Government of **Western Australia**
Department of **Water and Environmental Regulation**

Bunbury East Water Reserve

drinking water source protection plan

Bunbury town water supply

Water resource protection series
Report WRP 190
September 2019

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Cover photograph: Aerial photo of Bunbury

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Summary

This is the first drinking water source protection plan for the Bunbury East Water Reserve. It establishes a water reserve to protect two bores which form part of Aqwest's drinking water supply scheme for Bunbury, located 160 km south of Perth (Figure A1). The plan assesses risks to water quality surrounding these bores and recommends strategies to address the risks to ensure a safe, reliable, good-quality and affordable drinking water supply for Bunbury now and in the future.

Bunbury's drinking water comes from a scheme of bores spread across the Bunbury area. These bores draw water from a deep aquifer called the Yarragadee. The Yarragadee aquifer is generally confined by a layer of rock. However, immediately south of Bunbury that layer of rock is absent, creating an unconfined area of the aquifer. The *Bunbury Water Reserve drinking water source protection plan* (DoW 2008) protects the drinking water bores that draw water from this unconfined area (Figure A1).

This 2019 plan protects two bores to the east of the Bunbury Water Reserve that are not included in the *Bunbury Water Reserve drinking water source protection plan* (DoW 2008). Unlike the bores within the Bunbury Water Reserve, these two bores are located in a confined area of the Yarragadee aquifer (Figure A2). The confining layer above the aquifer here is largely impermeable and protects it from surface contamination that might be caused by surrounding land uses. The bores are screened for abstraction between 150 and 180 m (Robertson 3) and 400 and 450 m (Glen Iris 1).

These bores are located on freehold land owned by Aqwest, within compounds that contain the bores and associated drinking water treatment plants (Figure A4).Given that the bores are drawing water from a confined aquifer, the department has determined that establishing a small boundary, called the Bunbury East Water Reserve, over the compounds will be an appropriate level of protection for these bores.

The main outcomes of this plan are to:

- Constitute the Bunbury East Water Reserve under the *Country Areas Water Supply Act 1947* to allow by-laws to be applied that protect it as a source of drinking water.
- Assign a priority 1 (P1) area over the water reserve, to apply a management outcome of 'risk avoidance'.
- Include the water reserve boundary in the City of Bunbury's local planning scheme.
- Delegate by-law enforcement and surveillance of the water reserve to Aqwest.

This plan helps implement the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011), State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) and Strategic policy: *Protecting public drinking water source areas in Western Australia* (DoW 2016a).

The Department of Water and Environmental Regulation prepared this document in consultation with key stakeholders:

- Aqwest
- City of Bunbury
- Department of Health
- Department of Planning, Lands and Heritage.

Important information about the Bunbury East Water Reserve is shown in Table 1.

Table 1 Key information about the Bunbury East Water Reserve

Bunbury East Water Reserve	
Local government	City of Bunbury
Location supplied	Bunbury
Number of services supplied	Approximately 17 000 are supplied by bores from the Bunbury East Water Reserve and the Bunbury Water Reserve combined
Water service provider	Aqwest
Aquifer name and type	Yarragadee aquifer – confined
Licence to take water	7 600 000 kL per year, issued under the *Rights in Water and Irrigation Act 1914* (Licence no. 150896). This licence covers Aqwest bores within the Bunbury East Water Reserve and Bunbury Water Reserve
Number of bores	2
Bore locations	Glen Iris 1 (E 377 811, N 6 309 538, zone 50) Robertson 3 (E 376 023, N 6 308 196, zone 50)
Date of bore completion	Glen Iris 1: 2009 Robertson 3: 2003
Bore screen depths (m below ground level)	Glen Iris 1: 404–441 m, 444–453 m Robertson 3: 152–182 m
Bore compounds	Bores are located in separate fenced compounds on freehold land owned by Aqwest of the following sizes: • Glen Iris 1: approximately 19 000 m^2 • Robertson 3: approximately 3 000 m^2
Date of drinking water source protection reports	2019 – *Bunbury East Water Reserve drinking water source protection review* (this document)
Consultation	2019 – government agency and water service provider consultation
Gazettal status	Proposed to be constituted under the *Country Areas Water Supply Act 1947* after this report is published

Bunbury East Water Reserve	
Reference documents	*Australian drinking water guidelines* (NHMRC & NRMMC 2011) State planning policy no. 2.7: *Public drinking water source policy* (WAPC 2003) *Bunbury Water Reserve drinking water source protection plan* (DoW 2008) *South West groundwater areas allocation plan* (DoW 2009) *South West groundwater areas allocation plan: Evaluation statement 2009–2012* (DoW 2013) *South West groundwater areas allocation plan: Evaluation statement 2012–2015* (DoW 2015)

1 Overview

1.1 The drinking water supply system

Bunbury's drinking water is abstracted from the Yarragadee aquifer by a scheme of 13 bores that supply water to six Aqwest water treatment plants located across the city.

Two of those bores, Glen Iris 1 and Robertson 3, occur to the east and outside of the existing Bunbury Water Reserve and are proposed to be protected by this new Bunbury East Water Reserve. Unlike the Bunbury Water Reserve, which covers an unconfined area of the Yarragadee aquifer, the two Bunbury East Water Reserve bores draw water from a confined area of the aquifer (Figure A1). This means that the drinking water source here is protected by a confining layer from contamination via surrounding land uses.

Both bores are contained within individual compounds adjacent to water treatment plants. Robertson 3 is screened for abstraction between about 150 and 180 m while Glen Iris 1 is screened between about 400 and 450 m.

Robertson 3 has supplied drinking water to Bunbury since 2004. Glen Iris 1 was drilled in 2009 and is expected to be commissioned in the next 12 months.

Water drawn from Robertson 3 is treated to reduce naturally occurring iron concentrations and chlorinated to disinfect the water before being distributed to the Bunbury scheme.

Public drinking water source area (PDWSA) management is the first step in protecting water quality and ensuring a safe drinking water supply. Although treatment and disinfection are essential barriers against contamination, catchment protection is the most important barrier, as advocated by the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011). The ADWG is based on preventing risks and installing multiple barriers for providing safe drinking water to consumers. This combination of catchment protection and water treatment delivers a more reliable, safer and lower-cost drinking water to consumers than either approach could achieve individually.

For more information about how PDWSAs are protected in WA, read Appendix E. For more information about our preventive risk management approach, read Appendix F.

