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

Badgingarra Water Reserve

Drinking water source protection review

Badgingarra town water supply

Securing Western Australia's water future

Water resource protection series
Report WRP 174
June 2017

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Cover photograph: Aerial photo of Badgingarra Water Reserve

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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.

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Summary

This drinking water source protection review considers changes that have occurred in and around the Badgingarra Water Reserve since completion of the *Badgingarra Water Reserve water source protection plan* (Water and Rivers Commission 1999). Both of these documents are available on our website or by contacting us.

Badgingarra is a small rural town located about 200 km north of Perth in the wheatbelt region of Western Australia, within the Shire of Dandaragan. Water Corporation supplies the town's drinking water from two production bores which draw water from a deep, semi-confined aquifer. The bores are located in a secure compound on Crown land vested with Water Corporation.

The entire Badgingarra Water Reserve is located over Crown land, predominantly unallocated Crown reserve.

The Department of Water prepared this document in consultation with key stakeholders, including Water Corporation, the Department of Health and the Shire of Dandaragan.

The main changes since the 1999 plan are:

- the boundary and wellhead protection zones are being extended over Crown reserve to a 500 m radius around the production bores to reflect current policy
- the water reserve is being assigned Priority 1.

The proposed water reserve boundary extension will not cover the adjacent rural property or any land in the area zoned for residential purposes in the Shire of Dandaragan's *Local planning scheme No. 7* (Department of Planning 2006).

This review is consistent with the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011) and State planning policy no. 2.7: *Public drinking water source policy.*

Table 1 below, shows important information about the Badgingarra Water Reserve.

Table 1 Key information about the Badgingarra Water Reserve

Badgingarra Water Reserve	
Status of this report	This report has been prepared based on information for the 2014/15 financial year
Location supplied	Badgingarra
Water service provider	Water Corporation
Aquifer type	Deep, semi-confined (Yarragadee)
Licensed abstraction	50 000 kL/year (Licence number 65341)

Badgingarra Water Reserve	
Number of bores	two
Bore names and GPS coordinates	1/89 (E 356 778, N 6 637 007, zone 50) 2/89 (E 356 770, N 6 636 988, zone 50)
Date of bore completion	1/89 (December 1989) 2/89 (December 1989)
Dates of drinking water source protection reports	1999 – Badgingarra Water Reserve water source protection plan (Water and Rivers Commission) 2015 – Badgingarra Water Reserve drinking water source protection review (this document)
Consultation	1999 – advertised public consultation as part of the water source protection plan 2015 – government and Water Corporation
Proclamation history	Proclaimed on 16 November 1999 under the Country Areas Water Supply Act 1947. An amended proclamation will need to be progressed under the Country Areas Water Supply Act 1947 when this report is finalised.
Reference documents	*Australian drinking water guidelines* (NHMRC & NRMMC 2011) State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) *Jurien groundwater allocation plan* (Department of Water 2010) *Jurien groundwater allocation plan: evaluation statement 2010–2011* (Department of Water 2012) *Jurien groundwater area subarea reference sheets: plan companion for the Jurien groundwater area allocation plan* (Department of Water 2009)

1 Review of Badgingarra's drinking water source protection plan

1.1 Boundary, priority areas and protection zones

The Badgingarra Water Reserve was proclaimed in 1999 under the *Country Areas Water Supply Act 1947*. The water reserve boundary covers a 300 m radius around the production bores and was assigned a priority 3 (P3) area (Figure A1) via the *Badgingarra Water Reserve drinking water source protection plan* (Water and Rivers Commission 1999). A wellhead protection zone (WHPZ) was designated over the entire water reserve.

This review recommends that the water reserve boundary and WHPZ are extended over Crown land to a 500 m radius around the production bores (Figure A3). The boundary will be truncated to exclude the adjacent rural property and land within the area zoned for residential purposes in the Shire of Dandaragan's *Local planning scheme No. 7* (Department of Planning 2006). The water reserve is proposed to be assigned priority 1 (P1). This will help prevent contamination from inappropriate land uses in the immediate vicinity of the bore field.

The Department of Water will arrange proclamation of the revised Badgingarra Water Reserve boundary under the *Country Areas Water Supply Act 1947* as recommended in section 2.2. At the same time we will change the priority area from P3 to P1 to reflect the importance of this redefined area. The final change will be the extension of the wellhead protection zone over the entire water reserve.

The boundary, priority areas and protection zones above have been determined in accordance with current departmental policy.

If you require more information about how we protect drinking water sources, please read Appendix E.

1.2 Update on water supply scheme

The Department of Water has recently renewed the Water Corporation's groundwater allocation licence. The licence allows Water Corporation to draw 50 000 kL of water from the Yarragadee aquifer (semi-confined) to supply Badgingarra's drinking water.

The Badgingarra bore field still consists of two deep bores (1/89 and 2/89, figures C1 and C2) which draw water from the semi-confined Yarragadee aquifer. Groundwater from this source undergoes pH correction and is then chlorinated to disinfect the water and ensure microbiological quality for consumers. It is then pumped into the storage tank and distributed via gravity to the town scheme.

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* (ADWG;

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.

For more information on why it is so important to protect our catchments, read Appendix E.

1.3 Aboriginal native title claims

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 one native title claim within the Badgingarra Water Reserve; Yued (WAD6192/1998).

The State Government of Western Australia and the Noongar native title claimants have negotiated an agreement called an Indigenous Land Use Agreement (ILUA). This agreement recognises the Noongar people as the traditional owners of land in the South West Settlement Area, which extends from a point south of Dongara on the west coast, approximately east to a point north of Moora and then south-easterly to a point midway between Albany and Esperance (see Figure A4). It enablez some types of land-based customary activities to be undertaken by Noongar people in PDWSAs within the South West Settlement Area. Some of the land-based activities include:

- entry to registered Aboriginal sites in reservoir protection zones
- designated camping sites for Noongar people (outside reservoir protection zones and wellhead protection zones)
- gathering invertebrates and eggs, lighting fires and gathering flora for customary purposes.

