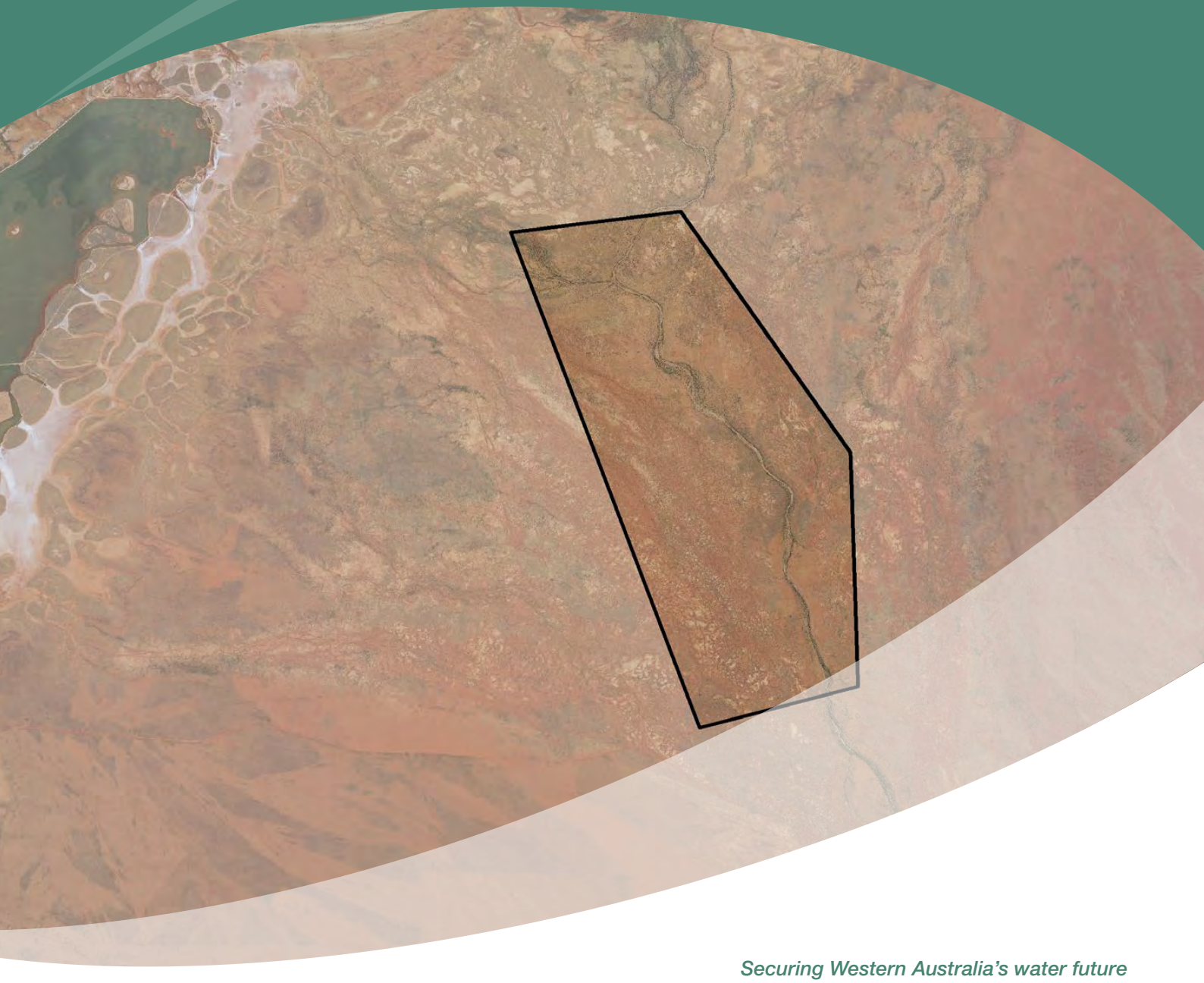
Government of **Western Australia**
Department of **Water**

Cane River Water Reserve

Drinking water source protection review

Onslow town water supply



Securing Western Australia's water future

Water resource protection series
Report WRP 163
December 2016

Cane River Water Reserve drinking water source protection review

Onslow town water supply

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Department of Water

Water resource protection series

Report no. WRP 163

December 2016

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Cover photograph: Aerial photo of Cane River Water Reserve

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 Cane River Water Reserve since completion of the *Cane River Water Reserve water source protection plan* (Water and Rivers Commission 1999). The plan still contains relevant information, so it is important that these documents are read in conjunction. Both are available on our website or by contacting us.

The Cane River Water Reserve supplies drinking water to the town of Onslow. Onslow is a small fishing and tourist town on the Western Australian coast in the Shire of Ashburton. It is around 300 km by road south-west of Karratha. There are 667 people in the suburb of Onslow (Australian Bureau of Statistics 2011).

The Cane River Water Reserve is within a pastoral station, 30 km east of Onslow. There are 19 production bores in the water reserve on the banks of the Cane River, which draw water from an unconfined alluvial aquifer.

We prepared this document in consultation with key stakeholders including the Water Corporation, Shire of Ashburton and Peedamulla Station.

The main changes since the 1999 plan are:

- some old production bores have been decommissioned
- there are a number of new production bores
- wellhead protection zones with a 500 m radius are proposed for all the current production bores.

This review is consistent with 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* (Department of Water 2016a).

Important information about the Cane River Water Reserve is shown in Table 1.

