Government of **Western Australia**
Department of **Water**

Rottnest Island Water Reserve

Drinking water source protection plan

Rottnest Island water supply

Looking after all our water needs

Water resource protection series
Report WRP 148
May 2014

Rottnest Island Water Reserve drinking water source protection plan

Rottnest Island water supply

Looking after all our water needs

Department of Water

Water resource protection series

Report no. WRP 148

May 2014

Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601

National relay service 13 36 77
www.water.wa.gov.au

May 2014

ISSN 1835-3924 (online)

ISBN 978-1-922248-02-2 (online)

Acknowledgements

The Department of Water would like to thank the following for their contribution to this publication: Christa Loos, Patrick Ridley, Fiona Mullen, Carmel Sullivan, Chris Qiu, Stephen Watson and Nigel Mantle (Department of Water); Richard Warby, Mark Botica and Ryan Benson (Programmed Facility Management) and Andrew Tarpley, Janett Enke, Sara McAllister and Shane Kearney (Rottnest Island Authority).

For more information about this report, contact
Water Source Protection Planning on +61 8 6364 7600 or drinkingwater@water.wa.gov.au.

Cover photograph: Rottnest Island, GIS image created by Chris Qiu

This publication is available at our website <www.water.wa.gov.au> or for those with special needs it can be made available in alternative formats such as audio, large print, or Braille.

Contents

Tables

Summary

Rottnest is a limestone island located about 19 km from the coast of Fremantle, Western Australia. It is a popular holiday destination, attracting half a million visitors per year. The number of visitors and permanent residents on the island fluctuates on a seasonal basis (peak and off-peak seasons). The Rottnest Island Authority (RIA) manages Rottnest Island.

The RIA is licensed by the Economic Regulation Authority to operate the island's drinking water supply. The supply consists of water drawn from the Wadjemup bore field (fresh water) and a saltwater bore field at Longreach Bay. Together, these two sources form the proposed Rottnest Island Water Reserve. The saltwater bores supply water to the desalination plant and the treated water is blended with fresh water from the Wadjemup bore field. The volume of fresh water abstracted is managed under a licence to take water issued by the Department of Water (the department) and the Minister for Environment's Statement 324 (1993). Programmed Facility Management manages the island's drinking water supply on behalf of the RIA.

Software known as the Well Head Analytic Element Model (WhAEM) was used to determine the hydrogeological boundary of the Wadjemup bore field. The boundary for the Longreach Bay saltwater bore field has yet to be determined scientifically. Its boundary is based on the extent of the wellhead protection zones (300 m radius) around each bore. A more refined boundary for the saltwater bore field may need to be considered when this plan is updated.

The proposed water reserve boundary, priority areas and protection zones will help to protect the water quality of Rottnest Island's drinking water supply.

Land uses and activities within the proposed Rottnest Island Water Reserve include:

- Wadjemup bore field: on-site wastewater treatment systems for public toilets, roads and tracks, infrastructure, Wadjemup Lighthouse precinct, and recreational activities such as cycling, walking and sightseeing.
- Longreach Bay saltwater bore field: wastewater pump station including infrastructure collecting wastewater from tourist accommodation and commercial premises at Geordie Bay, Fays Bay and Longreach Bay, roads and tracks, infrastructure, water treatment plant (desalination plant, reverse osmosis), and recreational activities such as cycling, playing golf and walking.

The bore fields of the proposed Rottnest Island Water Reserve are vulnerable to contamination from surrounding land uses and activities due to the unconfined and shallow nature of the aquifer.

The following key strategies are recommended to protect the quality of the raw water drawn from the Rottnest Island Water Reserve (see full list of strategies in section 5):

- The boundaries of the Rottnest Island Water Reserve, consisting of the Wadjemup bore field and Longreach Bay saltwater bore field, should be proclaimed under the *Country Areas Water Supply Act 1947*. The South West Aboriginal Land and Sea Council will be consulted as part of the proclamation process.
- The water reserve's boundaries and priority areas 1 (P1) and priority 3 (P3) should be recognised in the next edition of the *Rottnest Island management plan*, the *Rottnest Island drinking water quality plan* and other applicable strategies.
- The raw (source) water quality monitoring program should ensure that the chemical and microbiological parameters are monitored in accordance with the Australian drinking water guidelines (NHMRC & NRMMC 2011).
- All production bores should be constructed in accordance with the *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).
- Best management practices and guidelines for land uses that occur in the proposed Rottnest Island Water Reserve should be made available to the RIA to help them protect this drinking water source.

Wadjemup bore field (freshwater lens)

- Define a 500 m wellhead protection zone around each production bore.
- All Crown land within the proposed boundary for this bore field should be managed for P1 source protection.

Longreach Bay saltwater bore field

- Define a 300 m wellhead protection zone around each production bore.
- All Crown land within the proposed boundary of this bore field should be managed for P3 source protection.

This plan is consistent with the *Australian drinking water guidelines* (NHMRC & NRMMC 2011) and State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003). Its contents have been consulted with key stakeholders, including the RIA, Programmed Facility Management and Department of Health.

The following table shows important information about the Rottnest Island Water Reserve.

Key information about the Rottnest Island Water Reserve:

Authority	Rottnest Island Authority
Locations supplied	Rottnest Island
Aquifer type	Perth – Rottnest Superficial aquifer (unconfined)
Licensed abstraction	120,000 kL per year
Number of bores	29 fresh water bores at Wadjemup bore field: • 13 production bores (1/81, 1/83, 3/83, 4/83, 2/90, 16/90, 6/93, 29/76, 1/77, 2/81, 4/90, 12/90, and 1/93) • 8 stand-by bores (24/76, 2/77, 3/77, 17/90, 2/93, 3/93, 7/93, and 8/93), and • 9 saline bores (23/76, 1/90, 6/90, 8/90, 10/90, 30/90, 32/90, 9/93, and 10/93). 6 saltwater bores for the island's desalination plant: • RID01 (not used), RID02, RID03, RID04, RID05, and RID06.
Date of drinking water source protection plan	2014 – this document
Proclamation status	Proclamation under the *Country Areas Water Supply Act 1947* will need to be progressed when this plan is finalised.
Stages involved in the preparation of this drinking water source protection report	2012 – Initial catchment survey to gather preliminary information. The model known as Well Head Analytic Element Model (WhAEM) was used to identify the boundary for the Wadjemup bore field. 2012 and 2013 – Advice sought from the RIA and Programmed Facility Management for developing appropriate management strategies to protect the quality of water in this water reserve. 2014 – Final protection plan published after considering stakeholder's comments.

1 Overview

Rottnest is an island made of a limestone formation which is located approximately 19 km from the coast of Fremantle, Western Australia (Appendix A, Figure A1). The island is about 11 km long and 4.5 km wide and comprises of an area of 1835 ha. The island is an A-class reserve under the *Land Administration Act 1997* (Crown reserve 16713), and includes the marine reserves Swan Location 10976 and Swan Location 11022. It is a popular holiday destination with around 500 000 visitors per year. This number includes approximately 185 000 visitors arriving by private boats.

The number of visitors and permanent residents on the island fluctuates due to seasonal changes (peak and off-peak seasons). Approximately 250 permanent residents live on the island – mostly staff of tourist and authority facilities. The island can provide accommodation for up to 2150 visitors (beds per night). A number of visitors also moor their boats in the designated mooring sites along the island. The island also has an airport, allowing visitors to arrive by plane.

1.1 The drinking water supply system

Programmed Facility Management operates and manages the drinking water supply on behalf of the Rottnest Island Authority (RIA). This includes the island's distribution system on the island consisting of approximately 20 km of mains pipes supplying water to 396 dwellings, 9 shops and 3 public drinking water fountains (Programmed Facility Management 2013).

Approximately 75 per cent of the island's drinking water is now supplied by a desalination plant fed by five of the six saltwater bores. The remainder of the drinking water is sourced through groundwater abstraction from the Wadjemup freshwater lens.

The average amount of water supplied to the Island is 110 000kL per year (Programmed Facility Management 2012).

Wadjemup bore field

The Wadjemup bore field was developed in 1977 and is located near the Wadjemup Lighthouse precinct in the central north-west of the island. Thirty production bores were constructed over the years, but one bore has been decommissioned. Therefore, the bore field consists of 29 production bores. Only 13 production bores are used for drinking water supply on an alternating basis. There are eight stand-by bores (used if the production bores are unavailable) and a further nine bores are considered too saline for use. The bores range from 4.5 m to 26.9 m in depth, and the water is abstracted from the shallow, unconfined Tamala limestone aquifer. The Wadjemup bore field is not used over the winter months due to lower water demand, and this allows the unconfined freshwater aquifer to recharge.

The production bores are operated by the island's electricity supply, but also have back-up diesel generators, which are located outside the water reserve so do not pose a risk to the drinking water quality.

Saltwater bore field

There are six saltwater bores in the dunes at Longreach Bay that supply water to the desalination plant, five of which are currently being used. The desalination plant is powered predominately by wind turbines and produces approximately 500 kL of water per day.

The desalination plant was built in 1995, upgraded in 2006 and is proposed to be upgraded again during the 2013–14 financial year. The plant is the main source of drinking water on Rottnest Island, and is the most viable option to fulfil the island's long-term drinking water requirements.

1.1.1 Water treatment

At the desalination plant, salt water is filtered to remove any fine materials (e.g. sand), undergoes reverse osmosis (forced through a membrane) to remove the salt, and then is delivered to tanks where it is mixed with fresh water from the Wadjemup bore field and undergoes chlorination prior to distribution. The concentrated salt water (brine) is disposed of via a pipeline into the ocean at Fays Bay.

The drinking water is stored in two 4500 kL storage tanks where the water is blended and chlorinated. The treated water is stored in a third tank before being gravity-fed to the settlement area. The maximum capacity of water storage is about 14 000 kL. This corresponds to at least 17 days of water storage depending on the season. During the 2011–12 financial year, 119 166 kL of drinking water was supplied to the Rottnest Island community.

It should be recognised that although treatment and disinfection are essential barriers against contamination, public drinking water source area (PDWSA) management is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the *Australian drinking water guidelines* (NHMRC & NRMMC 2011) and reflects a preventive, risk-based, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver a more reliable, safer and lower-cost drinking water to consumers than either approach could achieve individually.

1.2 Water management

1.2.1 Ministerial approval statement 324

The Wadjemup bore field (freshwater lens) is managed in accordance with the conditions set out in *Ministerial approval statement 324* (1993). The conditions are audited by the Office of the Environmental Protection Authority.

The ministerial conditions for the Wadjemup bore field are subject to a review to ensure they are up-to-date and in accordance with the conditional licence (i.e. licence to take water) that has been issued by the department.

1.2.2 Licence to take water

Water resource use and conservation in Western Australia is administered by the department in accordance with the *Rights in Water and Irrigation Act 1914*. Under this act, the right to use and control water is vested with the Crown. This means that a licence is required for drilling bores and abstracting groundwater (pumping water from a bore, spring or soak) within proclaimed groundwater areas throughout the state. Some exemptions apply such as abstracting water for domestic purposes only.

The proposed Rottnest Island Water Reserve is located within the Rottnest Island Groundwater Area (Perth – Rottnest Superficial aquifer) which is proclaimed under the *Rights in Water and Irrigation Act 1914*). The RIA is licensed by the department to abstract water from the Rottnest Island Groundwater Area for public drinking water supply, subject to conditions. The maximum abstraction from this aquifer for public water supply is set at 120 000 kL per year.

The RIA is required by the department to prepare an operating strategy for the water source.

1.2.3 Water services operating licence

The Economic Regulation Authority (ERA) granted a water services operating licence to the RIA on 14 December 2010, allowing the RIA to operate and manage the island's drinking water source. This licence contains standards for water service delivery and the ERA regularly monitors compliance with these standards.

