3 VBA and water corporation contacts

The above information should be e-mailed to both the:

- VBA at: audits@vba.vic.gov.au
- appropriate contact for the relevant water corporation. This will be listed within the school's Conditions of Connection document supplied by your water corporation. Contact details are also provided on any recent invoice.

## 18.4 A reminder of the obligations of any recycled water customer

A person who carries out plumbing work in Victoria must be registered or licensed with the VBA. There are significant penalties for anyone undertaking plumbing work who is not registered or licensed. All registered and licensed plumbers are issued with a photo identification card which lists the type of work they are eligible to do.

Specific measures to prevent recycled water cross connection are detailed in the *National Plumbing and Drainage Code (AS/NZS 350033)* and summarised in your water corporation's Conditions of Connection. These include requirements for special tapware and fittings for recycled water outlets and instructions for the appropriate usage of recycled water. A licensed plumber is the best placed to discharge these obligations on school's behalf.

# 19 Example cross-connection incident report

| **Contact details of officer making notification** | |
|---|---|
| **Name** | |
| **Organisation** | |
| **Title** | |
| **Contact phone number(s)** | |
| **Email address** | |

| **Details of cross-connection** | |
|---|---|
| **Property details** | |
| Location of the cross connection (street address, and business name, if applicable) | 11 Wayagu Street |
| Number of properties known to be affected | 1 |
| Are other properties likely to be affected by the same event/incident | No |
| Type of property (residential, commercial - including commercial type such as school, hotel) | Residential |
| Initial response actions undertaken on site | • Reinstated locking pin.<br>• Flushed internal potable lines through to rear tap.<br>• Verified adequacy of flushing through EC testing at the property impacted and neighbouring property.<br>• Recorded meter reads to determine potential volume of water used.<br>• Contacted plumber and explained nature of problem.<br>• Contacted builder and site supervisor and explained what had happened.<br>*Please note the cross connection has not been removed as this is required for plumbing commissioning purposes.* |
| Number of site users, for example:<br>• House: number of residents and regular visitors<br>• School: staff, students and contractors<br>• Commercial site: staff, contractors, regular visitors | Unknown. Construction workers. |
| **Cross connection details** | |
| Date when cross-connection was first identified | 5/6/2019 |
| Reason leading to identification:<br>• Scheduled inspection (R1,2,3).<br>• System wide auditing.<br>• Customer complaint (taste, colour, illness).<br>• Other. | Scheduled R1 inspection |
| Estimated duration that cross-connection has been in place | Based on available information, it is estimated that the cross-connection has been put in place sometime between 21 Feb (when RW meter read was 0) and 13 May |
| Description of the cross-connection. Please attach any available photos and/or schematics for the site | Meter locking pin illegally removed whilst internal standard plumbing cross connection was in place. |
| How was the cross-connection identified? | Identified by East West Water plumbing auditor during routine scheduled inspection |
| How was the water corporation notified about the cross connection? | Issue was identified by East West Water |
| Is there a plumbing standards issue requiring notification to the plumbing regulator (VBA)? | Yes |
| Does this cross connection have potential to contaminate the reticulated drinking water network (supply side of meter?) | No, dual check drinking water meter in place. |

