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

Boyup Brook Dam Catchment Area

drinking water source protection review

Boyup Brook town water supply

Water resource protection series
Report WRP 172
March 2019

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Report no. 172

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Cover photograph: Aerial photo of Boyup Brook Dam Catchment Area

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

Contents

Tables

Summary

This drinking water source protection review considers up-to-date hydrological information and changes to land uses that have occurred since the *Boyup Brook Catchment Area drinking water source protection assessment* was prepared (Water Corporation 2004). The assessment 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.

Boyup Brook is a small regional centre located in the south-west corner of Western Australia, approximately 270 km south-east of Perth and 116 km south-east of Bunbury. The town has a population of around 500 people and services the surrounding agricultural area that extends over the Darling Plateau.

Boyup Brook Dam is one of nine dams connected to the Warren–Blackwood Regional Water Supply Scheme, supplying water to an estimated population of 10 500 people across nine towns (Figure A1): Bridgetown, Balingup, Boyup Brook, Greenbushes, Hester, Kirup, Manjimup, Mullalyup, Nannup.

The scheme is also augmented by the Nannup bore (DoW 2012) using groundwater from the Yarragadee aquifer.

Based on the most up-to-date hydrological information and assessment techniques, DWER proposes a new boundary for the Boyup Brook Dam Catchment Area that differs from the boundary in the 2004 assessment (figures A1, A2 and A5). A catchment area for the Boyup Brook Dam has not yet been constituted under the *Country Areas Water Supply Act 1947*. To protect the quality of this drinking water source, we propose to constitute the proposed Boyup Brook Dam Catchment Area (figures A2, A3 and A5).

We propose to assign a priority 1 (P1) area over land owned by and vested in the Water Corporation and all Crown land in the catchment area. This includes the areas of bituminised catchment that surround Boyup Brook Dam which help to increase rainfall runoff inflows via a constructed drainage channel.

We also propose to assign a priority 2 (P2) area over the portions of two rural-zoned, private properties within the proposed Boyup Brook Dam Catchment Area. P2 areas do not change the zoning of land and land uses that are consistent with rural zoning do not need to change. We recommend that landowners undertake best management practices to help protect drinking water quality as per the information contained in Table 2.

The department proposes that a reservoir protection zone (RPZ) be assigned to the whole Boyup Brook Dam Catchment Area and be applied over Crown land. Current legislation and policy states that RPZs generally extend 2 km from the high water mark of a water body being used for public drinking water supply. As the Boyup Brook Dam’s catchment area boundary is less than 2 km away from the high water mark of the dam in all directions, the whole catchment is proposed to be a RPZ.

Additionally, due to its small size, the use of bituminised catchment areas and constructed drainage channel, this catchment area is considered highly vulnerable to contamination, so an RPZ will assist in its protection.

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

The main changes since the 2004 assessment are:

- The proposed boundary is being amended to reflect the most up-to-date hydrological information.
- Subject to further stakeholder consultation, the proposed Boyup Brook Dam Catchment Area will be constituted under the *Country Areas Water Supply Act 1947.*
- Priority areas and a reservoir protection zone have been assigned within the proposed Boyup Brook Dam Catchment Area based on the Shire of Boyup Brook's local planning scheme zoning and land tenure.

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

Table 1 Key information about the proposed Boyup Brook Dam Catchment Area

Boyup Brook Dam Catchment Area	
Status of this report	This report is based on information from the 2015–16 financial year. Public drinking water source area boundaries, priority areas, reservoir protection zones and other data may be subject to change. For up-to-date information, please email drinkingwater@dwer.wa.gov.au.
Local government authority	Shire of Boyup Brook
Location supplied	Boyup Brook as part of the Warren–Blackwood Regional Water Supply Scheme
Water service provider	Water Corporation
Dam/reservoir capacity	129 ML – (built 1943, 3.3ha in size)
Catchment area	338.36 ha – Comprised of four bitumen catchment areas, land owned or vested with the Water Corporation, unallocated Crown land and private rural land.

Boyup Brook Dam Catchment Area	
Licensed abstraction (2013–2019)	SWL69108(4) with an entitlement for 772 000 kL for the Millstream, Hester and Boyup Brook dams
Date/s of drinking water source protection reports	2004 – *Boyup Brook Dam Catchment Area drinking water source protection assessment* (Water Corporation) 2016 /17 – *Boyup Brook Dam Catchment Area assessment review* (this document).
Consultation	2004 – government and water service provider consultation 2016 – mail out to all private landowners, and consultation with key stakeholders that included Water Corporation and the Shire of Boyup Brook.
Proclamation status	We will progress proclamation under the *Country Areas Water Supply Act 1947* when this drinking water source protection review is published
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) The *South West regional water plan: strategic directions and action* (2010–2030) (DoW 2010) *Water Forever: South West final report* (Water Corporation 2015)

1 Review of Boyup Brook's drinking water source protection assessment

1.1 Catchment area

The proposed Boyup Brook Dam Catchment Area is approximately 338.36 ha and is contained within the Darling Plateau which consists of an undulating, dissected peneplain (Figure A2). Soils are predominately gravels with occasional block laterite outcrops and some elevated areas of sands and sandy loams.

Boyup Brook Dam is located on a tributary of the Blackwood River approximately 4.5 km south-east of the town of Boyup Brook. Boyup Brook Dam Catchment Area is mostly covered by native jarrah and wandoo forest, with the surrounding areas extensively cleared and used mainly for broad hectare agriculture with rotational sheep grazing (figures A2 and A3).

The catchment includes four bitumen catchment areas, which cover a total area of approximately 18.3 ha. Two of these bitumen areas (approximately 6.3 ha in total) are located directly north and south of the dam wall. The remaining two areas (approximately 12 ha in total) are located 370 m upstream from the dam to the south east. A constructed drainage channel conveys rainfall runoff to the dam from these bituminised areas.

1.2 Hydrological assessment

The department undertook a hydrological assessment of the Boyup Brook Dam Catchment Area in December 2014 (Figure A2). The assessment reviewed the 2004 catchment boundary using ArcHydro (version 2.0). ArcHydro is a suite of Geographical Information System software tools (ESRI ArcGIS) designed to support water resource applications. In conjunction with ArcHydro, we evaluated the catchment area using the latest available information, including:

- One second Shuttle Radar Topography Mission (SRTM) Derived Digital Surface Model (DSM) and Digital Elevation Model (DEM) updated in 2011.
- Aerial photography: Bridgetown 50cm Orthomosaic – Landgate 13.
- Departmental hydrographic sub-catchment boundary and stream network data.
- The use of bitumen catchment areas to increase rainfall runoff inflows via a constructed drainage channel.

