South Australian
Reclaimed Water Guidelines

Treated Effluent

The Department of Health and

Environment Protection Agency
Government of South Australia

Cover Photograph: Leigh Creek School Oval Irrigated with Effluent

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FOREWORD

This publication, *South Australian Reclaimed Water Guidelines (Treated Effluent)*, has been prepared on behalf of the Environment Protection Authority (the Authority) and the Public and Environmental Health Council (the Council) by the Environment Protection Agency (EPA) and the Department of Health (DH).

The Authority was established under the provisions of the *Environment Protection Act 1993*. One of the aims of the Authority is to facilitate cooperation and collaboration with the general community, industry and public authorities to achieve its environmental goals through the development, acceptance and implementation of guidelines.

The Council was established under the provisions of the *Public and Environmental Health Act 1987* with a function to initiate, carry out or oversee programs and activities designed to improve public and environmental health. The Public and Environmental Health Act empowers the Council to issue guidelines to assist in the administration of that Act.

These guidelines are endorsed by the Authority and the Council.

Reclaimed water from the treatment of sewage effluent can be used for many purposes to reduce the demand on freshwater supplies and to reduce the need for disposal of this effluent onto land or into receiving waters. The *South Australian Reclaimed Water Guidelines (Treated Effluent)* describes methods by which reclaimed water can be used in a sustainable manner without imposing undue risks to public health or the environment. It considers the use of reclaimed water for agricultural, municipal, residential (non-potable), environmental, and industrial purposes. It provides information on the quality of reclaimed water required for each use, treatment processes, system design, operation and reliability, site suitability, and monitoring and reporting.

This publication does not contain mandatory provisions and is not a prescribed code but compliance is recommended to those proposing to use reclaimed water. Provisions of this publication could be incorporated in a licence issued pursuant to the Environment Protection Act or an approval issued pursuant to the Waste Control Regulations of the Public and Environmental Health Act.

This publication does not supercede or override the *Standard for the Construction, Installation and operation of Septic Tank Systems in South Australia* nor supplements A *Aerobic Sand Filters* and B *Aerobic Wastewater Treatment Systems.*

CONTENTS

GLOSSARY OF TERMS

Alarm	An instrument or device which continuously monitors a specific function of a treatment process and automatically gives warning of an unsafe or undesirable condition by means of visual and audible signals.
Biosolids	The solids removed from wastewater by primary and secondary treatment.
BOD	Biochemical oxygen demand (usually BOD_5) — a measure of the quantity of oxygen used in the biochemical oxidation of organic matter in a period of 5 days under specified conditions.
Chlorination	The application of chlorine to water, wastewater or industrial waste generally for the purpose of disinfection.
Coagulation	The aggregation of very small suspended particles (<0.1 mm) into small visible particles (0.1–1.0 mm) by adding a chemical coagulant.
Disinfection	A process which destroys, inactivates or removes pathogenic micro-organisms.
Dual reticulation system	Two separate and distinct piping systems, one of which is used to transport water for potable use, the other for non-potable uses.
Effluent	The water discharged following a wastewater treatment process (eg secondary effluent).
Faecal coliforms	Thermotolerant coliform organisms mainly indicating faecal pollution. *Escherichia coli* is generally the dominant species.
Groundwater recharge	Replenishing of groundwater naturally by precipitation or runoff or artificially by spreading or injection.
Impoundment	Enclosed waterbody.
Lagooning	Storage in treatment ponds for purification of primary or secondary treated effluent. The processes of sedimentation and biological oxidation usually take place.
Licensing or approving authority	As appropriate the South Australian Health Commission or the Environment Protection Authority.
NATA	National Association of Testing Authorities.
Non-potable water	Water not suitable for human consumption eg by drinking, cooking.
NTU	Nephelometric turbidity unit — unit of measure of the turbidity of water due to suspended, colloidal and particulate matter, measured using a nephelometer.
Open access	Public access permitted to areas where reclaimed water is in use.
Passive recreation	Recreation activities such as picnicking and fishing which do not involve bodily contact with the water.
Pathogens	Micro-organisms that can cause infection or illness.
Potable water	Water suitable for human consumption eg by drinking, cooking.

Primary contact recreation	Recreational activities involving the immersion of a person in water, eg swimming, surfing, skiing. It has been estimated that ingestion could be as much as 100 mL / person / day.
Primary treatment	Wastewater treatment involving sedimentation (sometimes preceded by screening and grit removal) to remove gross and settleable solids. Sludge is removed and treated separately.
Reclaimed water	Water which has been derived from sewerage systems (including STEDS) and treated to a standard which is satisfactory for its intended use.
Residential reuse	Use of reclaimed water at individual residences.
Restricted access	Where reclaimed water of lesser quality than Class A is irrigated, access by the public will be restricted as specified in sections 2–7.
Secondary contact recreation	Recreational activities involving limited bodily contact with water, such as boating, wading.
Secondary treatment	Treatment of primary effluent by biological aerobic processes to remove organic matter, usually followed by separation of solids from the liquid (clarification).
STEDS	Septic tank effluent disposal scheme.
Suspended solids (SS)	Filterable material suspended in water or wastewater.
Tertiary treatment	The treatment of wastewater beyond the secondary biological stage. This normally implies the removal of a high percentage of dissolved and suspended solids followed by disinfection. It may also include additional processes such as filtration.
Total dissolved solids (TDS)	The inorganic salts (major ions) and organic matter (nutrients) that are dissolved in water; used as a measure of salinity.
Trade waste management programme	A comprehensive programme to monitor and control wastes of non-domestic origin entering a sewerage system.
Turbidity	A condition in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light; any suspended solids imparting a visible haze or cloudiness to water, which can be removed by filtration; an analytical quantity usually reported in turbidity units determined by measurements of light scattering.
Urban reuse	Use of reclaimed water for applications in the urban area excluding use within private residences.
User	A person or organisation with approval to use reclaimed water.
Vector	An insect or animal (often a rodent) capable of carrying disease causing organisms from one site to another. Mosquitoes are the main vectors of concern in use of reclaimed water.
Wastewater	Water collected and transported through sewers and STEDS. Wastewater normally includes water from both domestic and industrial sources.

INTRODUCTION

The demand for water increases each year as urban and rural development continues. In the past the focus has been on providing fresh groundwater and surface water for domestic, municipal, industrial and agricultural purposes.

Opportunities for ecologically sustainable development can be pursued by the more efficient use of traditional sources of fresh water and by the increased use of alternative resources such as reclaimed water. However, reclaimed water from the treatment of sewage effluent requires extra management to ensure sustainability. These guidelines describe this management.

Reclaimed water can be used for many purposes including agricultural and municipal irrigation to reduce the demand on freshwater supplies. Its use can defer the need to establish new or enlarged water storages and new or enlarged water treatment plants.

These guidelines establish acceptable levels of constituents of reclaimed water for a variety of uses and describe means for assuring reliability in production so that using reclaimed water does not impose undue risks to health and the environment.

These guidelines will help facilitate the design, approval and subsequent licensing of works that use reclaimed water if you are planning to use reclaimed water: to irrigate recreation areas that are accessible to the public or land used for agricultural and forestry purposes; for certain approved recreational and municipal purposes; or for industrial purposes.

The guidelines do not consider the use of reclaimed water for potable (drinking quality) supplies, hydroponics or food grade aquaculture. The guidelines also do not consider the use of stormwater or domestic greywater.

These guidelines discuss factors which the approving authorities believe are important to ensure safe and environmentally acceptable reuse but, at the same time, are sufficiently flexible to permit a variety of cost-effective applications. They also outline the treatment processes and facilities to be used, and the conditions likely to be attached to the approval and licence for the commissioning of a reuse proposal.

These guidelines are intended to be complementary to the *Draft Guidelines for Sewerage Systems — Use of Reclaimed Water* (National Water Quality Management Strategy 1996).

Initial considerations for reuse schemes

The procedure for site assessment and evaluation of reclaimed water schemes is comprehensive. Seek local knowledge and relevant expertise to assess the feasibility of any proposal.

Do not proceed with a detailed investigation until you have established that:

- the site is potentially suitable for the intended use
- reclaimed water quality is suitable for the purpose required
- the proposed use is consistent with the development plan.

For instance, high salinity of reclaimed water may preclude irrigation of certain crops.

Public acceptance and community consultation

Public acceptance is important for projects involving use of reclaimed water. While there is general support for the concept there are also some concerns. Community consultation is an important part of alleviating concerns and promoting the beneficial uses of reclaimed water.

Where the use of reclaimed water is proposed, the community, particularly those adjacent to the proposed site(s), should be informed about the extent of reuse and the benefits as well as the responsibilities of users to comply with licence or approval conditions including water quality requirements, public access restrictions and restrictions on use or methods of application.

How to use the guidelines

The guidelines are arranged in sections:

Section 1 General requirements contains information relating to all uses of reclaimed water.

Sections 2–7 Specific requirements contain information relevant to specific applications.

Section 8 Aquifer storage and recovery contains information relevant to this technology.

Section 9 Winter storage contains information relevant to the need, design and operation of buffering storages.

Section 10 Irrigation management plans contains information relevant for applications that require an Environment Protection Authority licence.

As a generalisation, schemes proposing to use reclaimed water which involve greater potential risk to public health and the environment will be subject to greater scrutiny.

For further information contact the Environment Protection Agency (EPA) or the Department of Health (DH).

Government agencies that can provide advice or have regulatory authority

For each of the relevant major government agencies, the relevant section and a contact telephone number are as follows:

Department of Health (DH)

Health risks Approval of systems	Environmental Health Service (08) 8226 7100

Environment Protection Agency (EPA)

Approval of systems Licences Approval of irrigation management plans	Operations Branch (08) 8204 2097

Primary Industries and Resources, SA (PIRSA)

Control of stock movement and fodder for cattle etc.	Chief Veterinary Officer (08) 8226 0222
Irrigation and crop requirements	Regional Irrigation Adviser/Agronomist
Aquaculture	Manager (Aquaculture) (08) 8226 2326 or local district office
Groundwater	(08) 8274 7500

Obtain planning regulations from the local government office in your district.

The approval process

For all proposals for use of reclaimed water consult the EPA on the need for an environmental authorisation, an irrigation management plan **(see section 10)** and public health requirements.

If the proposal does not require an environmental authorisation consult the DHS on the public health requirements and system approval.

If the proposal involves stock grazing or aquaculture consult PIRSA.

Include in the proposal information that demonstrates compliance with general provisions (**section 1**) and with the provisions specific to the proposed use as may be appropriate, considering use and the scale of the system (**sections 2–7**).

Once an outline of a proposal has been assembled, consult the appropriate government agencies for advice.

The following list provides an indication of the type of information needed in the proposal:

- source of reclaimed water
- reclaimed water treatment facility
  - type of treatment process
  - volume and characteristics of reclaimed water
  - size of population connected and growth trends
  - discharge location (if any)
- measures for ensuring the protection of the health of the public and employees
- any requirement for storage of reclaimed water, method of storage and storage capacity
- depth to watertable at the storage area
- quality of groundwater and any current use
- treatment and reticulation systems
- proposed system controls including timers, alarms, distribution safeguards, runoff collection provisions and maintenance programmes
- management and monitoring.

Additional information may be required for irrigation with reclaimed water:

- proposed method of application of reclaimed water
- measures for ensuring protection of surface and groundwater
- topography and area of irrigation site, soil stratigraphy and preparation of a soil map
- a water balance including climate variables, proposed application rates, average evapotranspiration and percolation rates, all on a monthly basis
- salt and nutrient balance
- proximity of the irrigation site to wells, watercourses or other surface waters, dwellings, public areas and public roads, as may be applicable
- risk of flooding of the site
- types of crop, pasture or vegetation and their ultimate use, if applicable.