| | |
|---|---|
| **Water supplied** | |
| Source of drinking water to this location | Tarato WQR234 |
| Water treatment plant | Glenton (East West Water) |
| Source of recycled water to this location | RQR020 |
| Recycled water treatment plant | Epsilon RWTP |
| Any treatment plant issues (leading to supply of out of spec recycled water) | No – All Critical Control Points operated within specification and source water characteristics within specification. |
| Total number of customers | Unknown |
| Are there any sensitive end users/customers in this location requiring notification | No – isolated to the individual property |
| When was recycled water first supplied to this location? | 11 April 2019 (recommencement of production at Epsilon RWTP) |
| Estimated volume of drinking water supplied through the drinking water meter for the estimated duration of the cross connection | 11 kL since connection of the property |
| Estimated volume of recycled water supplied through the recycled water meter for the estimated duration of the cross connection | 0.6 kL since connection of the property |
| Estimated percentage of drinking water in recycled water supply for the estimated duration of the cross connection (the estimated time that drinking water has been added to recycled water network by the water corporation during the estimated duration of the cross connection) | It is estimated that potable water was supplied through the recycled network 80% of the time while the property was cross connected.<br>Assuming consistent usage between meter read the estimated maximum volume of recycled water that may have entered the drinking water supply is 14L. |
| Details of any Critical Control Point failures at either the RWTP, or downstream of the RWTP, that have occurred during the estimated duration of the cross connection | No failures occurred |
| What recycled water quality verification monitoring results information is available:<br>Recycled water quality results (micro, chemical).<br>Network chlorine residuals. | No *E. coli* detections<br>Average chlorine residual 0.025 mg/L<br>Further results available upon request |
| **Exposure to recycled water** | |
| Has, or is it likely, recycled water has been consumed by the customer for drinking? | Potentially low volume consumption by construction workers |
| What information is available on consumption of water for drinking (usage patterns, behaviours, boiling water, bottled water, filtered water)? | No information has been provided by the site supervisor or plumber to date |
| **Inspection information** | |
| When was the last inspection for cross connections undertaken at this location? | This was the first scheduled inspection |
| What other inspections have been undertaken at this location? (include all available inspection information) Please attach any available reports and photos. | N/A |
| **Actions** | |
| If known, so far, have any consumers at this location claimed that they have become ill from consuming the cross-connected supply? | No |
| Advised to exposed people seeking medical advice if needed. | Yes |
| What actions has your organisation taken since being notified of the cross-connection (in addition to the initial response)? | East West Water staff handling customer calls and complaints will advise persons feeling unwell to seek medical attention. |
| Recycled water supply isolated | Yes |
| Cross connection removed | No |
| Private plumbing flushed, disinfected, EC checked | Yes |
| Advised occupier to get private plumber to fix issue | No |

| | |
|---|---|
| Provided alternative supply of water for drinking | N/A |
| At the time of reporting, which agencies have been notified? | EPA – relevant region<br>DHHS – Water Unit<br>DELWP – State Water Duty Officer<br>VBA – East West Water called on Fri 12/5. Awaiting call back from VBA.<br>Council – N/A<br>DET/School – N/A |

# 20 Useful contacts

Victorian Building Authority (VBA)

733 Bourke St, Docklands 3008

Tel: 1300 815 127

www.vba.vic.gov.au

Bureau of Meteorology

www.bom.gov.au

Australian Institute of Agricultural Science and Technology

Tel: (03) 9637 8481

www.aginstitute.com.au

Australian Society of Soil Science Inc.

PO Box 1349, Warragul 3820

Tel: (03) 5622 0804

www.soilscienceaustralia.com.au

Engineers Australia Victoria Division 21

Bedford St, North Melbourne 3051

Tel: (03) 9329 8188

www.engineersaustralia.org.au/victoria-division

# 21 Relevant legislation, policies and guidance documents

## 21.1 Legislation

This section summarises the relevant legislation and statutory processes for obtaining the necessary approvals for recycled water schemes.

## 21.2 Acts

The Acts, policies and regulations administered by EPA and other government agencies that are relevant to recycling and use of recycled water are:

- *Environment Protection Act 1970*
- *Public Health and Wellbeing Act 2008*
- *Livestock Disease Control Act 1994*
- *Food Act 1984*
- *Australian New Zealand Food Authority Act 1991 (Commonwealth)*
- *Building Act 1993.*

## 21.3 Regulations

The relevant Regulations for recycled water use include:

- Environment Protection (Scheduled Premises) Regulations 2017, which outline the premises and activities that are scheduled and subject to works approval and licensing provisions of the *Environment Protection Act 1970*
- Building Regulations 2018
- Plumbing Regulations 2018
- Environment Protection (Industrial Waste Resource) Regulations 2009

## 21.4 Policies

Managers of recycled water schemes should consider the following policies:

- State Environment Protection Policy (Waters)

## 21.5 Guidance documents

Guidance referred to but not incorporated into this guideline include the following:

- *Guidelines for wastewater irrigation,* (publication 168) (EPA Victoria, 1991)
- *Environmental guidelines for the dairy processing industry,* (publication 570*)* (EPA Victoria, 1997)
- *Guidelines for validating treatment processes for pathogen reduction, supporting class A recycled water schemes in Victoria* (DoH Victoria, 2013)
- *Australian guidelines for water recycling* (NRMMC et al., 2006)
- *Victorian Building Authority plumbing guidance (2015) for the related Australian and New Zealand Standards* (AS/NZS 3500).