1.2 Water management

Licence to take water

Water resource use and conservation in WA is administered by the Department of Water and Environmental Regulation in accordance with the *Rights in Water and Irrigation Act 1914*. Under this act, the right to use and control water is vested with the Crown. This means that a licence is required for drilling bores and abstracting groundwater (pumping water from a bore, spring or soak) within proclaimed

groundwater areas throughout the state. Some exemptions apply such as abstracting water for domestic purposes only.

The Bunbury East Water Reserve is located within the Bunbury Groundwater Area (and the Bunbury-Yarragadee subarea) which is proclaimed under the *Rights in Water and Irrigation Act 1914*. Aqwest is licensed by the department to abstract a total of 7.6 ML of water from the Yarragadee aquifer each year for public water supply. This allocation covers bores in the Bunbury Water Reserve and Bunbury East Water Reserve.

Total annual abstraction for Bunbury's drinking water has averaged about 6.6 ML per year over the past five years. About 1.7 ML per year, or over 25 per cent of Bunbury's drinking water, has been abstracted by Robertson 3.

Future water needs

The department has consulted with Water Corporation, Aqwest and Busselton Water to complete water supply plans that project scheme demand and identify supply options for towns and cities in the south-west region over the next 50 years. Sufficient water is reserved to meet this demand from a number of groundwater sources across the region (DoW 2015).

Annual abstraction under Aqwest's groundwater licence 150896 has declined by about 2 per cent each year since 2014–15 to about 84 per cent of the total annual allocation of 7.6 ML. An increase in Aqwest's allocation is not expected to be required in the short term.

To help manage the risk of salt-water intrusion, water abstracted by Glen Iris 1 will replace some of the current abstraction from bores near the sensitive coastal freshwater–seawater interface within the Bunbury Water Reserve (Aqwest 2018).

1.3 Characteristics of the catchment

Physical environment

The Bunbury East Water Reserve is located about 5 km inland from the coast on the Swan Coastal Plain. Robertson 3 is within a commercial/light industrial area in Davenport while Glen Iris 1 is surrounded by an urban residential area and future service/commercial area in Glen Iris (Figure A3).

Both Glen Iris 1 and Robertson 3 are within Aqwest compounds containing the bore, water treatment plant and associated infrastructure (figures C1 and C3).

Climate

Bunbury has a Mediterranean-type climate with cool, wet winters and warm, dry summers. The average annual rainfall in Bunbury is - about 725 mm. Average winter temperatures typically range from about 7–18^{o}C, while average summer temperatures typically range from about 15–29^{o}C (Bureau of Meteorology 2019).

Hydrogeology

In the Bunbury region the Yarragadee aquifer is typically overlain by superficial formations and the Leederville formation. Bunbury basalt generally separates the Leederville from the deeper Yarragadee formation. The Yarragadee aquifer is confined by this layer of basalt, except along the coast south of Bunbury where the Leederville aquifer and Bunbury basalt are absent (Figure A1). The Bunbury Water Reserve covers the majority of the unconfined area of the Yarragadee aquifer.

Glen Iris 1 and Robertson 3 draw water from the Yarragadee aquifer east of Bunbury where it is confined by Bunbury basalt.

The Yarragadee aquifer is recharged by direct infiltration of rainfall where it outcrops in areas of the Blackwood Plateau around Nannup. Regional groundwater flow is north-west, becoming more westerly closer to Bunbury. (DoW 2009)

1.4 How is this drinking water source currently protected?

The Bunbury East Water Reserve is not yet constituted under the *Country Areas Water Supply Act 1947*. Once this plan is published, the department will arrange for this to happen so that it can be protected (see recommendation 1).

The proposed water reserve covers land owned by Aqwest. The bores and water treatment plants are contained in fenced, locked compounds to deter unauthorised access and vandalism (figures C1 and C3). Aqwest employs best management practices for operating and managing the bores, water treatment plants and compounds, including regular site surveillance.

This plan recommends that by-law enforcement is delegated to Aqwest (see recommendation 5). This also includes:

- erecting and maintaining signs (see recommendation 6)
- maintaining security and fencing surrounding the bore compounds
- ongoing regular surveillance and inspections.

1.5 Native title claims

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights and interests in lands and water.

The Bunbury East Water Reserve lies within the Gnaala Karla Booja claim area.

The State Government of Western Australia and the Noongar native title claimants have negotiated a South West Native Title Settlement. The settlement recognises the Noongar people as the traditional owners of land in the South West Settlement Area, which includes the Bunbury East Water Reserve (see Figure A6).

The settlement includes six identical Indigenous Land Use Agreements (ILUAs). The agreements enable some types of land-based customary activities to be undertaken by Noongar people in PDWSAs within the South West Settlement Area. On 8 June

2016, we amended two sets of by-laws (Metropolitan Water Supply, Sewerage and Drainage By-laws 1981 and the Country Areas Water Supply By-laws 1957) to enable Noongar people to undertake some of these land-based activities.

The ILUAs are available via the Department of Premier and Cabinet, see www.dpc.wa.gov.au. Refer to Water quality information sheet 39: *Aboriginal customary activities in public drinking water source areas in the South West Native Title Settlement Area* (DoW 2017).

DWER 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.

Typically, PDWSAs in the South West occur over land that would be subject to the South West Native Title Settlement. In this case, the Bunbury East Water Reserve covers freehold land only and as such its constitution will not impact on the South West Native Title Settlement.

2 Contamination risks in this drinking water source

2.1 Water quality

Aqwest regularly monitors the quality of raw water from Bunbury bores for microbiological, health-related and aesthetic (non-health-related) characteristics. This data indicates the quality of water in the PDWSA. An assessment of the drinking water quality once treated is also made against the ADWG. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water, chaired by the Department of Health.

Water supplied from Robertson 3 is of very high quality. Naturally occurring iron in raw water from Robertson 3 exceeds the aesthetic guidelines. However, treatment reduces iron concentrations before supply to consumers. All other parameters are within aesthetic and health-related guidelines. A water-quality summary for Robertson 3 is presented in Appendix B.

Water quality monitoring data for Glen Iris 1 will be available once the bore is commissioned.

It is important to appreciate that this raw-water data 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 and provision of safe drinking water to consumers.

2.2 Land uses and activities

The Bunbury East Water Reserve covers two compounds on freehold land owned by Aqwest. The compounds each contain a single production bore, water treatment facilities and storage tanks.