1 GENERAL REQUIREMENTS

1.1 Responsibilities

Reclaimed water quality

The user has the responsibility for the use and quality of the reclaimed water

Preclusions to use

Do not draw reclaimed water from the distribution system for use other than for the approved purpose.

Do not use reclaimed water for the following purposes:

- drinking, cooking or kitchen purposes
- baths, showers or personal washing
- clothes washing
- swimming pools
- washing, packaging or processing of food for sale or distribution
- pork production.

Hydroponics and food chain aquaculture

The use of reclaimed water for hydroponics or food chain aquaculture is not specifically covered by these guidelines. Authorisation will be addressed for each proposal.

Domestic greywater reuse

Reuse of greywater is not covered by these guidelines. Authorisation will be addressed for each proposal.

1.2 Reclaimed water quality — Summary

The major risk of human contact with wastewater is infection from micro-organisms. Human pathogens that may be present in wastewater include types of bacteria, viruses, helminths and protozoa. Helminths and protozoa are sometimes combined under the heading of intestinal parasites. In general the microbiological quality of the reclaimed water determines the use allowed. The degree of public contact has also been used as a criterion for determining the quality required for some uses. Table 1.1 summarises the classes of reclaimed water to be recognised in South Australia and the acceptable uses for each classification

These criteria are minimum requirements and for some specific applications additional chemical and microbiological criteria may be imposed.

1.3 Reclaimed water treatment processes

Untreated and primary treated wastewater

Wastewater treatment reduces the numbers of disease causing organisms. Untreated wastewater is not to be used, and primary treated wastewater will rarely be approved for reuse.

Minimum requirements

The minimum treatment for reclaimed water is:

- primary sedimentation or an equivalent process for removal of solids, plus a stabilisation process such as lagooning

  or

- full secondary treatment.

Treatment processes

PRIMARY TREATMENT

Essentially a sedimentation process with or without chemical assistance which removes about 50% of the suspended solids (SS).

SECONDARY TREATMENT

Removes dissolved and suspended organic material by biological oxidation and sedimentation. Processes include activated sludge, trickling filters and oxidation ditches, all with secondary sedimentation, and lagoons or oxidation ponds.

Secondary effluent generally has biochemical oxygen demand (BOD) < 20 mg/L, and SS < 30 mg/L which may rise to > 100 mg/L due to algal solids in lagoon or pond systems.

TERTIARY TREATMENT

Removes further suspended solids and pathogenic organisms. Processes include filtration (conventional and membrane) and detention in lagoons or wetlands.

All treatment processes lead to some reduction in the numbers of pathogens. Specific pathogen reduction can be achieved by chemical or ultraviolet (UV) disinfection or by detention in lagoons.

TREATMENT LAGOONS

Detention in lagoons or wetlands, after primary treatment, can reduce the number of pathogens. The longer the detention the greater the reduction. A minimum detention time of 25 days removes helminth eggs. Detention in a multiple lagoon system for 20–25 days should provide effluent containing less than 1000 thermotolerant coliforms (or *E. coli*) / 100 mL while more than 60 days could be required to remove intestinal protozoa and viruses. Longer detention times may be required in cooler climates.

DISINFECTION

Disinfection methods currently in use in Australia include lagooning (sunlight photo-oxidation and natural dieoff), chlorination, UV irradiation and chlorine dioxide. Any proposed disinfection method must demonstrate inactivation of all types of disease-causing organisms considered to represent a risk associated with the proposed reuse. Generally disinfection is the final step in a treatment process train.

ALTERNATIVE PROCESSES

Alternative treatment processes will be considered providing they can be shown to reliably achieve the required quality of effluent.

Treatment lagoon design

Design, construct and operate treatment lagoons so as to achieve the microbiological goal and to prevent the release of any floatable matter. Take care to prevent short-circuiting by using baffles and other design features or by using multicell lagoons. Lagoons should also

Table 1.1 Classification of reclaimed water for use in South Australia.

Class	Uses[a] (relevant section)	Microbiological criteria therm coliforms (or *E. coli*)/100 ml (median)[b]	Chemical/physical criteria (mean)[b]	Typical treatment process train
A	Primary contact recreation (5) Residential non-potable (4) - garden watering - toilet flushing - car washing - path/wall washing Municipal use with public access/adjoining premises (3) Dust suppression with unrestricted access (3) Unrestricted crop irrigation (2)	< 10 Specific removal of viruses, protozoa and helminths may be required.[c]	Turbidity ≤ 2 NTU BOD < 20 mg/L Chemical content to match use	Full secondary plus tertiary filtration plus disinfection Coagulation may be required to meet water quality requirements
B	Secondary contact recreation (5) Ornamental ponds with public access (3) Municipal use with restricted access (3) Restricted crop irrigation (2) Irrigation of pasture and fodder for grazing animals (2) Washdown and stockwater (2) Dust suppression with restricted access (3) Fire fighting (3)	< 100 Specific removal of viruses, protozoa and helminths may be required.[c]	BOD < 20 mg/L[d] SS < 30 mg/L[d] Chemical content to match use.	Full secondary plus disinfection
C	Passive recreation (5) Municipal use with restricted access (3) Restricted crop irrigation (2) Irrigation of pasture and fodder for grazing animals (2)	< 1000 Specific removal of viruses, protozoa and helminths may be required.[c]	BOD < 20 mg/L[d] SS < 30 mg/L[d] Chemical content to match use	Primary sedimentation plus lagooning or Full secondary (Disinfection if required to meet microbiological criteria only)
D	Restricted crop irrigation (2) Irrigation for turf production (2) Silviculture (2) Non food chain aquaculture (2)	< 10 000 Helminths need to be considered for pasture and fodder[c]	Chemical content to match use	Primary sedimentation plus lagooning or Full secondary

[a] Restrictions, where indicated, are specified in sections 2–7.

[b] See Analysis of data in **section 1.8**

[c] Treat Class A reclaimed water to reduce the risk of infection from all types of potential human pathogens. The risk associated with the possible presence of intestinal parasites and viruses in Classes B–D reclaimed water depends on use eg the helminth *Taenia saginata* represents a risk to cattle (beef measles) and should not be present in reclaimed water used to irrigate pasture or for stock water for cattle.

[d] Filter lagoon effluent samples for analysis and determine soluble BOD; suspended solids may contain algae and need not be measured.

(2)–(5) Section numbers of the Reclaimed Water Guidelines.

be designed and constructed to prevent contamination of groundwater and to avoid flooding and overflows. Seek appropriate expert advice. Once constructed and operating, an adequate inspection and maintenance programme for lagoons is essential to ensure their continued satisfactory operation.

Treatment process trains to achieve Classes A–D

Class A reclaimed water typically requires full secondary treatment, plus tertiary filtration plus disinfection. Coagulation may be required for the reclaimed water to meet the turbidity requirement. Providing the turbidity requirement is satisfied the reclaimed water should be essentially free of pathogens after disinfection.

Class B reclaimed water typically requires full secondary treatment plus disinfection with an assurance that suspended solid levels are not exceeded.

Class C reclaimed water typically requires either primary sedimentation followed by lagooning or full secondary treatment. Disinfection may be required to meet the microbiological criteria.

Class D reclaimed water typically requires either primary sedimentation followed by lagooning or full secondary treatment.

1.4 Wastewater treatment plant operation — System reliability

It is essential that wastewater treatment plants (WWTPs) and associated distribution systems operate reliably and consistently to provide reclaimed water of the specified quality and quantity. Give careful attention to reliability during design, construction and operation. Fallible elements include:

- the power supply
- individual treatment units
- mechanical equipment
- maintenance programmes
- operational personnel.

Training

Provide each treatment plant with sufficient appropriately trained personnel to operate the facility to achieve the required level of treatment at all times.

Operations manual

Develop an operations manual that is available to all staff.

Detection of process failure and emergency procedures

Develop procedures to detect process failure. These could include regular site visits or automatic alarm devices. In general the higher the class of reclaimed water the more exacting the detection procedures. Develop emergency responses to respond to all reasonable types of failure.

Specific requirements for emergency response procedures, automatic alarms and control devices applicable to each proposal may be specified by the licensing authority.

Backup power supply

A standby power source may be needed to achieve the requirements of Detection of process failure and emergency procedures.

Emergency storage and disposal

Provide facilities for the diversion or emergency storage and retreatment of effluent which fails to meet the reclaimed water quality standards.

Short term retention or disposal provisions used as a reliability feature, shall consist of facilities reserved for the purpose of storing or disposing of untreated or partially treated wastewater for at least a 24-hour period. The facilities shall include all of the necessary diversion devices, provisions for odour control, conduits, and pumping and pump back equipment.

Where public health or environmental risk due to failure are high, provision for long term storage or disposal may be required.

Maintenance

TREATMENT PLANT

Provide a preventative maintenance programme at each treatment plant to ensure that equipment is kept in a reliable operating condition.

PUMPING STATIONS

Maintain pumping stations to a suitable standard and visit them at least weekly. Keep mechanical and electrical maintenance histories.

DISTRIBUTION SYSTEM

Isolate and repair bursts as soon as possible.

Keep a register of bursts / leaks including parameters such as exact location, cause, time of occurrence, response time and repair time. Make this register available to the licensing authority upon request.

Ensure valves and fire plugs and scours are maintained in operational condition.

Contingency

GENERAL

Develop contingency plans for events of non-compliance as per the terms of the approval given by the licensing authority. Report any such event.

Contingency plans should cater for but not be limited to the following events:

- burst mains
- treatment plant failures.

NON-COMPLIANCE WITH HEALTH PARAMETERS

Report any events involving significant exceedance of health parameter criteria immediately to the DHS and EPA. Events could include, but not be limited to:

- disinfection system failure
- excessive numbers of thermotolerant coliforms (or *E. coli*)
- high suspended solids or turbidity
- chemical pollutants.

Specific health alert conditions or levels will be negotiated on a case by case basis as part of the licensing or approval process.

Operating records

Maintain operating records at the WWTP including results of all specified analyses required, and records of operational problems and plant or equipment breakdowns, of diversions to emergency storage or disposal, and of corrective or preventative actions taken.

Commissioning procedures

During commissioning do not provide reclaimed water for its intended use until satisfactory operations are achieved.

Following commissioning, the WWTP may be required to undergo a period of quality assurance. During the commissioning and quality assurance testing period, monitor at the frequency specified in the approval.

Fully test the operation of all equipment and the WWTP as a whole during commissioning.

Bypass

Design the treatment plant so that bypassing of untreated or partially treated wastewater direct to the point of use is not possible. Report immediately any discharge of untreated or partially treated wastewater to the area, and the cessation of same, by telephone to the EPA, DH and the local health authority.

Trade waste management programme

Wastes discharged to the wastewater collection system should be able to be treated by conventional treatment processes to provide water of sufficient quality for reuse. An appropriate strategy for minimising concentrations of contaminants discharged in trade waste will increase its potential for reuse.

1.5 Physical plant and equipment

Cross connection control and backflow prevention

A fundamental principle in the design of reclaimed water distribution systems is to maintain separation of the reclaimed water and potable water systems to avoid potential health risks from cross connection.