Table 1 Key information about the Cane River Water Reserve

Cane River Water Reserve	
Local government authority	Shire of Ashburton
Location supplied	Onslow
Water service provider	Water Corporation
Aquifer type	Unconfined alluvial
Licensed abstraction	550 000 kL per year (expires November 2025)
Number of bores	19

Cane River Water Reserve	
Bore names and GPS coordinates	1. 1/69 (E 331 093, N 7 601 189, zone 50) 2. 2 (E 330 543, N 7 602 137, zone 50) 3. 8/79 (E 330 651, N 7 602 791, zone 50) 4. 13/94 (E 331 970, N 7 601 008, zone 50) 5. 15/94 (E 331 859, N 7 599 572, zone 50) 6. 4/82 (E 331 993, N 7 600 871, zone 50) 7. 5/82 (E 332 112, N 7 600 653, zone 50) – solar-powered 8. 31/88 (E 331 471, N 7 600 423, zone 50) 9. 32/88 (E 330 999, N 7 600 024, zone 50) 10. 4/97 (E 330 648, N 7 601 887, zone 50) 11. 5/97 (E 330 801, N 7 601 611, zone 50) 12. 16/97 (E 331 652, N 7 599 930, zone 50) – solar-powered 13. 1/09 (E 330 817, N 7 602 010, zone 50) 14. 2/09 (E 332 150, N 7 600 497, zone 50) 15. 3/09 (E 333 201, N 7 598 238, zone 50) – electric-powered 16. 11/09 (E 331 242, N 7 601 181, zone 50) 17. 2/10 (E 334 474, N 7 598 195, zone 50) – electric-powered 18. 3/10 (E 333 867, N 7 598 672, zone 50) – electric-powered 19. 8/10 (E 332 860, N 7 599 028, zone 50) – electric-powered
Dates of drinking water source protection reports	1999 – *Cane River Water Reserve water source protection plan* 2016 – *Cane River Water Reserve drinking water source protection review* (this document)

Cane River Water Reserve	
Consultation	1999 – public consultation as part of the water source protection plan 2016 – consultation with Water Corporation, Shire of Ashburton and other key stakeholders
Proclamation history	Proclaimed on 16 January 2001 under the *Country Areas Water Supply Act 1947*
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) *Lower Cane groundwater allocation limit report* (Department of Water 2011) *Pilbara groundwater allocation plan* (Department of Water 2013)

1 Review of Onslow's drinking water source protection plan

1.1 Boundary, priority areas and protection zones

The Cane River Water Reserve was originally proclaimed in 1994 under the *Country Areas Water Supply Act 1947*.

The 1999 *Cane River Water Reserve water source protection plan* proposed to expand the water reserve by around 500–1000 m on all sides. It also proposed a further expansion of the boundary to the south by approximately 5.5 km, to include new production bores and to allow for further future development of the bore field. This expanded boundary was proclaimed in 2001 under the *Country Areas Water Supply Act 1947*. The water reserve was assigned a priority 1 (P1) area (Figure 1).

In 2015, the Department of Water conducted an assessment of the Cane River Water Reserve boundary. The assessment concluded that the existing boundary is sufficient to protect the current production bores and did not recommend any changes.

This review proposes wellhead protection zones (WHPZs) with a 500 m radius to be assigned around each of the current 19 production bores. It also recommends removing WHPZs from around decommissioned bores.

The boundary, priority areas and protection zones for this water reserve have been determined in accordance with current departmental policy.

More information about how we protect drinking water sources can be found in Appendix E.

1.2 Update on water supply scheme

There are 19 bores in the Cane River Water Reserve that provide drinking water to the town of Onslow.

The Water Corporation has an allocation licence to take 550 ML per year from the Cane River Water Reserve (Groundwater licence 55612).

Water from the bores is pumped to a collector tank in the bore field, then chlorinated to disinfect the water, to ensure microbiological quality for consumers.

The treated water is pumped into the second storage tank in town and distributed through the town.

The majority of the production bores are diesel-powered, however two are solar-powered (bores 5/82 and 16/97, see Figure C6) and four are electrically powered (bores 3/09, 2/10, 3/10 and 8/10, see Figure C4).

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 an approach based on preventive risk and multiple barriers 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 sites of significance and native title claims

Aboriginal sites of significance are important places with special cultural connections to Aboriginal people. They are important because they link Aboriginal cultural tradition to place, land and people over time. These sites are integral to the lives of Aboriginal people, and are found in urban, rural and remote areas. They are most common near rivers, lakes, swamps, hills and the coast. The *Aboriginal Heritage Act 1972* protects all Aboriginal places and objects that are culturally important to Aboriginal people. It is against the law to disturb a site or to remove artefacts.

There are four Aboriginal sites of significance within the Cane River Water Reserve. These are Cane River (P00755), CR07-01 (24782), CR07-02 (24783) and CR07-03 (24784).

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 application within the Cane River Water Reserve. This is the Thalanyji 2 (WAD104/2010).

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

The Water Corporation operator currently conducts daily inspections of all the production bores. However catchment inspections occur less regularly.

This review recommends that the Water Corporation continue by-law enforcement under the existing delegation arrangement (see section 2.2, recommendation no. 5). This also includes:

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

- maintaining security and fencing surrounding the production bores and treatment compound
- ongoing regular surveillance and inspections.

1.5 Other Department of Water work

1.5.1 Pilbara Regional water plan

In June 2010, the Department of Water published the *Pilbara Regional water plan 2010–2030*. This plan sets the strategic directions for the management and development of the Pilbara region's water resources in a sustainable manner. The plan has a long-term view and identifies priority actions for implementation. It forms the basis for the allocation planning and water supply strategies developed after its release.

1.5.2 Lower Cane groundwater allocation limit report

In 2011, the Department of Water published the *Lower Cane groundwater allocation limit report*. This report outlines the process the Department of Water uses to set the allocation limit and licensing rules for the lower Cane alluvial aquifer. This was required because water demand in the area was thought to be increasing due to the proposed expansion of the offshore oil and gas industry and the associated increase in population.

1.5.3 Pilbara groundwater allocation plan

In October 2013, the Department of Water published the *Pilbara groundwater allocation plan*. The plan outlines how groundwater in the Pilbara, including the Lower Cane alluvial, will be regulated and managed over the next seven years or longer. The plan outlines how proposed management of the area will occur through allocation limits, water licensing and ongoing monitoring and evaluation.

1.5.4 Pilbara regional water supply strategy

In October 2013, the Department of Water published the *Pilbara regional water supply strategy*. The strategy describes water demand and supplies in the region and plans for future water supplies for the Pilbara coastal towns and ports, including Onslow. Section 3.5 of the strategy outlines Onslow's current supplies, water demand, committed water supplies and future water supply options.