As bores Glen Iris 1 and Robertson 3 draw water from a confined aquifer there is little potential for contamination from surrounding land uses. This is because the source is adequately protected from surface contamination by the considerable depth to the groundwater and the presence of a confining layer of rock (Bunbury basalt) that sits above the groundwater. This confining layer acts as a barrier to any potential contamination.

The bores are constructed and sealed to prevent intrusion of any potentially contaminated surface waters into the bores (figures C2 and C4).

For more information on typical contamination risks in groundwater sources, read Appendix D.

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 DWER'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). It is important that GIS coordinates for all bores are recorded correctly, to ensure proper assessment of the risk to drinking water bores.

There are three licensed users of the Yarragadee aquifer near Robertson 3 and no licensed users near Glen Iris 1.

3 Protecting your drinking water source

The objective of this plan is to protect water quality in the proposed Bunbury East Water Reserve to ensure safe drinking water to consumers.

3.1 Constituting public drinking water source areas

Once this plan is published, the department will arrange to constitute the Bunbury East Water Reserve under the *Country Areas Water Supply Act 1947* to protect the drinking water source (Figure A5 and recommendation 1).

Drinking water sources that are supplied from a confined aquifer, such as this one, only require a boundary that reflects the compound in which the drinking water bores are located. This ensures that the location of this important drinking water supply will be proclaimed and mapped so it is considered in future land use decisions or development of other bores. A larger boundary is not deemed necessary because the source is adequately protected from surface contamination risks by the confining layer of basalt (Figure A2).

The boundary of the Bunbury East Water Reserve has been determined in accordance with our Strategic policy: *Protecting public drinking water source areas in Western Australia* (DoW 2016a).

3.2 Defining priority areas

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

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

The department determines priority areas based on the strategic importance of the land or water source, risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas* (DoW 2016b).

The department will assign all land in the Bunbury East Water Reserve as a P1 area, because all the land within the water reserve is owned by Aqwest. This is in accordance with current department policy (DoW 2016a) (see recommendation 2).

The department's WQPN no.25: *Land use compatibility in public drinking water source areas* (DoW 2016b) outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas.

3.3 Defining protection zones

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

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

WHPZs are not considered necessary for the Bunbury East Water Reserve due to the confined nature of the water source, depth of the bores and the fenced compounds around the bores.

3.4 Planning for future land uses

Appropriate protection mechanisms in statutory land-use planning processes are necessary to secure the long-term protection of drinking water sources.

Once the water reserve is constituted the City of Bunbury should incorporate it into its planning schemes consistent with State planning policy no. 2.7: *Public drinking water source policy*. PDWSAs are commonly shown in planning schemes as special control areas. This will ensure that the Bunbury East Water Reserve is considered when making land use planning decisions (see recommendation 3).

3.5 Using best management practices

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

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and WQPNs. They recommend practices to help managers reduce their impacts upon water quality. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

Education and awareness-raising (such as through providing information on signs and publications) are key mechanisms for protecting water quality, especially for people visiting the area.

3.6 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The City of Bunbury local emergency management committee (LEMC) should be familiar with the location and purpose of the Bunbury East Water Reserve. A locality plan will be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. Aqwest should have an advisory role to the HAZMAT team for incidents in the Bunbury East 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 Bunbury East Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this drinking water source (see recommendation 4).

4 Consultation

4.1 Stakeholder consultation process

The department consulted with the City of Bunbury, Aqwest, Department of Health and Department of Planning, Lands and Heritage to prepare this plan by providing draft copies for their comment.

All issues raised during consultation were addressed during the preparation of this plan.

5 Recommendations

The following recommendations apply to the Bunbury East Water Reserve. The stakeholders listed in brackets are responsible for, or have an interest in, implementing that recommendation.

1. Constitute the boundary of the Bunbury East Water Reserve under the *Country Areas Water Supply Act 1947*. (DWER)
2. Assign a priority 1 (P1) area to the Bunbury East Water Reserve. (DWER)
3. Incorporate the Bunbury East Water Reserve, as per Figure A5, in the City of Bunbury local planning scheme in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*. (City of Bunbury)
4. Ensure incidents covered by Westplan–HAZMAT in the Bunbury East Water Reserve are addressed by checking that:
   - the City of Bunbury local emergency management committee is aware of the location and purpose of the Bunbury East Water Reserve
   - the locality plan for the Bunbury East Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
   - Aqwest acts in an advisory role during incidents in the Bunbury East Water Reserve
   - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Bunbury East Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Aqwest)
5. Investigate delegation of by-law enforcement and surveillance for the Bunbury East Water Reserve to Aqwest. (DWER)
6. Maintain signs on bore compounds advising of the location of public water supply bores, including an emergency contact telephone number. (Aqwest)
7. Continue best management practices for operating and managing the bores, water treatment plants and compounds. (Aqwest)
8. This report will be reviewed in seven years or in response to changes in water quality contamination risks. (DWER)

