Victorian guideline for irrigation with recycled water

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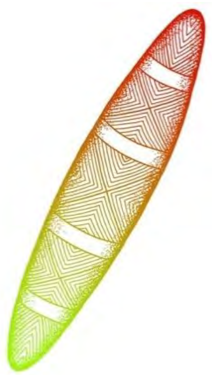

EPA acknowledges Aboriginal people as the first peoples and Traditional custodians of the land and water on which we live, work and depend.
We pay respect to Aboriginal Elders, past and present.

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.

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Preface

This guideline has been prepared following a review of feedback from a wide range of government departments, water authorities, industry, and other relevant stakeholders. It incorporates lessons from the application of the current recycled water guidance, and feedback from stakeholders involved in irrigating with recycled water.

EPA Victoria led the review, as part of a working group of regulator and industry representatives from:

- EPA Victoria
- Department of Environment, Land, Water and Planning (DELWP)
- Department of Health
- Agriculture Victoria
- VicWater
- South East Water
- Goulburn Valley Water
- Greater Western Water

RM Consulting Group (RMCG) was engaged by EPA to assist with the review.

Disclaimer

EPA guidance does not impose compliance obligations. Guidance is designed to provide information to help duty holders understand their obligations under the Environment Protection Act 2017 and subordinate instruments, including by providing examples of approaches to compliance. In doing so, guidance may refer to, restate or clarify EPA's approach to statutory obligations in general terms. It does not constitute legal or other professional advice and should not be relied on as a statement of the law. Because it has broad application, it may contain generalisations that are not applicable to you or your particular circumstances. You should obtain professional advice or contact EPA if you have any specific concerns. EPA Victoria 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.

Acronyms and Abbreviations

Acronym/abbreviation	Full title
AgVic	Agriculture Victoria
AGWR	Australian Guidelines for Water Recycling
AHA	*Aboriginal Heritage Act 2006* (Vic)
AHAR	*Aboriginal Heritage Regulations 2018* (Vic)
ANZECC	Australian and New Zealand Environment and Conservation Council
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	Biological oxygen demand
BoM	Bureau of Meteorology
CCL	Cumulative contaminant loading
CEC	Cation exchange capacity
CF	Crop factor
CHMP	Cultural heritage management plan, under the AHA and AHR
CHP	Cultural Heritage Permit
CMA	Catchment Management Authority
CVO	Chief Veterinary Officer
DELWP	Department of Environment, Land, Water and Planning
EC	Electrical conductivity
EPA	Environment Protection Authority

Acronym/abbreviation	Full title
EP Act	*Environment Protection Act 2017* (Vic)
EP Regulations	*Environment Protection Regulations 2021* (Vic)
ER	Effective rainfall
ERS	Environment reference standard
ESP	Exchangeable sodium percentage
ET	Evapotranspiration
ETo	Reference crop evapotranspiration
FAO	Food and Agriculture Organisation
GED	General environmental duty, under the EP Act
HA	*Heritage Act 2017* (Vic)
HEMP	Health and environment management plan
IR	Irrigation requirement
K	Potassium
Kc	Crop coefficient
Kp	Lagoon pan factor
LCA	Land capability assessment
LTV	Long-term trigger value
ML	Megalitre
M3-PSR	Mehlich-3 phosphorus saturation ratio
N	Nitrogen
Na	Sodium

Acronym/abbreviation	Full title
NWQMS	National Water Quality Management Strategy
P	Phosphorus
PE	Pan evaporation
PFAS	Per- and poly-fluoroalkyl substances
Publication 1910	*Victorian guideline for water recycling*
Publication 1911	*Technical information for the Victorian guideline for water recycling*
RAP	Registered Aboriginal Party, under the AHA and AHAR
RF	Rainfall
SAR	Sodium adsorption ratio
SMP	Site management plan
SS	Suspended solids
STP	Sewage treatment plant
STV	Short-term trigger value
TDS	Total dissolved solids
TPZ	Tree protection zone

Glossary of terms

Term	Description
Aboriginal cultural heritage	As defined in the AHA: Aboriginal places, Aboriginal objects and Aboriginal ancestral remains. See also 'Living cultural heritage' below.
Aboriginal intangible heritage	As defined in the AHA: any knowledge of, or expression of, Aboriginal tradition, other than Aboriginal cultural heritage. This includes oral traditions, performing arts, stories, rituals, festivals, social practices, craft, visual arts, and environmental and ecological knowledge. It does not include anything that is widely known to the public. It also includes any intellectual creation or innovation based on or derived from that knowledge or expression. See also 'Living cultural heritage' below.
Aquifer	A geological structure or formation, or an artificial land fill, permeated or capable of being permeated permanently or intermittently with water (as defined in the Water Act 1989 (Vic)). Aquifers include confined, unconfined, and artesian types.
Biological oxygen demand (BOD)	The decrease in oxygen content in a sample of water that is brought about by the microbial breakdown of organic matter in the water (note: BOD_5 is BOD measured over 5 days).
Buffer distances and strips	A transition zone between areas managed for different objectives to minimise detrimental interaction between the two.
Cation exchange capacity	The sum of exchangeable cations that a soil can absorb at a specific pH. It is usually expressed in centimoles of charge per kilogram of exchanges (cmolc/kg).
Consequence	The level of harm or severity of impact that a hazard can cause.
Contaminant	A biological or chemical substance or entity, not naturally present, or present at a higher concentration than naturally occurring in a system, which is a hazard to human health or the environment.
Country Plan	A strategic Healthy Country Plan as adopted by the relevant First Peoples corporation or Registered Aboriginal Party.
Cyanobacteria	A phylum of phototrophic bacteria containing chlorophyll and phycobilins, commonly known as ‘blue-green algae’.

Term	Description
Distribution system	A network of pipes leading from a treatment plant to customers' plumbing systems.
E. coli	*Escherichia coli.* A bacterium found in the gut of warm-blooded animals used as an indicator of faecal contamination.
Electrical conductivity (EC)	Used to derive salinity, electrical conductivity is a measure of a solution's ability to carry an electrical current. This is directly related to the concentration of ions in the water, which include dissolved salts. Measured in dS/m or µS/cm.
Environment	As defined in the EP Act: the physical factors of the surroundings of human beings including the land, waters, atmosphere, climate, sound, odours and tastes; and the biological factors of animals and plants; and the social factor of aesthetics.
Environmental value	As defined in the EP Act: A use, an attribute or a function of the environment.
Eutrophication	Degradation of water quality due to enrichment by nutrients such as nitrogen and phosphorus, resulting in excessive algal growth and decay and often low dissolved oxygen in the water.
Evapotranspiration	A combination of the amount of water used by plants and water evaporated from the surface.
ESP (exchangeable sodium %)	The proportion of sodium adsorbed on soil clay mineral surface, as a percentage of total cation exchange capacity (used as a measure of soil sodicity).
Flocculation	Clumping or aggregation of particles to form larger aggregates. Used in this document in relation to soils. Soil particles will flocculate if the amount of soluble salts in the soil is increased (increased EC).
General Environmental Duty	The general environmental duty (GED) is central to the *Environment Protection Act 2017* (the EP Act). It compels all Victorians to reduce the risk of harm from their activities to human health and the environment from pollution or waste.

Term	Description
Groundwater	As defined in the EP Act: Any water contained in or occurring in a geological structure or formation or an artificial landfill below the surface of land.
Heavy metals	Metallic elements with high atomic weights, such as mercury, chromium, cadmium, arsenic and lead. They can cause damage to living organisms at very low concentrations and tend to accumulate in the food chain.
Helminth	A worm-like invertebrate of the order Helminthes. A parasite of humans and other animals.
Industrial wastewater	Produced from processes at industrial or commercial premises, including all waterborne waste from these facilities except sewage. See also the term 'wastewater' below.
Irrigation	The artificial application of water to supply the water requirements of plants and crops for agricultural production, recreational land use or public amenity.
Leaching	The loss of water-soluble compounds (e.g. nutrients) through the soil profile due to rain, irrigation, or other water source.
Leaching irrigation	The practice of applying a small amount of excess irrigation for salinity control. It assists with flushing salts through the soil.
Licence to take and use water	A licence granted under Section 51 of the Water Act 1989 to take and use water from unregulated water systems such as a waterway, catchment dam, spring, soak or aquifer, for a use other than domestic and stock use. This does not apply to recycled water. See also the term ‘water-use licence’ below.
Likelihood	The probability or chance that a hazard will cause harm.
Living Cultural Heritage	Includes Aboriginal cultural heritage and Aboriginal intangible heritage as defined under the AHA and AHAR (see definitions above).
Municipal	Of or relating to a town, city or district governed by a local government. For municipal use of recycled water, this refers to the local government irrigating racetracks, ovals, lawn, bowls greens, roadsides, parklands, golf courses and any other area under its control.

Term	Description
Osmosis	The passive (natural) movement of water through a membrane where the water moves from low to high salt concentration. Process by which plants absorb water and nutrients from soil.
Pathogen	Organism capable of causing disease. In untreated wastewater, the key pathogen groups are bacteria, viruses, protozoa and helminths.
Potable water	Water suitable, based on both health and aesthetic considerations, for drinking or culinary purposes.
Recycled water	Water that has been derived from sewerage systems or industry processes and treated to a standard that is appropriate for its intended use. For this guideline, the term does not include water derived from stormwater or farm effluent (e.g. dairy effluent, piggery effluent) that has been created on-farm, captured, and applied to the farm as irrigation.
Reverse osmosis	The forced movement of water through a semipermeable membrane from high to low salt concentration when pressure is applied. Used for salt reduction in wastewater treatment.
Risk	Risk is the threat that a hazard poses to a receptor, where: • a hazard is something that has the potential to cause harm (e.g. spills into stormwater) • a receptor is something of value that can be harmed (e.g. the environment or human health) • a pathway is the route that the hazard can take to reach the receptor (e.g. air, water, soil). Risk is made up of likelihood and consequence as those terms are defined above.
Runoff	Surface overland flow of water resulting from rainfall or irrigation exceeding the infiltration capacity of the soil.
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.
Shandying	The addition of one water source to another, which modifies the quality of the water through dilution. You must not supplement recycled water with other water sources to improve the quality of inadequately treated recycled water, prior to use,

Term	Description
	other than to dilute elevated salinity concentrations or to supplement volumes.
Significant ground disturbance	"disturbance of – (a) the topsoil or surface rock layer of the ground; or (b) a waterway – by machinery in the course of grading, excavating, digging, dredging or deep ripping, but does not include ploughing other than deep ripping" as defined in the AHAR.
SILO	A database of Australian climate data from 1889 to the present, available via www.longpaddock.qld.gov.au.
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 (dispersing).
Soil ameliorant	Product that can be added to soils to improve chemical or physical properties (examples include using lime to increase pH, and dolomite or gypsum to reduce soil sodicity).
State of Knowledge (SoK)	What do you know, should reasonably know, or what can you find out, about the risks your activities pose, which means all the information you should reasonably know about managing your business's risks. This includes information from EPA and other sources.
Surface water	Waters other than groundwater. Examples: river, stream, billabong, lake, tidal water, estuary, marine and coastal water.
Suspended solids	Solid particles which remain in suspension in water.
Total dissolved solids (TDS)	A measurement of the total dissolved solids, which is the sum of all ion particles, including salts. Used as a measure of salinity with the units of mg/L. Major salts in recycled water typically include sodium, magnesium, calcium, carbonate, bicarbonate, potassium, sulphate, and chloride.
Trade waste	Any waterborne waste (other than sewage) which is suitable, according to the criteria of a Water Authority, for discharge into the Authority's sewerage system.
Turbidity	The cloudiness of water caused by the presence of fine suspended matter.
Wastewater	As defined in the EP Regulations: Waste principally consisting of water and including any of the following:

Term	Description
	a) sewage or other human-derived wastewater; b) wash down water or cooling water; c) irrigation runoff or contaminated stormwater; d) contaminated groundwater; e) water containing any commercial, industrial and trade waste.
Waterlogging	Waterlogging is the natural flooding and over-irrigation that brings water at underground levels to the surface.
Water table	The surface of saturation in an unconfined aquifer at which the water pressure is equal to atmospheric pressure (the depth below which ground is saturated).
Water-use licence	A licence granted under Division 2 of Part 4B of the Water Act 1989. Applies to water that is from a declared water supply system. See also the term 'licence to take and use water' above.

1. Introduction

1.1. Irrigation with recycled water in Victoria

Irrigation has been a part of the landscape in Victoria since time immemorial. First Peoples in Victoria manipulate freshwater and saline water systems for terrestrial food irrigation, and eel and fish aquaculture, in a careful and sustainable manner thereby protecting and conserving water as well as the animal and plant system. The most prominent examples in Victoria include the Budj Bim aquaculture system (as recognised in its World Heritage designation), the Lake Bolac system and the Barwon River system.

More recently, irrigation has been used to enable large scale intensive agricultural production and greening of our cities and towns.

Irrigation has become a vital component of Victoria's recycled water management.

1.2. Purpose of this Guideline

This guideline provides information to support designers and operators of irrigation systems using recycled water, including water corporations, industries that produce recycled water for irrigation and irrigation managers. It is also a key resource for regulatory decision makers evaluating and approving recycled water irrigation schemes, and for end users.

The guideline does not prescribe performance objectives, but rather, it articulates risks that may need to be identified and managed. Appropriate controls should be considered to minimise the risks of harm to the environment - including the crops being irrigated - and to human and animal health, so far as reasonably practicable.

By encouraging the use of recycled water for irrigation, the guideline aims to support the reduction in demand on potable water and other fresh water sources.

Great care has been taken to ensure that the guideline can be use by a broad range of people, and regardless of the scheme size. However, it is acknowledged that at times, the information in this guideline may not be suitable for all end users, due to the range of situations that apply to specific proposed recycled water schemes. In these instances, it is recommended that recycled water producers and recycled water scheme managers consult with the EPA to develop risk-based and site-specific approaches.

1.3. Benefits

There are a range of benefits that can be achieved through the design and implementation of a sustainable recycled water irrigation scheme. These include:

- Enhanced water security given the reliability of recycled water supply compared with the variability associated with other irrigation water sources
- Reduced demand on Victoria's drinking water supplies
- Reduced diversion of water from watercourses and groundwater
- Potential treatment and disposal cost savings by turning a waste into a resource with economic or social benefits
- Reduced wastewater discharges to surface waters
- Improved public open spaces due to the watering of sporting grounds and other critical public assets (especially during periods of water restrictions)
- Utilisation of the nutrients contained within the recycled water and the potential for a reduction in the use of finite fertiliser resources.

1.4. Scope

1.4.1. Broader Recycled Water Guidance

This publication forms part of EPA Victoria's guidance for recycled water as described in Figure 1-1. It should be read in conjunction with both Publication 1910: *Victorian guideline for water recycling*, and Publication 1911: *Technical information for the Victorian guideline for water recycling*.

Publication 1910 provides the overarching framework for water recycling. Publication 168 (this guidance) provides additional detail to support risk assessment and identification of management controls for recycled water irrigation.

EPA Victoria also promotes the use of the *Australian Guidelines for Water Recycling* (AGWR) which provide a framework for management of recycled water quality and use. The AGWR framework provides a structured risk-based approach to recycled water management.

Information about the Victorian environment protection legislative framework including the regulations that underpin this guideline is provided in Section 1.5.

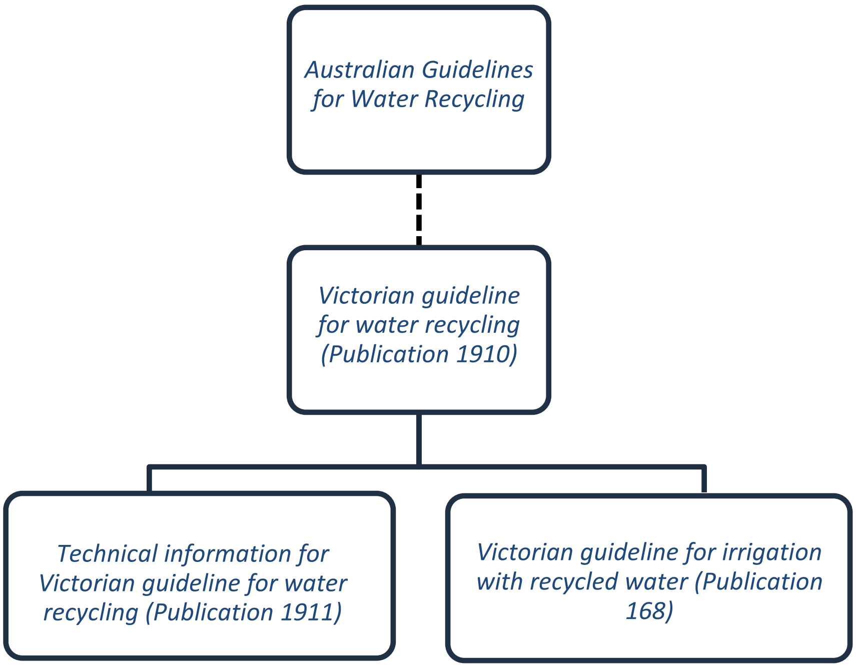

Figure 1-1 Relationship between the Victorian and Australian recycled water guidance

1.4.2. Limitations

The information in this publication contributes to the state of knowledge in relation to the risks of irrigating with recycled water. It suggests technical approaches and methods that can be used to align with EPA Publication 1910. This guideline is not a comprehensive design manual for irrigation systems.

This guideline does not relate to farm effluent (e.g. dairy effluent or, piggery effluent) that has been generated on-farm, captured and applied to the farm as irrigation. Farmers managing effluent and looking for management advice should refer to Agriculture Victoria's codes for animal production:

- Planning for sustainable animal industries in Victoria
- Planning for sustainable animal industries

There is also technical guidance for specific animal sectors. Additional detail can be accessed from Agriculture Victoria:

https://agriculture.vic.gov.au/about/agriculture-in-victoria/sustainable-animal-industries

1.5. Regulatory Framework

The *Environment Protection Act 2017* aims to minimise the risk of harm to human health and the environment from pollution and waste.

The centrepiece of the legislation is the general environmental duty (GED). The GED requires that any person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable.

Doing what is **reasonably practicable** means that you must *put in proportionate controls to mitigate or minimise the risk of harm.* Reasonably practicable involves consideration of all the relevant circumstances and, at least, the following six factors:

1. Eliminate first: Can you eliminate the risk?
2. Likelihood: What's the chance that harm will occur?
3. Degree (consequence): How severe could the harm be on human health or the environment?
4. State of knowledge: What do you know, should reasonably know, or what can you find out, about the risks your activities pose and the possible management controls for those risks?
5. Availability and suitability: What technology, processes or equipment are available to control the risk? What controls are suitable for use in your circumstances?
6. Cost: How much does the control cost compared to how effective it would be in eliminating or reducing the risk?

For further information about how to determine what is reasonably practicable, please read Publication 1856: *Reasonably practicable*.

Other key duties relating to environmental protection in the Environment Protection Act, include:

- **Duty to Take Action:** if you are engaging in an activity which causes a pollution incident, and the pollution incident causes or is likely to cause harm to human health or the environment, you must, so far as is reasonably practicable restore the affected area to the state it was in prior to the incident.
- **Duty to Notify of Notifiable Incident:** if you are engaging in an activity that results in either a pollution incident that causes or threatens to cause material harm to human health or the environment, or a prescribed notifiable incident, then you must notify the EPA as soon as practicable after you become aware, or should be aware, of the incident.
- **Duty to Manage Contaminated Land:** if you manage or are in control of contaminated land, you must minimise risks of harm to human health and the environment from the contaminated land so far as reasonably practicable. This includes, but isn't limited to, identifying and assessing the contamination, provision and maintenance of reasonably practicable measures, and providing adequate information to anyone who might be affected by the contamination.
- **Duty to Notify of Contaminated Land:** if you manage or are in control of land, you must notify the EPA as soon as practicable after you become aware, or should be aware, of the land becoming contaminated by notifiable contamination.

Supplying or using recycled water is a prescribed permission activity under Schedule 1 of the Environment Protection Regulations 2021. This means if you are using or supplying recycled water you may need a permit (A14 recycled water supply or use) for your activities, or an exemption, otherwise you may be in breach of the EP Act and subject to a penalty or other enforcement action.

You can apply for a permit online. For application support, see How to apply for a permit.

This guideline also provides some references to, or brief overviews of, legislation relating to the potential need for permits or licences under other legislative regimes; for example, water licences, planning permits, or permits relating to works that may affect Aboriginal and other cultural heritage.

In this guideline, discussion of the EP Act and EP Regulations, and other legislative frameworks, is not intended to be comprehensive. Users of this guideline, such as proponents or managers of recycled water irrigation schemes, or producers of recycled water, are responsible for understanding, managing, and complying with, any applicable legal requirements.

1.6. Objectives and Principles

1.6.1. Objectives

The overall objective when using recycled water for irrigation should be to:

> *Use the recycled water resource in a manner that provides direct or indirect economic or social benefit, whilst minimising (eliminating or reducing) risk of harm to the environment, human and animal health, and food/produce safety.*

This means recycled water is to be used in a way that:

- Meets the water and nutrient needs of the plants irrigated
- Maintains soil conditions for optimum plant growth/yield
- Maintains or improves environmental values of land, surface water and groundwater
- Ensures the production of food or other products that are safe and useful to the community
- Supports amenity of public open spaces in a manner that is safe for users.

This guideline aims to ensure the overall objective is achieved by:

- Setting clear objectives for irrigating with recycled water
- Suggesting practices that allow the objectives to be met
- Identifying potential risks and situations that contribute to increased risk when using recycled water for irrigation
- Managing/mitigating risk of harm to the environment and human health.

A variety of sites can be irrigated. However, the specific management requirements to minimise risk of harm to the environment and human health, the cost of development and the recycled water itself, may vary for each site.

1.6.2. Waste Hierarchy

Victoria's waste management hierarchy (Figure 1-2) should be applied when considering use of recycled water. The first preference, before using recycled water, should be to avoid and reduce water and resource consumption by implementing water conservation and efficiency measures and cleaner production initiatives. Improved resource efficiency can reduce the volume of water needed, as well as improve the quality of water available for recycling.

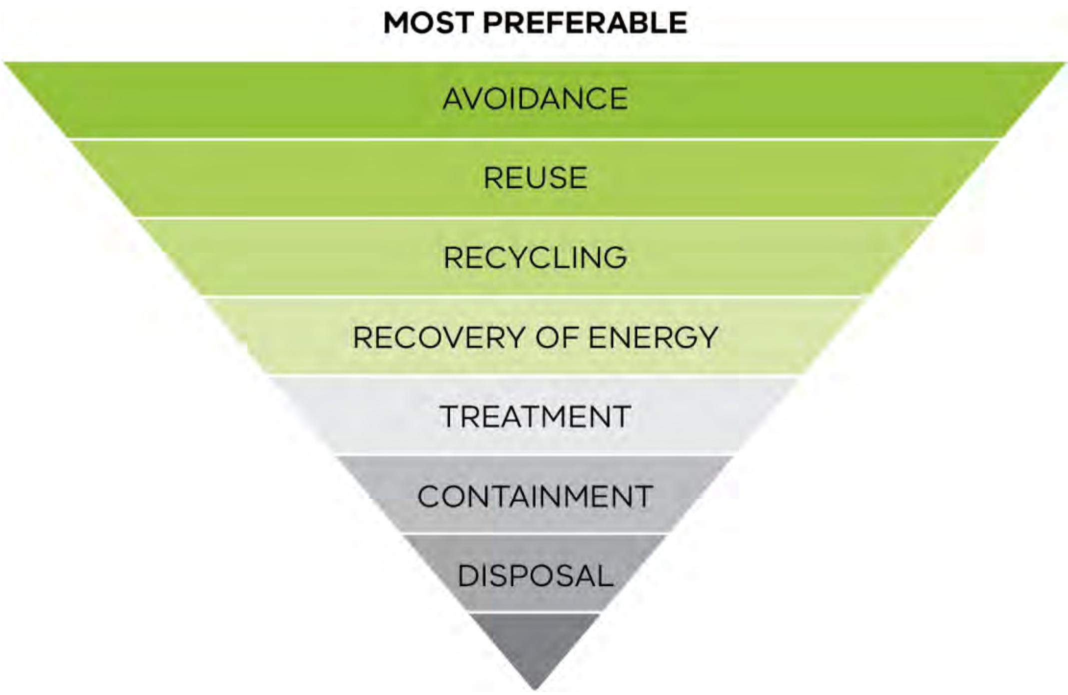

Figure 1-2 Victoria's Waste Management Hierarchy

2. How to use this guideline

2.1. Assessment Process

The process for developing an irrigation scheme using this guideline is as shown below. The level of detail builds at each stage depending on site circumstances and risks identified.