No connection of the reclaimed water system into the potable supply system shall be permitted. If potable water is supplied into the reclaimed water system as make-up water, an approved air gap or backflow prevention device meeting the requirements of AS 3500–1992 National Plumbing and Drainage Codes Part 1 must be installed in the potable supply at the point where it enters the reclaimed system. If it is practical to do so, reduce the risk of backflow further by operating the reclaimed system at a lower pressure than the potable system. Consult the local water authority for advice.

Identification

Clearly identify distribution systems so they cannot be mistaken for any system used to convey potable water, and do not lay them closer than 300 mm from potable water pipes.

All above-ground and buried facilities in areas of public access shall be distinctively colour-coded (deep purple) and / or marked with the words:
WARNING: RECLAIMED WATER — DO NOT DRINK.

In certain circumstances these conditions can be replaced by increased signage as in Warnings in **section 1.6**.

Taps and hoses

Ensure hose fittings connected to the reclaimed water system are of a different pattern to those on the potable water system or are distinctively marked or colour coded (see Identification section above) so that the two are not interchangeable.

Plumbing codes

All plumbing and drainage shall comply with AS 3500–1992 National Plumbing and Drainage Codes Parts 1 and 2, and to SA variations and additional provisions to this code. Advice can be obtained from SA Water.

Draining or flushing of pipes

Irrigation pipes should be capable of being drained or completely flushed to allow odorous effluent or decomposing matter to be run to waste before beginning any application. This would typically be required following an extended period of time during which the scheme was not used. To reduce effluent loss and improve supply reliability in the event of burst pipes etc provide adequate valving in pipelines to allow isolation of sections for repairs and subsequent recharging.

Drainage and flushing may also be required to allow the disposal of effluent that does not comply with prescribed guidelines and is not to be used.

The number of valves and provision for drainage and flushing facilities will be influenced by the size of the effluent distribution schemes. Larger schemes with larger supply pipes require more extensive valving and drainage facilities.

ISOLATION

Install line valves to enable sections of main to be isolated during periods of repair, alteration or replacement. Install an adequate number of valves to segment larger supply mains from smaller distribution mains and to divide the distribution system into smaller blocks or subsystems.

DRAINAGE

Install scour valves and air release valves as required to allow effluent to be drained and air to be bled from pipelines. Valving also allows the alignment of the pipelines to be determined.

Air valves are typically located:

- at high points in the system
- adjacent to line valves to facilitate charging of the main.

Scour valves are typically located at low points in the system to facilitate drainage.

Drain reclaimed water mains in a controlled manner to avoid environmental pollution. When draining reclaimed water mains the options for disposal should be in the following order:

- to land (subject to approval by licensing authority)
- to sewer (subject to SA Water / United Water approval)
- to STEDS (subject to local council approval)
- to stormwater (subject to licensing authority approval).

Depending on the size of the scheme specific disposal sites may need to be included in the design of reclaimed water reticulation systems as per the approval given by the licensing authority.

Disinfection

Where disinfection of a reclaimed water main is required to remove pipe growths it shall be done in a controlled manner.

In situ pressure testing

Provide pressure tappings to permit *in situ* testing for correct operation.

Controls on public access

Lock, fence or enclose as necessary to prevent unauthorised access or interference with all waste treatment facilities, pumps, valves and controls.

Vector control

Design and maintain treatment facilities, distribution systems and storages so that the development of pests such as mosquitoes is not supported.

Odour control

Control odour emission during distribution so that nuisance or offensive conditions are not created.

Inspection

Establish a systematic inspection procedure for all properties served by reclaimed water to verify compliance with the irrigation management plan (IMP) and systems are being adequately maintained. Such an inspection should be performed on any change of ownership.

Algae

Algae are likely to flourish in stored reclaimed water because of the available nutrients and may clog the distribution system. Screen or filter where this is likely to create a problem or provide suitable mechanisms to clean and flush the system.

1.6 Control at site of application

Generally, the higher the quality of reclaimed water the lower the requirement for site controls.

Warnings

Wherever reclaimed water is used, erect prominent warning signs indicating RECLAIMED WATER BEING USED — DO NOT DRINK. Additional signage could be required for specific uses of Class B, C or D reclaimed water as indicated in s**ections 2–7**.

Public access

No restriction of public access is required when Class A reclaimed water is used. Restrictions on public access or limits on irrigation times could be required for specific uses of Class B, C or D reclaimed water as indicated in **sections 2–7**.

Enclose any unroofed storage of reclaimed water with a lower quality than Class A to restrict public access or signpost to warn against swimming (Class B) or swimming, wading and boating (Class C and D).

Spray drift control

As a general practice minimise airborne drift when using Class A reclaimed water but there are no specific restrictions required.

When using Class B, C or D reclaimed water, prevent airborne drift into residential areas and areas of public access using means such as tree screens, buffer zones and anemometer switching systems. The need to prevent spray drift on to roads and road reserves will depend on the level of public traffic at the times of irrigation. Protect picnic areas, barbecue facilities and drinking fountains from reclaimed water and reclaimed water spray.

When spray irrigation is used, establish buffer zones from the edge of the wetting area between the application site and dwellings or public areas. Where possible direct sprays away from dwellings and public areas and use devices that minimise the production of fine mists.

The standard buffer zone for spray irrigation with Class B reclaimed water is 30 metres, with Class C reclaimed water 50 metres and with Class D reclaimed water 100 metres. Buffer zones can be reduced by using:

- low rise (7–10°) sprinklers
- small throw or microsprinklers
- part circle sprinklers
- tree / shrub screens
- anemometer switching systems
- night time watering.

For example the use of microsprinklers or 180° part circle sprinklers together with tree / shrub screens with Class B reclaimed water could reduce the required buffer zone from 30 metres to 5–10 metres.

Control of runoff

Install and operate irrigation systems so that surface runoff and ponding do not occur. Locate application sites so that there is no impact on natural watercourses and wells.

Site suitability

An ideal site for the irrigation of reclaimed water is one that:

- has a slope of no more than 10%
- has permeable, well-drained soil
- provides adequate protection for groundwater
- is not prone to frequent flooding.

Application rate

Apply reclaimed water to land in accordance with crop requirements for nutrients and tolerance levels to any toxicant. The volume of water applied should not exceed that used by the crop or lost via evaporation or deep drainage to prevent waterlogging within the rootzones. Seek expert advice for the design and management of the irrigation system as outlined in **section 10**.

1.7 Health risks, hygiene and occupational safety

The restrictions on application methods and requirements for specified quality of reclaimed water for various uses are to ensure that risks to health are minimised.

Personal hygiene

There are potential health hazards associated with the use of reclaimed water. These arise from the pathogens that may be present in raw sewage which are removed to varying degrees during treatment processes.

Persons engaged in any operation involving wastewater and the use of reclaimed water should practice the following:

- Wash hands well with soap before eating, drinking or smoking, and at the end of the working day.
- Do not consume food or drink, and do not smoke while working with reclaimed water.
- Wear / use equipment appropriate to tasks being undertaken.
- Avoid drinking reclaimed water, and high exposure to and inhalation of spray.

Occupational health, safety and welfare

Instruct all employees and others exposed to effluent in appropriate health and safety procedures pursuant to the *Occupational Health Safety and Welfare Act 1986* and Regulations.

Provide appropriate facilities such as wash basins.

1.8 Monitoring and reporting — Reclaimed water

Monitoring

Effluent quality and quantity may change with time as a result of the seasonal nature of some industries or changes to production or treatment processes. Monitor reclaimed water regularly to maintain quality assurance and compliance with the approved IMP.

The range of parameters to be tested depends on the specific use (see **sections 2–7**), the source of the reclaimed water (eg urban or rural) and the volumes to be used. Conduct monitoring intensively during commissioning and routinely (and less frequently) thereafter, unless conditions change, at which time the frequency should increase.

Ideally coordinate sampling with season changes and periods of peak use.

In general, monitor using samples collected from the point of entry to the reclaimed water distribution system.

Specific requirements for monitoring applicable to each proposal may be provided by the licensing authority prior to approval.

Monitoring groundwater, surface water and soil

Groundwater is a high value resource. Assess the characteristics of groundwater that might be affected by any use of reclaimed water. Depending on this assessment, monitoring may be required.

Prevent runoff into surface waters where reclaimed water is applied to land. If runoff into surface water is suspected, regular monitoring could be required to measure the impact.

When reclaimed water is used for irrigation, monitor soil quality to ensure that no harm is being done to soil structure and chemistry.

See **section 10.5** for more details.

Analysis of data

The principle in assessing data is the production of reclaimed water of a consistent quality. Investigate treatment processes if variability in data indicates that this is not being achieved.

Assess microbiological data in terms of median values over agreed periods. Where the median value complies to that prescribed, further investigations should be undertaken if more than 20% of results exceed four times the prescribed median.

Assess chemical data in terms of mean values over agreed periods.

Microbiological

Reclaimed water is routinely tested for numbers of thermotolerant coliforms (or *E. coli).*

Turbidities and disinfectant concentrations (or UV light transmittance) also provide a measure of processes used to remove pathogenic organisms. Tests can be performed on samples or the parameters can be monitored continuously. Continuous monitoring is normal practice when the aim is to produce Class A reclaimed water.

Chemical and physical criteria

Routinely test reclaimed water for compliance with the determinants specified in Table 1.1 eg BOD and suspended solids for Class B reclaimed water.

Chemical pollutants

Measure concentrations of specific chemical pollutants identified by the approval authority during commissioning and thereafter as directed.

Testing methodology

All testing shall be conducted by a laboratory accredited by National Associationof Testing Authorities (NATA) or approved alternative for the performance of such tests.

If any non-compliance is detected in reclaimed water quality, test repeat samples and take appropriate corrective action.

Reporting

Advise the approving authority and the DH when the reclaimed water scheme is commissioned and provide copies with a copy of test results from the commissioning and at regular periods during subsequent operation (generally annually).

2 AGRICULTURAL IRRIGATION

This section is to be read in conjunction with the General Requirements (section 1).

2.1 Introduction

These guidelines are for:

- irrigation of food and non-food crops
- pasture and fodder for grazing animals
- stock water
- washdown water for stockyards and non-food contact areas of dairies.

Irrigation of crops has great potential for large scale use of reclaimed water. Potential health risks are associated with direct ingestion of food crops irrigated with reclaimed water and with incidental exposure to aerosols generated by spray irrigation. The risks can be minimised using a combination of treatment and site controls. The nature of the crop can influence the level of risk. For example crops consumed raw, such as lettuce represent a much higher risk than crops processed before consumption or non-food crops such as turf. A summary of requirements for specific crops irrigated by reclaimed water is contained in Table 2.1.

When using reclaimed water in association with grazing animals control of helminths is a high priority. Risks can be minimised using processes that remove helminths from effluent (see Helminth controls for use with cattle in **section 2.2**). Withholding periods for pasture are required to reduce risks from other pathogens (see Withholding periods for pasture and harvesting controls for fodder in **section 2.2**). Alternatively fodder grown using reclaimed water should be ensiled or dried. Do not use reclaimed water in association with pork production.

2.2 Specific requirements

Chemical quality — Crops, pasture and fodder

As a first step it is suggested that a limited number of characteristics could be examined to evaluate the suitability of reclaimed water for irrigation of crops. The variables include:

- TDS (Tables A.1 and A.2)
- boron (Table A.3)
- chloride (Tables A.4, A.5 and A.6)
- sodium adsorption ratio (SAR) (Table A.7)
- pH (Table A.8)

If on the basis of these initial analyses the reclaimed water appears to be suitable for crop irrigation then further parameters may need to be examined including:

- heavy metals and trace elements (Table A.8)
- nutrients (see Nutrients in **section 10.4**)
- pesticides (Table A.9)
- organochlorines
- polyaromatic hydrocarbons
- monocyclic hydrocarbons
- disinfection by-products (depending on mode of disinfection).