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 Onslow's drinking water source, in accordance with the ADWG. Table 2 shows the risks that are new or have changed since the 1999 plan, and also includes risks that are still considered high.

There are many water quality risks that have remained the same since the 1999 *Cane River Water Reserve water source protection plan,* but some changes have actually reduced water quality risks.

The diesel-powered production bores still pose a water quality risk (see Figure C5). To maintain fuel supply to these bores, a fuel truck makes deliveries two or three times per year. The delivery of large quantities of fuel poses a contamination risk from road accidents, spills or leaks.

The newer production bores are either electric or solar-powered (see figures C4 and C6). These pose a lower water quality risk because there is no fuel that could leak or spill and cause contamination to the aquifer.

The 1999 plan identified that the use of herbicides around the production bores to control weeds was a water quality risk. Currently, herbicides are not used around the production bores. Glyphosate is occasionally used by the Water Corporation within the water reserve, however the appropriate use of Glyphsophate is consistent with the Department of Health's, Public sector circular no.88: *Use of herbicides in water catchment areas* (2007).

In 1999, there were some contamination concerns with production bore 16/94. This bore is no longer operational.

The airstrip within the Cane River Water Reserve documented as 'non-operational' in the 1999 plan remains closed.

The fencing and security varies amongst production bores. There are some production bores that are contained within secure compounds, while others are surrounded by a low fence or have no fencing at all. However, regardless of this variation, there has been limited evidence of problems with vandalism.

Flooding can be widespread in the area of the bore field, inundating the floodplain and the main river channel and extending to areas used for cattle grazing. This has the potential to mobilise contaminants associated with activities in these areas and increases the vulnerability of the aquifer to pollution. This is because when the river is flowing there is connectivity between the surface water system and the aquifer. However, the likely effect on bore water quality is low, because flooding will generally dilute concentrations and carry contaminants downstream, away from the bore field.

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.

1.6.1 Recreation

There is some unauthorised recreation occurring in the Cane River Water Reserve, including camping, hunting and off-road driving. People also use the tracks that traverse the Cane River Water Reserve to access crabbing and fishing locations on the coast.

The main water quality risks associated with these activities include pathogen contamination from human access, and spills of hydrocarbons and other chemicals from vehicles.

There are many small access tracks and easy off-road access within the water reserve, but recreation levels are low due to the small population of the area.

To reduce these risks, we recommend that signs are erected at more entry points and along the boundary of the Cane River Water Reserve to advise the public that they are within a public drinking water source area, the activities that are prohibited or regulated and educate them about the risks they are posing by entering it. The signs should include an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage*.

1.6.2 Cattle grazing

The main land use within the Cane River Water Reserve is a pastoral lease (see Figure C2) and many of the associated water quality risks have remained the same since the development of the plan, such as the cattle station, stockyards, watering points and grazing.

Livestock grazing and stockyards pose a risk of nutrient and pathogen contamination to the drinking water source (see Figure C3). Some cattle watering points are near production bores (see Figure C3). This can attract cattle closer to the production bores and poses a risk of pathogen contamination. To reduce these risks, the management of the stockyards should be consistent with the WQPN no. 80: *Stockyards* (Department of Water 2006) and all production bores should be contained within fenced compounds.

If pathogens from cattle are identified as a risk (via water sampling), the Water Corporation may decide to fence its land to prevent cattle from coming near the production bores. Flood-proof fencing, which is able to be removed during periods of flooding and then re-erected when floodwaters subside, may be required.

1.6.3 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).

There are currently no other licensed production bores within or close to the Cane River Water Reserve.

1.6.4 Shale and tight gas

The Cane River Water Reserve is within the Carnarvon basin. The Carnarvon basin is a prospective shale and tight gas area. Therefore any proposals for the extraction of shale or tight gas within the Cane River Water Reserve or within 5 km of any drinking water bore should be referred to the Department of Water for comment. This is consistent with the *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA* (2015a).

Oil or gas exploration and production is to be managed in accordance with government's response to the Legislative Council Standing Committee on Environment and Public Affairs, Report no. 42: *Implications for Western Australia of hydraulic fracturing for unconventional gas* (2015), the *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA* (2015a) and *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach* (2015b).

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]
Pastoral station	Pathogens and nutrients from animal excrement	High	Appropriate construction of production bores and fencing will reduce water quality risks.	WQPN no. 35: *Pastoral activities within rangelands* WQPN no. 80: *Stockyards*
Flooding	Pathogens, turbidity and chemicals	Medium	The Water Corporation manages the risks of flooding with an operating strategy.	*Floodplain Management in Australia* (CSIRO 2000) recommends against the development of flood-prone areas
Unauthorised recreation activities such as: - hunting - camping - off-road driving	Pathogens from human access	Medium	Levels of recreation are low, but are inconsistent with Operational policy no.13: *Recreation within public drinking water source areas on Crown land*.	Operational policy no.13: *Recreation within public drinking water source areas on Crown land* (Department of Water 2012)
Roads and tracks	Hydrocarbons and turbidity	Low	Existing sealed roads are acceptable. Unsealed roads need to be managed to control access.	WQPN no. 44: *Roads near sensitive water resources*

[1] Water quality protection notes (WQPNs) are available www.water.wa.gov.au.

1.7 Water quality information

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

No water quality parameters exceeded the ADWG during the review period.

Positive *Escherichia coli* counts were recorded in 2.7% of samples, which could be attributed to pathogens from cattle grazing.

Treatment processes are in place to treat any *E.coli* present prior to supply to consumers.

1.8 Future water supplies

1.8.1 Predicted water demand

The shallow Lower Cane Alluvial aquifer has a total allocation limit of 1000 ML per year which includes 350 ML reserved for public water supply purposes. There is only 93 ML/year remaining for further allocation, therefore the status of water availability in the Lower Cane alluvial is 'limited' (Department of Water 2011).

1.8.2 Birdrong aquifer supply

As part of the Wheatstone LNG project, Chevron Australia entered into an agreement to supply an additional 2 ML per day of drinking water to the town of Onslow.

The water is sourced from a bore about 360 m deep in the Birdrong aquifer, which is a confined, artesian source. A second production bore is proposed. As the water is around 48^{o}C, the water requires cooling prior to treatment with reverse osmosis.

