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

# Windy Harbour Water Reserve

## drinking water source protection assessment

## Windy Harbour town water supply

Water resource protection series
Report WRP 180
June 2018

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Cover photograph: Aerial photo of Windy Harbour

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# Summary

Windy Harbour is a holiday settlement on the south-west coast of Western Australia, about 60 km south of Pemberton.

Windy Harbour's drinking water comes from two bores about 700 m north-west of the settlement. The bores are screened in a multiple aquifer system; an unconfined aquifer zone at the surface and a semi-confined aquifer zone deeper down, meaning the bores are vulnerable to contamination. The Shire of Manjimup operates the drinking water supply system under an exemption from water services licensing granted by the Minister for Water.

This assessment determines a boundary for the Windy Harbour Water Reserve and considers water quality contamination risks within it, so that the drinking water source can be protected. The Department of Water and Environmental Regulation prepared this document in consultation with the Shire of Manjimup, Department of Health and Department of Biodiversity, Conservation and Attractions. After this assessment is finalised, a drinking water source protection plan should be developed for Windy Harbour with broader consultation.

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

Important information about the Windy Harbour Water Reserve is shown in Table 1.

*Table 1 Key information about the Windy Harbour Water Reserve*

| **Windy Harbour Water Reserve** | |
|---|---|
| Local government authority | Shire of Manjimup |
| Location supplied | Windy Harbour |
| Population | 30–40 permanent residents, increasing to around 2000 people in peak periods |
| Water service provider | Shire of Manjimup |
| Aquifer type | Multiple aquifer system, unconfined and semi-confined |
| Average annual abstraction | Approximately 50 000 kL per year (no groundwater licence required) |
| Number of bores | 2 |

| **Windy Harbour Water Reserve** | |
|---|---|
| Date bores drilled | Production bores – 2006<br>Monitoring bores – 1978 (old production bores) |
| Bore locations | Pump station no. 1, E 410 625.55, N 6 145 507.94, zone 50<br>Pump station no. 2, E 410 708.68, N 6 145 444.93, zone 50<br>Monitoring bore 4/78, E 410 702.17, N 6 145 436.93<br>Monitoring bore 7/78, E 410 619.60, N 6 145 503.09 |
| Date of drinking water source protection reports | 2017 – *Windy Harbour Water Reserve drinking water source protection assessment* (this document) |
| Consultation | 2017 – key stakeholder consultation as part of the development of this drinking water source protection assessment |
| Proclamation status | Windy Harbour Water Reserve is not yet constituted under the *Country Areas Water Supply Act 1947* |
| Reference documents | *Australian drinking water guidelines* (NHMRC & NRMMC 2011)<br>State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003)<br>*Windy Harbour drinking water quality management plan* (Shire of Manjimup 2016) |

# 1 Catchment to tap: Windy Harbour's drinking water supply system

## 1.1 Catchment

### 1.1.1 Location

Windy Harbour is a small beachside tourist village on the coast of south-west Western Australia, about 60 km south of Pemberton and 28 km south-south-west of Northcliffe (Figure A1).

### 1.1.2 Climate

Windy Harbour has a temperate climate with warm, dry summers and mild, wet winters.

The mean maximum temperature in Windy Harbour ranges from 16.8ºC in winter (July) to 23.8ºC in summer (February) (Bureau of Meteorology 2016). Mean minimum temperature ranges from 8.6ºC in winter to 14.7ºC in summer (Bureau of Meteorology 2016). Coastal areas often receive a cooling south-westerly breeze by early afternoon through the summer months (De Silva 2004).

The average annual rainfall at Windy Harbour is 1062 mm, occurring mostly during the winter months. Rainfall ranges from a monthly mean of 14.9 mm in February to 194 mm in July (Bureau of Meteorology 2016).

### 1.1.3 Physiography

Windy Harbour is on the Scott Coastal Plain within the Warren bioregion (Department of Environment and Conservation and Conservation Commission 2012). The area consists of sand dunes and a flat to gently undulating landscape (Figure C1) reaching an elevation of approximately 25 m AHD, rising steeply to an elevated limestone plateau to the west, approximately 100 m AHD.