It is unlikely, for most proposals, that concentrations of all the chemicals listed above will need to be determined. The range will depend on a number of factors including the specific use, the origin and characteristics of the wastewater before treatment and the volumes to be used. Assessing the characteristics of wastewater requires a **catchment survey** to determine the non-domestic types of wastes received by the system. These could include, for example, agricultural, chemical, electroplating, engineering, manufacturing, pharmaceutical, photographic, plastics and printing industries.

Where reclaimed water is derived from WWTPs receiving little or no industrial waste the concentrations of only a few chemicals may need to be determined.

Chemical qualities stock watering

The minimum requirement for stock watering using reclaimed water is Class B.

Initially determine magnesium and TDS concentrations (tables A.10 and A.11) to evaluate the suitability for watering various types of stock.

If on the basis of these initial analyses the reclaimed water appears to be suitable for stock watering then further parameters, as listed in tables A.12 and A.13, may need to be examined. As above (Chemical quality — Crops, pasture and fodder) it is unlikely, for most proposals, that concentrations of all of the chemicals listed in these tables will need to determined.

Warnings

No signs other than those specified in Warnings in **section 1.6** are required when Class A reclaimed water is used. When Class B reclaimed water is used in dairies additional words should be added indicating NO CONTACT WITH MILK OR MILKING EQUIPMENT. When Class C or D reclaimed water is being used for spray, flood or furrow, additional words should be added indicating: RECLAIMED WATER BEING USED — DO NOT ENTER WHEN IRRIGATION IN PROGRESS.

Public access

No restriction of public access is required when Class A reclaimed water is used. Restrict public access during periods of spray irrigation with Class B or C reclaimed water. Restrict access when Class C and D reclaimed water are being used for flood or furrow irrigation.

Spray drift control

For spray irrigation, use the controls specified under Spray drift control in **section 1.6.**

Site suitability

Land with a slope greater than 2% is considered not suitable for flood or furrow irrigation.

Application methods, harvesting controls and preclusions for crops

Table 2.1 summarises types of crops, application methods and harvesting controls. Other crops, methods and controls are considered case-by-case.

Do not use reclaimed water for washing, packaging or processing of food for sale or distribution.

Do not harvest produce when wet from irrigation with reclaimed water.

Helminth controls for use with cattle

Use processes that ensure helminth removal when reclaimed water is used in association with pasture or fodder for cattle. This can be achieved by ensuring a minimum of 25 days detention in a lagoon or holding pond or by appropriate filtration as approved by the EPA.

Withholding periods for pasture and harvesting controls for fodder

Use withholding periods when pasture is irrigated with reclaimed water so the ground can dry before grazing animals are allowed access. Wait a minimum of 4 hours when the pasture is used for non-dairy animals. Wait 4 hours when Class B effluent is used to irrigate pasture or fodder for dairy animals and 5 days when Class C reclaimed water is used. Alternatively dry or ensile all fodder irrigated with reclaimed water before use.

Washdown water controls

Exclude the public when reclaimed water is used for washdown of dairies, stockyards etc. There should be no contact of reclaimed water with milk or milking equipment. Avoid pooling.

Table 2.1 Irrigation requirements for specific food crops.

Type of crop	Application method	Harvesting controls	Reclaimed water
Large surface area grown on or near the ground and consumed raw (eg broccoli, cabbage, cauliflower, celery, lettuce)	Spray, flood	None	Class A
	Drip, furrow	None	Class B
	Subsurface	None	Class C
Root crops consumed raw (eg carrots, onions)	Spray, drip, flood, furrow	None	Class A
	Subsurface	Crop surface dry at harvest	Class B
Crops without ground contact (eg tomatoes, peas, beans, capsicums, non-citrus orchard fruit, non-wine grapes)	Spray	None	Class A
	Flood	Dropped produce not to be harvested	Class B
	Drip, furrow	Dropped produce not to be harvested	Class C
	Subsurface	None	Class D
Crops without ground contact and skin that is removed before consumption (eg citrus, nuts)	Spray	Produce should not be wet from irrigation with reclaimed water when harvested	Class B
	Flood	Dropped citrus not to be harvested	Class C
	Drip, furrow, subsurface	None	Class D
Crops with ground contact and skin that is removed before consumption (eg melons)	Spray	Produce should not be wet from irrigation with reclaimed water when harvested	Class B
	Drip, flood, furrow	Produce should not be wet from irrigation with reclaimed water when harvested	Class C
	Subsurface	None	Class D
Root crops processed before consumption (eg potatoes and beetroot)	Spray, drip, flood, furrow, subsurface	None	Class C
Surface crops processed before consumption (eg brussel sprouts, pumpkins, cereals, grapes for wine making)	Spray, drip, flood, furrow	None	Class C
	Subsurface	None	Class D
Crops not for human consumption Silviculture, turf growing	Any	Withholding period of 4 hours or until ground dry before public access	Class D
Irrigation of pasture and fodder for dairy animals	Any	Withholding period of 4 hours before pasture used for dairy animals; alternatively dry or ensile fodder before use.	Class B
		Withholding period of 5 days before pasture used for dairy animals; alternatively dry or ensile fodder before use	Class C
Irrigation of pasture and fodder for non-dairy animals	Any	Withholding period of 4 hours before pasture used for non-dairy animals; alternatively dry or ensile fodder before use	Class C

3 MUNICIPAL USE

This section is to be read in conjunction with the General Requirements (section 1)

3.1 Introduction

Reclaimed water can be used for a wide range of purposes under the broad heading of municipal use including:

- irrigation of public parks and gardens, sports fields, school ovals and median strips
- irrigation of golf courses including those incorporating residential developments
- ornamental landscapes including decorative ponds
- dust suppression at construction sites and mines.

Potential health risks are associated with body contact, particularly in the case of sports fields irrigated with reclaimed water, and with exposure to aerosols generated by spray irrigation. These risks can be minimised using a combination of treatment requirements and site controls. The higher the quality of reclaimed water the lesser the site restrictions. There are few restrictions required when Class A reclaimed water is used. Class B or C reclaimed water can be used with restrictions but Class D reclaimed water is generally not suitable for municipal irrigation.

3.2 Specific requirements

Chemical quality

Where irrigation of grasses or plants is proposed it is suggested as a first step that a limited range of chemical variables could be examined to evaluate the suitability of reclaimed water for this purpose. These variables could include:

- TDS (Tables A.1, A.2 and A.14)
- boron (Table A.3)
- chloride (Tables A.4, A.5 and A.6)
- sodium adsorption ratio (SAR) (Table A.7)
- pH (Table A.8).

Generally grasses are tolerant to relatively high concentrations of the chemicals listed and to high SARs.

If on the basis of these initial analyses the reclaimed water appears to be suitable for grass or plant irrigation then further parameters may need to be examined including:

- herbicides (Table A.9)
- nutrients (see Nutrients in s**ection 10.4**)
- heavy metals and trace elements (Table A.8).

It is unlikely, for most proposals, that concentrations of all of the chemicals listed above will need to determined. The range will depend on a number of factors including the specific use, and the origin and characteristics of the wastewater before treatment. Assessing the characteristics of wastewater requires a **catchment survey** to determine the non-domestic types of wastes received by the system. These could include, for example, agricultural, chemical, electroplating, engineering, manufacturing, pharmaceutical, photographic, plastics and printing industries.

Where reclaimed water is derived from WWTPs receiving little or no industrial waste the concentrations of only a few chemicals may need to be determined.

Warnings

No signs other than those specified under Warnings in **section 1.6** are required when Class A reclaimed water is used.

When spray irrigation is used with Class B or C reclaimed water additional words should be added indicating: RECLAIMED WATER BEING USED — NO ACCESS WHEN SPRINKLERS IN OPERATION.

Public access

No restriction of public access is required when Class A reclaimed water is used. Restrict public access during periods of spray irrigation with Class B or C reclaimed water. Do not use sports grounds and playing fields while they are wet from spray irrigation with Class B or C reclaimed water. Lock or fit with removable controls all valves and controls on the site.

Spray drift control

Control of spray drift is of particular importance when reclaimed water is used for municipal irrigation both for users of facilities irrigated and for users of adjacent areas. Restrictions are specified Spray drift control in **section 1.6**.

Application methods

Use spray, drip or subsurface irrigation methods.

4 RESIDENTIAL (NON-POTABLE) USE

This section is to be read in conjunction with the General Requirements (section 1)

4.1 Introduction

Class A reclaimed water can be used for defined non-potable residential use including:

- garden watering
- toilet flushing
- car washing
- path / wall washing.

The potential for exposure is high and only Class A reclaimed water can be used. Particular attention should be paid to the requirements of the first four subsections of **section 1.5**.

4.2 Specific requirements

Chemical quality

Reclaimed water for residential use should comply with the chemical quality requirements for raw waters used for drinking purposes (Table A.15).

It is unlikely, for individual proposals, that concentrations of all of the chemicals listed in Table A.15 will need to be determined. The range will depend on a number of factors including the specific use, the characteristics of the wastewater before treatment and the volumes to be used. Assessing the characteristics of wastewater requires a **catchment survey** to determine the non-domestic types of wastes received by the system. These could include, for example, agricultural, chemical, electroplating, engineering, manufacturing, pharmaceutical, photographic, plastics and printing industries.

Where reclaimed water is derived from WWTPs receiving little or no industrial waste the concentrations of only a few chemicals may need to be determined.

5 RECREATIONAL USE

This section is to be read in conjunction with the General Requirements (section 1)

5.1 Introduction

Reclaimed water can be used to supplement impoundments used for recreational activities. Two types of exposure need to be considered: direct contact and ingestion. Primary contact recreation represents a high exposure activity with full body immersion possible and an estimated maximum ingestion of 100 mL (NHMRC 1990). Reclaimed water used for this purpose should comply with the Class A guidelines. Reclaimed water used for secondary contact recreation should comply with Class B guidelines and for passive recreation with Class C guidelines.

5.2 Specific requirements

Chemical quality

Reclaimed water added to impoundments used for recreational activities should comply with chemical quality requirements of the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992). According to those guidelines, waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. In general, toxic substances should not exceed the concentrations for raw waters used for drinking purposes (Table A.15).

It is unlikely, for most proposals, that concentrations of all of the chemicals listed in Table A.15 will need to determined. The range depends on a number of factors including the specific use, the origins and characteristics of the wastewater before treatment, and the volumes to be used. Assessing the characteristics of wastewater requires a **catchment survey** to determine the non-domestic types of wastes received by the system. These could include, for example, agricultural, chemical, electroplating, engineering, manufacturing, pharmaceutical, photographic, plastics and printing industries.

Where reclaimed water is derived from WWTPs receiving little or no industrial waste the concentrations of only a few chemicals may need to be determined.

Nutrients

Reclaimed water can contain higher concentrations of nutrients than receiving waters. Increased concentrations of nutrients could lead to problems with algal growths. Treat effluent so that addition of reclaimed water to a surface water impoundment does not lead to significant increases in nutrient concentrations

Reduce ammonia concentrations to levels not toxic to fish.

Receiving water quality

Impoundments used for primary and secondary contact recreation shall comply with all requirements of the *Australian Guidelines for Recreational Use of Water* (NHMRC 1990).