The Onslow Birdrong Aquifer Water Reserve drinking water source protection plan (August 2015) states that post commissioning, ongoing ownership and management of this source will be taken over by the Water Corporation.

As the source is confined, the contamination risks from surface-based land uses are considered to be minimal, provided bores are constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

The Birdrong drinking water source is proposed to be proclaimed. Due to the low water quality risks, the water reserve boundary may be limited to the production bore compounds or the land managed by the Water Corporation that surrounds the production bores.

2 Implementation of Onslow'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 Cane River Water Reserve

No.	Recommendation	Comments
1	Gazettal of water reserve.	The Cane River Water Reserve was gazetted in 2001 under the *Country Areas Water Supply Act 1947.*
2	Incorporation into land planning strategies.	The water reserve has been incorporated into the Shire of Ashburton *Town planning scheme (no.7)* as a special control area. This review recommends including the proposed new wellhead protection zones into the next update of the scheme (section 2.2, recommendation no. 1).
3	All development proposals likely to impact on water quality should be referred to the Water and Rivers Commission (Department of Water's predecessor).	Development proposals within the PDWSA are currently referred to the Department of Water's North West Region. This has been continued as a recommendation of this review (section 2.2, recommendation no. 2).
4	Signs should be erected along the boundaries of the water reserve.	Signage exists on some entry roads and around production bore compounds. Additional signs should be installed and maintained in accordance with *S111 Source protection signage* (Water Corporation 2013). This has been continued as a recommendation of this review (section 2.2, recommendation no. 5).

No.	Recommendation	Comments
5	Implement a detailed emergency response plan and HAZMAT information and education program.	Emergency response protocols have since changed to Westplan-HAZMAT and the local emergency management committee. This has been continued as a recommendation of this review (section 2.2, recommendation no. 4).
6	A surveillance program should be developed to identify any incompatible land uses or potential contamination threats within the water reserve.	Water Corporation undertakes surveillance within the water reserve, including regular surveillance undertaken by a site operator who lives onsite within the water reserve. This has been continued as a recommendation of this review (section 2.2, recommendation no. 6).
7	The contamination risks to aquifers from river flows should be investigated, to determine appropriate management principles for the surface water catchment area.	This has been undertaken as part of the boundary review, which determined that recharge to the aquifer is a direct result of rainfall and river flows.
8	Bunding constructed for the oil drum storage at the Water Corporation pumping station.	The Water Corporation oil drum storage is now bunded.
9	The area between bund and mono pumps fenced off to prevent livestock access.	The homestead and pumping station are fenced to prevent livestock access, including the bund area. The mono pumps no longer exist.
10	Investigation into contamination of production bore 16/94.	This production bore has now been decommissioned.
11	The well field should be fenced to prevent stock access to the bores.	Each of the production bores is individually fenced but stock are still able to access the 500 m wellhead protection zones of each production bore.

No.	Recommendation	Comments
	The arrangement between the Peedamullah Station owner and Water Corporation pumper should be formalised.	Best management practices on the pastoral station are recommended and Water Corporation officers communicate with the station owner as required.
12	The use of non-chemical weed control measures within bore compounds should be investigated.	Water Corporation's operational site officer favours non-chemical methods of weed management. Other weed control measures used are in accordance with *Use of herbicides in water catchment areas* (Department of Health 2007).
13	Review of the plan and recommendations.	This will be undertaken through the preparation of this review document.

2.2 Consolidated recommendations

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

1. Incorporate the findings of this review including its updated protection zones in the Shire of Ashburton'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 Ashburton)
2. Refer development proposals within the Cane River Water Reserve that are inconsistent with the Department of Water's WQPN no. 25: *Land use compatibility tables for public drinking water source areas* or recommendations in this review to the Department of Water regional office for advice. (Department of Planning, Shire of Ashburton, proponents of proposals)
3. Ensure incidents covered by Westplan–HAZMAT in the Cane River Water Reserve are addressed by ensuring that:
    - the Shire of Ashburton local emergency management committee is aware of the location and purpose of the Cane River Water Reserve
    - the locality plan for the Cane River Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
    - the Water Corporation acts in an advisory role during incidents in the Cane River Water Reserve