This process is potentially iterative. For example, at the risk assessment stage, identification of a high risk may mean selecting an alternative site and so may require stepping back to the site selection and land capability assessment.

Note that proposals should be discussed with EPA Victoria early in the development process, particularly where high risks have been identified.

The recycled water scheme is documented in a health and environment management plan (HEMP) that details the health and environmental risks and associated management practices. This may be supported by a user site management plan (SMP) that is specific to the irrigation reuse site. Further information on HEMPs and user SMPs is provided in EPA Publications 1910 and 1911.

Figure 2-1 Assessment process

2.2. Risk Assessment and Management Controls

The intent of the risk assessment is to identify and understand potential risks of harm to the environment or human health associated with a particular site.

Within subsequent chapters, tables are provided outlining examples of lower risks and higher risks in relation to recycled water irrigation. Between these lower and upper bounds, there is medium or moderate risk to the environment or human health. The risk tables provide guidance to assist with risk assessment but should not be seen as exhaustive.

The overall assessment of risk is the aggregation of the assessment of risks associated with various decisions to be considered when designing a recycled water scheme, including:

- quality of the recycled water and its acceptable uses
- recycled water volume
- site selection
- land use and crop selection
- risk to the environment.

The risk assessment informs the management controls required in response. This is explained further in the following diagram.

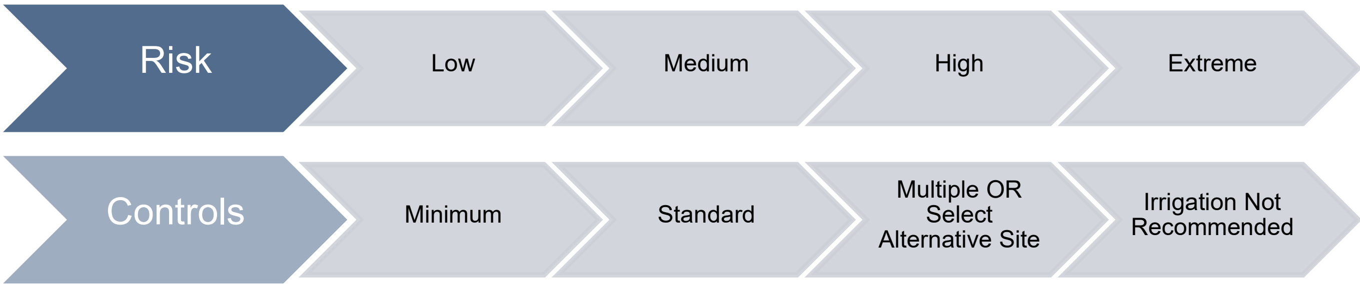

Figure 2-2 Risk assessment and selection of management controls

Controls can be divided into two categories, preventative, and mitigating:

- Preventative controls prevent harmful events from happening in the first place.
- Mitigating controls limit the consequence or damage from a harmful event.

Preventative controls are intended to eliminate the risk altogether or reduce it by making the risk less likely to materialise. Mitigating controls aim to minimise the harmful impacts of any residual risk that cannot otherwise be eliminated.

Standard controls are relatively straightforward and common in irrigation management, such as the use of a runoff collection and reuse system with surface (flood) irrigation. In high-risk situations, additional (or multiple) controls would be needed such as installation of a wetland for stormwater nutrient management. Where high risks cannot be adequately controlled, consideration should be given to an alternative site or an alternative approach to wastewater management.

Controls used at one site may appear to be less sophisticated or use a more basic level of technology than another. However, both sites may be using the most reasonably practicable controls for the associated risk level.

It is important that the management controls selected for a particular situation are not seen as static. They will need to be updated as objectives, strategies or circumstances change, and as technology and state of knowledge improve. This guideline encourages suppliers and users of recycled water to strive for continuous improvement in performance.

Further guidance on risk assessment and management is provided in Publication 1695: *Assessing and controlling risk: A guide for business* and the *Australian Guidelines for Water Recycling* (AGWR).

2.3. Introduction to Guideline Components

Six components are described in this guideline: volume, land use and irrigation system, water quality, receiving environment, cultural and social values, and health. Each component has sub-components as shown in Figure 2-3. All need to be considered when planning and developing appropriate management controls for irrigating with recycled water.

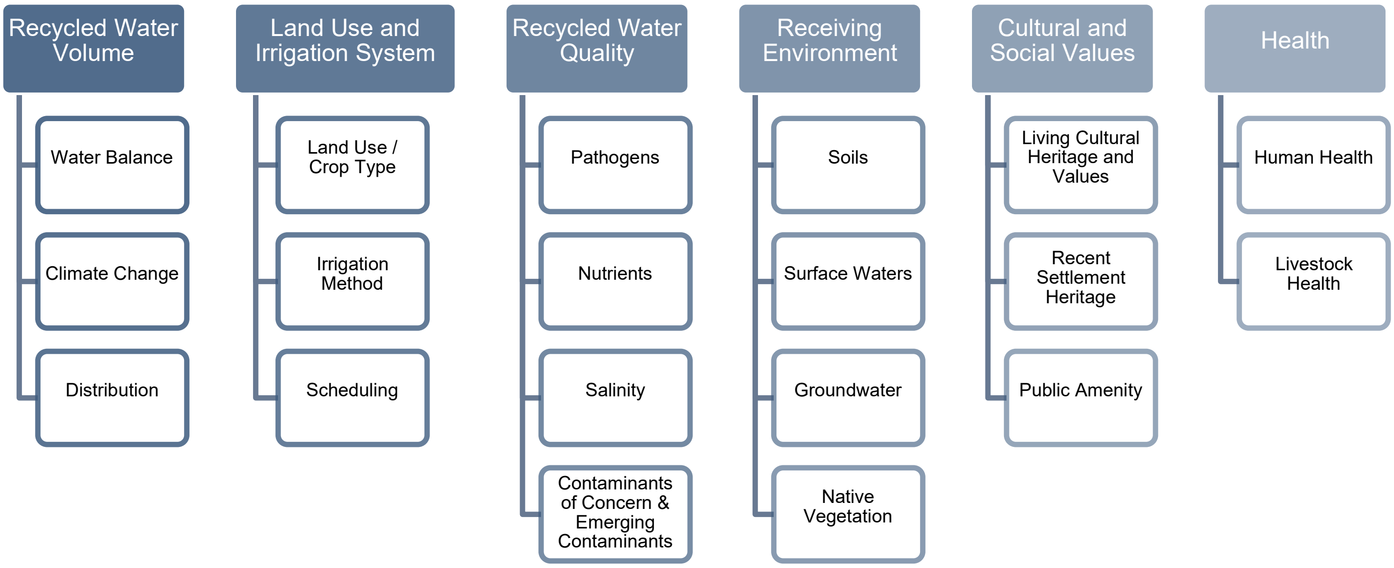

Figure 2-3 Components of a recycled water irrigation scheme

Note that Public Amenity incorporates consideration of odour and noise.

Each component of a recycled water irrigation scheme is discussed further in Chapters 4 to 9, including consideration of:

- The desired performance objectives
- The circumstances leading to different risk levels
- Appropriate management controls to use in response to risk
- Monitoring and review activities
- Further information sources.

Each component can be worked through in turn, but meeting all performance objectives requires interaction between the components. Therefore, an iterative approach is needed to develop the final set of appropriate and relevant management controls for the irrigation system, as indicated in Figure 2-4.

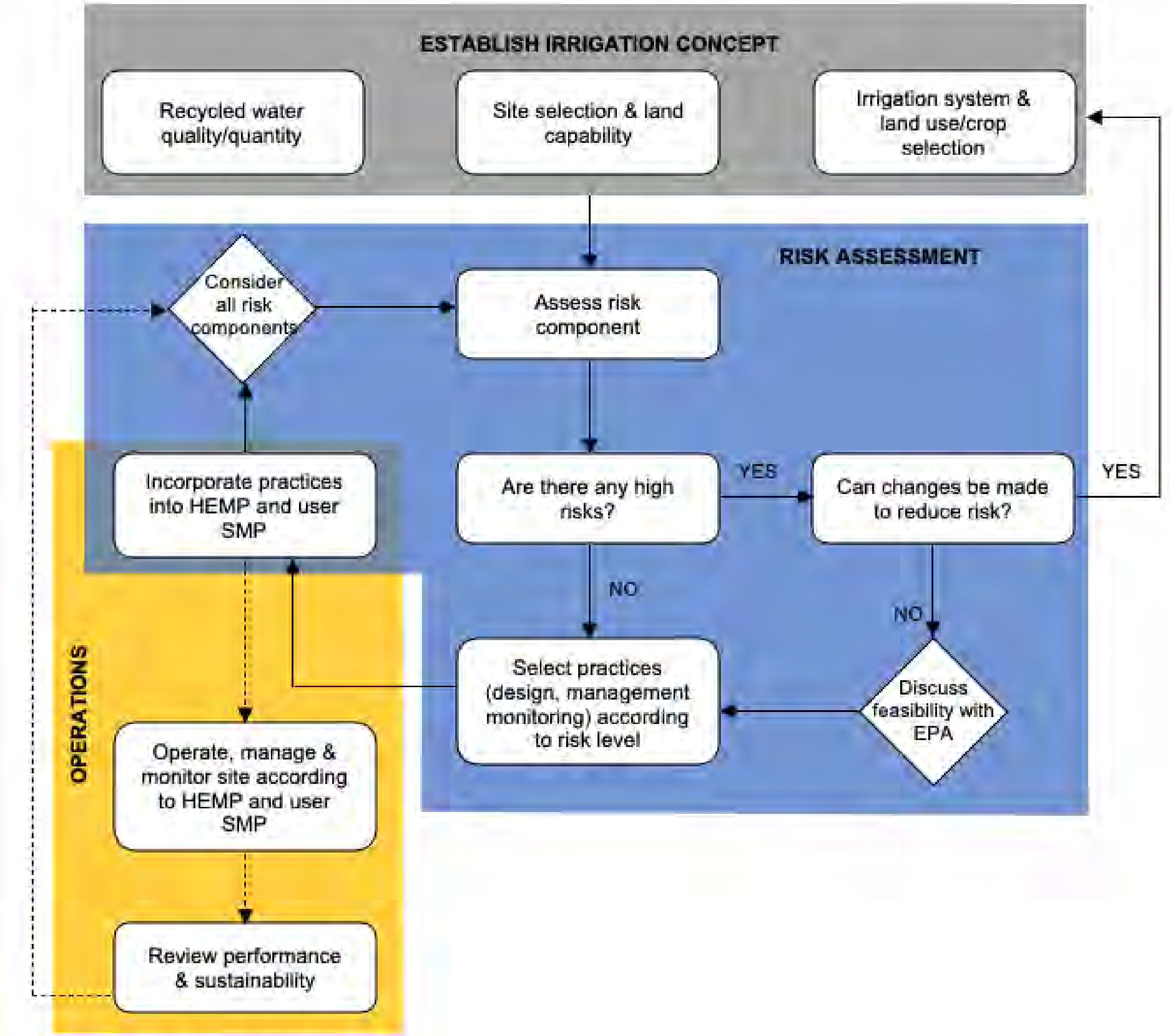

Figure 2-4 Assessment Process for Recycled Water Irrigation Schemes

3. Preliminary assessment

3.1. Recycled Water Quality and Acceptable Uses

Understanding the quality of the recycled water available is critical in determining appropriate irrigation land uses. Conversely, if the land use is already established, this will determine the quality and thereby treatment standards required for the recycled water supply.

Publication 1910 outlines three classes of recycled water (Class A, B and C) and provides the corresponding standards of biological treatment and pathogen reduction for each class. It also defines categories of use that are acceptable for each class and management controls such as livestock withholding periods. A summary, specific to irrigation uses, is provided in Table 3-1 – see Section 9.2.

Table 3-1 Recycled water class required for specified irrigation uses of recycled water

Recycled water class	Agricultural uses					Municipal uses	
	Raw human food crops exposed to recycled water	Dairy Cattle grazing / fodder and livestock drinking (not pigs)	Cooked / processed human food crops or raw human food crops not directly exposed to	Grazing / fodder for cattle, sheep, horses and goats	Non- food crops, woodlots, turf, flowers	Public open spaces with Unrestricted Access	Public open spaces with Controlled Public Access
Class A	✓	✓	✓	✓	✓	✓	✓
Class B		✓	✓	✓	✓		✓
Class C			✓	✓	✓		✓

Publication 1910 applies to municipal sewerage facilities and to industrial wastewater treatment facilities.

The quality and quantity of industrial wastewater is highly variable, and the risks it presents to agriculture, the environment and the community may differ to municipal sewage. It may have different pathogen levels and a different microbial risk profile than recycled water from municipal sewerage facilities. It could also have higher loads of other contaminants such as metals, nutrients and salts. The standard conditions adopted for each Class of recycled water may not always be applicable.

For example, the median objectives for biological oxygen demand (BOD) and suspended solids (SS) for Class C recycled water primarily relate to the treatment performance of municipal sewage treatment plants. There could be instances where industrial wastewater treatment facilities produce recycled water with higher BOD and SS concentrations than the Class B or C objectives, but the risks they present remain low. This is because any odour generated by the treatment plant will not impact on surrounding land uses or the broader community, and the suspended solids are appropriate for the type of irrigation system and present a low risk of clogging of soil pores.

For scheme proponents to demonstrate manageable risks with higher concentrations than the Class B or C objectives, they need to undertake a detailed risk assessment that justifies the higher concentration, and consult with EPA prior to commencing. A monitoring plan would also need to be developed and implemented to demonstrate that the risks are being managed as proposed.

Other quality parameters impacting on the suitability of recycled water for irrigation are:

- Nutrients are utilised in plant growth and can be beneficial in terms of production. However, if nutrients are applied in excess, they can be transported offsite and cause harm to surface waters and groundwater. The nutrient content of secondary treated sewage is normally between 10 and 30 mg/L nitrogen, and between 5 and 10 mg/L phosphorus (refer to Australian Guidelines for Water Recycling for further discussion). Tertiary treatment plants configured for nutrient removal can reduce these levels to < 5 mg/L of nitrogen and < 1 mg/L of phosphorus. Industrial wastewater can have very high nutrient levels depending on the source industry.
- Salts in recycled water can limit the type of land use and/or the volume of water that can be used for irrigation. Recycled water with a salinity of up to 500 mg/L TDS can generally be used without significant risk to the environment or the plants irrigated. When recycled water with salinity levels over 500 mg/L TDS is used, there is potential risk to the environment and the plants irrigated. Salinity controls will usually be needed and detailed assessment required.
- Other contaminants, such as organic and inorganic chemicals and heavy metals, may risk harm to soils and the safety levels of produce for human and animal consumption. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) provide criteria for the quality of irrigation water, above which contaminants may pose risks to agricultural land, farm produce quality and the environment.

Water quality is discussed in further detail in Chapter 6.

3.2. Site Selection

The site refers to the potential area of land that could be used for irrigation.

Characteristics of the site that impact on recycled water irrigation suitability are outlined in Table 3-2. The lower and higher-risk situations for each characteristic are provided. In addition to increasing the risk to the environment or human health, higher risk situations can significantly increase the cost and degree of complexity in irrigation design and management.

Table 3-2 Indicative Risk Levels – Site Selection

Characteristic	Lower risk	Higher risk
Slope	Flat to moderate and uniform grades	Steep and/or undulating (>10%)
Soil type	Deep sandy loam	Shallow soils Highly permeable sands Heavy poorly structured clays Duplex soils with shallow topsoils and heavy clay subsoil
Existing salinity	Low soil salinity (<2 dS/m ECe)	High soil salinity (>4 dS/m ECe) Saline groundwater (Segment C-F) with potential for interaction with plant rootzone Presence of salt tolerant species
Rainfall	Low (< 400 mm/year)	High (> 900 mm/year)
Irrigation history	Well managed existing irrigation Current water supply is insufficient or unreliable	No previous irrigation Existing irrigation is creating risks of harm to the environment or human health
Land use history	Low intensity agriculture	Potentially contaminated land Relatively undeveloped site (refer to living cultural heritage and native vegetation below)
Surface waters	None present within 500 m of site	Waterways or wetlands on site or within 100 m of site Potable water supply catchment area
Groundwater	Groundwater quality in Segment C-F (see 0) Limited potential for leaching due to soil type (e.g. impermeable clay subsoils)	Groundwater quality in Segment A1 or A2 Water table is close to surface. High potential for leaching due to soil type (e.g. high permeability sands)
Native vegetation	None present	Significant amount of remnant grasslands, shrubs or trees present

Characteristic	Lower risk	Higher risk
Proximity to sensitive areas (e.g. urban development, public parks, schools)	Large buffer (> 200 m)	Close (< 100 m)
Living cultural heritage values	No known Aboriginal tangible cultural heritage places present Consultation undertaken with the relevant RAP and/or Traditional Owner groups to clarify there is no Aboriginal intangible heritage present Alignment of project and works to the relevant Country Plan and its values Site has long history of agricultural or municipal development	Living cultural heritage on site or pertinent to the site/s Relatively undeveloped site in proximity to waterways (<200m) or remnant vegetation areas

3.3. Land Use and Crop Selection

Land use or the crop selected for the area to be irrigated determines the level of water use, the sensitivity to water quality parameters and the level of management required to ensure sustainable irrigation. Examples of land uses, and a guide to their suitability for recycled water irrigation, is provided in Table 3-3. The land use selected for a recycled water irrigation scheme should balance all the factors listed.

Table 3-3 Land Use / Crop Type and General Suitability for Recycled Water Irrigation

Plant	Water use	Nutrient uptake	Salt tolerance	Preferred soil types[1]	Management level required
Woodlots (e.g. native trees, pines, poplars)	High	Very Low	Moderate to high	Class I–IV	Basic (e.g. relatively easy to irrigate)
Food trees (e.g. apples, olives etc.)	Moderate	High	Low	Class I (citrus, cherries) Class I–II (apples, olives)	Intensive
Food crops intensive (e.g. cabbage, beans, broccoli, lettuce etc.)	Moderate to high	High	Low to moderate	Class I–II	Intensive
Food crops broadacre (e.g. wheat, rice, potatoes)	Moderate to high	Moderate (wheat) to high (potatoes)	Low to moderate	Class I–IV	Moderate
Viticulture	Low to moderate	Moderate	Moderate	Class I–III	Intensive
Pastures for grazing or fodder	Moderate to high	High (hay) Moderate (grazed)	Low to moderate (some high)	Class I–IV	Basic to moderate
Turf grass	Moderate to high	Low	Low to moderate	Class I–III (soil is often imported)	Moderate
Ornamental gardens	Moderate to high	Low	Low	Class I–III	Intensive/specialist

[1] Soil types (soil classes) are defined in Appendix 5.

3.4. Land Capability Assessment

A land capability assessment (LCA) aids site selection, determination of land use and identification of risk to the environment.

As outlined in Publication 1911, understanding the land system where recycled water will be used is crucial for a scheme in which water is applied directly to the land. The LCA should characterise the environmental pressures in the context of the recycled water scheme and provide the basis for the environmental risk assessment.

With a LCA, land is considered to include all the elements of the physical environment, including climate, geology, topography, soils, hydrology, and vegetation. Thus, the word ‘land’ is used in a wider sense than the traditional concepts of soils or terrain. There may be one characteristic (such as soils or topography) that exerts a dominant influence. However, it is the interaction between all the land characteristics which determines the potential for sustainable land use.

Confusion sometimes arises over the use of the terms: land capability and land suitability. In some instances, they are used synonymously. In the context of land evaluation, land capability should be used in reference to the influence that the characteristics of the land have on its use. Land suitability applies where other considerations such as location or access are also favourable. For example, a piece of land may have a high capability for irrigation but may not be close enough to the source of the recycled water to make it suitable for that purpose.

Completion of a LCA involves use of maps, spatial data, aerial photography, soil sampling, visual site assessment and other relevant data.

Aspects to consider in the LCA include:

- Topography
- Soil type, considering physical and chemical characteristics
- Climate data
- Local and regional hydrogeology
- Groundwater depth, flow direction, quality and environmental values
- Location of groundwater bores and their uses
- Nearby major waterways and drainage paths, flow regime, water quality and environmental values
- Evidence of site constraints such as flooding, poor drainage, salting, rock outcrops or erosion
- Living cultural heritage and values
- Current or previous land use
- Vegetation types and cover
- Land zoning and planning specifications
- Location of sensitive land uses (e.g., nearby residences)
- Location of services such as electricity.

A useful reference is the *Guidelines for Land Capability Assessment in Victoria*, developed in 1981 by R K Rowe, D F Howe, and N F Alley of the former Soil Conservation Authority. This provides generalised definitions of land capability (see an edited version in Table 3-4), as well as land capability rating systems specific to a number of land uses.

The regional Irrigation Development Guidelines (accessed by contacting your local Catchment Management Authority) also provide a land capability assessment process that can support recycled water development.

Table 3-4 Land capability general definitions

Class	Land capability	Degree of limitation / hazard	Level of management required
1	Very good	None to very low	No special management needed
2	Good	Low or slight	Limited management needed
3	Fair	Moderate	Careful management is required
4	Poor	High	Skilled managed and extensive conservation measures required
5	Very poor	Severe	Unlikely to be sustainable even with special management Risk to land and/or water always present

4. Recycled Water Volume

4.1. Water Balance

4.1.1. Objective

Adequate irrigation area and storage is provided for both present and projected future recycled water volumes.

4.1.2. Potential Impacts

An inadequate balance between irrigation area and storage could lead to discharge to the environment, potentially impacting on adjacent land, downstream surface waters and/or groundwater.

To achieve full reuse of recycled water, the area of irrigation and the volume of storage should be able to contain all wastewater up to the 90th percentile wet year. This includes recycled water, irrigation runoff and contaminated stormwater.

Factors that can influence the water balance include:

- Managing the irrigation site to achieve a high level of agricultural production or recreational amenity will ensure that water use is maximised. This in turn, will minimise the volume of storage needed and the likelihood of offsite discharge.
- Surface water can flow onto the irrigation area from adjacent land. This can reduce the irrigation water required, cause waterlogging/flooding (which reduces plant productivity and increase the risk of recycled water moving off-site)) or can lead to excessive leaching (which may pollute groundwater). This run-on should be prevented (by installation of cut-off drains upslope from the irrigation area) or it needs to be accounted for in the water balance. Poor surface drainage can have a similar impact to run-on.
- Where groundwater exists close to the surface, this may be accessed by plants for transpiration. This could reduce the amount of irrigation water that is required. It could also cause waterlogging and/or soil salinisation (depending on soil type). This needs to be accounted for in determining land capability and the irrigation area required.
- The quality of the recycled water (e.g. salinity / nutrients) can impact on application rates and plant water usage. This needs to be accounted for in determining the irrigation area required. A supplementary water supply may be required for shandying (diluting) to manage salinity or topping up the recycled water and can affect significantly the irrigation area required for a scheme.
- The land use selected and associated management controls (e.g. stock withholding periods) may affect the ability of the irrigation manager to meet plant demand.
- The storage design should minimise evaporation, which can increase salinity levels in the recycled water.
- The storage design should minimise seepage, to avoid pollution of groundwater. Refer to Publication 1911 for further recommendations on storage design and construction.
- For sites that have access to surface water or groundwater for irrigation, through a water-use licence or a licence to take and use water under the Water Act 1989 (Vic), consideration needs to be given to the cumulative impact of multiple water sources on irrigation and the priority given to recycled water within this mix.

It is recognised that in some circumstances, full reuse via irrigation is not practical or the most sustainable approach (e.g. irrigation of poor soils with steep terrain). In these circumstances, irrigation could be combined with other forms of reuse or with discharge, subject to approval by EPA. Where discharge to waterways is being considered, opportunities to provide environmental benefit to the receiving waterway should be explored.

4.1.3. Risk Assessment

The following table provides guidance on levels of risk associated with aspects of the water balance.

Table 4-1 Risk assessment – water balance

Lower risk	Higher risk
Steady wastewater inflows and clear projections/trends Small total volume (<100 ML/year) Recognised irrigation district providing local experience of typical crop water usage Irrigation manager is experienced and has vested interest in production/amenity outcomes High land capability Supplementary water source available for dry years Plants selected are tolerant of under-irrigation and/or poor water quality Contingency storage/irrigation area available	Variable inflows (e.g. in response to wet weather, population growth or tourism) Large total volume Limited demand for irrigation – e.g. high rainfall area Sensitive plants needing high level of management Poor land capability Limited land area available High seepage or high evaporation from storages There is regular run-on to the site from neighbouring areas, or water table is close to the surface, potentially causing waterlogging or flooding

4.1.4. Management Controls

Water Balance Modelling

Modelling is typically undertaken to determine the water balance for a recycled water irrigation site or system.

