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Recycled Water

A Manual for the Pasture and Fodder Crop Industries

Australian Government

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Summary

Prolonged drought, along with a growing population and projected global warming effects are driving a focus on more efficient management of water in Australia. As the major user of water, the agriculture sector is currently considering alternative sources such as recycled water.

Recycled water provides an opportunity for the pasture and fodder crop industries by supplying a secure and reliable water source with high levels of nitrogen and phosphorus contributing to plant growth.

This manual is designed predominantly to assist landholders in managing recycled water for irrigation. It will also be of use to industry groups, water authorities and others involved in irrigation and recycled water schemes.

Information is provided on how recycled water can be safely used including; how a scheme can be started, what needs to be considered when using recycled water, some case studies describing some of the key issues and information sources.

1. Introduction

This manual is designed predominantly to assist landholders in managing recycled water for irrigation. It will also be of use to industry groups, water authorities and others involved in irrigation and recycled water schemes.

Since the quality of recycled water often differs from other water sources, some crop management practices may need to be altered. There may also be a need to meet additional regulatory and/or Quality Assurance (QA) scheme requirements.

This manual provides:

- Background information on recycled water including treatment processes and application in an agricultural context (section 1)
- Information on how to access recycled water (section 2)
- Description of the key issues to consider when using recycled water for pastures and crops including checklists and case studies (section 3) and
- Key terminology and information resources (sections 4 and 5)

1.1 Why a Manual for Recycled Water?

Using recycled water provides an opportunity for irrigators in the pasture and fodder crop industries.

While getting and using recycled water may appear daunting to an individual, this manual will help identify what needs to be done and who takes care of different parts of a recycled water scheme.

The manual is designed as a "how to" guide and will direct you to relevant regulation and information. An irrigator should be able to minimise the risks of using recycled water provided that the steps in this manual are followed.

1.2 What is Recycled Water?

Recycled water is water that has been used, captured and used again. There are other terms that are frequently used with slightly different meaning including:

- Water reclamation;
- Water recycling;
- Water reuse;
- Wastewater;
- Sewage effluent;
- Reclaimed water; and
- Treated and untreated grey water.

More detail on what these terms mean is provided in section 4.

The different sources of recycled water and suitable uses are listed in Table 1.

Table 1. Typical sources and uses of recycled water

Sources	Uses
Bathroom and laundry effluents (grey water)	Irrigation (pasture, field crops, horticulture)
Domestic sewage stream (black water)	Industrial processing
Municipal wastewater (grey and black water)	Residential housing (toilet flushing and gardens)
Agricultural and industrial wastewater	Public and recreation spaces
Stormwater	

Treatment is usually required before use. The level of treatment required is so that the water is 'fit-for-purpose' (i.e. the quality of water is appropriate for the intended use, refer to section 3.3.3).

1.3 Recycled Water for Irrigation

There are a number of sources of recycled water. The source determines the contaminants (e.g. salts, nutrients, toxicants) in the irrigation water and will influence the key risks that are present and the appropriate management practices.

Three major sources of water that may be considered when recycling are:

1. Dairy effluent – water derived from washdown areas (e.g. milking shed, feedpad, barns) and collected for irrigation purposes on the farm where it was generated.

2. Food processing wastewater – excess water used in the operation of a factory for cleaning and the processing of food products. This water is collected and distributed to irrigators.

3. Treated effluent – sewage water that is treated at a Waste Water Treatment Plant (WWTP) and distributed to irrigators.

In some cases, the recycled water (be it dairy effluent, industrial waste water or treated effluent) is shandied with higher quality irrigation water so as to achieve sustainable agronomic and environmental outcomes (refer to section 3.5.6 for more detail).

While the principles described in this manual are applicable to all water sources, the information focuses on water for irrigation that is derived from treated effluent and food processing wastewater.

Specific information relating to dairy effluent management can be found in the Victorian Department of Primary Industries publication Victorian Guidelines: Management of Dairy Effluent (DPI, 2008).

Recycled water is treated to different degrees according to the level which is fit for the intended purpose. The levels are defined in classes of quality.

The classes of water relate only to the microbiological quality of the water (i.e. the number of pathogens, viruses and protozoa in the recycled water). It is possible for two different classes of water (e.g. Class A and Class C) to have the same salinity and nutrient concentrations. Likewise, it is possible for a better class of water, say Class A, to have higher salinity or nutrient concentration than a lower class, Class C.

It is important to fully define the quality of recycled water prior to irrigation, so as to determine the management practices required to facilitate safe, profitable and sustainable use. It cannot be assumed that Class A water is an 'overall' better quality of water (i.e. not just microbiological parameters) than a lower class.

The four classes of recycled water are as follows:

Class A

Usually the best quality recycled water and must meet with stringent microbial health standards before it is fit for the purpose of irrigating all crops, including fresh vegetables (Queensland uses Class A+ which is equivalent to Class A in all other states). It is generally produced using tertiary and/or advanced treatment processes and includes an advanced disinfection process.

Class B, C, D

These are of increasingly lower microbiological quality, and have restrictions placed on them for health reasons. For example crops that can be grown (fresh produce versus peeled or processed); extent of human contact; and method of irrigation (spray versus subsurface drip).

The treatment processes are carefully controlled and monitored using food safety systems ensuring consistent water quality and compliance with State, Territory and Commonwealth guidelines (see section 5).

1.4 Recycled Water Uses

This manual focuses on the use of recycled water for pastures and crops. The utilisation of the pastures and crops (direct grazing or fodder production) is also important when undertaking risk assessment and considering management changes.

This manual focuses on all these end use possibilities.

	Pastures	Crops
Direct Grazing	Grazed in the paddock by livestock - sheep, cattle (beef and dairy), and other species	Crops are directly grazed
Fodder Production	Pasture is cut and removed - fed as silage or hay	Crop is cut and grain and/or straw is fed

1.5 Recycled Water in Context of Australia's Water Resources

Australia's annual water use is approximately 1.3 million litres per person, the third highest consumption rate in the world. Agriculture and domestic water uses are the highest users of water in Australia at 65% and 11% respectively in 2004-05. The majority of water used for irrigation originates from surface waters (74%) with groundwater accounting for 23%.

Prolonged drought, along with a growing population and projected global warming effects are driving a focus on more efficient management of all water sources in Australia.

Recycled water currently contributes approximately 280 GL of total water supplied by water providers representing just under 4%.

Agriculture is the predominant user of this water accounting for approximately two thirds of recycled water consumption through more than 270 recycled water schemes (Boland et al, 2006). The majority of these schemes are for pastures (including dairy) and fodder crops. Other significant users include production and amenity horticulture and urban reuse.

Regional Australia provides some of the highest rates of recycling, however volumes are generally small.

2. How to Access Recycled Water

This section provides a summary of the key requirements and procedures when planning and implementing wastewater recycling schemes in pastures and crops. It should assist all participants in better understanding each other's expectations.

The water authorities and agencies will undertake most of this planning work once they have established that there is a potential market for their recycled water with the irrigators. It is important that the irrigators continue to be involved to some extent so that their particular needs are clearly understood.

2.1 Guiding Principles

The following outlines the basic elements or requirements that should be met when planning and implementing recycled water schemes in pastures and crops. The principles consider all participants in a scheme (e.g. irrigators, water providers, agencies and the community) and will help to ensure that a successful recycled water scheme is implemented.

The need for planning and communication strategies

For stakeholders to make informed decisions about water recycling, it is crucial to provide comprehensive plans including thorough communication strategies that engage all stakeholders. Appropriate engagement will also build trust between stakeholders and the people who approve, manage and monitor the use of recycled water. Effective engagement takes time and must be factored in at the planning stages.

Water Treatment Technologies are proven and safe

Water treatment technologies are well proven, with water recycling having been practised around the world for more than half a century. Risk management procedures (e.g. Hazard Analysis and Critical Control Points – HACCP) ensure that any specified quality can be produced consistently and made 'fit-for-purpose'. The technologies used and their safety records need to be clearly communicated.

Managing public health and environmental risks

Recycled water schemes must comply with state/territory regulatory arrangements, which are overseen by the designated government departments (Section 5). This manual advises on minimum standards to manage risks to humans and to the environment. It is the responsibility of the water treatment authority to ensure the recycled water meets appropriate standards approved by the government.

Customer site management plans

Landholders will generally be required to describe how they will manage the application of recycled water and what measures they have implemented to monitor potential impacts on their property. This process is generally referred to as the customer site management plan (CSMP) or the environment improvement plan (EIP).

In the majority of cases, the CSMP/EIP will be prepared by the supplier of the recycled water in conjunction with the landholder. Section 3.7 provides a list of information to be included in the CSMP.

Changes in irrigation technologies and practices

Minor modifications to current farming practices may be required in order to implement use of recycled water. However, where existing irrigation properties are to use recycled water, the aim is to provide a recycled water scheme that complements the current farming systems by utilising existing irrigation infrastructure and practices.

Community acceptance and trust

Building positive community perceptions of recycled water schemes can only be achieved through widespread trust in the relevant authorities, technologies, regulatory arrangements and compliance measures. The track record of established schemes and experience of regulatory bodies (e.g. their scientific and technical advisers) is a positive way of achieving this.

2.2 How to Engage with Participants and Stakeholders

When considering a recycled water scheme it is important that all relevant participants are involved in the decision-making process. The purpose of this involvement is two-fold:

- Ensures they are aware of the scheme and satisfied that it will be operated in a safe and sustainable manner; and
- Enables the scheme to draw upon their skill and expertise.

Key stakeholders that often need to be involved in the scheme (particularly at the planning stage) include environment protection authorities, catchment management authorities, state/territory environmental and agricultural departments, rural and urban water authorities, state/territory health departments and the general community.

The establishment of a scheme and its ultimate success frequently relies on the strength of relationships between different groups, degree of trust and definition of a common purpose. The time taken to undertake effective community engagement should not be underestimated. In many regions, there are processes in place to facilitate discussion and engagement with the community and these should be utilised where possible. For example, the water authority may have established water service committees and/or the catchment management authority may have an established community consultation process.

The following will assist in initiating and maintaining engagement of participants and stakeholders.

Identify key contacts - All stakeholder groups involved with the recycled water and agricultural product need to be contacted and encouraged to nominate the appropriate representative(s) to participate in the planning of the recycled water scheme. This includes allowing opportunities for individuals of the wider community to participate or comment.