The RIA also has a memorandum of understanding (MoU) with the Department of Health, as required by the ERA's water services licence. The MoU ensures protection of Rottnest Island's drinking water supply and requires that water quality is regularly tested and the results are reported to the Department of Health to safeguard public health. The MoU also requires the RIA to have a drinking water source protection plan for the island's drinking water source in accordance with the Department of Water's guidelines. The Department of Health ensures compliance with the requirements of the MoU.

1.2.4 Water planning

In recent years the demand for drinking water on Rottnest Island has increased and may increase even further.

Rottnest Island has a limited supply of fresh water, therefore the Wadjemup bore field requires careful conservation to ensure there is sufficient good quality drinking water to meet current and future demand.

To become more independent of the freshwater lens, the RIA has advised the department that it is proposing to upgrade the desalination plant by adding a third train for treatment and considering construction of additional seawater production bores at Longreach Bay. Both these measures should assist in meeting the expected increase in demand and ensure less fresh water needs to be abstracted from the Wadjemup bore field.

The RIA is also considering the use of treated wastewater from the wastewater treatment plant (once upgraded) for irrigating the golf course in the near future to ease pressure on the drinking water source. There are plans to upgrade the island's wastewater treatment plant, but this is subject to securing the required funding.

The RIA is required to prepare annual environmental reports and submit them to the department, as outlined in the Rottnest Island groundwater, lakes and fresh water monitoring program.

1.2.5 Future water needs

Over the years various developments (e.g. a marina, luxury hotel at Longreach Bay, a low-impact eco-tourism development, more affordable accommodations in the style that already exist) have been considered, but have not been progressed. The RIA indicated that they expect an increase in the numbers of visitors to the island in the future, but no decisions have been made for increasing accommodation on the island at this stage.

1.3 Characteristics of the catchment

1.3.1 Physical environment

Rottnest Island is a limestone island with sheltered beaches and bays, and a diverse and scientifically important salt lake system. Sand dunes overlie the Tamala and Herschell limestone and are about 20 m thick. It has a unique and diverse environment with coastal dunes of Quaternary age and biodiversity with native woodland species (e.g. the Rottnest Island Pine, *Melaleuca lanceolata* and *Acacia rostellifra*). The coast is vegetated by plants known as 'sea rocket', spinifex and wild rosemary, and there are many native grasses, sedges, and saltwater-tolerant plants on the island. Many birds (e.g. pied cormorant, osprey, silver gulls, sacred kingfisher, banded stilts, grey plover, and reef heron), quokkas, reptiles (e.g. green and loggerhead turtles) and amphibians (e.g. western green tree frog and the moaning frog) can be found on the island. The marine life, including humpback whales, is also diverse and attracts many visitors.

As part of European settlement, land on the island was cleared for the Thompson Bay settlement and other areas. The Wadjemup Lighthouse and associated research house are located in the Wadjemup bore field. The desalination plant, bituminised catchment area (which is no longer used for drinking water supply), wind turbine and parts of the Longreach holiday settlement are located near the saltwater bores.

RIA is actively revegetating the island. Rottnest Island pine (*Callitris preissii*) and Rottnest Island tea tree (*Melaleuca lanceolata*) seedlings are used for replanting.

1.3.2 Climate

Rottnest Island has a Mediterranean-type climate, with cool, wet winters and warm to hot, dry summers. Since 1983, the average monthly maximum temperatures have ranged from 17.7 ^{o}C in July to 27.3 ^{o}C in February and the average monthly minimum

temperatures have ranged from 12.3 ^{o}C in July to 19.5 ^{o}C in February. Average annual rainfall since 1983 is 575.6 mm, with most occurring during the winter months (Bureau of Meteorology 2013).

1.3.3 Hydrogeology

Groundwater occurs in the Tamala Limestone forming a shallow, unconfined aquifer at Rottnest Island. The aquifer is recharged by direct rainfall to form a thin freshwater lens resting on saline water with a mixing zone.

The Tamala Limestone formation contains various proportions of fine- to coarse-grained quartz sand, fine- to medium-grained shell fragments, and small, clayey lenses. The aquifer's storage characteristics depend on the properties of the limestone (e.g. hydraulic conductivity and pore size). The hard calcrete layer which occurs on the mainland of Western Australia seems to be less developed at Rottnest Island. This means the aquifer is less protected from saline intrusion. Refer to Playford and Leech (1977) and Hirschberg and Smith (1990) for a comprehensive review of the geology and hydrogeology.

The thickness of the freshwater lens in the Tamala Limestone ranges from less than 0.5 m to 8.5 m with an average thickness of 4.2 m. The fresh water layer is likely to be thickest underneath the highest ground (Leech 1976). From the centre of the catchment, flow is assumed to travel radially to the perimeter of the island and discharge into the ocean and saline lakes to the east.

1.4 How is this drinking water source currently protected?

The RIA manages Rottnest Island under the provisions of the *Rottnest Island Authority Act 1987* and Rottnest Island Regulations 1988, and in accordance with the *Rottnest Island management plan 2009–2014*. This plan was approved by the Minister for Tourism in 2009. The Minister for Tourism has the responsibility of administrating the *Rottnest Island Authority Act 1987*.

The drinking water supply system is managed in accordance with the conditions outlined in *Ministerial approval statement 324* and the current licence issued by the department (see sections 1.2.1 and 1.2.2).

According to the RIA's development guidelines water quality must be protected through pollution control measures imposed on developments, specified in business leases and in facilities maintenance, cleaning and other contracts and through education. The guidelines also stipulate that groundwater abstraction or recharge must be managed to protect freshwater flows and ecosystem values.

The water quality of the Rottnest Island drinking water supply is regularly monitored (after treatment) and the results are reported in quarterly drinking water reports from the RIA to the Department of Health. The raw water from the Wadjemup and saltwater bores are generally monitored at the beginning of the peak season

(September or October) and at the end of the peak season (March or April), when the fresh water bore field is used for supplementing the drinking water supply.

The Rottnest Island drinking water source is currently not proclaimed under the *Country Areas Water Supply Act 1947*. Proclamation identifies the location of the water reserve and ensures that its drinking water value is considered in land use planning decisions. It also allows by-laws to be applied for the protection of water quality. Therefore, the department recommends the proposed Rottnest Island Water Reserve is proclaimed under the *Country Areas Water Supply Act 1947* (Appendix A, Figure A2).

The *Rottnest Island management plan 2009–2014* does not recognise the proposed Rottnest Island Water Reserve as a special control area. Special control areas help protect public drinking water source areas (PDWSAs) from incompatible land uses and activities via the land use planning decision process. The department recommends that the RIA include the Rottnest Island Water Reserve as a special control area in the next edition of the *Rottnest Island management plan*. The types of development supported should be guided by the department's Water quality protection note (WQPN) no. 25: *Land use compatibility in public drinking water source areas*. This note is linked to the Western Australian Planning Commission's Statement of planning policy no. 2.7: *Public drinking water source policy*, which addresses development in PDWSAs.

1.5 Other water management information

1.5.1 Other groundwater bores in the area

Literature indicates the presence of historical wells close to the Wadjemup Lighthouse precinct. If bores for other purposes (e.g. irrigation, private household use) are drilled near a public drinking water supply bore, they can cause contamination of the drinking water source. For example, a poorly constructed private bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

It is therefore important to ensure that any bores are appropriately located and constructed to prevent contamination of the public drinking water source. This will be assessed through the department's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914*. All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

1.5.2 Water monitoring

Rottnest Island's groundwater and associated lake systems are important to the island's unique ecology and are monitored in accordance with the *Rottnest Island groundwater, lakes and freshwater monitoring program* that is overseen by the Department of Environment Regulation (previously the Department of Environment and Conservation). The program is also used by this department for ensuring compliance with the groundwater licence until the RIA has prepared its operating strategy for the water source.

Monitoring of groundwater levels and quality is conducted to meet priorities identified in the *Terrestrial management strategy 2012–2015* and climate adaptation strategies developed under the *Rottnest Island management plan 2009–2014*.

1.5.3 Boating management strategy 2014

The RIA released its draft *Boating management strategy* for public comment in May 2013 as part of the implementation of the *Rottnest Island management plan 2009–2014*. This strategy has now been finalised. According to this strategy, approximately 185 000 people visit Rottnest Island by private or charter boats. The strategy will assist the RIA in making decisions about future planning and development in the marine reserves such as facilities for recreation, sullage disposal and water supply for boats, infrastructure (additional mooring sites) and emergency response in accordance with the island's marine environmental values.

2 Common contamination risks

Land development and land- or water-based activities within a water reserve can directly affect the quality of drinking water and its treatment. Contaminants can reach drinking water sources through run-off over the ground and infiltration through soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of a reliable, safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health. Other impurities can affect the water's aesthetic qualities, including its appearance, taste, smell and 'feel' but are not necessarily hazardous to human health. For example, cloudy water with a distinctive odour or strong taste may not be harmful to health, but clear, pleasant-tasting water may contain harmful microorganisms (NHMRC & NRMMC 2011). Contaminants can also interfere with water treatment processes, and damage water supply infrastructure (such as iron corroding pipes).

The *Australian drinking water guidelines* (NHMRC & NRMMC 2011) outlines criteria for acceptable drinking water quality to protect human health, manage aesthetics and maintain water supply infrastructure.

For more information about water quality in this PDWSA, see section 3: *Contamination risks in this drinking water source*.

Some commonly seen contamination risks relevant to groundwater drinking water sources are described below.

2.1 Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness. These include bacteria, protozoa and viruses. In drinking water supplies, pathogens are commonly found in the faeces of humans and domestic animals (such as dogs and cattle).

Pathogens can enter drinking water supplies from faecal contamination in the water reserve. In groundwater sources, this occurs indirectly – faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (e.g. *Salmonella*, *Escherichia coli* and cholera), protozoa (e.g. *Cryptosporidium*, *Giardia*) and viruses. Monitoring for the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (e.g. humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water. The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 to 4.3 per cent of people are

infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

The survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and the length of time it normally takes to decay) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature and pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, some reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1000–1600 m in channelled limestone
- 250–408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

Unlike chemicals, which dissipate and dilute when they enter a water source, pathogens can multiply under the right conditions, increasing the likelihood of contamination. Therefore it is important to understand both the surface water and groundwater systems to be able to protect the drinking water source from pathogens.

When people consume drinking water contaminated with pathogens the consequences vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and sometimes even death. During 2000, seven people died in Walkerton, Canada, because the town's water supply was contaminated by a pathogenic strain of *Escherichia coli* and *Campylobacter* (NHMRC & NRMMC 2011).

Given the wide variety of pathogens, the differences in how they act in the environment and the potential consequences of consuming contaminated water, the most effective way to protect public health and reduce water treatment costs is to avoid the introduction of pathogens into a water source.

2.2 Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water (cloudiness). Increased turbidity can result in cloudy or muddy-looking water, which is not aesthetically appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens can adsorb onto soil particles and may be shielded from the effects of disinfection. Chemicals can also attach to suspended soil particles.

Some physical properties of water such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. Other properties such as iron and dissolved organic matter can affect the colour and smell of water. Although not necessarily harmful to human health, coloured or 'hard' water will not be as appealing to consumers. Salinity can affect the taste of drinking water.

2.3 Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2011). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides (and other chemicals) may occur as a result of accidental spills, incorrect use or leakage from storage areas. In these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

Hydrocarbons (e.g. fuels and oils) are potentially toxic to humans, and harmful chemical by-products may be formed when they are combined with chlorine during the water-treatment process. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

Drinking water sources can also be contaminated by nutrients (such as nitrogen) from fertiliser, septic systems, and faecal matter from domestic or feral animals that washes through or over soil and into a water source. Nitrate and nitrite (forms of nitrogen) can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2011).

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter drinking water sources and could be harmful to human health.