The soils are sandy with peaty deposits in numerous wetland depressions. The area is poorly drained, with semi-permanent wetlands in the swales and flats between dunes, and an intermittent creek draining to the coast.

Vegetation around Windy Harbour is mostly coastal scrub and heath (Figure C1), ranging to sedge in the depressions and low woodlands in the more elevated inland areas (Department of Parks and Wildlife 2014).

### 1.1.4 Geology

The basement rock in the Windy Harbour area consists of Proterozoic age metamorphic and igneous rocks including granulite, other granitic gneiss, granite, granodiorite and adamellite. Isolated, low outcrops of the basement rock occur at the coast and at an elevation of about 30–40 m in an area 5 km inland.

The basement rock is estimated to be about 40 m below ground in the area of the Windy Harbour bores, and is unconformably overlain by Cenozoic sediments. The lower sediments range in age from Eocene to Pliocene and consist of estuarine, lagoonal and lacustrine sand, silt and clay.

Quaternary deposits either unconformably and directly overlie the basement rock, or conformably overlie the older Cenozoic sediments. The Quaternary sediments consist of calcareous to non-calcareous quartz sands which form vegetated dunes and are mostly lithified to calcarenite along the western coast. The non-calcareous sands may be equivalent to the Bassendean Sands found on the Swan Coastal Plain near Perth (De Silva 2004).

### 1.1.5 Hydrogeology

General groundwater flow in the Windy Harbour area is to the south-south-west.

An unconfined aquifer zone exists within the Quaternary sand and limestone and the upper portion of the Eocene to Pliocene sediments. This zone has an overall saturated thickness of 15–20 m. Recharge to this aquifer is from rainfall, with estimates ranging from 10 to 20 per cent of the annual rainfall. Wetland depressions in the area form a direct surface water connection to the unconfined aquifer. An intermittent stream drains excess surface water and elevated groundwater to the coast immediately east of the Windy Harbour settlement.

An aquitard (a confining layer) approximately 7 m thick underlies the unconfined aquifer zone in the area of the Windy Harbour drinking water bores. This aquitard creates semi-confined conditions in the aquifer zone below, which is mostly medium to fine sand of the Pliocene age sediments, either directly overlying the basement or a thin occurrence of Eocene age Werillup Sand. This lower, semi-confined aquifer zone has a saturated thickness of approximately 10 m.

Windy Harbour's drinking water bores (see 1.2.1) draw water from both the unconfined and semi-confined aquifer zones. The drinking water source is therefore considered to be vulnerable from contamination at the surface.

## 1.2 Water supply system

### 1.2.1 Bores

Drinking water for Windy Harbour comes from two bores approximately 700 m north-west of the settlement, called Pump station no. 1 and Pump station no. 2 (see figures A2, C2 and C4). The bores are adjacent to D'Entrecasteaux Drive (Figure C8), among native vegetation in national park. Both bores screen two aquifer zones; the unconfined aquifer zone near the surface, and the semi-confined aquifer zone deeper down (see section 1.1.5). The bores are operated interchangeably.

### 1.2.2 Water treatment

Water from the bores is pumped by diesel-powered pumps to four storage tanks on a hill about 1 km away (Figure C6), via a chlorine dosing system to disinfect the water.

The tanks are balanced by interconnecting pipework. From there, the water is gravity-fed through the Windy Harbour reticulation network about 500 m away (Shire of Manjimup 2016). During periods of high demand, the tanks can be by-passed and chlorinated water fed directly to the settlement.

It should be recognised that although disinfection is an essential barrier 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 is 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.

### 1.2.3 Services

There are approximately 230 leasehold cottages in Windy Harbour (Shire of Manjimup 2016). The water supply system provides drinking water to a permanent population of about 30 to 40 residents, increasing to around 2000 people during the peak holiday periods of summer and Easter (Shire of Manjimup 2016).

## 1.3 Managing the drinking water supply system

### 1.3.1 Water service provider

The Shire of Manjimup operates the Windy Harbour water supply scheme under a water services licence exemption. The exemption was granted by the Minister for Water in 2005, via the Licence Exemption (Shire of Manjimup) Order 2005 under section 19 of the *Water Services Licensing Act 1995*.