Determine key objectives - Key objectives of all stakeholders need to be identified so that all understand interests, concerns and expectations. Associated benefits and costs expected with the scheme need to be explicit.

Undertake thorough planning - The planning process requires a comprehensive and positive approach that is also flexible and adaptable to changing circumstances. It should run together with an extensive communication strategy to help maximise the acceptance and use of recycled water.

Provide appropriate information - General public acceptance of the safety of recycled water to irrigate pastures and crops will improve with information from trusted scientific and regulatory sources, targeted education, transparency and gradual exposure.

2.3 Key Considerations for Participants

The following assessment includes some of the key issues that may be a priority for different groups during the establishment of a recycled water scheme.

Stakeholder	Key Concerns
Governments	• State/regional policies e.g. planning and regional development • Public health and environmental protection through guidelines and regulation • External costs and/or benefits of a scheme • Cost of treatment - funding arrangements and partnerships • Water resource management – availability, alternative uses, potable substitution • Economic, environmental and social sustainability • Demand by landholders • Acceptable risk as defined by community and landholders
Water suppliers	• Public health and environmental protection • Water supply and demand • Quality of water is fit for purpose • Costs (establishment and operational) • Training for recycled water manufacturers and users • Communication and engagement strategy • Users' concerns and risk allocation
Primary producers	• Water supply – demand, reliability, fit for intended purpose • Business opportunities – security for investment • Water quality and product compliance • Training required • Monitoring and reporting – Customer Site Management Plan • Modifications required to current management
Wholesalers and retailers	• Market place compliance - quality control, environmental assurance • Stakeholder education • Consumer perceptions and acceptance • Consumer acceptance
Community and consumers	• Health and environmental compliance • Product safety • Quality control • Price and transparency (for the development of trust)

2.4 Accessing Recycled Water

When proposing establishment of a recycled water scheme, the key message that landholders need to be aware of is that the supplier of the recycled water (e.g. a water authority) will undertake the bulk of the work required to make recycled water available.

Landholders are generally not required to develop the scheme themselves– there will be a great deal of support and advice provided by the supplier of the recycled water.

Landholders will often be asked to think about how their farming operation can best utilise recycled water in a safe and sustainable manner, however, even these aspects of the scheme will be covered by the recycled water supplier.

Some key issues to be considered when accessing recycled water are listed below. Consideration of these issues will generally maximise the success of a scheme being implemented and a landholder gaining access to the recycled water.

- Have all participants and stakeholders been identified?
- Have the roles and responsibilities of participants been clearly identified?
- Has enough time been allowed for the community engagement process?
- Has an engagement strategy been developed that is well planned, has defined objectives, utilises existing key contacts and networks, and will create trust and confidence in the authorities and the scheme?
- Does the engagement strategy and partnership program include a communication plan?
- Have the economic, social and environmental costs been considered?
- Is a range of information about recycled water (e.g. Fact sheets) available for stakeholders, and is there the ability to efficiently produce further information on nominated topics?
- Have the most appropriate authorities been identified to ensure the safety of the public and environment when irrigating with recycled water?
- Can the scheme meet all appropriate guidelines and regulations for the state and region?
- Is the recycled water fit for the intended use?
- Is the water delivered for immediate use or is there a requirement for on-farm storage?
- Is appropriate monitoring, reporting and quality assurance program/s in place?

3 How to Use Recycled Water

3.1 Guidelines and Risk Manangement

The Australian National Guidelines for Water Recycling completed in 2006 (NRMMC and EPHC. Australian Guidelines for Water Recycling. Managing Health and Environmental Risks Phase 1) provide the national approach for using recycled water and refer to the water being fit for the intended purpose. There is also a range of current state and territory guidelines that provide advice on recycled water management (refer to section 5).

Different guidelines have specific standards that vary from state to state. Guidelines for irrigation of crops and pastures with recycled water have been developed from extensive research using risk management principles and are available in most states (SA, Tas, Vic, NSW, QLD). Where specific state guidelines are not available, the Commonwealth guidelines prevail.

Scheme operators, managers and practitioners need to comply with state and national guidelines. Refer to your relevant state guidelines for detailed information on appropriate water qualities required for a specific recycled water scheme.

3.2 Planning to Use Recycled Water

The following tables outline general issues associated with the use of recycled water. They focus on recycled water from treated effluent sources, however many of the issues relate to best practice that could be applied when using other water sources.

These include the:

Compliance of the recycled water with:

- Regulatory requirements – human health (food safety and Occupational Health and Safety) and environmental; and
- Marketing requirements – quality and environmental assurance.

Management requirements including:

- Infrastructure modifications; and
- Management changes.

3.2.1 Compliance

Regulatory Requirements - human health and environment

Have relevant state bodies approved the recycled water for the intended use? Is it fit for purpose?

New recycled water schemes in Australia generally require a 'fit for purpose' approval. The regulatory body varies from state to state (Refer to Section 5). For example in Victoria the Environmental Protection Agency (EPA) approve all recycled water schemes and for Class A schemes the Department of Human Services (DHS) approval will also be required.

Has a land capability assessment (site suitability) been undertaken on the land to be irrigated with recycled water?

At the beginning of the scheme all properties to be irrigated with recycled water are to be investigated to ensure they can meet specific requirements of recycled water use and there is a low risk of detrimental environmental or human impact. The collection of this information will not only enable the scheme to proceed, but will be valuable when preparing the Customer Site Management Plan.

Do you have an agreement in place for the use of recycled water with the provider and do you understand the conditions of supply?

Water suppliers will generally require you to enter into an agreement that describes the terms and conditions and your rights and responsibilities. Water suppliers and recycled water scheme managers are also a valuable source of information and have responsibility to ensure their users are sufficiently equipped with knowledge.

Have you attended the relevant workshops or training sessions on the use of recycled water?

It is a condition of water supply for some new recycled water schemes, that you attend information or training sessions on the use of recycled water. Attendance is still helpful to understanding using recycled water regardless of whether it is compulsory or not.

Are you aware of any monitoring requirements?

The agreement and CSMP covering recycled water supply generally indicates if there are any compliance and monitoring requirements. The requirements are important to understand as the supply of recycled water is linked to environment and human service authorities.

Have you implemented an OH&S strategy?

Depending on the class of water and state legislation the health department may require additional changes such as signage, withholding periods and staff training.

Marketing - quality and environmental assurance

Will buyers accept produce grown with recycled water?

It is important to check with the commodity buyers/processors whether they have any concern in regard to the use of recycled water for irrigation. Acceptable uses for recycled water are quite well defined – operating within these guidelines will provide buyers with confidence and ensure there are no concerns.

Are consumers generally comfortable with the use of recycled water for the growing of pastures and crops?

Acceptance of recycled water varies depending on the perceived risk associated with its use. The use of recycled water on pastures and crops is generally considered by consumers to be low risk provided there is trust in the organisations involved in growing of the produce.

Does the use of recycled water fit with your quality and environmental assurance programs?

Many irrigators have voluntary Quality Assurance (QA) programs in place that include food safety through Hazard Analysis and Critical Control Points (HACCP). It is important that the use of recycled water meets the requirements of these schemes. Environmental assurance programs are becoming increasingly popular and it is important to check that the use of recycled water meets the requirements of the different standards.

Does recycled water use fit with other programs in place e.g. organic production?

Organic production has a number of standards for production. It is important to ensure that recycled water use fits with your specific standard.

3.2.2 Management Requirements

Management changes

Do you have a map or schematic layout of your property with prominent features marked?

Besides improving general access to the property, a layout of the property will facilitate the assessment and decision making if reportable incidents such as off-site movements of recycled water occurs. Generally it is best to include irrigated areas, property boundaries, buildings and water storage facilities, water supply pipes, drainage points, soil types and buffer distances. Experts are available to assist with the irrigation design to ensure that the irrigation efficiency of the scheme is maximised.

Has a Customer Site Management Plan (CSMP) been prepared for the site?

As discussed in Section 2.1, a CSMP is required for the majority of recycled water schemes. The preparation of this document will be undertaken by the supplier of the recycled water, with strategic input (i.e. farm specifics) by the landholder.

Do you have appropriate signage where recycled water is being, or will be used?

Many schemes require strategic and prominent signage where recycled water is used in accordance with Australian Standard 1319 – 1994, Safety Signs for the Occupational Environment. The current requirement is that the pipes carrying recycled water should be painted lilac and that appropriate signage, e.g. 'Recycled Water – Do Not Drink', is used to advise everyone concerned.

Have you advised your family members and employees about the use of recycled water on the property?

All family members, employees and other people entering the property need to be made aware of the use of recycled water on-site and that it is unsuitable for drinking in compliance with Occupational Health and Safety requirements.

Are you aware of your first point of contact in case of any concerns or incidents in relation to recycled water use?

Your water supplier will be the first point of contact, in most cases, if there are any concerns or incidents. Examples include contamination of the potable water supply by recycled water, significant leaks or overflows from the recycled water storage dams, discharges of recycled water to rivers or creeks, and soil salinity, sodicity or acidity problems caused by the use of recycled water.

Do any of your management practices need to be changed because you are using recycled water?

The scheme operator should make you aware of any changes you may need to make to current management practices, if required. Changes may include better record keeping and monitoring of soil condition, groundwater and/or surface water quality under recycled water use.

Do you have an on-farm storage facility for recycled water?

If you need to store recycled water make sure you have appropriate controls in place to prevent seepage (groundwater pollution), leaks or overflows. There could also be requirements for fencing the storage and providing warning signs to control access.

Do you have an algal management plan in place?

Blue-green algae are of primary concern as they may produce toxins. Algal outbreaks may be prevented or reduced by controlling the environment and avoiding conditions that promote algal growth (warmth, sunlight, high nutrients and still waters). This is the preferable management plan, however if you must use chemical treatment, seek expert advice as the chemical recommendations may vary according to situations. Chemical label recommendations and directions must be strictly followed.

Are you aware of where you can find further information?

Every recycled water scheme will have communication strategies and information sources available to its users. Your water supplier and government agencies should be able to provide all the information you need or advise you where to find it (Refer to Section 5).

3.3 Quality of Recycled Water

The quality of the recycled water is the most important factor that will determine the purpose for which it can be used and the management practices that will need to be implemented.