3 Contamination risks in this drinking water source

3.1 Water quality

3.1.1 Treated drinking water

Programmed Facility Management regularly monitors the quality of treated water from the Rottnest Island drinking water supply for microbiological, health-related and aesthetic (non-health-related) characteristics and the results are published in the quarterly and annual drinking water reports by the RIA and submitted to the Department of Health. The drinking water supply meets the criteria provided in the *Australian drinking water guidelines* (NHMRC & NRMMC 2011).

The RIA's annual and quarterly water reports are provided on their website at <www.rottnestisland.com> *About us* > *Policy and reports* > *Rottnest Island utility reports*.

3.1.2 Raw (untreated) drinking water

The quality of raw (source) water of the freshwater and saltwater (desalinated) bores is monitored regularly for basic characteristics (including electrical conductivity, pH, total dissolved solids and water temperature). Samples for testing the health-related and aesthetic (non-health-related) characteristics of the freshwater and saltwater bores are taken twice a year (Programmed Facility Management, 2011). During 2011–12, the raw (source) water from 7 out of 13 freshwater bores and 3 out of 5 saltwater (desalinated) bores were analysed by a National Association of Testing Authorities accredited laboratory and the results were reported to the RIA.

Freshwater bores at Wadjemup bore field

Salinity in the bores fluctuates seasonally in response to groundwater abstraction and rainfall recharge. The salinity of the freshwater bores was recorded to range between 434 mg/L and 917 mg/L (Rockwater 2011).

A major risk to the quality of the freshwater lens is from saltwater intrusion as a result of over-pumping. Therefore the groundwater source needs to be carefully managed to avoid this.

Microbiological results (*Escherichia coli* and thermotolerant coliforms) were reported as less than 1 CFU per 100 mL. According to the *Australian drinking water guidelines*, no *E. coli* or thermotolerant coliforms should be present in a 100 mL sample of water used for drinking water supply. This should be addressed by the water service provider when reviewing the raw (source) water quality monitoring program for the island.

Saltwater bore field at Longreach Bay

Increased boron levels between 4.8 mg/L and 4.9 mg/L were reported for several saltwater bores. In general, higher levels of boron are associated with natural seawater and seawater intrusion (NHMRC & NRMMC 2011).

Freshwater bores at Wadjemup and saltwater bores at Longreach Bay

The results for arsenic and selenium for both bore fields were reported at higher detection levels than identified in the *Australian drinking water guidelines*, i.e. the guideline value for selenium is 0.01 mg/L, but the results were reported as <0.03 mg/L. This makes it difficult to compare the raw water results to the *Australian drinking water guidelines* (NHMRC & NRMMC 2011).

The department recommends that the RIA should review its raw (source) water quality monitoring program, particularly with respect to:

- number and frequency of samples to be taken for each production bore
- detection levels that are comparable to the Australian drinking water guidelines
- reporting on quality of raw (source) water
- consistent numbering and reporting of production bores for the Rottnest Island drinking water source.

These measures will ensure that sufficient data is obtained to determine the trends of the raw water quality of the drinking water source.

3.2 Current contamination risks

The RIA manages Rottnest Island in accordance with the *Rottnest Island management plan 2009–2014*. The key objective for the RIA is to provide holiday and recreation facilities for visitors while protecting and maintaining the natural and built environment of the island.

Development on the island is limited to the designated Rottnest Island settlement area that is defined in the *Rottnest Island Authority Act 1987*, unless approved by the Minister for Tourism or specified in the management plan. The location of the Rottnest Island settlement area, illustrated in Figures A2 and A5, is based on information taken from the management plan. Any proposed development applications for the island are considered by the RIA, but the RIA may request advice relating to the proposed developments from any other relevant local or state government agencies during the assessment process.

The proposed Rottnest Island Water Reserve will consist of two bore fields; the Wadjemup bore field and the Longreach Bay saltwater bore field. These bore fields are located over Crown land. Current land uses and activities and their risks to the drinking water source are described below. Table 1, at the end of this section, summarises this information in an easy-to-read format. Appendix B displays a more detailed risk assessment, and includes recommended protection strategies to address water quality risks.

Land uses and activities within the proposed Rottnest Island Water Reserve that could have a potential impact on water quality include:

Wadjemup bore field

- on-site wastewater treatment systems for public toilets
- roads and tracks
- infrastructure such as water pipes, bores and associated tracks
- Wadjemup Lighthouse precinct
- recreational activities such as cycling, walking and sightseeing.

Longreach Bay saltwater bore field

- wastewater pump station including infrastructure collecting wastewater from tourist accommodation and commercial premises at Geordie Bay, Fays Bay and Longreach Bay
- roads and tracks
- infrastructure such as water pipes, bores and associated tracks
- water treatment plant (desalination plant, reverse osmosis)
- recreational activities such as cycling, playing golf and walking.

These land uses and activities are illustrated in Appendix A (Figure A3) and some photographs are provided in Appendix C (figures C1 to C12).

Only land down to the low water mark of the island can be proclaimed under the *Country Areas Water Supply Act 1947* for the protection of a public drinking water source. The RIA should be aware that water-based activities such as shipping channels (potential spills), sullage from boats (mooring), and decomposing bodies of dead marine life such as whales may pose potential risks to the saltwater bore field at Longreach Bay. Only the land-based risks have been addressed in this report. The department recommends that the risks and management options of the water-based activities should be discussed in the RIA's *Boating management strategy* and the RIA's *Drinking water quality risk management plan*, to ensure the protection of the bore field at Longreach Bay.

3.2.1 Land uses and activities on Crown land

The proposed Rottnest Island Water Reserve (Wadjemup bore field and Longreach Bay saltwater bore field) contains only Crown land (Crown reserve 16713). The RIA has a small number of lease arrangements (e.g. with the Australian Maritime Safety Authority) at the Wadjemup Lighthouse precinct.

The bore fields are considered vulnerable to contamination from the surrounding land uses and activities due to their unconfined and shallow nature.

Roads and tracks

There are several bitumised roads and unsealed tracks in the proposed Rottnest Island Water Reserve. The RIA maintains these on a regular basis to ensure adequate access for the island's bus services, service vehicles, bicycles and visitors.

However, only limited numbers of vehicles are permitted to drive on the island. All drivers are inducted by the RIA and need to hold a special driver permit.

Erosion caused by vehicles can contribute to turbidity in a water body, but this is considered a low risk to a groundwater source. Hydrocarbon contamination can come from vehicle accidents, leaks and spills. Therefore, the number of roads and tracks in the proposed Rottnest Island Water Reserve should be kept to a minimum. Tracks not essential to the management of the bore field should be closed to the public or rehabilitated, and the RIA's emergency response plan should be made available to all officers responsible for emergency response on the island. Signs to advise staff and visitors of the PDWSA should be put in place. Appropriate signs can assist in educating visitors and staff of the sensitive nature of the drinking water source.

In general, new major roads and associated infrastructure are not supported in P1 areas and wellhead protection zones, unless it can be demonstrated that alternative siting is impractical or the alignment is important to the island's interest.

The department recognises that the RIA is obliged to provide a safe and efficient road network for the visitors and other users on the island, and best management practices should be employed in the bore fields to protect the quality of this drinking water source.

Any further extensions or upgrades of the road network on Rottnest Island that are located in the bore fields should consider the department's WQPN no. 44: *Roads near sensitive water resources*.

Recreation

The objective for the RIA is to provide holiday and recreation facilities on the island for visitors while protecting and maintaining the natural and built environment of the island. Recreational activities such as cycling, walking, and sight-seeing on constructed roads, tracks and trails are supported in the proposed Rottnest Island Water Reserve. The department's Operational policy no. 13: *Recreation within public drinking water source areas on Crown land* also supports passive recreation in the wellhead protection zone and outer catchment of a groundwater source area. Recreational activities such as off-road driving, camping and caravanning, hunting, and training animals are not supported in a water reserve under this policy, and are unlikely to occur on the island.

Wastewater disposal

Public toilets with an on-site septic tank and leach drain system are located at City of York Bay, Nancy Cove and the research house in the Wadjemup bore field. The septic systems at City of York Bay and the research house are also located within wellhead protection zones. Pathogens from human wastewater are considered to pose a high level of risk to drinking water sources (see section 2.1). Therefore, this hazard has been assigned as a high level of risk in Table 1. The department

encourages the RIA to adopt best management practices to prevent or reduce pathogens and nutrients from entering the groundwater source.

Composting toilets such as those used at Stark Bay and Rocky Bay at Rottnest Island (the latter is located outside of the proposed Rottnest Island Water Reserve) are considered to pose a lower risk to drinking water quality, and similar systems are recommended to be used in the event that the on-site wastewater systems in the proposed water reserve need to be upgraded or replaced.

A sewer pump station and associated wastewater pipe servicing over 100 holiday units and commercial premises (e.g. shops, café and laundry) is located in the Longreach Bay saltwater bore field. The wastewater is disposed of in the island's wastewater treatment plant that is located outside the Longreach Bay saltwater bore field. Any overflow of the sewer pump station or sewer pipe leakages into the environment at Longreach Bay may pose a high level of pathogenic risk to the saltwater bores and requires careful management (Table 1).

Road drainage is also situated in proximity to the sewer pump station and it discharges stormwater into the dunes at Longreach Bay beach. Therefore, any overflow of the sewer pump station may indirectly enter the beach and marine environment via the stormwater system.

Rinsing down rubbish trucks at this road drainage point should be avoided, as any contaminated run-off could enter the beach and marine environment and indirectly pose a risk to the water quality of the saltwater bores.

Golf course

Fertiliser, pesticides and machinery are commonly used for the establishment and maintenance of golf courses. These activities may pose a risk of contamination to the drinking water source. The risks include nutrient and chemical contamination from fertiliser and pesticide use, and hydrocarbon contamination from the use of machinery (e.g. oil and fuel leaks and spills). Best management practice guidance for this land use is provided in Table 1.

Rehabilitation work

Conservation Volunteers Australia and other volunteer groups undertake rehabilitation work on Rottnest Island with funding from independent volunteer organisations, schools, clubs and corporate groups, who wish to contribute their time on Rottnest Island. This includes removal of weeds and replanting with native vegetation. Establishing native vegetation buffers help to improve the quality of run-off entering the waterways. If any rehabilitation work is undertaken in the proposed Rottnest Island Water Reserve involving the use of pesticides, then the RIA and its contractors must consider the department's Statewide policy no. 2: *Pesticide use in public drinking water source areas* and the Department of Health's Public sector circular (PSC) no. 88: *Use of herbicides in water catchment areas*.

Water treatment plant

The Rottnest Island Desalination Plant (reverse osmosis) was commissioned in October 1995 and upgraded in 2006. The plant is located on Mount Herschel, in the Longreach Bay saltwater bore field, and is considered the major drinking water supply for the island. Water treatment plants are considered a compatible land use in a drinking water source area according to WQPN no. 25: *Land use compatibility in public drinking water source areas.*

Bitumen catchment area

The island has a man-made surface catchment area covered in bitumen, which was originally commissioned by the Australian Army in 1939 and is located at Mount Herschel. It covers the area bounded generally to the west and south by the road from Geordie Bay to Bovell Highway, to the north by the cycle track from Longreach settlement to the Basin, and to the east by the golf course (Appendix A, Figure A3). This catchment provided drinking water for many years, but in 2010, as a result of low annual rainfall and disintegration of the bitumen, the catchment area ceased being used as a drinking water supply. The Rottnest Island Regulations 1988 still contain provisions to protect the bitumen catchment from incompatible land use activities.

This catchment is now used for the supply of irrigation water.

Aboriginal sites of significance and native title claims

Aboriginal sites of significance are those areas that Aboriginal people value as important and significant to their cultural heritage. The sites are significant because they link Aboriginal culture and tradition to place, land and people over time. These areas form an integral part of Aboriginal identity and the heritage of Western Australia. The *Aboriginal Heritage Act 1972* protects all Aboriginal sites in the state.