A condition of the exemption is that the Shire of Manjimup review the water supply against, and achieve compliance with, the ADWG (NHMRC & NRMMC 2011). The Department of Health audits this condition (Shire of Manjimup 2006).

The Shire of Manjimup has a draft drinking water quality management plan for Windy Harbour's drinking water supply (2016), which addresses water quality issues to ensure the continuous provision of safe drinking water. This plan is not yet endorsed by the Department of Health.

### 1.3.2 Allocation

Windy Harbour's drinking water bores supply approximately 120 kL per day for most of the year, and approximately 300 kL per day during peak holiday periods. The current abstraction rate is approximately 50 000 kL per year.

Windy Harbour is not in a proclaimed area under the *Rights in Water and Irrigation Act 1914* so a licence is not required to abstract groundwater.

### 1.3.3 Water source protection

The Department of Water and Environmental Regulation has prepared this drinking water source protection assessment to implement the ADWG (NHMRC & NRMMC 2011). This document assigns a boundary, priority areas and protection zones for the Windy Harbour Water Reserve (see Figure A4) and identifies potential water quality contamination risks within it (see section 2). Once this assessment is finalised, a *drinking water source protection plan* should be developed with broader consultation. In the meantime, this assessment makes some recommendations to help protect Windy Harbour's drinking water source (see section 3).

To protect Windy Harbour's drinking water source, the Windy Harbour Water Reserve should be constituted under the *Country Areas Water Supply Act 1947* to allow by-laws to be applied (see section 1.3.5) and to recognise it in land use planning processes.

The Department of Water and Environmental Regulation will assign a priority 1 (P1) area to the whole water reserve to reflect the land tenure and two 500 m wellhead protection zones surrounding the drinking water bores to protect them from immediate contamination threats (see Figure A4).

The Shire of Manjimup's local planning scheme should recognise the Windy Harbour Water Reserve as a special control area. This will ensure it can be considered in any future land use planning decisions. Any proposals within the water reserve should be considered against Water quality protection note (WQPN) no. 25: *Land use compatibility tables for public drinking water source areas* (Department of Water 2016b).

### 1.3.4 Water supply planning

There are approximately 230 leaseholds in the Windy Harbour townsite, with the potential to expand to up to 400 (Shire of Manjimup 2016). There is a marked increase in water demand during summer, coinciding with the tourist season.

The bores are likely to meet current and future demand. The shire advocates water conservation measures to ensure that the supply continues to meet demand.

### 1.3.5 Enforcing by-laws, surveying the area and maintenance

As the Windy Harbour Water Reserve is not proclaimed under the *Country Areas Water Supply Act 1947*, by-laws do not currently apply.

The Shire of Manjimup employs a caretaker to operate and maintain the bores, and water quality sampling is undertaken regularly. This assessment recommends that maintenance and water quality sampling continues (see section 3). Security and fencing around the bores and tanks should also regularly be inspected and kept well-maintained.

The shire has local emergency management arrangements and recovery arrangements, with these documents due for review in 2018 (Westplan–HAZMAT). It is recommended that they take note of the location and purpose of the Windy

Harbour Water Reserve. Contingency planning and incident response procedures should also be addressed (Ecosafe 2015).

# 2 Risk assessment

As part of this review, the Department of Water and Environmental Regulation has conducted a risk assessment which considers water quality contamination risks in the Windy Harbour Water Reserve, in accordance with the ADWG. See Table 2 for a summary.

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

## 2.1 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 two Aboriginal sites of significance within the Windy Harbour Water Reserve. These are the Nookanellup burial site and the Windy Harbour art site.

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights to lands and water arising from their traditional laws and customs.

There is one native title claim within the Windy Harbour Water Reserve, South West Boojarah 2.

The Government of Western Australia and the Noongar native title claimants have negotiated a South West Native Title Settlement. The settlement recognises the Noongar people as the traditional owners of land in the South West Settlement Area, which extends from a point south of Dongara on the west coast, approximately east to a point north of Moora and then south-easterly to a point midway between Albany and Esperance (see Figure A5).

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. The Department of Water and Environmental Regulation amended two sets of by-laws (Metropolitan Water Supply, Sewerage and Drainage By-laws 1981 and the Country Areas Water Supply By-laws 1957) on 8 June 2016 to enable Noongar people to undertake some of these land-based activities.

