



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

Nilgen Water Reserve

Drinking water source protection plan

Ocean Farms Estate, Nilgen town water supply



Looking after all our water needs

Water resource protection series
Report WRP 112
June 2010



Important information

The *Nilgen Water Reserve drinking water source protection plan* (2010, WRP no. 112) was reviewed in 2021.

Please read the updated *Nilgen Water Reserve drinking water source protection review* (2021, WRP no. 198) alongside the 2010 plan to obtain all of the information about this drinking water source.

The 2021 review considers changes that have occurred in and around the Nilgen Water Reserve since the completion of the 2010 plan. Additional recommendations have been prepared to ensure the ongoing protection of this public drinking water source area:

- update the WHPZ of the Nilgen Water Reserve to reflect the current bore locations
- amend the boundary of the Nilgen Water Reserve, to reflect the WHPZ realignment, in consultation with key stakeholders.

You can find the 2021 *Nilgen Water Reserve drinking water source protection review* at www.dwer.wa.gov.au or by contacting the Department of Water and Environmental Regulation on +61 8 6364 7000 or drinkingwater@dwer.wa.gov.au.

Nilgen Water Reserve drinking water source protection plan

Ocean Farms Estate, Nilgen town water supply

Looking after all our water needs

Department of Water

Water resource protection series

Report WRP 112

June 2010

Department of Water

168 St Georges Terrace

Perth Western Australia 6000

Telephone +61 8 6364 7600

Facsimile +61 8 6364 7601

www.water.wa.gov.au

© Government of Western Australia 2010

June 2010

This work is copyright. You may download, display, print and reproduce this material in unaltered form only (retaining this notice) for your personal, non-commercial use or use within your organisation. Apart from any use as permitted under the *Copyright Act 1968*, all other rights are reserved. Requests and inquiries concerning reproduction and rights should be addressed to the Department of Water.

ISSN 1326-7442 (print)

ISSN 1835-3924 (online)

ISBN 978-1-921736-50-6 (print)

ISBN 978-1-921736-51-3 (online)

Disclaimer

This document has been published by the Department of Water. Any representation, statement, opinion or advice expressed or implied in this publication is made in good faith and on the basis that the Department of Water and its employees are not liable for any damage or loss whatsoever which may occur as a result of action taken or not taken, as the case may be in respect of any representation, statement, opinion or advice referred to herein. Professional advice should be obtained before applying the information contained in this document to particular circumstances.

Acknowledgements

The Department of Water would like to thank the following for their contribution to this publication: Kellie Clark, Carl Dyde, Stephen Watson and Nigel Mantle (Department of Water), Neil Pemberton-Ovens (Water Corporation).

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

Cover photograph: Aerial photography of Ocean Farms Estate, Nilgen, WA.

Contents

Preface	v
Summary	vii
1 Drinking water source overview	1
1.1 Existing water supply system.....	1
1.2 Water treatment.....	1
1.3 Catchment details	1
1.3.1 Physiography	1
1.3.2 Climate.....	1
1.3.3 Hydrogeology.....	2
1.4 Future water supply requirements	2
1.5 Existing drinking water source protection	2
1.6 Department of Water management.....	2
1.6.1 Current allocation licence.....	2
2 Water quality monitoring and contamination risks	3
2.1 Microbiological	3
2.2 Health related	4
2.3 Aesthetic.....	4
2.4 Groundwater bores	5
3 Land-use assessment	6
3.1 Existing land uses and activities	6
3.1.1 Private land.....	6
3.1.2 Crown land.....	6
3.1.3 Native title	6
3.2 Proposed land uses and activities	7
4 Catchment protection strategy	10
4.1 Protection objectives.....	10
4.2 Proclaimed area.....	10
4.3 Priority areas	11
4.4 Protection zones	12
4.5 Land-use planning	12
4.6 Best management practices	12
4.7 Surveillance and by-law enforcement	13
4.8 Emergency response.....	13
4.9 Implementation of this plan.....	14
5 Recommendations	15
Appendices.....	17
List of shortened forms	29
Glossary	31
References	35

Appendices

Appendix A Figures	17
--------------------------	----

Appendix B Water quality data	22
Appendix C Land use, potential water quality risks and recommended protection strategies.....	25
Appendix D Photographs.....	27

Figures

Figure A1 Locality of Nilgen Water Reserve.....	17
Figure A2 Proposed Nilgen Water Reserve	18
Figure A3 Land use tenure in the Nilgen Water Reserve	19
Figure A4 Aerial photography and land uses in the Nilgen Water Reserve.....	20
Figure A5 Proposed boundary, priority areas and protection zone for Nilgen Water Reserve	21

Tables

Table 1 Land use and potential water quality risks	8
--	---

Preface

How do we protect public drinking water source areas?

The Australian drinking water guidelines (ADWG) (NHMRC & NRMCC 2004a) outlines how we should protect drinking water in Australia. The ADWG recommends a ‘catchment to consumer’ framework that uses a risk-based, multiple-barrier approach. A similar approach is recommended by the World Health Organization in other countries worldwide.

The ‘catchment to consumer’ framework applies across the entire drinking water supply system, from the water source to your tap. It ensures a holistic assessment of risks to water quality to maximise the delivery of safe drinking water to consumers.

A risk-based approach means that we look at all the different risks to water quality, and how to address them. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system. The first barrier is protecting the catchment (the whole area from which water flows into the bore). This plan helps to do that. Other barriers against contamination include:

- storage of water to help reduce contaminants
- treating the water (e.g. chlorination for pathogens)
- maintenance of pipes
- testing of water quality.

As water treatment practices evolve, many people think that we no longer need to protect the catchment because we can ‘engineer out the risks’. Nothing could be further from the truth (Krogh et. al 2008). Recent research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That’s why this drinking water source protection plan is important. It’s about protecting the catchment’s water quality now and for the future.

In Western Australia, the Department of Water protects public drinking water source areas (PDWSAs) by putting the ADWG into practice; writing plans, policies and guidelines; and providing input into land-use planning.

The *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA) allow us to protect water. We proclaim PDWSAs under these Acts so that we can apply legislation to protect water quality.

The ADWG outlines 12 elements to protect drinking water. This plan implements element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management). Plans have been, or are being written for all PDWSAs around the state. They give an overview of a drinking water source and outline the risks to water quality and how to address them.

Our regional offices work with the community, other government agencies and landowners to put the recommendations into practice.

We also define special areas within PDWSAs: priority areas and protection zones. There are three different priority areas, each reflecting a certain level of risk to water quality. Protection zones surround drinking water extraction points, so that the most vulnerable areas may be protected from contamination. Under legislation, some activities are restricted in protection zones.

If you would like more information about how we protect drinking water in Western Australia, go to <<http://drinkingwater.water.wa.gov.au>>.

The following table outlines the stages involved in the preparation of this drinking water source protection plan:

Stages in development of a plan		Comment
1	Conduct stakeholder consultation. (October 2009)	Advice sought from key stakeholders and analysis of a boundary is started using particle tracking data.
2	Prepare draft drinking water source protection plan. (January - May 2010)	Draft protection plan developed taking into account input from stakeholders and any additional advice.
3	Release proposed boundary of the water reserve. (May 2010)	Proposed boundary sent to key stakeholders for comment.
4	Publish approved drinking water source protection plan. (June 2010)	Final protection plan published after considering stakeholder comments. Includes recommendations on how to protect water quality. Proclamation of this public drinking water source area can now be progressed.