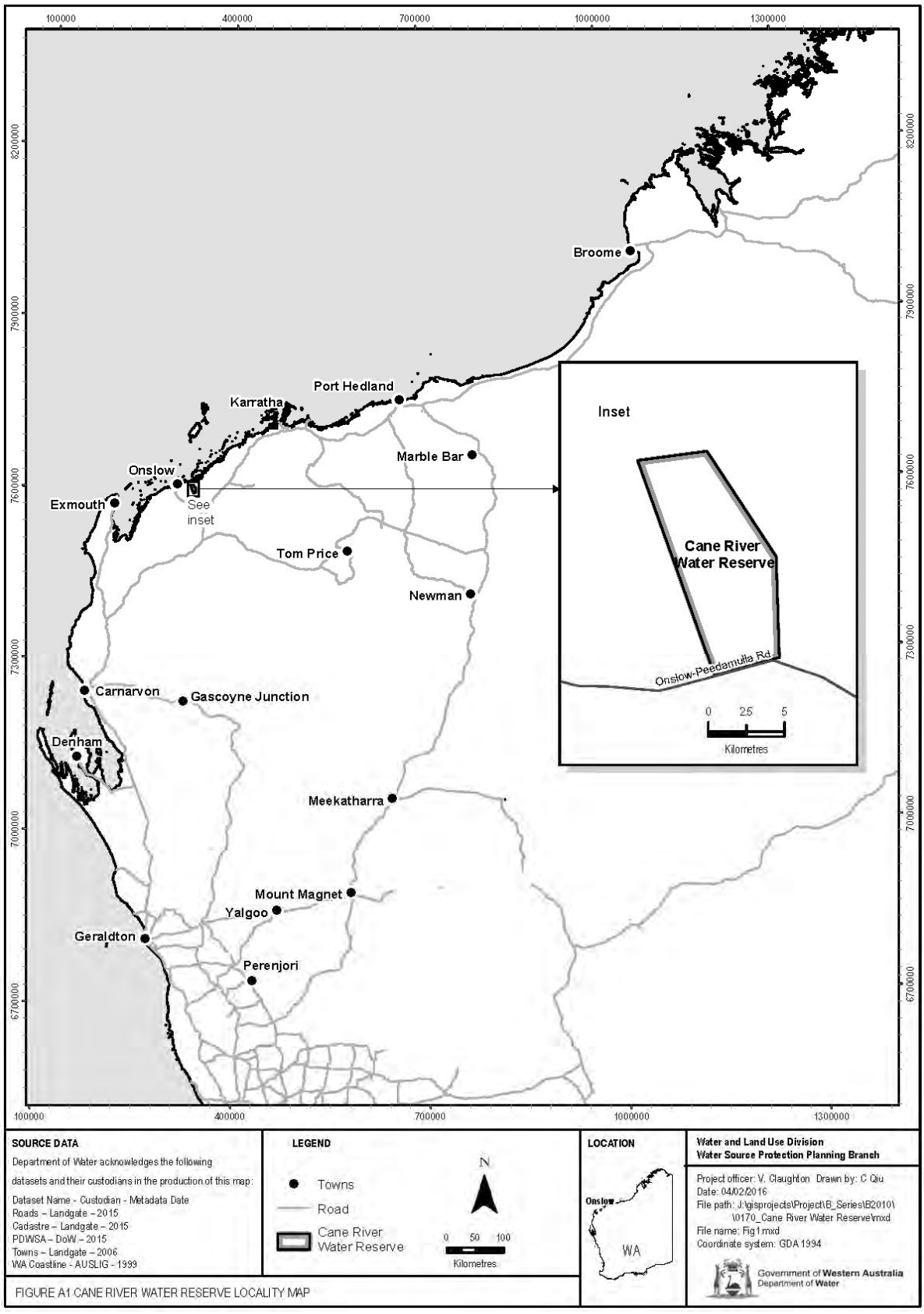
- personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Cane River Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

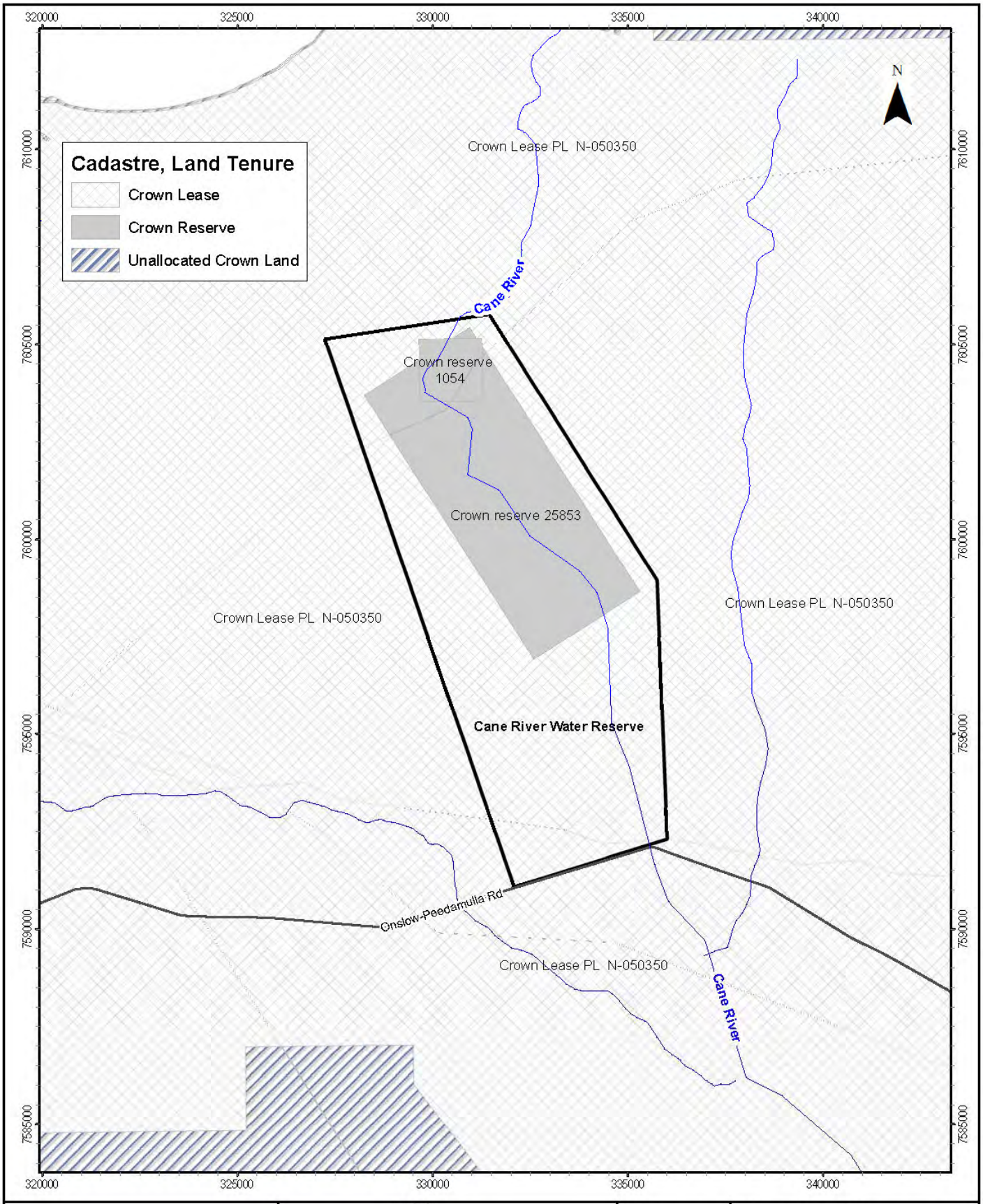
(Water Corporation)