# Appendix A

# 22 Useful checklists

## 22.1 Chief Veterinary Officer (CVO) checklist

For a new scheme application or change of treatment/use, the submission by the applicant should address all relevant livestock health and related food safety issues that may need to be assessed due to livestock exposure to recycled water.

**Table 31 – Checklist for seeking Chief Veterinary Officer (CVO) endorsement for a new scheme or change of treatment/use**

| Item | Checklist components | Checked |
|---|---|---|
| 1 | Outline the treatment process and justify why/how the process meets the LRV equivalent. | |
| 2 | Describe the end users/downstream exposure and specify if any pig or cattle producers are nearby as this will alter the risk profile of the application. | |
| 3 | Outline how the microbial quality of the recycled water (class A, B or C) will adhere to the required specifications. | |
| 4 | All components identified in the HEMP in the guidelines, where the risks are being managed due to recycled water exposure to livestock and relate this to the relevant CVO requirements in the checklist (for example. as defined above) | |

Note: Producers are liable if they use the water, so while it is their responsibility to use water that is appropriate for their system, water corporations must advise downstream users (both licenced and inadvertent) of the quality of the effluent being produced by sewage treatment plants.

## 22.2 Managing the supply system

### 22.2.1 Distribution, reticulation and plumbing

When storing and distributing recycled water after it has been treated, the water quality must be maintained and prevented from being used for a purpose for which that water is not fit.

Class A schemes require a higher level of risk management compared to traditional agricultural recycling schemes. This is primarily due to the reduced ability of the supplier to tightly control residential behaviour in using the recycled water and greater exposure to a large population. The management aim is to prevent cross-connections and non-compliant uses and include surveillance systems to identify issues promptly.

Risks include, but are not limited to, the following:

- using recycled water for a purpose for which it is not fit due to inadequate identification of the recycled water or failure to implement the required end use controls
- contamination of higher-grade recycled water supply systems, taps or fittings with lower grade recycled water due to cross-connections between the two supplies or mis-connections
- pathogen contamination from the use of sewer repair equipment during mains alteration and repair
- pathogen contamination from the environment during mains alteration and repair
- opportunistic pathogen proliferation within recycled water during storage and/or distribution
- environmental impact due to burst mains and flushing events.

Methods to help mitigate these risks include, but are not limited to the following:

- Design, construction and installation:
  - adoption of suitable codes, such as the Water Supply Code of Australia (as amended from time to time, and noting utilities often have their own editions and supplemental codes). This code recommends against retaining permanent cross-connections between the recycled water and drinking water systems within the network downstream of storages
  - if drinking water or higher-grade recycled water supply back-up is provided to a recycled water system, then an approved registered air-gap should be implemented at the inlet to the recycled water storage. Alternative means of backflow prevention may be appropriate but these would need to be justified on a case-by-case basis
  - develop a process to ensure pipes and meters are only connected to the appropriate pipes that match their designation as being drinking water or a particular class of recycled water

  - include a process to inspect new connections in areas that include multiple reticulation lines of recycled water of higher and lower class and/or drinking water, this can be 100 per cent or some other proportion determined based on a risk
  - engage design, construction and installation contractors with appropriate accreditation and experience
  - conduct regular auditing of contractors' work
  - fire hydrants carrying recycled water should be clearly marked (for example, through labelling hydrants and fire plug covers with 'recycled water' and colouring hydrant covers or plug/valve surrounds purple) and be identified in accordance with the current fire services' guidelines for identifying street hydrants for firefighting purposes.