3.3.1 Quality of Source

As previously stated the quality will be largely determined by the source of the water. Quality can differ significantly depending on the primary source. However, there are practices that can be put in place to manage some of the variability.

Food processing wastewater - is waste from factories and food processing facilities. It is generally high in salts that are used as cleaning agents. Cleaner production techniques are promoting the more efficient use of water in dairy processing however this can result in a wastewater that is more concentrated with contaminants posing greater problems for irrigation.

Treated effluent - sewage refers to material collected from all internal household drains, containing all the contaminants of greywater and urine, in addition to high concentrations of faecal material from toilets. Sewage can contain a range of human infectious enteric pathogens, plus wastes from industrial and commercial premises that can introduce a range of contaminants, particularly chemicals. Sewage also contains moderate levels of nutrients (lower than food processing wastewater), particularly phosphorus and nitrogen, which have been identified as key environmental hazards. Groundwater infiltrating into sewers can cause substantial increases in chloride, salinity and sodicity (high sodium concentrations relative to calcium and magnesium), which have also been identified as key environmental hazards.

3.3.2 Fit for Purpose – Appropriate Quality for End Use

The risk management approach to water quality and use involves identifying and managing risks in a proactive way, rather than simply reacting when problems arise.

This is achieved by assessing all the potential hazards that could affect human or environmental health. The likelihood of the risk occurring, and the magnitude of consequence is then assessed for each risk. Preventative measures are put in place for significant risks. The final step is to verify that the management system consistently provides recycled water of a quality that is fit for the intended use (i.e. 'fit for purpose').

Whilst this principle of 'fit for purpose' has been adopted in the National Recycled Water Guidelines, state and territory regulatory guidelines generally use the Class A, B, C, D classification system.

This classification system can be used as a 'quick guide' to indicate the microbiological quality of the recycled water. However, it does not consider other key parameters such as salinity, nutrients, Biological Oxygen Demand (BOD) and pH. The fit for purpose approach captures all relevant parameters.

Regardless of the classification system used, the key point is to make sure all relevant water quality parameters have been identified and included in the recycled water risk assessment.

Recycled water suppliers need to ensure that their irrigators fully understand the quality of recycled water that is going to be supplied to their property, and the relevant risks requiring management.

3.3.3 Understanding Quality Parameters

It is critical that the quality parameters of the water source (concentrations and variability) are fully understood prior to undertaking a risk assessment.

The knowledge of the water source needs to be matched with an understanding of the end use including crop to be grown and site attributes such as soil type, climatic conditions, topography, groundwater, surface water and current irrigation systems and management.

Only when a thorough investigation into the source and end use has been made can management recommendations be suggested for a particular site.

3.3.4 Differences Between Different Water Sources

Food processing wastewaters are typically higher in Biological Oxygen Demand (BOD) due to high organic loads e.g. milk solids, fats, grease and fodder. They also have no human pathogens so there is less emphasis on the health-based risks.

Treated effluent generally has lower salt (total EC, sodium (Na) and chloride (Cl), nitrogen (N) and phosphorus (P)) than food processing water due to cleaning agents used in the industrial process.

Parameter	Units	Food processing waste*	Treated effluent**
pH	pH units	6.5 – 8.5	7.9
Salinity	EC (µS/cm)	2,000 – 5,000	800 - 1,500
BOD	mg/L	20 – 1,000	20
N	mg/L	20 – 1,000	15
P	mg/L	10 – 50	6
Na	mg/L	100 – 1,000	180
Cl	mg/L	100 - 500	135
Boron	mg/L	-	290

* data range from Victorian Milk Processing Factories.
** Average values: Australian Guidelines for Water Recycling. Managing Health and Environmental Risks (Phase 1) (NWQMS No 21)

Odour management associated with recycled water schemes is incorporated into the design and operation of the treatment and storage facilities. A properly designed and constructed treatment and storage facility will ensure there are no odour problems associated with the scheme.

3.4 Major Risks for Recycled Water Users

Some of the common environmental risks from the use of recycled water for irrigation include:

- Salinity;
- Sodicity;
- Hydraulic Loading;
- Nutrients; and
- Other contaminants.

A summary of these risks is provided below:

3.4.1 Salinity

Soil salinity refers to the presence of soluble salts in soils. It mainly results from natural processes of landscape evolution, however human activity can contribute to the development and exacerbation of soil salinity (e.g. through irrigation water and fertilisers).

Sodium chloride (NaCl, i.e. table salt) is generally the predominant salt, however salinity can also be made up of many other salts (e.g. salts of calcium, magnesium, potassium), which may even come from common fertilisers.

Soil salinity usually affects plant growth by increasing osmotic tension in the soil making it more difficult for the plants to absorb water from the soil. Excessive uptake of salts by plants from the soil may also have a direct toxic effect on plant cells. Saline water, depending on the concentration of salts, applied through sprinkler irrigation can also cause direct damage to the leaves (foliar injury).

When irrigating with recycled water the salts will generally accumulate in the soil. These salts will need to be flushed from the rootzone to prevent plant injury.

Salinity can impact on agricultural crops through irrigation but can also impact on freshwater plants and invertebrates in natural ecosystems if discharged directly with little dilution.

Salinity is a problem common to nearly all recycled water schemes and requires active management. Most schemes therefore have a requirement for the recycled water to be managed below a maximum acceptable salt load.

Sodium

Sodium can be toxic to some plants if it accumulates in soils from ongoing irrigation or if it is taken up through the leaves. Plants vary in their tolerance to sodium. Sodium is generally more of a problem as a component of salinity and sodicity.

Chloride

Chloride can be toxic to plants if sprayed directly on leaves, and if it accumulates in soils from ongoing irrigation.

3.4.2 Sodicity

Sodicity refers to a condition where too much exchangeable sodium is present in the soil compared with other cations. This has a negative impact on soil structure causing soil dispersion/swelling, reducing water infiltration on heavier textured soils.

Sodic soils are hard setting with restricted infiltration of water, prone to waterlogging and difficult to work with. This results in poor root development and restricted nutrient and water uptake for plants.

The effect of sodicity can be difficult to remedy and is a common problem with recycled water schemes. Selection of the site is therefore critical.

3.4.3 Hydraulic Loading

Hydraulic loading refers to the volume of irrigation applied. In situations where hydraulic loading is poorly managed and irrigation applications exceed plant demand, groundwater recharge, water logging and run-off, and secondary salinity can result. The maximum hydraulic loading will vary between sites depending on the soil type and structure, presence and depth of groundwater and inherent soil salinity.

Site selection and irrigation design are important factors to ensure the maximum hydraulic loading.

3.4.4 Nutrients

Nitrogen

Nitrogen is a primary nutrient required for the production of healthy plants. Nitrogen is beneficial to the majority of cultivated plants. Excess nitrogen from irrigation that is not used by the plant can cause eutrophication (high nutrient levels) in land and aquatic ecosystems.

Phosphorus

Phosphorus is a primary nutrient required for the production of healthy plants. Phosphorus is beneficial to the majority of cultivated plants. Excess phosphorus from irrigation that is not used by the plant and/or retained in the rootzone can cause eutrophication (high nutrient levels) in land and aquatic ecosystems.

3.4.5 Other Contaminants

Chlorine residuals

Chlorine is a by-product of the disinfection process. These residuals may be harmful to aquatic or marine ecosystems if discharged directly with little dilution.

Boron

Boron can be toxic to some plants if it accumulates in soils from on-going irrigation. Signs of boron toxicity in plants include a yellowing and speckling pattern between the veins and near the edge of the leaf, tip burn, cupping of the leaves, reduced size, and premature leaf drop.

Surfactants

Some organic and inorganic surface-active agents from detergents can remain in recycled water and can be harmful to aquatic organisms.

3.5 Management of Recycled Water

3.5.1 Roles and Responsibilities

One of the key tasks when establishing a recycled water scheme is to determine the roles and responsibilities of the participants involved.

Typically, this will involve three main parties; the recycled water supplier, the recycled water end user and the regulatory authority(s) approving the scheme. However, it may also involve additional parties (e.g. lessee's) depending on the circumstances.

The roles and responsibilities of the three main parties listed above can be summarised as follows:

Recycled water supplier

- Overall responsibility for the scheme
- Operate and maintain the recycled water treatment plant to reliably produce the class of water required
- Undertake regular monitoring to confirm the quality of recycled water (results to be supplied to the end users)
- Obtain regulatory approval for the scheme and the application of recycled water to the farm(s)
- Undertake assessment of the farms to ensure they can use recycled water within the state territory recycled water guidelines (i.e. safe and sustainable manner)
- Understand and comply with the relevant regulatory guidelines
- Ensure no environmental or public harm results from the use of recycled water
- Ensure recycled water use does not impact on the farmers ability to operate a viable business
- Audit the recycled water scheme in accordance with state and territory regulatory auditing requirements
- Ensure there is on-going liaison with key stakeholders, including the community
- Respond to any positive or negative community feedback in a prompt manner

Recycled water end user (landholder)

- Use recycled water in accordance with the farms Customer Site Management Plan (CSMP)
- Perform and record any monitoring requirements as detailed in the CSMP and make them available to either the recycled water supplier or regulatory body upon request
- Inform the recycled water supplier immediately of any issues they have with the recycled water, or any instances of non-conformity (i.e. recycled water use outside of the CSMP)
- Continue to operate the farm in a viable and sustainable manner
- Inform the recycled water supplier of any changes to the farm or farming operations/practices

Regulatory authority

- Provide approval of the recycled water scheme and ensure it meets state and territory recycled water guidelines
- Ensure no environmental or public harm will result from the use of recycled water for the irrigation of pastures or crops
- Assess the performance of the scheme on an on-going basis to ensure it continues to meet the relevant state and national recycled water guidelines

From an overall scheme point of view, the supplier of the recycled water bears the risk of the scheme, from the production of the recycled water, to its end use. The supplier holds the EPA (or equivalent) licence.

If the risks of using recycled water have been properly identified and practices put in place to manage these risks, and the recycled water end use is in accordance with state and territory recycled water guidelines, the landholder bears very little risk.

The landholder is obligated to ensure the use of recycled water on their property is in accordance with their CSMP, however any problems with the scheme are the responsibility of the recycled water supplier.