We assessed the available elevation datasets and decided that the one second SRTM DSM was the best one to use for this study.

1.3 Update on water supply scheme

Boyup Brook Dam is an earthen dam construction, built in 1943. The reservoir is 3.3 ha and has a storage capacity of 129 ML.

Boyup Brook Dam is one of nine surface water storages connected to the Warren–Blackwood Regional Water Supply Scheme. The scheme supplies water to an estimated population of 10 500 people across nine towns (Water Corporation 2015): Bridgetown, Balingup, Boyup Brook, Greenbushes, Hester, Kirup, Manjimup, Mullalyup, Nannup.

The dam supplies the town of Boyup Brook as part of the Warren–Blackwood Regional Water Supply Scheme.

During winter, water from the Nannup bore supplements the scheme via the Millstream and Hester Dams. Millstream Catchment Area (Bridgetown), Bridgetown Catchment Area (Hester Dam) and the Nannup bore are addressed in other drinking water source protection reports (see www.water.wa.gov.au).

As part of an upgrade to the scheme to increase its capacity, Water Corporation built a duplicate of the existing nine kilometre pipeline between the Hallet tanks and Boyup Brook, which was completed in October 2015.

The DWER has issued a licence to the Water Corporation (SWL69108(4)) with an allocation of 772 000 kL of water for the Millstream, Hester and Boyup Brook dams.

Water from the reservoir is chlorinated and pumped to a ground level storage tank and a high level tank located in Boyup Brook. Water then gravitates into the town reticulation.

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

For additonal information on why it is important to protect our catchments, see Appendix E.

1.4 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 is one Aboriginal site of significance within the proposed Boyup Brook Dam Catchment Area. The Kaniyang People 11 site (ID 17488) is in the south-west corner of the catchment area (figures A3 and A4).

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 are three native title claims within the proposed Boyup Brook Dam Catchment Area (Figure A4). These are:

- the Southern Noongar (WAD6134/1998)
- the Wagyl Kaip (WAD6286/1998)
- the Single Noongar Claim (Area 1) (WAD6006/2003).

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 (see Figure A4).

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 this.

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).

The 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.

1.5 Enforcing by-laws, surveying the area and maintenance

This review recommends that the Water Corporation continue surveillance under the existing delegation arrangement (see section 3, recommendation no. 2). This also includes:

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

- maintaining security and fencing for the dam
- ongoing regular surveillance and inspections.

1.6 Update on water quality risks

As part of this review, the department and the Water Corporation conducted a new assessment of water quality contamination risks to the Boyup Brook Dam Catchment Area in accordance with the ADWG. Table 2 shows the risks that we have identified since the 2004 assessment, and also includes risks that are still considered high. Remaining risks are discussed in the 2004 assessment.

The proposed Boyup Brook Dam Catchment Area (Figure A3) includes:

- land owned by the Water Corporation
- Crown land vested with the Corporation
- unallocated Crown land
- private rural land.

Reservoir Road, an unsealed rural access road, passes through the southern part of the catchment. Private rural properties used for broadacre farming and sheep grazing occupy the northern and southern parts of the catchment area.

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 Agriculture

There is privately owned land in the northern, eastern and southern parts of the catchment area (see Figure A3). The land is zoned rural and covers 15.45 per cent of the total catchment area. The current land use is broadacre farming for canola and legumes and seasonal pasture rotation for sheep grazing.

Lot 4, in the northern part of the catchment, covers 19.27 ha of the catchment area. Lot 11 is in the southern part of the catchment and covers 33.04 ha of the catchment area.

During a site inspection in October 2015, officers from Water Corporation and the department observed surface water runoff from rural areas entering the adjacent forest via drainage channels. This presents a risk of contaminants such as pathogens, nutrients, chemicals and hydrocarbons entering the drinking water source.

There is a drainage channel extending from Lot 4 in a south-westerly direction to a major tributary of the reservoir. In this case, the risk of contaminants entering the reservoir is lower because the water flows through 1.6 km of vegetation which naturally attenuates the contamination before it enters the reservoir.

Surface water runoff via drainage channels originating from Lot 11 could enter Reservoir Road or the bituminised catchment area on Crown Reserve (47025) and

from there it could be transported directly via the drainage channel into the reservoir. For this reason the risk of contamination from fuel, pesticides, nutrients and pathogens is high.

1.6.2 Crown land

Crown Reserve 47025, vested in the Water Corporation, covers 145 ha (43 per cent) of the catchment area. The reserve is forested and has two bituminised catchment areas which are used to increased rainfall runoff via a constructed drainage channel and also includes part of the reservoir.

Any contamination that occurs within the bituminised areas could be transported directly into the reservoir via the drainage channel. For this reason there is a higher level of risk associated with activities that could cause contamination in the bituminised areas. Public and vehicular access to the bituminised areas is restricted via fencing, which reduces the risk of fuel spills from vehicles.

During a site visit, officers from Water Corporation and the department observed vegetation growing on the bituminised areas. This needs to be removed to maintain flows into the reservoir. If it cannot be removed manually, herbicides may be required, which poses a contamination risk.

People picnic and camp in the reserve next to the reservoir. Evidence of these activities, such as recent campfires, has been found by officers of the Water Corporation and the department. Water Corporation rangers stated the amount of evidence associated with picnicking and camping suggested the activity occurred frequently. Rangers have also observed evidence of marroning occurring in the reservoir. Hunting occurs at low levels, evidenced by a reduction in the number of feral pigs in the area. These activities are unauthorised, and once the catchment area is proclaimed, penalties may apply.

The level of risk by pathogen contamination from native animals that traverse the bituminised catchment area is increased due to the lack of attenuation by vegetation and increased transport rate directly into the reservoir via the drainage channel.

1.6.3 Water Corporation land

Lots 66 (81.8 ha), 67 (202.8 ha) and 50 (5.7 ha) are owned by the Water Corporation and include the land to the north and south of the reservoir, the reservoir itself and the area upstream of the reservoir. These lots cover 41.55 per cent of the total catchment area. Collectively Water Corporation is the proprietor of the majority of land contained within the catchment area (refer to the Lots selected by a red boundary in Figure A3 where Water Corporation is the proprietor).