The ILUA is available via the Department of Premier and Cabinet, see www.dpc.wa.gov.au/lantu/Claims/Pages/SouthWestSettlement.aspx.

The Department of Water 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.

1.4 Enforcing by-laws, surveying the area and maintenance

This review recommends that Water Corporation continue by-law enforcement under the existing delegation arrangement (see section 2.2, recommendation no. 6). This includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013)

- maintaining security and fencing surrounding the bore compound
- ongoing regular surveillance and inspections.

1.5 Other Department of Water work

The *Jurien groundwater allocation plan* (Department of Water 2010) provides direction for the allocation and licensing of the groundwater resources in the Jurien groundwater area. The plan describes the allocation and availability of groundwater for a variety of industries, such as mining and agriculture, as well as for the expected population growth in the area.

The *Jurien groundwater allocation plan: evaluation statement* (Department of Water 2012) evaluated the extent to which the objectives of the plan were met and updated the allocation status of groundwater resources in the area. The Yarragadee aquifer in the Badgingarra subarea was considered to have water available for licensing at the time of publication.

The *Jurien groundwater area subarea reference sheets: plan companion for the Jurien groundwater area allocation plan* (Department of Water 2009) provides local subarea information and guidance on the groundwater licensing process in the *Jurien groundwater allocation plan*.

1.6 Update on water quality risks

As part of this review, the Department of Water has conducted a new assessment of water quality contamination risks to the Badgingarra Water Reserve in accordance with the ADWG. Table 2 shows the risks that are new or changed since the 1999 plan.

Refer to Appendix D for information about typical contamination risks in PDWSAs. Refer to Appendix F to gain a greater understanding about the risk assessment process we use.

As Badgingarra's drinking water is drawn from a deep, semi-confined aquifer the source is not considered highly vulnerable to contamination from land uses in the broader recharge area. This is because the source is largely protected from surface contamination by the considerable depth to the aquifer and the presence of multiple layers of rock that sit above the groundwater. The main risks to Badgingarra's water quality would arise from inappropriate land uses or activities in the immediate vicinity of the bore field.

The Badgingarra Water Reserve is predominantly located on unallocated Crown reserve covered by native scrub (figures A1 and A2). There is a minimum 300 m buffer of vegetation between the bores and nearby farms and the town site (Figure C3). The only activity evident within the proposed water reserve is off-road driving on unsealed roads and tracks.

The two production bores are located within a fenced compound managed by Water Corporation (Figure C4).

1.6.1 Unsealed roads and tracks

Unsealed roads and tracks run through the proposed water reserve, from the Badgingarra town site to a disused sandpit (figures A2 and C5), which is now being used for off-road vehicle recreation. The tracks within the proposed water reserve appear to be used infrequently as there are alternative tracks to the sandpit that don't run through the water reserve. There has been no evidence of activities or incidents with the potential to contaminate groundwater, such as accidents, vehicle repairs, refuelling or vehicle dumping.

There is no indication that unauthorised recreation, off-road driving or vandalism is occurring near the bore field. There are alternative sites outside the proposed water reserve that appear to be preferred for recreation.

1.6.2 Other groundwater bores

Bores drilled near a public drinking water supply bore – such as for irrigation or private purposes – can cause contamination of the drinking water source. For example, a poorly constructed 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 Department of Water'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). The Shire of Dandaragan is the only licensed user of the Yarragadee aquifer nearby, using the water for irrigating a recreation site.

Table 2 Summary of potential water quality risks, land use compatibility and best management practices

Land use/activity	**Hazard**	**Management priority**	**Comments**	**Best management practice guidance[1]**
Unsealed roads and tracks	Hydrocarbons and turbidity	Low	Surveillance of the water reserve should identify any water quality risks before the contamination reaches the bores, e.g. abandoned car bodies or fuel spills.	WQPN no. 44: *Roads near sensitive water resources*

[1] Water quality protection notes (WQPNs) are available <www.water.wa.gov.au> or see *Further reading*.

1.7 Water quality information

Water Corporation has provided updated water quality information for the Badgingarra Water Reserve This is shown in Appendix B.

Water from the Yarragadee aquifer at Badgingarra is naturally acidic, with a pH outside the ADWG aesthetic value range. Naturally occurring levels of nickel have occasionally exceeded the health guideline value. However, the water treatment process ensures that the levels of pH and nickel are within the ADWG health and aesthetic values before being supplied to consumers in Badgingarra.

2 Implementation of Badgingarra's drinking water source protection plan

2.1 Status of previous recommendations

Table 3 outlines recommendations from the 1999 plan and their current status.

Table 3 Implementation status for Badgingarra Water Reserve

No.	Recommendation	Comments
1	Gazettal of water reserve.	Gazetted in 1999 under the *Country Areas Water Supply Act 1947.*
2	Incorporation into land planning strategies.	The water reserve was incorporated in the Shire of Dandaragan's *Local planning strategy* (Shire of Dandaragan 2012), but has not yet been incorporated in the Shire of Dandaragan's local planning scheme. This has been continued as a recommendation of this review (section 2.2, recommendation no. 2).
3	Referral of development proposals: • Department of Water (formerly Water and Rivers Commission) to provide the Shire of Dandaragan with guidelines for referral of development proposals. • Referral of development proposals.	Guidelines have been provided through the WQPNs series. Development proposals within PDWSAs are referred to the Swan Avon Region office of the Department of Water. This has been continued as a recommendation of this review (section 2.2, recommendation no. 3).
4	Erection of signs: • Development of guidelines for signage. • Determine number and location of signs required. • Erect signs.	Water Corporation signs are displayed on the bore compound. Consider erecting additional signs at the boundary of the water reserve nearest the Badgingarra town site (section 2.2, recommendation no. 5).