Some of the land-based activities include:

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

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

The Department of Water and Environmental Regulation 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.

## 2.2 Land uses

### 2.2.1 National park

Most of the Windy Harbour Water Reserve is located within the D'Entrecasteaux National Park (Figure A2), managed by Parks and Wildlife Service of the Department of Biodiversity, Conservation and Attractions in accordance with the *Shannon and D'Entrecasteaux national parks management plan* (Department of Environment and Conservation and Conservation Commission 2012).

The park is an important conservation area, stretching along the coast for over 130 km from Augusta to Walpole (Department of Parks and Wildlife 2014). Its key values are conservation and culture, while supporting nature-based recreational opportunities.

The area is zoned as 'National park and other conservation reserves' in the Shire of Manjimup's *Local planning scheme no. 4* (Department of Planning 2010).

There are no designated areas for recreational activities in the national park within the Windy Harbour Water Reserve. It is possible that unauthorised bushwalking, camping and off-road driving could occur in the catchment, but no evidence has been found of this. Risks from unauthorised recreation include pathogens from humans, nutrients from litter and hydrocarbons from vehicles. Any proposed recreation in the national park within the Windy Harbour Water Reserve needs to be assessed against Operational policy no. 13: *Recreation within public drinking water source areas on Crown land.*

### 2.2.2 Crown lease

The southern strip of the Windy Harbour Water Reserve is located within Crown Reserve 38881 (Figure A2), which is vested with the Shire of Manjimup for the

purposes of camping, caravan park and recreation. This are no dwellings in this area; it is native bush.

Any proposed expansion of the Windy Harbour settlement should occur outside of the Windy Harbour Water Reserve, to avoid increased risk to the drinking water source. Risks from towns include pathogens from septic tanks and domestic animals, nutrients from fertilisers, chemicals from weed control, rubbish and household use, and hydrocarbons from vehicles (see Appendix D for more information).

### 2.2.3 Bores and tanks

Both of Windy Harbour's drinking water bores are housed in their own shed, with a fence surrounding each bore compound (see figures C3 and C5).

The bores are operated by diesel pumps, with 2000 L diesel storage tanks at each bore. The fuel storage areas are weatherproof and bunded with a sump drain to enable cleanup if required. Hydrocarbon spill kits are available. Chlorine to disinfect the water supply is also stored (see Figure C7). Appropriate weatherproof storage for the chlorine should be investigated.

Chlorine and diesel pose a risk to drinking water quality, through possible spills or leaks. However, they are essential to operating the water supply system. To reduce the risk, alternative energies such as solar power should be considered for the bores. Adequate incident response procedures should be in place to address any contamination events.

There is a low likelihood of deliberate contamination via sabotage or vandalism (Ecosafe 2015). There have been no problems historically, and the bore pump stations are fenced and locked with access limited to authorised people. Regular inspections by the caretaker will highlight any issues.

The monitoring bores are both within locked compounds, but more secure headworks would ensure no risk of contaminating the aquifer via these bores.

### 2.2.4 Road and carpark

D'Entrecasteaux Drive runs through the water reserve, about 18 m from the bores (Figure C8). It's a designated road used by quarry trucks, tourists and Windy Harbour residents. Along this road, there is a small carpark/rest area about 350 m south of the bores.

Vehicles on the road and in the carpark pose a risk to drinking water quality from hydrocarbons from fuels and oils, that could leak or spill, particularly during a road accident. Hydrocarbons are harmful to human health if consumed in drinking water.

Incident response procedures (Westplan–HAZMAT) should be in place to address any contamination events.

### 2.2.5 Quarry

A limestone quarry partially falls within the western boundary of the Windy Harbour Water Reserve (Figure A3), approximately 800 m west of the bores. The quarry is operated by the Western Agriculture Lime Company (WALCO), producing lime and limestone rock (WALCO 2017). Risks from the quarry include hydrocarbons from vehicles and machinery. Extractive industries are compatible with conditions in P1 areas, provided best management practices are applied to protect water quality.

When a drinking water source protection plan is developed for Windy Harbour, the quarry operators will need to be consulted.