The standard approach to water balance modelling involves use of site-specific rainfall and evaporation data to calculate irrigation requirements based on crop factors.

Water balance modelling uses a combination of calculations and requires iteration to solve the model and find an appropriate combination of storage and irrigation area.

The recycled water available is compared to the irrigation requirement at each timestep in the model. If the recycled water available exceeds the irrigation requirement, excess recycled water must be held in storage. Conversely, if the irrigation requirement exceeds the recycled water available, the storage can be drawn down or the irrigation application will need to be reduced.

There are multiple combinations of irrigation area and storage that can create a water balance. However, excessive storage should be avoided as this can promote disposal by evaporation and result in increasing salinity levels in the recycled water. Excessive under-irrigation, resulting in poor crop health, can occur if irrigation area is too large.

It is recommended that multiple years of climate data are modelled to better understand climate variability for the specific site, and to account for potential carry over in storage from one year to the next when conditions are wetter than average.

The water balance should be considered at a whole of system level. There may be multiple irrigation sites, multiple types of reuse, or a combination of reuse and discharge.

The water balance needs to be considered in both system planning/design and system operation. The planning or design step relates to sizing infrastructure to match the projected recycled water inflows. Then during operation, the water balance needs to be monitored to ensure the system is working effectively and if there are multiple end users, the recycled water is shared equitably.

Further guidance on water balance modelling is provided in Appendix 1.

Climate Variability

The Australian climate can be highly variable from year to year, resulting in times when there is a mismatch between recycled water supply and irrigation demand.

Recycled water irrigation generally involves designing for a wet year and this can result in under-irrigation in other years. The area of irrigation and the volume of storage should be able to contain all wastewater up to the 90th percentile wet year. This can be problematic, especially where the recycled water is provided or sold to private farmers/site managers . Detailed planning is required to consider this unavoidable consequence of designing for the wet year. Management controls that can be considered include:

- Selection of crops that can tolerate a range of water applications
- Provision of contingency irrigation area or storage for use in wet years
- Use of a secondary water supply to supplement the recycled water in dry years2

Where there are multiple users, rules for water sharing should be established and documented in reuse agreements.

In all cases, clear and consistent communication between the recycled water producer and end user will be important and should not be underestimated. Recycled water irrigation scheme managers should discuss the inevitability of under-irrigation, and the management of recycled water in wetter years with their customers/end users. Clear plans should be in place to demonstrate how these climate fluctuations will be managed.

Management and storage of recycled water should consider climate variability and potential for extreme weather events to avoid emergency discharges.

Management of Multiple End Users

The recycled water producer will have different needs/interests to the recycled water end user. A scheme may run out of recycled water in late summer when irrigators most want it, but this is a successful outcome for the recycled water producer. To manage competing interests, clear rules should be agreed at scheme establishment, and ongoing monitoring and communication with end users should occur to minimise surprises.

Ongoing communication with end users will support management of climate variability as discussed above.

Crop Selection and Design

Where high value or sensitive crops are grown (e.g. horticulture) under-irrigation is not appropriate as this can dramatically impact produce quality and/or yield. Systems that include high value or sensitive crops should have other contingencies in place to manage either the wet or dry year extremes. For wet years, this could include an area of pasture irrigation, additional storage or a licence for occasional discharge. For dry years, it could include a supplementary water supply such as surface water or groundwater.

Crop selection is therefore very important and, in some cases, it can be better to opt for a relatively uncomplicated crop type such as pasture, that can tolerate some variations in climate.

Management of Wastewater Inflows (Source Control)

Wastewater inflows are likely to vary over time due to a combination of factors including population change, trade waste change, age/condition of reticulation infrastructure, and climate change. Water balance modelling should consider these factors in forecasting future inflows and understanding the reliability of the recycled water supply. Further guidance in relation to climate change is provided in the Section 4.2.

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[2] Subject to access to an appropriate Water Use Licence or Take & Use Licence. Refer also to Irrigation Development Guidelines discussion in Section 5.2.

Active management of inflows should also occur through:

- A trade waste management program
- Demand management to minimise household/business water use and as a result wastewater flows
- Regular infrastructure inspection and maintenance.

Irrigation Scheduling

Accurate irrigation scheduling is critical to ensuring the water balance is achieved on an ongoing basis. Both under-irrigation and over-irrigation of crops can impact on plant and soil health and consequently reduce future plant demand and the resulting recycled water demand. Scheduling controls are discussed in detail in Section 5.2.

Wet Weather Discharge to Surface Waters

In extreme wet weather (> 90th percentile), EPA operating licence condition DW2.8 allows discharge of treated wastewater to surface waters subject to the criteria specified in EPA *Publication 1322 Licence Management Guidelines.* Publication 1322 should be consulted for the full range of requirements, including the advice provided in Attachment 2.

For sites that don't have an EPA operating licence or condition DW2.8, authorised disposals and discharge may be considered by EPA in specific circumstances. Under section 157 of the EP Act, the EPA may authorise the discharge or disposal of waste, for situations of temporary emergency, temporary relief of a public nuisance or community hardship, or to enable repair and decommissioning of plant or equipment, but only if they are satisfied the discharge or disposal will not have significant adverse effects on human health or the environment. Refer to EPA webpage Authorisation of discharges or disposal for more information.

4.1.5. Monitoring and Review

Monitoring of recycled water inflows, irrigation water uses, and storage volumes should be ongoing. An ongoing system water balance can be checked monthly to track usage and losses.

Comparing irrigation applications with recorded climatic data can assist in determining if irrigation is occurring according to plant demand.

4.1.6. Further Information

Bureau of Meteorology climate data http://www.bom.gov.au/climate/.

SILO Climate Database https://www.longpaddock.qld.gov.au/silo/.

Irrigation and Drainage Practice (Rural Water Commission of Victoria, 1988) – Chapter 4 Water Requirements of Crops.

Allen R, Pereira L, Raes D and Smith M (1998). Crop evapotranspiration: guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56, Food and Agriculture Organization, Rome.

4.2. Climate Change

4.2.1. Objective

Climate change is considered in planning and designing recycled water irrigation schemes.

4.2.2. Potential Impact

Victoria's climate is shaped by weather systems, seasonal influences, and large-scale climate drivers. It varies from year to year and decade to decade. Long-term observed records show that Victoria's climate is changing under the influence of both natural variability and global warming. In recent decades, Victoria's climate has become warmer and drier. These changes are expected to continue.

Recycled water irrigation is likely to increase in importance because of climate change. Recycled water is a relatively climate resilient water source and there will be increasing demand for irrigation to support agricultural production and public amenity (e.g., greening urban spaces).

Recycled water schemes should plan for and consider adaptation actions to minimise the risk of harm from future impacts of climate change.

4.2.3. Risk Assessment

Table 4-2 Risk assessment – climate change

Lower risk	Higher risk
Steady wastewater inflows and clear projections/trends Supplementary water source available for dry years	Variable inflows (e.g. in response to wet weather, population growth, or tourist seasonality) Sensitive plants needing high level of management Multiple end users

4.2.4. Management controls

Where climate data is used in water balance modelling or irrigation scheduling, an appropriate climate baseline period needs to be selected to take into account the potential impact of climate change. DELWP has developed *Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* and recommends use of a post-1975 historic climate baseline, because:

- It incorporates a wide range of natural climate variability
- It is long enough to reasonably apply data extension techniques
- It aligns with reference periods adopted by CSIRO from global climate models
- The start date is broadly consistent with observed step changes in climate behaviour
- It is consistent with recent research by the Bureau of Meteorology.

The impact of climate change should also be considered where there are third party and/or multiple users accessing a recycled water source. Reuse agreements should consider how recycled water is shared equitably in dry years and whether any supplementary water sources will be provided. Refer also to Section 4.1 for discussion on managing climate variability.

4.2.5. Further Information

Further information on the impacts of climate change on Victoria can be obtained from http://www.climatechange.vic.gov.au/. This includes local-scale projections developed in partnership with CSIRO's Climate Science Centre.

Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria, Department of Environment, Land, Water and Planning 2020.

4.2.6. Distribution

4.2.7. Objective

Water quality is maintained when storing and distributing recycled water after it has been treated.

4.2.8. Impacts, Risk, Management and Monitoring

Risks include, but are not limited to:

- Contamination of potable water supply systems with recycled water due to cross-connections or misconnections
- Odour generation, opportunistic pathogen and algal growth or concentration of salts within recycled water during storage and/or distribution
- Discharge to the environment due to burst mains and flushing events.

Methods to help mitigate these risks include adoption of appropriate design standards, construction/installation by accredited contractors, and system monitoring/auditing.

Publication 1911 provides guidance on managing distribution systems for recycled water. Refer to Section 5.0 Managing the Supply System, and Appendix A Useful Checklists.

Publication 1910 in Section 2.4 includes a list of mitigation measures for bursts and leakage from storage and reticulation systems.

5. Land Use and Irrigation System

5.1. Land Use / Crop Type

5.1.1. Objective

Healthy plant growth is achieved to ensure demand for recycled water irrigation.

5.1.2. Potential Impact

Land use or the crop selected for the irrigated area determines the level of water use, the sensitivity to water quality parameters and the level of management required to ensure sustainable irrigation.

Table 3-3 outlines the suitability of a range of land uses in relation to recycled water irrigation.

A mismatch between recycled water quality and the crop selected, or poor management of land use, can lead to a decline in plant health/yield and a corresponding decline in demand for irrigation water.

The potential impact on crop selection of pathogens, salts, nutrients and other contaminants is discussed in further detail in Chapter 6. Comprehensive lists of plant species, including their tolerance to salinity and demand for nutrients, are also provided in the *Australian Guidelines for Water Recycling*.

5.1.3. Risk Assessment

Table 5-1 Risk assessment – land use / crop type

Lower risk	Higher risk
Low pathogens, nutrients, salinity, and other contaminants in recycled water and soil (refer to chapter 6 for details) High land capability Plants selected are tolerant of under-irrigation and/or poor water quality	High pathogens, nutrients, salinity, and other contaminants in recycled water or soil Sensitive plants needing high level of management Poor land capability (e.g. Poorly drained soils)

5.1.4. Management controls

Select a land use (crop type) that is suited to the recycled water quality available, the volume of water available (which can be variable in nature), the land capability of the site and the management experience of the site operator. Consideration could be given to neighbouring land uses to understand what is likely to grow well.

Chapter 6.2 provides guidance on selecting a crop that is suited to the nutrient concentrations of recycled water, while the relative salt tolerance of crops is discussed in Section 6.3. Management of livestock health is discussed in Section 9.2.

Management experience could be obtained through leasing the recycled water site to an experienced operator or supplying recycled water to a nearby existing irrigation site.

Specific ongoing management controls will vary according to the land use selected and should be determined during scheme establishment.

5.1.5. Monitoring

Visual monitoring of plant health.

Benchmarking of crop production with regional data (e.g. neighbour discussions; AgVic data).

5.1.6. Further Information

Australian Guidelines for Water Recycling 2006. https://www.waterquality.gov.au/guidelines/recycled-water

Agriculture Victoria https://agriculture.vic.gov.au

5.2. Irrigation Method

5.2.1. Objective

The selected irrigation method is appropriate for the site in terms of land capability, land use, recycled water quality and ease of management.

5.2.2. Potential Impact

Irrigation systems should support plant growth while minimising salt imbalances, soil erosion and water loss.

There are several irrigation systems suitable for use with recycled water. Common irrigation methods include fixed spray irrigation, travelling spray irrigation (e.g. centre-pivot), drip irrigation (surface or sub-surface), and surface/flood irrigation. The conditions that are best suited to each method are listed in Appendix 2.

Poor system selection, design and management can lead to various impacts including:

- Impact to crop health if irrigation cannot meet plant demand across the range of seasonal conditions
- Waterlogging and impact to soil health
- Spray-drift beyond the irrigation site
- Risk to health of irrigation operators
- Irrigation runoff or contamination of rainfall runoff that can impact on downstream waterways
- Excess leaching to groundwater
- Disturbance to native vegetation
- Impact to sites of cultural significance
- Damage to irrigation equipment including blockages or corrosion if materials selected are inappropriate or filtering is not provided.

There have been considerable advances in irrigation technology and infrastructure over recent decades. For example, irrigation automation should be considered as it can help ensure irrigation is applied accurately, particularly where sites are remote, or irrigation needs to occur at night.

5.2.3. Risk Assessment

Table 5-2 Risk assessment – irrigation method

Lower risk	Higher risk

Experienced operator History of successful irrigation at site Irrigation method well suited to site conditions and land use Preventative maintenance program in place	Inexperienced operator New irrigation site in non-traditional irrigation area Poor land capability (e.g. steep topography, sensitive receptors in close proximity)

5.2.4. Management controls

Site Irrigation Plan

When designing and implementing a recycled water irrigation system, expert advice should be sought and a site irrigation plan (often referred to as a whole farm plan or an irrigation and drainage plan) should be prepared. A site irrigation plan details the irrigation system, how it is going to complement and improve the entire site operation, and how risks of harm to human health and the environment will be prevented or minimised.

The site irrigation plan should go beyond just irrigation design and help to specify how the protection and enhancement of native vegetation and waterways, as well as the development of shelter belts (i.e. tree plantations) and riparian strips (plus other measures) can be used to maximise productivity and environmental protection.

The site irrigation plan is complementary to the development of a HEMP and/or user SMP. It can be used within these plans to show efficiently how the irrigation system operates, key infrastructure and site features, exclusion areas and so on.

Irrigation Development Guidelines

Regional Irrigation Development Guidelines (IDGs) are in place across Victoria and managed by Catchment Management Authorities. IDGs provide guidance to both irrigators and government agencies on the process for approvals, matters for consideration and the conditions required for obtaining or modifying a water-use licence or take and use licence under the Water Act.

The IDGs do not apply to recycled water as the supply and use of recycled water is regulated by the EP Act. However, if a recycled water scheme will also use surface water or groundwater (e.g. as supplementary water for shandying or for managing dry years), and requires a water-use licence or licence to take and use water under the Water Act, any relevant regional IDGs must be considered.

It is not the intent of these guidelines to duplicate effort for proponents. These recycled water irrigation guidelines and the IDGs complement each other. Both sets of guidelines clearly require:

- all sources of water to be considered in planning and assessment.
- irrigation developments to meet standards that avoid or minimise the off-site impacts of irrigation water use.
- consideration of natural resource management issues.

Advice on the IDG that applies and the process for approval can be accessed by contacting your local Catchment Management Authority.

5.2.5. Monitoring

Regular maintenance checks should be undertaken on the irrigation system (including for build-up of salts/solids in pipes) to ensure it is operating effectively.

During irrigation, visual monitoring should be undertaken to check for system leaks and bursts.

5.2.6. Further Information

Agriculture Victoria irrigation factsheets and resources:

https://agriculture.vic.gov.au/farm-management/water/irrigation

DELWP Sustainable Irrigation Program:

https://www.water.vic.gov.au/water-for-agriculture/sustainable-irrigation-program

5.3. Irrigation scheduling

5.3.1. Objective

Plant demand for moisture determines when irrigation occurs.

5.3.2. Potential Impact

Irrigation scheduling ensures that the correct amount of water is applied to plants when required. It is the process by which an irrigator determines the timing and quantity of water to be applied.

The challenge with irrigation scheduling is to estimate plant water requirements for different growth stages and climatic conditions. To avoid over or under watering, it is important to know how much water is available to the plant, and how efficiently the plant can use it.

Under-watering can cause:

- Plant health impacts
- Reduction in recycled water use

Over-watering can cause:

- Waterlogging leading to impacts to plant and soil health, and/or increased runoff
- Soil erosion
- Runoff to downstream waterways
- Leaching to groundwater.

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 and risk of harm to groundwater environmental values.

Recycled water irrigation schemes are designed to provide sufficient area for a wet year as discussed in Section 4.1. Therefore in dry years under-irrigation will occur. For sites that don’t have a supplementary water supply source, it is likely that irrigation scheduling controls will be impacted as the irrigation season progresses. Decisions may be required to sacrifice plant production/yield over part, or all, of the irrigation area.

5.3.3. Risk Assessment

Table 5-3 Risk assessment – irrigation scheduling

Lower risk	Higher risk

Experienced operator History of successful irrigation at site	Inexperienced operator New irrigation site in non-traditional irrigation area Sensitive crop that needs very high standard of irrigation scheduling Poor land capability (e.g. shallow soils, heavy clays, steep topography)

5.3.4. Management controls

In all circumstances, an irrigation schedule that considers changes in irrigation demand throughout the year should be developed, and monitoring used to verify that the schedule is delivering the results required, and that what has been prepared in theory is aligning with what is occurring in practice.

The recycled water available needs to be monitored to inform the schedule, particularly as the irrigation season progresses and storages are drawn down.

The methods available for irrigation scheduling include:

- Soil moisture monitoring
- Monitoring evapotranspiration data
- Plant observation.

Directly monitoring soil moisture levels is the preferred method for determining actual water application rates throughout the irrigation season.

Soil moisture probes have advanced rapidly in recent years, and can help irrigation managers apply irrigation water accurately, and take the guesswork out of irrigation scheduling. Soil moisture probes can also communicate with irrigation systems to provide automated operation.

Soil moisture probes can be particularly useful for the non-traditional irrigation areas across Victoria, where soil, climate conditions, topography and lack of staff skills and experience can lead to higher risk.

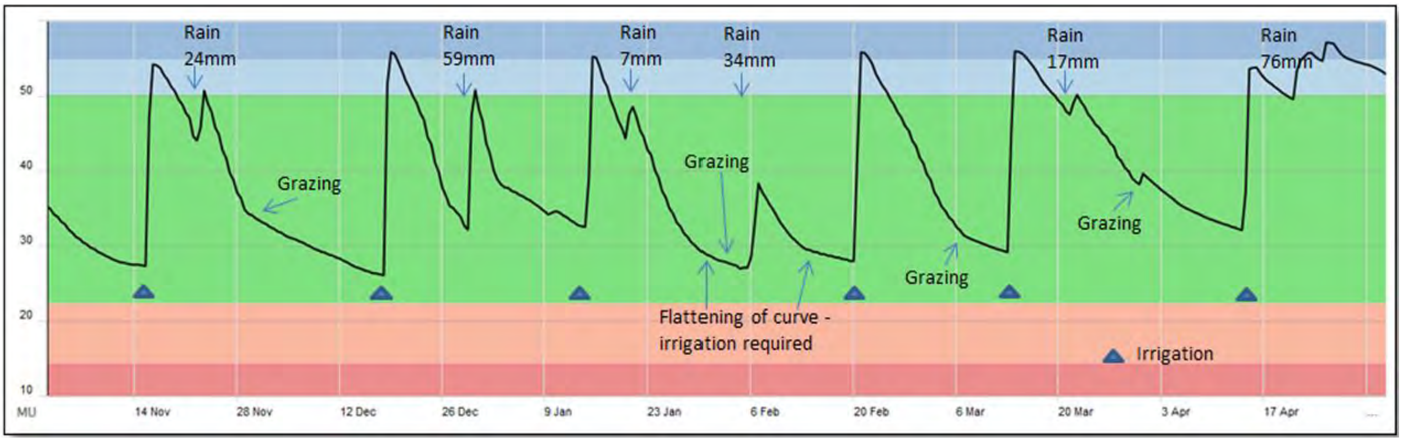

Figure 5-1 Weighted average soil moisture content (to a depth of 80cm) measured with a capacitance probe under surface irrigated lucerne (Soil Moisture Monitoring factsheet, Agriculture Victoria, December 2017)

Care needs to be taken when using soil moisture information to schedule irrigations across a paddock or larger site area because of variability in soil types, soil water-holding capacity, water extraction rates and evenness of watering.

Use of evapotranspiration data is a weather-based irrigation scheduling approach. It involves tracking how much water a crop has used daily and, from this data, determining how much irrigation needs to be applied. A specific crop coefficient (Kc) is estimated and combined with daily reference Evapotranspiration (ET_0) observations from a nearby weather station, to determine crop water usage. There are online tools available to support this approach including the Australian Landscape Water Balance (http://www.bom.gov.au/water/landscape/) and IrriSAT (https://irrisat-cloud.appspot.com).

Soil moisture monitoring complements evapotranspiration information. Ideally, they should be used together to inform irrigation decisions.

Most sites will benefit from the installation of soil moisture monitoring equipment. However, it is not needed in all cases. Simple monitoring techniques like using a shovel to check soil moisture levels and observing plant conditions for signs of stress are still effective ways of monitoring and managing irrigation, particularly for an experienced operator.

Consideration should be given to involving an irrigation professional with suitable expertise, particularly for high-risk sites.

5.3.5. Monitoring

During the irrigation season, the plants' capacity to take water should be monitored regularly (daily, weekly or fortnightly depending on climatic conditions) to determine when watering should occur.

It is important to maintain records of irrigation applications, to assist with monitoring, reporting and future planning.

5.3.6. Further Information

Agriculture Victoria irrigation factsheets and resources:

https://agriculture.vic.gov.au/farm-management/water/irrigation

6. Recycled Water Quality

6.1. Pathogens

6.1.1. Objective

Recycled water is treated to a standard that is appropriate for the intended end use.

6.1.2. Potential impacts

The most significant human health hazards in recycled water are microorganisms capable of causing gastrointestinal and respiratory illnesses. Such microorganisms can be found at high concentrations in wastewater, particularly wastewater comprising faecal waste. Numbers of individual pathogens will vary depending on rates of illness in the humans and animals contributing faecal waste. Safe use of recycled water requires pathogens to be reduced to acceptable levels through treatment.

6.1.3. Risk assessment

The required treatment level and associated water quality objectives vary depending upon the nature of a scheme's end uses. Publication 1910 outlines the three classes of recycled water (A, B and C) that represent the minimum standards of biological treatment and pathogen reduction for defined categories of use.

The required level of treatment increases with the potential for higher levels of exposure, reflecting the risks associated with particular uses. The recycled water criteria outlined in Section 1.4.2 of Publication 1910 and discussed in Section 3.1 of this guideline apply at the end of the treatment process, meaning it applies to recycled water before it is supplied to the first user. Scheme proponents should ensure that their recycled water quality aligns with the requirements as specified in Publication 1910 before commencing irrigation.

In addition to minimum levels of treatment, a specific recycled water use may also be subject to site management controls to ensure protection of human and animal health. Refer to Section 6 of EPA Publication 1911 and to Section 8.3 and Chapter 9 of this document.

Recycled water is not acceptable for the following uses:

- Drinking
- Cooking or other kitchen purposes
- Bathing and showering
- Filling domestic swimming pools and spas
- Children's water toys.

These uses may result in the regular ingestion of recycled water volumes that are significantly greater than the quantities considered in the risk assessment. Management controls should therefore be in place to ensure recycled water is only used for its intended purposes and end users need to be aware of limitations on use.

6.1.4. Management Controls, Monitoring and Review

The water quality objectives provided in Table 1 and Table 2 of Publication 1910 (BOD, SS, turbidity (as NTU), pH, E. coli bacterial indicator, and pathogen log reduction values) are indicators of treatment process performance and pathogen reductions. These criteria need to be achieved, and therefore regularly monitored to determine the class of recycled water. Further requirements for Class A recycled water are discussed in publication 1911.

The treatment processes described in Table 1 and Table 2 of Publication 1910 are nominally effective in removing viruses and other microbial pathogens to safe levels, given the specified recycled water use. However, treatment plant operators should periodically undertake process verification ('due diligence 'monitoring) to confirm that adequate removal of pathogenic microorganisms is occurring.

For Class A recycled water supplied to residential households there is an aesthetic threshold of 1 mg/L total chlorine at the point of application. Sensitive crops may also be damaged at total chlorine levels above 1 mg/L and users should consider the sensitivity of crops in this regard.

For livestock controls, see Section 9.2 of this guideline.

6.1.5. Further information

Australian Guidelines for Water Recycling: Managing Health and Environmental Risks – Phase 1, 2006

6.2. Nutrients

6.2.1. Objective

The nutrients applied through recycled water are utilised by plants and removed from the site in plant or animal products; or remain safely in the soil for future uptake by plants.