3.5.2 Costs Associated with Recycled Water

The economic drivers for the use of recycled water are currently unclear and as a consequence the pricing is often not transparent. These differences arise as recycled water has moved from a perceived waste product to a valuable resource.

The principles of polluter pays versus user pays are uncertain in many recycled water schemes with a diversity of outcomes resulting. The need to recoup the total costs of treatment from recycled water users rather than from previous water users frequently makes the price of recycled water too great compared with higher quality alternatives.

From a landholder's perspective it is important to consider the value of the recycled water from:

- Quality attributes – what is the level of contaminants/beneficial nutrients?
- Volume available – will this contribute to the development of business? Is business currently constrained by water?
- Delivery of the water – will the water be pressurised when it is delivered? Will on-farm storage be required?
- Alternative supplies – will this involve substitution of other irrigation supplies? Are there any other supply options? Is this a better/inferior product?
- Security of supply – is this product more secure (less variable), and how does the quantity, delivery flow and pressure compare to other options?

The value of recycled water to the landholder should be considered when setting the price taking into account cost of alternatives, cost of treatment and environmental and social externalities (e.g. reducing disposal; regional development; level of treatment; range of uses).

3.5.3 Water Application Rates and Hydraulic Loading

Application driven by plant demand

Water use should be driven by plant demand and not by other factors like overflowing or undersized winter storages.

Excessive irrigation not only has the potential to degrade the environment (e.g. groundwater recharge, waterlogging, eutrophication of waterways) but will also cause the plant to become less efficient. The practice of deliberately over-irrigating does not actually result in the plant using more water – it simply means that more water will end up where it shouldn't (e.g. ground or surface waters).

Estimating irrigation requirements

Crop water requirements should be calculated prior to irrigation occurring. This is important as it helps the landholder schedule irrigations and maximise productivity, and also helps the scheme manager to determine the volume of irrigation area required for a given volume of recycled water.

Crop water requirements can be calculated by performing a few simple calculations that uses evapotranspiration data and crop coefficients. An example of this calculation is provided (Text Box 1) and should be undertaken for every scheme.

The aim is to ensure that the volume of irrigation applied does not exceed the crop requirement (hydraulic loading limit). The estimation of irrigation requirement should include all water, regardless of its origins (e.g. channel/river water, groundwater, recycled water, dairy effluent) and should factor in the volume of effective rainfall contributing to crop growth.

Experienced irrigation landholders in the area, local agricultural government departments or private consultants will be able to help determine crop water requirements.

Text Box 1: Crop Water Requirements
Rye Grass Hay – Mildura
Mildura rainfall (average): 268 mm/annum

Month	Crop coefficient (Kc)	Average daily evapotranspiration ETo (mm/d)	Average daily water requirement ETc (mm/d)	Average monthly crop water requirement (mm/mth)
July	0.85	1.5	1.3	40
August	0.85	2.1	1.8	55
September	0.85	3.1	2.6	79
October	0.95	4.4	4.2	130
November	1.15	5.6	6.4	193
December	1.15	6.3	7.2	225
January	1.15	6.6	7.6	235
February	1.15	6.1	7.0	196
March	1.00	4.8	4.8	149
April	0.95	3.2	3.0	94
May	0.85	1.9	1.6	50
June	0.85	1.4	1.2	36
Total				**1,482**

Total (ML/ha/annum): 14.8
Mildura rainfall (ML/ha/annum): 2.7
Irrigation requirement (ML/ha/annum): 12.1

Growing season

Different pastures and crops have different growing seasons, meaning that they require more water at varying times of the year. Being aware of this, and scheduling irrigations throughout the season is important to ensure the water applied is utilised by the plant and productivity is maximised.

Irrigation scheduling relies on experience, understanding how much water plants use throughout the season and understanding how plants respond to soil moisture levels. There are a number of tools that can be used to assist scheduling such as soil moisture monitoring devices and plant based sensors.

The most experienced pasture and crop irrigators generally use a shovel to assess soil moisture levels and visually assess plants for signs of water deficiency (e.g. wilting). However, this form of scheduling is also backed up with a considerable amount of knowledge that takes into the account the characteristics (climate, soil, topography) of the individual’s farm.

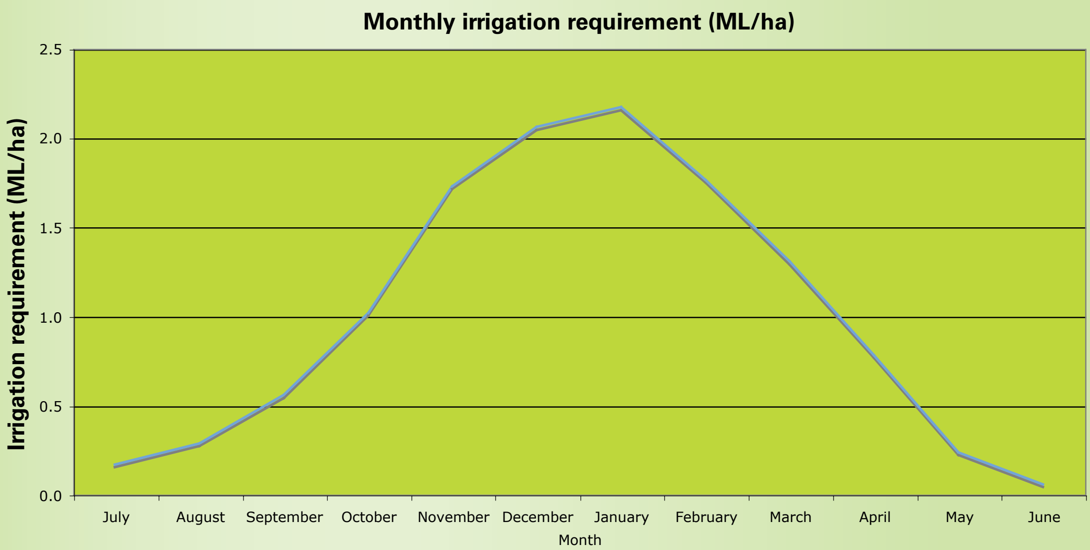
The irrigation requirement calculations can be used to provide a general guide as to how much irrigation is required throughout the season (Text Box 2). Outside of the tropics, irrigation requirements are generally negligible in June, July and August, peaking in December and January. The tropics have an irrigation period that generally runs from April to September (i.e. the dry season).

Knowledge of the general water use pattern for the plant over the irrigation season, awareness of the soil moisture and observing the health and signs of water stress in plants will ensure that the crop receives enough water and the hydraulic loading limits for the property are not exceeded.

Text Box 2: Monthly Irrigation Requirement

Rye Grass Hay – Mildura
Mildura rainfall (average): 268 mm/annum
Irrigation requirement (ML/ha/annum): 12.1

Month	Monthly water requirements (mm/mth)	Monthly rainfall (mm/mth)	Monthly irrigation requirement (mm/mth)	Monthly irrigation requirement (ML/ha)
July	40	22.6	17	0.2
August	55	26.7	29	0.3
September	79	23.2	56	0.6
October	130	27.7	102	1.0
November	193	20.5	173	1.7
December	225	18.7	206	2.1
January	235	18.2	217	2.2
February	196	20	176	1.8
March	149	18.2	131	1.3
April	94	16	78	0.8
May	50	26.5	24	0.2
June	36	29.9	6	0.1
Total	**1482**	**268**	**1214**	**12**



3.5.4 Nutrients – Nitrogen and Phosphorus

Potential for adverse environmental impacts

An advantage of using recycled water for irrigation is that nutrients in the water may be utilised for the benefit of plants and can subsequently be removed in plant and animal product.

Care must be taken to ensure that the nutrients do not build up in the soil to a level where they cause adverse impacts on the site. These impacts include:

- toxicity to some plants;
- toxicity to animals consuming the fodder; and
- leaching to groundwater or surface water causing environmental impacts

Nutrient balance

To minimise the above risks a nutrient balance should be undertaken. If nutrient removal is not sufficient to match the applied nutrients, the site is considered to be exceeding the nutrient balance.

A nutrient balance is calculated by estimating the amount of nutrients applied (in recycled water and fertilisers), the amount removed in product and the amount bound up in the soil (particularly for phosphorus). The system is in balance if the short to medium term nutrient removal is around the same as short to medium term nutrient loading rate.

Nitrogen and phosphorus product data for a number of common pastures and crops has been provided (Text Box 3). This data is used to calculate the nutrient balance as described below.

Text Box 3: Nutrient Export Data

Plant/Crop	Mean Nutrient Removed	
	Nitrogen (kg/t FW)	Phosphorus (kg/t FW)
Barley	16	2.7
Maize	13	2.3
Oats	16	2.7
Sorghum	17	2.3
Triticale	16	2.4
Wheat	28	2.5
Canola	35	5.1
Cotton	22	6.6
Lucerne seed	60	6.8
Lucerne	28	3
Clover or medic	28	2
Clover/grass	21	2
Pasture	18	1.8
Silage – Grass	24	2.8
Silage – Pasture	26	2.8

Source: Australian Guidelines for Water Recycling. Managing Health and Environmental Risks

Accurate nutrient concentrations can be obtained by getting a feed quality test performed on any pastures and crops grown with recycled water. It is recommended that this be undertaken periodically so that an accurate result can be obtained. An example of calculating nutrient balance is provided below.

Scenario

Crop: Lucerne hay
Recycled water quality: 4 mg/L phosphorus, 12 mg/L nitrogen
Recycled water hydraulic loading rate: 4 ML/ha/annum
Fertiliser addition: 20 kg/ha/annum single super
Production: 12 t/ha/annum

Nutrient balance

Imports	**Phosphorus:** - 4 ML of recycled water @ 4 mg/L = 16 kg/ha/annum P - 20 kg/ha/annum single super @ 9% phosphorus = 1.8 kg/ha/annum P - Total P imports = 17.8 kg/ha/annum P **Nitrogen:** - 4 ML of recycled water @ 12 mg/L = 48 kg/ha/annum N - Total N imports = 48 kg/ha/annum N
Exports	**Phosphorus:** - 12 t/ha/annum lucerne @ 3 kg/t/annum P = 36 kg/ha/annum P **Nitrogen:** - 12 t/ha/annum lucerne @ 28 kg/t/annum N = 336 kg/ha/annum N
Nutrient balance	**Phosphorus:** Imports – Exports: 17.8 – 36 = -18.2 kg/ha/annum **Nitrogen:** Imports – Exports: 48 – 336 = -280 kg/ha/annum The nutrients applied do not exceed the nutrients exported from the farm in product (i.e. nutrient deficit). Therefore, potential environmental harm from excess nutrient applications are not an issue.