4. Erect and maintain signs along the boundary of the Cane River Water Reserve including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
5. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
6. Oil or gas exploration and production should be managed in accordance with government's response to Report no. 42: *Implications for Western Australia of hydraulic fracturing for unconventional gas* (Legislative Council Standing Committee on Environment and Public Affairs 2015), the *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA* (2015a) and *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach* (2015b). (Department of Water and Department of Mines and Petroleum)
7. Update this review within seven years or in response to changes in water quality contamination risks. (Department of Water)

Appendices

Appendix A — Figures





SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2015
Cadastre – Landgate – 2015
PDWSA – DoW – 2015
Rivers, DoW – DoW – 2007

LEGEND

Rivers
Roads
Cane River Water Reserve

0 1 2
Kilometres

LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 04/02/2016
File path: J:\gisprojects\Project\B_Series\B2010\
\0170_Cane River Water Reserve\mxd
File name: Fig2.mxd
Coordinate system: MGA94 Zone 50

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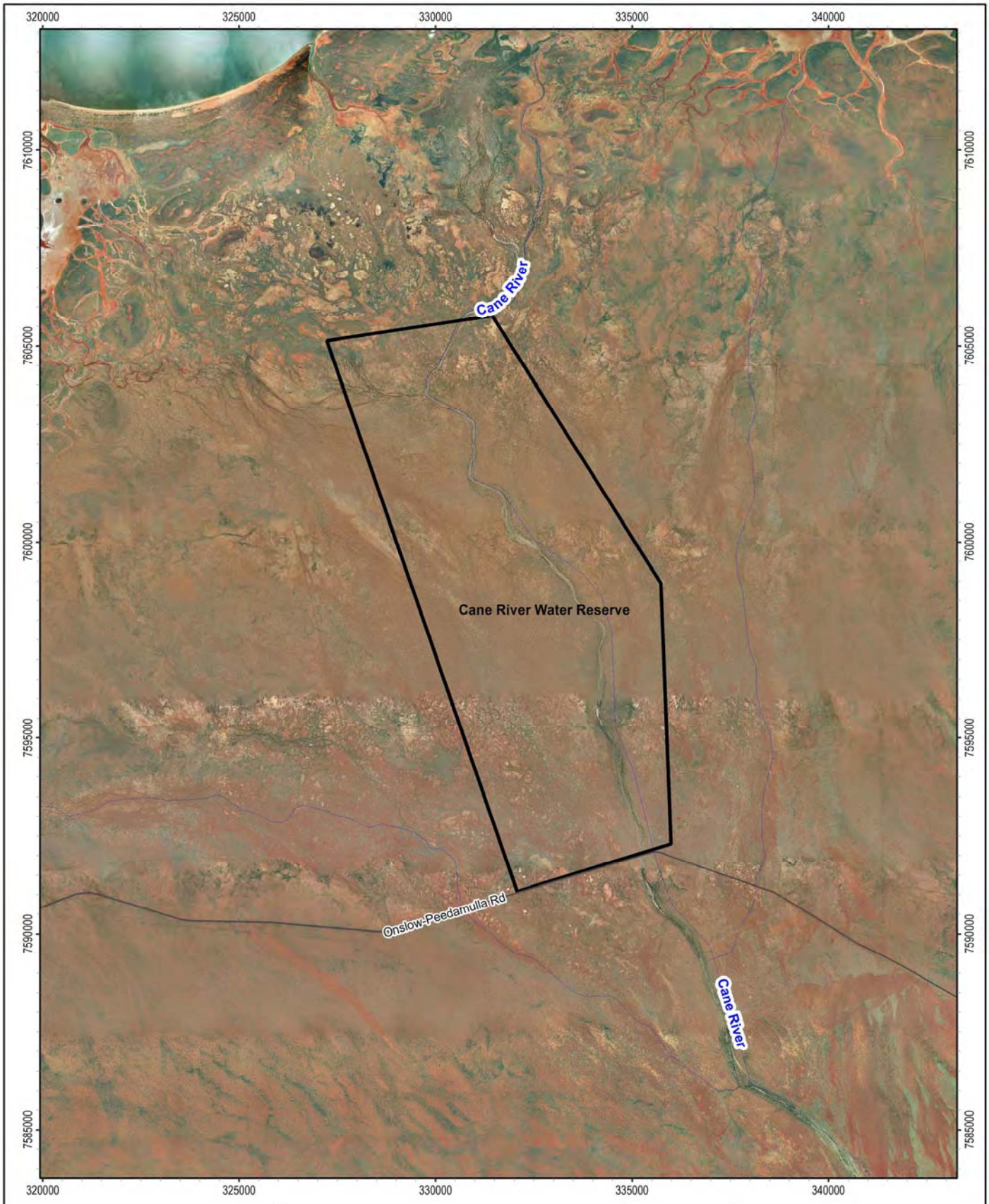
Department of Water

FIGURE A2 LAND USE, ACTIVITIES AND TENURE IN AND AROUND THE CANE RIVER WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
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Rivers, DoW – DoW – 2007
PDWSA – DoW – 2015
Onslow_2007_50cm_z50.ecw – Landgate– 2007

LEGEND

Rivers
Roads
Cane River Water Reserve

N

0 1 2
Kilometres

LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 04/02/2016
File path: J:\gisprojects\Project\B_Series\B2010\
\0170_Cane River Water Reserve\mxd
File name: Fig3.mxd
Coordinate system: MGA94 Zone 50