### 2.2.6 Fire

Wildfire poses a risk to water supply infrastructure. Significant damage could leave the settlement without a water supply, so contingency planning needs to include alternative sources. Firefighting foams contain nutrients, which can pose a risk to water quality. Wildfire has been assigned a high management priority.

### 2.2.7 Future land uses

Proposed land uses and activities within the Windy Harbour Water Reserve should be considered against WQPN no. 25: *Land use compatibility table for public drinking water source areas* (Department of Water 2016b). The Shire of Manjimup's local planning scheme should recognise Windy Harbour Water Reserve as a special control area, referring to WQPN no. 25.

## 2.3 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. All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012).

The Shire of Manjimup's *Statutory services policy* (2006) states that all bores in the Windy Harbour settlement need to be registered, and that regular water quality testing is required. This will assist in identifying any bores that may pose a risk to Windy Harbour's drinking water bores.

*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] |
|---|---|---|---|---|
| Camping and bushwalking | Pathogens and nutrients | Medium | There are no designated sites in the water reserve, so recreation is considered to be unauthorised. | Operational policy no. 13: *Recreation within public drinking water source areas on Crown land* |
| Off-road driving | Hydrocarbons | Medium | Off-road driving should not be undertaken in the water reserve. | |
| D'Entrecasteaux Drive and carpark | Hydrocarbons | High | Road is about 18 m from the bores, carpark is about 350 m south of the bores along the road. | WQPN no. 10: *Contaminant spills – emergency response*<br>WQPN no. 44: *Roads near sensitive water resources* |
| Using and storing chemicals required for the water supply scheme | Hydrocarbons and chemicals | High | Chlorine and diesel are stored and used at the pump stations. Contamination prevention measures must be in place. Consider alternative energies. | WQPN no. 10: *Contaminant spills – emergency response*<br>WQPN no. 65: *Toxic and hazardous substances* |
| Quarry | Hydrocarbons | Medium | Quarries are compatible with conditions in P1 areas. | WQPN no. 15: *Extractive industries near sensitive water resources* |
| Wildfire | Nutrients | High | Fire is a risk to infrastructure and firefighting foams contain nutrients. | Adequate contingency planning should in place to deal with wildfire. |

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

## 2.4 Water quality information

The Shire of Manjimup has provided raw-water quality information for the Windy Harbour drinking water source (see Appendix B).

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Water suppliers are required to ensure that drinking water supplied to the public meets the ADWG.

# 3 Recommendations

The current risks to drinking water quality from land uses and activities within the Windy Harbour Water Reserve have now been assessed. High management priorities have been assigned to D'Entrecasteaux Drive, fuel and chemical storage at the bores and wildfire.

Further water source protection planning measures will be considered in the future through a drinking water source protection plan. The plan will be widely consulted and make recommendations to address water quality risks. For more information about our different types of drinking water source protection reports, see the table at the end of Appendix E.

This assessment recommends the following to protect Windy Harbour's drinking water source:

- Constitute the Windy Harbour Water Reserve under the *Country Areas Water Supply Act 1947* (Figure A4) to ensure its protection via the application of by-laws and ability to be recognised in land use planning (Department of Water and Environmental Regulation).
- Assign a P1 area to the Windy Harbour Water Reserve, and 500 m wellhead protection zones around the two drinking water bores (Figure A4) (Department of Water and Environmental Regulation).
- Include the Windy Harbour Water Reserve as a special control area in its local planning scheme (Shire of Manjimup).
- Consider alternative energy sources for powering the bore pumps (i.e. solar) to avoid the risk of storing diesel in the water reserve (Shire of Manjimup).
- Ensure adequate incident response procedures are in place to deal with a contamination event that may affect drinking water quality or availability (Shire of Manjimup).
- Ensure that incidents covered by Westplan–HAZMAT consider the location and purpose of the Windy Harbour Water Reserve (Shire of Manjimup).
- Maintain and enhance (where required) the security of the production and monitoring bores (Shire of Manjimup).
- Erect signs along the boundary of the Windy Harbour Water Reserve to alert people of its location and purpose, including an emergency contact phone number. Guidance on the format can be provided by Department of Water and Environmental Regulation (Shire of Manjimup).
- Conduct regular water quality and quantity monitoring and reporting to Department of Health as required (Shire of Manjimup).
- Undertake regular surveillance of the bores, tanks and surrounding water reserve (Shire of Manjimup).