Warnings

No signs other than those specified under Warnings in **section 1.6** are required when Class A reclaimed water is used.

When Class B reclaimed water is used for secondary contact recreation additional words should be added indicating: RECLAIMED WATER BEING USED — NO SWIMMING.

When Class C reclaimed water is used for passive recreation additional words should be added indicating: RECLAIMED WATER BEING USED — NO SWIMMING, WADING OR BOATING.

6 ENVIRONMENTAL USES (WETLANDS)

This section is to be read in conjunction with the General Requirements (section 1)

6.1 Introduction

Reclaimed water can be used to supplement streams and natural wetlands to restore or enhance the habitat. The complexity of natural ecosystems requires the reuse of reclaimed water in this manner to be site specific. In general reclaimed water should, at a minimum, comply with Class B guidelines. Consider hydrologic impacts on wetlands and impacts on stream regimes.

6.2 Specific requirements

Chemical quality

Reclaimed water used for stream and natural wetland augmentation should not contain chemicals at concentrations that are directly or indirectly harmful to the ecosystem. Each use needs to be assessed individually. Water quality criteria for aquatic ecosystems are contained in Table A.16.

In general the pH of the reclaimed water should match that of the receiving water, and additions should not lower the dissolved oxygen concentration below 6 mg/L or add agents that would adversely impact the quality of the water.

It is unlikely, for most proposals, that concentrations of all of the chemicals listed in Table A.16 will need to determined. The range will depend on a number of factors including the specific use, the origin and characteristics of the wastewater before treatment and the volumes to be used. Assessing the characteristics of wastewater requires a **catchment survey** to determine the non-domestic types of wastes received by the system. These could include, for example, agricultural, chemical, electroplating, engineering, manufacturing, pharmaceutical, photographic, plastics and printing industries.

Where reclaimed water is derived from WWTPs receiving little or no industrial waste the concentrations of only a few chemicals may need to be determined.

6.2.2 Nutrients

Reclaimed water can contain higher concentrations of nutrients than receiving waters. Increased concentrations of nutrients could lead to problems with algal growth and eutrophication. Treat effluent so that the addition of reclaimed water to surface waters does not lead to significant increases in nutrient concentrations.

Reduce ammonia concentrations to levels not toxic to fish.

7 INDUSTRIAL USE

This section is to be read in conjunction with the General Requirements (section 1)

7.1 Introduction

There are many potential applications for reclaimed water within industry and it is an ideal resource for processes not requiring water of potable quality.

Some examples of potential applications include:

- cooling system make-up water
- boiler feed water
- process water
- washdown water
- fire protection
- dust control.

7.2 Specific requirements

Ensure the quality of the reclaimed water is suitable for the task intended. Guidance is available from the *Australian Water Quality Guidelines for Fresh and Marine Water* (ANZECC 1992). Quality requirements for industrial uses are highly variable and Table 7.1, while not exhaustive, outlines some of the potential quality concerns:

Table 7.1 Potential quality concerns.

Quality	Concern
Microbiological quality	OHSW for employees, public health
Chemical quality	corrosion, scale formation, foaming etc.
Physical quality	solids deposition, fouling, blockages
Nutrients	slime formation, microbial growth

To ascertain the suitability of reclaimed water for a particular industrial application, obtain water quality data of the reclaimed water and compare against the industrial-use water quality requirements.

Treatment requirements

Reclaimed water from a municipal WWTP will generally be secondary treated and disinfected. This water may be of a suitable quality for some industrial uses, however some quality upgrading may be necessary. It is the responsibility of industry to further treat the reclaimed water to a suitable standard for that industry.

Treatment systems vary depending on the quality deficiencies of the reclaimed water (Table 7.2).

Table 7.2 Treatment processes.

Industrial water use	Nitrification	Chemical precipitation	Filtration
Cooling tower makeup	Normally	Yes	Yes
Once-through cooling:			
– Turbine exhaust condensing	Sometimes	Seldom	Sometimes
– Direct contact cooling	Seldom	No	Sometimes
– Equipment and bearing cooling	Yes	Yes	Yes
Process water	Yes	Yes	Yes
Boiler feedwater(1)	Yes	Yes	Yes
Washdown	Sometimes	Seldom	Yes

(1) Water used for boiler feedwater would also require carbon absorption, ion exchange or reverse osmosis.
Source: Water Pollution Control Federation. Manual of Practice SM-3, 1989.

When designing a treatment system consider appropriate disposal of any residuals from the treatment process (see the *SA Biosolids Guidelines* and other relevant publications available from the EPA). Regulations also apply for the disposal of wastewater to the marine environment (*Environment Protection (Marine) Policy 1994*) and for the disposal of industrial wastes to the sewer (*Sewerage Act 1929*).

8 AQUIFER STORAGE AND RECOVERY

This section is to be read in conjunction with the General Requirements (section 1)

8.1 Introduction

Aquifer storage and recovery (ASR) is an emerging technology in South Australia, with the potential to provide opportunities for the storage and beneficial reuse of reclaimed water. However, aquifer systems are vulnerable to pollution with varying abilities to assimilate or attenuate introduced contaminants. Inappropriate or poorly managed ASR projects could result in contamination of an aquifer that may be difficult or impossible to rectify, thereby prejudicing the environmental value of the resource or creating a potential pollution source for other environmental receptors (eg surface waterbodies).

Accordingly, a precautionary approach should be adopted in the approval, development and operation of ASR schemes in order to ensure that the aquifer system and any environmental receptors are protected from contamination or other adverse impacts. Proponents should address issues such as:

- quality of the reclaimed water and the receiving groundwater
- the potential impacts of the scheme on the aquifer regime and any associated environmental receptors
- sustainability of the scheme
- suitability of the recovered water for the intended use
- monitoring and management.

ASR schemes will need to comply with the objectives and requirements of the *Environment Protection Act 1993*.

These guidelines recognise and support the principles advocated in the *Draft Guidelines for Groundwater Protection* (National Water Quality Management Strategy 1995) which provides a national framework for the protection of groundwater resources based on the goal of maintaining and supporting the identified beneficial use and value of the resource.

Use of aquifers as part of the treatment process for improving reclaimed water quality is generally not advocated. Nevertheless, it is recognised that there may be opportunities for developing ASR schemes for reclaimed water where it can be established with scientific certainty that the scheme will not cause degradation of the aquifer or detriment to the existing beneficial use or value of the resource. Any proposal relying on sustainable contaminant attenuation within an aquifer must be supported by definitive scientific evidence and an adequate knowledge of the physical and chemical characteristics of the aquifer.

8.2 Specific requirements

Quality

Water infiltrated or injected into an aquifer should be chemically and microbiologically compatible with the native groundwater and of a chemical and biological quality that is no worse than the existing groundwater quality. At the point of withdrawal, the stored water should meet the relevant water quality guidelines for the proposed beneficial use of the water, as described in **sections 2–7**.

Hydrogeological investigations

Prior to submitting an ASR proposal for approval, carry out sufficient hydrogeological investigations and monitoring to adequately characterise the aquifer system, its suitability for the ASR scheme, groundwater quality and the potential impacts that the operation of

the scheme may have on the aquifer itself, or on any other overlying or underlying aquifer systems or connected waterbodies.

Monitoring

The ASR scheme should incorporate systems to monitor:

- reclaimed water quality prior to discharge to the aquifer, with analyses carried out at sufficient frequencies to ensure that the water quality complies with the above requirement
- impacts on groundwater quality, aquifer hydraulic pressures, leakage to other aquifer systems or the environment, changes in aquifer properties, quantities of discharge and recovery, and movement of residual unrecovered water.

Management plan

Environmental management and contingency plans should be developed by the proponent and approved by the EPA prior to commissioning the scheme.

9 WINTER STORAGE

This section is to be read in conjunction with the General Requirements (section 1)

9.1. Introduction

Storage facilities are often an integral part of a reclaimed wastewater scheme and provide a balance between reclaimed water supply and daily, monthly or seasonal fluctuations in irrigation demand. They may become a significant design consideration and have a substantial impact on the capital cost of a reuse scheme.

Seasonal storage may also impact on the cost of operating the scheme, for example where the quality of the reclaimed water is degraded during storage, retreatment may be required to maintain the desired or required reuse water quality.

9.2. Need for storage

The need for storage of reclaimed water generally results from one or more of the following requirements:

Seasonal factors

- avoiding irrigation during periods of high rainfall
  (eg when rainfall is greater than irrigation demand and to prevent surface ponding and runoff)
- ensuring that sufficient water is available to meet peak irrigation demand
  (eg summer period)
- storing during periods of low seasonal demand
  (eg in the case of seasonal food crops)

Design factors

- balancing input/output flow rates through the system
  (eg where limits are placed on irrigation times)
- providing emergency backup
  (eg in the case of plant failure or to provide for peak flows)
- allowing permitted/approved and controlled discharge to the environment
  (eg to a stream or estuary during periods of high stream flow, where reclaimed water supply exceeds reuse requirements).

9.3 Control at site of application

The management of reclaimed water supplies will depend on the volume and pattern of the proposed reuse and the source of supply which may be constant or variable.

Storage will be required to contain the reclaimed water when the total available supply (rainfall + reclaimed water) is greater than demand (evaporation + crop demand).

The stored reclaimed water is then available to meet irrigation requirements during periods when demand is greater than the available supply.

Seasonal storage factors

Storage capacity is influenced by irrigation demand, precipitation and evaporation.

Where the reclaimed water is continuously generated, store volumes that cannot be reused for use at another time.

Determine storage capacity by analysis of monthly or daily water balances based on historical rainfall, evaporation data and reclaimed water source flows.

Ensure the storage dam has a minimum total capacity to store the surplus daily flow of reclaimed water for the determined 'storage period'.

The storage period is the number of days when rainfall matches or exceeds irrigation demand, and/or the number of days when irrigation is not required in the case of seasonal crops.

Where the reuse scheme is not the sole mechanism for using the available reclaimed water, limit storage capacity to seasonal irrigation demand.

Design storage factors

In systems where daily flows and irrigation demand are balanced but limitations are placed on irrigation times, limit storage capacity to the average daily flow through the treatment system.

Determine storage capacity for emergency backup and peak flows by system design parameters and approval requirements. These may vary according to system capacity and site determinants.

9.4 Quality of reclaimed water for storage

If further treatment before irrigation is not intended, ensure the reclaimed water discharged to storage complies with the standard appropriate to the selected use, as set down in these guidelines; in any other case the reclaimed water should comply with at least Class C.

If the quality of the reclaimed water is degraded during storage, retreatment may be required to maintain the desired or required reuse water quality.

9.5 Siting of storage

Site storage facilities for reclaimed water to:

- avoid close proximity to public areas and residential dwellings (seek EPA advice)
- avoid obstructing watercourses
- avoid areas subject to flooding events more frequently than once every 25 years
- minimise nuisance from odour and pests such as mosquitoes.

The cost to develop storage ponds increases on sloping land and soils with high permeability.

9.6 Construction of storage

Construct storage facilities for reclaimed water to:

- be lined with a suitable material (eg compacted clay and / or synthetic membrane) to minimise seepage
- unless a synthetic liner is used ensure that the base of the storage pond is at least 1 metre above the highest seasonal groundwater level
- prevent rupture of embankments
- provide embankments to prevent inflow of surface runoff or provide additional storage capacity to prevent overtopping
- provide a minimum embankment freeboard of 600 mm above design storage capacity
- minimise concentration of salts through evaporation
- prevent unapproved / non-permitted or uncontrolled discharge of reclaimed water to adjoining land, waterbodies or the marine environment
- prevent weed growth at the junction between the water level and embankments.