Appendices

Appendix A – Figures

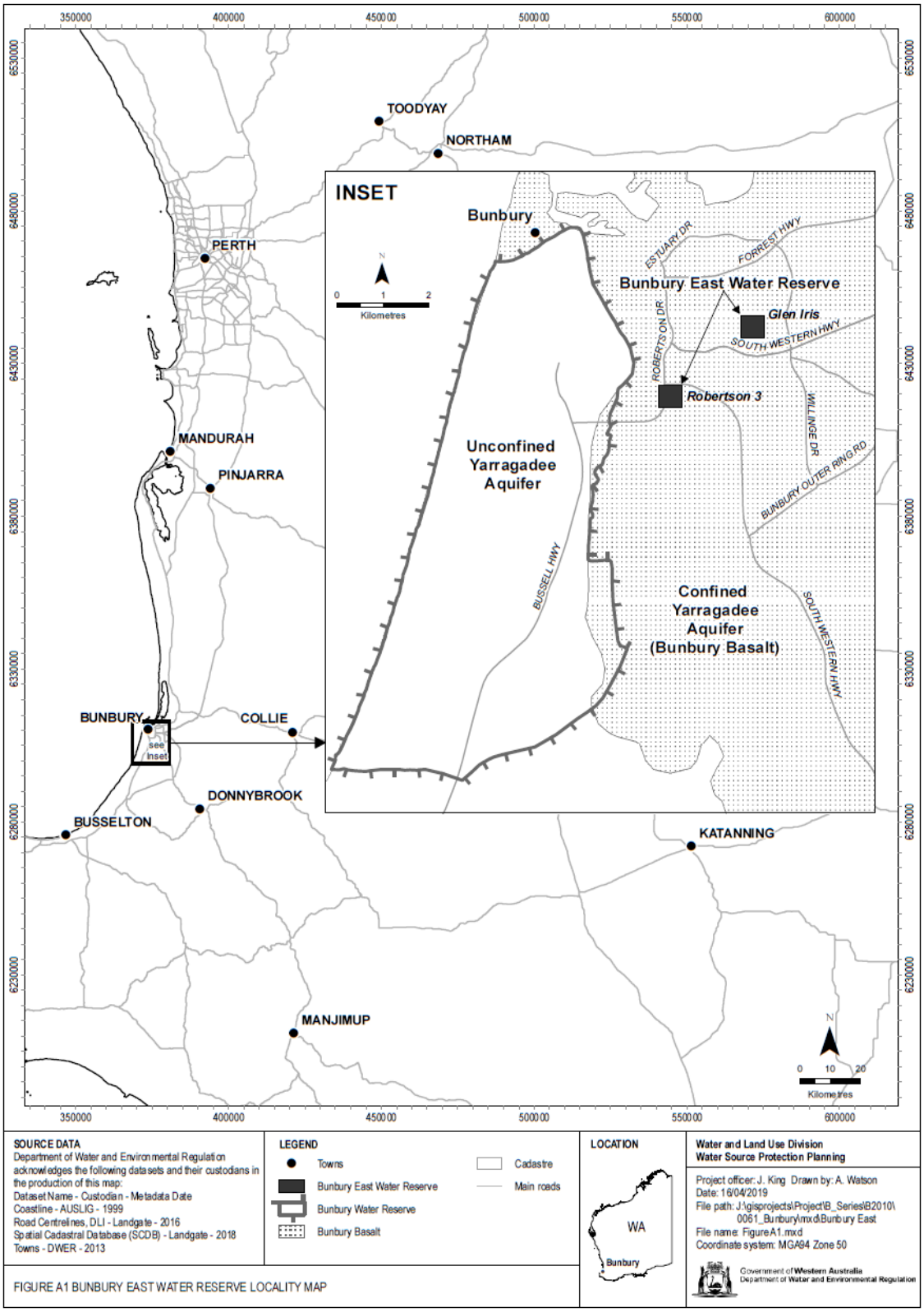

Figure A1 Bunbury East Water Reserve locality map

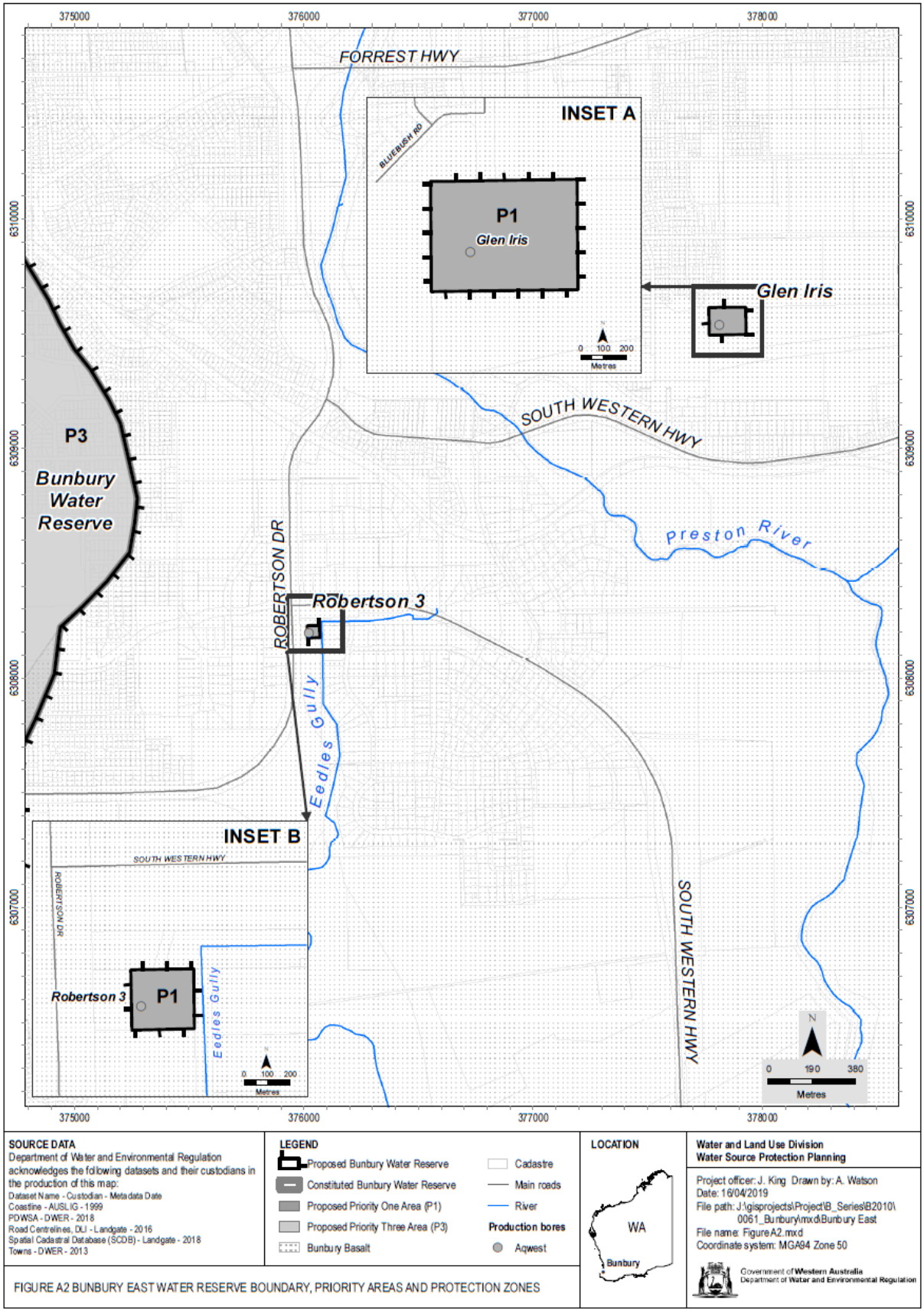

Figure A2 Bunbury East Water Reserve priority areas

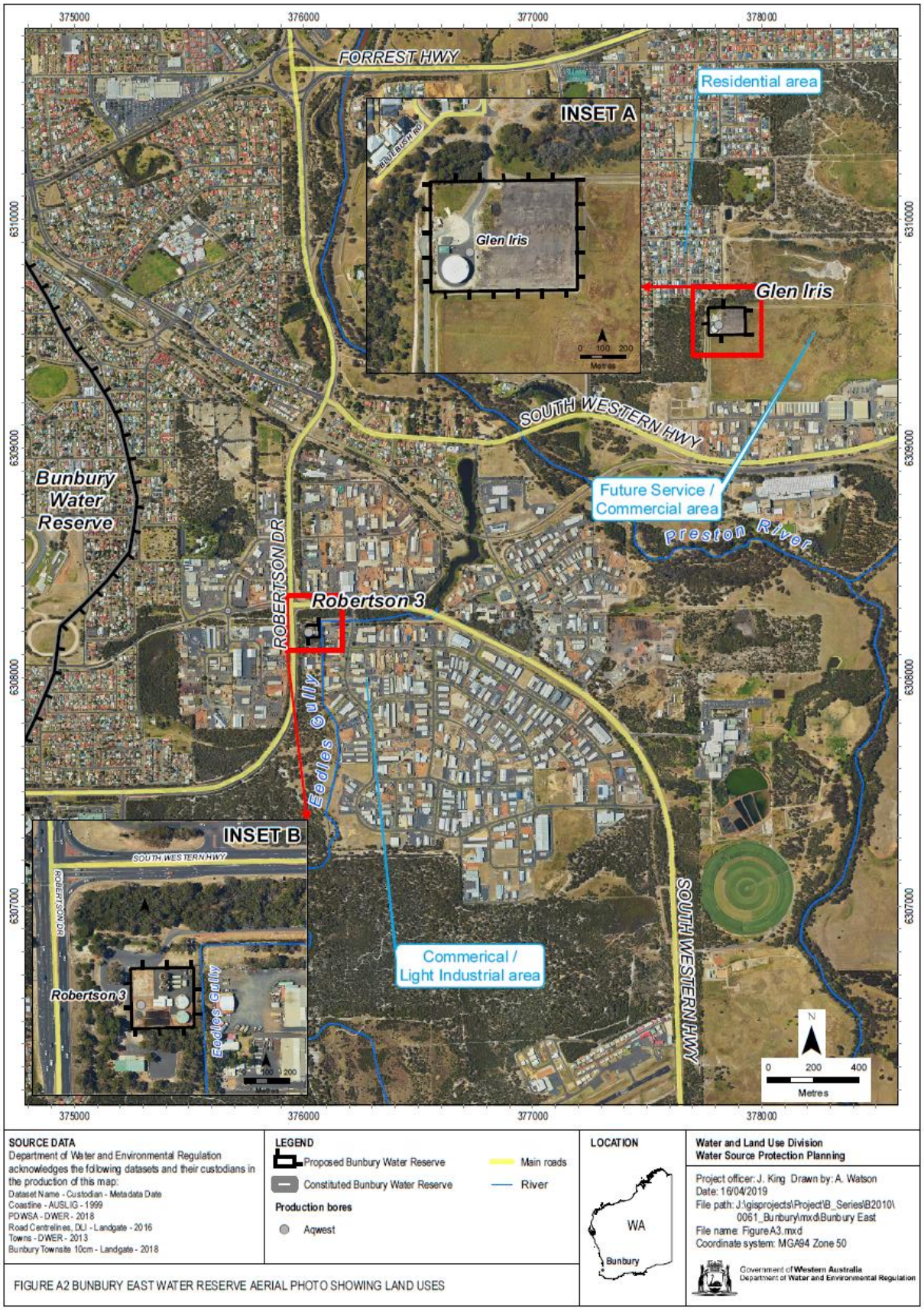

Figure A3 Bunbury East Water Reserve aerial photo showing land uses

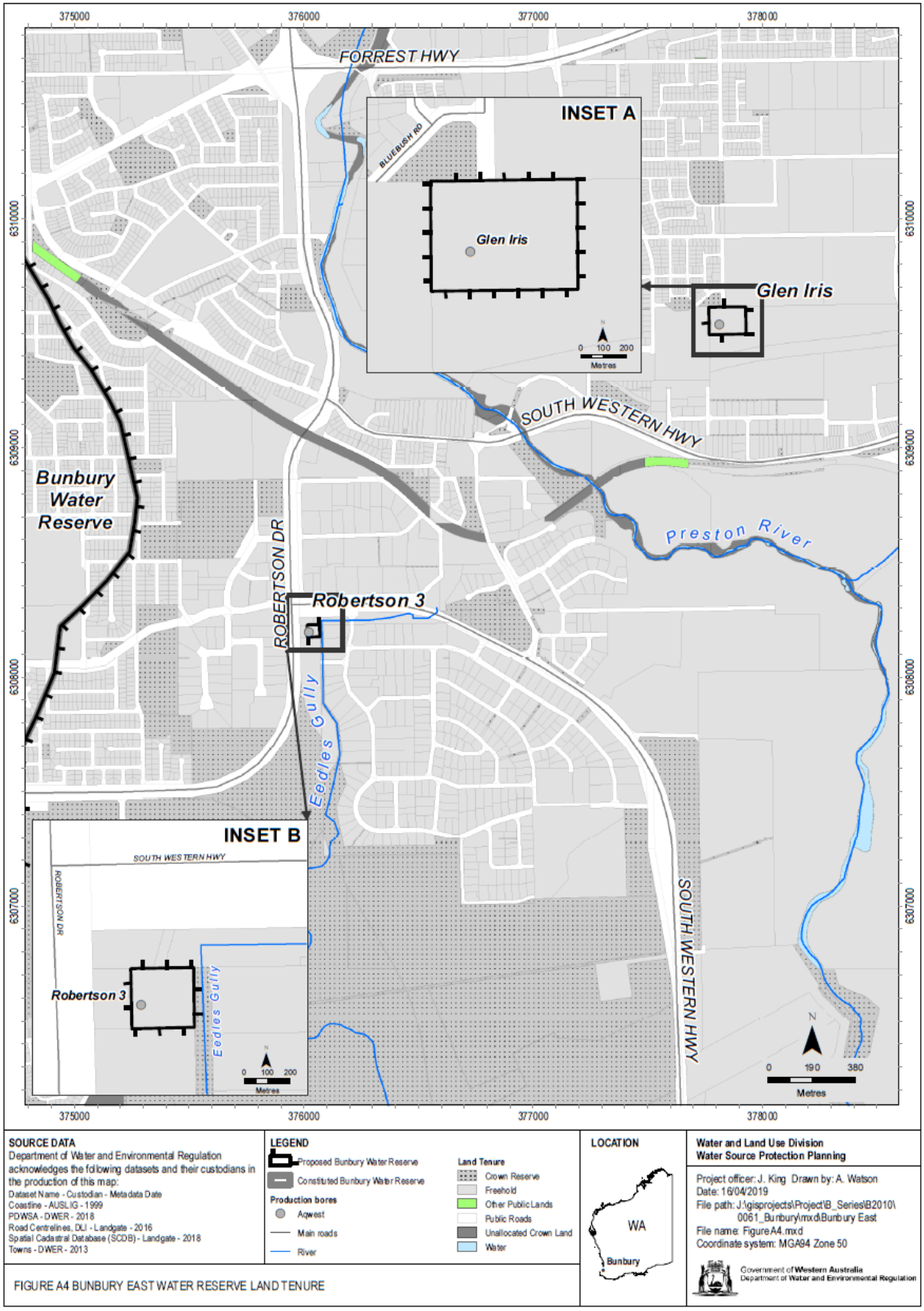

Figure A4 Bunbury East Water Reserve land tenure

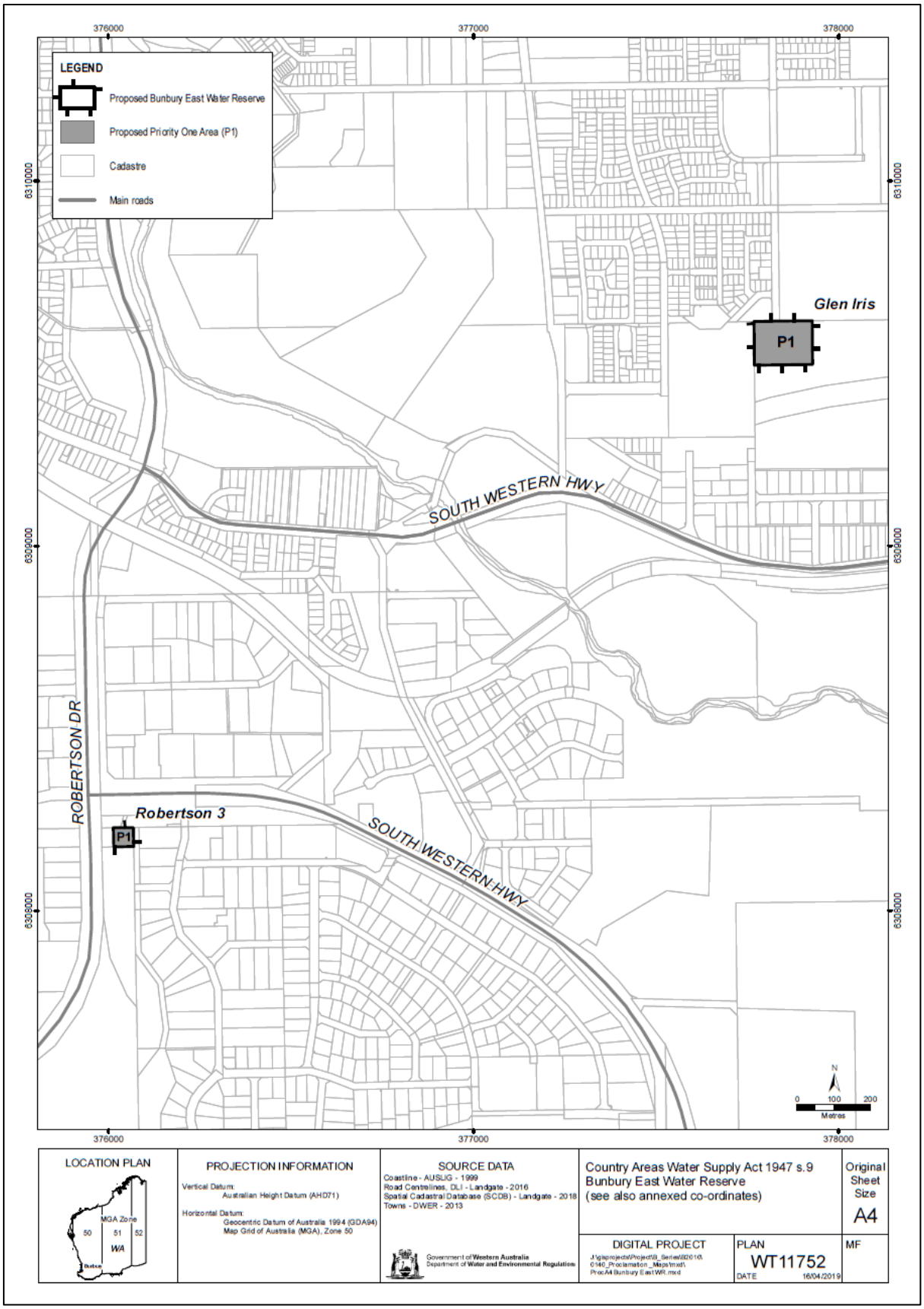

Figure A5 Proposed Bunbury East Water Reserve

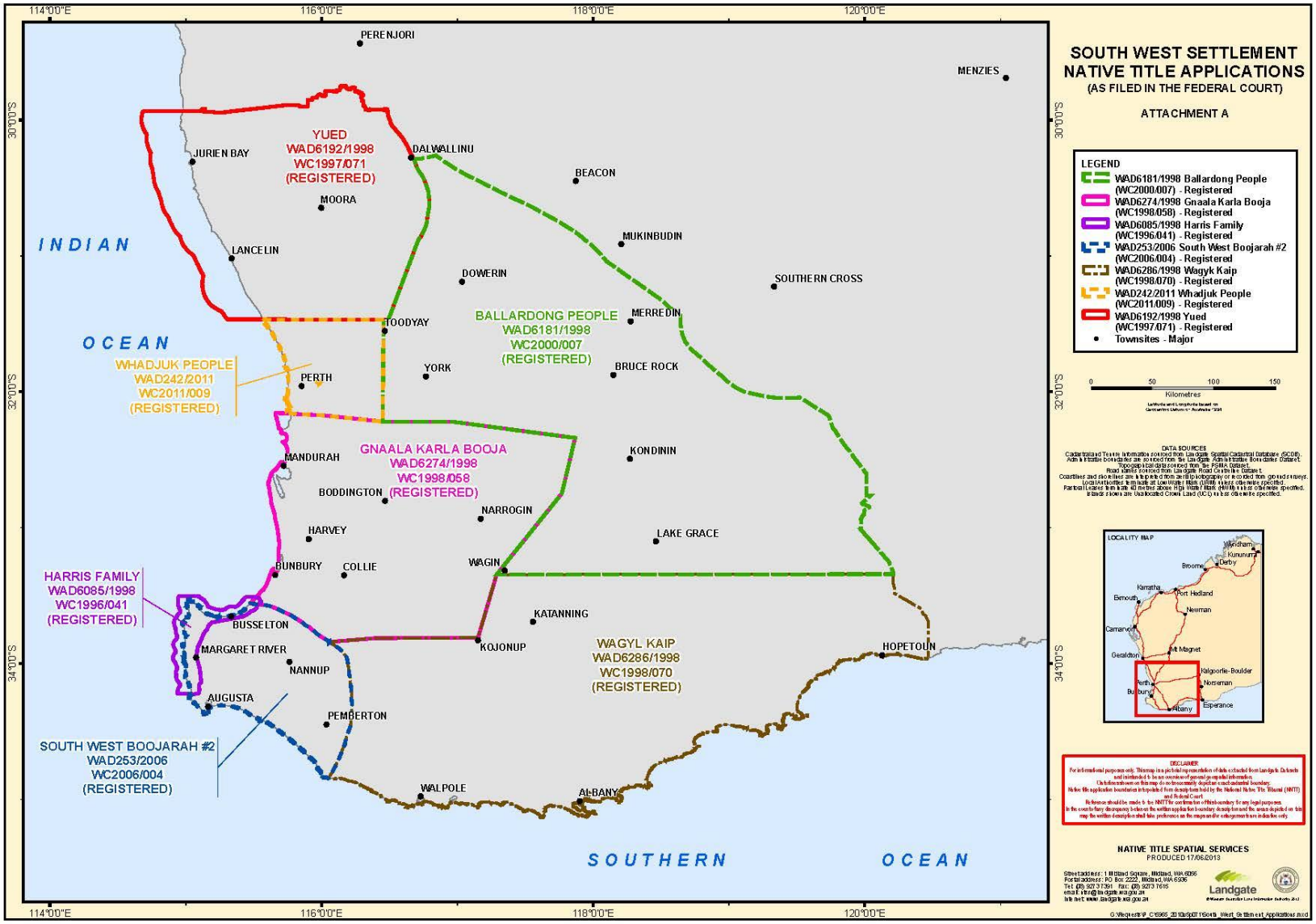

Figure A6 South West Native Title Agreement area (source: Department of Premier and Cabinet)

Appendix B – Water quality data

The information provided in this appendix has been supplied by Aqwest.

Aqwest has monitored the raw (source) water quality from Bunbury in accordance with the requirements of the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011) 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 Robertson 3. Water quality monitoring for Glen Iris 1 will be available once the bore is commissioned. 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 sampling during April 2018.

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.

Aesthetic characteristics

The aesthetic quality analyses for raw water from Robertson 3 are presented in the following table.