In situations where nutrient applications are close to or in balance and no increase in soil nutrient levels are desired, it is critical to cease fertiliser applications so as nutrient excess does not occur.

Nutrient balances can also be used as a planning tool to determine the maximum volume of recycled water that can be applied to a farm.

Nitrogen and phosphorus management

Limiting, or ceasing the use of fertilisers on properties irrigated with recycled water is a key nutrient management practice.

The decision of whether to apply fertilisers or not should be supported by:

- Undertaking a nutrient balance (as discussed above); and
- Using soil and plant tissue tests to determine if fertilisers are required or not.

Plant tissue analysis should be used in conjunction with soil chemistry results to determine if nitrogen levels are satisfactory (soil tests alone do not provide enough information on available nitrogen levels).

Soil tests should be undertaken at least on an annual basis and used to check that soil nutrient levels are remaining in balance, or if desired, increasing to an optimum level.

Soil phosphorus levels should not exceed 20-30 mg/kg Olsen P, as there is no economic value in increasing soil phosphorus beyond this level (i.e. the cost of increasing soil phosphorus above this level is not recovered through the additional production it may provide).

Other practices that can be undertaken to manage nitrogen and phosphorus applications include:

- Ensuring surface irrigation systems (e.g. flood/border check irrigation) have an irrigation tailwater system and no irrigation water leaves the farm;
- Ensuring the operation of sprinkler irrigation systems does not create irrigation run-off;
- Irrigating crops that have a demand for the nutrients being applied in the recycled water;
- Visually monitoring crop health for signs of nutrient deficiency/toxicity; and
- Shandying recycled water with good quality channel/river/groundwater to decrease the final nutrient concentration applied (refer to Section 3.5.6 for more detail).

3.5.5 Salinity and Sodicity

When applying recycled water, it is important to consider the levels and composition of the applied salts. Salts applied through irrigation may prevent the plant from achieving the desired growth and water use and potentially adversely impact on surface waters, groundwater or surrounding land.

The maximum allowable salinity in the irrigation water will depend on a number of factors including:

- Climatic conditions including leaching rainfall;
- Tolerance to salts of the crop being grown;
- Soil type and potential for leaching and/or waterlogging;
- Management practices; and
- Irrigation systems.

As a general guide, recycled water salinities should be kept below 500 EC (μS/cm), with 800 EC (μS/cm) often used as an upper limit benchmark. In some situations, where low volumes of recycled water are being applied, and the soils have good leaching characteristics, 1,000 EC (μS/cm) may be acceptable. The safest way to determine the maximum salinity a plant can tolerate is to look at the plants relative salt tolerance and consider the leaching ability of the soils.

Relative salt tolerances for a number of common pasture and crop species are provided in Text Box 4, while Government Agriculture Departments and private agricultural consultants will be able to advise on the leaching ability of a property's soils.

Text Box 4: Relative Salt Tolerance Data

Plant/Crop	Soil Salinity – ECe (dS/m)	Irrigation Water Electrical Conductivity – ECi (dS/m)			
		25% LF (eg. sand)	20% LF (eg. sandy loam)	17% LF (eg. loam)	12% LF (eg. light clay)
Annual ryegrass	4.0*	1.7	1.5	1.2	1.0
Perennial ryegrass	5.6	5.6	4.8	4.1	3.1
Barley	8.0	8.0	6.9	5.9	4.5
Canola (oilseed rape)	2-4	3.0	2.6	2.2	1.7
Oats	5.0	5.0	4.3	3.7	2.8
Corn (grain, sweet)	1.7	1.7	1.5	1.3	1.0
Cotton	7.7	7.7	6.6	5.7	4.3
Sorghum	6.8	6.8	5.9	5.0	3.8
Wheat	2-6	4	3.4	2.9	2.2
Lucerne	2.0	2.0	1.7	1.5	1.1
Tall wheat grass	4-8	6.0	5.2	4.4	3.4
Vetch (common/spring)	3.0	3.0	2.6	2.2	1.7

* 50% growth stage

LF = leaching fraction

1 dS/m = 1,000 EC (µS/cm)

Source: Australian Guidelines for Water Recycling. Managing Health and Environmental Risks

Management of salinity can include:

- Reducing salt input through shandying (mixing) saline water with low salinity water (refer to Section 3.5.6);
- Leaching salt from the root zone;
- Irrigation management to ensure optimal water availability;
- Appropriate crop selection for tolerance to salinity; and
- Monitoring of the salts in the soil.

The impacts of sodicity will vary depending on the soil type and structure, quality of irrigation water and drainage.

Management practices to improve soils affected by sodicity include:

- Application of gypsum or lime; and
- Improving organic matter to maintain good soil structure through retaining and incorporating crop residues, growing and ploughing in green manure crops or application of manures and other organic amendments.

3.5.6 Shandying Recycled Water

Shandying (diluting) is the practice of mixing recycled water with another source of good quality irrigation water (e.g. channel, river, groundwater).

Shandying of recycled water occurs best at the point where the good quality water enters the property, as this will generally result in the two sources of water mixing (diluting) prior to being applied to the plant.

The aim of shandying is to reduce the salt and nutrient concentrations of the water back to a sustainable level. If the shandy water needs to be stored, it must not compromise the storage requirements for the recycled water (i.e. additional storage may be needed).

Two examples of how shandying can be used are provided below.

Salinity Scenario

Recycled water: 1,500 EC (μS/cm)
Desired application salinity: ≤500 EC (μS/cm)
River water to be used as the shandy water: 100 EC (μS/cm)

Required shandy rate = 1:3 (1 part recycled water for every 3 parts of river water) will give a salinity of 450 EC (μS/cm)
((1 x 1,500) + (3 x 100)) /4 = 450 EC (μS/cm)

The shandy reference table (Text Box 5) provides detail on shandy requirements for recycled water salinities.

Text Box 5: Salinity Shandy Reference Table

Assume shandy water quality of 100 EC (µS/cm)

Shandy rate (recycled water : shandy water)	Recycled Water Salinity – EC (µS/cm)								
	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
1:1	550	800	1,050	1,300	1,550	1,800	2,050	2,300	2,550
1:2	400	567	733	900	1067	1233	1,400	1,567	1,733
1:3	325	450	575	700	825	950	1,075	1200	1,325
1:4	280	380	480	580	680	780	880	980	1,080
1:5	250	333	417	500	583	667	750	833	917
1:6	229	300	371	443	514	586	657	729	800
1:7	213	275	338	400	463	525	588	650	713
1:8	200	256	311	367	422	478	533	589	644
1:9	190	240	290	340	390	440	490	540	590
1:10	182	227	273	318	364	409	455	500	545

Phosphorus Scenario

Recycled water: 12 mg/L P
Irrigation demand: 9 ML/ha/annum
Desired application phosphorus: ≤40 kg/ha/annum P
River water to be used as the shandy water: no P

Required shandy rate = 1:2 (1 part recycled water for every 2 parts of river water) will give a phosphorus application 36 kg/ha/annum.

(9 x 12)/3 = 36 kg/ha/annum

In this scenario, every hectare of land to be irrigated with recycled water needs 6 ML of river water to achieve the shandy.

In some cases, the shandy may need to be applied to reduce both the salt and nutrient concentrations. The key is to identify the parameter, or parameters that have the potential to impact negatively on the plant, soil or surrounding environments (if recycled water is applied straight), and calculate the shandy rate that will minimise the risk.

Shandied recycled water will require more land for irrigation than straight recycled water applications, as there will be greater total volumes of water applied. Shandying the recycled water will not be possible if a suitable quality and quantity of alternative water is not available.

If recycled water needs to be shandied, investigations into the availability and reliability of shandy water needs to be undertaken prior to the scheme commencing. If shandying is not an option and the recycled water has elevated levels of salt and nutrients, the concentrations of the recycled water will either need to be reduced at the source or removed during treatment.

3.5.7 Microbiological Quality

The microbiological quality of the recycled water will determine the need for stock withholding periods and other management practices.

Crops grown with recycled water (except for Class A) need to be dried or ensiled before being used as fodder for stock, and no produce grown with recycled water (sourced from human sewage) can be fed to pigs. Furthermore, helminth reduction during the treatment process is required where recycled water is to be used on crops grazed by cattle.

In some cases, birds defecating in lagoons can compromise the microbiological quality of the recycled water. Where this is a concern, specialised sampling processes can be undertaken to ensure accurate microbiological results are obtained.

Major restrictions apply for dairy cows grazing pastures irrigated with recycled water. Where Class C water is used (<1,000 orgs/100 mL), the withholding period (prior to irrigation) for lactating dairy cows is 5-days (note: this is only relevant where the recycled water contains sewage inputs). A withholding period of 5-days can be a challenge for most dairy farmers, being difficult to schedule with standard irrigation and grazing rotations of the farm.

To meet the needs of a dairy farm, consideration should be given to treating the recycled water to a minimum of Class B standard (<100 orgs/100 ml). At this class, the withholding period reduces to 4 hours, or when the pasture is dry.

Another consideration is the potential for the recycled water to contain saleyard and abattoir inputs, and therefore the potential for the transmission of Johne's disease. If the scheme is unable to demonstrate that the risk of Johne's transmission is low to negligible, stock 12 months of age or younger should be isolated from coming in contact with recycled water (this includes grazing pasture irrigated with recycled water and drinking recycled water).

3.5.8 Water Storage

Winter storage of recycled water is generally required for all schemes.

In some cases, an individual property will require a balancing storage on the farm to ensure peak irrigation demand in summer can be met. In other situations, recycled water can be pumped directly from the schemes winter storage to the irrigation system.

Volumes of recycled water generated must be managed to ensure that:

- Water is utilised by the plants being irrigated; and
- Plant demand drives water use.

Facilities for recycled water storage and irrigation should be designed and constructed to contain all recycled water, irrigation run-off (sometimes this will be separate) and contaminated stormwater in at least the 90^{th} percentile wet year (stormwater containment may be separate to the recycled water storage). For some states (e.g. NSW), the requirement is 50^{th} percentile containment.