6.2.2. Potential impacts

Nutrients are required for healthy plant growth. Australian soils are generally low in nutrients and can benefit from the additional nutrients that can come from recycled water.

However, an excess build-up of nutrients in the soil can cause:

- Toxicity to plants reducing plant growth and therefore lowering water use
- Toxicity to animals consuming the fodder
- Soil acidification
- Leaching to groundwater, creating risk of harm to human health and/or the environment
- Runoff to surface waters through contamination of rainfall runoff, or erosion of nutrient rich topsoil, causing eutrophication and algal blooms.

Of the range of nutrients required for plant growth, phosphorus and nitrogen create the greatest risk of harm to the environment. Therefore, this section will concentrate on these two nutrients. The toxic impact of other nutrients, such as zinc and selenium, is considered in Section 6.3 – Contaminants of Concern and Emerging Contaminants.

Nutrients in recycled water can be a factor in blue-green algae blooms in recycled water storages. Management of blooms is discussed in Sections 9.1 Human Health and 9.2 Livestock Health.

6.2.3. Risk assessment

Table 6-1 Risk assessment – nutrients

Lower risk	Higher risk

Low nutrient levels in recycled water (see below for further discussion) Nutrient balance maintained	High nutrient levels in recycled water High nutrient levels in soil due to historic management (e.g. fertiliser use) Steep slopes Soil susceptible to erosion Sensitive waterway <100m downstream Groundwater quality in Segment A1 or A2 Water table is close to surface (<5m) and/or high potential for leaching due to soil type (e.g. high permeability sands)

Nutrient balance calculation

The risk level is largely determined by whether a site is in nutrient balance or not, and the existing nutrient status of the soils being irrigated. If nutrient removal (in plants or animal products) is not sufficient to match the applied nutrients, the site is considered to be exceeding the nutrient balance.

The level of nutrient uptake in plants varies according to the type of plant and the type/level of production. Appendix 5 of the Australian Guidelines for Water Recycling provide a comprehensive list of nutrient removal rates for various crops or land uses. There are also several industry sources as listed under Further Information at 6.2.6.

The calculation to determine the nutrient balance is provided below. The crop demand and irrigation rate is generally considered on an annual/seasonal basis.

$$NB = nutrientdemand(kg/ha) - (concentrationinrecycledwater(mg/l) \times irrigationrate(ML/ha))$$

A similar calculation, the nutrient load to demand ratio (NLDR), can be found in Publication 1911 – refer to Section 3.7.5.

A balance is achieved if the nutrient removal is the same as the nutrient loading. Where the nutrient balance is positive, nutrients will build up in the soil or leach to the surrounding environment. Where the nutrient balance is negative, some additional fertiliser may be needed to maintain production levels.

In the short-term where soil nutrient status is low, some build-up of soil nutrients is likely to be beneficial in ensuring adequate crop production.

For high-risk sites, further investigations may be required during the nutrient assessment process, including:

- Investigating the phosphorus buffering capacity of the soil (refer to Appendix 3).
- Considering the nutrient balance on a paddock scale rather than a property scale to determine if the risk varies across a property. Controls can then be targeted at problem areas.
- Considering nutrient loading and removal in greater detail. For example, considering inputs such as animal feed and internal reuse of water, as well as outputs such as pruning and crop cycles and loss of ammonia to the atmosphere.

Phosphorus

When phosphorus is added to soil (particularly clay-based soils) it is usually strongly bound to soil particles, and thereby remains stored in the soil for potential future use by plants. However, there is a point where the soil effectively becomes saturated with phosphorus, and it starts to leach into stormwater (rainfall runoff) or groundwater. Therefore, soil phosphorus levels are a key indicator of risk of harm to the environment.

Several soil extraction methods can be used to determine available soil phosphorus concentration. Common methods include the Olsen P and Colwell P tests. Where these indicate elevated soil phosphorus levels, the risk of environmental impact can be assessed using the Phosphorus environmental risk index (PERI), which combines Colwell P and the Phosphorus buffering index (PBI), or the Mehlich 3 phosphorus saturation ratio (M3-PSR).

Risk is dependent on a combination of the application rate and the concentration of phosphorus in the soil, and any assessment method should include both factors. The amount of phosphorus applied includes that sourced from recycled water, fertiliser, and other potential inputs (such as biosolids, farm effluent, manures etc.).

An initial screening risk assessment is outlined below based on Olsen P and M3-PSR. Alternative methods are discussed in Appendix 3.

Olsen P can be used to make an initial assessment in relation to environmental risk, as outlined in Table 6-2.

Table 6-2 Soil phosphorus initial risk analysis using Olsen P

Phosphorus application (kg/ha/year)	Soil phosphorus concentration– Olsen P (mg/kg)				
	<20	**20–30**	**30–40**	**40–60**	**>60**
<20	Very Low	Very Low	Low	Medium	High
20–40	Very Low	Low	Medium	High	High
40–60	Low	Medium	High	High	Extreme
>60	Medium	High	High	Extreme	Extreme

Where soil phosphorus concentration is low (<20 mg/kg Olsen P), some build-up of soil nutrients is likely to be beneficial in ensuring adequate crop production.

In an agronomic sense, phosphorus application provides marginal economic benefit for pastures and broadacre crops at Olsen P of 30-40 mg/kg and negligible economic benefit at Olsen P > 40 mg/kg.

The Olsen P test has some limitations in that:

- It only measures orthophosphate, the plant available phosphorus. It does not pick up organic phosphorus forms. This is usually not an issue where fertilisers are used, as they generally contain inorganic phosphorus. However, recycled water can contain significant levels of organic phosphorus.
- Soils high in free aluminium and iron (e.g. Ferrosol soils pH < 5.5) generally "lock up" most of the soil phosphorus. This reduces the accuracy of this test.

Mehlich P testing can be undertaken in addition, or as an alternative, to Olsen P. It can be used over a wider pH range.

Mehlich P test results can be used to calculate the Mehlich 3 Phosphorus Saturation Ratio (M3-PSR). This ratio has been developed as an environmental management tool and is commonly used in the US and other countries, and there is a growing trend for its use in Australia. Research has shown it accurately predicts both agronomic value (profitable crop responses to phosphorus inputs) and risk to the environment. It can therefore be used to enhance the accuracy of decisions. This is recommended particularly for sites that are in a high environmental risk category according to Olsen P.

A risk assessment based on M3-PSR is provided in Table 6-3 below.

Table 6-3 M3-PSR assessment table[3]

Soil phosphorus M3-PSR	P status	Risk level
< 0.06	Below optimum (soil build up would be beneficial to production)	Low
0.06–0.11	Optimum	Low
0.11–0.15	Above optimum, could be P movement offsite	Medium
> 0.15	Risk to environment	High

Nitrogen

Soil tests for nitrogen are generally a poor indication of the amount of nitrogen in the soil due to the mobility of nitrogen and the constant cycling of nitrogen compounds found in soils.

As such, risk related to nitrogen should be assessed through calculation of a nutrient balance and assessment of site risk factors. As an initial guide, 0 can be used to characterise potential high risk nitrogen scenarios.

The oversupply of nitrogen should be avoided on any soil type, but risk of harm to the environment is increased on permeable soils as nitrogen can be easily leached though the soil profile to groundwater.

Table 6-4 Nitrogen initial risk assessment

Risk level	Nitrogen applied (kg/ha/year)
Very low	<50
Low	50–100
Medium	100–300
High	>300

[3] Based on: Sims J, Maguire R, Leytem A, Gartley K, Pautler M (2002) Evaluation of Mehlich 3 as an Agri-Environmental Soil Phosphorus Test for the Mid-Atlantic United States of America. SSSAJ 66: 2016–2032

Site Risk Factors

In addition to analysis of soil and recycled water nutrient levels, the factors that control nutrient transport in the environment should be considered. If any of the following factors are present, the risk of nutrient loss is considered high:

- Steep slopes >10%
- Soil type that is susceptible to erosion
- Sensitive waterway within 100m of area irrigated
- Groundwater quality in Segment A1 or A2
- Water table is close to surface (<5m) and/or high potential for leaching due to soil type (e.g. high permeability sands).

6.2.4. Management controls

All sites should calculate a nutrient balance on at least an annual basis or as appropriate to the crop cycle.

Additional controls for high-risk sites include:

- Increase nutrient removal via improved production or a change in land use. For example, move from grazing to hay production
- Reduce nutrient applications via:
  - Reducing or ceasing fertiliser use
  - Reducing hydraulic loading or shandying (and consequently irrigation of a larger area)
  - Improved treatment or source control to remove nutrients from recycled water
- Consider installation of wetlands or vegetated buffer zones for nutrient stripping of rainfall runoff
- Provision of additional storage and irrigation area for collection and reuse of contaminated rainfall runoff
- To reduce leaching to groundwater, add soil ameliorants (e.g. calcium, clay, organic matter4) and/or use deep rooted crops (e.g. lucerne) to enhance take up of nutrients through the soil profile
- Install subsurface drainage to collect leachate for reuse (provided leachate can be managed sustainably).

Note: where the treatment system is changed to lower the nutrient concentration of the recycled water, and additional biosolids or industrial sludge is produced, consideration needs to be given to the management of these streams. This is because they have the potential for risk of harm to the environment.

6.2.5. Monitoring and review

- Monitoring in relation to nutrients should incorporate:
- Monitor nutrient levels in recycled water
- Maintain records of irrigation applications
- Maintain records of fertiliser applications

Undertake soil testing (refer to Section 7.1 for further information)

Visually monitor plant health.

For high-risk sites add:

- Plant tissue analysis to confirm level of nutrient uptake
- Monitoring of groundwater nutrient levels (refer to Section 7.3 Groundwater)
- Monitoring of rainfall runoff nutrient levels (refer to Section 7.2 Surface Water).

[4] Organic matter can contain nutrients, particularly if sourced from composts or animal manures. This needs to be considered in nutrient balance calculations.

6.2.6. Further information

Australian and New Zealand Guidelines for Fresh and Marine Water Quality:

https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries

Melland, Smith and Waller (2007) *Farm Nutrient Loss Index: User Manual*, Department of Primary Industries, Victoria.

Hort Innovation resources on soil management and crop protection: https://www.soilwealth.com.au/resources/

6.3. Salinity and Sodicity

6.3.1. Objective

Salt or sodicity levels in the recycled water do not impact on plant health, soil health, surface waters, groundwater or surrounding land

Stored salt in the subsoil and groundwater is not mobilised by irrigation.

6.3.2. Potential impacts

Salinity

Salinity impacts can result from applied salts and from the mobilisation of existing salts (from subsoils or groundwater).

Impacts caused by applied salts can include:

- Toxicity to plants – occurs within the plant itself and normally results when certain ions are taken up with the soil water or absorbed through plant leaves (from direct irrigation spray onto leaves). It can be displayed as foliar damage or leaf burn. Not all crops are equally sensitive to these ions. The usual toxic ions in irrigation water are chloride, sodium and boron.
- Build-up in the soil – the risk of salts accumulating in the soil depends on irrigation water quality, rainfall received, and the adequacy of drainage through the soil profile. Impacts of any build-up are then dependent on plant sensitivity to salts. Plants obtain water by exerting an absorptive force greater than that which holds the water to the soil. Salts in the soil-water increase the force the plant must exert. This additional force is referred to as the osmotic effect or osmotic potential. Some plants are better able to make the needed osmotic adjustments to obtain more water from a saline soil (i.e. some plants will be more salt tolerant than others).
- Migration of salts to surface or groundwater systems.

Induced salinity arises when irrigation causes:

- The water table to rise such that salts in groundwater move into the plant root zone
- Existing salts in soil to be mobilised to surface or groundwater systems.

Salts are highly soluble, so water is the key to movement of salts in the landscape. A careful balance is required at all irrigation sites between the need for some movement of water and salts below the rootzone (to avoid accumulating salts in the root zone), and too much water passing below the rootzone resulting in excessive leaching to groundwater, thus raising the water table and leading to induced salt impacts.

In practice, leaching of salts occurs naturally and is generally constrained by the soil characteristics. A detailed description of soil classes is provided in Appendix 5. Class I soils are highly permeable and provide high leaching potential, whereas Class IV soils are relatively impermeable.

Migration of salts and induced salinity impacts are a function of the volume applied, rather than the salinity of the recycled water. Management controls in relation to these risks are discussed in Sections 4.1 Water Balance, 7.2 Surface Water, and 7.3 Groundwater.

Of the range of salts, sodium and chloride are more likely to remain as ions in solution and contribute to the effects of salinity.

Many soils are naturally saline, particularly in semiarid areas where high evaporation rates and low rainfall concentrates salts near the soil surface. Some soils of marine origin also have high natural salinity. The salinity of both the irrigation water and soil must be considered.

Recycled water schemes in the Murray Darling Basin may trigger compliance obligations under Schedule B to the Murray-Darling Basin Agreement (the agreement is included at Schedule 1 to the Water Act 2007 (Cth)). For further information please refer to:

https://www.water.vic.gov.au/mdb/compliance/basin-salinity-management

Sodicity

Sodicity is a chemical imbalance that occurs when an excess of sodium (a monovalent ion) is present in the soil relative to divalent ions such as calcium and magnesium. This results in clay particles being held together more loosely, and dispersion can occur. Dispersion blocks off the passages that water and air can pass through, leading to waterlogging and increased runoff. Plants also have difficulty extending their roots through sodic soils.

The risk of soil sodicity is much lower in sandy soils than clay soils. Sandy soils usually have only small amounts of clay and readily leach sodium ions.

Sodicity can be caused through the application of recycled water with high sodium absorption ratio (SAR) or it can occur naturally in soils. In some instances, application of recycled water with high bicarbonate may also cause sodicity, especially where the recycled water and soil are alkaline (pH ≥8.2).

There is a relationship between the sodium absorption ratio (SAR) and salinity (EC) levels in irrigation water and soils. Further detail is provided in Figure 2 of Publication 1911.

6.3.3. Risk Assessment

Recycled Water Salinity

Salinity of irrigation water can be described in terms of:

- Electrical conductivity – measured as µS/cm EC
- Concentration of total dissolved solids – measured as mg/L TDS
- Concentration of each individual ion – measured as mg/L for e.g. sodium and chloride. Important in assessment of plant tolerance.
- Relative concentrations of individual ions – e.g. sodium absorption ratio SAR. For assessment of sodicity impacts.

There is a ratio between EC and TDS and this depends on the relative concentrations of various salts. An approximate conversion is 1000 µS/cm EC = 640 mg/L TDS. However, laboratory analysis should be used to confirm the relationship for each recycled water source.

Low	Medium	High	Extreme
<800 µS/cm EC	800 - 1,500 µS/cm EC	1,500 - 3,000 µS/cm EC	3,000 µS/cm EC
< 500 mg/L TDS	500 - 1,000 mg/L TDS	1,000 - 2,000 mg/L TDS	>2,000 mg/L TDS
<175 mg/L Cl	175 - 350 mg/L Cl	350 - 700 mg/L Cl	>700 mg/L Cl
<115 mg/L Na	115 - 230 mg/L Na	230 - 460 mg/L Na	>460 mg/L Na

Figure 6-1 Recycled water salinity risk assessment

Soil Salinity and Sodicity

Baseline soil sampling is required to understand existing salinity and sodicity.

More detailed salinity surveys (e.g. EM38) can be completed, where the risk is medium or above, to understand variability across a site.

Low	Medium	High	Extreme
<2 dS/m ECe	2 - 4 dS/m ECe	4 - 8 dS/m ECe	> 8 dS/m ECe
< 6 % ESP	6 - 15 % ESP	> 15 % ESP	

Figure 6-2 Soil salinity and sodicity risk assessment (ESP = exchangeable sodium percentage, ECe = Electrical conductivity of the soil extract)

Salt Balance – Risk of Soil Salinity Build-Up

To understand a site’s salt balance, or potential for salts to build up in the soil, recycled water salinity needs to be assessed in combination with soil texture. The permeability of different soil textures influences the leaching rate of water and salts through the profile.

Table 6-5 Risk assessment for soil salinity build-up

Application salinity mg/L TDS	Soil texture				
	Sand	Sandy Loam	Loam	Clay Loam	Clay
<500	Very Low	Very Low	Low	Low	Medium
500–1000	Low	Low	Low	Medium	High
1000–2000	Low	Medium	Medium	High	High
>2000	Medium	High	High	Extreme	Extreme

Notes to 0:

- The application salinity is the annual weighted average of all sources of water applied to the site, including rainfall.
- Salt balance modelling can be undertaken for medium to high-risk sites to predict changes in soil salinity more accurately. This should be undertaken for all sites with existing high soil salinity (>4 dS/m ECe). Refer to Appendix 4 for an example approach.

6.3.4. Management controls

Recycled Water Salinity

Salinity levels in the recycled water will increase following evaporation from storages. Design and management of storages should aim to minimise evaporation (e.g., by reducing surface area) where salinity levels are a concern.

Salinity levels in the recycled water can be reduced via:

- Source control – management of salts discharged to the treatment plant through trade waste agreements
- Supplementing or shandying the recycled water with another water source
- Treatment to remove salts using reverse osmosis.

Crop Selection and Irrigation Method

Select a crop that is appropriate for the salinity of the recycled water. A list of crops and their relative salt tolerance can be found in the Australian Guidelines for Water Recycling (refer to Appendix 5, Section A5.6).

For high-risk sites additional management controls could include:

- Selection of an irrigation method that avoids directly spraying irrigation water to sensitive crop leaves
- Irrigation at night-time to avoid hot sunny days when evaporation is high, and the risk of leaf burn is increased
- Sow crops after rainfall and allow them to establish before starting irrigation (crops are generally most sensitive in their early growth stages).

Soil Salinity

It is recommended that the irrigation application should focus on plant demand requirements, and account for natural leaching due to rainfall and based on soil characteristics. Application of leaching irrigations (excess irrigation to promote leaching) is usually not required and can lead to raising the water table or waterlogging of soils if not managed appropriately. Careful planning and management are required if this is going to be undertaken.

For high-risk sites additional management controls could include:

- Accept lower productivity rates
- Supplement or shandy the recycled water with another water source to reduce or spread applied salts
- Use of leaching irrigations to flush salts out of the plant root zone. This may require installation of sub-surface drainage to enhance leaching through the soil profile and to manage accessions to the water table.

Sodicity

To manage potential sodicity issues:

- Perennial crops can be selected to minimise soil cultivation and help build organic matter
- Soil amelioration can be undertaken through application of gypsum, lime or organic matter
- Soil disturbance (e.g. deep ripping) should be avoided on sites with naturally occurring sodic soils, due to the risk of bringing sodic subsoils to the soil surface.

6.3.5. Monitoring and Review

Monitoring in relation to salinity/sodicity should incorporate:

- Monitor salts in recycled water
- Maintain records of irrigation applications
- Undertake soil testing (refer to Section 7.1 for further information)
- Visual monitoring of plant health
- Visual monitoring for waterlogging (which could be an indication of sodicity issues).

For high-risk sites add:

- Monitoring of groundwater salinity levels (refer to Section 7.3 Groundwater)
- Monitoring of rainfall runoff salt levels (refer to Section 7.2 Surface Water).

6.3.6. Further Information

Regional Salinity Management Plans. Contact your local Catchment Management Authority for further information.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality:

https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries

Water Quality for Agriculture, FAO, Irrigation and Drainage Paper No. 29 Rev. 1, 1985.

The use of saline waters for crop production, FAO, Irrigation and Drainage Paper No. 48, 1992.

Sustainable Use of Reclaimed Water on the Northern Adelaide Plains – Grower Manual, PIRSA Rural Solutions, 2001.

6.4. Contaminants of Concern and Emerging Contaminants

6.4.1. Objective

Contaminants do not impact on human health, animal health, plants irrigated, soil , surface waters, groundwater or surrounding land. Develop a site-specific risk assessment for contaminants of concern or emerging contaminant.

6.4.2. Potential impacts

Potential impacts caused by applied contaminants include:

- Uptake into food crops and animal products which result in human and animal health impacts
- Direct phytotoxicity to crops during irrigation
- Build-up of contaminants in soil, to levels that are toxic to crops or to soil biota
- Infrastructure impacts such as clogging of irrigation lines due to iron or manganese mineral precipitation
- Leaching to groundwater, or runoff to surface waters, that can cause harm to aquatic ecosystems and human health.
- Contaminants of concern and emerging contaminants include:
    - legacy contaminants, such as heavy metals, per- and poly-fluoroalkyl substances (PFAS), organic chemicals, and pesticides
    - new contaminants of concern, such as pharmaceuticals and personal care products, endocrine disrupting chemicals, disinfection bi-products, flame retardants, and micro-plastics.
- For some of these substances, specific guidance (e.g. *Australian and New Zealand Guideline for Fresh and Marine Water Quality*) is available on acceptable irrigation water quality limits. However, for a number of contaminants, such guidance is limited and continues to be under development both nationally and internationally. Recycled water irrigation scheme managers and users should therefore consistently review

and update their state of knowledge with respect to the management of contaminants of concern and emerging contaminants.

Where specific guidance exists (at the time of publication) for the management of these substances, they are referenced or provided below. However, the information provided in this publication is not exhaustive and cannot be relied upon as up-to-date state of knowledge. As discussed above, scheme proponents must ensure they continue to inform themselves of the latest science and associated management requirements for any contaminants.

References such as the *Australian and New Zealand Guideline for Fresh and Marine Water Quality* (ANZG), the *Australian Guidelines for Water Recycling* (AGWR), and the *PFAS National Environmental Management Plan (NEMP)* provide further specific information on potential impacts.

The ANZG provide criteria for contaminants in irrigation water to protect agricultural land, farm produce quality, groundwater, surface waters and the environment. The ANZG criteria include:

- Long-term trigger values (LTV) – maximum concentration that can be tolerated for up to 100 years of irrigation
- Short-term trigger values (STV) – maximum concentration that can be tolerated for up to 20 years of irrigation
- Cumulative contaminant loading limits (CCL) – maximum cumulative amount of contaminant recommended in soils.

Note that the ANZG was revised in 2018. Guideline values for primary industries published in the ANZECC and ARMCANZ (2000) guidelines have been retained to date, including water for aquaculture and the production of foods for human consumption, and water for irrigation. The AGWR includes the same criteria as the ANZG, along with information on some other contaminants such as boron.

The *PFAS NEMP* outlines the general environmental obligations regarding PFAS. The current version of the NEMP provides guideline values for PFAS in a range of materials (e.g. soils, drinking water, maintenance of ecosystems), but there are no specific guideline values for recycled water. However, it does provide a framework and context for risk assessment to support understanding potential risks, and PFAS levels in recycled water may pose a risk to be considered and addressed.

The *Designation – Classification of PFAS-impacted soil (January 2022)* specifies an upper limit for reuse of PFAS contaminated soil. While it is acknowledged that these guidance values are not specific to recycled water, they may help to understand the risk posed from the irrigation of recycled water.

Recycled water managers should maintain their state of knowledge relevant to PFAS management by referring to the latest version of the NEMP and other PFAS specific information developed by EPA.

6.4.3. Risk assessment

Risk due to contaminants of concern and emerging contaminants is dependent on a combination of the contaminant concentrations applied in recycled water and the existing contaminant concentrations in the soils irrigated.

Where a medium or high risk is identified and ongoing monitoring is required, the focus should be on the substance/s creating the risk.

Table 6-6 Risk assessment – contaminants of concern and emerging contaminants

Lower risk	Higher risk
Negligible contaminant inputs to treatment plant Contaminant levels in recycled water are less than Long-term trigger values for irrigation as outlined in ANZG <0.7 mg/L boron in recycled water	Contaminant levels in recycled water exceed Short-term trigger values for irrigation as outlined in ANZG Contaminant levels in soils exceed cumulative contaminant loading limits as outlined in ANZG >3.0 mg/L boron in recycled water PFAS identified in recycled water Catchment characterisation indicates a high risk of contaminants being present in the recycled water

For some hazards, little information is available, making risk assessment difficult. If any part of a recycled water system changes, or new hazards are identified through the recycled water quality monitoring program, then a revised risk assessment may need to be completed.

It is important to ensure familiarity with the current state of knowledge and respond to risks as identified and/or guided by EPA Victoria.