Summary

Ocean Farms Estate is located within Nilgen; it is a small settlement of approximately 186 people (ABS 2006) located 117 km north of Perth, Western Australia. The closest town is Lancelin, which is 8 km south-west of Nilgen. The local government authority for Nilgen is the Shire of Gingin.

When Ocean Farms Estate was first approved for development, residents relied on their own community-operated water supply system. However, in 2006 the Water Corporation commenced the operation of a public water supply system.

The Water Corporation abstracts groundwater from one production bore (bore 1) to supply the Ocean Farms Estate. This bore is vulnerable to contamination from surrounding land uses and activities due to the unconfined and shallow nature of the aquifer at Nilgen.

The proposed water reserve proposed at Nilgen includes the recharge area of bore 1 occurring within the Ocean Farms Estate. However, it should be noted that the full recharge area for bore 1 extends to the east as far as the Brand Highway.

The following strategies are recommended to protect water quality within the proposed Nilgen Water Reserve:

- establish a 300 m wellhead protection zone (WHPZ) around bore 1
- all Cown land and Water Corporation land should be managed for Priority 1 source protection
- Private land in the water reserve (zoned rural and rural-residential) should be managed for Priority 2 source protection
- the boundary of the proposed Nilgen Water Reserve should be proclaimed under the *Country Areas Water Supply Act 1947* (WA).
- best management practices and guidelines need to be made available to the community to help them protect their drinking water source.
- the sampling program for groundwater at Nilgen needs to consider land uses within the recharge area of production bore 1 that occur outside the boundary of the proposed Nilgen Water Reserve (i.e. east of Brand Highway).

We prepared this document in consultation with key stakeholders, including land owners, the Water Corporation and the Shire of Gingin.

1 Drinking water source overview

1.1 Existing water supply system

Nilgen is a small settlement located 117 km north of Perth and 8 km north-east of Lancelin (see Figure A1). The proposed Nilgen Water Reserve provides drinking water to the Ocean Farms Estate, which is a small rural and rural residential subdivision of Nilgen.

The Nilgen wellfield is located within the Ocean Farms Estate (see Figure A2). In 2006 the Water Corporation took over the wellfield's operation from the Nilgen Service Company. Currently only one bore (bore 1) is required to meet this settlement's water demand.

Water abstracted from this bore is treated at the wellfield before being transferred approximately 1 km east into five water storage tanks. It is then reticulated throughout the settlement.

1.2 Water treatment

Raw (untreated) water from bore 1 is treated at the bore site through an AQ2 – sodium hypochlorite chlorination module. Chlorination provides a disinfection barrier against possible microbiological contamination.

It should be recognised that although treatment processes are essential barriers against contamination, managing the recharge area of a wellfield (to prevent or reduce contamination risks to water quality) is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (ADWG) (NHMRC & NRMCC 2004a) and reflects a risk-based, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver more reliable, safe and lower-cost drinking water to consumers than either approach could achieve individually.

1.3 Catchment details

1.3.1 Physiography

Nilgen is located in the central part of the Perth Basin within the Swan Coastal Plain. It is bounded to the east by the Gingin and Darling Scarps, which rise steeply to more than 200 m above sea level.

1.3.2 Climate

The Nilgen area experiences a Mediterranean-type climate with hot, dry summers and mild, wet winters. The long-term average annual rainfall at Lancelin (8 km

south-west of Nilgen) is 608.5 mm. Most rainfall is recorded during the winter months, from May through to September (BoM 2010).

1.3.3 Hydrogeology

Bore 1 draws water from the superficial aquifer which consists of the highly permeable Tamala Limestone formation. The thickness of the superficial formation at the bore site is about 110 m with a saturated thickness of 30 m. Groundwater flow is mainly in a westerly direction, discharging into the Indian Ocean at the coast. Recharge is mainly through rainfall, from May to September.

The Leederville formation underlies the superficial formation. Because no confining layer occurs between the two formations, some interactions between the two aquifers can be expected.

1.4 Future water supply requirements

The current annual water abstraction is approximately 18 per cent of the annual licensed allocation. Calculations indicate that the current licensed allocation will be adequate to cater for future development.

1.5 Existing drinking water source protection

A water reserve for Ocean Farms Estate, Nilgen, has yet to be proclaimed under the *Country Areas Water Supply Act 1947* (WA). We propose to proclaim the water reserve for the purpose of protecting the public drinking water source from potential contamination, after this plan is published.

1.6 Department of Water management

1.6.1 Current allocation licence

Water resource use and conservation in Western Australia is administered by the Department of Water in accordance with the *Rights in Water and Irrigation Act 1914* (WA). Under this Act, the right to use and control surface water and groundwater is vested with the Crown. The Act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within groundwater areas proclaimed under the Act and all artesian wells throughout the State.

The Nilgen groundwater resource lies within the Gingin Groundwater Area, which was proclaimed in 1975 under the *Rights in Water and Irrigation Act 1914* (WA).

The Water Corporation is licensed to draw 529 500 kL a year (groundwater well license 63819) from the Nilgen wellfield for public water supply purposes. The current number of services is 136. Abstraction in 2009 was 115 852 kL, which was well under the licensed limit.

2 Water quality monitoring and contamination risks

A wide range of chemical, physical and microbiological factors can impact on water quality and therefore affect the provision of safe, good quality drinking water to consumers.

The Water Corporation regularly monitors the quality of raw water from the Nilgen wellfield for microbiological, health-related and aesthetic (non-health-related) characteristics. Please note that in order to ensure the ongoing quality of water provided to consumers, an assessment of the drinking water once treated is made against the ADWG. This assessment is made by an agency committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health.

A water quality summary of water taken from bore 1 from July 2004 to June 2009 is presented in Appendix B. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at www.watercorporation.com.au What we do > Water quality > Water quality publications > Water quality annual report 2008-09.

Contamination risks relevant to drinking water sources are described below.

2.1 Microbiological

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

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. *E. coli* counts are a way to measure these pathogens and provide an indication of 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 environment. 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).

When people or animals use the land near a bore, pathogens may enter that water source. This could occur through the direct transfer of faecal material (even a very

small amount can cause contamination) or indirectly through infiltration moving faecal material into the groundwater.

When people consume drinking water contaminated with pathogens the effects 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 water source and supply was contaminated by a pathogenic strain of *E. coli* and campylobacter (NHMRC & NRMMC 2004b). Where possible, avoiding the introduction of pathogens into a water source is the most effective way to protect public health.

2.2 Health related

Land-uses and activities within a water reserve can directly affect water quality and the treatment that is required to make the water safe to drink.

Chemicals can occur in drinking water sources, as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2004a). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

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 such cases, the relevant authorities should be notified promptly and the spill cleaned up.

Drinking water supplies can also be contaminated by nutrients (such as nitrogen) from fertiliser applications, faulty septic systems, leach drains and from domestic animal faecal matter that washes through or over soil and into a water source. Nitrate and nitrite can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons (e.g. fuels, 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 and machinery.