- Finalise the risk management plan, incorporating any additional findings from this drinking water source protection assessment, and submit to Department of Health as required (Shire of Manjimup).
- Prepare a fully-consulted drinking water source protection plan to address risks to the Windy Harbour Water Reserve (Department of Water and Environmental Regulation).

# Appendices

## Appendix A — Figures

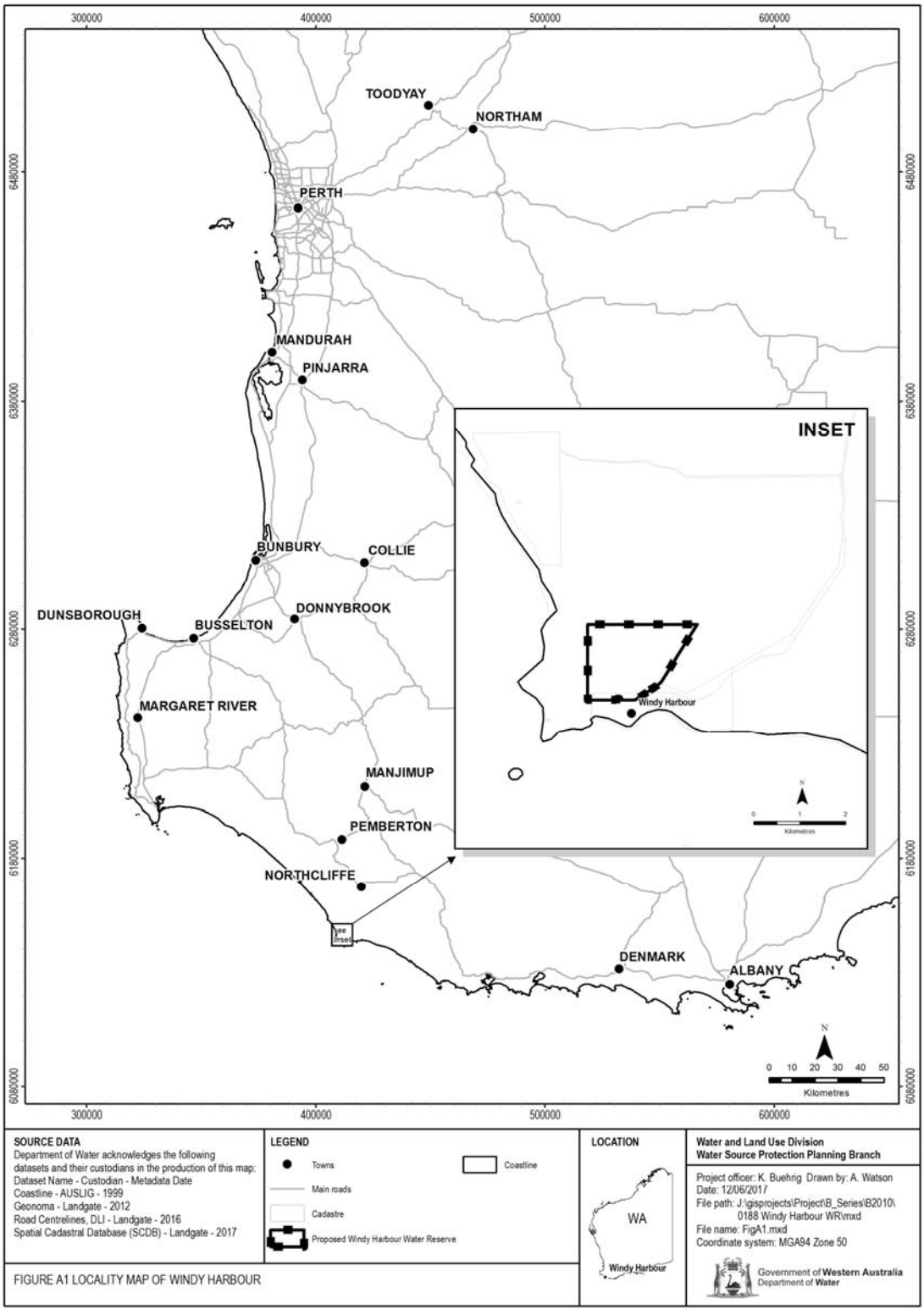


*Figure A1 Windy Harbour Water Reserve locality map*

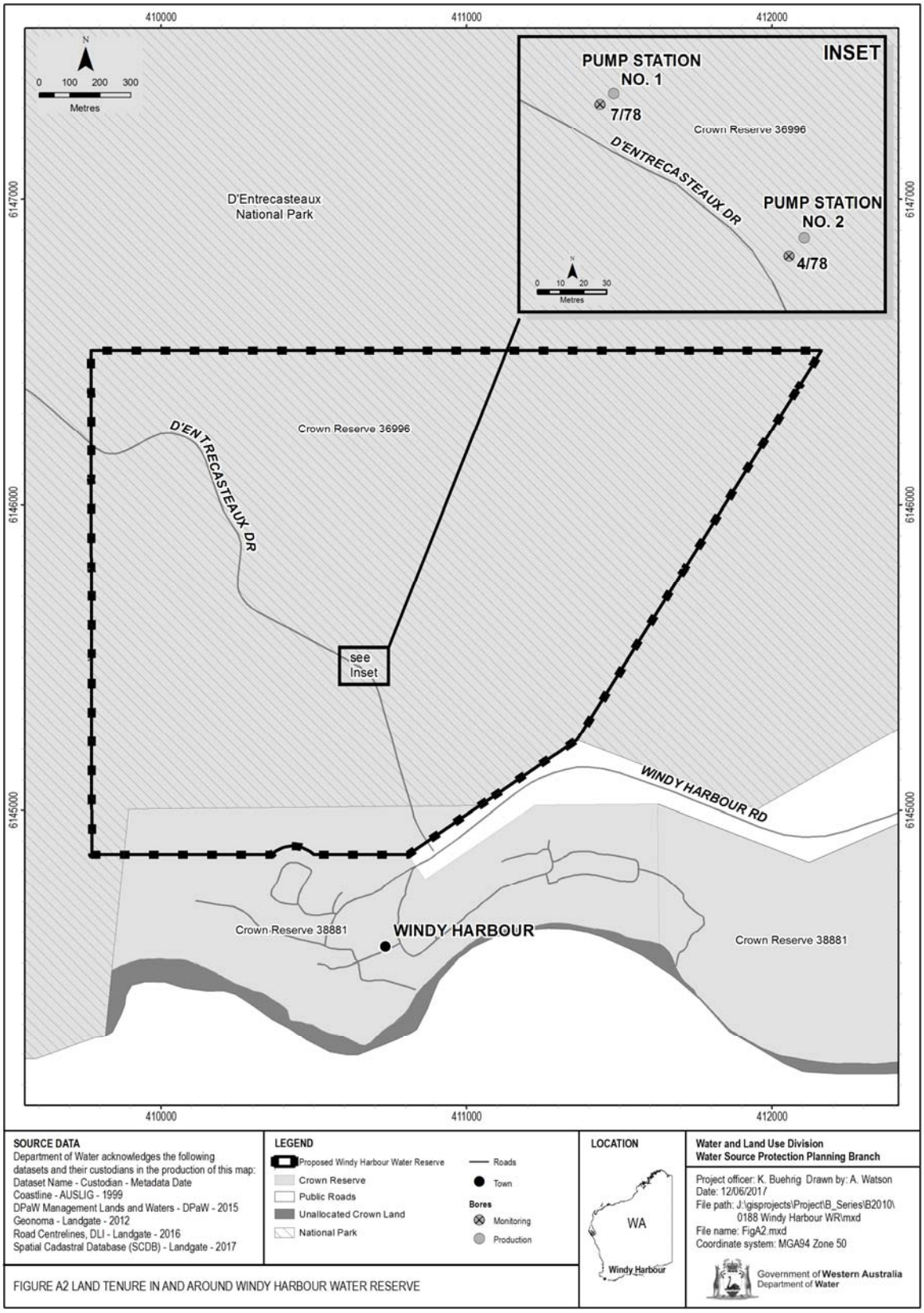