Table B1 Aesthetic detections for Robertson 3

Parameter	Units	ADWG aesthetic guideline value[1]	Robertson 3
Aluminium	mg/L	0.2	<0.005
Ammonia	mg/L	0.5	0.085
Chloride	mg/L	250	86
Hardness as $CaCO_3$	mg/L	200	90
Iron unfiltered	mg/L	0.3	***1.3***

Parameter	Units	ADWG aesthetic guideline value[1]	Robertson 3
Manganese	mg/L	0.1	0.08
pH measured in laboratory	no units	6.5–8.5	7.2
Sodium	mg/L	180	53
Sulfate	mg/L	250	14
TDS	mg/L	600	255

[1] 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 Robertson 3 is analysed for chemicals that are potentially 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.

Table B2 Health-related detections for Robertson 3

Parameter	Units	ADWG health guideline value[2]	Robertson 3
Boron	mg/L	4	0.06
Fluoride	mg/L	1.5	0.2
Manganese	mg/L	0.5	0.08
Nitrate	mg/L	50	<0.05

[2] 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 2011).

Microbiological contaminants

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.

There were no detections of *E. coli* in samples from 2017-18.

Appendix C – Photographs

Figure C1 Glen Iris 1 bore compound and water treatment plant

Figure C2 Glen Iris 1 unequipped production bore (between yellow posts)

Figure C3 Robertson 3 bore compound and water treatment plant

Figure C4 Robertson 3 production bore