Current land uses and activities in these areas are described in section 1.6.2. The level of risk from activities occurring on lots 50 and 66 is higher because they are closer to the reservoir. Swimming, including pets, and marroning occur in the reservoir. These activities pose the highest risk of pathogen contamination.

Of primary concern is the number of waterbirds inhabiting the reservoir and its immediate surrounds. Based on raw water quality data (Appendix B) for the Boyup Brook dam, the high numbers of water fowl are attributing to the levels of microbiological contamination being recorded.

1.6.4 Mining and petroleum

There is one pending exploration mining tenement (E 7004809) that covers the catchment area, held by Metalcity Limited. However there are no mining activities occurring. There are no petroleum titles in the Boyup Brook Catchment Area.

Table 2 Summary of potential water quality risks and best management practices

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance[1]
Waterbirds on reservoir	Pathogens (avian)	High	Large populations of wild ducks frequent the dam. Detention time effectiveness is reduced because the birds have frequent contact with the water.	WQPN 96: *Pest animal management in PDWSAs*
Swimming in or body contact with the reservoir	Pathogens (human)	High	Gates at access points. Signs located at the reservoir and main access point. Detention time effectiveness is reduced due to frequent body contact with the water. Proclaim under the *Country Areas Water Supply Act 1947.* Implement an RPZ to prevent access.	Operational policy no. 13: *Recreation in PDWSAs on Crown land*
Fishing and marroning	Pathogens (human)	High	Activity occurs on land owned and managed by the Water Corporation. Proclaim under the *Country Areas Water Supply Act 1947.* Implement an RPZ to prevent access.	Operational policy no. 13: *Recreation in PDWSAs on Crown land*

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

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance[1]
Picnicking and camping	Pathogens from bodily contact and food waste Nutrients from food waste	High	Gates and fences restrict access at known vehicle access points along Reservoir Road. Proclaim under the *Country Areas Water Supply Act 1947.* Implement an RPZ to prevent access.	Operational policy no. 13: *Recreation in PDWSAs on Crown land*
Broadacre cropping	Nutrients from fertiliser Pesticides Turbidity from erosion Hydrocarbons from farm machinery	Low	Existing, approved land use consistent with the rural zoning. Rural-zoned areas are proposed as P2 areas.	WQPN 1: *Agriculture – dryland crops near sensitive water resources*
Rotational grazing with sheep	Pathogens animal excreta	Medium		WQPN 80: *Stockyards*
	Nutrients from animal excreta	Low		

1.7 Water quality information

The Water Corporation has provided updated water quality information for the Boyup Brook Dam Catchment Area. This is shown in Appendix B.

During the review period, positive *Escherichia coli* counts were recorded in 93.5 per cent of samples. Of these, 96 per cent had *E. coli* counts greater than 20 MPN/100mL within the raw water quality monitoring data.

The frequency of positive *Escherichia coli* monitoring results indicates an ongoing pathogen source for the Boyup Brook dam. The high number of waterbirds observed inhabiting the reservoir and surrounds is a likely contributing factor.

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 health guideline values of the ADWG.

2 Protecting your drinking water source

The objective of this drinking water source protection review is to update the 2004 assessment, improve water quality from its current level through the application of best management practices, policy objectives and legislative protection regarding the identified contamination risks. This will provide safe, good quality drinking water to the Boyup Brook town water supply scheme.

This review recognises the rights of existing, approved land uses that are consistent with the shire's zoning to continue to operate at their present level. Avoiding and minimising of risks to public water sources is imperative to protect public health. DWER will work with land owners, land managers and operators to implement best management practices to help protect water quality. Email drinkingwater@dwer.wa.gov.au for more information.

2.1 Proclaiming public drinking water source areas

The DWER hasn't constituted (proclaimed) the Boyup Brook Dam Catchment Area under the *Country Areas Water Supply Act 1947* yet. To protect Boyup Brook Dam's water quality, we propose to constitute the proposed Boyup Brook Dam Catchment Area (section 4, recommendation no. 1 and Figure A5). We will consult with stakeholders before we arrange this.

Constitution of the proposed catchment area under *Country Areas Water Supply Act 1947* will not change the zoning of land within the proposed boundaries. All existing land uses and activities that are consistent with the zoning of the land can continue. However, we recommend that best management practices are employed to protect the quality of the drinking water source. New developments or expansion of existing land uses or activities need to consider the recommendations in this plan. The department does not recommend land use intensification in a PDWSA, because of the inherent increased risks to water quality and public health. More people, more buildings, more cars and more infrastructure mean more water quality and public health risks.

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

2.2 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.

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

In accordance with our current policy, we determined the proposed priority areas for the proposed Boyup Brook Dam Catchment Area. These areas are described below and displayed in Figure A5. Our WQPN no.25: *Land use compatibility tables for public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

We propose to assign the Water Corporation land and all Crown land in the proposed Boyup Brook Dam Catchment Area as P1 (see Figure A5), because:

- the P1 risk avoidance policy objective is consistent with the land tenure
- this source supplies drinking water to the town of Boyup Brook
- the catchment contains bitumen areas that are vulnerable to contamination and foster rapid transport of contaminants into the reservoir
- current, approved land uses are considered 'acceptable' in P1.

We propose to assign the remaining private land as P2 (see Figure A5), because:

- the P2 risk minimisation policy objective is consistent with the land tenure
- current land use is considered 'compatible with conditions' in P2 areas provided best management practices are applied
- the land is privately owned and zoned rural.

2.3 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 extraction facilities (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.

Reservoir protection zones (RPZs) are assigned over the most vulnerable part of the catchment. They include the water storage body but do not extend outside the catchment or downstream of the dam wall. They adopt the priority area of the land over which they occur.

RPZs that occur in the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* are referred to as 'prohibited zones' and are legislatively set at a distance of 2 km from the high water level of a reservoir.

For consistency, and where reasonable, we also apply RPZs to country sources. In proposed new water resource management legislation, the DWER has recommended that a 2 km RPZ – or other distance approved by the Minister for Water following development of a drinking water source protection report – should apply across the whole state.

An RPZ has been defined to cover the whole of the proposed Boyup Brook Dam Catchment Area (see Figure A5), because the catchment area boundary is less than 2 km away from the high water mark of the reservoir. As it is small, the catchment area is vulnerable to contamination and an RPZ will help to protect it.