6.4.4. Management controls

Table 6-7 Management controls – contaminants of concern and emerging contaminants

All sites	Additional controls for high risk
Assess inputs to treatment plant to determine possible sources of contaminants Test recycled water for contaminants based on industrial/trade waste sources Undertake soil and groundwater sampling and analysis for contaminants, if these substances are identified in recycled water or history of land use suggests potential for contamination Undertake source control of contaminants entering the treatment plant (e.g. through trade waste agreements) Scheme managers to remain informed of latest science and guidance	If analysis results indicate concentrations that exceed guideline limits, seek specialist advice regarding continued irrigation at the site If you suspect that contaminant concentrations in the recycled water are above safe levels, then you may need to undertake a risk assessment to determine if there are impacts to human health and the environment Consider predictive modelling (or equivalent) for accumulation in receiving environments to assess lifespan of recycled water application

6.4.5. Monitoring and review

All sites:

- Visually monitor plant health
- Monitor sources of industrial/trade waste and test recycled water for contaminants according to type of trade waste.

Additional controls for medium risk and above:

- Regular testing of recycled water for contaminants of concern
- Test soils for contaminants of concern (refer to Section 7.1 for further information)
- Test food produce for contaminants of concern
- Monitor rainfall runoff and groundwater quality (refer to Sections 7.2 and 7.3 for further details)
- If contaminants in the recycled water exceed ANZECC trigger values (LTV or STV) review risk levels and associated management controls.
- Keep knowledge up-to-date on contaminants of concern and emerging contaminants.

6.4.6. Further information

Australian and New Zealand Guidelines for Fresh and Marine Water Quality: www.waterquality.gov.au/anz-guidelines

Australia Guideline for Water Recycling 2006. https://www.waterquality.gov.au/guidelines/recycled-water

PFAS National Environment Management Plan Version 2.0 (2020). https://www.awe.gov.au/environment/protection/publications/pfas-nemp-2

Designation of the Authority under Regulation 86(1) of the Environment Protection Regulations 2021: Classification of PFAS-impacted Soil (January 2022) http://www.gazette.vic.gov.au/gazette/Gazettes2022/GG2022S026.pdf

7. Receiving Environment

7.1. Soil Health

7.1.1. Objective

Soil ecosystems and soil productivity is maintained or improved.

7.1.2. Potential Impacts

Characteristics of soil can be separated into inherent and dynamic properties:

- Inherent properties are those that are intrinsic to a particular soil, such as texture, and normally do not change when irrigated.
- Dynamic properties are those that can change under land use or be in a state of constant change, e.g. structure, chemistry (nutrient, salt, pH levels).

The inherent properties of a soil determine its suitability for irrigation, the types of crops that can be grown successfully and the potential crop yields that can be achieved. For example, the texture and depth of the soil dictates rooting depth, water holding capacity and permeability. Soils can be separated into six classes according to their inherent properties. These classes are detailed in Appendix 5, along with the types of crops that can be grown within each class.

Dynamic properties of a soil determine ongoing management requirements. The main soil management issues relating to irrigation with recycled water are:

- Nutrients, salts, sodicity and contaminants of concern (as already covered in Chapter 6)
- If soil pH is either very acidic or very alkaline it can cause nutrient deficiency, toxicity and soil structural problems. Most soils can buffer and resist pH changes. A soil pH range of 5.5 to 8.0 is favourable for most plants
- Infiltration can be reduced by excessive amounts of suspended solids in the applied water clogging up soil pores, potentially causing waterlogging and increased runoff
- Steep slopes and bare soil surfaces are susceptible to sheet and gully erosion
- Inappropriate cultivation practices (e.g. Cultivating wet soil, pulverising dry soil) can cause soil structure breakdown (which can inhibit aeration and root growth) and soil loss from wind erosion
- Overstocking of irrigated land can cause soil compaction and pugging, which reduces infiltration potentially resulting in waterlogging and increased runoff.

Many recycled water nutrients and contaminants can be concentrated in soil, being stripped out of the water and absorbed by soil particles, as it moves through the soil matrix.

Any fertilisers, chemical products, manures, organic matter and soil ameliorants (such as gypsum and lime) that are to be applied to the irrigated area, should also be evaluated for potential contamination, chemical and physical properties, and migration behaviour in the soil profile.

7.1.3. Risk Assessment

The following table provides guidance on the assessment of risks associated with soil health.

Table 7-1 Risk assessment – soil health

Lower risk	Higher risk
Soil Type Deep, well-structured soils suited to a wide range of crops (Class I – II as per Appendix 5)	Soil Type Poorly structured, heavy soils (Class IV – V as per Appendix 5) Shallow soils
pH Soil pH and recycled water pH are close to neutral.	pH soil pH $_{(water)}$ less than 5 or greater than 8.5 recycled water pH is less than 6 or greater than 9
Land Use Perennial crops	Land Use High stocking rates Intensive cropping (regular cultivation)
Erosion Relatively flat site	Erosion Steep slopes (slopes steeper than 10% are generally not suited to irrigation) Dispersive soils

7.1.4. Management controls

Table 7-2 Management controls – soil health

All sites	Additional controls for high risk
Select enterprise according to soil type Undertake baseline soil chemistry testing Assess recycled water quality to determine potential impact on soil Select irrigation system appropriate to topography and soil type (slopes steeper than 1:10 generally shouldn't be considered for irrigation) Undertake appropriate scheduling for soils irrigated (eg. duplex soils require smaller more frequent irrigations)	Where significant amount of Class IV or V soils are present consider alternative sites, or reduce application rates Where Class I soils are irrigated with recycled water, consider risk to groundwater due to soil permeability Consider using soil amendments (e.g. lime) to maintain optimum soil chemistry and structure Manage stock to prevent over-trafficking and compaction when wet Additional recycled water treatment controls (e.g. pH correction)

Organic matter can be added to soils to:

- improve soil structural stability
- increase water holding capacity
- decrease erosion losses
- supply 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 or composts as they may contain salts and nutrients and need to be considered in nutrient budgets.

7.1.5. Monitoring and Review

Soil sampling and analysis should be conducted annually for high-risk sites and every 3 years for low-risk sites, with both chemical and physical properties being monitored. Refer to Appendix 6 for a recommended approach to sampling and analysis.

Visually monitor site for signs of waterlogging, which can indicate soil structural decline.

Visually monitor site (particularly slopes) and any runoff (turbidity) for signs of erosion.

7.1.6. Further Information

Dairy Soils and Fertiliser Manual - Australian Nutrient Management Guidelines, (Victorian Department of Primary Industries, 2013)

Soil Analysis, an Interpretation Manual Peverill, K.I., Sparrow L.A. and Reuter D.J. eds (CSIRO, 1999).

Soil Guide – A Handbook for Understanding and Managing Agricultural Soils, Moore, G. ed (Agriculture Western Australia Bulletin No. 4343, 1998).

Soil Testing: Guidelines for the Interpretation of Soil Chemical Analysis Results,Wrigley, R. and Dillon, C. (Draft Only).

Sampling and analysis of waters, wastewaters, soils and wastes (EPA Victoria, 2009, Publication IWRG701).

Soil sampling (EPA Victoria, 2009, Publication IWRG702).

Victorian Resources Online accessed via vro.agriculture.vic.gov.au. This includes the Victorian Soil and Land Survey Directory and online soil survey maps covering most of Victoria.

Soil Science Australia: soilscienceaustralia.org.au.

7.2. Surface Water

7.2.1. Objective

Surface water environmental values are maintained or improved.

7.2.2. Potential Impacts

There are two key aspects to consider in relation to surface water impacts:

- Volume and timing of flows – irrigation runoff could increase dry season flows
- Quality – contamination (e.g. by pathogens, nutrients, salts, etc) must be prevented.

In any irrigation system, there are three potential sources of surface runoff that should be considered:

- Direct irrigation runoff – caused by over-irrigation or the practical consequence of flood irrigation. Direct irrigation runoff from properties irrigated with recycled water will contain contaminants. It also occurs at times when there is no normal runoff from the site. Therefore, direct irrigation runoff should be prevented, or collected and reused.
- Irrigation induced runoff – caused by soils being wetter than normal due to irrigation, which reduces rainfall infiltration and therefore increases rainfall runoff. There are two components: the first flush; the remainder. First flush rainfall runoff can be contaminated, particularly where it picks up residue from a recent irrigation. This portion of runoff also increases the volume of flow to surface waters. Therefore, first flush runoff should be prevented, or collected and reused. The remainder of the irrigation induced rainfall runoff is a slight increase on natural flows to surface waters. This runoff should be allowed to leave the site unless the receiving waters are sensitive to flow, or the runoff contains contaminants.
- Normal rainfall runoff – the natural flow from the land. It is critical to the health of the downstream surface waters in terms of maintaining flows. Normal rainfall runoff should continue to discharge to surface water from the irrigation site if it is free from contamination The likelihood of contamination being present in runoff is related to the levels of contaminants present in the surface soils on the site.

In addition to surface runoff, there are other mechanisms through which transport of contaminants can occur to surface waters, such as:

- Lateral movement through soils: where there is a distinct change in soil permeability between topsoils and subsoils (e.g. from sandy loam to heavy clay), lateral flow can occur through the soil to nearby surface waters
- Break of slope: Irrigation or rainfall can infiltrate (leach) through the soil to the water table, travel some distance, then re-emerge at a natural break of slope and discharge into surface waters
- Base flow into streams: Irrigation or rainfall can infiltrate into the groundwater system, which may have a direct connection to an adjoining waterway

- In areas prone to erosion, runoff can wash off soil particles, potentially ending up in surface waters.

In these cases, contamination can occur due to irrigation with recycled water, or due to irrigation causing migration of existing contaminants (particularly salt) in the soil or groundwater.

Flooding

In flood-prone areas, the demand for irrigation water can decrease and land use options may be reduced. Many crops do not survive if inundated with water for any length of time. Flood mapping and risk assessments are available for Victoria's most flood-prone areas and can be used to help determine a site's suitability for recycled water irrigation. Where flooding is expected to be more frequent than every 1 in 10 years, recycled water irrigation should be avoided.

7.2.3. Risk Assessment

The following table provides guidance on the assessment of risks associated with surface waters.

Table 7-3 Risk assessment – surface waters

Low	Medium	High	Extreme
No waterways in close proximity Low pathogens, nutrients, salinity, other contaminants in recycled water and soil (refer to Chapter 6 for details) Flat topography Flood risk: less frequent than 1 in 20 years	Waterway adjacent to irrigation area (<100m) Sensitive waterway at moderate distance (100m–500m) Medium levels of pathogens, nutrients, salinity, other contaminants in recycled water or soil Nutrient balance can be maintained with standard controls Groundwater may provide baseflow to nearby waterways	Sensitive waterway adjacent to irrigation area (<100m) High pathogens, nutrients, salinity, other contaminants in recycled water or soil Difficult to maintain nutrient balance at site Steep slopes with waterway downslope Groundwater provides baseflow to nearby waterways Flood risk: more frequent than 1 in 10 years	Multiple High risks at a site

7.2.4. Management controls

Irrigation Method and Runoff Controls

The irrigation method selected influences the type of runoff controls that will be needed:

- Surface (Flood) Irrigation – collection of irrigation runoff and first flush rainfall runoff to ensure efficient irrigation as well as preventing potential contamination from leaving the site
- Spray/Drip Irrigation – irrigation and first flush runoff can be prevented through accurate irrigation scheduling.

For all sites, recycled water irrigation should not occur during rain.

Table 7-4 Irrigation method and runoff controls

Irrigation type	Design	Management	Additional options for high-risk sites
Surface (flood) Irrigation	Reuse dam required. Design should ensure: Minimum capacity equates to 15% of irrigation water applied at each irrigation Captured irrigation runoff (tailwater) is returned to the irrigation channel and re-applied as irrigation. This typically requires a pump to return the water from the reuse dam to the channel, and the runoff (tailwater) should be applied to at least 30% of the total irrigation area Allow for appropriate buffer to nearby surface waters (refer below)	Reuse dam emptied (via irrigation) at start irrigation season, and after each irrigation	Monitoring of rainfall runoff quality Reuse dam capacity could be increased to collect all rainfall runoff. (Note: Trade-off is reduced natural rainfall runoff to surface waters) A wetland could be installed downstream of the reuse dam to strip nutrients Enhanced treatment of recycled water – e.g. nutrient reduction
Spray/Drip Irrigation	Install automatic rainfall cut-off Allow for appropriate buffer to nearby surface waters (refer below)	Practise irrigation scheduling so that a 5 – 10 mm soil deficit remains following irrigation (this prevents irrigation runoff and provides a buffer to take up the first flush of rainfall runoff)	Monitoring of rainfall runoff quality A reuse dam could be added to capture first flush rainfall runoff A wetland could be installed downstream of the irrigation area to strip nutrients Enhanced treatment of recycled water – e.g. nutrient reduction

Notes to Table 7-4:

- The Water Act 1989 provides that some private dams, including dams for the purpose of capturing irrigation drainage water for reuse, can be used to store up to 0.1 ML capacity per irrigated hectare, without the need for a separate licence to take and use water. This capacity recognises that irrigation runoff and first flush rainfall runoff is an increase on natural rainfall runoff flows.

- The effectiveness of reuse dams can be enhanced by:
  - Ensuring the reuse dam is off-line when full so further rainfall runoff does not flush it out
  - Providing multiple small reuse dams over a large property, rather than one large dam.
- A soil deficit relates to soil saturation (point at which runoff occurs) not field capacity (upper limit of a soil's capacity to store water for plant use). Usually irrigating to field capacity leaves approximately 10mm to saturation.
- Drainage reuse sumps and storages that are used to collect irrigation and the first flush of rainfall runoff should not be used as wet weather storages for recycled water. Typically, these sumps and storages will overflow to the environment under wet weather conditions (i.e. release of normal rainfall runoff to the environment) and therefore should not be used.

Buffer Distances

Buffer distances provide a physical barrier between the wetted irrigation area and waterways. Recommended buffer distances for Class C recycled water, based on irrigation method, are:

- Flood/high pressure spray (i.e. ≥300 kPa; e.g. hard and soft hose sprinklers, impact sprinklers): 100 m
- Low pressure spray (i.e. ≤300 kPa; e.g. centre pivot and lateral move irrigators): 50 m
- Drip/subsurface: 30 m

Recommended buffer distances could be reduced where:

- a class A or B recycled water is used
- the surface waters are seasonal or a drainage channel
- effective measures are implemented to prevent contaminated runoff 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 featuring steep slopes and/or impermeable soils.

Refer also to Section 3.7.2 of Publication 1911.

Surface Drainage (onsite)

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.

Land-forming and laser levelling is used with flood irrigation to ensure water is distributed efficiently. This is combined with constructed end of bay drains that carry surface drainage to the reuse dam.

Constructed drainage can also be used, if required, with spray or drip irrigation. There are various methods including shallow surface drains (which can be grassed and grazed as part of the paddock) and mole or tile drainage (subsurface).

Where constructed drainage is used, it should be designed to prevent erosion, and should be maintained to ensure it operates effectively, and water collected should be managed appropriately (e.g. a reuse dam may be required to capture irrigation and first flush runoff).

Run-on

External surface water (e.g. stormwater run-on) should be prevented from flowing onto the irrigation site, as this may result in reduced irrigation rates and soil waterlogging. Suggested measures to control run-on include the placement of diversion banks and/or cut off drains around the irrigation site.

Flooding

Where the site is in an area prone to infrequent flooding, this will impact on land use or crop selection, due to the cost of damages. Flooding is of greater risk to permanent plantings such as fruit trees and vines, and these land uses are typically not undertaken in flood-prone areas. If a flood of sufficient severity occurs, the crop losses and cost of re-establishment are much higher for permanent plantings, in comparison to annual crops such as vegetables, and medium term or low value crops such as pasture. Where flooding is expected to be more frequent than every 1 in 10 years, recycled water irrigation should be avoided.

7.2.5. Monitoring and Review

Maintain records of irrigation applications.

Visual monitoring for irrigation runoff leaving the site.

Soil sampling (refer to Section 7.1 for further information).

At high-risk sites, implement rainfall runoff quality monitoring. To facilitate sampling, a collection point (comprising a bank/drain to channel runoff to a small sump) should be installed at the point of discharge. Monitoring of the downstream waterway could also be considered.

7.2.6. Further Information

EPA Victoria, 2021. *Environment Reference Standard (ERS)*. Outlines surface water segments, environmental values and associated indicators and objectives.

Interactive maps and surface water datasets are available from:

- DELWP Water Measurement Information System: https://data.water.vic.gov.au/
- Data.Vic provides spatial data including Water Supply Protection Areas and Flood Database: https://www.data.vic.gov.au

7.3. Groundwater

7.3.1. Objective

Groundwater environmental values are maintained or improved.

7.3.2. Potential Impacts

Environmental values

Irrigation with recycled water may pose a risk to groundwater quality and threaten its environmental values. Risk to groundwater quality arises from concentrations of salts, nutrients, pathogens and other contaminants that may be present in recycled water, and from increased mobilisation of contaminants that may be present in the soil. The likelihood and degree of harm is dependent on the quality of the groundwater beneath a site, the quality of the irrigation water, the volume and rate of seepage (which depend on irrigation applications and soil permeability), the leachability of contaminants, and the depth to the water table.

On most soils, nitrogen is generally considered the nutrient most likely to leach (in the form of nitrate). However, on sandy soils with low clay contents, considerable amounts of phosphorus may also be leached to groundwater. From a microbial perspective, viruses are the pathogens most likely to migrate to groundwater.

The *Environment Reference Standard* (May 2021) sets out the environmental values of groundwater against which risk of harm should be considered. The environmental values of groundwater should also be considered in terms of being existing or likely/unlikely to be realised in the future. Groundwater environments are divided into seven segments which are defined by the background level of total dissolved solids (TDS) concentrations in the groundwater. TDS is a measure of salinity.

Table 7-5 Groundwater segments

SEGMENT	A1	A2	B	C	D	E	F
TDS range (mg/L)	0–600	601–1,200	1,201–3,100	3,101–5,400	5,401–7,100	7,101–10,000	>10,001

The segment groundwater belongs in, determines which environmental values should be protected. Environmental values include potable water supply, irrigation, stock watering, industrial or commercial use, interaction with buildings, living cultural heritage, and ecosystem support. All environmental values should be protected for segment A1 groundwater, whereas Segment F may require only a subset of the environmental values to be protected.

Further information regarding the Environment Reference Standard and its use is available in EPA Publication 1992: *Guide to the Environment Reference Standard*.

High water table

Where irrigation increases the seepage of water past the rootzone, the groundwater level may rise. This can cause:

- Waterlogging – excessive saturation of the rootzone resulting in loss of productivity
- Salinisation – increased soil salinity resulting in decreased ability for the plant to extract water
- Offsite discharge – there are complex interactions between groundwater and the land surface or surface water systems. Groundwater levels at a site may need to be maintained to prevent increased groundwater discharge to surrounding land and surface waters.
- Contamination of groundwater

7.3.3. Risk Assessment

A hydrogeological assessment (refer to EPA Publication 668: *Hydrogeological assessment (groundwater quality) guidelines*) will be required to understand local and regional hydrogeology, including groundwater depth, flow direction, groundwater quality and environmental values. Information is also required on soil type and geology to understand potential for seepage to groundwater and likely interaction with the irrigation system and nearby surface waters.

The following table can be used to help you to determine the level of detail required in the hydrogeological assessment.. Different factors apply in relation to risk to groundwater (as measured against environmental values) and risk of rising water tables leading to waterlogging/salinisation. Therefore, two separate screening risk assessments are provided.

Environmental values

Step 1: Assess Risk Based on Groundwater Conditions

Table 7-6 Risk assessment – groundwater environmental values

Depth to water table (mbgl)	Groundwater segment			
	A1	A2	B	C–F
< 5 m	Extreme	High	Medium	Low
5–10 m	High	Medium	Low	Low
10–20 m	Medium	Low	Low	Very Low
> 20 m	Low	Low	Very Low	Very Low

Step 2: Refine Risk Based on Recycled Water Quality

If recycled water quality has high pathogen, salinity, nutrient or other contaminant concentrations (as defined in Chapter 6), the risk level in Table 7-6 needs to be increased by one, for Segments A1 and A2, and for Segment B where depth to water table is <10m.

Step 3: Finalise Risk Based on Soil Type and Geology

If the site contains highly permeable soil layers (e.g. sand) or fractured rock the risk outlined in Table 7-6 needs to be increased by one level.

High water table

Table 7-7 provides a screening risk assessment in relation to the potential for rising water tables leading to waterlogging/salinisation.

Table 7-7 Risk assessment – high water table

Depth to water table	Groundwater segment		
	A1/A2	B	C–F
< 2 m	Low	Medium	High
2–5 m	Low	Low	Medium
> 5 m	Low	Low	Low

Where an impermeable subsoil layer exists beneath permeable soils (e.g. a duplex soil with loam surface soils over heavy clay subsoils), there is potential to create a perched water system, which can lead to localised waterlogging, salinisation or offsite discharge of groundwater.

7.3.4. Management controls

Irrigation scheduling (refer to Section 5.3) must be matched to plant demand and soil type to minimise leaching past the root zone.

Surface (flood) irrigation should not be used on permeable soils (Class I or II soils) due to risk of leaching.

Ensure storages are constructed to prevent leakage (i.e. permeability of ≤1 x 10-9 m/sec; refer to Section 4.1 for additional discussion).

Additional controls for high-risk sites:

- Use of drip or spray irrigation so that applications can be accurately controlled
- Enhanced treatment of recycled water – e.g. Class A, salt or nutrient reduction
- Installation of subsurface drainage to collect leachate (where threat to environmental values is high) or to control the groundwater level (where risk of waterlogging/salinisation is high).

7.3.5. Monitoring and Review

Visual monitoring of site and surrounding area for waterlogging or evidence of salinisation.

Soil sampling (refer to Section 7.1).

Sites with higher risk should install groundwater monitoring bores to assess the depth and quality of groundwater, as follows:

- The number of bores in the monitoring network should be sufficient to enable the groundwater flow and changes in quality to be characterised (typically this would require a minimum of three bores)
- Locations selected should include both up-gradient and down-gradient of the irrigation area (based on groundwater flow direction), so irrigation impacts can be separated from regional influences on groundwater
- Standard groundwater monitoring parameters include static water level, salinity (EC and TDS), nitrogen (NO_3 and NH_3) and phosphorus. Other analytes may need to be included depending on the quality of the wastewater. For example, monitoring of E. coli and enteric viruses may be warranted when groundwater is used for water supply and domestic purposes
- Groundwater is typically monitored for the standard parameters at least every three months initially so that trends can be established. After that (i.e. after trends are established), the frequency of monitoring can be reviewed, based on the results/trends observed and assessed risk to groundwater
- Personnel with hydrogeological expertise should be consulted to help develop a program appropriate to the identified risks.

7.3.6. Further Information

EPA Victoria. *Environment Reference Standard (ERS)*. This outlines groundwater segments, environmental values and associated indicators and objectives.

EPA Publication 668: *Hydrogeological assessment (groundwater quality) guidelines*

EPA Victoria, 2022. *Groundwater Sampling Guidelines (Publication 669)*

Interactive maps and groundwater datasets are available from:

- DELWP www.water.vic.gov.au/groundwater/groundwater-resource-reports
- DELWP Water Measurement Information System: https://data.water.vic.gov.au/
- Visualising Victoria's Groundwater: www.vvg.org.au.

7.4. Native Vegetation

7.4.1. Objective

Native vegetation is protected by considering and mitigating risks.

7.4.2. Risk to native vegetation to be considered and mitigated. Potential impacts

Native vegetation includes all trees (including dead standing trees), shrubs, herbs and grasses that are indigenous to Victoria. Removal or destruction of native vegetation can have a significant impact on:

- Biodiversity and ecological processes
- Land stability
- Habitat for fauna
- Water quality
- Shade/shelter for livestock
- Landscape and amenity value
- Living cultural heritage.

Native vegetation is protected in Victoria and a permit is usually required to remove, destroy or lop native vegetation. This is legislated through the Planning and Environment Act 1987(Vic) and planning schemes made under it. Application for a planning permit is made through the relevant local council. If a permit is granted, a native vegetation offset must be obtained before the native vegetation is removed, to compensate for the impact of the removal on biodiversity.

Planning permit applications must comply with the DELWP *Guidelines for the removal, destruction or lopping of native vegetation*, which outline how native vegetation removal is assessed and offset. The Guidelines are an incorporated document in all Victorian planning schemes.

There are some exemptions that do not require a permit, and these are listed in DELWP guidance document: *Exemptions from requiring a planning permit to remove, destroy or lop native vegetation*.

Removal of native vegetation includes assumed losses from development works. Assumed losses account for indirect loss of native vegetation. Examples include: encroachment into tree protection zones, losses from changed water flows (which could be connected to recycled water use) and shading. Potential for assumed losses needs to be considered when calculating extent of native vegetation removal or destruction.