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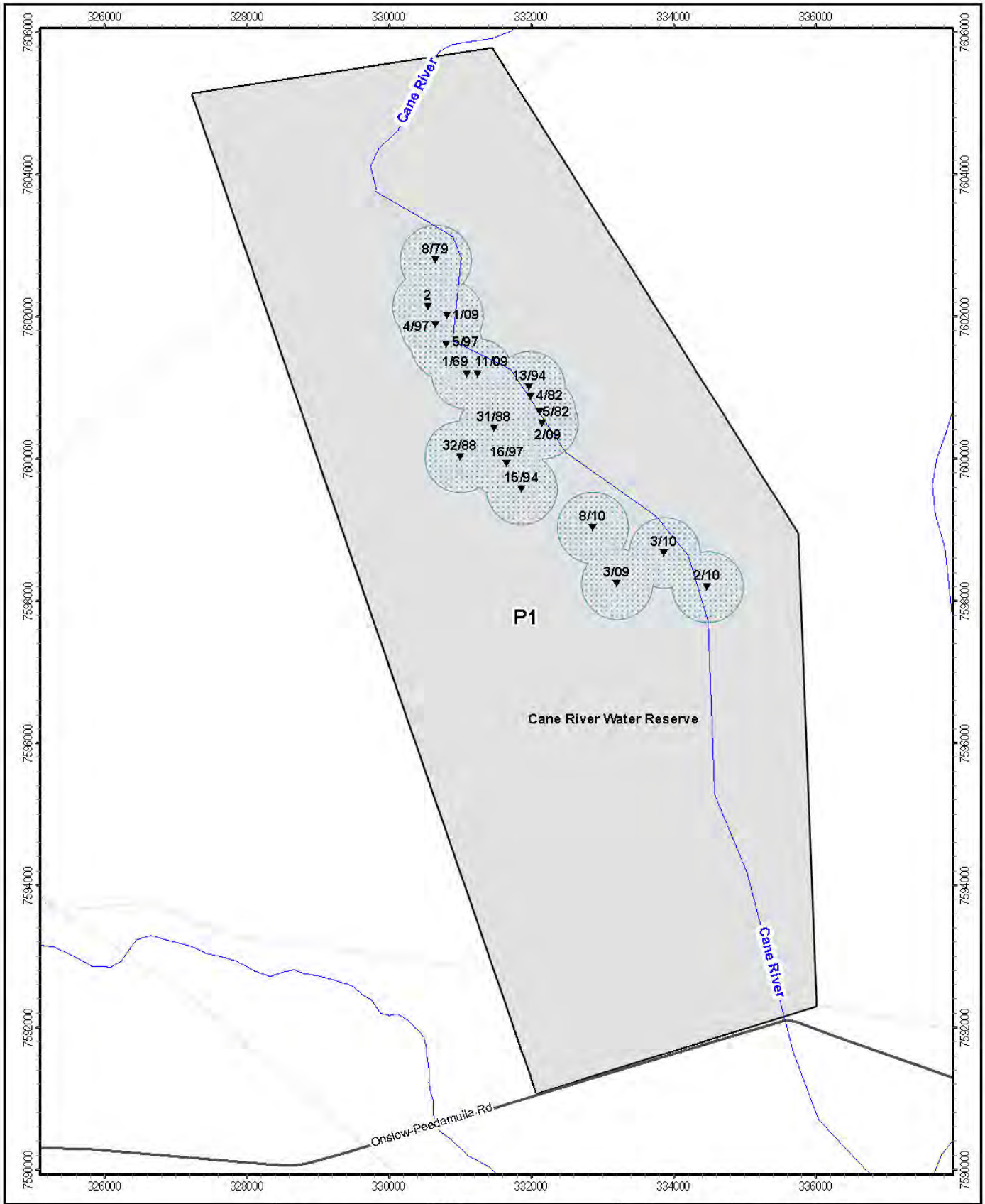
FIGURE A3 AERIAL PHOTOGRAPHY AND LAND USES IN THE CANE RIVER WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2015
Rivers, DoW – DoW – 2007
PDWSA – DoW – 2015

LEGEND

- Production bores
- Rivers
- Roads
- Cane River Water Reserve
- Priority One (P1) area
- Wellhead Protection Zones (Updated 2016)

N

0 0.5 1
Kilometres

LOCATION

Onslow
WA

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 04/02/2016
File path: J:\gisprojects\Project\B_Series\B2010\
\0170_Cane River Water Reserve\mxd
File name: Fig4.mxd
Coordinate system: MGA94 Zone 50

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FIGURE A4 BOUNDARY, PRIORITY AREA AND WELLHEAD PROTECTION ZONES IN THE CANE RIVER WATER RESERVE

Appendix B — Water quality data

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

The Water Corporation has monitored the raw (source) water quality from Cane River bore field 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 catchment. The raw water is regularly monitored 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 Cane River bore field. 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 five-year period from 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 Onslow refer to the most recent Water Corporation drinking water quality annual report at watercorporation.com.au.

Aesthetic

The aesthetic water quality analyses for raw water from Cane River bore field are summarised in the following table.

Aesthetic detections for Cane River bore field

Parameter	**Units**	**ADWG aesthetic guideline value***	**Cane River raw water**	
			Range	**Median**
Chloride	mg/L	250	60–125	77.5
Colour – true	TCU	15	<1–1	<1
Hardness as $CaCO_3$	mg/L	200	160–200	180
Iron (unfiltered)	mg/L	0.3	<0.003–0.03	<0.003
Manganese (unfiltered)	mg/L	0.1	<0.002–0.004	<0.002
Silicon as SiO_2	mg/L	80	65–80	75
Sodium	mg/L	180	23–63	31
Sulfate	mg/L	250	8.5–13	10
Total filterable solids by summation	mg/L	600	418–559	450
Turbidity	NTU	5	<0.1–0.4	<0.1
pH (lab measured)	–	8.5	7.41–8.22	7.805

* 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 Cane River bore field 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 Cane River bore field

Parameter	Units	ADWG health guideline value*	Cane River raw water	
			Range	Median
Manganese unfiltered	mg/L	0.5	<0.002–0.004	<0.002
Nitrite plus nitrate as N	mg/L	11.29†	0.23–0.36	0.3
Arsenic	mg/L	0.01	0.005–0.007	0.006
Barium	mg/L	2	0.5–0.7	0.6
Boron	mg/L	4	0.1–0.25	0.14
Molybdenum	mg/L	0.05	<0.0005–0.001	<0.0005
Uranium	mg/L	0.017	<0.001–0.001	<0.001
Chromium	mg/L	0.05	0.0006–0.0008	0.0006
Fluoride laboratory measurement	mg/L	1.5	0.5–0.7	0.65
Nitrate as nitrogen	mg/L	11.29†	0.23–0.34	0.285
Radon-222	Bq/L	100	20.9–20.9	20.9

* 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 (NHRMC & ARMCANZ, 2011).