No.	Recommendation	Comments
5	Emergency response: • Develop response plan. • Inform WAHMEMS personnel of special requirements for the Woodridge Water Reserve.	Emergency response protocols have since changed to Westplan-HAZMAT and the local emergency management committee (LEMC). This has been continued as a new recommendation of this review (section 2.2, recommendation no. 4).
6	Surveillance program: • Develop guidelines for the surveillance of water reserves. • Implement the surveillance program.	Water Corporation undertakes surveillance within the water reserve. This has been continued as a new recommendation of this review (section 2.2, recommendation no. 6).
7	Review of the plan and recommendations.	Undertaken through the preparation of this review document. This has been continued as a new recommendation of this review (section 2.2, recommendation no. 7).

2.2 Consolidated recommendations

Based on the findings of this review, the following recommendations will now be applied to the Badgingarra Water Reserve. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Amend the boundary of the Badgingarra Water Reserve under the *Country Areas Water Supply Act 1947*. (Department of Water)
2. Incorporate the findings of this review and the location of the Badgingarra Water Reserve (including its priority area and protection zones) in the Shire of Dandaragan's local planning scheme in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*. (Shire of Dandaragan)
3. Refer development proposals within the Badgingarra Water Reserve that are inconsistent with the Department of Water's WQPN no.25: *Land use compatibility in public drinking water source areas* or recommendations in this review to the Department of Water regional office for advice. (Department of Planning, Shire of Dandaragan, proponents of proposals)
4. Ensure incidents covered by Westplan–HAZMAT in the Badgingarra Water Reserve are addressed by ensuring that:
    - the Badgingarra LEMC is aware of the location and purpose of the Badgingarra Water Reserve

- the locality plan for the Badgingarra Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
- Water Corporation acts in an advisory role during incidents in the Badgingarra Water Reserve
- personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Badgingarra Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

(Water Corporation)

5. Erect signs along the boundary of the Badgingarra Water Reserve near the Badgingarra town site, including an emergency contact telephone number, in accordance with Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
6. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
7. Update this review within seven years. (Department of Water).