Consideration should be given to the appropriate mix of irrigation area and storage capacity for present and future volumes and should consider a water balance for the site.

Winter storage and irrigation area modelling is generally very poorly understood leading to poor estimates and design decisions that impact on the scheme. Expert advice should be sought. Monitoring of water use and storage volumes needs to be ongoing to ensure there is adequate water available. Shandying volumes must not compromise storage availability.

Another key consideration is the potential for toxic algal blooms (e.g. blue green algae) due to the nutrient concentrations in recycled water. Favourable conditions for algal blooms include a nutrient source, still water and hot weather – all of which can occur across much of Australia.

The impact of a blue green algae bloom can be severe, with restriction periods for grazing stock needing to be enforced, and in some cases the storage will need to be emptied to completely remove the toxic algae.

Algal blooms can be minimised by storing water for the shortest possible time, or where extended storage is required (e.g. a winter storage), by installing an aerator, which will eliminate stagnant water conditions. It is also recommended that internal battens of any storages be maintained in a clean and weed free state.

Some water authorities have had success with the use of algicides, however expert advice on the use of these products should be sought prior to use.

Lagoons and dams associated with the treatment and storage of recycled water will also need to ensure they have a suitable permeability rating to restrict seepage to groundwater. The typical requirement is that the lagoon/storage has a permeability no greater than 1×10^{-9} m/sec. Independent testing of the site should be undertaken prior to construction to determine that this criteria can be met. Otherwise, practices will need to be undertaken to meet the permeability criteria (e.g. compaction).

3.6 Irrigation Management

Irrigation systems

Recycled water can be applied using a number of different irrigation systems. The key to selecting the most appropriate irrigation system is to consider the quality of the recycled water, characteristics of the property to be irrigated (e.g. soil type, topography, proximity to sensitive environments), salinity tolerance of the crop, available labour and cost of establishment.

In some cases, a property's existing irrigation system may not be suited to the quality of recycled water, or recycled water may not suit the product being grown. The cost of replacing or modifying an existing irrigation system can be prohibitive and needs careful consideration.

A general overview of the positives and negatives of a number of different irrigation systems with respect to recycled water irrigation is provided below.

In a very broad sense, sprinkler irrigation systems can be adopted for a range of soil types, while surface irrigation systems will not be suitable for light soils. No irrigation should be undertaken on very heavy clay soils that have poor internal drainage (due to the risk of waterlogging and land salinisation), or very light sandy soils where groundwater accessions may occur.

Surface Irrigation (flood/border check)	• Not suitable for light soils (sands, sandy loams) due to leaching of nutrients and salts to groundwater and poor efficiency. Requires relatively flat topography to enable grading of the paddock surface to be undertaken. • Reduces the potential for foliar injury, as irrigation water is not sprayed onto the leaves of the plant. Also reduces buffer requirements, as there is no spray drift. • Needs to be managed to ensure waterlogging of soils and excessive leaching to groundwaters does not occur. Must be operated with a suitably sized and positioned irrigation tailwater collection system. • Is labour intensive and difficult to apply small volumes of water or different volumes of water over the one paddock. • Lower set-up costs than other forms of irrigation. • Laser levelling should be used to form the irrigation bays, to ensure efficient irrigation and drainage occurs.
Fixed sprays (solid set)	• Can be designed to accommodate a range of topographies, soil types and paddock shapes. • Less efficient than other forms of irrigation (they can be easily effected by wind). • High set-up costs. • Potential to cause foliar injury as the salty water is sprayed onto the leaf of the plant where it can evaporate and cause leaf burn. • System can be easily automated which provides a number of advantages, including labour savings.

Travelling Irrigator (big gun)	• Least efficient of the sprinkler systems, however has all the normal sprinkler system advantages of being suited to a range of soil types, topographies and paddock shapes. • Foliar injury is a concern with moveable sprinklers. • One sprinkler can be used to irrigate a number of different areas.
Long lateral (Van Den Bosch)	• Higher application efficiency than travelling irrigator (although still low when compared with other systems).
Centre Pivot/ Lateral Move	• Most efficient of the sprinkler irrigation systems and will cover a large irrigation area more easily than other sprinkler options. • Has the ability to irrigate more than 90% of a chosen area and can be automated. • Need to consider the shape and topography of the area to be irrigated. Centre pivot irrigators irrigate in a circle, while lateral moves require rectangular paddocks to operate. Both systems will cover a range of topographies, however they are not suited to very steep land. • Centre pivot irrigators may be simpler to operate as they are pivoted around a central point (no 'crabbing' issues), however both systems are being used successfully across a range of farms. • Typically the most economically viable of the sprinkler irrigation systems and equally suited to light sandy and heavy clay soils. • Potential for foliar injury needs to be considered and managed. • Can be moved to irrigate a number of different areas, however most farmers end up purchasing one irrigator per area due to the time and effort associated with moving the machines.
Sub-surface irrigation	• Very efficient form of irrigation that also minimises buffer distances and potential for foliar injury. • Soil selection is critical to the effective operation of sub-surface systems. Sandy soils – risk of accessions to the watertable and inability to irrigate the entire paddock. Heavy clay soils – risk of localised watering not spreading to all plants. • Can be automated and operated from a central location, decreasing labour requirements. • Difficultly associated with crop establishment, as irrigation tapes are often too deep to allow seedling emergence. • Potential of clogging of tapes with Class B or C recycled water. Algae management for this reason is also very important. • Systems constantly improving and adoption in the broad acre farming industries is increasing. Technological improvements will ensure that systems become more suited to broad acre farming.

Adapted from Irrigation Management and Systems Choice: A Guide for Dairy Farmers, Department of Primary Industries, Victorian Government, Dairy Australia, Murray Dairy, 2004

While foliar injury is a key concern of sprinkler irrigation systems it can be managed by:

- Irrigating at night - avoiding the heat of the day and therefore high evaporation periods. If night-time irrigation is used, this reduces the available irrigation time, and therefore may require more irrigation area to be developed. This should be factored into any irrigation area modelling undertaken;
- Selecting species that are tolerant of sodium and chloride concentrations; and
- Using drop tubes (tubes that hang down from the centre pivot or lateral irrigator span and drag through the crop applying the water to the soil surface) that effectively apply the irrigation water to the soil surface much like a surface irrigation system.

System performance

Appropriate site selection, system design and management are necessary to achieve performance outcomes for the scheme. A well-designed and regularly maintained irrigation system will continue to perform efficiently into the future.

Irrigation scheduling

Best practice irrigation management is determined by a number of factors:

- Experience – understanding soil and plant conditions that indicate a need for water;
- Local knowledge – being aware of the local environment and knowing how to modify irrigation practices to account for seasonal climatic variations;
- Crop type – understanding seasonal crop water requirements and sensitivity to water stress;
- Utilising irrigation tools – using tools to assess irrigation conditions and crop performance; and
- Understanding risks to surface waters or groundwater – assessing the risks of runoff or leaching.

Irrigation scheduling may involve inspection of soil moisture and plant condition, monitoring of climatic conditions (rainfall and evaporation) and the use of tensiometers, neutron probes or similar to measure soil moisture.

Forage management

The following table provides a range of information on pasture and summer fodder crops that may be irrigated with recycled water.

Pastures	
Perennial Ryegrass	• Temperate; optimum growing temp 18⁰C; grows best at start and end of irrigation season; dependent on effective grazing, irrigation and fertiliser management
Tall Fescue	• Temperate; more tolerant of hot conditions, and responsive to moisture over summer; tolerant of moderately wet and saline soil and is adapted to a wide range of soil pH; most productive when soil fertility high
White Clover	• Requires irrigation or rainfall greater than 700mm; grows on a wide range of soil types provided moisture is available; not suited to highly acidic, alkaline or saline soils; shallow rooted (most roots in top 200mm of soil); sensitive to moisture stress; requires good irrigation scheduling
Lucerne	• Deep rooted, drought tolerant, can be grown in dryland; very responsive to water; greater yields achieved through irrigation; not tolerant of water logging or acidic/high aluminium soils; similar water requirements to other pasture varieties; frequency of irrigation can be extended to nine to ten days (as deep roots permit)
Irrigated summer fodder crops	
Millet	• Not sensitive to low temperatures and water logging; can be sown earlier in spring
Forage Sorghum	• Possibility of prussic acid poisoning
Maize	• High yielding if suitable variety; high water and nutrient use requirements; best suited to pit silage
Turnips	• Prone to moisture stress; irrigation management is important
Rape	• Responds well to irrigation; can tolerate low soil fertility

Adapted from Irrigation Management and Systems Choice: A Guide for Dairy Farmers, Department of Primary Industries, Victorian Government, Dairy Australia, Murray Dairy, 2004

3.7 Environment Improvement Plan Checklist and Monitoring

The Victorian EPA Guidelines for Environmental Management, Use of Reclaimed Water, Publication 464.2 (EPA, June 2003) provides a useful checklist for the development of Customer Site Management Plan (CSMP)/Environment Improvement Plans/Environment Management Plans.

The checklist includes the following information:

- Type of reuse (including quantity and quality of recycled water used);
- Treatment and water distribution reliability controls;
- Plan showing location of key infrastructure, site characteristics, irrigation areas, sensitive environments, monitoring locations and recycled water warning signs;
- Occupational health and safety controls;
- Spray drift controls (if relevant;)
- Access controls – public and/or stock, including withholding periods (if relevant);
- Inspection and maintenance programs;
- Training programs;
- Contingency plans;
- Recycled water monitoring program;
- Reporting program;
- Auditing program;
- Water budget (including irrigation scheduling), nutrient and salt balance calculations;
- Irrigation method, operation and maintenance procedures;
- Winter storage requirements, crop management practices;
- Soil salinity controls (if relevant);
- Leaching controls;
- Buffer requirements;
- Irrigation drainage (if relevant) and stormwater run-off and collection controls; and
- Receiving environment monitoring and reporting programs (including livestock monitoring program – if relevant).