Private land in the RPZ is not subject to the same protection measures as Crown or government-owned land, therefore land uses and activities that are consistent with the rural zoning (lots 4 and 11) will not be affected by the RPZ.

3 Consultation

The Water Corporation, Shire of Boyup Brook and private land owners were contacted to provide comment on the 2004 *Boyup Brook Dam Catchment Area drinking water source protection assessment* in relation to any new land use changes that have occurred since its publication. Further consultation will be undertaken during the proposed constitution of the Boyup Brook Dam Catchment Area.

3.1 Stakeholder consultation process

In 2016, the previous DoW sent letters to the Shire of Boyup Brook, the Water Corporation and private landowners inviting them to comment on the *Boyup Brook Dam Catchment Area drinking water source protection assessment* that was published in 2004. We used those comments to inform this review.

3.2 Issues raised in consultation

The following table provides a summary of the issues raised during consultation of the *Boyup Brook Dam Catchment Area drinking water source protection review*. Individual stakeholders have not been identified in order to protect their privacy. Issues that are very specific or are not related to this review have not been listed, but have been explained or resolved directly with the affected stakeholder(s).

Table 3 Key issues raised during consultation for the proposed Boyup Brook Dam Catchment Area

Issue raised	Response
The town is not currently supplied from the Boyup Brook Dam and supplies some rural holdings who heavily rely on the source. Once the Water Corporation no longer require the dam, access will be given to the local government.	The Water Corporation has advised us that the Boyup Brook Dam is part of its water supply strategy for the Warren–Blackwood Regional Water Supply Scheme. The Water Corporation still needs to use the source until new infrastructure to supply water in the region is complete. If the Water Corporation advises that it intends to abandon the dam, consultation between DWER, Water Corporation and the Shire of Boyup Brook regarding access to the dam will be progressed.

4 Consolidated recommendations

Based on the findings of this review, the following recommendations will now be applied to the proposed Boyup Brook Dam Catchment Area. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Constitute the proposed Boyup Brook Dam Catchment Area (Figure A5) under the *Country Areas Water Supply Act 1947*. (DWER)
2. Incorporate the findings of this review and the location of proposed Boyup Brook Catchment Area (including its proposed priority areas and protection zones) in the Shire of Boyup Brook's local planning scheme in accordance with the WAPC's State planning policy no. 2.7: *Public drinking water source policy*. (Shire of Boyup Brook)
3. Refer development proposals within the proposed Boyup Brook Dam Catchment Area that are inconsistent with the DWER's WQPN no.25: *Land use compatibility tables for public drinking water source areas* or recommendations in this review to the DWER regional office for advice. (Department of Planning, Shire of Boyup Brook, proponents of proposals)
4. Ensure incidents covered by Westplan–HAZMAT in the proposed Boyup Brook Dam Catchment Area are addressed by ensuring that:
    - the South West district local emergency management arrangements include the location and purpose of the proposed Boyup Brook Dam Catchment Area
    - the locality plan for the proposed Boyup Brook Dam Catchment Area 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 proposed Boyup Brook Dam Catchment Area
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the proposed Boyup Brook Dam Catchment Area and information to help them recognise the potential impacts of spills on drinking water quality. (Shire of Boyup Brook, Water Corporation)
5. Maintain signs along the boundary of the proposed Boyup Brook Dam Catchment Area including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
6. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and surveillance. (Water Corporation)
7. Update this review within seven years or in response to changes in water quality contamination risks. (DWER)