There are a number of significant Aboriginal sites on Rottnest Island, but according to the Department of Indigenous Affairs' records, no sites are located within the proposed Rottnest Island Water Reserve.

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights to lands and water arising from their traditional laws and customs.

There is a native title claim that covers the proposed Rottnest Island Water Reserve. This is the claim made by the Noongar people (WAD6006/03) under the custodianship of the Whadjuk people. Rottnest Island is known as Wadjemup (meaning place of spirits) to the Noongar people and is spiritually important to Aboriginal people.

The department is committed to working with Aboriginal people in its planning and management activities. The department recognises that native title is an important framework for water management.

The RIA released its *Reconciliation Action Plan 2012-2015* for recognising the cultural significance of the Aboriginal people, and works in partnership with the South West Aboriginal Land and Sea Council to facilitate a Noongar advisory group to assist in the ongoing development and implementation of the plan.

Heritage place

The Rottnest Island Lighthouse station (including the lighthouse and lighthouse keeper's residence) is a National Trust registered heritage place (heritage number 3254) and is recognised for its cultural, scientific, aesthetic and social values. This heritage place was important for shipping in Western Australia and for the development of Fremantle Port. The Lighthouse station precinct is located in the Wadjemup bore field.

3.3 Future contamination risks

3.3.1 Proposed chemical storage at Wadjemup light house

The RIA proposes to replace the power supply for the Wadjemup Lighthouse with a hybrid power system that combines technology from renewable power solutions and conventional systems to save fuel when the renewable energy source is available. As part of this upgrade, approximately 1000 L of fuel is proposed to be stored in proximity to the lighthouse. The storage of hydrocarbon in a PDWSA is a risk to the drinking water source, due to potential contamination from oil and fuel leaks and spills. Therefore, the RIA should reconsider the location of the chemical storage area and investigate if this storage tank could be installed outside the Wadjemup bore field. If this cannot occur, best practice fuel storage and transfer engineering is required. Guidelines on best management practices for chemical storage are available in the department's WQPN no. 56: *Tanks for elevated chemical storage*.

3.3.2 Re-use of treated wastewater on the golf course

Treated wastewater is planned to be used on the greens and fairways of the island's golf course. Small portions of the golf course are located along the southern boundary of the Longreach Bay saltwater bore field.

This proposal was referred to the Environmental Protection Authority (EPA) for assessment. The EPA concluded that the use of treated wastewater on the golf course is not likely to have a significant impact on the environment and the potential impacts associated with this use can be managed under Part V (Industry Licensing) of the *Environmental Protection Act 1986*. The proposal was supported subject to a number of conditions, including:

- preparation of a nutrient irrigation management plan to the satisfaction of the then Department of Environment and Conservation.
- amending the RIA current operating licence under Part V of the *Environmental Protection Act 1986* for the upgrade of the wastewater treatment plant prior to irrigating the golf course with treated wastewater (Environmental Protection Authority, 2012).

The use of treated wastewater is generally not permitted in a PDWSA, because pathogens from human wastewater are considered to pose a high level of risk to drinking water sources (NHMRC & NRMMC 2011). Any re-use of treated wastewater needs to consider the *Australian guidelines for water recycling – Managing health and environmental risks and related guidelines* (NHMRC & NRMMC 2006).

The work for installing treated wastewater pipes has commenced on the golf course (Appendix C, figures C9 and C10).

The existing Rottnest Island wastewater treatment plant is proposed to be replaced. This proposal is in the preliminary planning stage and is subject to obtaining the required funding.

Table 1 Summary of potential water quality risks, land use compatibility and best management practices (full details are provided in Appendix B)

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance[1]
Wadjemup bore field and Longreach Bay saltwater bore field				
Roads and tracks traversing the bore fields	• hydrocarbons • nutrients • pesticides	Medium	In general, major new roads are considered incompatible in P1 areas and WHPZs. However, there is limited traffic on the island (authorised driving only).	WQPN no. 44: *Roads near sensitive water resources* *WQPN 10: Contaminant spills – emergency response* Statewide policy 2: *Pesticide use in PDWSAs* Department of Health PSC 88: *Use of herbicides in water catchment areas*
Infrastructure maintenance • power lines • pipelines • associated tracks • production bores and associated fixtures/ structures • disused bitumised catchment area	• chemicals • hydrocarbons • nutrients • pathogens	Low	Infrastructure corridors are compatible with conditions in P2 and P3 areas, and occasionally approved with conditions in P1 areas where it can be demonstrated alternative siting is impractical or vital to the island's interest.	WQPN 83: *Infrastructure corridors near sensitive water resources* Statewide policy 2: *Pesticide use in PDWSAs* Department of Health's PSC88: *Use of herbicides in water catchment areas*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance[1]
Crown land reserve (passive recreational activities)	• nutrients • chemicals • hydrocarbons • pathogens • rubbish	Low	Crown land is a compatible land use in a P1 PDWSA. Passive recreation in a water reserve (groundwater) is considered compatible on Crown land.[1]	Department of Water's Operational policy 13: *Recreation within public drinking water source areas on Crown land*
Wadjemup bore field				
Public toilets	• pathogens • nutrients	High	Toilet blocks are considered as compatible with conditions in P1 areas.[1]	WQPN 70: *Wastewater treatment and disposal-domestic systems* Department of Health's Environmental health guide: *Understanding septic tank systems*
Proposed chemical storage at Wadjemup Lighthouse	• hydrocarbons	Medium	Chemical storage of fuel is considered an incompatible land use in P1 areas[1].	WQPN 56: *Tanks for elevated chemical storage* WQPN 65: *Toxic and hazardous substance: storage and use* WQPN 10: *Contaminant spills – emergency response*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance[1]
Longreach Bay saltwater bore field				
Sewer pump station servicing holiday units and commercial premises from Geordie Bay, Fays Bay, and Longreach Bay	• pathogens • nutrients • chemicals • hydrocarbons	High	A sewer pump station is considered as a compatible land use with conditions in a P3 area[1].	Sewer pump stations should be designed, constructed and operated in accordance with all relevant standards
Golf course	• nutrients • chemicals • hydrocarbons • pathogens	Medium	A golf course is considered an acceptable land use in a P3 area. Re-use of treated wastewater for irrigation is considered an incompatible land use in a PDWSA.	*Environmental guidelines for the establishment and maintenance of turf and grassed areas* Statewide policy 2: *Pesticide use in PDWSAs* Department of Health's PSC 88: *Use of herbicides in water catchment areas*
Water treatment plant (reverse osmosis)	• chemicals • high salt (brine) from treatment process	Low	Water treatment plants are compatible with conditions in a P1 area.	WQPN 65: *Toxic and hazardous substance : storage and use*

[1]Water quality protection notes are available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for *water quality protection notes*.

4 Protecting your drinking water source

The main objective of this plan is to protect the proposed Rottnest Island Water Reserve in the interests of providing a reliable and safe drinking water to the island's visitors, staff and residents. In addition, this plan aims to balance water quality protection, social needs and the expectations of visitors.

The objective of water source protection is to preserve water quality at its current level, and where practical, achieve an improvement.

Where water reserves remain covered with native vegetation and experience little human activity, the risk of contamination is low. Contamination risks will however inevitably increase with human activity and development.

This plan recognises the right of existing approved land uses to continue to operate in the Rottnest Island Water Reserve. However, these land uses should be managed with best management practices to reduce the risks to water quality. The avoidance, minimisation and management of risks to water quality for public supply is imperative for the protection of public health.

4.1 Wellhead analytic element model

The software used for determining the extent of the Wadjemup bore field is called the Wellhead analytic element model (WhAEM) and was developed by the Environmental Protection Authority (United States) in 2007 (Kraemer, Haitjema and Kelson 2007). The model includes a suite of simple analytic methods for delineating the capture zone of the production bores (i.e. the groundwater flow paths which contribute water to a bore). Hydraulic data for Rottnest Island is limited, therefore the hydraulic parameters (such as conductivity, gradient, porosity and saturated thickness for the Wadjemup freshwater lens) used for determining the capture zones of the bores are primarily based on the work of Playford and Leech (1977). The pumping rates for the production bores have been taken from the Rockwater report that was commissioned by the RIA in 2011.

4.2 Proclaiming public drinking water source areas

There are a number of potential contamination risks from the marine environment (e.g. swimming, sullage from boat mooring in the bay, chemical spillages from cargo ships passing the island, and decomposition of dead marine animals) that should be considered when protecting the Longreach Bay saltwater bores. Therefore, the marine environment cannot be protected under the *Country Areas Water Supply Act 1947.* The risks and management options of the water-based activities should be discussed in the RIA's draft *Boating management strategy* and the RIA's *Drinking water quality risk management plan* (section 3.2).

This plan recommends proclamation of the proposed Rottnest Island Water Reserve under the *Country Areas Water Supply Act 1947*, as shown in figures A2 and A5. The

proclamation process begins with consultation during the development of a drinking water source protection report.

Once the water reserve is proclaimed, the RIA should incorporate the PDWSA into the next edition of the *Rottnest Island management plan* consistent with State planning policy no. 2.7: *Public drinking water source policy*. PDWSAs are commonly shown in local planning schemes as special control areas. This provides guidance for state and local government planning decision makers and developers.

Proclamation of a PDWSA will not change the zoning of the land. All existing, approved land uses and activities in a proclaimed area can continue. However, the department recommends that best management practices are employed in PDWSAs to protect the quality of the drinking water source. New developments or expansion of existing land uses or activities need to consider the recommendations in this plan. As a general guide, the department does not recommend land use intensification in a PDWSA that will increase risks to water quality and public health.

For more guidance on appropriate land uses and activities please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

4.3 Defining priority areas

The protection of PDWSAs relies on statutory and non-statutory measures for water resource management and land-use planning. The department's policy for the protection of PDWSAs includes a system that defines three specific priority areas within PDWSAs:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance (e.g. state forest and other Crown land).
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation (e.g. land that is zoned rural).
- Priority 3 (P3) areas have the fundamental water quality objective of risk management (e.g. areas zoned urban, industrial or commercial).

The determination of priority areas is based on the strategic importance of the land or water source including risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

The proposed priority areas for the Rottnest Island Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Appendix A (Figure A5). Our WQPN no.25: *Land use compatibility in public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

It is proposed to assign all Crown land in the Wadjemup bore field as P1 because:

- water from this source is the only fresh water available for the Rottnest Island drinking water supply
- water from this source constitutes a strategic supply to the Rottnest Island drinking water supply and it should be afforded a high level of protection
- the bore field represents the groundwater recharge area of the current sole water supply source and the source is vulnerable to contamination from incompatible land uses
- the current land uses (e.g. drinking water treatment plant and toilet blocks) on the Crown land are considered 'compatible with conditions' in a P1 area provided best management practices are applied.

It is proposed to assign all Crown land in the Longreach Bay saltwater bore field as P3 because:

- the land is located in the Rottnest Island settlement area that is designated for development related to tourism and recreation
- the existing land uses (e.g. wastewater pump station, roads and shops) are considered 'compatible with conditions' provided best management practices are applied.

There is no land that is proposed to be assigned for P2 source protection in the proposed water reserve.

4.4 Defining protection zones

In addition to priority areas, protection zones are defined in PDWSAs to protect water from contamination in the immediate vicinity of water extraction facilities (i.e. bores or dams). Specific legislative- or policy-based conditions may apply within these zones such as restrictions on the storage of chemicals or prohibition of public access.

Wellhead protection zones (WHPZs) are generally circular (unless information is available to determine a different shape or size), with a 500 m radius around each production bore in a P1 area and a 300 m radius around each production bore in P2 and P3 areas. WHPZs do not extend outside the boundary of the water reserve and they adopt the priority area of the land over which they occur.