9.7 Warnings and access

Enclose storages of reclaimed water with a lower quality than Class A to restrict public access or display signs at appropriate intervals around the storage area indicating RECLAIMED WATER STORAGE — NO SWIMMING for Class B reclaimed water or RECLAIMED WATER STORAGE — NO SWIMMING, WADING OR BOATING for Class C reclaimed water.

Prevent stock access.

10 IRRIGATION MANAGEMENT PLANS

This section is to be read in conjunction with the General Requirements (section 1)

10.1 Introduction

An irrigation management plan (IMP) is a document describing a scheme to irrigate reclaimed water sourced from municipal wastewater on land used for agriculture or recreation. The objective of the IMP is to describe in appropriate detail the sustainable management of the reclaimed water irrigation scheme taking into account the physical features of the site to be irrigated, soil characteristics, impact on surface and groundwaters, air quality (for spray irrigation) and public health.

Prepare IMPs for all schemes involving the irrigation of reclaimed water. IMPs are required for activities licensed by the Environment Protection Authority (the Authority) where irrigation of reclaimed water from licensed plants is carried out on land owned or under the control of the licensee. Where an agreement exists for reclaimed water from a licensed plant to be irrigated on a site not owned by or under the control of the licensee, a term of that agreement must require the irrigator to prepare an IMP acceptable to the EPA.

These guidelines have been prepared for people who manage reuse schemes on how to prepare an IMP.

10.2 Background

Description of the irrigation scheme

Include in the IMP adequate background information on the purpose of the scheme so those responsible for regulation can understand the objectives of the irrigation scheme. The type of information needed includes:

- source of reclaimed water
- reclaimed water treatment facility
  - type of treatment process
  - volume and characteristics of reclaimed water
  - connected population and growth trends
  - discharge location (if any)
- measures for ensuring the protection of the health of the public and employees
- any requirement for storage of reclaimed water, method of storage and storage capacity
- depth to watertable at the storage area
- quality of groundwater and any current use
- treatment and reticulation systems
- proposed system controls including timers, alarms, distribution safeguards, runoff collection provisions and maintenance programmes
- management and monitoring.
- proposed method of application of reclaimed water
- measures for ensuring protection of surface water and groundwater
- topography and area of irrigation site, soil stratigraphy and preparation of a soil map
- a water balance including climate variables, proposed application rates, average evapotranspiration and percolation rates, all on a monthly basis
- salt and nutrient balance

- proximity of the irrigation site to wells, watercourses or other surface waters, dwellings, public areas and public roads, as may be applicable
- risk of flooding of the site
- types of crop, pasture or vegetation and their ultimate use, if applicable.

Short term environmental considerations

Consider impacts on the environment in the short term (1–5 years), including:

- the effects of runoff on adjacent surface waters
- percolation to shallow groundwater
- the effect of irrigation on soil structure and fertility
- the effect of aerosols where spray irrigation methods are used.

Long term environmental sustainability

Consider the long term (up to 50 years) impact on the environment when considering a reclaimed water irrigation scheme. In addition to surface and groundwaters and soil characteristics mentioned in the section relating to short term impact, the most important factor to consider is the need for drainage (see Drainage in **section 10.4**).

10.3 Approvals

Public and Environmental Health Act

Include in the IMP evidence of approval under the *Public and Environmental Health (Waste Control) Regulations* of the *Public and Environmental Health Act 1987* (DH), which is required for all irrigation schemes using reclaimed water and by Authority licence conditions. Existing reuse schemes or those planning to use reclaimed water from plants which do not require Authority licences, still require approval under the Public and Environmental Health (Waste Control) Regulations.

Environment Protection Authority

The Authority licenses certain WWTPs and STED schemes as follows:

- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters in a **water protection area** (proclaimed pursuant to section 61A of Environment Protection Act), being works with a peak loading capacity designed for more than 100 persons per day
- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters (**other than land or waters in a water protection area**), being works with a peak loading capacity designed for more than 1000 persons per day.

Planning

Development applications which require referral to the EPA as activities of environmental significance include:

- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters **in a water protection area** (proclaimed pursuant to section 61A of the Environment Protection Act), being works with a peak loading capacity designed for more than 50 but not more than 100 persons per day
- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters (**other than land or waters in a water protection area**), being works with a peak loading capacity designed for more than 250 but not more than 1000 persons per day.

Developments considered to be of **major environmental significance** include:

- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters **in a water protection area** (proclaimed pursuant to section 61A of the Environment Protection Act), being works with a peak loading capacity designed for more than 100 persons per day
- works that involve the discharge of treated or untreated sewage or septic tank effluent to land or waters (**other than land or waters in a water protection area**) being works with a peak loading capacity designed for more than 1000 persons per day.

Direct enquires regarding development approval of any new reclaimed water irrigation schemes to your local council (or Development Commission).

10.4 Design and operation of the irrigation scheme

Distribution system and flow measurement

Include in the IMP comprehensive plans showing the location of pumping plant, disinfection facilities, reclaimed water rising mains and distribution pipework. Clearly mark the location of scours and drainage points. For complex systems, a flowsheet would be advantageous. Provide details of irrigation system type (eg drippers, sprays, centre pivot). Indicate buffer zones complying with Spray drift control guidelines in **section 1.6**.

Accurately assess the total flow to be irrigated in order to balance irrigation rates with land and crop requirements. Take rainfall and evaporation into account when calculating an irrigated water balance. Make provision for flow to be measured by flowmeter or calibrated hours run meter and keep accurate records. Where a number of sites or crops are irrigated from the same source water, keep records for each distinct irrigation area. Report flows on an annual basis to measure performance against IMP.

System maintenance

Any pumping and distribution system has the potential to accumulate biological solids and bacteria regrowth. Provide a well-managed system for disinfection or slug dosing of pipework with disinfectant or algicide to control these growths. During winter, manage the reclaimed water to prevent contamination by regrowth (see **section 1.5**). Control water drained or scoured from pipework to prevent environmental harm in waterways. Specify a method of record keeping in the IMP to provide assurance of the maintenance of water quality in the pumping and distribution system.

Nutrients

The quantity of reclaimed water to be applied to a given area can sometimes be limited by the loading rates of nutrients. Include assessment of the wastewater for nutrient concentrations (see **section 10.5**).

Consider in the IMP a mass balance of nutrients, particularly nitrogen and phosphorus, with the objective where possible of balancing nutrient loading with crop requirements. If such balance is not possible, the monitoring programme must account for the fate of nutrients.

Salinity

Inorganic chemical constituents of reclaimed water such as mineral salts can introduce problems through soil salinity and the effect of specific ions on soil, plants and groundwaters. Include data on the salinity, including summer and winter variations, in the

IMP and comment on the suitability of crops or grasses to be irrigated. Reclaimed water with a salinity of up to 500 mg/L can be used without significant environmental and crop effect. For reclaimed water with salinity over 500 mg/L, include details of the management of irrigation and drainage to avoid short or long term environmental harm in the IMP.

Other contaminants

Other contaminants may also affect irrigation proposals and data on reclaimed water characteristics should be included in the IMP to demonstrate whether or not this may be a problem. Guidance on irrigation water criteria is given in section 5 of the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992).

Drainage

Where the presence of groundwater or impervious soil type indicates that mounding and potential salinisation may be a problem in the future, specify details of methods such as drainage to manage such site conditions.

10.5 Monitoring

Reclaimed water

A sampling programme must form part of the IMP to allow impact of the irrigation on public health and the environment to be measured. Sampling for public health requirements will be stated as conditions of approval under the Public and Environmental Health (Waste Control) Regulations. Weekly initial sampling for bacteriological quality is normally required for a fixed period to establish quality control, followed by routine monthly sampling. In addition to health requirements, sample effluent quality for organics and nutrients.

Design the monitoring programme to give assurance that the quality of the reclaimed water complies with the appropriate Class A, B, C or D criteria given in Table 1.1.

Groundwater

The IMP may need to provide for monitoring and reporting of the impact on groundwater resources and any associated environmental receptors (eg surface waterbodies). In developing the IMP, assess the beneficial use or environmental values of groundwater that may be affected by the irrigation scheme, and the nature and risk of such effects on the groundwater resource and any connected environmental receptors. This will determine the extent and type of monitoring required.

A scheme that can potentially impact on potable groundwater resources requires a comprehensive monitoring programme to give assurance of a sound management system to safeguard against contamination of such a high value resource. Minimal monitoring may be required for a scheme underlain by saline groundwater with no obvious environmental value provided there is no risk of impact on adjoining sensitive environmental receptors by induced lateral displacement of the saline groundwater or to mounding of the watertable.

A typical groundwater monitoring programme could:

- record groundwater levels and collect groundwater samples from monitoring bores installed at suitable depths and locations to provide representative water level and water quality data for all aquifer systems likely to be affected by the scheme including areas:
  - upgradient of the irrigation scheme
  - beneath each irrigation area

- downgradient of each irrigation area
- adjacent to the lagoon system so that any leakage will be detected (if lagoons are used as part of the treatment process)

· take samples at least twice yearly and analyse for at least nitrate and salinity (and other parameters depending on quality of reclaimed water).

Surface water

Take representative samples of runoff from an irrigated area in circumstances where runoff may impact on surface waters of high environmental value or those used for potable water. Take samples upstream and downstream of the affected area to indicate the impact of the irrigation. Ensure frequency of sampling is at least twice during each irrigation season or every six months for continuous irrigation.

Analyse surface water for oxidised nitrogen and total Kjeldahl nitrogen to give an indication of the runoff of effluent.

Soil

The maintenance of soil quality is essential for long term sustainability of irrigation schemes. The IMP should provide for soil sampling and analysis on a regular basis to provide assurance that no harm is being done to the soil structure and chemistry. Recommended parameters, at a minimum frequency of every three years, for soil sampling are:

· conductivity

· pH

· P

· N_{total}.

NOTE: These determinands are the minimum required assuming that the wastewater is domestic. Where industrial or trade wastes are accepted into the system, additional determinands may be required by the EPA.

Annual reporting

The EPA requires an independently verified report to be submitted annually for monitoring programmes for schemes irrigated with effluent from Authority licensed WWTPs and STED schemes. Details on the process of independent verification are given in Appendix B. Include in the report all relevant events during the year in question which would have had the potential to impact on the environment in addition to all items included in the monitoring programme.

For schemes which use reclaimed water from unlicensed treatment plants or STED schemes, monitoring may be required by conditions which form part of Public and Environmental Health (Waste Control) Regulations approval.

In the long term, it is anticipated data (especially from larger schemes and plants) will be transferred electronically to the EPA. In anticipation of this, presentation of data on a spreadsheet (preferably Excel) with determinands being presented by row and time of sampling by column is preferred (Table 10.1).

Table 10.1 Preferred spreadsheet format for EPA monitoring results.

Determinand	July 99	August 99	Sept 99	Oct 99	etc
BOD, mg/L					
SS, mg/L					
Flow, ML					
TKN, mg/L					
NH_3-N, mg/L					
PO_4-P, mg/L					
E. coli/100 mL					
etc					

The format for reporting for schemes approved under the Public and Environmental Health (Waste Control) Regulations is covered in **section 1.8** of these guidelines.

10.6 Health and safety

Guidance for operators

Include in the IMP information and directions for personnel consistent with **section 1.7** of these guidelines. Include in the annual report evidence of compliance with the requirements of **section 1.7**.