Appendices

Appendix A — Figures

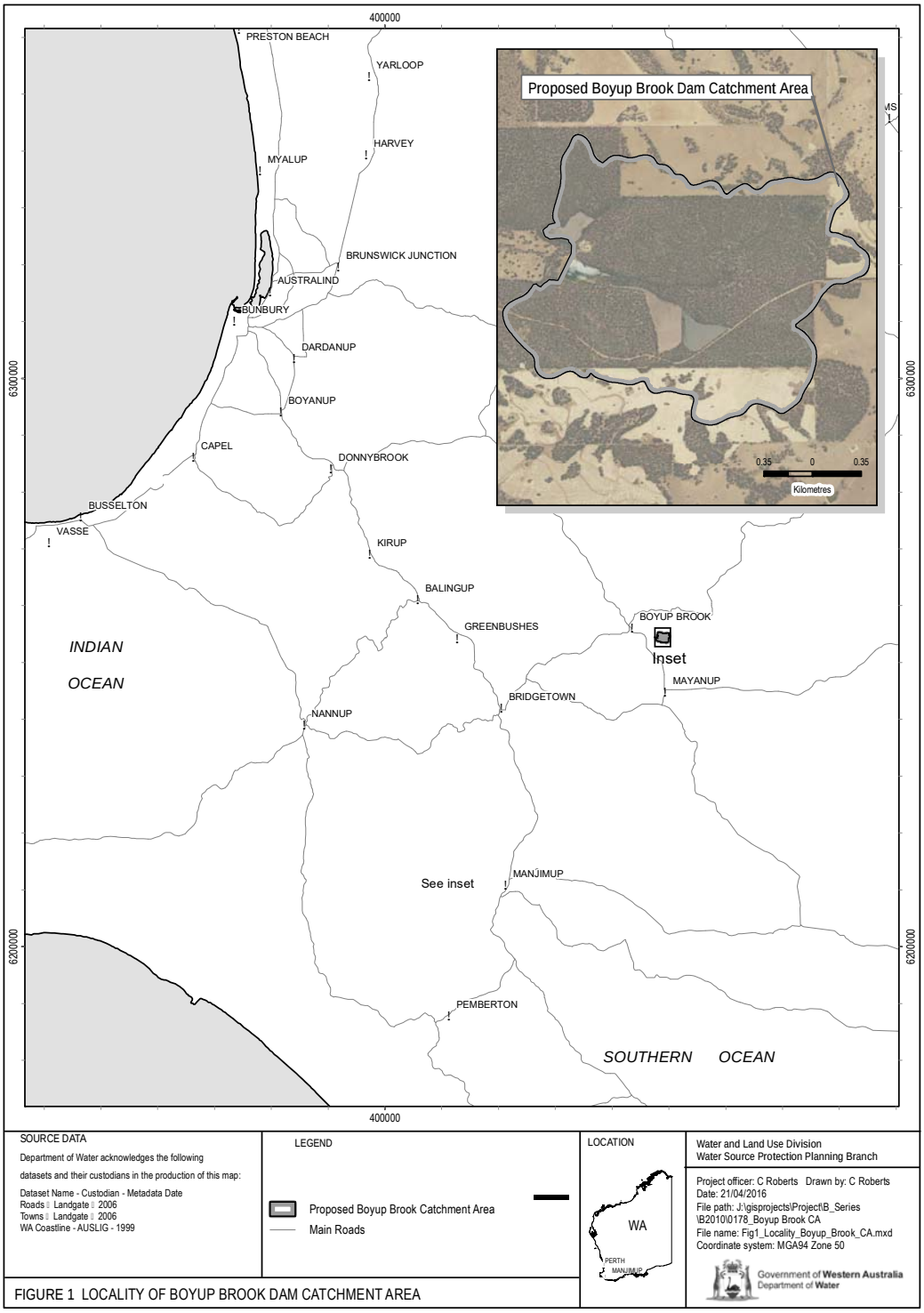

Figure A1 Locality of Boyup Brook Dam Catchment Area

Figure A2 Boyup Brook Dam Catchment Area

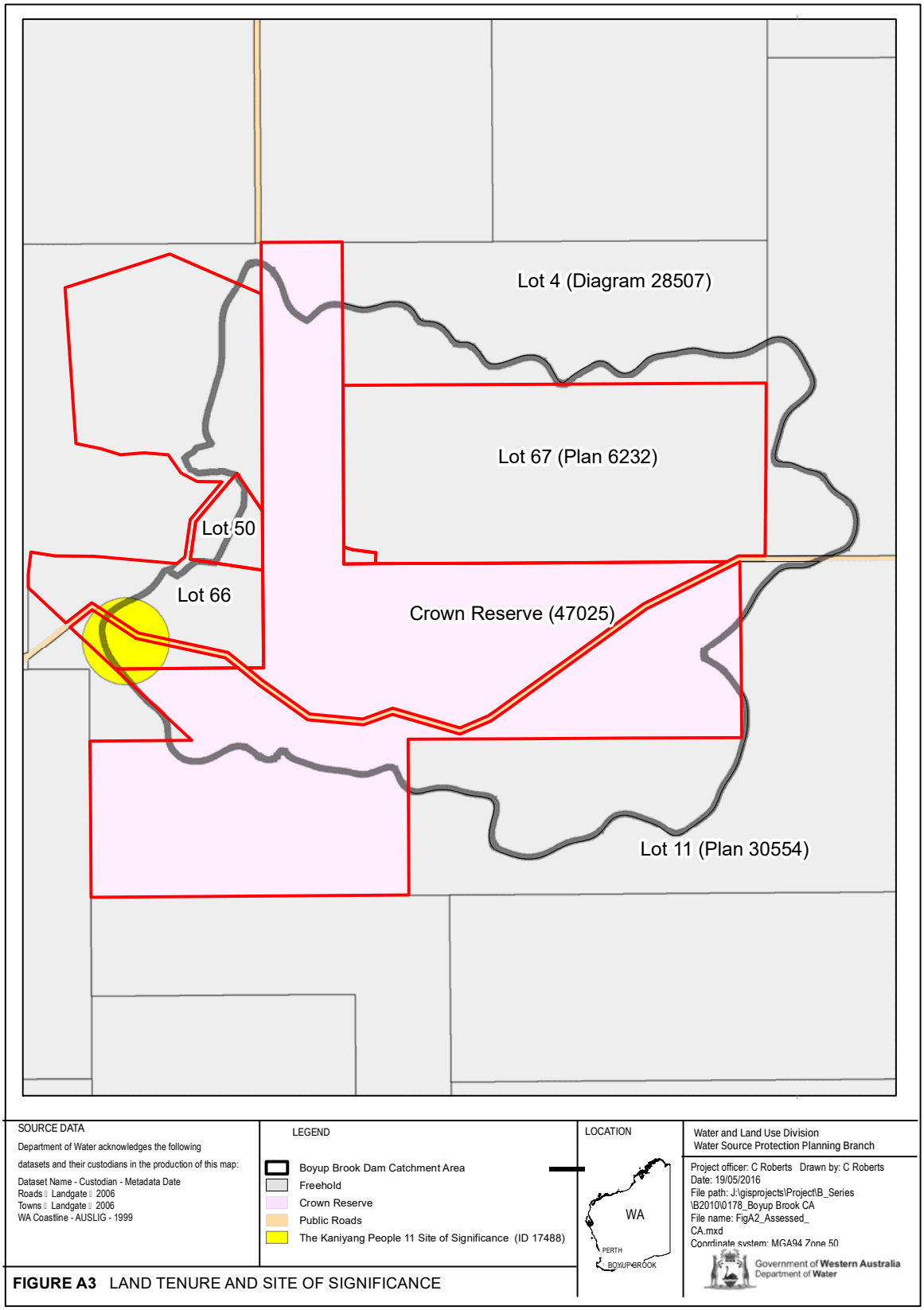

Figure A3 Land tenure and site of significance

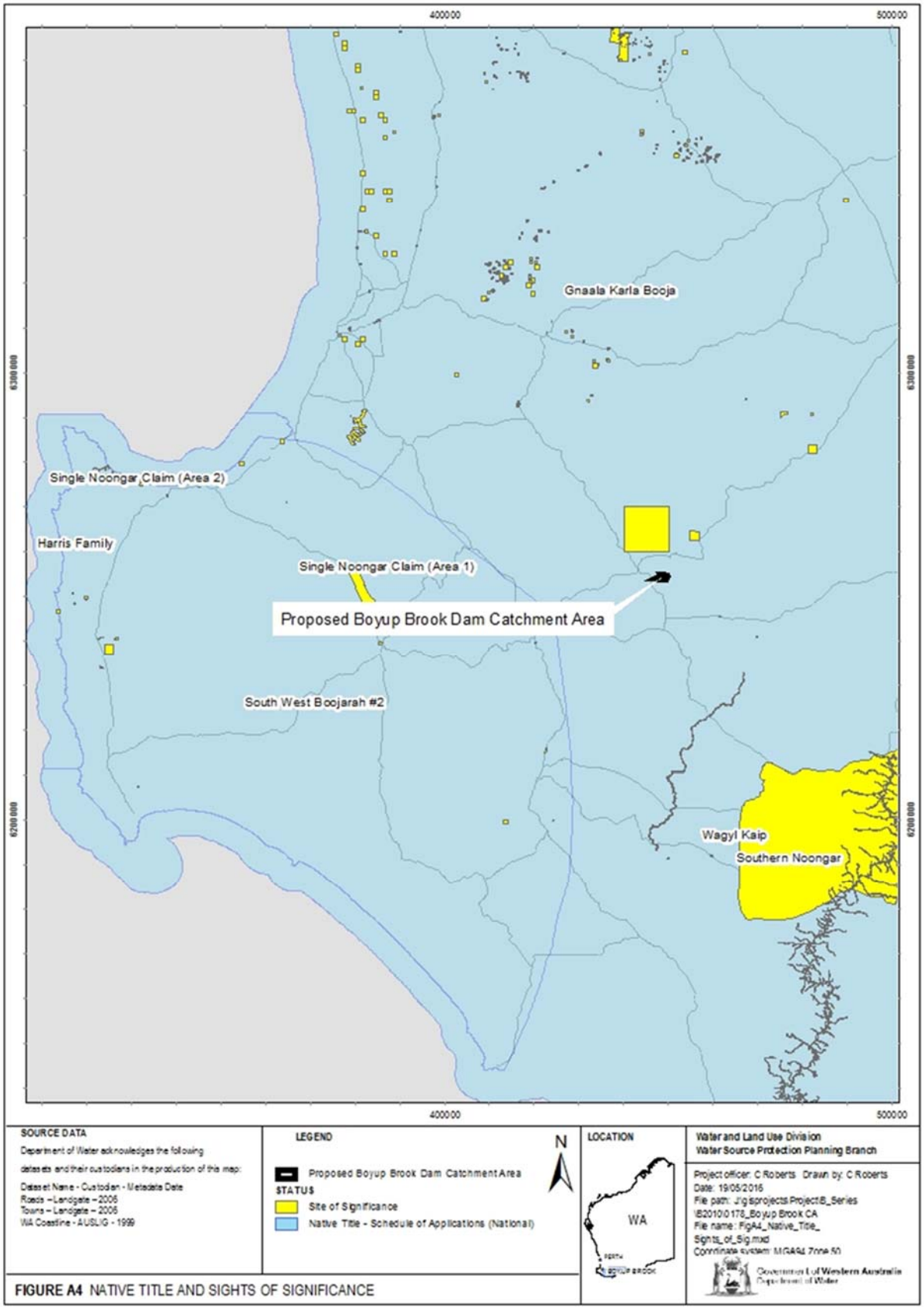

Figure A4 Native title and sites of significance

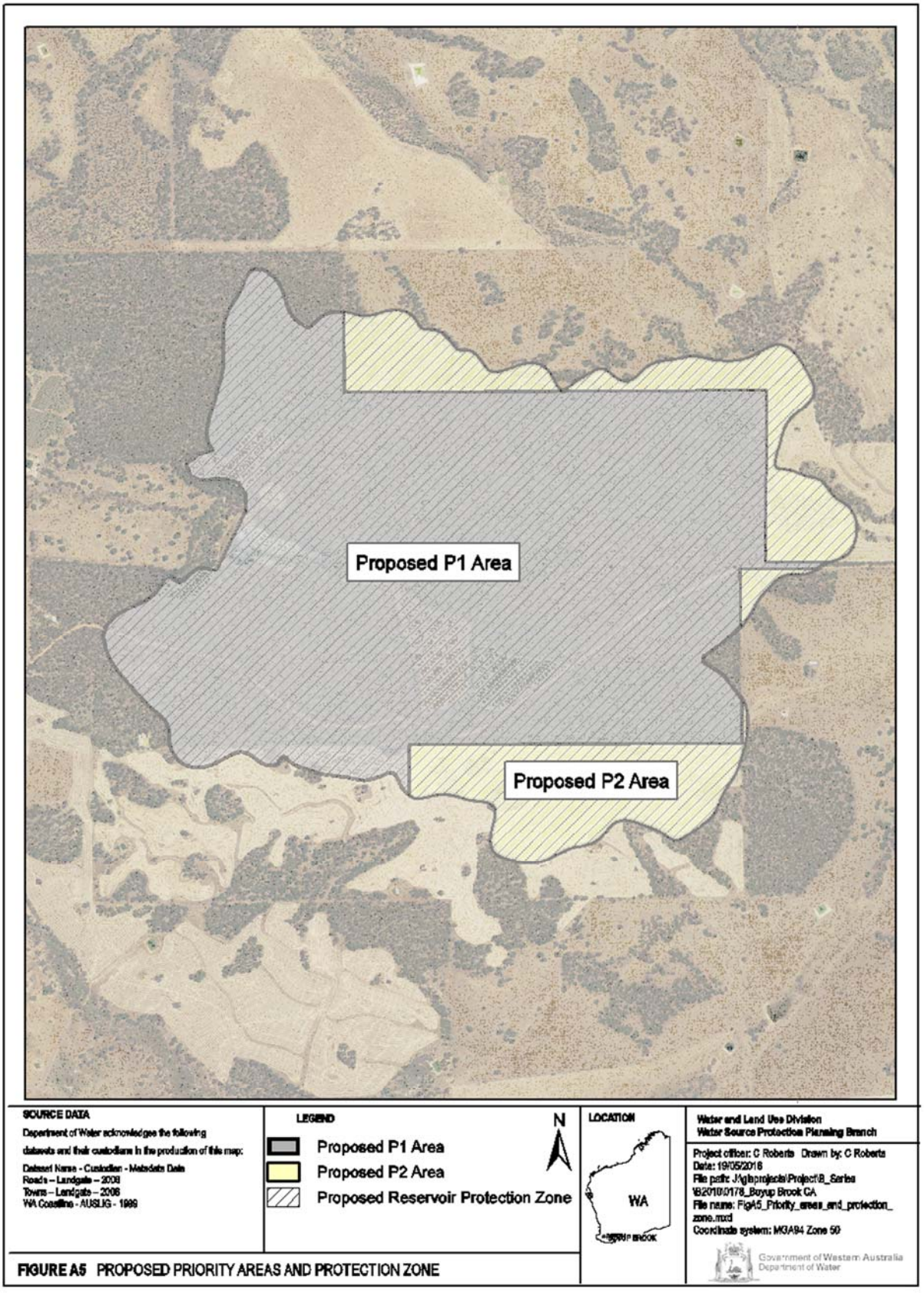

Figure A5 Proposed priority areas and protection zone

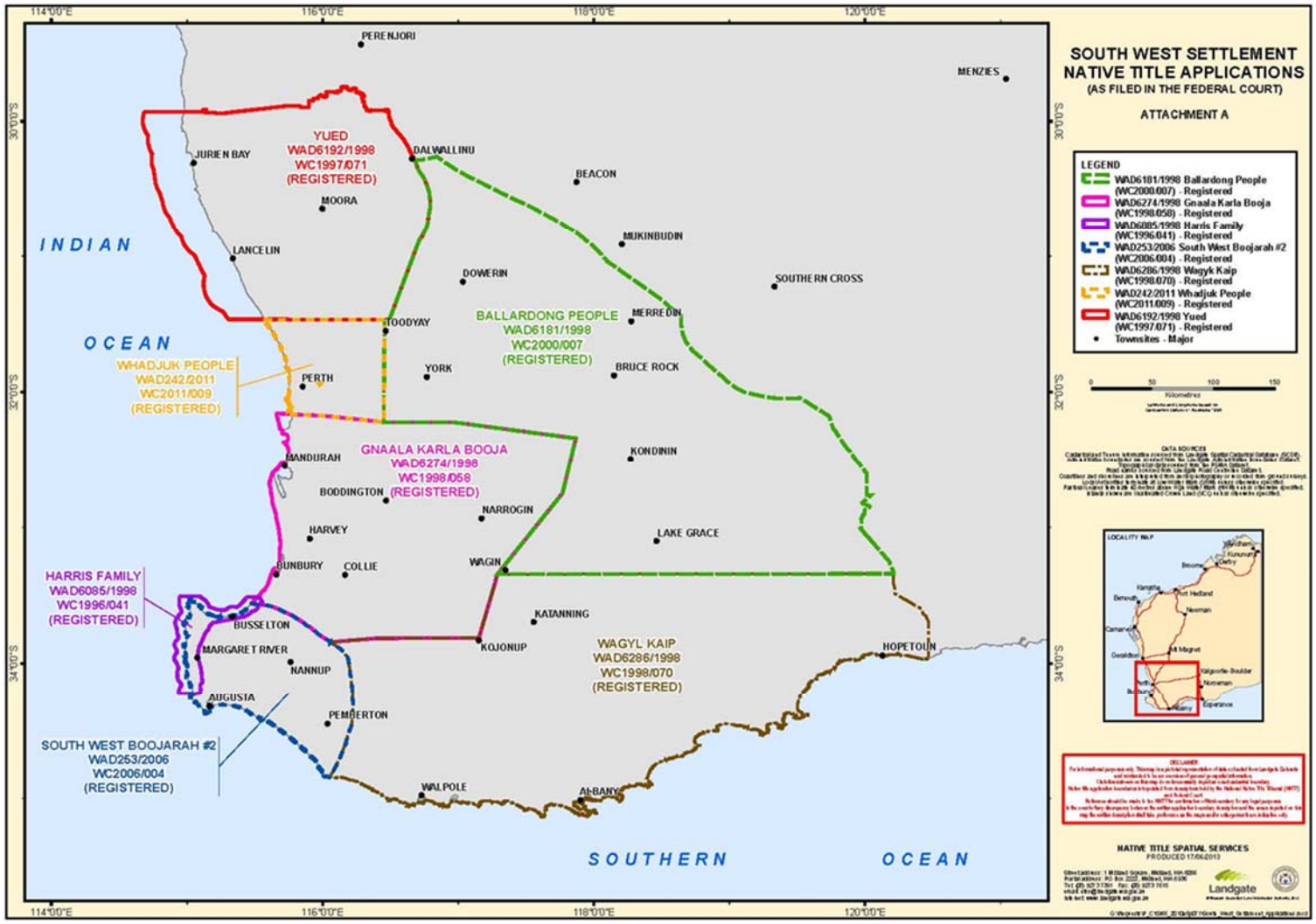

Figure A6 South West Native Title Agreement area (source: Department of Premier and Cabinet)

Appendix B — Water quality data

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

The Water Corporation has monitored the raw (source) water quality from Boyup Brook 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 Boyup Brook. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in bold and italics to give an indication of potential raw-water quality issues associated with this source. The values are taken from ongoing monitoring for the period May 2011 to April 2016.

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 health guideline values of the ADWG.