Appendices

Appendix A — Figures

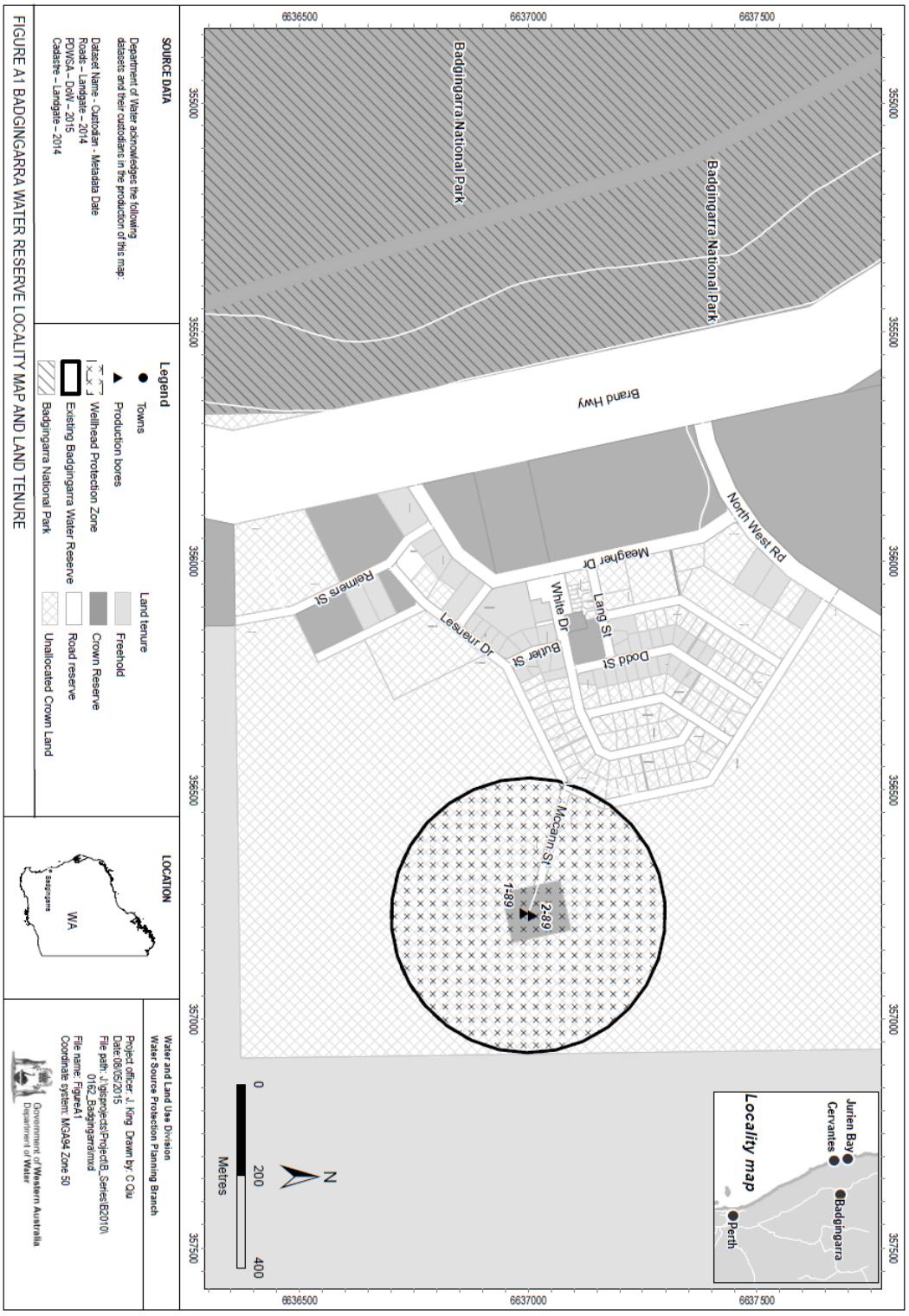

Figure A1 Badgingarra Water Reserve (1999) locality map and land tenure

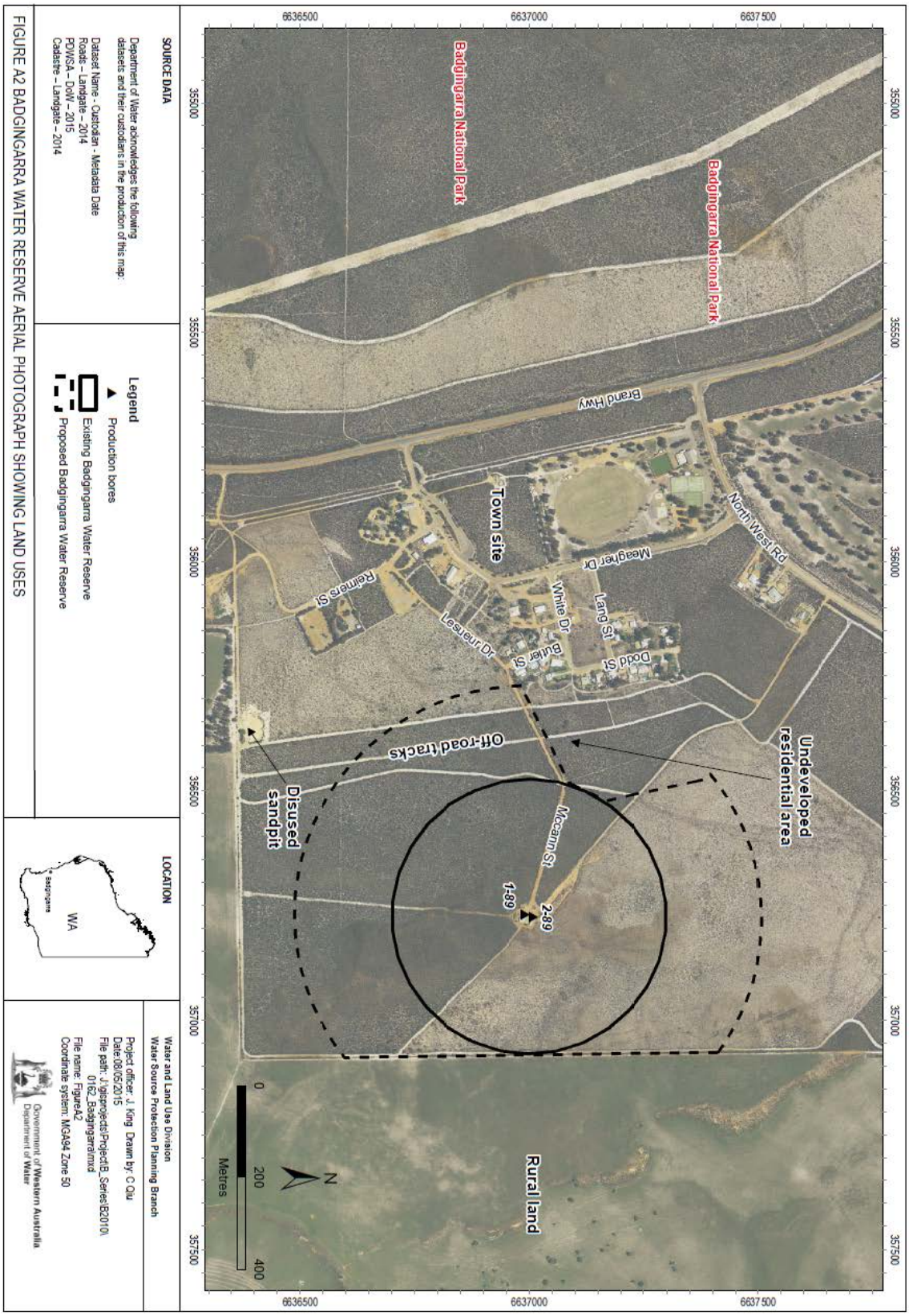

Figure A2 Badgingarra Water Reserve aerial photo showing land uses

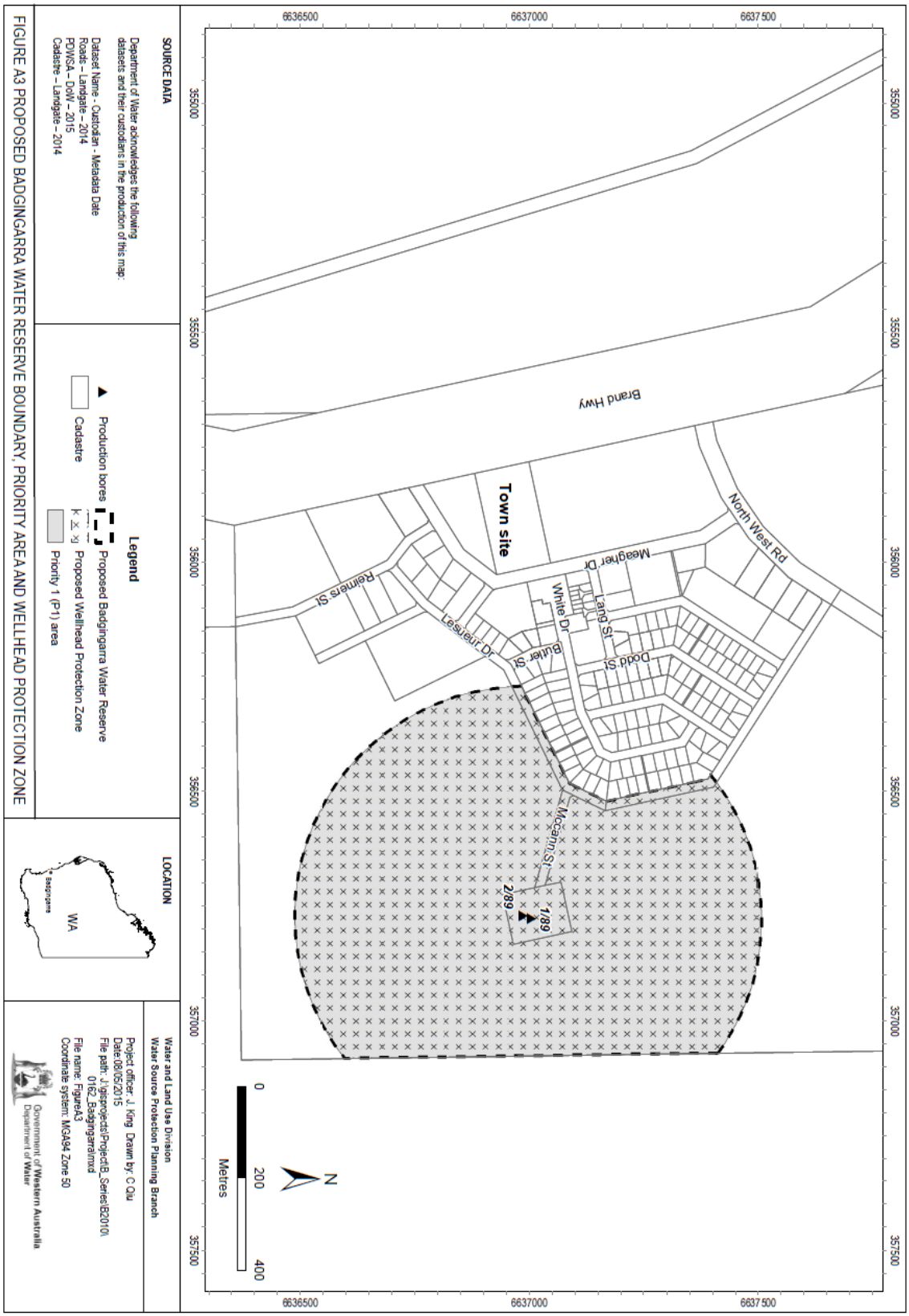

Figure A3 Badgingarra Water Reserve proposed boundary, priority areas and protection zones (2015)

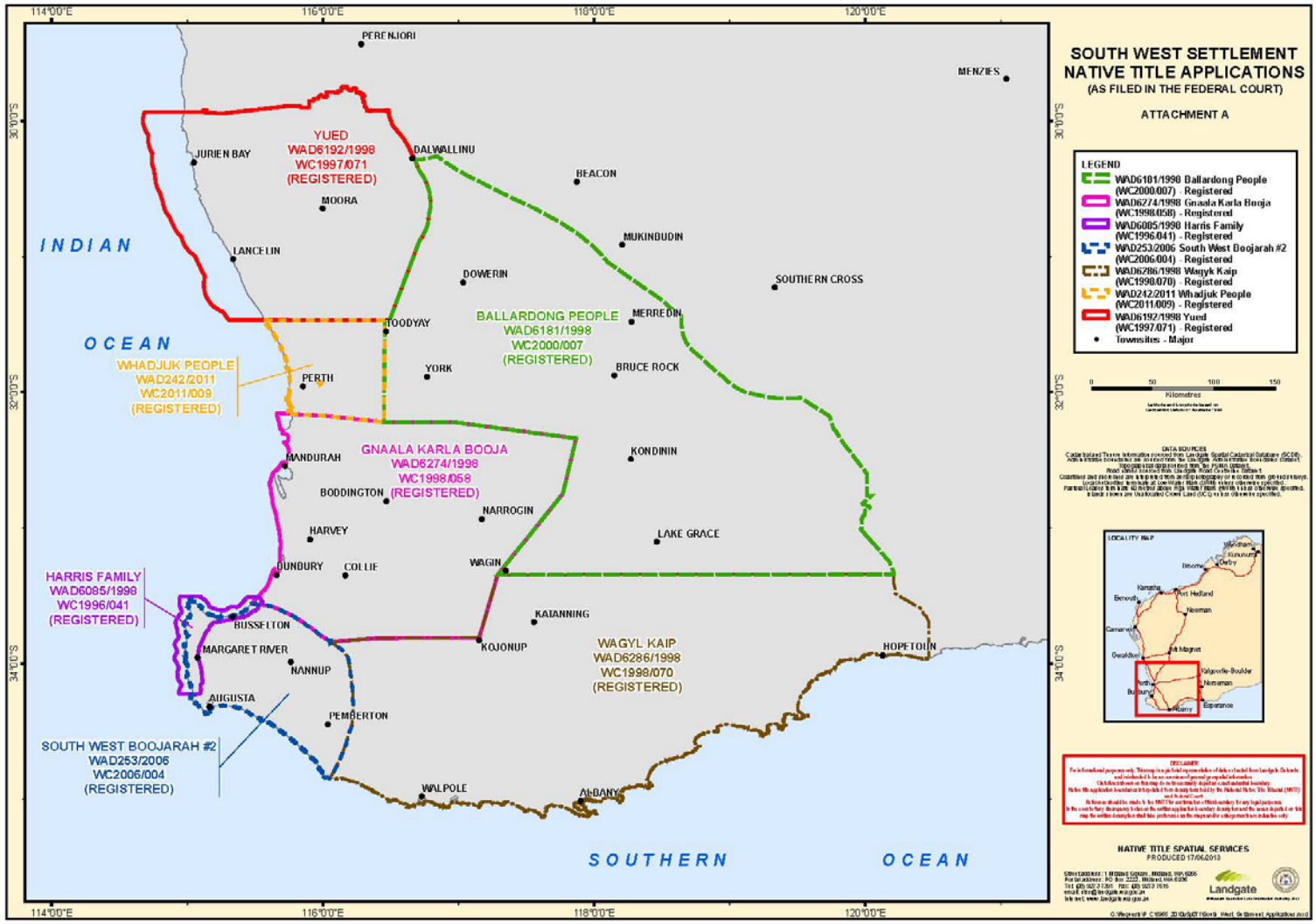

Figure A4 South West Native Title Agreement area (source: Department of Premier and Cabinet)

Appendix B — Water quality data

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

Water Corporation has monitored the raw (source) water quality from Badgingarra in accordance with the requirements of the 2004 *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2004) and interpretations agreed to with the Department of Health. This data shows the quality of water in the public drinking water source area (PDWSA). 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 Badgingarra. 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. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in bold and italics to give an indication of potential raw-water quality issues associated with this source. The values are taken from ongoing monitoring for the period December 2009 to November 2014.