Protection of the public

Where reclaimed water is irrigated to privately owned sites, provide details of fencing and signs in accordance with **section 1.6** of these guidelines in the IMP. In cases of irrigation of sites accessible to the public, include information sufficient to provide evidence of compliance with the requirements of Table 1.1.

10.7 Quality control

Data quality

Licence conditions require that collection and analysis of determinands be carried out in accordance with internationally accepted methods to ensure there is no doubt as to the quality of the data. Normally, this would require collection and analysis by a laboratory with registration with the NATA or an approved equivalent.

Independent verification

OBJECTIVES

Independent verification of monitoring programmes provides:

- assurance to the EPA that the monitoring programme meets requirements specified in conditions of licence and relevant environment protection policies
- confidence to all stakeholders that reported results of monitoring programmes accurately reflect the impact of activities on the environment
- confirmation for the licensee that they are complying with regulatory requirements
- independent feedback to the licensee of ways to improve the monitoring programme and the need to modify site practices in light of the monitoring results.

WHO CONDUCTS INDEPENDENT VERIFICATION?

Verification of results of monitoring must be undertaken by a specialist who is able to make an independent professional examination of records, procedures and processes of the licensee, and give an opinion as to whether the licensee's report is accurate and whether appropriate controls and procedures have been followed.

When selecting appropriate people to conduct independent verification of monitoring programmes, licensees should take into account:

- the independence of the verifier
- membership of appropriate professional bodies
- experience in the establishment of relevant monitoring programmes
- knowledge in a relevant field of environmental science.

CONTENT OF THE VERIFICATION REPORT

The following items should be included in the verification report:

- A statutary declaration signed by the verifier that the report presents fairly the results of the verification of the monitoring programme.
- The name of the person undertaking the verification and details of qualifications, experience and professional affiliation.
- A statement establishing the independence of the person and their company from the licensee.
- Statements verifying that
  - the monitoring programme achieves the required objectives
  - samples of monitoring were taken from required or identified sampling points by persons who can be identified for each sample
  - all sampling equipment was in good working order
  - sampling followed appropriate industry practice (including Australian and International Standards methods)
  - data and any logging apparatus were secure from interference
  - analysis was consistent with professional standards (where NATA accredited laboratories were used, NATA registration details should be provided)
  - air emission testing was conducted in accordance with the document *Emission Testing Methodology for Air Pollution*, available from the EPA)
  - findings of verification studies (and, where appropriate, samples) were comparable with monitoring results.
- A statement confirming compliance with the relevant conditions of authorisation or qualifying statements where there is reason to believe that monitoring was inconsistent with requirements of the authorisation (including gaps in monitoring data series).
- Recommendations for alterations to the monitoring programme to ensure achievement of monitoring programme objectives (if they are not being achieved) and / or more efficiency in monitoring.

ADDITIONAL REQUIREMENTS

In conducting the verification, an independent verifier must take into account not only licence condition, but also requirements for monitoring contained in relevant Environmental Protection Policies.

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APPENDIX A SUMMARIES OF WATER QUALITY CRITERIA

Sources of criteria

In general criteria have been taken from the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992) except for Table A.14 which is from Neylan (1994).

Table A.1 Relative tolerance of plants to salinity in irrigation waters.

TDS(mg/L)	Pastures and fodders	Fruits	Vegetables	Ornamentals
0–500	Ladino clover Red clover Alsike clover White Dutch clover Subterranean clover	Persimmon Loquat Passionfruit Strawberry Avocado Almond Apricot Peach Plum Lemon Grapefruit Orange Grape Walnut	Parsnips Green beans Celery Radish Cucumber Squash Peas Onion Carrot Potatoes Sweet Corn Lettuce French beans	Violet African violet Primula Gardenia Begonia Azalea Camellia Magnolia Fuchsia Dahlia
500–1500	Cocksfoot Perennial ryegrass	Mulberry Apple Pear Raspberry Quince	Cauliflower Bell pepper Cabbage Broccoli Tomato Broad beans Field beans Sweet potato Artichoke	Geranium Gladiolus Bauhinia Zinnia Rose Aster Poinsettia Musa Podocarpus
1500–3500	Oats (hay) Wheat (hay) Rye (hay) Lucerne Sudan grass Paspalum dilatatum Strawberry clover Sweet clovers Millet Wimmera ryegrass Rhodes grass Couch grass Barley Birdsfoot trefoil	Olive Fig Pomegranate Cantaloupe	Spinach Asparagus Kale Garden beets Gherkins	Stock Chrysanthemum Carnation Hibiscus Oleander Bougainvillea Vinca Aust. hop bush Coprosma Japanese pepper *Ficus* spp False acacia Qld pyramid tree NZ Christmas bush False mahogany Rottnest cyprus *C. cuppressiformis* *Acacia longifolia* Buffalo grass Kikuyu grass Portulaca Mesembryanthemum Boobyalla Morrel Swamp yate York gum Couch grass Bamboo Kondinin blackbutt
> 3500	Seashore paspalum *Puccinella ciliata* Saltwater couch	Date palm		Canary palm *Paspalum vaginatum* Salt sheoaks Salt river gum Tamarisks Saltbushes

Table A.2 General criteria for salinity for irrigation water.

Electrical conductivity (µs/cm)	TDS (mg/L)*	Comment
0–280	0–175	Low salinity water can be used with most crops on most soils and with all methods of water application with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.
280–800	175–500	Medium-salinity water can be used if moderate leaching occurs. Plants with medium salt tolerance can be grown, usually without special measures for salinity control. Sprinkler irrigation with the more-saline waters in this group may cause leaf scorch on salt-sensitive crops, especially at high temperatures in the daytime and with low application rates.
800–2300	500–1500	High-salinity water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and the salt tolerance of the plants to be irrigated must be considered.
2300–5500	1500–3500	Very high-salinity water is not suitable for irrigation water under ordinary conditions. For use, soils must be permeable, drainage adequate, water must be applied in excess to provide considerable leaching, and salt-tolerant crops should be selected.
> 5500	> 3500	Extremely high-salinity water may be used only on permeable, well-drained soils under good management, especially in relation to leaching and for salt-tolerant crops, or for occasional emergency use.

Table A.3 Relative tolerances of agricultural crops to boron.

Tolerance*	Concentration of boron in soil water (mg/L)**	Agricultural crop
Very sensitive	<0.5	Blackberry
Sensitive	0.5–1.0	Peach, cherry, plum, grape, cowpea, onion, garlic, sweet potato, wheat, barley, sunflower mung bean, sesame, lupin, strawberry, Jerusalem artichoke, kidney beans, lima beans
Moderately sensitive	1.0–2.0	Red pepper, pea, carrot, radish, potato, cucumber
Moderately tolerant	2.0–4.0	Lettuce, cabbage, celery, turnip, Kentucky bluegrass, oat, corn, artichoke, tobacco, mustard, clover, squash, musk, melon
Tolerant	4.0–6.0	Sorghum, tomato, alfalfa, purple, vetch, parsley, red beet, sugar beet
Very tolerant	6.0–15.0	Asparagus

* Tolerance will vary with climate, soil conditions and crop varieties; values are to be used as a guideline only

** Maximum concentrations tolerated in irrigation water without reduction in yield or vegetative growth are approximately equal to soil water values

Table A.4 Chloride tolerance of fruit and woody crops by root uptake.

Rootstocks	Chloride in irrigation water (mg/L)	Cultivars	Chloride in irrigation water (mg/L)
Grapes	710–960	Boysenberry	250
Stone-fruits (eg peaches, plums)	180–600	Blackberry	250
Strawberries	110–180	Raspberry	250

Table A.5 Chloride concentrations in irrigation water causing foliar damage.

Sensitivity	Chloride(mg/L)	Affected crop
Sensitive	< 178	Almond, apricot, plum
Moderately sensitive	178–355	Grape, pepper, potato, tomato
Moderately tolerant	355–710	Alfalfa, barley, corn, cucumber
Tolerant	> 710	Cauliflower, cotton, safflower, sesame, sorghum, sugar-beet, sunflower

Table A.6 Tolerance of chloride sensitive crops to chloride in irrigation water.

Crop	Irrigation method	Maximum chloride concentrations (mg/L)
Citrus	Overhead sprinklers Under-tree sprinklers	100 265
Stone-fruit	Overhead sprinklers Under-tree sprinklers	70 175
Vines	–	350
Tobacco	Overhead sprinklers	30

Table A.7 Tolerance of crops to sodium.

Tolerance	SAR* of irrigation water	Crop	Condition
Very sensitive	2–8	Deciduous fruits, nuts, citrus, avocado	Leaf tip burn, leaf scorch
Sensitive	8–18	Beans	Stunted, soil structure favourable
Moderately tolerant	18–46	Clover, oats, tall fescue, rice	Stunted due to nutrition and soil structure
Tolerant	46–102	Wheat, lucerne, barley, tomatoes, beets, tall wheat grass, crested grass, fairway grass	Stunted due to poor soil structure

* SAR = sodium adsorption ratio

Table A.8 Heavy metals, trace elements and pH criteria for irrigation water quality.

Parameter	Guideline value (mg/L unless otherwise stated)	Comment
Aluminium	5.0	High toxicity in acid soils
Arsenic	0.1	
Beryllium	0.1	
Cadmium	0.01	Higher toxicty in acid soils
Chromium	1.0	
Cobalt	0.05	
Copper	0.2	
Fluoride	1.0	
Iron	1.0	
Lead	0.2	
Lithium	2.5	Citrus: 0.075 mg/L
Manganese	2.0	0.2 mg/L in acid soils
Mercury	0.002	
Molybdenum	0.01	
Nickel	0.2	
Selenium	0.02	
Uranium	0.01	
Vanadium	0.1	
Zinc	2.0	1.0 mg/L for sandy soil if ph < 6
pH	4.5–9.0	pH < 4.8 could cause solubilisation of Al, Mn or heavy metals
		Water with pH > 8.3 may contain high Na, carbonate, bicarbonate.

Table A.9 Water quality criteria for herbicides registered for use in or near waters.

Herbicide	Residue limits in irrigation water (mg/L)	Hazard to crops from residue in water**	Crop injury threshold in irrigation water (mg/L)
Acrolein	0.1	+	Flood or furrow: beans 60, corn 60, cotton 80, soybeans 20, sugar-beets 60
			Sprinkler: corn 60, soybeans 15, sugar-beets 15
AF 100	*	+	Beets (rutabaga) > 3.5, corn 3.5
Amitrol	0.002	++	Lucerne 1600, beans 1200, carrots 1600, corn 3000, cotton 1600, grains sorghum > 800, oats 2400, potatoes 1300, wheat 1200
Aromatic solvents (Xylene)	*	+	
Asulam	*	++	
Atrazine	*	++	
Bromazil	*	+++	
Chlorthiamid	*	++	
Copper sulphate	*	+	Apparently above concentrations used for weed control (see irrigation for copper)
2,4-D	*	++	Field beans 3.5–10, grapes 0.7–1.5, sugar-beets 1.0–10, corn 125, beans 5
Dicamba	*	++	Cotton 0.18
Dichlobenil	*	++	Lucerne 10, corn > 10, soybeans 1.0 – 10, corn 125, beans 5
Diquat	*	+	
Diuron	0.002	+++	
2,2-DPA (Dalapon)	0.004	++	Beets > 7.0, corn < 0.35
Fosamine	*	+++	
Fluometuron	*	++	Sugar-beets, alfalfa, tomatoes, squash > 2.2
Glyphosate	*	+	
Hexazinone	*	+++	
Karbutilate	*	+++	
Molinate	*	++	
Paraquat	*	+	Corn > 10, field beans 0.1, sugar-beets < 1.0
Picloram	*	+++	
Propanil	*	++	Alfalfa 0.15, brome grass (eradicated) 0.15
Simazine	*	++	
2,4,5-T	*	++	Potatoes, alfalfa, garden peas, corn, sugar-beets, wheat, peaches, grapes, apples, tomatoes > 0.5
TCA	*	+++	
Terbutryne	*	++	
Triclopyr	*	++	

* Guideline not set except as a general limit (0.1 mg/L) for specific herbicides in Tasmania and all herbicides in New South Wales

** Hazard from residue at the expected maximum concentration: + = low, ++ = moderate, +++ = high

> Damage may occur at greater than this level

Table A.10 Total dissolved solids concentrations for drinking water for livestock.