For more information on the quality of drinking water supplied to Bridgetown Region Water Supply Scheme, refer to the most recent Water Corporation drinking water quality annual report at www.watercorporation.com.au .

Aesthetic characteristics

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

Aesthetic detections for Boyup Brook

Parameter	Units	ADWG aesthetic guideline value[2]	Boyup Brook	
			Range	Median
Aluminium (acid soluble)	mg/L	0.2	0.02–0.02	0.02[3]
Ammonia as nitrogen	mg/L	0.41	<0.005–0.046	<0.005
Chloride	mg/L	250	32–85	60
Colour (true)	TCU	15	<1–14	9
Conductivity	mS/m	–	19–50	30
Hardness as $CaCO_3$	mg/L	200	38–110	60
Iron unfiltered	mg/L	0.3	<0.09–***0.44***	0.22
Manganese unfiltered	mg/L	0.1	<0.002–0.025	0.005
Sodium	mg/L	180	19–47	32
Sulfate	mg/L	250	6–26	8
Total filterable solids by summation	mg/L	500	124–188	325
Turbidity	NTU	5	0.3–3.1	1.2
pH measured in laboratory	no units	6.5–8.5	7.35–***8.97***	7.80

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

[3] Only one sample taken during the reporting period.

Health-related chemicals

Raw water from Boyup Brook 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 Boyup Brook

Parameter	Units	ADWG health guideline value[4]	Boyup Brook	
			Range	Median
Fluoride	mg/L	1.5	<0.1–0.1	0.1
Manganese unfiltered	mg/L	0.5	<0.002–0.025	0.005
Nitrite plus nitrate as N	mg/L	11.29[5]	<0.002–0.025	0.005
Sulfate	mg/L	500	7.5–10	8.75

Microbiological contaminants

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

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

During the reviewed period, positive *E. coli* counts were recorded in 93.5 per cent of samples. Of these, 96 per cent of samples had *E. coli* counts greater than 20 MPN/100mL.

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 health guideline values of the ADWG.

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

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

Appendix C — Typical contamination risks in surface water sources

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

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

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

Some commonly seen contamination risks relevant to surface water 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.

Directly: When people or domestic animals come into contact with a body of water pathogens may enter that water source. This occurs through the direct transfer of faecal material into the water such as while fishing, marroning or swimming.