4.4.1 Wellhead protection zones in Wadjemup bore field

The Wadjemup bore field has 29 production bores on Crown land that are managed for P1 source protection. Circular 500 m radius WHPZs are proposed around each production bore (Appendix A, Figure A5). The RIA's consultant report identified seven production bores that are too saline for blending with the water for the Rottnest Island drinking water supply. However, bore 6/90 is still used for blending the drinking water. Therefore all 29 production bores are proposed to be protected by a WHPZ.

There is a public toilet block at City of York Bay and toilet facilities at the research house (Wadjemup Lighthouse precinct) with on-site septic tank and leach drain systems located within WHPZs. These pose a water quality risk as they are close to drinking water bores.

The RIA proposes to replace the power supply for the Wadjemup Lighthouse precinct with a hybrid power supply system that uses diesel as a back-up energy source. Diesel poses a water quality risk if it is stored near drinking water bores.

Best management practices for both of these land uses should be undertaken as provided in this report. Water quality monitoring programs also need to consider these risks.

4.4.2 Wellhead protection zones in Longreach Bay saltwater bore field

The Longreach Bay saltwater bore field has production bores on land that is managed for the objective of P3 drinking water source protection. Therefore circular, 300 m radius WHPZs are proposed around each production bore (Appendix A, Figure A5).

The RIA indicated to the department that the saltwater bore field may need to be extended in the future in order to be able to meet the demand of Rottnest Island's drinking water supply. This should be considered when this plan is reviewed in seven years' time, as additional wellhead protection zones may be required.

A sewer pump station and associated infrastructure, holiday units, commercial premises (such as the shop, café and laundry), golf course and roads and tracks are located within the WHPZs. Recreational activities such as cycling, sight-seeing and walking also occur in the WHPZs. Best management practices for these land uses and water quality monitoring programs need to be considered for these risks.

4.5 Planning for future land uses

It is recognised under the Western Australian Planning Commission's *State planning strategy* (1997) that appropriate protection mechanisms in statutory land-use planning processes are necessary to secure the long-term protection of drinking water sources. As outlined in the State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) it is appropriate that the proposed Rottnest Island Water Reserve, its priority areas and protection zones be recognised in the next edition of the *Rottnest Island management plan* as a special control area. Any development proposals in the Rottnest Island Water Reserve that are inconsistent with advice in our WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the department's nearest regional office for advice.

For further information on the integration of land-use planning and water source protection, please refer to our WQPN no. 36: *Protecting public drinking water source areas*. This note describes the findings of Parliamentary Committee reviews instrumental in the integration of water quality protection and land use planning in WA. The Parliamentary Committees all advocated protection over a reliance on costly water treatment or the clean-up of contaminated sources required in other parts of the world.

The department's protection strategy for PDWSAs provides for approved developments to continue even if those facilities would not be supported under current water quality protection criteria. In these instances, the department can provide advice to landowners or operators on measures they can use to improve their facilities and reduce water quality contamination risks (see section *4.6: Using best management practices*).

4.6 Using best management practices

There are opportunities to reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the department will continue to encourage the adoption of best management practices.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and WQPNs. They recommend practices to help managers reduce their impacts upon water quality. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include:

- Operational policy no. 13: *Recreation within public drinking water source areas on Crown land* (Department of Water 2012)
- Statewide policy no. 2: *Pesticide use in public drinking water source areas* (Water and Rivers Commission 2000)
- the Department of Health's Circular no. PSC 88: *Use of herbicides in water catchment areas* (2007)
- the Department of Water's WQPNs:
  - no. 10: *Contaminant spills : emergency response* (2006)
  - no. 65: *Toxic and hazardous substance : storage and use* (2006)
  - no. 44: *Roads near sensitive water resources* (2006)
  - no. 56: *Tanks for elevated chemical storage* (2006)
  - no. 84: *Rehabilitation of disturbed land in public drinking water source areas* (2009).

These documents are listed in this plan's *Further reading* section.

Education and awareness-raising (such as through providing information on signs and publications) are key mechanisms for protecting water quality, especially for people visiting the area. Signs should be erected on the boundaries of the Wadjemup bore field and Longreach Bay saltwater bore field to educate and advise the public about activities that are prohibited or regulated. Emergency contact details and the purpose of the bore field should be displayed on the signs.

4.7 Enforcing by-laws and surveying the area

The quality of water in the proposed Rottnest Island Water Reserve is recommended to be protected under the *Country Areas Water Supply Act 1947*. Proclamation of PDWSAs allows by-laws made under this act to be applied to protect water quality.

The department considers by-law enforcement, through surveillance of land-use activities in PDWSAs, to be an important mechanism to protect water quality.

This plan recommends that surveillance and by-law enforcement should be undertaken by the RIA. The delegation of the relevant by-laws should be considered by the department and the RIA when implementing this plan.

4.8 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Rottnest Island local emergency management committee (LEMC), which has specified public authority status under Section 35 of the *Emergency Management Act 2005*, should be familiar with the location and purpose of the proposed Rottnest Island Water Reserve.

In 2013, the LEMC consists of:

- RIA (chair)
- Western Australia Police
- Department of Fire and Emergency Services
- Department for Child Protection
- Department of Heath
- Programmed Facility Management.

A locality plan of the Wadjemup bore field and Longreach Bay saltwater bore field will be provided by the department to the fire and emergency services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The RIA should have an advisory role to the HAZMAT team for incidents in the proposed Rottnest Island Water Reserve.

Personnel who deal with Westplan–HAZMAT (Western Australian plan for hazardous materials) incidents within the area should have access to a map of the proposed Rottnest Island Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this drinking water source and public health.

The Rottnest Island Volunteer Fire and Rescue Services, a private brigade managed by the RIA, have a role during emergency responses on the island in consultation with the Department of Fire and Emergency Services.

4.9 Implementing and updating this plan

Table 1 (found at the end of Section 3) identifies the potential water quality risks associated with existing land uses in the proposed Rottnest Island Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix B.

With more than 130 PDWSAs across Western Australia, the department prioritises the update of drinking water source protection reports (such as this document). Our aim is to update each report every seven years. In some locations, more frequent updates may be required to address changing water quality risks and land uses. These updates allow us to make changes to the PDWSA boundary, priority areas and protection zones if required. They also allow solutions to new water quality risks to be considered.

The department can provide advice on source protection risk assessment to help protect the water quality and public health.

5 Recommendations

The following recommendations apply to the proposed Rottnest Island Water Reserve (consisting of Wadjemup bore field and Longreach Bay saltwater bore field). The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Proclaim the boundaries of the proposed Rottnest Island Water Reserve (consisting of Wadjemup bore field and Longreach Bay saltwater bore field) as the Rottnest Island Water Reserve under the *Country Areas Water Supply Act 1947*. (Department of Water)
2. Incorporate the findings of this plan and location of the proposed Rottnest Island Water Reserve (including its priority areas and protection zones) in the next edition of the *Rottnest Island management plan* and relevant planning strategies in accordance with State planning policy no. 2.7: *Public drinking water source policy*. (Rottnest Island Authority)
3. Refer development proposals within the proposed Rottnest Island Water Reserve that are inconsistent with the department's WQPN no.25: *Land use compatibility in public drinking water source areas* or recommendations in this plan to the department's regional office for advice. (Rottnest Island Authority, proponents of proposals)
4. Ensure incidents covered by Westplan–HAZMAT in the proposed Rottnest Island Water Reserve are addressed by ensuring that:
    - the Rottnest Island LEMC and RIVFRS is aware of the location and purpose of the Rottnest Island Water Reserve
    - the locality plan for the Rottnest Island Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
    - the Rottnest Island Authority acts in an advisory role during incidents in the Rottnest Island Water Reserve
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Rottnest Island Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Rottnest Island Authority)
5. A surveillance program should be established to identify and respond to any incompatible land uses or potential contamination threats within the Rottnest Island Water Reserve. Consideration should be given to delegation of surveillance and by-law enforcement responsibilities in the proposed Rottnest Island Water Reserve to the Rottnest Island Authority. (Rottnest Island Authority, Department of Water)
6. Erect signs along the boundaries of the Wadjemup bore field and Longreach Bay saltwater bore field. The signs should include an emergency contact telephone number, the purpose of the bore field, identify what activities may pose a risk to

water quality, who erected the signs and be purpose-designed for their intended audience (e.g. people visiting the island). (Rottnest Island Authority)

7. Review the raw (source) water quality monitoring program for the Rottnest Island drinking water source and ensure sufficient data is obtained to determine water quality trends of the groundwater source. Particular consideration should be given to:

   - the number and frequency of samples to be taken at each production bore
   - sensitivity of lower detection levels as results need to be comparable to the *Australian drinking water guidelines*
   - reporting on quality of raw (source) water
   - consistency in numbering of the production bores.

   (Rottnest Island Authority)

8. Reconsider the location of the proposed chemical (fuel) storage at Wadjemup Lighthouse precinct for the hybrid power system. Ideally, this should be located outside the proposed Rottnest Island Water Reserve. (Rottnest Island Authority)

9. Liaison with the South West Aboriginal Land and Sea Council should occur prior to proclaiming the proposed Rottnest Island Water Reserve. (Department of Water)

10. Ensure the proprietors of the lease agreements (e.g. the Australian Maritime Safety Authority) are informed about the nature and sensitivity of the proposed Rottnest Island Water Reserve. Any land uses and activities occurring within the water reserve should adopt best management practices to protect water quality. (Rottnest Island Authority)

11. Update this plan after seven years. This may require a new plan if substantial changes have occurred. If not, a drinking water source protection review may be developed. (Department of Water in consultation with Rottnest Island Authority)

12. A detailed hydrogeological investigation should be considered to further define the boundary of the Longreach Bay saltwater bore field prior to, or as part of, the update of this plan. (Department of Water)

13. The re-use of treated wastewater in the water reserve should consider the *Australian Guidelines for Water Recycling – Managing Health and Environmental Risks* and related guidelines. (Rottnest Island Authority, Department of Health, Department of Water)

14. The type and level of risks from water-based activities (e.g. from shipping channels, sullage from boats, and decomposing bodies of dead marine life) to the saltwater bore field at Longreach Bay should be considered in the Rottnest Island Authority's *Boating management strategy* and the Rottnest Island Authority's *Drinking water quality risk management plan.* (Rottnest Island Authority)