Monitoring associated with recycled water schemes is typically divided into three key segments:

- Baseline – prior to recycled water use. Will generally be extensive so that future monitoring results can be compared against how the property was before use of recycled water commenced;
- On-going – regular monitoring performed during the year. This monitoring can either include all of the parameters monitored during the baseline monitoring, or be restricted to some key indicators of the schemes performance (e.g. salinity, nutrients, hydraulic loading, groundwater); and
- Auditing – undertaken at set intervals, e.g. every 3 or 5 years. Audit monitoring will generally be a repeat of the baseline monitoring undertaken, enabling a formal assessment of changes of the site and scheme performance.

The supplier of the recycled water and regulatory body will determine the baseline, on-going and auditing monitoring requirements for the scheme. Any monitoring obligations of the landholder will be recorded in the CSMP and discussed directly between the landholder and supplier of the recycled water.

3.8 Case Studies

The following case studies highlight the key issues that should be considered when planning and implementing a recycled water scheme. These issues are relevant at both the scheme and irrigator level.

The major issues considered are:

- Shandy requirements - Campaspe Water Reclamation Project, Earth Tech;
- Nutrient balance – Mixed Farming Enterprises;
- Under irrigation – Goulburn Valley Water, Tatura;
- Impact of Drought and Water Conservation Activities - Murray Goulburn, Leitchville; and
- Return on Capital – Greengrove Effluent Irrigation Facility, Dubbo City Council, Hassall and Associates.

Case Study 1 - Shandy Requirements

Campaspe Water Reclamation Project – Earth Tech

The Campaspe Water Reclamation Project services the towns of Echuca and Rochester and provides approximately 1,500 ML/annum of Class B recycled water to a number of dairy and pasture/cropping farms.

The scheme delivers recycled water to more than 1,000 ha of previously irrigated land. To ensure sustainable irrigation is achieved, the scheme has adopted a number of sustainability targets that are strictly enforced. The quality of the recycled water requires it to be shandied (diluted) with existing irrigation entitlements from the Goulburn-Murray Water irrigation system to meet the sustainability targets. A shandy ratio of 3:1 (three parts irrigation water: one part recycled water) is undertaken. These aspects are described in the following table.

Parameter	Target	Median Water Quality
Hydraulic loading - off and on-farm drainage - either on or off-farm drainage - neither	 10 ML/ha/annum 7.2 ML/ha/annum 5 ML/ha/annum	-
Salt	<500 EC (μS/cm) applied	1,400 EC (μS/cm)
Nitrogen	<100 kg/ha/annum	40 mg/l
Phosphorus	<40 kg/ha/annum	11 mg/l

Under average climatic conditions, perennial pasture in the Echuca area has an annual irrigation requirement of approximately 9 ML/ha. Therefore, on average, each hectare of perennial pasture receives approximately 2.25 ML of recycled water. Additional irrigation area is required when irrigating with the shandied system (four times more than if the recycled water was applied straight). This requires significant additional investment in infrastructure, monitoring and reporting.

During the development of the Campaspe scheme, considerable effort was undertaken to ensure that the distribution of recycled water to local pasture and crop farmers would be a valuable and sustainable solution.

It is critical that the planning stages consider the shandy requirements of the scheme and ensure availability of sufficient irrigated land area and on-going access to secure and reliable shandy water.

Case Study 2 - Nutrient Balance

Mixed Farming Enterprises

Achieving nutrient balance with recycled water irrigation can be difficult in some pasture and crop situations. Issues associated with poor agricultural nutrient management are well documented. Recycled water schemes must ensure that nutrient applications are managed in a sustainable manner.

In general terms, dairy pastures have a high demand for nitrogen and phosphorus, with the harvesting of milk from the property providing high levels of nutrient removal (an average dairy farm has maintenance nutrient requirements of approximately 100-120 kg/ha/annum nitrogen and 35-40 kg/ha/annum phosphorus). For the Campaspe Reclamation Project, a nutrient balance would indicate that the dairy farm would be in nutrient deficit provided the recycled water was the only source of nutrients (90 kg/ha/annum nitrogen, and 25 kg/ha/annum phosphorus provided).

However, nutrient demand and removal varies considerably for different crops with the recycled water potentially providing more nutrients than can be utilised by the plant.

Crop	Dairy Pasture	Perennial Pasture	Annual Pasture	Lucerne
Irrigation demand (ML/ha/annum)	6	6	3	6
Recycled water phosphorus concentration (mg/l)	11	11	11	11
Phosphorus loading (kg/ha/annum)	66	66	33	66
Phosphorus Removal (kg/ha/annum)	40	45 (15t hay @ 3kg/t)	30 (10t hay @ 3kg/t)	45 (15t hay @ 3kg/t)
Balance	Excess	Excess	Excess	Excess

Increasing the shandy requirement and spreading the recycled water over a greater area can manage excess amounts of nutrients. Alternatively, growing a crop with a higher nutrient requirement could be considered.

It is critical that the planning stages of a scheme undertake a nutrient balance and consider potential options including cropping system, shandy with alternative water supplies and/or irrigation area.

Case Study 3 - Under Irrigation

Goulburn Valley Water, Tatura

Under irrigation is a practical consequence of most recycled water schemes. This arises, because legislation requires that a greater irrigation area be developed than can be irrigated in all years (to account for climatic variability and ensure maximum use of recycled water).

In Victoria, recycled water irrigation schemes are required to have sufficient winter storage volume and irrigation area to contain recycled water volumes in a 90^{th} percentile year. In NSW, 50^{th} percentile containment is required.

An approved water balance model is used to determine winter storage volume and irrigation area requirements over a 20-year period. In Victoria, the typical period selected is 1971 to 1991 as it contains a good spread of 'average', 'dry' and 'wet' years.

Goulburn Valley Water has undertaken water balance modelling for their Tatura recycled water scheme that has a current recycled water inflow volume of approximately 1,600 ML/annum. The optimum combination of winter storage and irrigation area predicted by the model is approximately 850 ML of storage and 175 ha of irrigation area (perennial pasture, unshandied).

However, analysis of the model demonstrates that full irrigation will only be achieved in five of the 20 years with the lowest year resulting in only 43% of the irrigation requirement being applied. The average volume applied over the period would be 80% of that required. This variable quantity of water can either be managed through a reduction in the area irrigated, or more likely, reduced volumes applied over the whole area leading to a decline in productivity (unless shandy water or another source of water is available to meet the increased requirement).

While recycled water is capable of providing greater reliability of supply (i.e. there will be some water in all years), the volumes will vary between seasons.

The seasonal variability of recycled water volumes needs to be considered in the planning of a scheme and clearly communicated to landholders. On-going communication is essential to ensure that farmers can balance predicted irrigation requirement with recycled water volumes in storage and likely availability during irrigation season.

Case Study 4 - Impact of Drought and Water Conservation Activities

Murray Goulburn, Leitchville

The drought has significantly impacted on recycled water usage declining from 507 GL in 2000-01 to 425 in 2004-05 (ABS, 2006). This decline has primarily been attributed to a reduction in agricultural use, most likely a reflection of the decreases in the availability of water.

The drought has also severely impacted on those recycled water schemes relying on irrigation allocations to shandy with recycled water. In some cases, these allocations have been insufficient to allow the planned shandying to proceed. Schemes managers have had to purchase water to meet the shandy requirements, or negotiate recycled water applications above the sustainability targets for the scheme. The practice of purchasing shandy water has been very expensive (in some cases temporary trade prices have exceeded $1,000/ML).

The drought has also contributed to the declining quality of recycled water. With many households and businesses using water more efficiently there has been less dilution of recycled water contaminants occurring resulting in an increase of salt and nutrient levels.

Murray Goulburn's Milk Processing Factory in Leitchville, has similarly seen an increase in recycled water concentrations from the recycling of water within the factory. The recycled water at Leitchville is a combination of good quality permeate water, and poorer quality treated factory wastewater that contains significant proportions of salt, nitrogen and phosphorus.

The contribution of permeate water and treated factory wastewater has generally been approximately 1 for 1. Following an initiative from Murray Goulburn to recycle the permeate water in the factory the ratio has altered, resulting in a final recycled water product much higher in salt and nutrient concentrations (salinity 2,010 to 2,890 EC; nitrogen 78 to 95 mg/l; phosphorus 23 to 34 mg/l). As a consequence, the shandy for the scheme has increased from 1:5 to 1:8 (recycled water to shandy water) requiring additional irrigation area and shandy water, and in this instance, extension of the recycled water distribution pipeline.

It is critical that the impacts of drought and water conservation be considered during the planning stages. The impacts of water conservation measures should be thought through with a strategy for addressing these consequences established i.e. identify externalities of a project.

Case Study 5 - Return on Capital

Greengrove Effluent Irrigation Facility – Dubbo City Council, Hassall and Associates

The Greengrove Effluent Irrigation Facility is Dubbo City Council's first recycled water irrigation facility and a major infrastructure project. The key elements of the facility include a 1,090 ML winter storage, 12 km of pipeline to the farm, 4.8 km of internal pipelines and 208 ha of irrigation area.

The scheme was developed to utilise recycled water for the production of fodder crops. The total cost of the scheme was in the order of $6.8 million including land purchase, environmental studies, design and pre-construction, groundwater monitoring bores, pipe supply and construction, centre pivots and on-farm infrastructure, pumps and project management.

In 'return on investment' terms, the project will never recover costs. Income generated from the farming operations will contribute to operating costs.

This project highlights that recycled water schemes should be considered more broadly than using a return on investment perspective. The costs and benefits of establishing and operating a recycled water scheme for agriculture need to be considered against any other alternatives.

For the Greengrove scheme, the alternative was constructing a tertiary treatment facility that treated the water to a very high standard, suitable for discharge to the environment. At the time of establishing the Greengrove facility, Council identified a number of drivers for change including:

- Increasingly stringent environment standards and difficulty meeting these standards at the existing treatment plant;
- Encroachment of the urban area towards the existing treatment plant;
- Need to re-centralise Dubbo by growth of urban development in West Dubbo;
- New occupational health and safety standards (the old plant was incapable of meeting these standards and could not be easily modified); and
- Discharge fees to the environment (estimated at approximately $200,000/ annum).

Assessment of these factors, resulted in the recycled water irrigation scheme selected as the most appropriate option. It provides a safe and sustainable recycled water solution that presents minimal risk.

It is critical that the broader economic benefits and costs are considered in the assessment of options for recycled water use. These must consider the costs of alternatives, the environmental and social costs and the concept of fit-for-purpose. Return on investment is a narrow tool for analysing options.