- System operation:
  - implement standard operating procedures for managing and maintaining the recycled water system
  - devise and implement an appropriate scheduled maintenance program
  - ensure that sewer or lower grade recycled water repair tools are not used to repair the higher-grade recycled water mains
  - flush higher-grade recycled water systems after recharge if potentially contaminated during repair and maintenance work
  - manage environmental impacts due to burst mains and flushing events
  - for operational reasons to assist in the control of biofilm, fouling, sloughing and odour formation, maintaining a disinfectant residual (for example free chlorine above 0.2 mg/L or combined chlorine above 0.5 mg/L) during recycled water storage and distribution is often helpful. The maintenance of such a disinfectant residual may also be required in some recycled water schemes for public health reasons to control opportunistic pathogens if relevant exposures (for example small size-class aerosol exposures to at risk groups) are considered reasonably foreseeable
  - The distribution system should be covered by a monitoring program to verify recycled water quality at the point of supply
  - auditing of schemes should take place periodically to confirm operation in alignment with the operating procedures.

### 22.2.2 Special considerations for plumbing

Distributing and storing recycled water continues beyond water supply points to customers. Since 1 July 2015, the identified supplier has been responsible for inspecting recycled water connections to achieve the objective of drinking water supply protection and prevention of recycled water consumption.

This includes developing and implementing a risk-based approach that adequately manages health risks to individual property occupants by preventing internal plumbing cross-connections between drinking water and recycled water systems.

The AGWR contain additional information and guidance on inspection, monitoring and auditing. The VBA undertakes some risk-based audits of domestic recycled water connections, as part of its regulatory role. However, this only covers a portion of recycled water plumbing works.

Plumbing-related risks are similar to those related to reticulation, although in some cases the controls are somewhat different as are those responsible for those controls. The following preventive measures are recommended to control these risks:

- undertake all plumbing works in accordance with the *Plumbing Regulations 2018, National Construction Code Volume Three: Plumbing Code of Australia, the Australian/New Zealand Standards AS/NZS 3500 Plumbing and drainage series* and any additional utility-specific obligations (the local water corporation should be consulted for the latter), ensuring the most current and appropriate versions are in use in each case. Special considerations for schools are summarised in Section 18
- ensure a licensed plumber installs the recycled water system, including appropriate backflow prevention on the recycled water service. At the residential property level, dual check meters or dual check valves provide appropriate backflow prevention in areas that reticulate class A recycled water. Higher levels of protection should be considered at sites with increased levels of on-site hazards such as lower grades of recycled water
- conduct periodic auditing of meter and backflow prevention installations
- use approved materials with the appropriate WaterMark and standard markings
- separate above-ground recycled water and drinking water infrastructure or higher and lower grade recycled water infrastructure by at least 100 mm
- separate below-ground recycled water and drinking water infrastructure or higher and lower grade recycled water infrastructure by at least 300 mm

- use purple identification tape for all below-ground recycled water pipes
- ensure that outdoor recycled water taps are coloured purple, consider having a removable handle and have them located at least 300 mm from any drinking water tap
- ensure recycled water taps are not interchangeable with drinking water taps. To prevent drinking water taps from being installed on a recycled water outlet, tap inlets should have different sized threads
- locate prohibition signs on all recycled water tap outlets no further than 150 mm from the tap handle. These signs should read 'Do Not Drink' and show a visual image
- use purple coloured recycled water meters
- ensure the recycled water meter is not interchangeable with the drinking water meter. To prevent the incorrect installation and swapping of meters, recycled water meters should have different threads from drinking water meters
- the supplier should provide advice enabling customers to self-check that the drinking water outlets are connected to the drinking water supply. This advice should also be provided to new owners, tenants and occupants
- the supplier should conduct an ongoing risk-based audit program to inspect properties for incorrect connections based on providing a reasonable sample size and inspection frequency (nominally inspecting all plumbing at least every five years or at some other appropriate risk-based frequency within the bounds of reasonable affordability and practicability). The design of the program should be informed by an assessment of risk and review of performance
- all internal plumbing connections to the dual water supply system are to be inspected during construction and installation. Three logical inspection points are:
    - connection from the recycled water meter to the house prior to backfilling
    - rough-in stage within the house prior to covering up the plumbing
    - testing and commissioning as part of the recycled water system commissioning process.
- consideration should be given to plumbing risks into the future, including for plumbing modifications and education of owners/residents when there is change in occupancy.

An example of a possible inspection process is given below.

While individual approvals from the VBA are not required, the VBA conducts audits of plumbing work to ensure work complies with relevant legislation. All plumbing work in Victoria must be carried out by an appropriately qualified registered and licensed plumber. Plumbing in the context of recycled water includes but is not limited to, drainage, fire protection, irrigation, mechanical services (including cooling towers), roofing, sanitary water supply, fire sprinkler systems and backflow prevention.