Indirectly: Pathogens can wash over or infiltrate into the soil, and find their way into water supplies, such as from septic tanks or animal manure deposited in paddocks.

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 ability of pathogens to survive in surface water differs between species. *Salmonella* may be viable for two to three months, *Giardia* may still infect after a month in the natural environment (Geldrich 1996) and *Cryptosporidium* oocysts (cells containing reproductive spores) may survive weeks to months in fresh water (NHMRC & NRMMC 2011).

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 groundwater and surface water 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 (cloudiness). Erosion from activities such as off-road driving and clearing of vegetation can cause turbidity in surface water sources. Increased turbidity can result in cloudy or muddy-looking water, which is not aesthetically appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens and chemicals can attach onto soil particles and become more difficult to remove during disinfection and treatment processes. High levels of turbidity in a water body can also affect the environment. Suspended particles smother riparian vegetation and reduce the ability of light to penetrate the water column. This affects plant growth which in turn can affect water quality.

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)
- pests (insecticides, rodenticides)
- worms (nematicides
- mites (miticides).

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 deposited in the catchment that washes over soil and down waterways and into the water supply. 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 D — How do we protect public drinking water source areas?

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

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

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
- 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, 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 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 (WAPC) 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.

DWER's Water quality protection note (WQPN) no. 25: *Land use compatibility tables for PDWSAs* outlines appropriate development and activities within each of the priority areas (P1, P2 and P3).

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 WAPC (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 or contact DWER's Water source protection planning branch on +61 8 6364 7600 or email drinkingwater@dwer.wa.gov.au.

Drinking water source protection reports produced by the DWER

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 E — Understanding risks to drinking water quality

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

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

SPP no. 2.9: *Water resources*. This integrated program relies upon a preventive risk–based assessment process in each PDWSA through the development of drinking water source protection reports. It is important to understand how risks are assessed to appreciate the impact of development within PDWSAs.

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

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

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

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

For example, just because a drinking water contamination incident has not occurred for many years (low likelihood), does not mean that the risk is low, because we also

need to consider the consequence of that contamination when determining risk. Furthermore, no previous detection of contamination is not proof that the risk is acceptable.

Shortened forms

List of shortened forms

ADWG	*Australian drinking water guidelines*
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
CFU	colony forming units
DEM	Digital Elevation Model
DoW	Department of Water
DSM	Digital Surface Model
DWER	Department of Water and Environmental Regulation
EC	electrical conductivity
ESRI ArcGIS	Environmental Systems Research Institute
HAZMAT	hazardous materials
ILUA	Indigenous Land Use Agreement
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
P1, P2, P3	priority 1, priority 2, priority 3
PSC 88	Public sector circular number 88
PDWSA	public drinking water source area
RPZ	reservoir protection zone
SRTM	Shuttle Radar Topography Mission
TCU	true colour units
TDS	total dissolved solids
WAPC	Western Australian Planning Commission

Westplan–HAZMAT	Western Australian plan for hazardous materials
WQPN	water quality protection note

Units of measurement

Bq/L	becquerel per litre
ha	hectare
mSv	millisievert
mS/m	millisiemens per metre
m	metres
mg/L	milligram per litre
mm	millimetre
km	kilometre
km^2	square kilometre

Volumes of water

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

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, for example appearance, taste and odour (NHMRC & NRMMC 2011).
Allocation	The volume of water that a licensee is permitted to abstract, usually specified in kilolitres per annum (kL/a).
Anisotropic	Having different properties in different directions. For example, an aquifer with variations in hydraulic conductivity horizontally and vertically, or different grain sizes in all directions.
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*).
Augment	To increase the available water supply. For example, pumping back water from a secondary storage/reservoir dam.
Australian height datum	The height of land in metres above mean sea level. For example, at Fremantle the AHD is +0.026 m.
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.
Colony forming units	A measure of pathogen contamination in water.
Confined aquifer	An aquifer that is overlain by relatively impermeable rock or clay that limits movement of water into and out of the aquifer. Confined aquifers are usually deeper under the ground than unconfined aquifers. Groundwater in a confined aquifer is under pressure and will rise up inside a bore hole that is drilled into the aquifer.

Contamination	A substance present at concentrations exceeding background levels that presents – or has the potential to present – a risk of harm to human health, the environment, water resources or any environmental value.
Drinking water source protection report	A report on water quality hazards and risk levels within a public drinking water source area; includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.
Electrical conductivity	This estimates the volume of TDS or the total volume of dissolved ions in a solution (water) corrected to 25ºC. Measurement units include millisiemens per metre and microsiemens per centimetre.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Half-life	The time required for one half of a sample of material to disintegrate.
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).
Hectare	A measurement of area, equivalent to 10 000 square metres.
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Hydrogeology	The 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.
Hydrology	The science dealing with water on the land, including such things as its properties, laws and geographical distribution.
mg/L	A measurement of something (such as salinity) in a solution, i.e. 0.001 grams per litre.
Microbe	A microorganism, usually one of vegetable nature, a germ. Also known as a bacterium, especially one causing illness.
Millisiemens per metre	A measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity.

Most probable number	A measure of microbiological contamination.
Nephelometric turbidity units	A measure of turbidity in water.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
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.
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.
Point source	Pollution originating from a specific localised source, such as sewage or effluent discharge; industrial waste discharge.
Pollution	Water pollution occurs when waste products change the physical, chemical or biological properties of the water, adversely affecting water quality, the ecosystem and beneficial uses of the water.
Public drinking water source area	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* 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*.
Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.

Reservoir	A dam, tank, pond or lake that captures water from a surface catchment to create a water supply source.
Reservoir protection zone	A buffer measured from the high water mark of a drinking water reservoir, and inclusive of the reservoir (usually 2 km). This is referred to as a prohibited zone under the Metropolitan Water Supply, Sewerage, and Drainage Act By-laws 1981.
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 runoff the ground surface, roads, paved areas etc., and is usually carried away by drains.
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 total dissolved solids. Total dissolved solids comprise sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMMC 2011).
Total filterable solids by summation	A water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO_4 equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO_2 (silicon oxide). It is used as a more accurate measure than total dissolved solids. The higher the value, the more solids that are present and generally the saltier the taste.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
True colour units	A measure of degree of colour in water.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.

Water quality	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.
Westplan–HAZMAT	State emergency management plan for hazardous materials emergencies.

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