4 Glossary

Algae – Comparatively simple chlorophyll-bearing plants, most of which are aquatic, and microscopic in size.

Anaerobic – Conditions where oxygen is lacking; organisms not requiring oxygen for respiration.

Aquifer – A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water. Aquifers include confined, unconfined and artesian types.

Biochemical oxygen demand (BOD) – The decrease in oxygen content in a sample of water that is brought about by the bacterial breakdown of organic matter in the water (note: BOD5 is the BOD measured over 5 days).

Biodiversity – The variety of life forms, including the plants, animals and microorganisms, the genes they contain and the ecosystems and ecological processes of which they are part.

Blackwater – Water containing human excrement.

Boron – An inorganic chemical that is micronutrient for plants with a narrow concentration range between deficiency and toxicity. Water softeners are an important source in wastewaters. The main impact of boron is toxicity to plants after soil accumulation, especially on finer textured, higher pH soils.

Buffer distances and strips – A transition zone between areas managed for different objectives to minimise detrimental interactions 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).

Chloride – Chloride in recycled waters comes from a variety of salts (including detergents) and is present as an ion (Cl). In addition to its role in salinity, it can be toxic to plants, especially if applied directly to foliage and aquatic biota.

Chlorination – Use of chlorine as a means of disinfection.

Disinfection – The process designed to kill most microorganisms in water, including essentially all pathogenic (disease-causing) bacteria. There are several ways to disinfect, with chlorine being most frequently used in water treatment.

Effluent – The out-flow water or wastewater from any water processing system or device.

Eutrophication – Degrading 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.

Filtration – Process in which particulate matter in water is removed by passage through porous media.

Fit for purpose – safe for intended use.

Greywater – Wastewater from the hand basin, shower, bath, spa bath, washing machine, laundry tub, kitchen sink and dishwasher. Water from the kitchen is generally too high in grease and oil to be reused successfully without significant treatment.

Groundwater – Water contained in rocks or subsoil.

Hazard – A biological, chemical, physical or radiological agent that has the potential to cause harm.

Helminth – A worm-like invertebrate of the order Helminthes. A parasite of humans and other animals.

Impact – Has an effect on endpoints, such as people, plants, soil, biota, water or part of the environment.

Indicator – Measurement parameter or combination of parameters that can be used to assess the quality of water; a specific contaminant, group of contaminants or constituent that signals the presence of something else.

Leaching fractions – The ratio of actual drainage water to irrigation water applied.

Microorganism – Organism too small to be visible to the naked eye. Bacteria, viruses, protozoa, and some fungi and algae are microorganisms.

Monitoring – Systematically keeping track of something, including sampling or collecting information and documenting it.

Nitrification – The oxidation of ammonia nitrogen to nitrate nitrogen in wastewater by biological means.

Nitrogen – An important nutrient found in high concentrations in recycled water, originating from human and domestic wastes. A useful plant nutrient that can also cause off-site problems of eutrophication in lakes, rivers and estuaries. It can also contaminate groundwaters.

Pathogen – A disease-causing organism.

pH – An expression of the intensity of the basic or acid condition of a liquid. Natural waters usually have a pH between 6.5 and 8.5

Phosphorus – An important nutrient found in high concentrations in recycled water, originating principally from detergents but also from other domestic wastes. A useful plant nutrient that can also cause off-site problems of eutrophication in water bodies.

Pollutant – Substance that damages the quality of the environment.

Quality Assurance – All the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality (AS/NZS ISO 8402:1994).

Reclaimed water – Alternative but less accurate term for treated sewage.

Recycled Water – Water generated from sewage, greywater or stormwater systems and treated to a standard that is appropriate for its intended use.

Risk – The likelihood of a hazard causing harm in exposed populations in a specified time frame, including the magnitude of that harm.

Runoff – Surface overland flow of water resulting from rainfall or irrigation exceeding the infiltration capacity of the soil.

Salinity – The presence of soluble salts in soils or waters. Electrical conductivity and total dissolved salts are measures of salinity.

Sewage – Material collected from internal household and other building drains. Include faecal waste and urine from toilets, shower and bath water, laundry water and kitchen water.

Shandying – Addition of one water source to another, which modifies the quality of the water.

Sodicity – This is a condition where the positively charged sodium ions cause the soil particles to repel each other, resulting in soil swelling, dispersion and reduced soil permeability.

Sodium – An element found endemic in the environment. High concentrations of sodium in soil relative to calcium and magnesium cause sodicity (ESP>6 or SAR>3).

Stakeholder – A person or group (e.g. an industry, a government jurisdiction, a community group, the public etc.) that has an interest or concern in something.

Total dissolved solids (TDS) – A measurement of the total dissolved salts in a solution. Major salts in recycled water typically include sodium, magnesium, calcium, carbonate, bicarbonate, potassium, sulphate and chloride. Used as a measure of soil salinity with the units of mg/L.

Toxicity – The extent to which a compound is capable of causing injury or death, especially by chemical means.

Turbidity – The cloudiness of water caused by the presence of fine suspended matter.

Virus – Molecules of nucleic acid (RNA and DNA) that can enter cells and replicate them.

Wastewater – Water which is being disposed after it has been used.

Waterlogging – Saturation of soil with water.

Water recycling – A generic term for water reclamation and reuse. It can also be used to describe a specific type 'reuse' where water is recycled and used again for the same purpose (e.g. recirculating systems for washing and cooling), with or without treatment in between.

Water reuse – Beneficial and planned use of recycled or treated water for specific purposes such as irrigation, industrial or environmental uses especially on-site (e.g. reuse household 'greywater' for garden irrigation.

Watertable – Groundwater in proximity of the soil surface with no confining layers between the groundwater and soil surface.

5 Further Information

5.1 Recycled Water Guidelines

5.1.1 National

National guidelines have been released by the Natural Resource Management Ministerial Council (NRMMC) and, in some cases, in collaboration with the National Health and Medical Research Council (NHMRC) and the Australian Health Ministers Conference.

Hard copies of these guidelines can be ordered from the *Australian Water Association* and some are available as pdf: http://www.environment.gov.au/water/publications/quality/index.html#nwqmsguidelines

The critical guidelines for recycled water of agricultural crops are:

Australian Guidelines for Water Recycling. Managing Health and Environmental Risks (Phase 1) (NWQMS No 21)

Other relevant guidelines are:
Australian Guidelines for Water Recycling. Managing Health and Environmental Risks (Phase 2) (NWQMS No 22)

Australian and New Zealand guidelines for fresh and marine water quality - 2000 (NWQMS no 4)

Australian guidelines for water quality monitoring and reporting – 2000 (NWQMS no 7)

Guidelines for sewerage systems - effluent management – 1997 (NWQMS no 11)

Guidelines for sewerage systems - acceptance of trade waste (industrial waste) – 1994 (NWQMS no 12)

Guidelines for sewerage systems - use of reclaimed water – 1999 (NWQMS no 14)

Effluent management guidelines for dairy sheds – 1999 (NWQMS 16a)

Effluent management guidelines for dairy processing plants – 1999 (NWQMS 16b)

5.1.2 State

Victoria

Publication 464.2, Use of Reclaimed Water - Guidelines for Environmental Management, Environment Protection Agency Victoria, June 2003

http://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256ce90001cbb5/64c2a15969d75e184a2569a00025de63/$FILE/464.2.pdf

Publication 168, Guidelines for Wastewater Irrigation, Environment Protection Agency, April 1991
Available for purchase at EPA Victoria. Not currently available in pdf format.

New South Wales

Environmental Guidelines: Use of Effluent by Irrigation, Department of Environment & Conservation New South Wales, Oct 2004

http://www.environment.nsw.gov.au/resources/effguide.pdf

Queensland

Queensland Water Recycling Guidelines, WaterWise Queensland, Dec 2005

http://www.nrw.qld.gov.au/compliance/wic/pdf/guidelines/recycle/recycle_guidelines.pdf

South Australia

South Australian Reclaimed Water Guidelines: Treated Effluent, Environment Protection Agency and Government of South Australia Department of Human Services, April 1999

http://www.epa.sa.gov.au/pdfs/reclaimed.pdf

EPA Guidelines. Reclaimed Water Irrigation of Pasture for Grazing of Cattle and Pigs, Government of South Australia, August 2005

http://www.epa.sa.gov.au/pdfs/guide_reclaimed.pdf

Western Australia

State guidelines not available (utilise Commonwealth guidelines)

Northern Territory

State guidelines not available (utilise Commonwealth guidelines)

Australian Capital Territory

ACT (1999). ACT Wastewater Reuse for Irrigation — Environment Protection Policy, Environment ACT

http://www.tams.act.gov.au/__data/assets/pdf_file/0015/13515/wastewaterreuseforirrigationepp.pdf

Tasmania

Environmental Guidelines for the Use of Recycled Water in Tasmania, Department of Primary Industries, Water and Environment; National Heritage Trust, Dec 2002

http://www.environment.tas.gov.au/_downloads/em_eppps_egurwt_GRWFINAL.pdf

5.2 Useful References

5.2.1 Recycled Water

Guidelines for Developing Recycled Water Schemes in Horticulture, National Heritage Trust; National Program for Sustainable Irrigation; Horticulture Australia Ltd; Arris

http://www.environment.gov.au/water/publications/urban/pubs/water-use-recycling-hort-guidelines.pdf

Water Recycling in Australia, National Program for Sustainable Irrigation; Horticulture Australia Ltd; Arris, April 2006

http://downloads.lwa2.com/downloads/publications_pdf/PX061130.pdf

Radcliffe J, 2004. Water Recycling in Australia. Australian Academy of Technological Sciences and Engineering, Parkville, Victoria.

Stevens, D.P. 2006. Growing crops with reclaimed wastewater. CSIRO Publishing, Melbourne, Australia.

5.2.2 Irrigation Management

Irrigation Management and Systems Choice: A Guide for Dairy Farmers, Department of Primary Industries, Victorian Government, Dairy Australia, Murray Dairy, 2004

Crop evapotranspiration – guidelines for computing crop water requirements 1998, FAO 56 Irrigation and Drainage Paper

5.3 Websites

National Coordinator for Reclaimed Water Development in Horticulture

www.recycledwater.com.au

National Program for Sustainable Irrigation

www.npsi.com.au