Contact the VBA on 1300 815 127 or visit www.vba.vic.gov.au for more information.

### 22.2.3 Possible inspections for recycled and drinking water supply systems

**Table 32 – Inspection 1: System integrity inspection on street main to ball valve at end of service pipe – dry tapping**

| Check item | Status |
|---|---|
| Turn off recycled water system and drain main empty. | |
| Charge drinking water system with water. | |
| Open successively all hydrants/fire plug and scours on drinking water system. Check that all outlets run with water. | |
| Open successively all hydrants/fire plug and scours on recycled water system. All outlets should run dry after a short time. | |
| Check that all hydrants/fire plug covers, hydrants/fire plugs/valve surrounds and marker posts/retro- reflective pavement markers are marked in accordance with WSAA standards. | |
| Open successively all service line ball valves on drinking water system. Check that all outlets run with water. | |
| Check that all service pipes and ball valve handles on drinking water system meet WSAA/water company standard and are not purple. | |
| Open successively all service line ball valves on recycled water system. All outlets should run dry after a short time. | |
| Check that all service pipes and ball valve handles on recycled water system are purple. | |
| Recharge recycled water system. | |

**Table 33 – Inspection 2A: Meter assembly installation inspection – dry tapping**

| Check item | Status |
|---|---|
| Check that drinking water meter has a dual non-return aspect or single non-return aspect with dual check valve and is connected to the drinking water service pipe ball valve and is not purple. Check that stop valve handle is not purple. | |
| Check that purple recycled water meter has at least a single non-return aspect and is connected to purple ball valve with purple handle. Check that stop valve handle is coloured purple. | |

**Table 34 – Inspection 2B: Service pipe and meter assembly installation inspection – wet tapping**

| Turn off recycled water system and drain main empty | Status |
|---|---|
| Tapping ferrule for drinking water is on blue drinking water main and handle is purple. | |
| Drinking water service pipe is not purple and is connected to drinking water tapping ferrule. | |
| Drinking water meter has dual non-return aspect or single non-return aspect with dual check valve aspect and is connected to the drinking water service pipe ball valve and is not purple. | |
| Tapping ferrule for recycled water is on purple recycled water main and handle is purple. | |
| Purple recycled water service pipe is connected to recycled water tapping ferrule. | |
| Purple recycled water meter is connected to purple service line and stop valve handle is purple. | |
| Then: turn on drinking water system ferrule. | |
| Turn off recycled water system ferrule. | |
| Open stop valve on drinking water system. Check that outlet runs with water. | |
| Open stop valve on recycled water system. Check that outlet runs dry after a short time. | |
| Turn off drinking water system ferrule. | |
| Turn on recycled water system ferrule. | |
| Open stop valve on drinking water system. Check that outlet runs dry after a short time. | |
| Open stop valve on recycled water system check that outlet runs with water. | |
| Turn on drinking water system ferrule. | |

## 22.3 RWQMP checklist

This checklist is intended to help support timely review of submissions:

- Complete submission:
  - Submissions and RWQMP should be presented as complete documents and not in separate parts at different times
  - the HACCP and CCP components of the RWQMP must be presented along with the validation information. That needs to include supplier validation reports.
- Prior discussion of novelty:
  - novel end uses or concepts presented for the first time (examples seen include sand mine water use, or something like concurrent disinfection with chlorine dioxide and free chlorine in the one reactor) that are not already familiar to regulator and the sector, and not covered explicitly in the Victorian or AGWR guidance, need to be presented and discussed prior to submission to avoid lengthy delays.
- Preliminary review of submissions:
  - including an independent review of the RWQMP, validation documents and application to the specific treatment plant operating conditions by the proponent would be useful in finding potential issues before submission and would probably speed up acceptance of schemes.
- Realistic timeframes:
  - Completion or commissioning dates are often clumped, for example end June or end December, which means that EPA might receive large quantities of reviews at times of minimal staff, and have been unable to respond to due to limited staff numbers, availability, holidays and multiple priorities. Therefore, submitting documents at times of low demand will increase review speed.