Stock	TDS (mg/L)		
	Desirable maximum concentration for healthy growth	Maximum concentration at which good condition might be expected	Maximum concentration that may be safe for limited periods
Sheep, dry feed	6,000	13,000	**
Beef cattle	4,000	5,000	10,000
Dairy cattle	3,000	4,000	6,000
Horses	4,000	6,000	7,000
Pigs	2,000	3,000	4,000
Poultry	2,000	3,000	4,000

Table A.11 Magnesium and TDS concentrations in drinking water for livestock

Category	Guideline	Comments
1	TDS below 5000 mg/L, magnesium below 600 mg/L	suitable for sheep & cattle of all ages
2	TDS of 5000–10,000 mg/L, magnesium below 600 mg/L	Generally unsuitable for lambs, calves & weaners, Caution needed with lactating stock if unaccustomed. Suitable for dry, mature sheep & cattle
3	TDS of 10,000–15,000 mg/L, magnesium below 600 mg/L	Suitable for dry, mature sheep. Caution needed with cattle if unaccustomed
4	TDS above 15,000 mg/L, any magnesium level	Generally unsuitable for stock
5	Any TDS level, magnesium above 600 mg/L	Generally unsuitable for stock

Table A.12 Criteria for stock water quality.

Parameter	Guidance value (mg unless otherwise stated)	Comment
MAJOR IONS & NUTRIENTS		
Calcium	1000.00	
Nitrate — N	30.0	30 (horses), 40 (cattle), 60 (sheep)
Nitrite — N	10.0	
Sulphate	1000.0	
TRACE ELEMENTS		
Aluminium	5.0	
Arsenic	0.5	
Beryllium	0.1	
Boron	5.0	
Cadmium	0.01	
Chromium	1.0	
Cobalt	1.0	
Copper	0.5	0.5 (sheep), 1.0 (poultry), 5.0 (cattle)
Fluoride	2.0	
Lead	0.1	
Mercury	0.002	
Molybdenum	0.01	
Nickel	1.0	
Selenium	0.02	
Uranium	0.2	
Vanadium	0.1	
Zinc	20.0	
ORGANIC COMPOUNDS		
Benzene	10.0 µg/L	
Benzo(a)pyrene	0.01 µg/L	
Carbon Tetrachloride	3.0 µg/L	
1,1-Dichloroethene	0.3 µg/L	
1,2-Dichloroethane	10.0 µg/L	
Pentachlorophenol	10.0 µg/L	
Polychlorinated biphenyls	0.1 µg/L	
Tetrachloroethene	10.0 µg/L	
2,3,4,6-Tetrachlorophenol	1.0 µg/L	
Trichloroethene	30.0 µg/L	
2,4,5-Trichlorophenol	1.0 µg/L	
2,4,6-Trichlorophenol	10.0 µg/L	

Table A.13 Water quality criteria values for pesticides.

Compound	Maximum concentration (µg/L)	Compound	Maximum concentration (µg/L)
Acephate	20.0	Fenvalerate	40.0
Alachlor	3.0	Flamprop-methyl	6.0
Aldrin	1.0	Fluometuron	100.0
Amitrol	1.0	Formothion	100.0
Asulam	100.0	Fosamine (ammonium salt)	3000.0
Azinphos-methyl	10.0	Glyphosate	200.0
Barban	300.0	Heptachlor	3.0
Benomyl	200.0	Hexaflurate	60.0
Bentazone	400.0	Hexazinone	600.0
Bioresmethrin	60.0	Lindane	10.0
Bromazil	600.0	Maldision	100.0
Bromophos-ethyl	20.0	Methidathion	60.0
Bromoxynil	30.0	Methomyl	60.0
Carbaryl	60.0	Metolachlor	800.0
Carbendazim	200.0	Metribuzin	5.0
Carbofuran	30.0	Mevinphos	6.0
Carbophenothion	1.0	Molinate	1.0
Chlordane	6.0	Monocrotophos	2.0
Chlordimeform	20.0	Nabam	30.0
Chlorfenvinphos	10.0	Nitralin	1000.0
Chloroxuron	30.0	Omethoate	0.4
Chlorpyrifos	2.0	Oryzalin	60.0
Clopzralid	1000.0	Paraquat	40.0
Cyhexatin	200.0	Parathion	30.0
2,4-D	100.0	Parathion-methyl	6.0
DDT	3.0	Pendimethalin	600.0
Demeton	30.0	Perfluidone	20.0
Diazinon	10.0	Permethrin	300.0
Dicamba	300.0	Picloram	30.0
Dichlobenil	20.0	Piperonyl butoxide	200.0
3,6-Dichloropicolinic acid	1000.0	Pirimicarb	100.0
Dichlorvos	20.0	Pirimiphos-ethyl	1.0
Diclofop-methyl	3.0	Pirimiphos-methyl	60.0
Dicofol	100.0	Profenofos	0.6
Dieldrin	1.0	Promecarb	60.0
Difenzoquat	200.0	Propanil	1000.0
Dimethoate	100.0	Propargite	1000.0
Diquat	10.0	Propoxur	1000.0
Disulfoton	6.0	Pyrazophos	1000.0
Diuron	40.0	Quintozene	6.0
DPA	500.0	Sulprofos	20.0
Endosulfan	40.0	2,4,5-T	2.0
Endothal	600.0	Temephos	30.0
Endrin	1.0	Thiobencarb	40.0
EPTC	60.0	Thiometon	20.0
Ethion	6.0	Thiophanate	100.0
Ethoprophos	1.0	Thiram	30.0
Fenchlorphos	60.0	Trichlorofon	10.0
Fenitrothion	20.0	Triclopyr	20.0
Feneprop	20.0	Trifluralin	500.0
Fensulfothion	20.0		

Table A.14 Summary of water quality criteria for salt tolerance of turf grasses.

*Relative salt tolerance (producing an acceptable turf quality)	Water salinity TDS (mg/L)	Turfgrass species/variety
Tolerant	up to 3600	Common couchgrass
		Tifway couchgrass
		Tifgreen couchgrass
		Santa anna couchgrass
		Kikuyu
		Seaside creeping bentgrass
		Strawberry clover
Moderate tolerance	up to 1800	Tall fescue
		Perennial ryegrass
		Creeping bentgrass
Low tolerance	less than 1200	Kentucky bluegrass
		Red fescue
		Highland bentgrass
		Annual wintergrass

* Salt tolerance of grasses will vary depending on a range of factors, such as soil type, drainage, turf maturity, wear.

Table A.15 Summary of water quality criteria for raw waters used for drinking.

Parameter	Guideline value
INORGANIC:	**(mg/L)**
Arsenic	0.05
Barium	1.0
Boron	1.0
Cadmium	0.005
Chromium	0.05
Cyanide	0.1
Lead	0.05
Mercury	0.001
Nickel	0.1
Nitrate-N	10.0
Nitrite-N	1.0
Selenium	0.01
Silver	0.05
ORGANIC:	**(μg/L)**
Benzene	10.0
Benzo(*a*)pyrene	0.01
Carbon Tetrachloride	3.0
1,1-Dichloroethene	0.3
1,2-Dichloroethane	10.0
Pentachlorophenol	10.0
Polychlorinated biphenyls	0.1
Tetrachloroethene	10.0
2,3,4,6-Tetrachlorophenol	1.0
Trichloroethene	30.0
2,4,5-Trichlorophenol	1.0
2,4,6-Trichlorophenol	10.0

Table A.16 Summary of water quality criteria for protection of aquatic ecosystems.

Parameter	Guideline value (µg/L unless otherwise stated)
PHYSICO-CHEMICAL PARAMETERS:	
Dissolved oxygen	> 6 mg/L
pH	6.5–9.0
Salinity	< 1000 mg/L
Suspended particulate matter/turbidity	< 10% change seasonal mean concentration
Temperature	< 2°C increase
TOXIC PARAMETERS:	
INORGANIC:	
Aluminium	< 5.0 (if pH ≤ 6.5) < 100.0 (if pH > 6.5)
Ammonia	20.0–30.0 (depending on temp and pH)
Antimony	30.0
Arsenic	50.0
Beryllium	4.0
Cadmium	0.2–2.0 (depending on hardness)
Chromium	10.0
Copper	2.0–5.0 (depending on hardness)
Cyanide	5.0
Iron	1000.0
Lead	1.0–5.0 (depending on hardness)
Mercury	0.1
Nickel	15.0–150.0 (depending on hardness)
Selenium	5.0
Silver	0.1
Sulphide	2.0
Thallium	4.0
Tin (tributyltin)	0.008
Zinc	5.0–50.0 (depending on hardness)
HALOGENATED ALIPHATICS:	
Hexachlorobutadiene	0.1
MONOCYCLIC AROMATICS:	
Benzene	300.0
Monochlorobenzene	15.0
1,2-Dichlorobenzene	2.5
1,3-Dichlorobenzene	2.5
1,4-Dichlorobenzene	4.0
1,2,3-Trichlorobenzene	0.9
1,2,4-Trichlorobenzene	0.5
1,3,5-Trichlorobenzene	0.7
1,2,3,4-Tetrachlorobenzene	0.1
1,2,3,5-Tetrachlorobenzene	0.1
1,2,4,5-Tetrachlorobenzene	0.2
Pentachlorobenzene	0.03
Hexachlorobenzene	0.007
Monochlorophenol	7.0
2,4-dichlorophenol	0.2
Trichlorophenol (total)	18.0
Tetrachlorophenol	1.0

Parameter	Guideline value (µg/L unless otherwise stated)
Pentachlorophenol	0.05
Phenol	50.0
Toluene	300.0
ORGANOCHLORINES:	
Aldrin	10 ng/L
Chlordane	4 ng/L
DDE	14 ng/L
DDT	1 ng/L
Dieldrin	2 ng/L
Endosulfan	10 ng/L
Endrin	3 ng/L
Heptachlor	10 ng/L
Lindane	3 ng/L
Methoxychlor	40 ng/L
Mirex	1 ng/L
Toxaphene	8 ng/L
ORGANOPHOSPHATES:	
Chlorpyrifos	1 ng/L
Demeton	100 ng/L
Guthion	10 ng/L
Malathion	70 ng/L
Parathion	4 ng/L
OTHER PESTICIDES:	
Acrolein	200 ng/L
PHTHALATE ESTERS:	
di-n-butyl-phthalate	4.0
di(2-ethylhexyl)phthalate	0.6
other phthalate esters	0.2
POLYAROMATIC HYDROCARBONS:	
Polychlorinated biphenyls	0.001
Polycyclic aromatic hydrocarbons	3.0