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.

For more information on the quality of drinking water supplied to the name Badgingarra refer to the most recent Water Corporation drinking water quality annual report at watercorporation.com.au > What we do > Water quality > Water quality publications > Most recent *Water quality annual report*.

Aesthetic characteristics

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

Aesthetic detections for Badgingarra

Parameter	Units	ADWG aesthetic guideline value*	Badgingarra raw water	
			Range	Median
Chloride	mg/L	250	220–245	232.5
Copper	mg/L	1	0.035–0.07	0.035
Hardness as $CaCO_3$	mg/L	200	41–45	45
Iron unfiltered	mg/L	0.3	<0.003–0.08	0.01
Manganese unfiltered	mg/L	0.1	<0.005–0.018	0.0085
Silicon as SiO_2	mg/L	80	40–47	44.5
Sodium	mg/L	180	130–140	135
Sulfate	mg/L	250	21–22	21
Total filterable solids by summation	mg/L	500	451–488	475.5
Turbidity	NTU	5	<0.1–0.3	<0.1
pH measured in laboratory	no units	6.5–8.5	***5.43–5.94***	***5.56***
Zinc	mg/L	3	0.04–0.06	0.06

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

Health-related chemicals

Raw water from Badgingarra is analysed for chemicals that are harmful to human health, including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that have been detected in the source are summarised in the following table.

Health-related detections for Badgingarra

Parameter	Units	ADWG health guideline value*	Badgingarra raw water	
			Range	Median
Barium	mg/L	0.7	0.14	0.14
Boron	mg/L	4	<0.02–0.03	<0.025
Manganese unfiltered	mg/L	0.5	0.005–0.018	0.0085
Chromium	mg//L	0.05	0.008–0.037	0.009
Copper	mg//L	2	0.035–0.07	0.035
Lead	mg//L	0.01	0.002–0.004	0.004
Nickel	mg//L	0.02	0.005–***0.085***	0.016
Nitrate as nitrogen	mg/L	11.29	0.16–0.17	0.165
Nitrite plus nitrogen as N	mg/L	11.29†	0.165–0.18	0.175
Radon-222	Bq/L	100	3.14	3.14
Sulfate	mg/L	500	21–22	21

* 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 & NRMMC 2004).

† A guideline value of 11.29 mg/L (as nitrogen) has been set to protect bottle-fed infants less than three months of age. Up to 22.58 mg/L (as nitrogen) can be safely consumed by adults and children over three months of age.

Microbiological contaminants

Microbiological testing of raw-water samples from Badgingarra is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals.

A detection of *E. coli* in raw water may indicate contamination of faecal material.

During the reviewed period, no *E. coli* counts were recorded.

Appendix C — Photographs

Figure C1 Badgingarra production bore 1/89, photograph by J. King, Department of Water

Figure C2 Badgingarra production bore 2/89, photograph by J. King, Department of Water

Figure C3 Natural vegetation surrounding the production bores, photograph by J. King, Department of Water

Figure C4 Fenced compound for the Badgingarra production bores and water treatment plant, photograph by J. King, Department of Water

Figure C5 Disused sandpit now used for off-road vehicle recreation, photograph by J. King, Department of Water

Appendix D — Typical contamination risks in groundwater sources

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 runoff 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 safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health, resulting in illness, hospitalisation or even death. 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, undetectable 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* (ADWG; NHMRC & NRMMC 2011) outline criteria for acceptable drinking water quality to protect human health, manage aesthetics and maintain water supply infrastructure.

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

Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness and include bacteria, protozoa and viruses. When people consume drinking water that is contaminated with pathogens, the consequences vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and in some cases even death. For example, seven people died and about 2500 became ill in Walkerton, Canada, during 2000, because the town's water supply was contaminated by a pathogenic strain of *E. coli* and *Campylobacter* (NHMRC & NRMMC 2011).

The types of pathogens that are likely to cause harm to people are commonly found in the faeces of humans and domestic animals – such as dogs and cattle. These pathogens can enter drinking water supplies from faecal contamination in the catchment area, either directly or indirectly.

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 (for example *Salmonella*, *Escherichia coli* and cholera), protozoa (such as *Cryptosporidium* and *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 (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 inactivation rate) 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.

Given the wide variety of pathogens, their behaviour 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.

Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water. 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 and chemicals can attach onto soil particles and become more difficult to remove during disinfection and treatment processes.

Other physical properties of water can affect water supply infrastructure, or the aesthetics of the drinking water. For example, pH can contribute to the corrosion and encrustation of pipes; iron and dissolved organic matter can affect the colour and smell of water; and salinity levels can affect its taste. Although not necessarily

harmful to human health, water with properties like this will be less appealing to customers.

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 used to control weeds (herbicides) and pests (insecticides, rodenticides, nematicides (for worms) and miticides (for 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 such as fuels and oils are potentially toxic to humans. Harmful chemical by-products may be formed when hydrocarbons are combined with chlorine during the water treatment process. Hydrocarbons can occur in water supplies as a result of spills and leaks from vehicles and machinery.

Drinking water sources can also be contaminated by nutrients such as nitrogen and phosphorus. Nutrients can be introduced into a catchment via the application of fertiliser, from septic systems, and from animal faecal matter that washes through soil and into the groundwater. Nitrate and nitrite are two forms of nitrogen that 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 groundwater and could be harmful to human health if consumed.

Appendix E — How do we protect public drinking water source areas?

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a preventive, risk-based and multiple-barrier approach. A similar approach is recommended by the World Health Organization.

The catchment to consumer framework applies across the entire drinking water supply system – from the water source to the taps in your home. It ensures a holistic assessment of water quality risks and solutions to ensure the delivery of a reliable and safe drinking water to supply your home.

A preventive, risk-based approach means that we look at all the different risks to water quality. We determine what risks can reasonably be avoided and what risks need to be minimised or managed to protect public health. This approach means that the inherent risks to water quality are as low as possible. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system.