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 the soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of reliable, 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 microorganisms that are undetectable by sight, taste or smell (NHMRC & NRMMC 2011). Contaminants can also interfere with water treatment processes and damage infrastructure.

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 *Escherichia 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 on to soil particles, making them 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 and from septic systems and 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 an approach based on preventive risk and multiple barriers. 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 supply to your home.

An approach based on preventive risk 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 risk-based approach is often suggested as a way to address risks to water quality in a public drinking water source area (PDWSA; the area from which water is captured to supply drinking water). However, a risk-based approach is not the same as an approach based on preventive risk. A risk-based approach is inadequate for addressing risks to public health, and is not recommended by the ADWG.

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 PDWSA. If we get this barrier right, it has a flow-on effect that can result in a lower-cost, 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.

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 report is important. We should not forget that ultimately it is about safeguarding your health by protecting water quality now and for the future.

An additional benefit from PDWSA protection is that it complements the state's conservation initiatives.

In Western Australia, the Department of Water and Environmental Regulation (DWER) 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 2 and 3 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 legislative tools to protect water quality for PDWSAs. These Acts and the associated by-laws 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 PDWSAs.

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. Our Strategic policy: *Protecting public drinking water source areas in Western Australia* (DoW 2016a) describes how we do this. It is available at www.dwer.wa.gov.au.

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.

Our Water quality protection note (WQPN) no. 25: *Land use compatibility tables for public drinking water source areas* (DoW 2016b) outlines appropriate development and activities within each of the priority areas (P1, P2 and P3).