Appendices

Appendix A — Figures

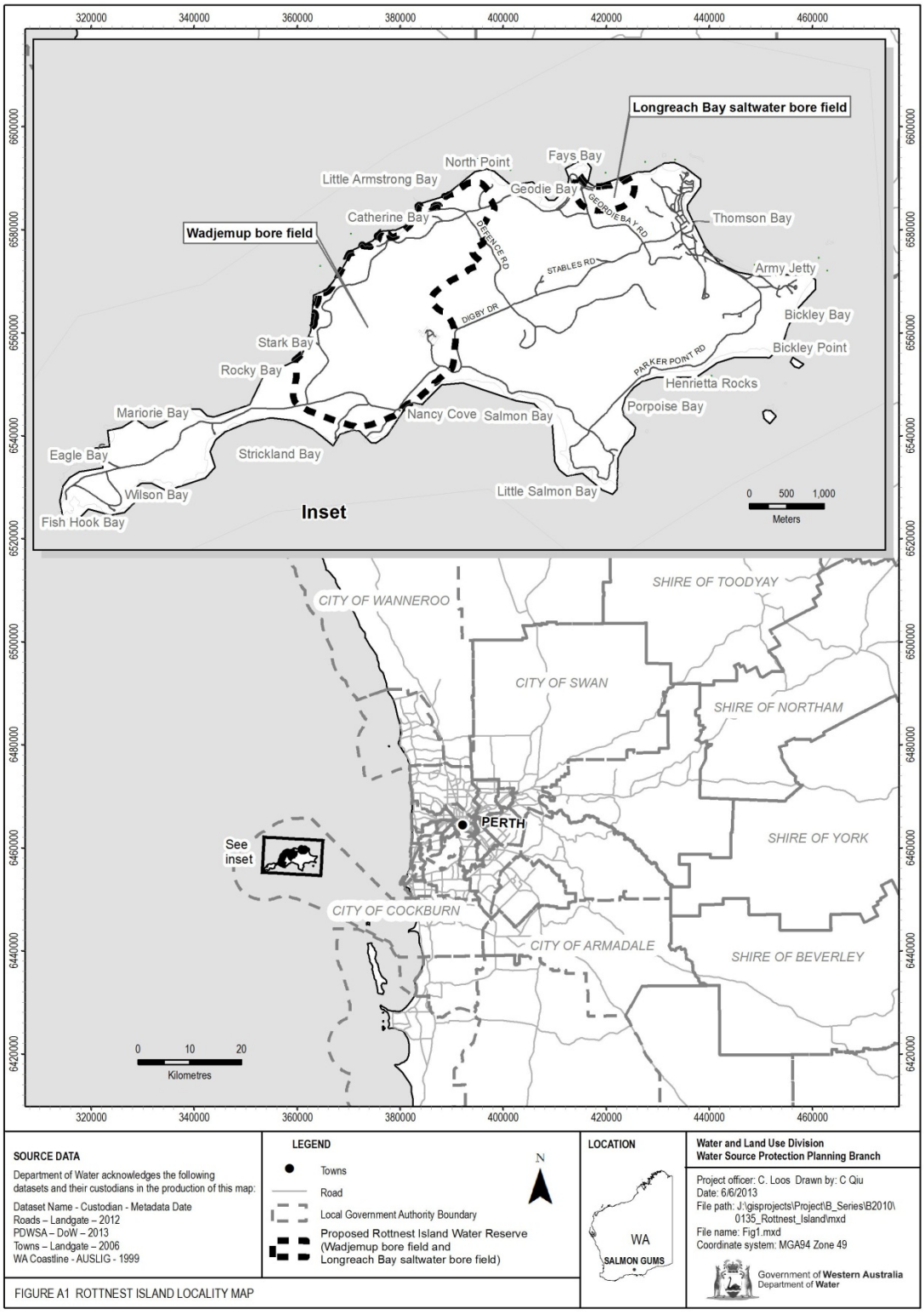

Figure A1 Rottnest Island Water Reserve locality map

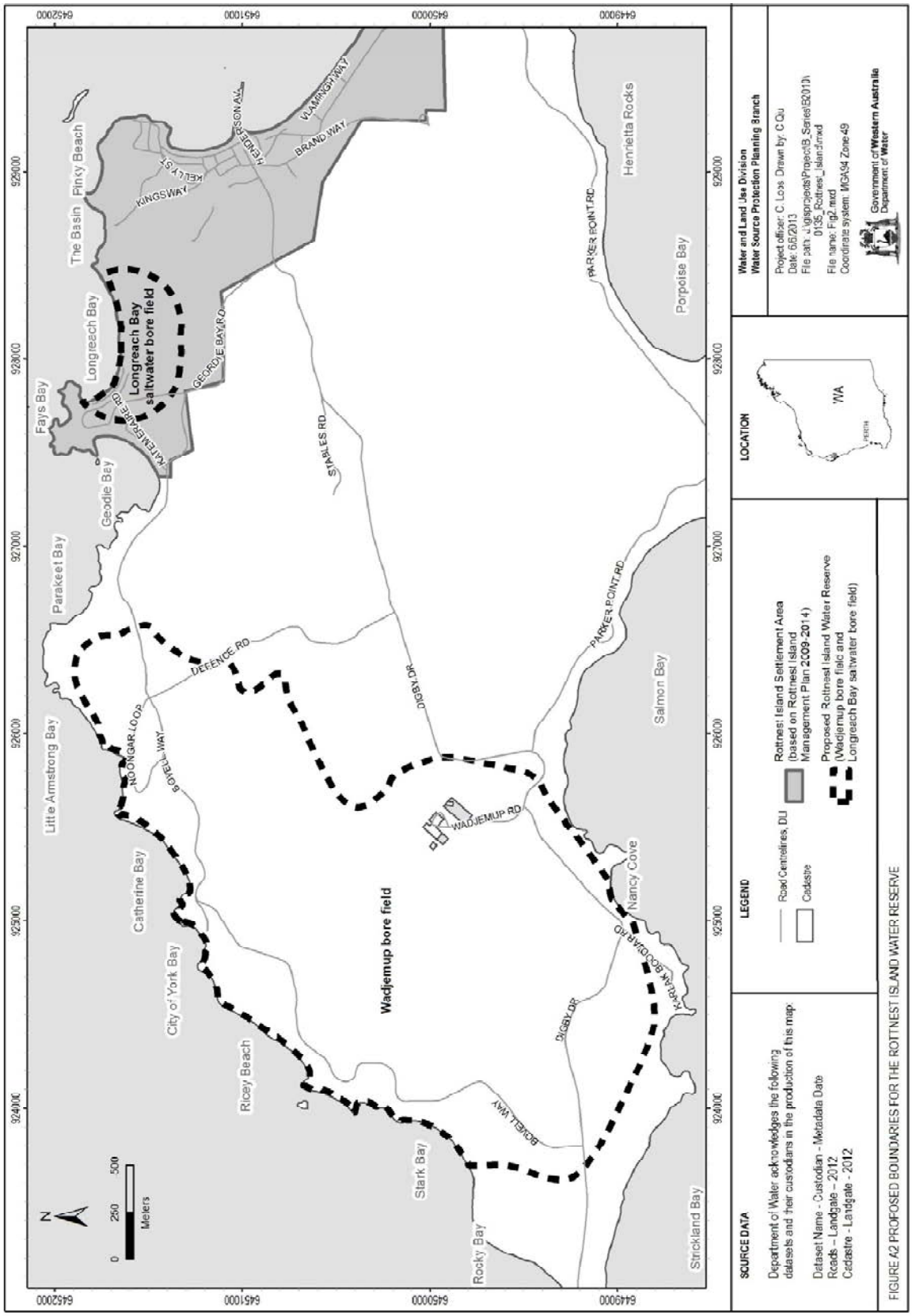

Figure A2 Proposed Rottnest Island Water Reserve

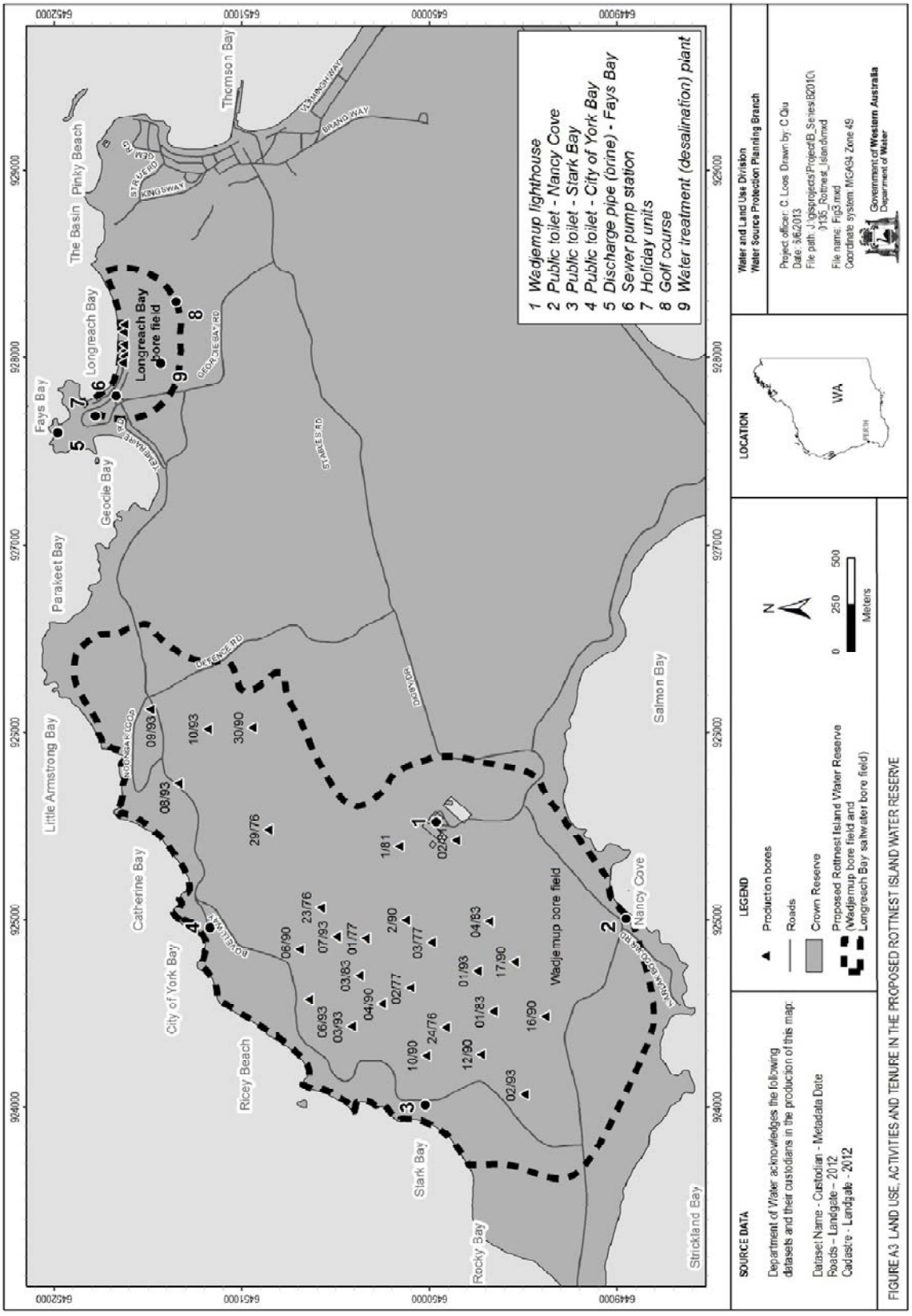

Figure A3 Land use, activities and tenure in the proposed Rottnest Island Water Reserve