The first and most important barrier is protecting the public drinking water source area (PDWSA) – the area from which water is captured to supply drinking water. If we get this barrier right, it has a flow-on effect that can result in a lower cost and safer drinking water supply. Other barriers against contamination include storage of water to help reduce contaminant levels, disinfecting the water (for example chlorination to inactivate pathogens), maintenance of pipes and testing of water quality. Another community benefit from PDWSA protection is that it complements the state's conservation initiatives.

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. We should not forget that ultimately it's about protecting your health by protecting water quality now and for the future.

In Western Australia, the Department of Water protects PDWSAs by implementing the ADWG, writing reports, policies and guidelines, and providing input into land-use planning.

This drinking water protection report achieves elements two and three of the 12 elements in the ADWG recommended for protecting drinking water. It shows the PDWSA's location, its characteristics, existing and potential water quality contamination risks, and makes recommendations to deal with those risks.

The *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947* provide us with important tools to protect water quality in proclaimed PDWSAs. These acts allow us to assess and manage the water quality contamination risks from different land uses and activities. The department works

cooperatively with other agencies and the community to implement this legislation and develop drinking water source protection reports. For example, the Western Australian Planning Commission has developed a number of state planning policies to help guide development in public drinking water source areas.

An important step in maximising the protection of water quality in PDWSAs is to define their boundaries, priority areas and protection zones to help guide land-use planning and to identify where legislation applies. There are three different priority areas. The objective of priority 1 (P1) areas is risk avoidance – ensuring there is no degradation of the water quality (for example over Crown land). The objective of priority 2 (P2) areas is risk minimisation – maintaining or improving water quality (for example over rural-zoned land). The objective of priority 3 (P3) areas is risk management – maintaining the water quality for as long as possible (for example, urban- or commercial-zoned land). Protection zones surround drinking water abstraction bores and surface water reservoirs so that the most vulnerable areas are protected from contamination.

The Department of Water's Water quality protection note no. 25: *Land use compatibility in PDWSAs* outlines appropriate development and activities within each of the priority areas (P1, P2 and P3) and is available on our website.

With 129 proclaimed 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.

There are three different types of drinking water source protection report – each providing for different needs. The following table shows the differences between the types of reports.

There is a fourth type of report – Land use and water management strategy – that performs the same functions as a drinking water source protection report. However, these strategies are prepared by the Western Australian Planning Commission (with input from the Department of Water) and are strategic documents that integrate land use planning with water management. There are currently land use and water management strategies for Gnangara, Jandakot and Middle Helena.

If you would like more information about the ADWG and how we protect drinking water in Western Australia, visit drinkingwater.water.wa.gov.au or refer to our Water quality protection note (WQPN) no. 36: *Protecting public drinking water source areas*. You can also contact the Department of Water's Water source protection planning branch on +61 8 6364 7600 or email drinkingwater@water.wa.gov.au.

Drinking water source protection reports produced by the Department of Water

Drinking water source protection report	Scope and outcome	Consultation	Time to prepare	Implementation table	Proclamation
Drinking water source protection assessment (DWSPA)	Desktop assessment of readily available information.	Preliminary	Up to 3 months	No	Proclamation to protect water quality and guide land use planning can occur as a result of any type of drinking water source protection report.
Drinking water source protection plan (DWSPP)	Full investigation of risks to water quality building on information in the DWSPA.	Public	6–12 months	Prepared from recommendations in the DWSPA and/or information from public consultation.	
Drinking water source protection review (DWSPR)	Review changes in land and water factors and implementation of previous recommendations. Sometimes prepared to consider specific issues in a PDWSA.	Key stakeholders	3–6 months	Prepared from recommendations in the DWSPA or DWSPP.	

Appendix F — Understanding risks to drinking water quality

The existing integrated land use planning and public drinking water source area (PDWSA) protection program is based on the findings of three parliamentary committee reports in 1994, 2000 and 2010 (see *Further reading*). Since 1995, this integrated program has resulted in the development of four Western Australian Planning Commission state planning policies (SPPs), recognising the importance of PDWSAs for the protection of water quality and public health:

- SPP no. 2.2: *Gnangara groundwater protection*
- SPP no. 2.3: *Jandakot groundwater protection*
- SPP no. 2.7: *Public drinking water source policy*
- SPP no. 2.9: *Water resources*.

This integrated program relies upon a preventive and risk-based assessment process in each PDWSA through the development of drinking water source protection reports. It is important to understand how risks are assessed to appreciate the impact of development within PDWSAs.

Risk-based assessments normally focus on the acceptability of risks after mitigation (residual risks). For drinking water sources, a preventive, risk based assessment that considers both the maximum and residual risks is required. This means that in some cases, the maximum risks from land uses will still be considered unacceptable, even after mitigation has reduced the risk. This is a more conservative approach needed to protect the health of consumers.

Water quality risks are evaluated by considering the type and scale of a potential contamination event (consequence), together with the probability/frequency of that event occurring (likelihood). An understanding of this relationship will prevent the common misunderstanding that probability equals risk (see risk matrix below).

Risk matrix: Level of risk (from the Australian drinking water guidelines *2011)*

Likelihood	**Consequences**				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Moderate	High	Very high	Very high	Very high
Likely	Moderate	High	High	Very high	Very high
Possible	Low	Moderate	High	Very high	Very high
Unlikely	Low	Low	Moderate	High	Very high
Rare	Low	Low	Moderate	High	High

For example, just because a drinking water contamination incident has not occurred for many years (low likelihood) does not mean that the risk is low, because we also need to consider the consequence of that contamination when determining risk. Furthermore, no previous detection of contamination is not proof that the risk is acceptable.