With more than 120 constituted 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 DWER) 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 www.dwer.wa.gov.au and read our Strategic policy:

Protecting public drinking water source areas in Western Australia (DoW 2016a). You can also contact DWER's Water source protection planning section on +61 8 6364 7600 or email drinkingwater@dwer.wa.gov.au.

Table E1 Drinking water source protection reports produced by DWER

Drinking water source protection report	Scope and outcome	Consultation	Time to prepare	Implementation table	Gazettal
Drinking water source protection assessment (DWSPA)	Desktop assessment of readily available information	Preliminary	Up to 3 months	No	Arrange for the constitution and gazettal of the source under legislation. This helps protect water quality and guides land use planning. All types of consulted drinking water source protection reports can recommend to constitute a source's boundary under legislation.
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 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 risk-assessment process based on preventing risk 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, we use an assessment based on preventing risks, which considers both the maximum risk (before installing barriers) and the residual risk (after installing barriers). This means that in some cases, the maximum risks from land uses will still be considered unacceptable, even after mitigation (installing barriers) has reduced the risk. We need this more conservative approach to protect the health of consumers; those that are drinking the water.

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).

Table F1 Risk matrix: Level of risk (NHRMC & NRMMC 2011)

Likelihood	**Consequence**				
	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. This is 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
DoW	Department of Water (former)
DWER	Department of Water and Environmental Regulation
HAZMAT	hazardous materials
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
P1, P2, P3	priority 1, priority 2, priority 3
PDWSA	public drinking water source area
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

km	kilometres	A measure of distance, 1 km equals 1000 m.
m	Metres	A measure of distance.
mg/L	milligrams per litre	A measure of concentration of a substance in a solution.
pH		A logarithmic scale for expressing the acidity or alkalinity of a solution; a pH below 7 indicates an acidic solution and above 7 indicates an alkaline solution.

TDS	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 micrometre filter membrane can also contribute to TDS. TDS comprises sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMMC 2011).

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.
Advisory Committee for the Purity of Water	A non-statutory interdepartmental committee chaired by the Department of Health providing advice to the Ministers for Health and Water on drinking water quality.
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 year (kL/y).
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* (ADWG; NHMRC & NRMMC 2011) outlines acceptable criteria for the quality of drinking water in Australia (see *References*).
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 (also see *wellfield*).
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Catchment area	An area constituted 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.
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.
Constitute	Define the boundaries of any catchment area or water reserve by Order in Council under the *Country Areas Water Supply Act 1947* or by proclamation under *the Metropolitan Water Supply, Sewerage and Drainage Act 1909*.

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.
Gazette	Publication within the Government Gazette of Western Australia of the Order in Council or proclamation defining the boundaries of any catchment area or water reserve.
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.
Hydrogeology	The branch of geology that deals with the occurrence, distribution and effects of groundwater. It is 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.
Maximum risk	This is the level of risk in the absence of any preventive measures (barriers) being installed in the system, or assuming that preventive measures have failed. Assessing maximum risk is useful for identifying high-priority risks, determining where attention should be focused and preparing for emergencies (NHRMC & NRMMC 2011).
Microbe	A microorganism, usually one of vegetable nature, a germ. Also known as a bacterium, especially one causing illness.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.

Order in Council	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a catchment area or water reserve under section 9 of the *Country Areas Water Supply Act 1947.*
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.
Proclamation	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a water reserve, catchment area or underground water pollution control area under section 13 and 57A of the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909.*
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*.
Priority 1, 2 and 3	Three different priority areas are assigned within PDWSAs to guide land-use decisions. The objective of priority 1 (P1) areas is *risk avoidance*, priority 2 (P2) areas is *risk minimisation* and priority 3 (P3) areas is *risk management*.
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.
Residual risk	This is the level of risk after considering preventive measures (barriers) that are applied in the drinking water supply system, such as fencing to keep cattle away from drinking water bores, or surveillance to identify people accessing protected areas. Residual risk provides an indication of how effective preventive strategies are, or the need for additional preventive measures (NHRMC & NRMMC 2011).
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.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
Superficial aquifer	Shallow (near to the surface) aquifers which are easily recharged and can be readily accessed by bores.
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 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 constituted 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.
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

Aqwest 2018, *Annual report 2018*, Aqwest, Bunbury, available at www.aqwest.com.au.

Bureau of Meteorology 2019, *Climate data – Bunbury*, accessed 11 April 2019, www.bom.gov.au.

Department of Water 2008, *Bunbury Water Reserve drinking water source protection plan*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

— 2009, *South West groundwater areas allocation plan*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

— 2013, *South West groundwater areas allocation plan: Evaluation statement 2009-2012*, Government of Western Australia , Perth, available www.dwer.wa.gov.au.

— 2015, *South West groundwater areas allocation plan: Evaluation statement 2012-2015*, Government of Western Australia , Perth, available www.dwer.wa.gov.au.

— 2016a, Strategic policy: *Protecting public drinking water source areas in Western Australia*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

— 2016b, Water quality protection note 25: *Land use compatibility tables for public drinking water source area*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

— 2017, Water quality information sheet 39: *Aboriginal customary activities in public drinking water source areas in the South West Native Title Settlement Area,* Government of Western Australia, Perth, available www.dwer.wa.gov.au.

Government of Western Australia 1914, *Rights in Water and Irrigation Act*, State Law Publisher, Perth, available www.legislation.wa.gov.au.

— 1947, *Country Areas Water Supply Act*, State Law Publisher, Perth, available www.legislation.wa.gov.au.

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 www.nhmrc.gov.au.

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.dwer.wa.gov.au.

Western Australian Planning Commission 2003, State planning policy no. 2.7: *Public drinking water source policy*, 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/.

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 microorganisms in public drinking water source areas*, Government of Western Australia, Perth, available www.dwer.wa.gov.au.

Department of Water 2011, *Living and working in public drinking water source areas,* Government of Western Australia, Perth, available www.dwer.wa.gov.au.

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*, State Law Publisher, Perth, available www.slp.wa.gov.au.

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,* Australian Government, Canberra, available www.nhmrc.gov.au.

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. 143–78.

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.

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 www.semc.wa.gov.au.

Western Australian Planning Commission 2006, State planning policy no. 2.9: *Water resources*, Government of Western Australia, Perth, available www.planning.wa.gov.au.

World Health Organization 2011, *Guidelines for drinking-water quality*, 4th edn, World Health Organization, Geneva, www.who.int.

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