Figure A4 Rottnest Island Water Reserve – aerial and other land use information

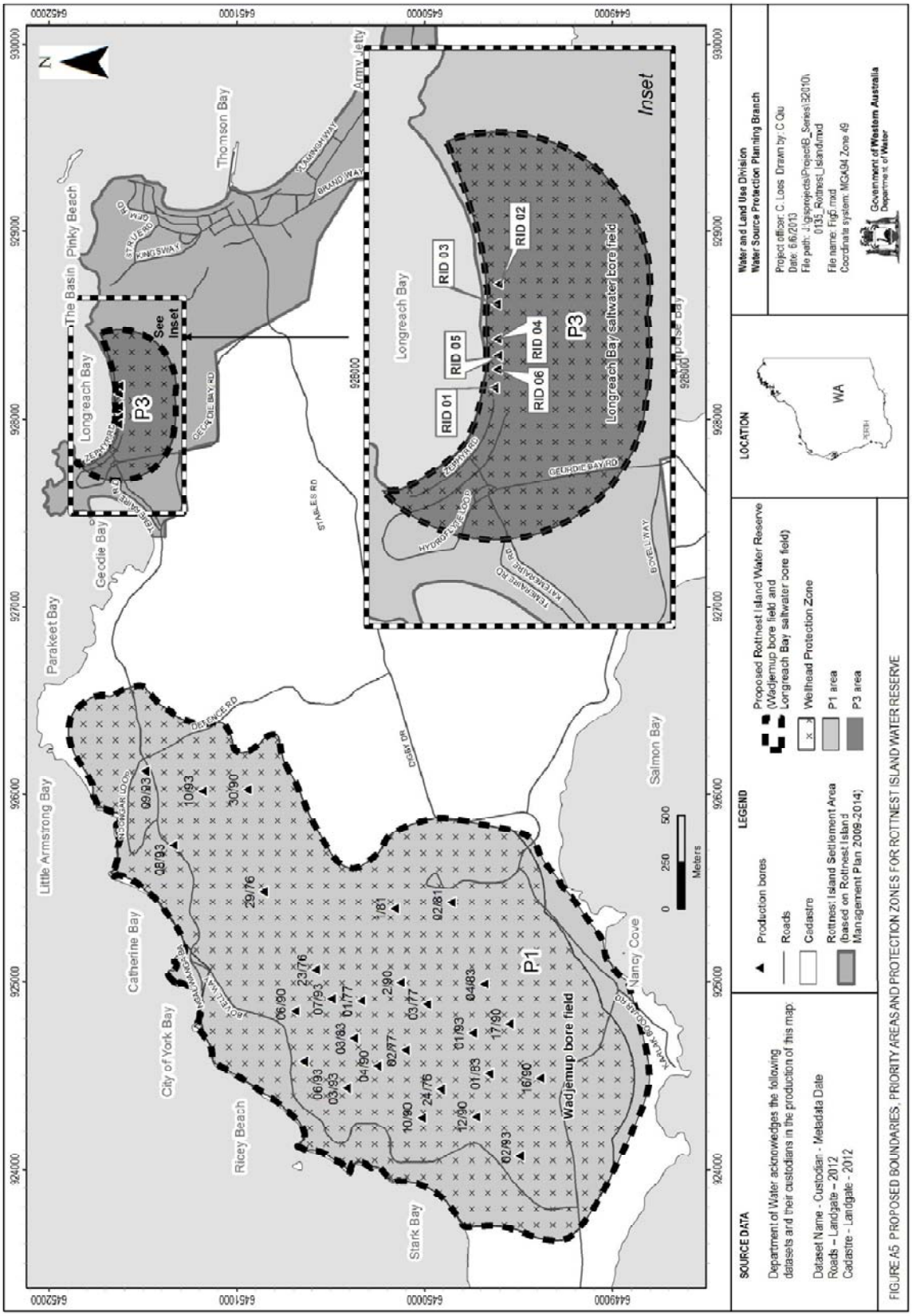

Figure A5 Recommended boundaries, priority areas and protection zones for Rottnest Island Water Reserve

Appendix B — Land use potential water quality risks and recommended protection strategies

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	Management priority			
Wadjemup bore field and Longreach Bay saltwater bore field					
Roads and tracks traversing the bore field	• Hydrocarbons from fuel and chemical spills from service vehicles	Medium	Roads can potentially have a high impact on water quality if fuel or chemical spills occur as a result of a road accident. However, there is limited traffic on the island (authorised driving only). Rubbish trucks are rinsed down above drain at Longreach Bay.	• under Regulation 46 of the Rottnest Island Authority Regulations 1988, a person shall not, without permission, use a vehicle on Rottnest Island. • water quality monitoring • Rottnest Island chemical spill procedures	In general, new major roads are considered incompatible in P1 areas and wellhead protection zones (WHPZs). The best management practices recommended in WQPN no. 44: *Roads near sensitive water resources* and WQPN 10: *Contaminant spills – emergency response* should be considered when planning and undertaking any future road upgrade. Avoid rinsing down rubbish trucks in water reserves.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	• Turbidity from erosion	Low	Turbidity is not considered a high risk to a groundwater source.	• Rottnest Island LEMC emergency response	Ensure the emergency response plan is implemented and the Rottnest Island LEMC is aware of the location and purpose of the Rottnest Island Water Reserve. Close unused tracks, if possible. Place signs along the roads used by staff servicing the island and visitors with an emergency contact number in the event of a spill. Ensure any pesticides used for weed control along road verges is in accordance with Statewide policy no. 2: *Pesticide use in PDWSAs* and Circular no: PSC 88: *Use of herbicides in water catchment areas.*
	• Pesticides from weed spraying along edges of roads	Low	Pesticide may be used to control weeds along road verges.		

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Infrastructure maintenance • power lines • pipelines • associated tracks • production bores and associated fixtures/ structures • disused bitumen catchment area	• Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery	Low	Unauthorised access to unsecured bores may result in direct addition of contaminants to the groundwater. There are records indicating historical wells around the Wadjemup Lighthouse. Location and purpose of production bores should be taken into consideration in any fire emergency plans. Possible chemical contamination from the use of fire suppressants (foams) and fire retardants in the control of bushfires.	• lockable lids on saltwater bore compounds • padlocks at production bores • water quality monitoring • Rottnest Island LEMC emergency response	Infrastructure is compatible with conditions in P3 areas, and occasionally approved with conditions in P1 areas where it can be demonstrated that alternative siting is impractical or vital to the state's interest. The RIA should ensure all bores are sealed and constructed in accordance with the *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee, 2012). Review raw (source) water quality monitoring program to ensure any potential risk can be detected. Provide secure fenced compounds around the production bores to limit access to the bores and infrastructure.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	• Chemicals, e.g. pesticides from weed spraying along edges of roads, pipelines and other structures	Low	Soil subsidence around monitoring bores can result in a shortened pathway for contaminants (e.g. fertilisers and pesticides) to travel to the groundwater.		Ensure lids of saltwater bore compounds are locked to limit access. This will assist in preventing any vandalism to the bores and infrastructure. The best management practices recommended in the WQPN no. 83: *Infrastructure corridors near sensitive water resources* should be considered when planning any upgrades to the infrastructure. Ensure any pesticide used for weed control in the proposed Rottnest Island Water Reserve is in accordance with the Statewide policy no. 2: *Pesticide use in PDWSAs* and the Circular no: PSC 88: *Use of herbicides in water catchment areas*. Historical wells should be identified and assessed to determine the level of risk to water quality.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	• Nutrients from any potential fire retardants and suppressants	Low			Ensure that all agencies and proprietors of lease agreements with responsibilities (and their maintenance contractors) are aware of the location of the proposed Rottnest Island Water Reserve, and that appropriate best management practices are followed while within the PDWSA.
	• Pathogens originating from native animal excreta	Low			
	• Turbidity from erosion	Low			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Crown land reserve (passive recreational activities)	• Pathogens	Low	Passive recreation in a water reserve (groundwater) is considered compatible on Crown land. There are on-site wastewater treatment systems (septic tanks and leach drains) at Nancy Cove, City of York and the research house at Wadjemup Lighthouse precinct. Bus services are provided for visitors to travel around the island (fuel or chemical spills as results of accidents).	• majority of visitors recreate in and around Thomson Bay • water quality monitoring • limited traffic on the island (permit by RIA) • Rottnest Island chemical spill procedures • Rottnest Island LEMC emergency response • staff monitoring and removing rubbish on island	Passive recreation in a water reserve (groundwater) is considered compatible on Crown land. This is outlined in the Department of Water's Operational policy no. 13 *Recreation within public drinking water source areas*. The RIA should induct staff about the requirements of protecting the island's drinking water source. Use appropriate signs and educational material to inform the visitors and staff about the protection requirements of the drinking water source. Best management practices is provided in WQPN no. 70: *Wastewater treatment and disposal: domestic systems.*
	• Nutrients	Low			
	• Hydrocarbons and chemicals	Low			
	• Rubbish	Low			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Wadjemup bore field					
Public toilets	• Pathogens from human wastewater	High	Conventional on-site wastewater treatment systems consisting of septic tank and leach drain are used at Nancy Cove and the research house (Wadjemup Lighthouse precinct). The septic tanks and leach drains at City of York and the research house are located within WHPZs.	• water quality monitoring (limited monitoring for microorganisms)	Toilet blocks are considered compatible land uses with conditions in P1 areas. Best management practices are provided in WQPN no. 70: *Wastewater treatment and disposal- domestic systems* and the Department of Health's Environmental health guide: *Understanding septic tank systems.* Any planned upgrades of these on-site wastewater treatment systems should consider the use of alternative wastewater treatment systems, such as the composting wastewater treatment system 'Rota-loo' at Rocky Bay.
	• Nutrients from human wastewater	Medium			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Proposed chemical storage at the Wadjemup Lighthouse precinct	• Hydrocarbons from fuel spills or accidents	Medium	Chemical storage is proposed at Wadjemup Lighthouse as part of upgrading the power supply to a hybrid power supply system. Chemical spills have the potential to have a significant impact on the quality of a drinking water source. There are a number of production bores (e.g. 1/81 and 2/81) and possibly a historical well in close proximity of the Wadjemup Lighthouse precinct.	This proposed land use is under consideration by the RIA. No chemical (i.e. fuel) is currently stored in the Wadjemup Lighthouse precinct	Chemical storage of fuel is generally considered an incompatible land use in P1 areas and WHPZs. The RIA should consider to locate the proposed chemical storage tank for the hybrid power supply outside the proposed Rottnest Island Water Reserve (if possible). The below WQPNs provide additional information for chemical storage in a PDWSA: • WQPN no 56: *Tanks for elevated chemical storage* • WQPN 65: *Toxic and hazardous substance : storage and use* • WQPN 10: *Contaminant spills – emergency response*.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Longreach Bay saltwater bore field					
Sewer pump station and associated infrastructure	• Pathogens	High	The sewer pump station at Longreach Bay services the holiday units (around 100 units) and commercial premises (shop, café and laundry) from Geordie Bay, Fays Bay and Longreach Bay. A road drain exists close to the sewer pump station. The drain directs stormwater (and any potential contaminants) into the dunes at Longreach Bay beach. The stormwater has the potential to enter the marine environment.	• water quality monitoring • water treatment (reverse osmosis)	A sewer pump station is considered a compatible land use with in a P3 area. Sewer pump stations should be designed, constructed and operated in accordance with all relevant standards. Monitor and maintain sewer pump station and associated infrastructure on a regular basis. Review raw (source) water quality monitoring program to ensure any potential risk can be detected. The RIA should investigate if the road drainage in proximity to the sewer pump station should be modified in order to prevent any contaminants from entering the beach and marine environment.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	• Nutrients	High	Any potential overflow from the sewer pump station could enter the beach and marine environment via the road drain.		
	• Chemicals	Medium			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	Management priority			
Golf course (including proposed use of treated wastewater for irrigation).	• Nutrients from using fertiliser on greens and fairways	Medium	The risks associated with golf courses and facilities can be managed through the implementation of best management practices. The use of treated wastewater for irrigation is generally considered an incompatible land use in a PDWSA, but this proposal was assessed by the EPA in December 2012 and supported subject to conditions.	• water quality monitoring • water treatment (reverse osmosis) • no signage or fencing	A golf course is acceptable with best management practices in a P3 area. However, the use of treated wastewater is generally considered an incompatible land use in a PDWSA. Any re-use of treated wastewater needs to consider the Australian guidelines for water recycling – Managing health and environmental risks and related guidelines (NHMRC & NRMMC 2006). The EPA's advice on the re-use of wastewater included conditions such as implementing a nutrient and irrigation management plan, automated monitoring system and visual inspection.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	• Pesticides from maintaining greens and fairways	Medium			Best management practices for maintaining the golf course are also provided in the Environmental guidelines for the establishment and maintenance of turf and grassed areas. Use of pesticides should be in accordance with Statewide policy no. 2: *Pesticide use in PDWSAs* and Circular no. PSC 88: *Use of herbicides in water catchment areas*.
	• Hydrocarbons and chemicals from fuel and chemical spills from vehicles and machinery	Low			
	• Pathogens from proposed use of treated wastewater for irrigating the greens and fairways on the golf course	High			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Drinking water treatment plant (desalination - reverse osmosis)	• High salt (brine) from treatment process.	Low	Brine is discharged at Fays Bay, outside the PDWSA.	• water quality monitoring	Water treatment plants are compatible with conditions in a P1 area. Continue with appropriate best management practices for the handling of brine.
	• Chemical use for water treatment	Low	Water is chlorinated. The plant is contained within a suitable, secure compound with signs surrounding it.		Continue with appropriate best management practices for the storage and handling of chlorine in accordance with WQPN 65: *Toxic and hazardous substance: storage and use*.