2.3 Aesthetic

Impurities in drinking water can affect its aesthetic qualities, including its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, cloudy water with a distinctive odour or strong taste is not necessarily harmful to health, while clear, pleasant-tasting water may still contain harmful, undetectable microorganisms (NHMRC & NRMMC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water and salinity can affect the taste. Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes.

The ADWG sets aesthetic water quality criteria to meet the aesthetic requirements of consumers and to protect water supply infrastructure (such as pipes).

2.4 Groundwater bores

The Nilgen Water Reserve is located within the Gingin Groundwater Area which is proclaimed under the *Rights in Water and Irrigation Act 1914* (WA). Under the provisions of sections 26D and 5C of the Act, a licence is required to construct a bore or abstract water within a proclaimed groundwater area (unless exempt under the Rights in Water and Irrigation Exemption and Repeal [Section 26C] Order 2001).

The Water Corporation operates the drinking water bore in the Nilgen Water Reserve. 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 that are appropriately located and constructed to prevent contamination of the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914* (WA). All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Minimum Bore Specifications Committee 2003).

3 Land-use assessment

3.1 Existing land uses and activities

The Nilgen Water Reserve is mostly located over privately owned land. Current land uses and activities are outlined below. This information has been summarised in Table 1 at the end of this section. This table also identifies the recommended management priorities for different hazards. Appendix C of this plan is the full version of Table 1. It recommends protection strategies for key stakeholders to consider.

3.1.1 Private land

All private land in the proposed Nilgen Water Reserve is either zoned as rural or rural residential under the *Shire of Gingin's town planning scheme no.8*. Associated land uses and activities include dwellings, septic tanks, and fertiliser and pesticide application. Potential contaminants from these land uses include pathogens, nutrients and chemicals.

The Water Corporation owns two lots of land within the water reserve:

- Lot 183, where bore 1 is located
- Lot 184, where the five water storage tanks are located.

Potential risks to water quality associated with the bore compound include chemical contamination from the storage of chlorine on-site. However, the chlorine is housed in a locked shed with a concrete base, which significantly reduces the risks. The Water Corporation also has a spill kit on the premises in case of a spill or leak.

3.1.2 Crown land

There are several areas of Crown land within the water reserve. There is a large tract of land zoned as parks and recreation that stretches from the bores to the water tanks. The remaining areas are mostly road reserves (see Figure A3).

3.1.3 Native title

Native title is a form of land title that recognises the unique ties some Aboriginal groups have to land. Native title exists where Aboriginal people have maintained a traditional connection with their land and waters, since sovereignty, and where acts of government have not removed it.

There is one native title claim within the proposed Nilgen Water Reserve. This claim is the Yued (WAD6192/98) claim.

3.2 Proposed land uses and activities

All privately-owned land within the Nilgen Water Reserve is zoned as rural residential and rural under the Shire of Gingin's town planning scheme. Some of the land is currently vacant. Any proposed land use or activities that are incompatible with our water quality protection note (WQPN) no. 25: *Land use compatibility in public drinking water source areas* need to be referred to us (usually through the Shire of Gingin or the Western Australian Planning Commission) for assessment and advice.

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Private land				
Rural and rural residential development and activities	Nutrients and pathogens from septic tanks	Medium	Rural and rural residential zoning and houses are acceptable in Priority 2 (P2) areas.	<ul style="list-style-type: none">• WQPN no. 70: <i>Wastewater treatment: onsite domestic systems</i>• Statewide policy no. 2: <i>Pesticide use in public drinking water source areas</i>• PSC 88: <i>Use of herbicides in water catchment areas</i>
	Nutrients from fertiliser application		For other land -use activities refer to water quality protection note (WQPN) no. 25: <i>Land use compatibility in public drinking water source areas</i> .	
	Chemicals from pesticide use on gardens			
	Nutrients and pathogens from domestic animals			
Crown land				
Roads	Hydrocarbons and chemicals from fuel and chemical spills	Low	Roads are compatible with conditions in P2 areas.	<ul style="list-style-type: none">• WQPN no.44: <i>Roads near sensitive water resources</i>
Water Corporation land	Chemicals from storage of chlorine	Low	Storage of chemicals above-ground in P1 areas is considered incompatible; however, as chlorine is required for treatment of the water supply, it is allowed to continue under a best management practice scenario.	<ul style="list-style-type: none">• WQPN no. 65: <i>Toxic and hazardous substances: storage and use</i>

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Fire management and wildfire	Nutrients from ash and fire retardants and fire-fighting foam	Low	Not applicable	<ul style="list-style-type: none"> • PSC 88: <i>Use of herbicides in water catchment areas</i> • Statewide policy no. 2: <i>Pesticide use in public drinking water source areas</i>
	Pesticides from weed control on fire breaks			

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to protect the drinking water source at Nilgen to ensure a reliable, safe drinking water supply to consumers in Ocean Farms Estate.

In 2006 the Water Corporation took over the supply of water to Ocean Farms Estate from the Nilgen Service Company. Particle track modelling (a scientific modelling tool) was conducted to determine a suitable boundary for the proposed water reserve since no boundary existed. Results from the particle tracking indicate that the recharge area extends to the east as far as the Brand Highway (i.e. groundwater flows from the east towards the estate then onto the ocean).

The area proposed to be proclaimed for protecting groundwater quality at Nilgen:

- reflects the transition of this water supply from private to public
- reflects the modelling work
- considers the extent of the recharge area to the boundary of the Ocean Farms Estate
- does not include private rural landholdings because no consultation occurred outside the Ocean Farms Estate when Bore 1 was established.

The modelling shows that it would take around five years for potential contamination originating outside the Ocean Farms Estate to reach Bore 1. If contamination is detected the Water Corporation will need to decide either to increase treatment levels for groundwater, or establish a new production bore in another location that provides greater water quality protection.

Fortunately, the likelihood of contamination is considered low given the existing rural, low-intensity land uses to the east.

4.2 Proclaimed area

The proposed Nilgen Water Reserve should be proclaimed under the *Country Areas Water Supply Act 1947* (WA) to ensure an appropriate level of protection for the drinking water source. Proclaiming the water reserve ensures that the by-laws of the Act apply, and allows the Department of Water to consider potentially contaminating land uses.

The water reserve covers the compound where bore 1 is located, a 300 m wellhead protection zone, and extends approximately 1.5 km by 1.9 km to encompass most of Stage 2 of the Ocean Farms Estate, finishing at Nilgen Road (see Figure A2).

4.3 Priority areas

The protection of PDWSAs relies on statutory measures available in legislation for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes three risk-based priority areas:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation
- Priority 3 (P3) areas have the fundamental water quality objective of risk management.

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

The proposed priority areas for the Nilgen Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure A5. The department's 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 a P1 area to all Crown land (lots 1000, 4322, 4323, 4324 and 4325) and all Water Corporation land (lots 183 and 184) within the Nilgen Water Reserve for the following reasons:

- water from this source constitutes a strategic supply to the Ocean Farms Estate, Nilgen town water supply scheme so it should be afforded the highest feasible level of protection
- existing land uses on the Crown land are considered compatible with P1 source protection objectives

It is proposed to assign a P2 area to all of the rural and rural-residential zoned land for the following reasons:

- water from this source will constitute a strategic supply to the Ocean Farms Estate, Nilgen town water supply so it should be afforded the highest feasible level of protection
- land is privately owned and zoned rural or rural-residential so the compatible development rights are recognised
- existing land uses in these areas can be managed for P2 source protection objectives by implementing best management practices

See Figure A5 for further information.