Shortened forms

List of shortened forms

ADWG	*Australian drinking water guidelines*
ANZECC	Australian and New Zealand Environment Conservation Council
HAZMAT	hazardous materials
ILUA	Indigenous Land Use Agreement
LEMC	local emergency management committee
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PDWSA	public drinking water source area
SPP	State planning policy
WAHMEMS	Western Australian hazardous materials emergency management scheme (previous name for Westplan–HAZMAT)
WAPC	Western Australian Planning Commission
Westplan–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

Units of measurement

Bq/L	becquerel per litre
mSv	millisievert
m	metres
mg/L	milligram per litre
km	kilometre

Volumes of water

One millilitre	0.001 litre	1 millilitre	(mL)
One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 gigalitre	(GL)

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, for example appearance, taste and odour (NHMRC & NRMMC 2011).
Allocation	The volume of water that a licensee is permitted to abstract, usually specified in kilolitres per annum (kL/a).
Aquifer	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) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see *References*).
Becquerel	A measure of radioactivity, as per the International System of Units.
Bore	A narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).
Bore field	A group of bores to monitor or withdraw groundwater.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Confined aquifer	An aquifer that is overlain by relatively impermeable rock or clay that limits movement of water into and out of the aquifer. Confined aquifers are usually deeper under the ground than unconfined aquifers. Groundwater in a confined aquifer is under pressure and will rise up inside a bore hole that is drilled into the aquifer.
Contamination	A substance present at concentrations exceeding background levels that presents – or has the potential to present – a risk of harm to human health, the environment, water resources or any environmental value.
Drinking water source protection report	A report on water quality hazards and risk levels within a public drinking water source area; includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.

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 2011).
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.
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 measurement of something (such as salinity) in a solution, i.e. 0.001 grams per litre.
Nephelometric turbidity units	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 *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Permeability	Also referred to as hydraulic conductivity, this is the ability of a rock or soil unit to transmit fluids. Its magnitude depends on the size of the pore spaces and the degree to which they are interconnected.
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.
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* or the *Country Areas Water Supply Act 1947*.

Recharge	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.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Semi-confined aquifer	A leaky aquifer, saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable.
Total dissolved solids	Consists 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 2011).
Total filterable solids by summation	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. 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.
True colour units	A measure of degree of colour in water.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.

Unconfined aquifer	An aquifer where the upper boundary is the watertable and therefore is in contact with the atmosphere through the pore spaces in the unsaturated zone. Typically (but not always) it is the shallowest aquifer at a given location.
Water quality	Collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	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.
Wellhead	The top of a well (or bore) used to draw groundwater.
Wellhead protection zone	Usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination risks.
Westplan–HAZMAT	State emergency management plan for hazardous materials emergencies.

References

Department of Planning 2006, *Shire of Dandaragan local planning scheme no. 7,* Government of Western Australia, Perth, available *http://online.planning.wa.gov.au/lps/localplanningschemes.asp?f=Dandaragan - Shire of (Scheme 7)*.

Department of Water 2009, *Jurien groundwater subarea reference sheets: plan companion for the Jurien groundwater area allocation plan,* Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/88972.pdf.

——2010, *Jurien groundwater allocation plan,* Water resource allocation planning series, Report no. 27, Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/95135.pdf.

——2012, *Jurien groundwater allocation plan,* Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/102704.pdf.

——2014, *WAter resources inventory 2014 – Water availability, quality and trends,* Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/107262.pdf.

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

- 2009, WQPN 36: *Protecting public drinking water source areas*
- 2016, WQPN 25: *Land use compatibility in public drinking water source areas*

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

Government of Western Australia 1909, *Metropolitan Water Supply, Sewerage, and Drainage Act*, reprinted under the *Reprints Act 1984* as at 27 April 2008, State Law Publisher, Perth.

——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.

National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2011, National water quality management strategy: *Australian drinking water guidelines*, Australian Government, Canberra, available https://www.nhmrc.gov.au/guidelines/publications/eh52.

——2004, National water quality management strategy: *Australian drinking water guidelines*, Australian Government, Canberra.

National Uniform Drillers Licensing Committee 2012, *Minimum construction requirements for water bores in Australia,* 3rd edn, Australian Government National Water Commission, Braeside, Victoria, available www.water.wa.gov.au/PublicationStore/first/102386.pdf.

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.

State Emergency Management Committee 2009, State emergency management policy no. 2.4: *District emergency management arrangements,* as amended 12 April 2010, Government of Western Australia, Perth, available https://www.semc.wa.gov.au/policyandlegislation/policiesandplans/Administration/SEMP_2.4_-_District_Emergency_Management.pdf.

Water Corporation 2009, *SG097 Source protection operations manual*, unpublished corporate manual, Water Corporation, Leederville.

Water and Rivers Commission 1999, *Badgingarra Water Reserve water source protection plan*, Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/10106.pdf.

Western Australian Planning Commission 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, available www.planning.wa.gov.au.

Further reading

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) & Australian and New Zealand Environment and Conservation Council (ANZECC) 2000, *Rural land uses and water quality – A community resource document*, ARMCANZ & ANZECC, Canberra, available http://www.environment.gov.au/resource/rural-land-uses-and-water-quality-community-resource-document.

Board M (MLA Member for Jandakot and Chairman of the Select Committee) 1994, *The Select Committee on Metropolitan Development and Groundwater Supplies – Report*, Legislative Assembly, Perth, Western Australia.

Department of Water & Department of Health 2008, *Risks from pathogenic micro-organisms in public drinking water source areas*, Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/82068.pdf.

Department of Water 2011, *Living and working in public drinking water source areas,* Government of Western Australia, Perth, available http://www.water.wa.gov.au/PublicationStore/first/97368.pdf.

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

- 2004, WQPN no. 25: *Land use compatibility in public drinking water source areas*
- 2009, WQPN no. 36: *Protecting public drinking water source areas*.

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

National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2004, W*ater made clear – A consumer guide to accompany the Australian drinking water guidelines 2004,* Australian Government, Canberra, available http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh33.pdf.

Sharp Hon C (MLC and Chairman of the Standing Committee) 2000, *Report of the Standing Committee on Ecologically Sustainable Development in relation to the quality of Perth's water supply*, Legislative Council, Perth, Western Australia, available www.parliament.wa.gov.au.

Standing Committee on Public Administration, 2010, *Report 11: Recreation activities within public drinking water source areas,* Legislative Council, Perth, available www.parliament.wa.gov.au.

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 www.planning.wa.gov.au.

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

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