7.4.3. Risk Assessment

Table 7-8 Risk assessment – native vegetation

Lower risk	Higher risk
No native vegetation on the development site Neighbouring land is relatively free of native vegetation Development site has previously been irrigated and any remaining native vegetation has adapted to this irrigation	Site contains rare, ecologically important, threatened or sensitive native vegetation Land is largely undisturbed by effects of recent settlement Site is within 100 m of areas containing rare, ecologically important or threatened native vegetation

7.4.4. Management Controls

Design and planning stages

- Undertake a visual assessment of site for presence of native vegetation
- In areas largely undisturbed by recent settlement, or where significant numbers of trees are present, a flora and fauna survey should be undertaken by an appropriate expert. EPA *Publication 1702: Fact sheet: Engaging consultants* may be helpful.
- Avoid development of native vegetation areas, where possible.

Application for planning permit (if required)

- Applicants must demonstrate they have: avoided the removal, destruction or lopping of native vegetation; minimised the impacts where removal, destruction or lopping cannot be avoided; provided an offset to compensate for the impact.
- Applicants must demonstrate that they have considered the impacts on biodiversity, including risk of assumed losses, such as the landscape change resulting in future death of trees.
- Early consultation with local council, DELWP and CMA to assist in avoiding loss of vegetation and the need to alter designs at later stages.

Development and management of an irrigation scheme

- Develop a management/revegetation plan with assistance of local council, DELWP and CMA (often undertaken as part of developing an irrigation and drainage plan)
- Fence off native vegetation areas where necessary to prevent stock/human access (ensure potential wildlife corridors are maintained)
- Where buffer zones are required to prevent spray drift or protect surface waters, it is recommended that these are planted with native vegetation (of varying heights and species, and indigenous to the region) to encourage biodiversity.

Revegetation and restoration

Where revegetation or restoration works are undertaken, any new plantings should be indigenous to the region. This is particularly relevant for repairing and/or healing country, and the associated living cultural heritage values and landscape values. Consultation with local Traditional Owners is recommended to assist with revegetation planning.

7.4.5. Monitoring and Review

- Monitor health of remaining native vegetation (or planted buffer zones) to ensure irrigation is not causing long term impact
- Review and update management plans for existing vegetation or revegetation.

7.4.6. Further information

Department of Environment, Land, Water and Planning – Native Vegetation:

https://www.environment.vic.gov.au/native-vegetation/native-vegetation

Examples of relevant publications on DELWP website:

- *Guidelines for the removal, destruction or lopping of native vegetation*
- Applicant's guide – Applications to remove, destroy or lop native vegetation
- Assessor's handbook – Applications to remove, destroy or lop native vegetation
- Exemptions from requiring a planning permit to remove native vegetation

- Planning for biodiversity
- Native vegetation removal regulations – Compliance and enforcement strategy

Supporting information can also be obtained from the local Catchment Management Authority and from local government.

Legislation to protect threatened species and communities:

- *Flora and Fauna Guarantee (FFG) Act 1988*
- *Environment Effects (EE) Act 1978*
- *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*
- *Environmental* assessment bilateral agreement between Victoria and the Commonwealth Government that avoids duplication of specified environmental impact assessment processes.

8. Cultural and Social Values

8.1. Recognising Traditional Owner Cultural Values and Heritage

This section addresses Traditional Owner cultural values under the EP Act and also cultural heritage under the Aboriginal Heritage Act. It has been developed in collaboration with Traditional Owners to encourage the full consideration and respect of cultural values and heritage when designing and operating irrigation schemes using recycled water.

For Traditional Owners, Country is embedded with culture, stories, songlines including ceremonial places and sites of significance. Each landscape, and each part of the environment has its own stories, lore and cultural history. There are no distinctions between water, land and air; culture, stories and songlines are embedded, connecting everything and everyone, in ways that are difficult for non-Aboriginal people to see and understand. For Traditional Owners, cultural values exist within landscapes and cultural heritage is still living.

“Traditional Owners approach land and water management with a holistic set of knowledge and practices that link the management of conservation and productive values to the environmental and cultural services upon which they depend.” (Victorian Aboriginal Heritage Council).

Development of recycled water irrigation schemes should consider Traditional Owner cultural values for water under the EP Act and also ensure protection of cultural heritage (under the *Aboriginal Heritage Act 2006* (Vic) (AHA) and the *Aboriginal Heritage Regulations 2018* (Vic) (AHR)).

8.1.1. Traditional Owner cultural values for water

The Environment Reference Standard (ERS) sets out the values for the protection of the environment in Victoria and is a new legislative instrument under Part 5.2 the Environment Protection Act 2017 (the EP Act). The ERS recognises Traditional Owner ’cultural values as an Environmental Value.

As described in the ERS Guidelines, the ERS is an environmental benchmark. It brings together a collection of environmental values, indicators and objectives that describe environmental and human health outcomes to be achieved or maintained in the whole or in parts of Victoria. These values, indicators and objectives are used to assess and report on changing environmental conditions by providing a reference point for decision makers to consider whether a proposal or activity is consistent with the environmental values identified in the ERS. The ERS also allows decision makers to evaluate potential impacts on human health and the environment that may result from a proposal or activity.

The ERS is a key instrument for the recognition of cultural values and is used to inform standards for environmental segments that apply across Victoria, not only as part of EP Act regulation but to all people, entities and agencies.

This means that all parties involved in proposals when designing and operating irrigation schemes using recycled water (including government entities that may assess those proposals) should have regard for Traditional Owner cultural values.

Table 8-1 Extract from Table 5.1 from Environmental values of waters of the ERS

Environmental value	Description of environmental value
Traditional Owner cultural values	Water quality that protects the cultural values of Traditional Owners, having recognised primary responsibility for protecting the values of water for cultural needs, to ensure that Traditional Owner cultural practices can continue. Values may include traditional aquaculture, fishing, harvesting, cultivation of freshwater and marine foods, fish, grasses, medicines and filtration of water holes

When designing and operating irrigation schemes using recycled water and where approvals are required, any assessment of Traditional Owner cultural values will need to be obtained from Traditional Owners of the land or waterway in question. The advice in the chapter on Cultural and Spiritual Values in *The Australian & New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG) may be of assistance. This indicates the primary importance of engagement and consultation with Traditional Owners on questions of the cultural values. However, secondary reference sources to assist could include:

- Traditional Owner Country Plan
- Aboriginal cultural heritage register and information systems
- the Aboriginal Water Program and Water Is Life strategy https://www.water.vic.gov.au/aboriginal-values/the-aboriginal-water-program
- Aboriginal Waterway Assessments
- Victorian Waterway Management Strategy
- Specific collaborations between Water Corporations, Catchment Management Authorities and Traditional Owners that give effect to Traditional Owner cultural values.

Advice may also be sought from First Peoples - State Relations Group on specific engagement with Registered Aboriginal Parties (RAPs) and/ or other Traditional Owner groups.

Consultation & Engagement

To ascertain the cultural values that are relevant to a waterway or proposal for the design and use of an irrigation scheme using recycled water, proponents should consult with Traditional Owners – cultural values cannot be ascertained in the absence of engagement and consultation with Traditional Owners.

In addition to information obtained from Traditional Owners other information that can inform consultation and decision-making processes include:

- Identifying any relevant practical reference points from information already in existence – for example whether it is an area of special significance or cultural sensitivity in Aboriginal Cultural Heritage Register and Information System (ACHRIS) (see 8.1.2 below)
- Whether there are other published materials such as an Aboriginal Waterway Assessment, or Traditional Owner Country Plan that sets out priorities for water and relevant considerations.

The Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZG) details the process by which cultural values, as they apply in the context of water quality, can be determined. The ANZG provide helpful and authoritative guidance on the appropriate approach.

Potential cultural heritage impacts

Irrigation schemes using recycled water may have impacts to cultural heritage and trigger considerations under the *Aboriginal Heritage Act 2006* (Vic) and the *Aboriginal Heritage Regulations 2018* (Vic). EPA does not have jurisdiction under these legislative regimes and cannot enforce compliance. The information in this section has been included at the suggestion of the Traditional Owners with whom EPA consulted, as there is some commonality and overlap between the recognition of Traditional Owner cultural values under the EP Act and the protection of cultural heritage under the *Aboriginal Heritage Regulations 2018* (Vic). The information is derived from *First Peoples – State Relations Group* and intended to support proponents and operators of schemes for the use of recycled water for irrigation to fully consider and manage any potential impacts on Aboriginal cultural heritage and is not a substitute for independent advice on the application of the *Aboriginal Heritage Act 2006* (Vic) and the *Aboriginal Heritage Regulations 2018* (Vic).

Cultural heritage must not be harmed without the appropriate statutory approvals.

Further information on possible requirements under the *Aboriginal Heritage Act 2006 (Vic)* and the *Aboriginal Heritage Regulations 2018 (Vic),* including assessing risk and management controls, can be found in Appendix 7.

8.1.2. Further Information

Further information can be obtained from:

- First Peoples – State Relations Group, within the Department of Premier and Cabinet

The Aboriginal Heritage Planning Tool can be accessed via: https://www.firstpeoplesrelations.vic.gov.au/cultural-heritage-management-plans

The Aboriginal Cultural Heritage Register and Information System (ACHRIS) is the online portal of the Victorian Aboriginal Heritage Register. It includes an Online Map that can be used to identify areas of Cultural Heritage Sensitivity and the boundaries of areas for which a Registered Aboriginal Party (RAP) is registered: https://achris.vic.gov.au/#/onlinemap

It is important to recognise that the mapping in ACHRIS is indicative only – the AHR defines areas of Cultural Heritage Sensitivity. It is also important to view the site cards associated with Aboriginal places, as actual place extents may differ from what is indicated on ACHRIS, particularly for older registrations.

8.2. Recent Settlement Heritage

8.2.1. Objective

Historic sites are protected.

8.2.2. Potential impacts

The *Heritage Act 2017* (Vic) provides for the protection and conservation of the cultural heritage of Victoria (other than places or objects of significance because of its association with Aboriginal tradition, which is protected under the *Aboriginal Heritage Act 2006* (Vic) and the *Aboriginal Heritage Regulations 2018* (Vic). It creates a framework to identify, register and protect cultural heritage places (and associated objects) in Victoria. Such places may include both cultural heritage and Aboriginal cultural heritage at the same location and/or pertaining to the same or different events or themes.

EPA does not have jurisdiction under the *Heritage Act 2017* (Vic) and cannot enforce compliance. The information in this section has been included to support proponents and operators of schemes for the use of recycled water for irrigation to fully consider and manage any potential impacts on historical sites and is not a substitute for independent advice on the application of the *Heritage Act 2017* (Vic).

The *Heritage Act 2017* (Vic)also establishes the processes for obtaining permits for changes to those places and creates offences and other enforcement measures to protect and conserve heritage. The *Heritage Act* establishes the Heritage Council, the Victorian Heritage Register and the Heritage Inventory.

Heritage sites cannot be disturbed without prior written consent from the relevant local government and/or Heritage Victoria.

Local government is responsible for locally significant heritage places. These places are listed in the Heritage Overlay of the relevant municipal planning scheme.

The National Trust is a heritage advocacy group and is not part of government. National Trust classification does not provide statutory protection for heritage places.

8.2.3. Risk assessment

Table 8-2 Risk assessment – recent settlement heritage

Lower risk	Higher risk
Site does not contain/comprise place listed on Victorian Heritage Register or Heritage Inventory Site not covered by a Heritage overlay	Site contains/comprises place listed on Victorian Heritage Register or Heritage Inventory Site is covered by a Heritage overlay

8.2.4. Management controls

Identify heritage sites

Assess if site is listed on Victorian Heritage Register, Heritage Inventory or covered by a Heritage Overlay via search function on Heritage Victoria's website.

If local heritage site exists (i.e. if the site is subject to a Heritage Overlay), consult with local council regarding management controls required.

Apply for permits

A heritage permit may be required for any work, including, for example, developing, altering or excavating parts of places listed on the Victorian Heritage Register (such places may include, for example, archaeological sites, areas of land covered with water, buildings, gardens, landscapes and trees), or for the removal, relocation or damage of a registered object. Activities that require a permit may include, for example:

- Extensions, interior works, demolition or relocation of buildings and structures
- Changes to colour schemes and signage
- Construction of new buildings and garden structures (e.g. fences, decks, pathways, driveways)
- Works to registered trees and gardens
- Excavation including damage or alteration to an archaeological artefact
- Relocation or repair of objects.

8.2.5. Monitoring and Review

Monitor implementation of any Heritage Permit, planning scheme or local council requirements.

8.2.6. Further information

Further information can be obtained from:

- Heritage Victoria
- Heritage Council of Victoria.

Municipal planning schemes which define Heritage overlays can be viewed online:
www.planning.vic.gov.au/schemes-and-amendments

The Victorian Heritage Register and Victorian Heritage Database can be accessed via:
heritagecouncil.vic.gov.au/register

8.3. Public Amenity

8.3.1. Objective

Risk of harm to public amenity is minimised.

Effective community consultation is undertaken.

8.3.2. Potential impacts

- Hazards relating to public amenity from use of recycled water include:
- Spray drift and odours associated with the use of recycled water causing discomfort or posing health risks to people living near the irrigation site
- Noise pollution associated with machinery and motors driving irrigation pumps
- Changes in land use due to implementation of recycled water irrigation that may affect land values
- Negative community perception and/or community objections regarding changes to the environment.

8.3.3. Risk assessment

Table 8-3 Risk assessment – public amenity

Lower risk	Higher risk
Existing irrigation site with no history of complaints Small scale development Rural setting, particularly where irrigated agriculture is common No tree removal required Flood or drip irrigation system is used (i.e. no spray drift produced) Development has direct public benefit (e.g. irrigation of golf course that previously had minimal access to water)	Existing site with significant complaint history Large scale development Site close to urban areas and/or sensitive land uses Proposal featuring clearing of heavily timbered existing site Tree plantation to be developed that would block views in an open environment Odour producing lagoon/storage on-site (potential or existing) High pressure, small droplet spray irrigation used where spray drift likely

8.3.4. Management controls

A proactive approach taken during the investigation and design phase of a recycled water irrigation scheme is more effective in addressing possible impacts on public amenity, than once the scheme has been established. The following controls should be considered in the design phase:

Planning

Development must be aligned with local planning scheme requirements, including applications for planning permits where needed, and any applicable local laws

Other amenity impacts

- Odour
- Noise
- Dust

Community consultation

Develop a consultation strategy prior to scheme establishment and when any changes to the system are proposed (refer to EPA Publication 1145: *A planning process for community engagement* for further information).

- Undertake community consultation early in development that includes personal contact with neighbouring landowners and key community groups.
- A proposal that has been co-designed with community will likely be more sustainable
- Develop procedures to record and respond to any inquiries or complaints from the public and/or in the media.
- For high-risk developments, consider including public meetings, an online forum for written comments, an education program, and other activities to support effective consultation.

Site maintenance

Keep the site in a tidy condition, with the amenity aligned with the surrounding land.

Additional controls for high-risk sites

- Implement amenity controls as identified through community consultation

- Locate storage sites for recycled water as far from human habitation as is practical
- Use tree plantings to visually screen water storage sites and irrigation areas from view
- Reduce risk of spray drift by planting trees in buffer zones and/or implementing automatic wind cut-off controls.

8.3.5. Monitoring and review

Ongoing recording and monitoring of inquiries, including responses, is recommended, to ensure queries are handled appropriately and to minimise negative community perceptions and views.

Investigate the cause, and provide a response in a timely manner, where negative public feedback is provided. Attempt to address the situation through rectifying issues, where possible, or negotiating.

8.3.6. Further information

EPA Publication 1145: A planning process for community engagement.

Contact the relevant local council regarding local planning schemes and permit requirements, and applicable local laws. Municipal planning schemes can be viewed online: www.planning.vic.gov.au/schemes-and-amendments

EPA Odour advice for businesses
EPA Noise advice for businesses
EPA Dust advice for businesses

9. Health

9.1. Human Health

9.1.1. Objective

Risks of harm to human health are minimised.

9.1.2. Potential Impacts

Recycled water can contain a wide range of hazards, including chemicals and pathogenic organisms, that may pose risks to human health. Pathogenic microorganisms can include types of bacteria, viruses, protozoa, and helminths that cause disease. Contaminants of concern and emerging contaminants (e.g. heavy metals, PFAS) should also be considered and are discussed in more detail in Section 6.4.

Contact with microorganisms can be direct (via drifting aerosols), or indirect, (arising from food consumption, of products grown on a site using recycled water for irrigation).

On-site workers that have direct contact with recycled water containing blue-green algae or other pathogenic microorganisms may be at risk of, for example:

- Skin and eye irritations
- Gastrointestinal illnesses
- Respiratory illnesses.

Other potential impacts to human health may occur indirectly via:

- Contamination of produce where food crops eaten raw have come into contact with recycled water
- Chemical bioaccumulation in animal meat where livestock have grazed pastures or accessed fodder/silage that has been irrigated with recycled water.

Where recycled water has been used in agricultural production, product specifications and consumer requirements of the end markets need to be considered. Some domestic and international markets may have negative perceptions regarding the use of recycled water.

9.1.3. Risk Assessment

Table 9-1 Risk assessment – human health

Factor	Lower risk	Higher risk
Water quality	Water quality is better (i.e. higher class) than what is required for the particular use Appropriate risk assessment has been undertaken identifying potential pathogens and contaminants and their management	Water quality is variable (i.e. does not consistently meet target quality) Treatment effectiveness may change and the recycled water deteriorates to a level that is not suitable for the intended end use
Access	Operator(s) have Occupational Health & Safety training in line with WorkCover requirements Adequate buffer distances for spray irrigation (refer to Appendix 2) No public access	Little or no OH&S training/ awareness at the site Minimal buffer distances for spray irrigation Uncontrolled public access to site (except for Class A water)
Irrigation system	Drip or centre-pivots with "dropper tubes"	High pressure, small droplet sprinklers or spray system

9.1.4. Management controls

Wastewater treatment processes should ensure the removal of pathogens and contaminants to the appropriate levels before reuse. The quality of recycled water to be used for irrigation must be fit for purpose. Table 3-1 outlines suitable uses for each class of recycled water and Publications 1910 and 1911 give detailed guidance. The *Australian Guidelines for Water Recycling (Phase 1) – Managing Health and Environmental Risk* also provide advice for undertaking recycled water irrigation risk assessments.

General management controls that focus on minimising human exposure to possible risks associated with irrigation of recycled water include:

- Restrictions on public access to sites, depending on the quality of the recycled water in use
- Use of prominent warning signs, in accordance with AS1319 – *Safety Signs for the Occupational Environment*
- Use of universal symbols (e.g. picture of a tap with a red circle with diagonal strip to illustrate 'no'), given people may not be able to read warning signs
- Buffer zones to prevent spray drift from the irrigation site.

On-site workers

Controls must be implemented to ensure risks to onsite workers (or others who may be affected by the workers' conduct) are eliminated or reduced, as far as reasonably practicable, in light of employers' duties under the *Occupational Health and Safety Act 2004* (Vic). These controls may include, for example:

- an appropriate occupational health and safety program, including documentation of any instances of direct contact of recycled water with workers (other than for approved Class A uses)
- education and training activities for onsite workers to outline the risks associated with use of recycled water

- ensuring appropriate immunisations are current
- use of protective equipment appropriate for the task being undertaken and quality of recycled water being used
- no consumption of food or drink while working directly with recycled water
- access to potable water supply or other fresh water source
- washing of hands with soap and water before eating, drinking, or smoking and at the end of the day
- covering wounds
- limiting access to irrigation areas to a minimum during irrigation periods to avoid exposure (including inhalation) to recycled water spray.

Sites with public access

Residential schemes can only use Class A recycled water, given the high exposure potential to humans, as controls on public access are not feasible.

For municipal schemes, Class A water should be used where it is not possible to manage public access. Class B or C water may be used where control measures to minimise public access can be implemented, including:

- irrigation method (sub-surface drip)
- restricted watering times (e.g. night time watering)
- withholding periods (minimum of four hours) to ensure areas are dry before access by public
- fencing.

Use of buffer zones for sensitive areas

Refer to Appendix 2 for outline of indicative buffer distances which vary according to irrigation method selected.

The buffer distances to sensitive areas may be reduced if one or more of the following controls to reduce spray drift are implemented:

- Tree plantings to provide screening
- Anemometer switching systems (i.e. wind cut-off)
- Restricted times of watering
- Using irrigation systems that prevent the generation of fine mist (e.g. low rise sprinklers, small throw or micro sprinklers and part circle sprinklers).

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

Minimum recommended buffer distances to waterways and sensitive receptors (e.g. houses, schools) are detailed in EPA Publication 1911.

Food safety of agricultural produce

The following controls should be implemented to ensure appropriate food safety is maintained when using recycled water in agricultural production, including:

- Produce should not be harvested when wet from irrigation of recycled water
- Recycled water should not be used as washdown water for food packaging or processing machinery or dairy milking machinery
- Awareness of relevant industry-based Quality Assurance (QA) and accreditation programs that feature a Hazard Analysis and Critical Control Point (HACCP) framework to manage produce safety risks
- Implement management controls to address food and produce safety associated with the use of recycled water, as part of relevant QA programs.

Refer also to Publication 1911 for food safety control measures (including in relation to the legislative framework for food safety in Victoria).

Managing blue-green algal blooms

For systems prone to algal blooms, an emergency response plan should be developed and include:

- Allowance for alternative supply systems
- Measures to allow screening or filtering to remove algae before supply or application
- Suitable mechanisms to clean and flush the distribution system
- Threshold blue-green algae cell numbers and algal toxin levels that trigger actions, such as cessation of food crop irrigation.

9.1.5. Monitoring and review

- Currency of OH&S program and training for onsite workers
- Register of direct contact with recycled water by onsite workers and/or public
- Location and quality of relevant signage
- Monitoring produce as part of a food safety QA program
- Blue-green algae monitoring program.

9.1.6. Further information

Employers should make themselves aware of their responsibilities and duties under the *Occupational Health and Safety Act 2004* (Vic).

WorkSafe Victoria has the following services and information (available on its website) to assist employers and employees:

- OHS Essentials Program – a free workplace safety consultation service
- Health and safety representative roles
- Consultation: a guide for Victorian workplaces
- Compliance codes (e.g. Workplace amenities and work environment, First aid in the workplace, Communicating occupational health and safety across languages).

Information regarding food safety and HACCP based QA systems is provided by:

- Food Standards Australia and New Zealand
- Food Safety, Department of Health Victoria
- Victorian Food Safety Regulatory Framework (Agriculture Victoria)
- Industry associations (e.g AUSVeg – industry body for vegetable and potato growers)
- *Guidelines for Fresh Produce Food Safety* 2022 published by the Fresh Produce Safety Centre.

9.2. Livestock Health

9.2.1. Objective

Risks of harm to animal health are minimised.

9.2.2. Potential impacts

Impacts on livestock health arise from either direct contact with recycled water or via toxicity/contaminants in plants or produce. They may include:

- "Beef measles" or Cysticercus bovis caused by cattle ingesting pasture or other foodstuffs contaminated with tapeworm (*Taenia saginata*) eggs
- Taenia *solium* tapeworm eggs can infect humans and pigs
- Toxins produced by blue-green algae that are ingested by stock drinking recycled water
- Johne's disease transmission where treatment plant inflows include trade waste from livestock saleyards or abattoirs.

End markets for produce from livestock that have grazed on irrigated pastures or crops should also be considered with respect to product specifications.

9.2.3. Risk assessment

Table 9-2 Risk assessment – livestock health

Factor	Lower risk	Higher risk
Water quality	Water quality is better (i.e. higher class) than what is required for the particular use The required helminth control is achieved Appropriate risk assessment has been undertaken identifying potential pathogens and contaminants and their management	Water quality is variable (i.e. does not consistently meet one type of class) Treatment effectiveness may change, and the recycled water deteriorates to a level that is not suitable for the particular use
Access	No stock access to recycled water storage and/or irrigation system	Poorly controlled stock grazing (e.g. fences in poor condition)

9.2.4. Management controls

Helminth control

The recycled water treatment process must include measures that reduce helminth numbers where livestock grazing is to occur. Helminth control can be achieved via:

- Retention in treatment/storage lagoons for at least 25 days
- An approved filtration method such as sand or membrane filtration.

Alternatively, a risk-based assessment and derivation of the level of reduction required can be separately agreed with the Chief Veterinary Officer (CVO) and EPA.

Refer to Publication 1910 for further details.