4.4 Protection zones

In addition to P1, P2 and P3 areas, protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. Specific conditions may apply within these zones such as restrictions on the storage of chemicals.

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.

A 300 m WHPZ will be established around bore 1 (see Figure A5). It will form a part of the Nilgen Water Reserve boundary and will lie over lots 143, 144, 151, 152, 153, 155, 358, 359, 360, 361, 368, 369, 370 and 371.

4.5 Land-use planning

It is recognised under the Western Australian Planning Commission's (WAPC) *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 WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy* (2003) it is appropriate that the Nilgen Water Reserve, its priority areas and protection zone be recognised in the *Shire of Gingin's town planning scheme no. 8*. Any development proposals within the Nilgen Water Reserve that are inconsistent with advice in the Department of Water's WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the Department of Water for advice.

The department's protection strategy for PDWSAs provides for lawfully established and operated developments to continue despite those facilities posing a potential level of risk to water quality that would not be accepted for new developments. The department will provide advice to landowners/operators on measures to improve these facilities and reduce water quality contamination risks.

For further information on the integration of land-use planning and water source protection, please refer to the Department of Water's WQPN no. 36: *Protecting public drinking water source areas*.

4.6 Best management practices

There are opportunities to significantly reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the Department of Water will continue to encourage the adoption of best management practices for various land uses.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and water quality protection notes. They outline the recommended practices to ensure the protection of water quality and can thus help managers reduce any detrimental effects of their operations. Such guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include *Land use compatibility in public drinking water source areas*, *Roads near sensitive water resources* and *Wastewater treatment: onsite domestic systems*, which are listed in this plan's References.

Education and creating awareness (e.g. signage and information) are also key mechanisms for protecting water quality, especially for people visiting the area. A brochure will be produced once this plan is finalised, describing the Nilgen Water Reserve, its location and the main threats to water quality. This brochure will be available to the community and will inform people in simple terms about the drinking water source and the need to protect it.

4.7 Surveillance and by-law enforcement

The quality of water in PDWSAs within country areas of the state is protected under the *Country Areas Water Supply Act 1947* (WA). Proclamation of PDWSAs allows existing by-laws to be applied to protect water quality.

The Department of Water considers by-law enforcement, through surveillance of land-uses and activities in PDWSAs, to be an important mechanism to protect water quality.

Signs will be erected on the boundaries of this water reserve to educate and advise the public about activities that are prohibited or regulated. This plan recommends that surveillance and by-law enforcement for the Nilgen Water Reserve be delegated to the Water Corporation.

4.8 Emergency response

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Gingin's local emergency management committee (LEMC), through the Wheatbelt emergency management district, should be familiar with the location and purpose of the Nilgen Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Water Corporation should have an advisory role to the HAZMAT team for incidents in the Nilgen 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

Nilgen Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this water resource.

4.9 Implementation of this plan

Table 1 identifies the potential water quality risks associated with existing land uses in the proposed Nilgen Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C. Major recommendations are outlined in Section 5.

After the *Nilgen Water Reserve drinking water source protection plan* is published, an implementation strategy will be drawn up, by this department, based on the recommendations in Section 5 and Appendix C.