Appendix C — Photographs

Figure C1 Rottnest Island water treatment (seawater desalination) plant and wind turbine, photograph by C. Loos

Figure C2 Wadjemup bore, photograph by C. Loos

Figure C3 Bore compound for saltwater bore at Longreach Bay, photograph by C. Loos

Figure C4 Holiday units at Longreach Bay, photograph by C. Loos

Figure C5 Sewer pump station at Longreach Bay, photograph by C. Loos

Figure C6 Road drain at Longreach Bay, photograph by C. Loos

Figure C7 Public toilets in Wadjemup bore field, photograph by C. Loos

Figure C8 On-site wastewater system (septic tanks and leach drains) in Wadjemup bore field, photograph by C. Loos

Figure C9 Golf course in Longreach Bay saltwater bore field, photograph by C. Loos

Figure C10 Pipes for treated wastewater for proposed use at the island's golf course, photograph by C. Loos

Figure C11 Pipe for discharging brine (hypersaline water) from desalination plant at Fays Bay, photograph by C. Loos

Figure C12 Vents for sewer pump stations and sealed roads in Longreach Bay saltwater bore field, photograph by C. Loos

List of shortened forms

CFU	colony forming units
ERA	Economic Regulation Authority
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
MoU	Memorandum of understanding
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
PSC 88	Public sector circular number 88
PDWSA	public drinking water source area
RIA	Rottnest Island Authority
TFSS	total filterable solids by summation
Westplan–HAZMAT	Western Australian plan for hazardous materials
WhAEM	Well Head Analytic Element Model
WHPZ	Wellhead protection zone
WQPN	water quality protection note

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Allocation	The quantity of water that a licensee is permitted to abstract is their allocation, usually specified in kilolitres per annum (kL/a).
Aquifer	An aquifer is a geological formation or group or formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6*, 2011 (NHMRC & NRMMC 2011) outlines acceptable criteria for the quality of drinking water in Australia.
Bore	A bore is a narrow, lined hold drilled into the ground to monitor or draw groundwater (also called a well).
Bore field	A group of bores to monitor or withdraw groundwater is referred to as a bore field (also see *wellfield*).
Catchment	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Colony forming units	Colony forming units are a measure of pathogen contamination in water.
Department of Environment Regulation	The former Department of Environment and Conservation was split on 1 July 2013 to form the Department of Environment Regulation and the Department of Parks and Wildlife.
Drinking water source protection report	This is a report on water quality hazards and risk levels within a public drinking water source area that includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.
Effluent	Effluent is treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.
Hectare	A measurement of area, equivalent to 10 000 square metres.
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.

Hydrogeology	The study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
mg/L	A milligram per litre (0.001 grams per litre) is a measurement of a total dissolved solid in a solution.
Most probable number	Most probable number is a measure of microbiological contamination.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as certain strains of *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Porosity	The state of quality of a material to be porous – that is permeable by water.
Public drinking water source area	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*.
Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
Recharge	Recharge is the action of water infiltrating through the soil/ground to replenish an aquifer.

Recharge area	An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable. This is also known as a superficial aquifer.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	A water reserve is an area proclaimed under the *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater is referred to as the watertable.
Wellfield	A wellfield is a group of bores located in the same area used to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
Wellhead protection zone	A wellhead protection zone is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

References

Department of Health 2007, *Use of herbicides in water catchment areas*, Circular no: PSC 88, February 2007, Department of Health, Perth.

Department of Health 2009, *A guide to the management of pesticides in local government pest control programs in Western Australia*, Department of Health, Perth.

Department of Health 2013, *A guide to use pesticides in Western Australia – Providing information on legislation, policies and best practice,* Department of Health, Perth.

Department of Health & Rottnest Island Authority 2012, *Memorandum of understanding between the Department of Health and Rottnest Island Authority for drinking water*, Rottnest Island Authority, Fremantle.

Department of Water & Department of Health 2008, *Risks from pathogenic micro-organisms in public drinking water source areas*, Department of Water, Perth.

Department of Water 2012, Operational policy 13: *Recreation within public drinking water source areas on Crown land*, Department of Water 2012, Perth.

——*Water quality protection notes* (WQPNs) Department of Water, Perth, available www.water.wa.gov.au > publications > series browse > water quality protection notes.

- 2004, WQPN 25: *Land use compatibility in public drinking water source areas*
- 2006, WQPN 10: *Contaminant spills – emergency response*
- 2006, WQPN 44: *Roads near sensitive water resources*
- 2006, WQPN 56: *Tanks for elevated chemical storage*
- 2006, WQPN 65: *Toxic and hazardous substance : storage and use*
- 2009, WQPN 36: *Protecting public drinking water source areas*
- 2007, WQPN 83: *Infrastructure corridors near sensitive water resources*
- 2009, WQPN 84: *Rehabilitation of disturbed land in public drinking water source areas*

Economic Regulation Authority 2010, *Water services operating licence*, Economic Regulation Authority, Perth.

Environmental Protection Authority 1991*, Integrated water supply and wastewater treatment system – Rottnest Island*, Bulletin 598, Assessment no. 236, November 1991, Environmental Protection Authority, Perth.

Environmental Protection Authority 2012, *Rottnest Island golf course upgrade*, Notice under section 39A(3) of the *Environmental Protection Act 1986*, 24 December 2012, Environmental Protection Authority, Perth.

Government of Western Australia 1914, *Rights in Water and Irrigation Act*, Reprinted under the *Reprints Act 1984* as at 1 February 2008, State Law Publisher, Perth.

——1947, *Country Areas Water Supply Act*, reprinted under the *Reprints Act 1984* as at 4 May 2012, State Law Publisher, Perth.

——1972, *Aboriginal Heritage Act*, reprinted under the *Reprints Act 1984* as at 18 September 2010, State Law Publisher, Perth.

——2007, *State water plan 2007*, Department of the Premier and Cabinet, Perth.

Geldreich, EE 1996, 'Pathogenic agents in freshwater resources', *Hydrological Processes*, vol. 10, pp. 315-333.

Hirschberg, KJ and Smith RA 1990, *A reassessment of the shallow groundwater resources of Rottnest Island*, Hydrogeology Report 1990/61, Geological Survey, Perth.

Hrudey, SE & Hrudey, EJ 2004, *Safe drinking water – Lessons from recent outbreaks in affluent nations*, IWA Publishing, London.

Kraemer, S, Haitjema H & Kelson V 2007, *Working with WhAEM2000,* DC20460 EPA/600/R-05/151, United State Environmental Protection Authority, Washington.

NHMRC, NRMMC 2011, *Australian drinking water guidelines paper 6 National Water Quality Management Strategy,* National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australian Government, Canberra.

——2006, *Australian Guidelines for Water Recycling – Managing Health and Environmental Risks (Phase 1),* Australian Government, Canberra.

——2004, W*ater made clear – A consumer guide to accompany the Australian drinking water guidelines 2004,* Australian Government, Canberra.

National Uniform Drillers Licensing Committee 2012, *Minimum construction requirements for water bores in Australia,* 3rd edn, Australian Government National Water Commission, Victoria.

Office of the Environmental Protection Authority 1993, *Integrated water supply and wastewater treatment system, Rottnest Island,* Ministerial approval statement 324 pursuant to the provisions of the *Environmental Protection Act 1986*, Office of the Environmental Protection Authority, Perth.

Playford, P and Leech, R 1977, *Geology and hydrogeology of Rottnest Island* Geological Survey of Western Australia Report 6, Perth.

Programmed Facility Management 2011, *Wadjemup bore field groundwater abstraction monitoring plan: Rottnest Island, Western Australia*. Programmed Facility Management, Perth.

Programmed Facility Management 2012, *Annual drinking water report to the Department of Health by the Rottnest Island Authority, July 2011 – June 2012*, Perth.

Robertson, JB & Edbery, SC 1997, *Natural protection of spring and well drinking water against surface microbial contamination. I. Hydrogeological parameters*, Critical Reviews in Microbiology, vol. 23(2), pp. 143 – 178.

Rockwater Proprietary Limited 2011, *Wadjemup bore field, Rottnest Island: Recommendations for future bore field operation*, Report for Rottnest Island Authority, Rockwater Proprietary Limited, Perth (unpublished).

Rottnest Island Authority 2009, *Rottnest Island management plan 2009–2014: Revitalised and moving forward*, Rottnest Island Authority, Fremantle.

Rottnest Island Authority 2012, *Rottnest Island landfill, WWTP & Wadjemup bore field: Annual environmental report 2012*, GHD, Perth.

Rottnest Island Authority 2012, *Reconciliation action plan 2012–2015*. Rottnest Island Authority, Fremantle.

Rottnest Island Authority 2013, *Boating management strategy 2014*, Rottnest island Authority, Fremantle.

State Emergency Management Committee 2005, Policy statement no. 7: *Western Australian emergency management arrangements,* Government of Western Australia, Perth.

Water Authority 1988, *Groundwater Management Review: Rottnest Island*. Report no. WG 50. Water Authority, Perth.

Water and Rivers Commission 2000, Statewide policy no. 2: *Pesticide use in public drinking water source areas*, Water and Rivers Commission, Perth.

Western Australian Planning Commission 1997, *State planning strategy*, Government of Western Australia, Perth.

——2003, State planning policy no. 2.7: *Public drinking water source policy*, Government Gazette Western Australia, 10 June 2003, pp. 2077-82, Government of Western Australia, Perth.

——2006, State planning policy no. 2.9: *Water resources*, Government Gazette Western Australia, 19 December 2006, pp. 5707-22 Government of Western Australia, Perth.

World Health Organization 2004, *Guidelines for drinking-water quality – Volume 1 – Recommendations*, 3rd edn, World Health Organization, Geneva.

Further reading

Department of Water 2011, *Living and working in public drinking water source areas,* Department of Water, Perth.

Department of Water 2012, Operational policy 13: *Recreation within public drinking water source areas on Crown land*, Department of Water 2010, Perth.

—— *Water quality protection notes* (WQPNs) Department of Water, Perth, available www.water.wa.gov.au > publications > series browse > water quality protection notes.

- 2006, WQPN 30: *Groundwater monitoring bores*
- 2006, WQPN 76: *Land use planning in Public Drinking Water Source Areas*
- *2009, WQPN 36: Protecting Public Drinking Water Source Areas*
- 2010, WQPN 33: *Nutrient and irrigation management plans*

Government of Western Australia 2003, Contaminated Sites Act (WA) as at 1 December 2010.

Krogh, M, Davison, A, Miller, R, O'Connor, N, Ferguson, C, McClaughlin, V & Deere, D 2008, Effects of recreational activities on source protection areas – Literature review, Water Services Association of Australia, Melbourne.

Playford, PE 1988, *Guidebook to the geology of Rottnest Island*, Excursion guidebook no. 2, Geological Survey of Western Australia, Perth.

Standing Committee on Public Administration, 2010, Report 11: Recreation activities within public drinking water source areas. Parliament of Western Australia, Perth.

World Health Organization 2006, *Guidelines for the safe use of wastewater, excreta and greywater,* Volume 1 – Policy and regulatory aspects, World Health Organization Press, Switzerland.

Department of **Water**
168 St Georges Terrace, Perth, Western Australia
PO Box K822 Perth Western Australia 6842
Phone: 08 6364 7600
Fax: 08 6364 7601
www.water.wa.gov.au

10182 00 0514