Stock Access

Access to pasture or fodder irrigated with recycled water depends on the type of livestock and the quality of the recycled water.

Withholding periods following irrigation with recycled water are applicable for other livestock, either with direct access to pasture/crops for grazing or with harvesting of fodder production.

As per Publication 1910, a withholding period of:

- 5 days is required for dairy cattle grazed on pasture irrigated with Class C recycled water

- 4 hours is required for beef cattle, sheep, goats, horses, alpacas etc. grazed on pasture irrigated with Class C recycled water
- 4 hours is required for dairy cattle grazed on pastures irrigated with Class B recycled water.
- Pigs must not be fed or exposed to any pasture or fodder produced or irrigated with recycled water sourced from human sewage.

An alternative source of water for livestock drinking should be provided where stock are grazing pastures irrigated with Class C recycled water. Class B recycled water can be used for livestock drinking.

Fodder production

Pasture or crops irrigated using recycled water may be grown for fodder production. Before use by stock, pasture or crops should be cut and dried as hay or made into silage. Appropriate withholding periods should be followed.

For fodder that is to be sold, producers should ensure that it is only fed to livestock appropriate to the quality of recycled water used. This could be achieved through:

- Fodder sales only to defined and known end users
- Labelling of produce (e.g. 'fodder not for consumption by pigs').

Recycled water containing animal effluent

Water recycling schemes require individual endorsement from the CVO where they involve irrigation of wastewater sourced from abattoirs, rendering plants and knackeries, or where these sources of wastewater are used for livestock production.

Other examples of stock pathogen sources entering the sewerage system are listed below and require the same verification prior to irrigation commencing:

- stockyards (sale yards, hold yards prior to slaughter or export), intensive livestock facilities, animal processing plants
- washing facilities for livestock cartage vehicles.

Chief Veterinary Officer endorsement and notifications

Publication 1910 details the circumstances of recycled water schemes where CVO endorsement or notification is required.

9.2.5. Monitoring and review

- Document grazing pattern and irrigation to confirm withholding periods have been met.
- Inspect and monitor health of livestock grazed on pasture irrigated with recycled water in accordance with the *Victorian Livestock Diseases Control Act 1994* and *Livestock Disease Control Regulations 2017*.
- Blue-green algae monitoring program.

9.2.6. Further information

Chief Veterinary Officer, Victoria.

Dairy Food Safety Victoria:

- Code of Practice for Dairy Food Safety
- Minimum requirements for farm food safety programs – Implementation guide
- Guidelines for Food Safety: Dairy Farms (Australian and New Zealand Dairy Authorities Committee).

Livestock management factsheets from Agriculture Victoria:

https://agriculture.vic.gov.au/livestock-and-animals

Using Recycled Water – a manual for the Pasture and Fodder Crop Industries (2008), published by Australian Government.

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Appendix 1: Water Balance Modelling

Modelling Approach

The standard approach to water balance modelling involves use of site-specific rainfall and evaporation data to calculate irrigation requirements based on crop factors. The model also calculates net evaporation from treatment and storage lagoons. It then finds a balance between the irrigation area and storage.

It is recommended that multiple years of climate data are modelled to better understand climate variability for the specific site, and to account for carry over in storage from one year to the next when conditions are wetter than average. The multiple years may be selected representative average, wet and dry years; or it could be a series of twenty years of historic climate data that includes a combination of average, wet and dry years.

Calculations

Water balance modelling uses a combination of calculations and requires iteration to solve the model and find an appropriate combination of storage and irrigation area.

The recycled water available is compared to the irrigation requirement at each timestep in the model. If the recycled water available exceeds the irrigation requirement, excess recycled water must be held in storage. Conversely, if the irrigation requirement exceeds the recycled water available, the storage can be drawn down or the irrigation application will need to be reduced.

Details are discussed in the table below based on the Pan evaporation[5] method.

Table A1-1: Water balance model calculations

Calculation	Notes and assumptions
Potential Evapotranspiration (mm) ET = PE x CF	Evapotranspiration (ET) is a combination of the amount of water used by plants and water evaporated from the surface. The main drivers of evapotranspiration are sunlight, wind, humidity and temperature. ET is determined by applying a crop factor (CF) to evaporation data measured from a Class A Pan (PE). Crop factors vary according to the crop selected and time within the growing season. They are determined based on trials and experience. Refer to the reference list below to obtain appropriate crop factors. Irrigation management can have a dramatic impact on plant growth and hence plant water use. The crop factor selected can be adjusted to include an allowance for the expected management standard. An allowance can also be made for irrigation efficiency. Although this is often already included in published crop factors.
Percolation (mm)	Percolation is the movement of water through the soil past the root zone. It is sometimes referred to as deep percolation or leaching. The rate of percolation through the soil is dependent on soil texture and permeability. Factoring in percolation via irrigation to the water balance modelling is not recommended. Modern efficient irrigation can occur with minimal percolation below

5 If an alternative measure of evaporation is used, the factors for conversion to evapotranspiration and storage evaporation will need to be adjusted. For example, Crop Coefficients (Kc) are used with Reference evapotranspiration (ETo), rather than Crop Factors.

Calculation	Notes and assumptions
	the plant root zone and generally percolation from natural rainfall is sufficient for salinity management.
Effective rainfall (mm) ER = RF x factor	Effective rainfall is the amount of rain that is available to the plant. It is the rainfall (RF) that remains in the root zone after evaporation, runoff and percolation. A factor of 0.7 is considered appropriate for water balance modelling. This is applied to measured rainfall data. This can be adjusted for site specific conditions. For example, in dry climates, the factor may be higher as percolation is reduced; or sloping sites may have more surface runoff so the factor could be lower.
Irrigation Requirement (mm) IR = ET – ER	The need for irrigation is determined by subtracting effective rainfall from evapotranspiration. If the answer is close to zero or a negative number, then irrigation is not needed for the time period assessed (that day/week/month).
Total Irrigation (ML)	The irrigation requirement can be converted from millimetres to megalitres per hectare as follows: 100 mm = 1 ML/ha This unit rate is then multiplied by the total irrigation area to determine total megalitres that can be irrigated.
Net Storage Evaporation (ML) = (PE x Kp – RF) x 0.01 x Surface Area	A lagoon pan factor (Kp) allows conversion of Class A Pan evaporation to storage evaporation. Evaporation from large lagoons (open storages) is usually less than pan evaporation, due to wind and wave action. The lagoon pan factor generally ranges from 0.7 to 0.9. Net evaporation is then determined by subtracting rainfall and multiplying by the storage surface area. The calculation assumes rainfall and evaporation data is in millimetres (mm). The 0.01 in the equation is a conversion to megalitres per hectare (ML/ha). This enables calculation of total net evaporation based on storage surface area in hectares. A negative result indicates rainfall is being captured by the storage, which increases the volume of water to be managed. In some cases, this can be influenced by the depth of lagoon and associated lagoon surface area, so lagoon depth and the impact on net storage evaporation should be considered throughout the water balance process. Where the treatment process includes open lagoons, the net evaporation can be included in this calculation by adding in their surface area.
Storage Seepage Loss = Surface Area x Seepage Rate	The seepage rate will be dependent on the storage lining. Storages using compacted clay liners must achieve a permeability of less than 1 x 10-9 metres per second.
Recycled Water Available	The volume of recycled water available for irrigation is determined by subtracting storage evaporation and seepage from the inflow to the system.

Calculation	Notes and assumptions
= Inflow – Net Storage Evaporation – Seepage Loss	
Need for Storage	The volume of storage needed is determined by comparing the recycled water available to the total irrigation volume. Storage is required if Recycled Water Available is greater than Total Irrigation. The cumulative impact from month to month is determined in the model. Iteration is required – the irrigation area can be increased or decreased in the model (subject to land area available) to assess the appropriate volume of storage to contain all recycled water flows.

Assumptions

Selecting the Right Combination of Irrigation and Storage

There are multiple combinations of irrigation area and storage that can create a water balance. The following diagram shows an example model output.

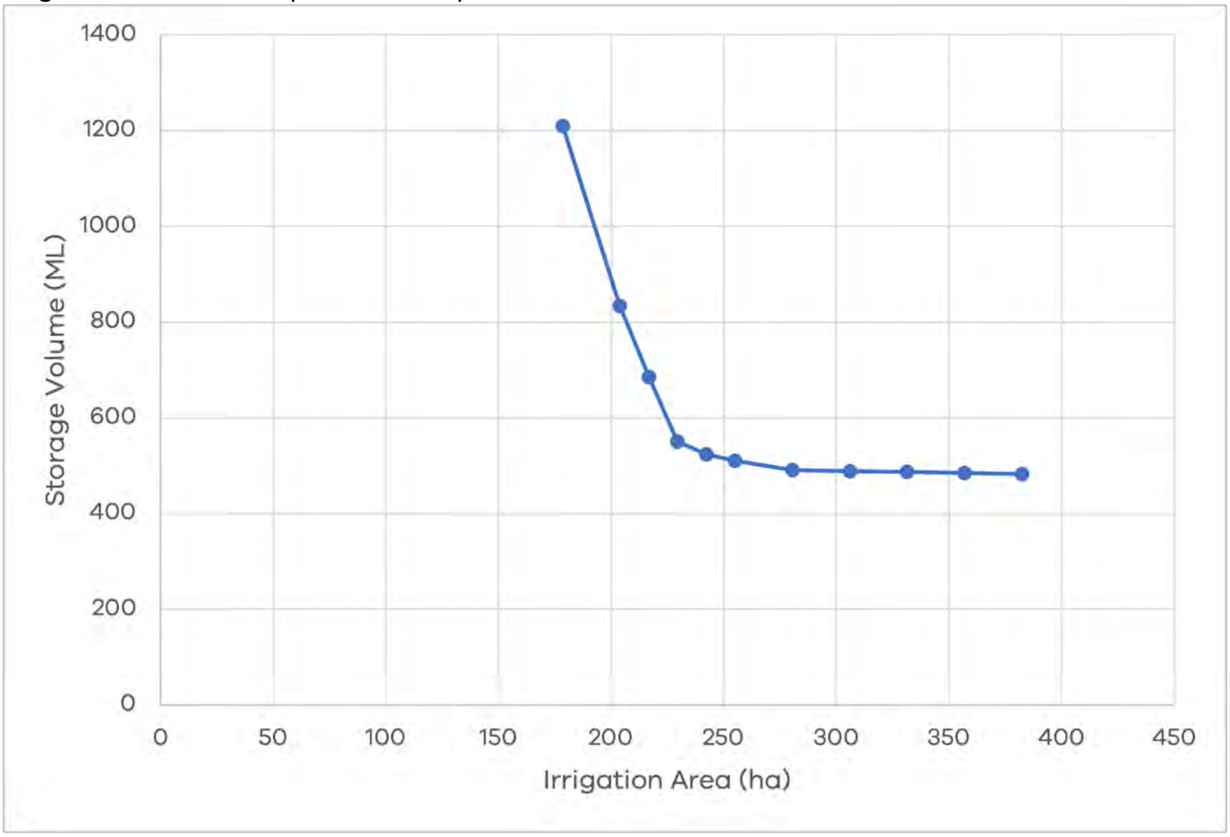

Figure A1-1: Water Balance Model – Example Output of Irrigation and Storage Combinations

The aim should be to develop a system that is in balance. In Figure A1-1, the ideal combination is at the point where the graphed line turns.

Excessive storage should be avoided as this can promote disposal by evaporation and result in increasing salinity levels in the recycled water.

Excessive irrigation area should also be avoided as this can lead to excessive under-irrigation such that crop death occurs.

Average Irrigation Applied

Recycled water irrigation generally involves designing for a wet year and often results in under-irrigation in other years. The amount of under-irrigation can be chosen by selecting different combinations of irrigation area/storage volume.

For pasture and tree crops it is recommended that, on average, application achieves 80% of total irrigation demand. Typically, this provides a good balance of irrigation area and storage volume, while also achieving reasonable crop production levels in most years.

Where high value crops are grown (e.g. horticulture) under-irrigation is not appropriate as this can dramatically impact produce quality and/or yield. Systems that include high value or sensitive crops need to have other contingencies in place to manage either the wet or dry year extremes. For wet years, this could include an area of pasture irrigation, additional storage or a licence for occasional discharge. For dry years, it could include a supplementary water supply such as surface water or groundwater.

Crop selection is therefore very important, and in some cases, it can be better to opt for a relatively straightforward crop type like pasture that can tolerate some variations in climate, as opposed to a higher value crop that is more sensitive.

Modelling Over Multiple Years

Modelling is typically undertaken on a daily or monthly timestep. It is recommended that a series of years of monthly/daily data are assessed. This:

- enables assessment of variations in seasonal rainfall distribution, so impacts of both wet and dry conditions can be considered
- allows for carryover of water in storage between irrigation seasons. If the volume of water in storage exceeds the irrigation demand, it is carried forward to the following irrigation season.
- negates the issue of splitting or cutting off either the irrigation season or an extended wet weather period. In Victoria, the irrigation season typically runs over the summer period, and therefore use of one calendar year is inappropriate as there is not a full irrigation season considered. Similarly, use of a financial year, may not enable consideration of storage build-up across the full winter to spring period when wet weather is typical in many locations.

Data Inputs

Water balance modelling relies on quality climate data, which is available from the Bureau of Meteorology and databases such as SILO, which is hosted by the Queensland Department of Environment and Science.

The data site selected should be close to the treatment and reuse location, so that it is representative of local conditions. If multiple locations apply for a system, the model should take a conservative approach and select the climate data for the “wetter” location. Monitoring can occur onsite, although care needs to be taken to ensure this data is accurate.

The climate period modelled should include a combination of wet and dry years, including extremes. This can be assessed through consideration of the historical climate record.

Note:

- A 90th percentile period is wetter than 90% of past rainfall totals for that same period. Typically, the period considered is a year. So, a 90th percentile year is a one-in-ten-year high rainfall outcome.

- By contrast, a very dry year is the 10th percentile year, where historically nine years out of ten would be wetter.
- Care needs to be taken when switching between monthly/daily data and annual historic averages/ranges. Taking the 90th percentile for each month and adding them together creates an unrealistically high annual total, as we do not experience 12 extreme wet months in a row.

Calibration

An important part of any water balance modelling is to calibrate the model to ensure that the predicted results make sense and are reflective of what may be expected for the study location. To assist with this, a series of contour maps have been developed (refer to Figures A1-2 and A1-3) that provide "rules of thumb" on evaporation rates, irrigation demand and storage requirements. These maps provide a useful 'sanity check' on the detailed modelling.

Design vs Operation

The theory and formulas used are the same for both planning/design and day-to-day operation modelling. The differences between the two are:

- Operational modelling is a monitoring tool that is updated or checked on a regular basis with inputs from actual data collected for the site/s. It is used to understand how the system is tracking and whether immediate action is needed to, for example, prevent an offsite discharge. It is about managing the current infrastructure.
- Modelling for planning or design is undertaken less frequently, either when a site is being established/upgraded, or when there is a significant change to recycled water inflows. It is focussed on determining the infrastructure required for sustainable reuse.

Alternative Methods

Alternative methods for water balance modelling may be used provided they result in equivalent or better environmental risk management and factors of safety as those outlined here. Proponents should consult with EPA if they are considering using a water balance model that varies significantly from the method described here, or that is not widely used by irrigation practitioners.

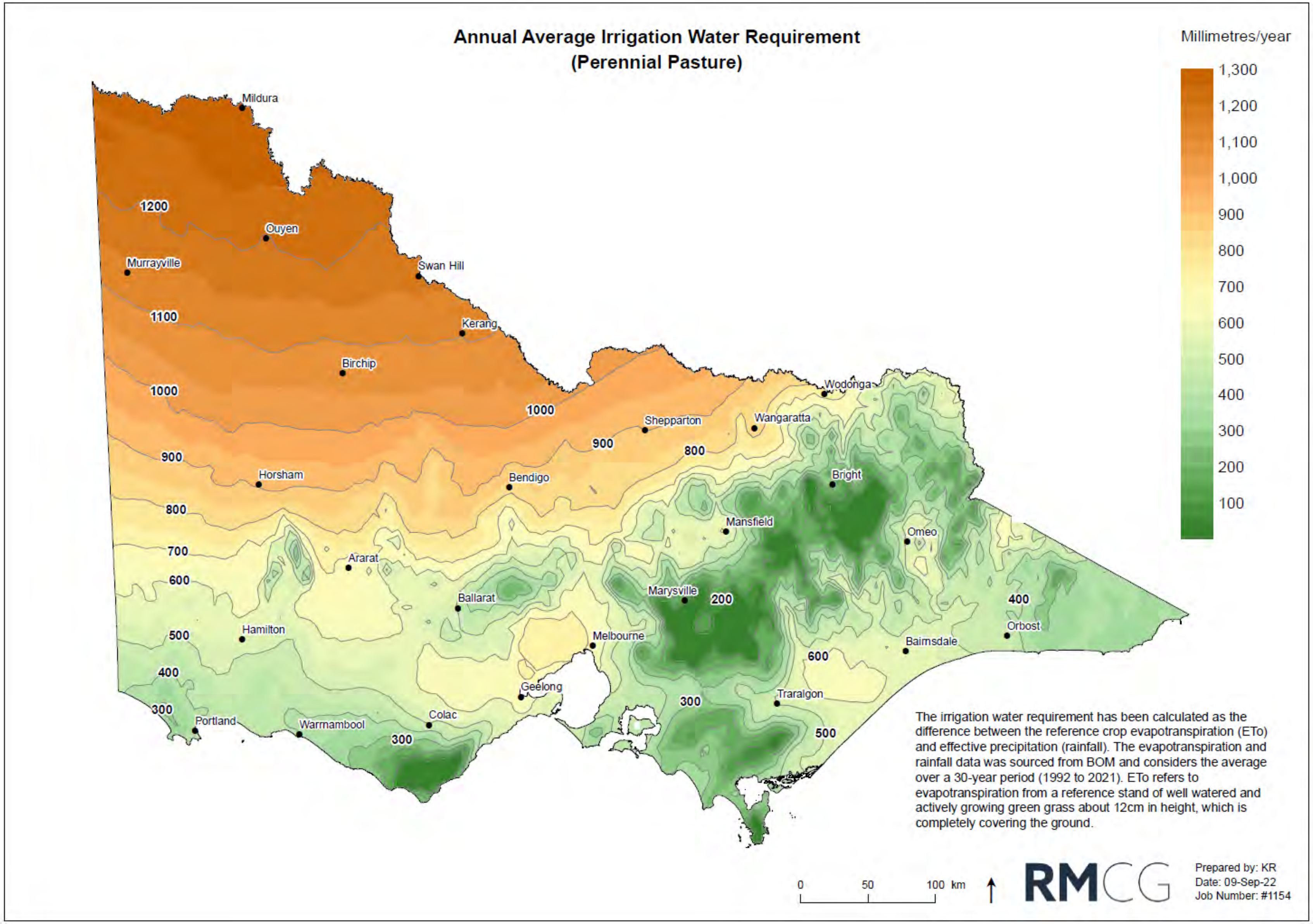

Figure A1-2: Estimated annual average irrigation requirement (Perennial Pasture)

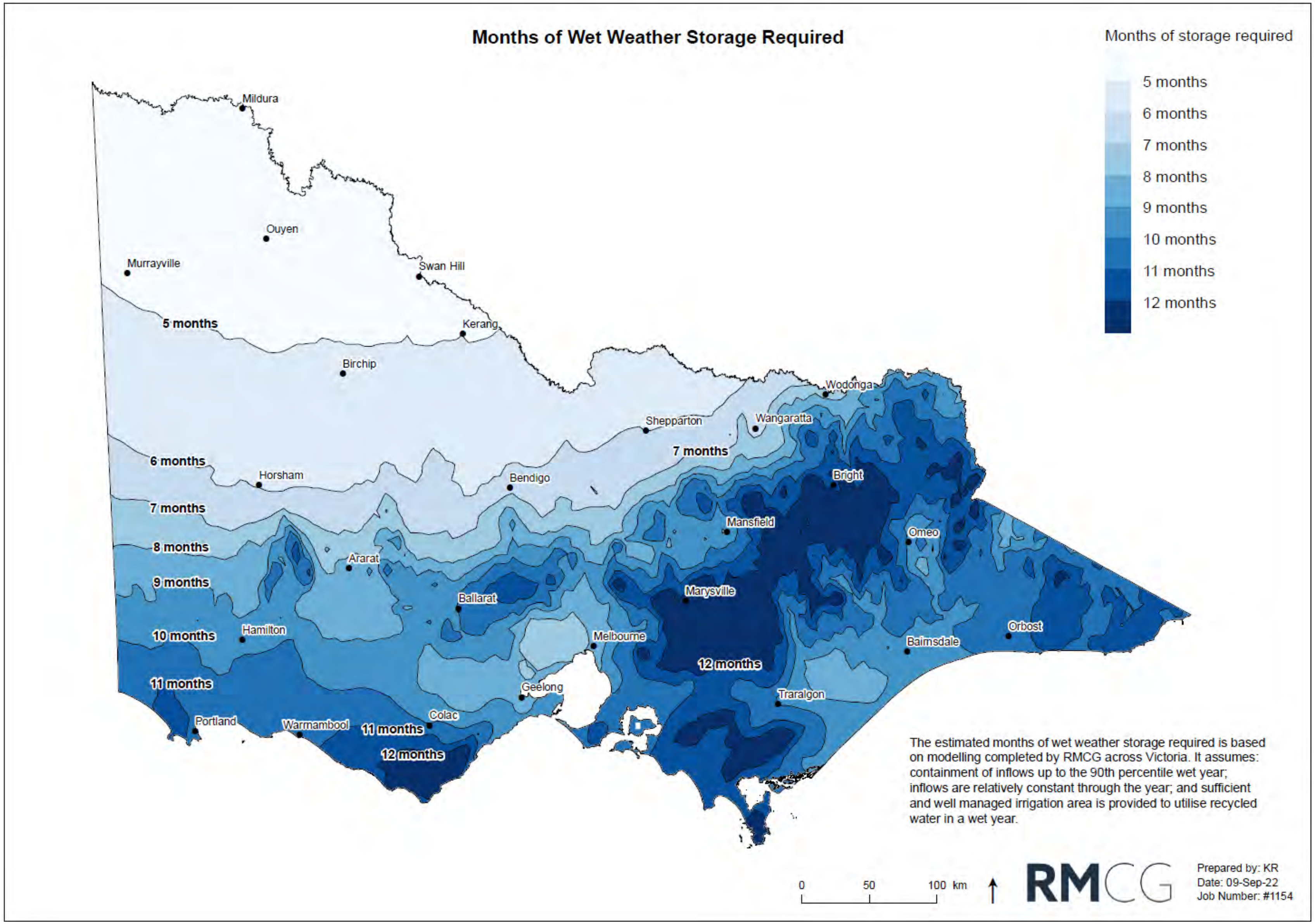

Figure A1-3: Months of Winter Storage Required

Appendix 2: Irrigation Method Selection

Table A2-1: Irrigation Methods

Irrigation Method	Suitable Slope (%)	Suitable Crops	Indicative Buffer Distances[6]	Special Conditions	Typical Cost	Ease of Management
Gravity						
Surface Irrigation (flood, border check)	0.1–2.0 (uniform)	Pasture, fodder, annual crops, trees	Surface waters, Class C >100 m No spray drift	Not suitable on porous sands Irrigation always occurs to saturation Higher risk of over irrigation Tailwater reuse system required	Low to moderate	Labour intensive Basic skills required Low energy inputs (minimal pumping required)
Pressure – Fixed						
Large nozzle sprinkler	0.1–10 (undulating)	Pasture, fodder, crops	Surface waters, Class C >100 m high pressure >50 m low pressure Spray drift to sensitive receptor Class A 0 m Class B >50 m Class C >100 m	Stock can damage Can require filtration system	High	Low labour Basic skills required Moderate to high energy inputs
Mini sprinkler	0.1–10 (undulating)	Trees, vegetables	Surface waters, Class C >50 m Spray drift to sensitive receptor Class A 0 m Class B >50 m Class C >100 m	High maintenance Can require filtration system If used on tree crops and spray does not reach produce Class B and C recycled water can be used for raw food crops	High	Moderate labour Moderate to high skills required Moderate to high energy inputs

[6] Minimum recommended buffer distances to waterways and sensitive receptors (e.g. houses, schools) are detailed in EPA Publication 1910. While there is no buffer distance to sensitive receptors for Class A recycled water, spray drift from Class A recycled water irrigation schemes should not cross the boundary of the site (i.e. consider impacts of wind).