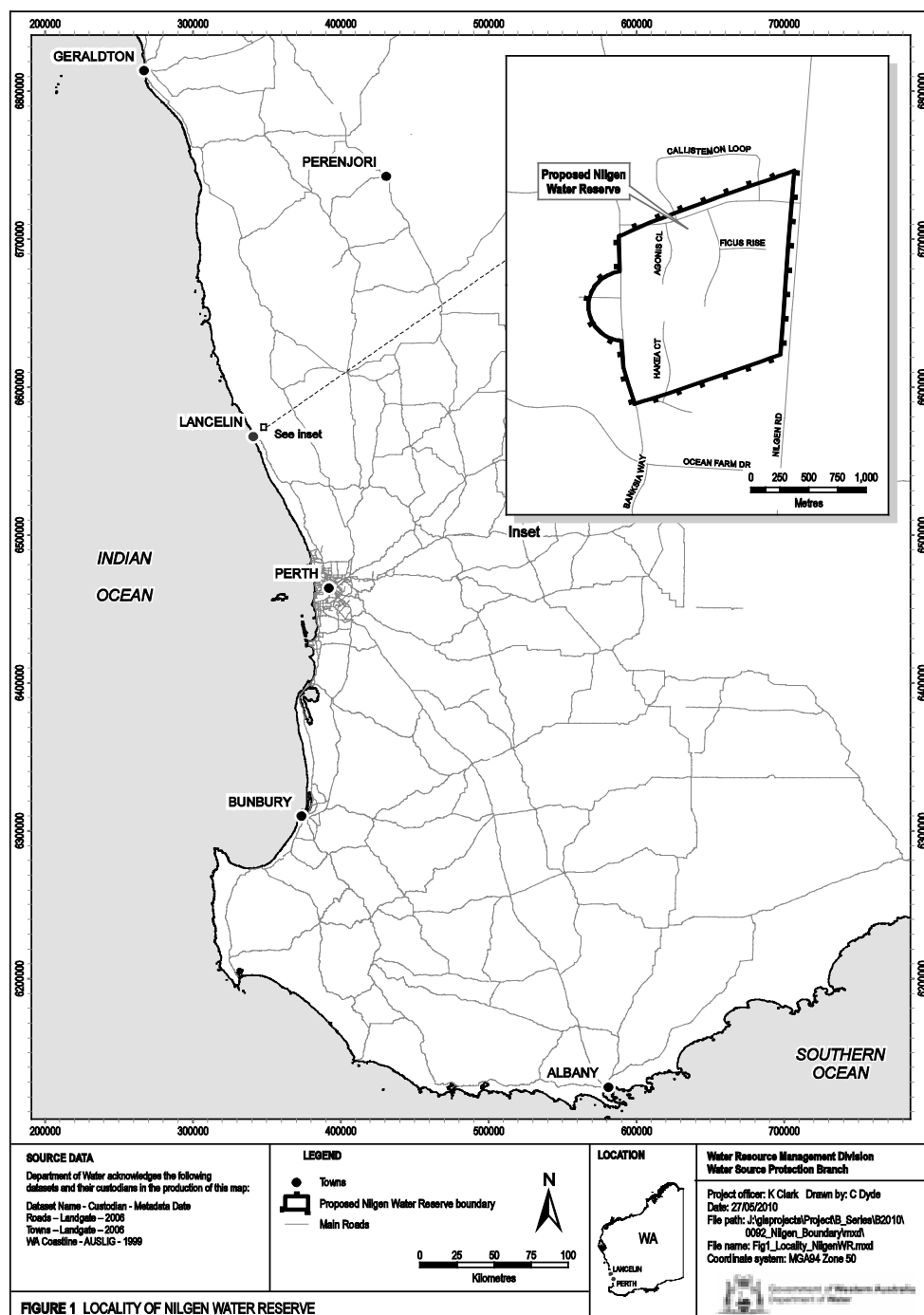
5 Recommendations

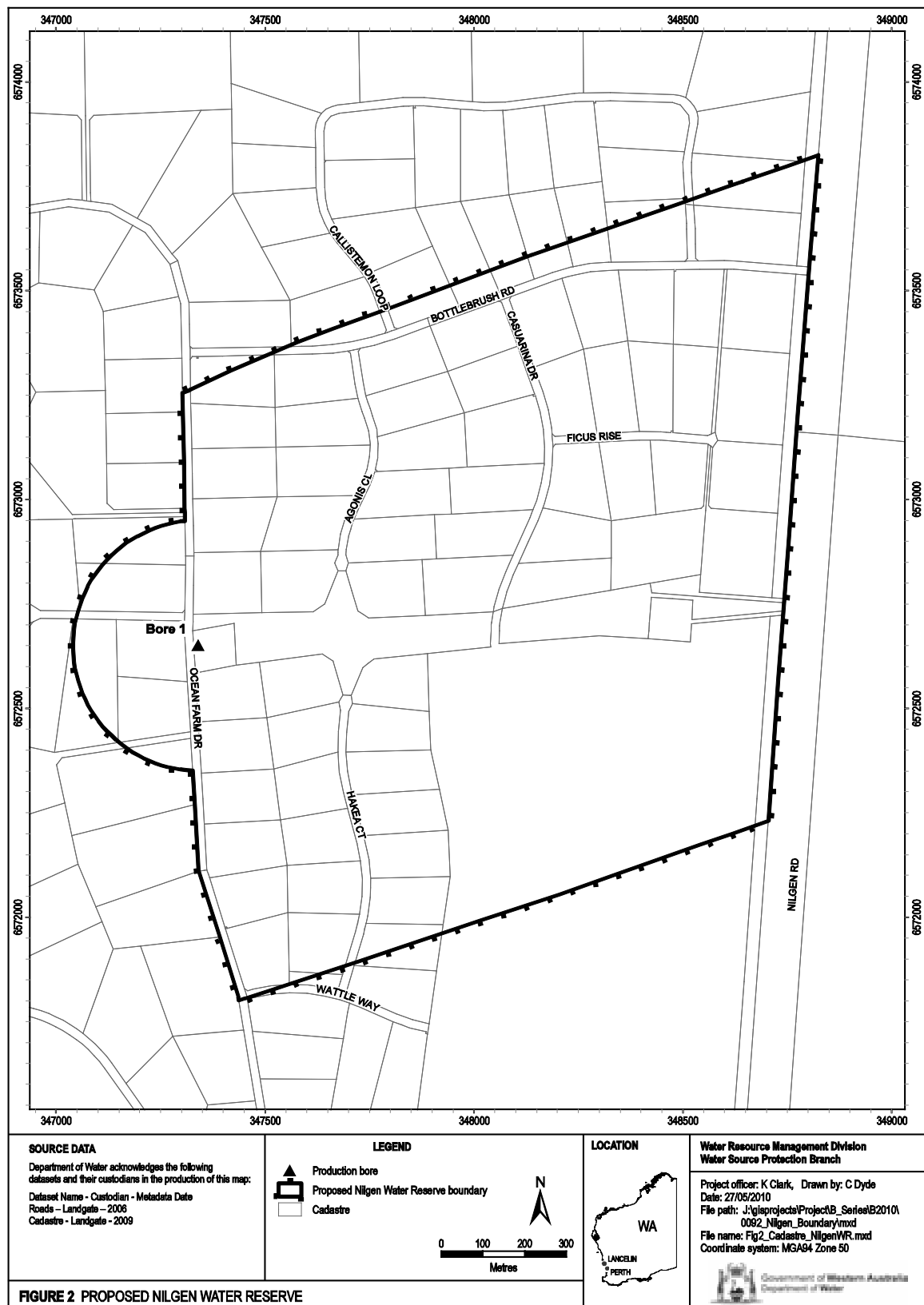
The following recommendations apply to the entire Nilgen Water Reserve. The bracketed stakeholders are those expected to have an interest in the relevant recommendation being implemented.

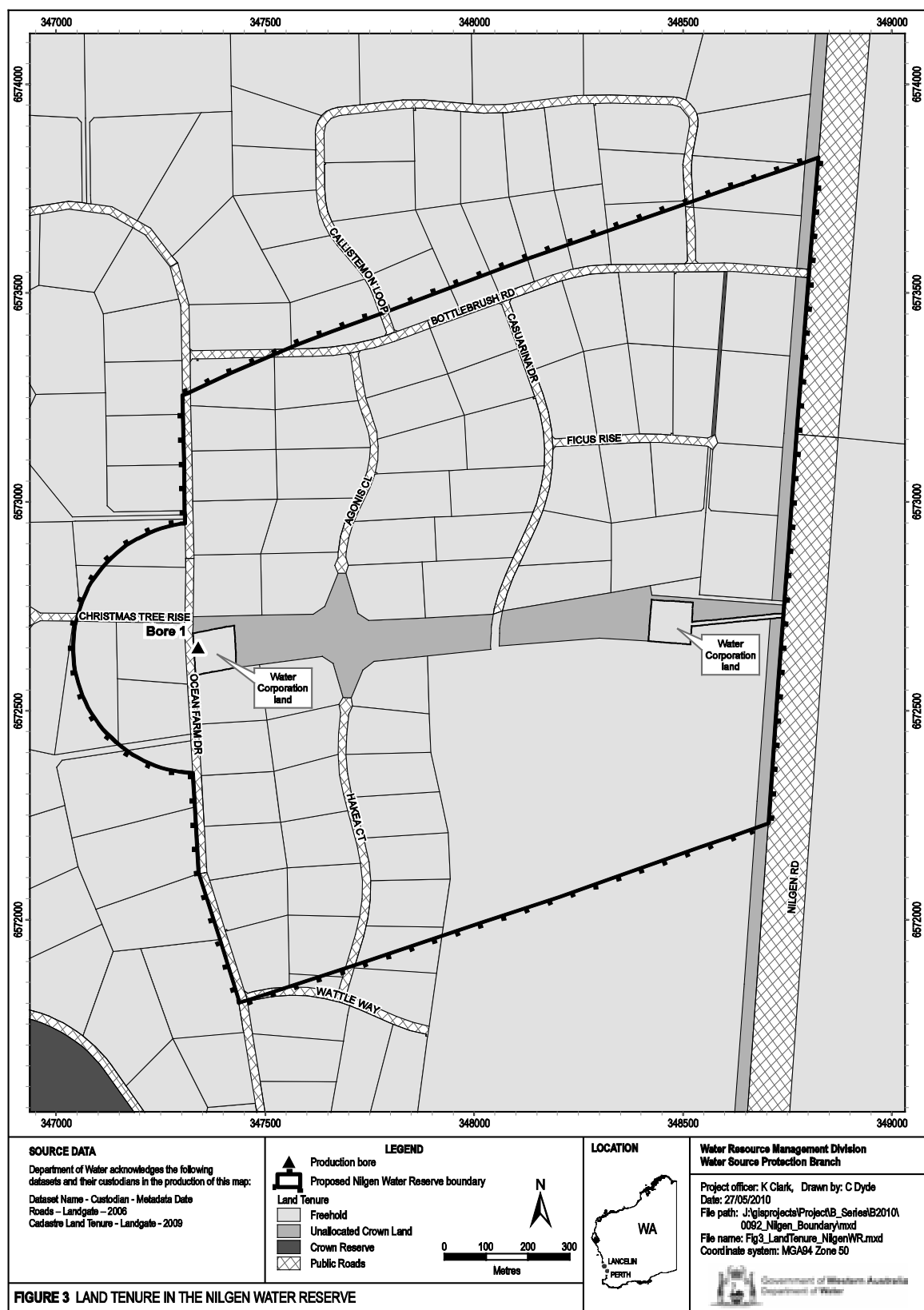
- 1 The boundary of the Nilgen Water Reserve should be proclaimed under the *Country Areas Water Supply Act 1947* (WA). (Department of Water)
- 2 Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C) showing responsible stakeholders and planned timeframes. (Department of Water, applicable stakeholders)
- 3 The *Shire of Gingin's town planning scheme no. 8* should incorporate this plan and reflect the identified Nilgen Water Reserve boundary, priority 1 and 2 areas and protection zone in accordance with the WAPC's Statement of planning policy no.2.7: *Public drinking water source policy*. (Shire of Gingin)
- 4 All development proposals within the Nilgen Water Reserve that are inconsistent with the Department of Water's Water quality protection note no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations. (WAPC, Shire of Gingin, proponents of proposals)
- 5 Incidents covered by WESTPLAN–HAZMAT in the Nilgen Water Reserve should be addressed by ensuring that:
 - the Wheatbelt LEMC is aware of the location and purpose of the Nilgen Water Reserve
 - the locality plan for the Nilgen Water Reserve is provided to the FESA headquarters for the HAZMAT emergency advisory team
 - the Water Corporation acts in an advisory role during incidents in the Nilgen Water Reserve
 - personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Nilgen Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.(Department of Water, Water Corporation)
- 6 The Department of Water should delegate responsibility for monitoring and enforcement measures within the Nilgen Water Reserve to the Water Corporation. (Department of Water, Water Corporation)
- 7 Signs should be erected along the boundary of the Nilgen Water Reserve to define the location and promote awareness of the need to protect drinking water quality. Signs should include an emergency contact telephone number. (Department of Water)
- 8 The Water Corporation should investigate alternative bore sites, away from potential contamination risks, within the next five years. (Water Corporation)
- 9 A review of this plan should be undertaken after five years. (Department of Water)