† The 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 Cane River bore field 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 abstracted from any bore may indicate contamination of faecal material through ingress into the bore, or recharge through to the aquifer (depending on aquifer type).

During the review period, positive *E. coli* counts were recorded in 2.7 per cent of samples (two samples, maximum 3 MPN/100mL).

Appendix C — Photographs

Figure C1 Water Corporation signage on boundary of the Cane River Water Reserve, photograph by V. Claughton, Department of Water

Figure C2 Cattle station signage on the within the Cane River Water Reserve, photograph by V. Claughton, Department of Water

Figure C3 Cattle gathering at a stock watering point within close locality to a production bore within the Cane River Water Reserve, photograph by V. Claughton, Department of Water

Figure C4 New electrically powered production bore within the Cane River Water Reserve, photograph by V. Claughton, Department of Water

Figure C5 A bunded fuel tank used to power a production bore within the Cane River Water Reserve, photograph by V. Claughton, Department of Water

Figure C6 A solar powered production bore within the Cane River Water Reserve, photograph by V. Claughton, 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 a 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 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, make 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, 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 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 to supply 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 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, 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 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 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 (WQPN) no. 25: *Land use compatibility tables for public drinking water source areas* outlines appropriate development and activities within each of the priority areas (P1, P2 and P3). A draft update of this document was released for public comment in October 2014, and an updated version is expected to be published during 2016.

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 www.water.wa.gov.au or refer to our 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 an assessment process based on preventive 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, an assessment based on preventive risk 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
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
PSC 88	Public sector circular number 88
PDWSA	public drinking water source area
Westplan–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

Units of measurement

Bq/L	becquerels per litre	A measure of radioactivity.
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.
NTU	nephelometric turbidity units	A measure of turbidity in water.
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.
TCU	true colour units	A measure of degree of colour in water.

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*).
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.
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.
Dissipate	To become scattered or dispersed.
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.
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.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
Porosity	The ratio of water (or air) filled pore spaces to the total volume of the rock or soil, expressed as a percentage or fraction.
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.
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.

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.
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.
Wellfield	A group of bores located in the same area used to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater.
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

Australian Bureau of Statistics 2011, *Census QuickStats, Western Australia State Suburbs Onslow Code SSC50609*, viewed 22 March 2016 www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/SSC50609?opendocument&navpos=220

Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2000, *Floodplain management in Australia: Best practice principles and guidelines*, CSIRO Publishing, Collingwood.

Department of Health 2007, *Use of herbicides in water catchment areas*, Circular no: PSC 88, February 2007, Government of Western Australia, Perth, available http://www.public.health.wa.gov.au/cproot/1418/2/PSC88_Use_of_Herbicides_in_Water_Catchment_Areas.pdf.

Department of Mines and Petroleum 2015, *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach,* Government of Western Australia, Perth, available www.dmp.wa.gov.au.

Department of Water 2010, *Pilbara Regional water plan 2010–2030*, Government of Western Australia, Perth, available www.water.wa.gov.au.

——2011, *Lower Cane groundwater allocation limit report, Method used to set an allocation limit and licensing rules for the lower Cane alluvial aquifer,* Government of Western Australia, Perth, available www.water.wa.gov.au.

——2012, Operational policy no.13: *Recreation within public drinking water source areas on Crown land*, Government of Western Australia, Perth, available www.water.wa.gov.au.

——2013, *Pilbara groundwater allocation plan,* Government of Western Australia, Perth, available www.water.wa.gov.au.

——2013, *Pilbara regional water supply strategy, A long-term outlook of water demand and supply,* Government of Western Australia, Perth, available www.water.wa.gov.au.

——2014 *WAter resources inventory 2014 Water availability, quality and trends*, Government of Western Australia, Perth, available www.water.wa.gov.au.

——*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 25: *Land use compatibility in public drinking water source areas*
- 2006, WQPN 35: *Pastoral activities within rangelands*
- 2006, WQPN 44: *Roads near sensitive water resources*
- 2007, WQPN 83: *Infrastructure corridors near sensitive water resources*

— 2009, WQPN 36: *Protecting public drinking water source areas.*

— 2015 WQPN 80: *Stockyards*

Department of Water and Department of Mines and Petroleum 2015a, *Administrative agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in WA,* Government of Western Australia, Perth, available www.dmp.wa.gov.au.

——2015b, *Guide to the regulatory framework for shale and tight gas in WA: A whole-of-government approach*, Government of Western Australia, Perth, available www.dmp.wa.gov.au.

——2016, *Administrative Agreement between the Department of Mines and Petroleum and the Department of Water For mineral exploration and mining operations in water resource areas of Western Australia*, Government of Western Australia, Perth, available www.dmp.wa.gov.au

Geldreich, EE 1996, 'Pathogenic agents in freshwater resources', *Hydrological Processes*, vol. 10, pp. 315–33.

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*, State Law Publisher, Perth.

——1947, *Country Areas Water Supply Act*, State Law Publisher, Perth.

——1972, *Aboriginal Heritage Act*, State Law Publisher, Perth.

Legislative Council Standing Committee 2015, Report no. 42: *Implications for Western Australia of hydraulic fracturing for unconventional gas*, Standing Committee on Environment and Public Affairs, Perth, available www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf.

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. 143–78.

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/policyandlegislation/policiesandplans/Administration/SEMP_2.4_-_District_Emergency_Management.pdf.

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

——2012, Water Forever, *Whatever the Weather A 10-year plan for Western Australia*, Water Corporation, Leederville.

——2013, *S111 Source protection signage,* unpublished corporate standard, Water Corporation, Leederville.

——2015, *Onslow Birdrong Aquifer Water Reserve - Drinking Water Source Protection Plan,* Water Corporation, Leederville.

Water and Rivers Commission 1999, *Cane River Water Reserve Water Source Protection Plan*, Government of Western Australia, Perth, available www.water.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/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 www.water.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 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 2011, *Guidelines for drinking-water quality – Volume 4 – Recommendations*, 4th edn, World Health Organization, Geneva, available www.who.int/water_sanitation_health/publications/dwq-guidelines-4/en/.

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