Irrigation Method	Suitable Slope (%)	Suitable Crops	Indicative Buffer Distances[6]	Special Conditions	Typical Cost	Ease of Management
Drip	0.1–10 (undulating)	Trees, vegetables, pasture, fodder, crops	Surface waters, Class C >30 m No spray drift	High maintenance Requires filtration system Requires certain soil to be successful Raw food crops where produce is above ground can be irrigated with Class B and C recycled water	Moderate to high	Low labour High skills required Moderate energy inputs
Long laterals (Van-den-Bosch / hand-move sprinklers)	0.1–10 (undulating)	Pasture, fodder, crops	Surface waters, Class C >100 m Spray drift to sensitive receptor Class A 0 m Class B >50 m Class C >100 m	High risk of poor uniformity Only suited to smaller irrigation areas (< 20 ha)	Low to moderate	Extremely labour intensive Basic skills required Moderate to high energy inputs
Pressure – Travelling						
Big gun	0.1–10 (undulating)	Pasture, fodder, crops	Surface waters, Class C >100 m Spray drift to sensitive receptor Class A 0 m Class B >50 m Class C >100 m	High risk of poor uniformity as susceptible to wind distortion	Low to moderate	Labour intensive Basic skills required High energy inputs
Centre pivot or linear move	0.1–5.0 (uniform)	Pasture, fodder, crops, vegetables	Surface waters, Class C >50 m Spray drift sensitive receptor: Class A 0 m Class B >50 m Class C >100 m	Centre-pivot is not efficient use of land, as irrigates circles leaving corners of blocks/ paddocks dry Linear move needs large rectangular areas	Low to moderate	Low labour Moderate skills required Moderate to high energy inputs

Appendix 3: Assessing Soil Phosphorus Risk – Alternative Methods

Section 6.2 outlines a soil phosphorus risk assessment approach based on Olsen P (one of the most used soil phosphorus extraction methods in Victoria) and the Mehlich 3 Phosphorus Saturation Ratio (which has been specifically designed for environmental management).

Here alternative methods are considered.

Colwell P

Colwell P is a commonly used soil extraction method in Australia.

For Colwell P, the critical soil test value changes with soil texture. Combining Colwell P with the Phosphorus Buffering Index (see below), allows modification of nutrient applications according to soil texture. Refer to Table A3-3 below for critical Colwell P values based on varying PBI levels.

Soil test results that indicate Colwell P values that exceed the critical value, would be considered as potential for high risk of harm to the environment.

Note that soils high in free lime (calcareous soils pH >7) generally "lock up" most of the soil phosphorus and this reduces the accuracy of the Colwell P test.

Phosphorus Buffering Index (PBI)

The PBI is a measure of the soil's capacity to hold on to, or release, phosphorus and is closely related to soil texture. Light textured soils such as sands tend to have a relatively low PBI, whereas heavy soils such as clays have higher PBI values.

In a practical sense, a high PBI soil will have a higher critical soil test value, compared to a low PBI soil, to achieve production potential and determine risk to environmental values.

Table A3-1: PBI and relationship with critical Colwell P

PBI	Rate of P-fixing ability	Critical Colwell P value (temperate pasture)
< 15	Extremely Low	16
15 – 35	Very very low	22
36 – 70	Very Low	27
71 – 140	Low	32
141 – 280	Moderate	39
281 – 840	High	43
>840	Very High	n/a

Phosphorus Environmental Risk Index (PERI)

The PERI is a calculation that provides some indication of the potential for phosphorus to move through the soil with water. It is calculated from the available Colwell P and the Phosphorus Buffer Index (PBI). As the available P to PBI ratio rises, the probability that the P buffer capacity of the soil is exceeded and leaching occurs, increases. Once a critical value of 2 is exceeded the risk of movement of P in the soil increases.

Validation of the PERI is still in progress but sufficiently advanced to provide confidence that it will provide worthwhile comment to defining the line between sufficient phosphorus for high productivity and where environmental risk increases.

Phosphorus Site Index

While environmental soil limits are useful in identifying potential problems, a more comprehensive approach, e.g., using a phosphorus site index, will be more accurate at identifying the relative risk of phosphorus losses than soil phosphorus testing, including M3-PSR and PBI indicators, alone.

Appendix 4: Salt balance modelling

STEP 1 – DETERMINE EQUILIBRIUM SOIL SALINITY

Alternative (a):

From FAO Irrigation and Drainage Paper 29 "Water Quality for Agriculture":

$$LR = ECw / (5\ ECe - ECw)$$

Where:

- LR is leaching rate – Use on-site soil observations to estimate leaching rate (see note below)
- ECw is salinity of the applied irrigation water (diluted for rainfall) – use recycled water salinity plus local climate information (to understand rainfall received and crop demand for irrigation) to estimate ECw
- ECe is soil salinity.

Note that if recycled water salinity seems unacceptably high, it may be worth checking for presence of organic salts, since this could mean effective salinity can be reduced.

In practice, this method is generally best, since the data requirements are not as great as for Alternative (b).

A common mistake with this method is to ignore rainfall, and therefore come to an unnecessarily conservative conclusion.

It should be noted that there will be some time lag before a soil reaches the equilibrium salinity level modelled. Generally, this would occur over a couple of irrigation seasons.

Alternative (b):

Use a computer program to model the equilibrium soil salinity in each layer of the soil profile. An example is the "Watsuit" model (described in FAO Irrigation and Drainage Paper 48).

This method can provide an advantage if good quality data is available, including concentrations of all individual ions (the program requires data for Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO^-, $CaCO_3$).

STEP 2 – COMPARE CALCULATED SOIL SALINITY TO CROP TOLERANCE

A list of crops and their relative salt tolerance can be found in the Australian Guidelines for Water Recycling. Refer to Appendix 5, Section A5.6.

Relationship between soil class and irrigation rate.

The leaching rate that can be achieved for a particular soil is site specific. However, the following provides a guide.

The maximum feasible leaching fractions for each soil class (see Appendix 5) are estimated at:

>20% for Class I soils,

12 to 20% for Class II soils,

8-12% for Class III soils (and artificially drained Class IV),

6-8% for Class IV soils,

5-6% for Class V soils

<5% for Class VI soils.

In general, there is little opportunity to manipulate leaching rates. For a given soil type, assuming that the optimum irrigation method is in place and an appropriate enterprise has been chosen, then irrigation should be undertaken with the purpose of achieving maximum productivity, and this will determine the leaching rate that occurs.

Therefore, it is generally not feasible to impose a set leaching rate for the purpose of maintaining a desired soil salinity. Application of ‘‘leaching irrigations” will usually lead to:

- accessions to the water table, if the soil is permeable (Class I or II soils)
- waterlogging, if the soil is impermeable (Class III or IV soils).

An exception to this is where reduced deficit irrigation is being practiced, in which case it may be necessary to pay attention to leaching. Reduced deficit irrigation is the practice of under-irrigating crops such as wine grapes to force the plant to develop in a certain manner.

Appendix 5: Soil Classes

Table A5-1: Soil Classes and Crops that can be Grown

Class	Suitability for agriculture	Crops that can be grown	Depth of a horizon (cm)	Texture of a horizon	Texture of b horizon	Texture of c horizon	Depth to lime (cm)
I	Excellent productivity	All fruits, olives, grapes, nuts, vegetable, tomatoes, lucerne, row crops, fodder crops, field crops, pastures and forest trees	> 25	Fine sandy loam & lighter	Light clay & lighter	Clay loam & lighter	> 60
II	Very good for most agriculture	All fruits (except citrus, early peaches, cherries), grapes, olives, most nuts, most vegetables, tomatoes, lucerne, row crops, fodder crops, field crops, pastures, and forest trees	17-25	Sandy loam Fine sandy loam Loam	Light clay Medium clay	Clay loam Sandy clay Sandy clay loam Sandy loam	45-60
III	Good for a range of agriculture	Apricots, apples, pears, plums, olives, grapes, some vegetables, row crops, fodder crops, field crops, pastures and forest trees Fair soils for tomatoes and lucerne	11-16	Loam	Medium clay Heavy clay	Light clay Medium clay	30-45
IV	Fair for a limited range of agriculture	Row crops, fodder crops, pastures and forest trees Fair soils for pears, plums, olives and grapes	7-10	Loam Clay loam Sandy clay	Medium clay Heavy clay	Light clay Medium clay	15-30

Class	Suitability for agriculture	Crops that can be grown	Depth of a horizon (cm)	Texture of a horizon	Texture of b horizon	Texture of c horizon	Depth to lime (cm)
V	Low yields: pastures and some crops only	Field crops, fodder crops, pastures and forest trees; only if well drained	5-6	Clay loam Clay	Heavy clay	Medium clay Heavy clay	6-15
VI	Unsuitable for agriculture	Unsuitable for irrigation	<5	Clay	Heavy clay	Heavy clay	<6

Source: A Soil Survey Method for Productivity in Agriculture (Bruce Cockroft, Soil Surveying in Agriculture: Current Practices and Future Directions Symposium Proceedings 3 October, 2003 DPI Tatura).

Appendix 6: Soil Sampling Method

Background

Soil properties are inherently highly variable in space and time, so correct sampling procedures are crucial to provide samples for analysis that are representative of the sample area. The use of correct sample protocols will help to ensure that detrimental changes in the soil environment are identified at an early stage, thus minimising, or preventing effects on vegetation, surface water and groundwater.

A consistent approach to soil sampling is required to ensure repeatability in data and allow for meaningful interpretation of test results (particularly trends over time).

Soils are to be sampled by driving a sampling tube (soil corer – see image below) into the soil and extracting a soil core. A large number of these sub-sample cores from within the sample area are combined into a representative composite sample. The more sub-samples that are combined, the more representative the final composite sample will be and the better the advice given.

Note: composite sampling will in most cases be suitable for recycled water irrigation schemes. However, if soil sampling is being undertaken to monitor for contaminants (see Section 6.4) then composite sampling may not be appropriate. In these instances, Australian Standard 4482.1 *Guide to the investigation and sampling of sites with potentially contaminated soil - Part 1: non-volatile and semi-volatile compounds* (AS 4482.1) should be referred to and, where required, followed.

Number and depth of samples

For topsoils:

- One composite sample for every 20 ha of irrigated area is to be collected, or a minimum of 2 composite samples if a site is <20 ha
- Sub-samples are to be collected to a depth of 100 mm (see Figure A4-1). This corresponds to the depth in which most root growth occurs, therefore providing useful data for determining crop performance.
- Each topsoil composite sample should comprise at least 20 sub-samples of topsoil, which should be collected across the irrigation area selected for sampling.

For subsoils:

- One composite sample for every 20 ha of irrigated area is to be collected, or a minimum of 2 composite samples for sites <20 ha.
- Ideally, the top 100 mm of the b-horizon (often a clay layer beneath the topsoil, Figure A4-1) will be collected for subsoil analysis. Where the b-horizon is not distinguishable, sub-samples should be collected at a nominal depth of approximately 300–400 mm. Analysis of soils from this underlying lithology will provide useful information regarding the leaching characteristics of the topsoil.
- Each subsoil composite sample should comprise at least 5 sub-samples of subsoil (the more the better), which should be collected across the irrigation area selected for sampling.

Transects and representative location sampling

Soil sampling is typically completed by collecting the samples along a transect (see A6-2). Transects provide an ‘average’ result across the area sampled and can be particularly useful for agronomic and horticultural (including amenity horticulture) production as they can help inform management practices necessary to maximise production across the sampled area (e.g. fertilisers or soil ameliorants that need to be applied across the paddock to maximise crop growth).

However, for some recycled water irrigation schemes, soil sampling also needs to be undertaken to monitor for changes in soil chemistry due to recycled water irrigation. In these instances, it can be useful to select a representative sample location(s) and collect the sub-samples from a circle (~3m radius) around the location and not along a transect. This allows sampling to be completed in this exact location each year, and potential changes in soil chemistry monitored over time.

For most recycled water irrigation schemes, it will be useful to undertake both transect and representative location sampling (sometimes known as 'environmental sampling') as the combination of the results can be used to help ensure the scheme maximises plant/crop growth, but is also applying nutrients and salts etc. in a sustainable manner.

For both forms of sampling, the process should involve

- Sampling locations, either transects of representative sites, should be recorded using GPS for future reference and repeat sampling
- Sub-samples should be spaced evenly along the transect or around the representative location (e.g. one sample every ten steps for transects and every 30cm for representative sites)
- Care should be taken to avoid sampling areas that are not representative of the area being tested. These may include gateways, obvious manure and urine patches, channel banks, water troughs, stock tracks, walkways, vehicle/cart paths (golf courses), stock camps etc. and within 10m of fence lines.

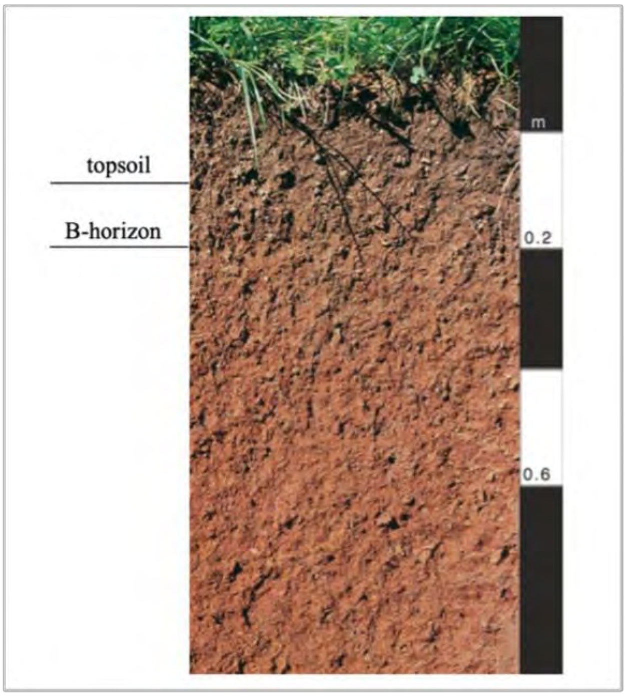

Figure A6-1: CROSS SECTION VIEW: sample soil profile showing horizons and areas for sampling

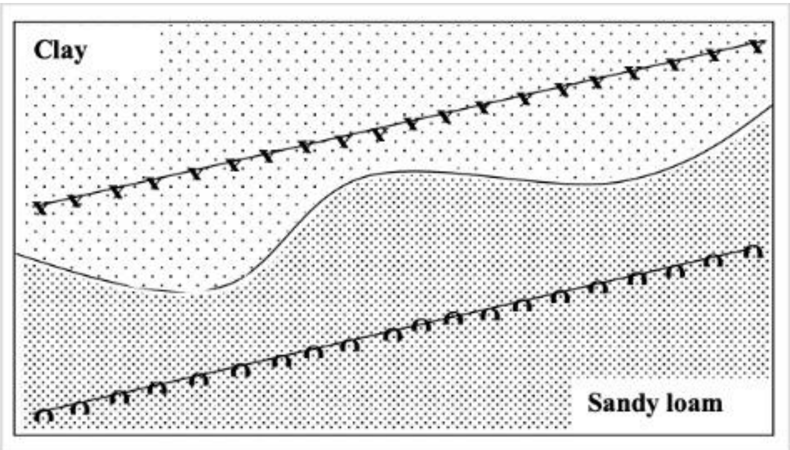

Figure A6-2: PLAN VIEW: sample paddock with two different soil types and transects showing locations of topsoil sub-samples

Sample Composition

- The sub-samples should be combined and thoroughly mixed and then a representative composite sample selected from this mixture
- The sampler should ensure that the sample collected is not saturated (i.e. sloppy) as the analytical results can be skewed if this is the case
- A sample of approximately 500 grams is sufficient for laboratory analysis.

Equipment

- A small auger or corer (see Figure A6-3) can be used to ensure minimal damage to pastures/crop/turf
- The corer should be cleaned of soil when moving between composite sample locations (note: this is not between sub-samples, but composite sample locations such as the different soil types shown in Figure A4-2).
- Clean bucket for mixing sub-samples and drawing a representative sample from. The bucket should be wiped clean between sub-samples
- Sample bags – often they will be provided by the laboratory used to undertake the analysis, or a sandwich (snap-lock) bag appropriately labelled with a permanent marker
- GPS for recording the sample transects or location
- Notepad to record weather conditions or other points of interest (e.g. paddock was recently grazed).

Figure A6-3: Soil Auger/Corer

Timing

- Soil sampling should be undertaken annually during the non-irrigation (winter) period (i.e. June or July). This will give a better indication of the average soil salinity as some leaching by rainfall will have occurred.
- Samples should not be collected when the soil is wet (saturated) or within 4-weeks of fertiliser, soil ameliorant, manure or compost applications.

Soil analytical suite

Soil samples should be tested for an analytical suite such as that provided in Table A6-1 below. This covers a range of both agronomic and environmental parameters to help understand likely impact of soil health on both crop health and the receiving environment (e.g. groundwater).

Table A6-1: Soil analytical suite

Soil analytical suite	
pH CaCl2 Water	Electronic Conductivity (EC) EC1:5 ECe (saturated extract)
Total Nitrogen (N)	Organic Carbon (OC)
Nitrate (NO3)	Available Potassium
Olsen Phosphorus (P) (or equivalent alternative selected)	Chloride (Cl)
Mehlich 3 Phosphorus (M3-P)	Cation Exchange Capacity (CEC)*
Mehlich 3 - Phosphorus Saturation Ratio (M3-PSR)	Calcium/Magnesium Ratio*
Exchangeable Calcium (Ca)	Exchangeable Sodium Percentage (ESP%)*
Exchangeable Magnesium (Mg)	Clay dispersion (Emerson)**
Exchangeable Sodium (Na)	Soil Texture***
Exchangeable Potassium (K)	

* Can be calculated outside of the laboratory.

** Only required when ESP >10%.

*** Only required at start up phase.

The properties of the recycled water, and the characteristics of the soil should 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 sampled in the soil in addition to the list above.

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.

Appendix 7: Further information on the Aboriginal Heritage Act 2006 (Vic) and the Aboriginal Heritage Regulations 2018 (Vic)

Applications for statutory approvals relating to Aboriginal cultural heritage may be made to the following organisations, where relevant:

- Registered Aboriginal Parties (RAP)
- The Secretary, Department of Premier and Cabinet, via First Peoples – State Relations Group, in areas where RAPs have yet to be appointed
- Victorian Aboriginal Heritage Council (where the RAP is the Sponsor of works).

Significant penalties may apply under the *Aboriginal Heritage Act 2006* (Vic) (AHA) if Aboriginal cultural heritage is harmed without statutory authorisation.

The following are references to, or brief overviews of, legislation pertaining to Aboriginal cultural heritage, that proponents should consider, and they should also consider their own investigations to ensure that cultural heritage and Traditional Owner values are being appropriately assessed and managed.

The *Aboriginal Heritage Act 2006* (Vic) and the *Aboriginal Heritage Regulations 2018* (Vic) (AHR) provide for the protection of tangible and/or intangible Aboriginal cultural heritage in Victoria. Authorised Officers and Aboriginal Heritage Officers have powers under the Act to prevent and investigate harm to Aboriginal cultural heritage.

A Cultural Heritage Management Plan (CHMP) is required when a listed 'high impact' activity is proposed in an area of Cultural Heritage Sensitivity. Both high impact activities and areas of Cultural Heritage Sensitivity are defined in the AHR. Areas of Cultural Heritage Sensitivity include land within 200 metres of named waterways, the coastline and certain lakes, and land within 50 metres of registered Aboriginal cultural heritage places listed on the Victorian Aboriginal Heritage Register. They also include certain landforms, watercourses, lakes, marine edges, caves, volcanic cones, Ramsar areas, lunettes and soil types where Aboriginal places are more likely to be located. Indicative areas of Cultural Heritage Sensitivity are mapped on the Aboriginal Cultural Heritage Register and Information System mapping tool on the Aboriginal Victoria website (https://achris.vic.gov.au/#/onlinemap).

High impact activities include those that cause significant ground disturbance such as utility installations, certain subdivisions of land, road construction, and the construction of dams.

All Aboriginal Cultural Heritage is protected, regardless of whether it is registered on the VAHR or not. Aboriginal places include tangible heritage such as artefact sites, middens, Ancestral burial sites, scarred trees (dead or living), and intangible heritage such as visual and trade corridors, and songlines. If a mandatory CHMP is not required, another form of statutory approval (usually a Cultural Heritage Permit – CHP) is required if an Aboriginal place is, or is likely to be, harmed by an activity. Harm can occur to Aboriginal cultural heritage through ground disturbance, groundwater and/or surface water regime changes and visual connectivity obstructions. In all instances, the proponent should consult a suitably qualified Heritage Advisor as to any provisions and places under the AHA and AHR, and whether a CHMP or CHP is required.

Risk Assessment

Table A7-1: Examples of risk assessment – cultural heritage

Lower risks	Higher risks
No Aboriginal cultural heritage listed on Victorian Aboriginal Heritage Register Site not within an Area of Cultural Heritage Sensitivity	Site contains tangible Aboriginal cultural heritage place/s Site contains or is traversed by intangible Aboriginal cultural heritage places Site or part of site is within an Area of Cultural Heritage Sensitivity Site is within 200 metres of named waterway Land is within 50 metres of registered Aboriginal cultural heritage places Land is largely undisturbed by effects of recent settlement

This table contains examples of cultural sensitivity, however, this is not an exhaustive list and other such areas exist.

Management controls

Identifying and managing possible Aboriginal living cultural heritage sites

The Victorian Aboriginal Heritage Register records details about Aboriginal places, objects, and Aboriginal intangible heritage. The Register is available online but is not publicly accessible given it features culturally sensitive information. However, First Peoples - State Relations staff can assist in accessing the Register, in line with s.146 of AHA.

Develop a Cultural Heritage Management Plan (CHMP)

Development of a CHMP may be required when works are planned. Certain minor works that do not cause significant ground disturbance, such as fencing, maintenance of existing farm tracks, soil cultivation and recycled water irrigation, are likely to be exempt from a mandatory CHMP but may require a Cultural Heritage Permit (CHP) if an Aboriginal place or cultural heritage will be impacted (harmed).

However, where a 'high impact activity '(as defined in the AHR) is proposed in an area of Cultural Heritage Sensitivity, a CHMP must be prepared prior to the activity, unless Significant Ground Disturbance, as defined in AHR, can be demonstrated. The AHA may require a CHMP in other circumstances as well.

A CHMP must assess the nature of any Aboriginal cultural heritage present in the area and set out the conditions to be complied with before, during and after the activity, to protect that Aboriginal cultural heritage. The sponsor of the CHMP (the proponent of the activity) must engage a Heritage Advisor to assist in preparing a CHMP and must ensure that it is prepared in accordance with applicable standards and the AHR. A CHMP must be approved by the relevant RAP or the Secretary to the Department of Premier and Cabinet.

Even if the proposed works do not require a CHMP, a voluntary CHMP may still be prepared, for example, to reduce delays if an Aboriginal place or object is uncovered. Alternatively, a Preliminary Aboriginal Heritage Test (PAHT) can be prepared if there is uncertainty regarding the requirements of the AHA and AHAR to assist in determining whether a CHMP is required for a proposed activity. A person/organisation proposing the activity can prepare the PAHT but may need to engage a Heritage Advisor who can access the Victorian Aboriginal Heritage Register for this purpose.

Engaging a Heritage Advisor may assist in managing any potential risk of harm to Aboriginal cultural heritage through development activity.

Apply for a Cultural Heritage Permit (CHP)

A CHP is required by any person planning to:

- Disturb or excavate land to uncover or discover Aboriginal cultural heritage
- Carry out research on an Aboriginal place
- Carry out an activity that will, or is likely to, harm Aboriginal cultural heritage
- Rehabilitate land at an Aboriginal place
- Inter Aboriginal Ancestral Remains at an Aboriginal place
- Sell an Aboriginal object
- Remove an Aboriginal cultural heritage object from Victoria.

A CHP is required for these activities even if a CHMP is not required.

Applications for CHPs must be made to the relevant RAP. If there is no relevant RAP, the application must be made to the Secretary to the Department of Premier and Cabinet.

Monitoring and Review

It is essential to monitor the implementation of, and compliance with, any required CHMP or CHP.

Accessibility

Contact us if you need this information in an accessible format such as large print or audio.
Please telephone **1300 372 842** or email **contact@epa.vic.gov.au**

Interpreter assistance

Interpreter

If you need interpreter assistance or want this document translated, please call 131 450 and advise your preferred language. If you are deaf, or have a hearing or speech impairment, contact us through the **National Relay Service**

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