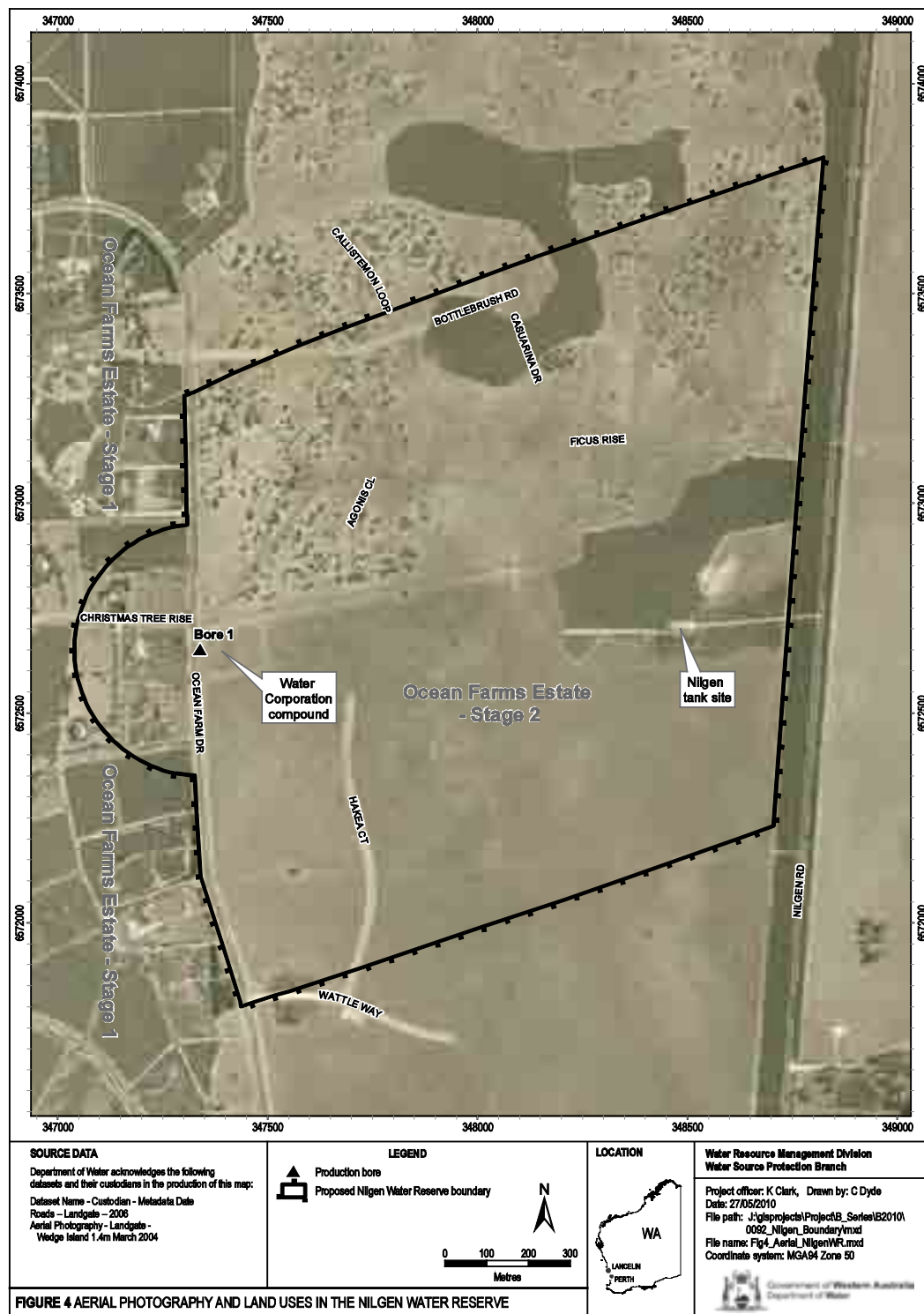
Appendices

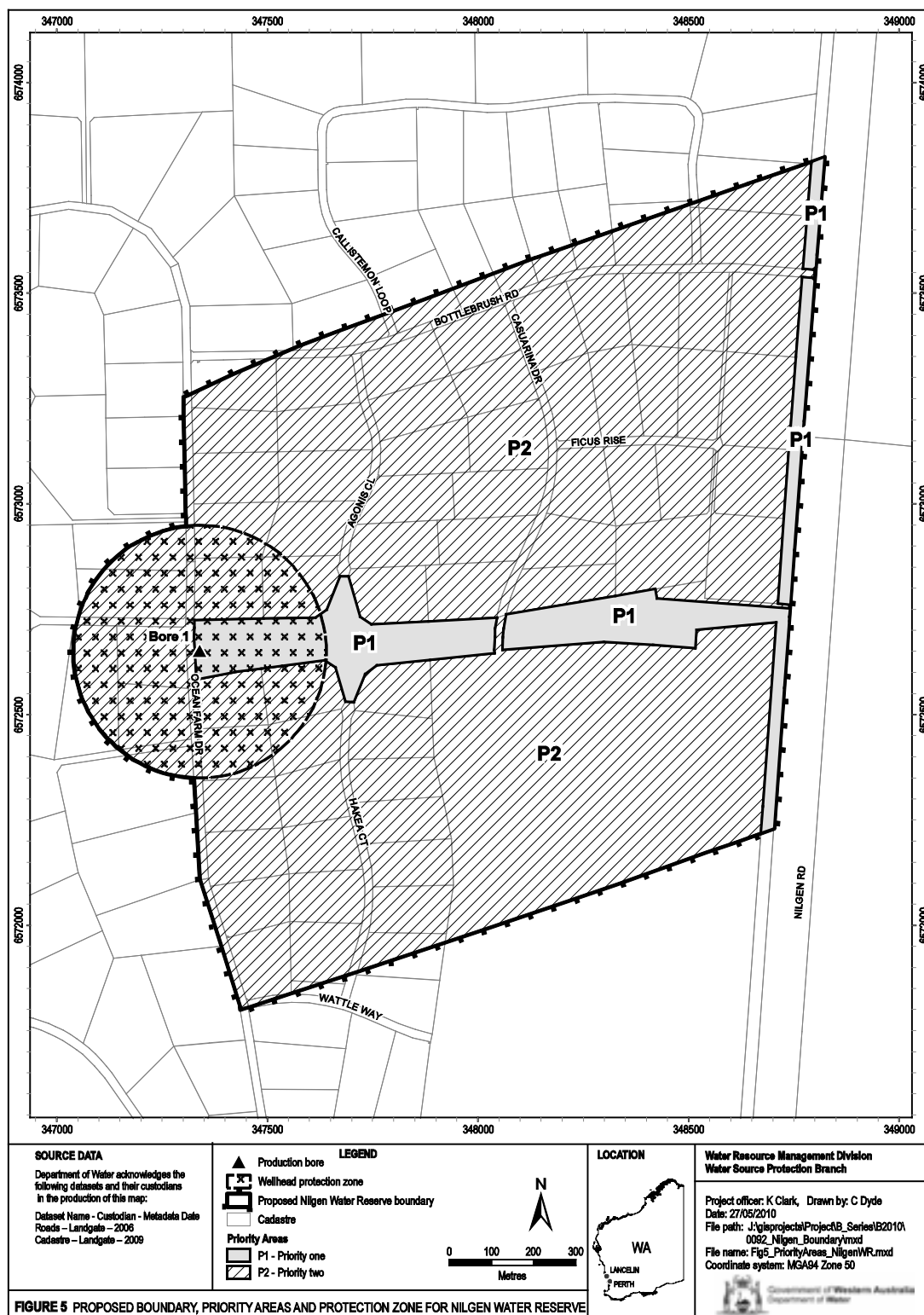
Appendix A Figures











Appendix B Water quality data

The information provided in this appendix has been prepared by the Water Corporation.

The Water Corporation has monitored the raw (source) water quality from Nilgen. This data shows the quality of water in the catchment. An assessment of the drinking water quality is also made in accordance with the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (ADWG) (NHMRC & NRMCC 2004a) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

- aesthetic characteristics (non-health-related)
- health-related characteristics including
 - health-related chemicals
 - microbiological contaminants

The following data represents the quality of raw water from Nilgen. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Results that exceed the ADWG have been shaded to give an indication of potential raw-water quality issues associated with this source.

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG. The values are taken from ongoing monitoring for the period July 2004 to June 2009.

Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are shaded.

For more information on the quality of drinking water supplied to the Ocean Farms Estate, Nilgen refer to the most recent Water Corporation drinking water quality annual report at <www.watercorporation.com.au> What we do > Water quality > Water quality publications > Water quality annual report 2008-09.

Aesthetic

The aesthetic quality analyses for raw water from Nilgen are summarised in the following table.

Aesthetic detections for Nilgen

Parameter	Units	ADWG aesthetic guideline value*	Nilgen	
			Range	Median
Aluminium unfiltered	mg/L	–	<0.008–0.012	<0.008
Chloride	mg/L	250	170–185	180
Conductivity at 25°C	mS/m	–	88–115	110
Hardness as CaCO ₃ [†]	mg/L	200	275–311	293
Iron unfiltered	mg/L	0.3	<0.003–0.07	0.004
pH	No unit	6.5–8.5	7.18–7.5	7.27
Sodium [†]	mg/L	180	100–115	105
Sulfate [†]	mg/L	250	16–19	19
Total filterable solids by summation [†]	mg/L	500	715–755	720
Turbidity	NTU	5	<0.1–1.2	<0.1

* An aesthetic guideline value is the concentration or measure of a water quality characteristic that is associated with good quality water.

[†] Results on three or less samples

Health related

Health-related chemicals

Raw water from Nilgen is analysed for chemicals that are harmful to human health, including categories of chemicals such as inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that impact on water quality are summarised in the following table.

Health-related detections for Nilgen

Parameter	Units	ADWG health guideline value*	Nilgen	
			Range	Median
Arsenic	mg/L	0.007	0.002–0.004	0.003
Fluoride [†]	mg/L	1.5	<0.1–0.1	<0.1
Nitrite plus nitrate as N	mg/L	11.29	2.8–3.6	3.15
Sulfate [†]	mg/L	500	16–19	16

* A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & ARMCAZ 2004a).

[†] Results on three or less samples

Microbiological contaminants

Microbiological testing of raw-water samples from Nilgen is currently conducted monthly. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals. A count of less than 20 MPN (most probable number) per 100 mL sample is typically associated with low levels of faecal contamination and is used as a microbiological contamination benchmark of the raw water (WHO 2004). As such, counts less than 20 MPN are seen as indicating raw water that has not been recently contaminated with faecal material.

During the reviewed period, positive *E. coli* counts were not recorded in any samples.

Appendix C Land use, potential water quality risks and recommended protection strategies

This table was prepared from data in Section 3 of this plan.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Private land					
Rural and rural residential development and activities	Nutrients and pathogens from septic tanks	Medium	Un-sewered lots ranging from 2 to 4 ha. Medium intensity	<ul style="list-style-type: none">• Groundwater quality monitoring• Surveillance• Shire of Gingin's <i>Town planning scheme no. 8</i>	<ul style="list-style-type: none">• Water quality protection note (WQPN) no. 70: <i>Wastewater treatment: onsite domestic systems</i>• Statewide policy no.2: <i>Pesticide use in public drinking water source areas</i>• Encourage proposed land uses to comply with 'acceptable' and 'compatible with conditions' land uses in WQPN no. 25: <i>Land use compatibility in public drinking water source areas.</i>
	Nutrients from fertiliser application				
	Chemicals from pesticide use on gardens				
	Domestic animals				
Crown land					
Roads	Hydrocarbons and chemicals from fuel and chemical spills, accidents and leaks.	Low	Low intensity	<ul style="list-style-type: none">• Groundwater quality monitoring• LEMC response	<ul style="list-style-type: none">• WQPN no. 44: <i>Roads near sensitive water resources</i>• Continuation of water quality monitoring, surveillance program and LEMC response

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Water Corporation land	Chemicals from chlorine storage	Low	Stored in a locked shed with a concrete base	<ul style="list-style-type: none"> • Spill kit on site • Water quality monitoring 	<ul style="list-style-type: none"> • WQPN no 65: <i>Toxic and hazardous substance: storage and use</i>
Fire management and wildfire	Nutrients from ash and fire retardants and fire-fighting foam	Low	Low intensity	<ul style="list-style-type: none"> • Groundwater quality monitoring • Fire breaks are maintained • LEMC response 	<ul style="list-style-type: none"> • PSC 88: <i>Use of herbicides in water catchment areas</i> • Statewide policy no.2: <i>Pesticide use in public drinking water source areas</i> • Establish the degree of usage of fire retardants and fire-fighting foam, and restrict its use close to the bores • Continuation of water quality monitoring, surveillance program and LEMC response
	Pesticides from weed control on fire breaks				

Appendix D Photographs



Figure D1 Bore 1



Figure D2 Nilgen tank site

List of shortened forms

ABS	Australian Bureau of Statistics
ADWG	<i>Australian drinking water guidelines</i>
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BoM	Bureau of Meteorology
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
LEMC	local emergency management committee
mg/L	milligram per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PSC 88	public sector circular number 88
PDWSA	public drinking water source area
WHPZ	wellhead protection zone
WESTPLAN–HAZMAT	Western Australian plan for hazardous materials

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, e.g. appearance, taste and odour (NHMRC & NRMMC 2004a).
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 of formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The <i>National water quality management strategy: Australian drinking water guidelines 6, 2004</i> (NHMRC & NRMMC 2004a) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).
Bore	A bore is a narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).
Catchment	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2004a).
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.

Leaching/ leachate	The process by which materials such as organic matter and mineral salts are washed out of a layer of soil or dumped material by being dissolved or suspended in percolating rainwater. The material washed out is known as leachate. Leachate can pollute groundwater and waterways.
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.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
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 <i>Escherichia coli</i>), protozoa (such as <i>Cryptosporidium</i> and <i>Giardia</i>) 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.
Public drinking water source area	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> (WA) and the <i>Country Areas Water Supply Act 1947</i> (WA).
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.
Total dissolved solids	Total dissolved solids consist of inorganic salts and small amounts of organic matter that are dissolved in water. Clay particles, colloidal iron and manganese oxides, and silica fine enough to pass through a 0.45 micrometer filter membrane can also contribute to total dissolved solids. Total dissolved solids comprise sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMMC 2004a).
Total filterable solids by summation	Total filterable solids by summation is a water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO ₄ equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO ₂ (silicon oxide). It is used as a more accurate measure than total dissolved solids (TDS). The higher the value, the more solids that are present and generally the saltier the taste.
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.
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 <i>Country Areas Water Supply Act 1947</i> (WA) or the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> (WA) 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 (WHPZ) is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

References

- Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) & Australian and New Zealand Environment and Conservation Council (ANZECC) 1996, *Draft rural land uses and water quality – A community resource document*, ARMCANZ & ANZECC, Canberra.
- Australian Bureau of Statistics 2006, *Census of population and housing: 2006 QuickStats – Nilgen (state suburb)*, Australian Bureau of Statistics, Canberra, available <<http://www.censusdata.abs.gov.au/>>.
- Bureau of Meteorology 2010, *Climate statistics for Australian locations – summary statistics Lancelin*, Bureau of Meteorology, available <http://reg.bom.gov.au/climate/averages/tables/cw_009114.shtml>.
- Department of Health 2007, *Use of herbicides in water catchment areas*, Circular no: PSC 88, February 2007, Department of Health, Perth.
- Department of Water various dates, Water quality protection note – *various titles*, Department of Water, Perth, available <<http://drinkingwater.water.wa.gov.au>> and scroll down to the link for water quality protection notes.
- Department of Water & Department of Health 2008, *Risks from pathogenic micro-organisms in public drinking water source areas*, Department of Water, Perth, available <<http://drinkingwater.water.wa.gov.au>> and scroll down to the link for our advisory brochures relevant to drinking water.
- Geldreich, EE 1996, 'Pathogenic agents in freshwater resources', *Hydrological Processes*, vol. 10, pp. 315-333.
- Government of Western Australia 1914, *Rights in Water and Irrigation Act*, reprinted under the *Reprints Act 1984* as at 1 February 2008, available <www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_844_homepage.html>.
- Government of Western Australia 1947, *Country Areas Water Supply Act*, reprinted under the *Reprints Act 1984* as at 14 April 2008, available <www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_208_homepage.html>.
- Government of Western Australia 2007, *State water plan 2007*, Department of the Premier and Cabinet, Perth, available <www.water.wa.gov.au> Publications > Find a publication > A–Z browse.
- Hrudey, SE & Hrudey, EJ 2004, *Safe drinking water – Lessons from recent outbreaks in affluent nations*, IWA Publishing, London.

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.

National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2004a, National Water Quality Management Strategy: *Australian drinking water guidelines*, Australian Government, Canberra, available <www.nhmrc.gov.au/publications/synopses/eh19syn.htm>.

NHMRC & NRMMC 2004b, *Water made clear – a consumer guide to accompany the Australian drinking water guidelines 2004*, Australian Government, Canberra, available <www.nhmrc.gov.au/publications/synopses/eh19syn.htm>.

National Minimum Bore Specifications Committee 2003, *Minimum construction requirements for water bores in Australia*, 2nd edn, Land and Water Biodiversity Committee, Queensland, available <www.water.wa.gov.au> Publications > Find a publication > A–Z browse.

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

Water and Rivers Commission 2000, Statewide policy no. 2: *Pesticide use in public drinking water source areas*, Water and Rivers Commission, Perth, available <<http://drinkingwater.water.wa.gov.au>> and scroll down to the link for our policies.

Water and Rivers Commission 2003, Statewide policy no. 13: *Policy and guidelines for recreation within public drinking water source areas on Crown land*, Water and Rivers Commission, Perth, available <<http://drinkingwater.water.wa.gov.au>> and scroll down to the link for our policies.

Water Corporation 2006, *Nilgen water resource management operation strategy*, Water Corporation, Perth.

Water Corporation 2006, *SG097 Source protection operations manual*, Water Corporation, Perth.

Western Australian Planning Commission 1997, *State planning strategy*, Government of Western Australia, Perth, available <<http://www.planning.wa.gov.au/Plans+and+policies/Publications/52.aspx>>.

Western Australian Planning Commission 2003, Statement of 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, available <<http://www.planning.wa.gov.au/Plans+and+policies/Publications/149.aspx>>

Western Australian Planning Commission 2005, *Shire of Gingin: town planning scheme no. 8*, Department for Planning and Infrastructure, Perth, available <<http://www.planning.wa.gov.au/The+planning+system/Region+schemes/Local+planning+schemes/509.aspx>>

Western Australian Planning Commission 2006, State planning policy no.2.9: *Water resources*, Government Gazette Western Australia, 19 December 2006, pp. 5707-22 Government of Western Australia, Perth, available <<http://www.planning.wa.gov.au/Plans+and+policies/Publications/1281.aspx>>

World Health Organization 2004, *Guidelines for drinking-water quality – Volume 1 – Recommendations*, 3rd edn, World Health Organization, Geneva, available <www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html>.



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