*Figure A2 Windy Harbour Water Reserve land tenure*


*Figure A3 Windy Harbour Water Reserve aerial photo and land uses*

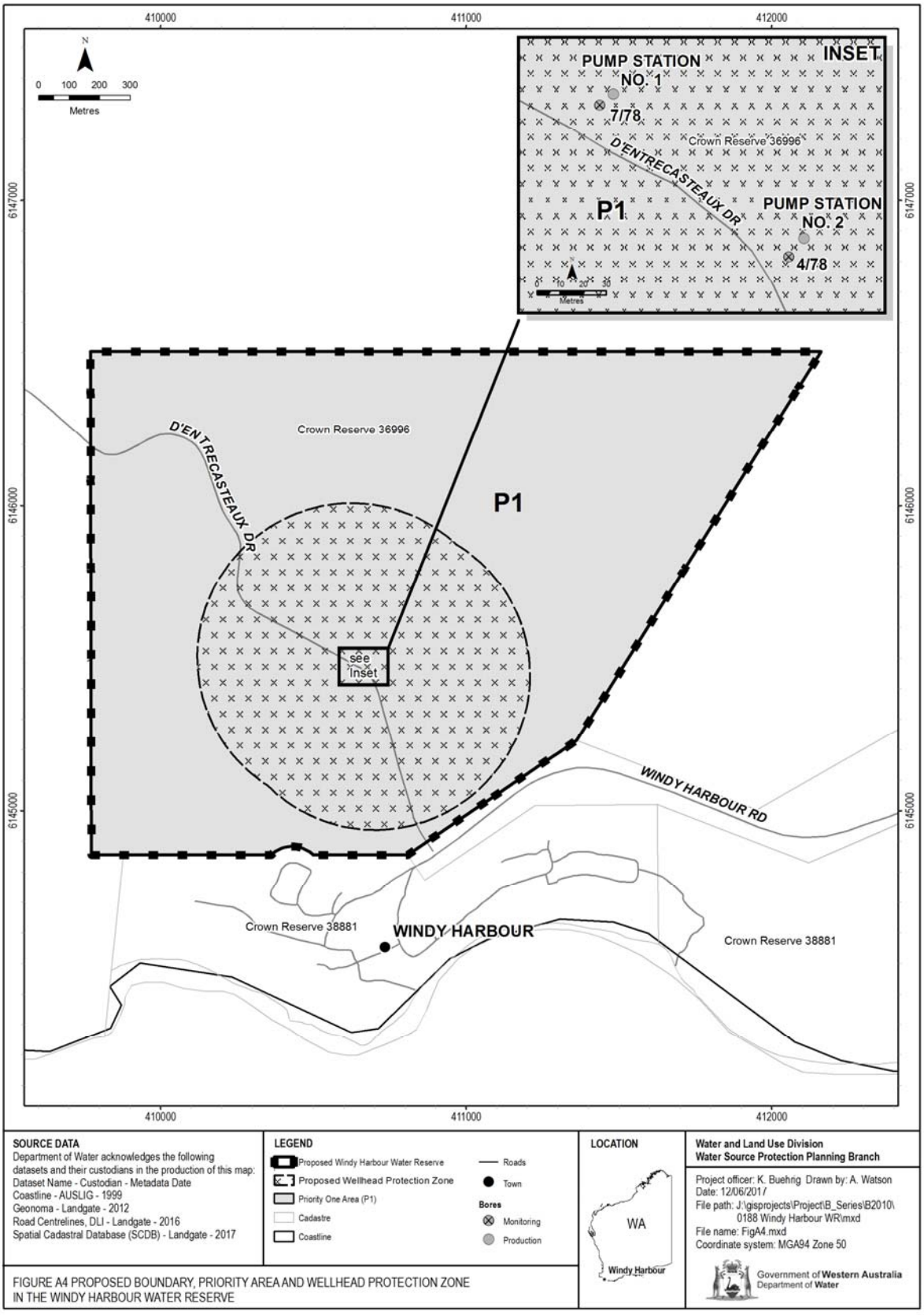


*Figure A4 Windy Harbour Water Reserve proposed boundary, priority areas and protection zones*

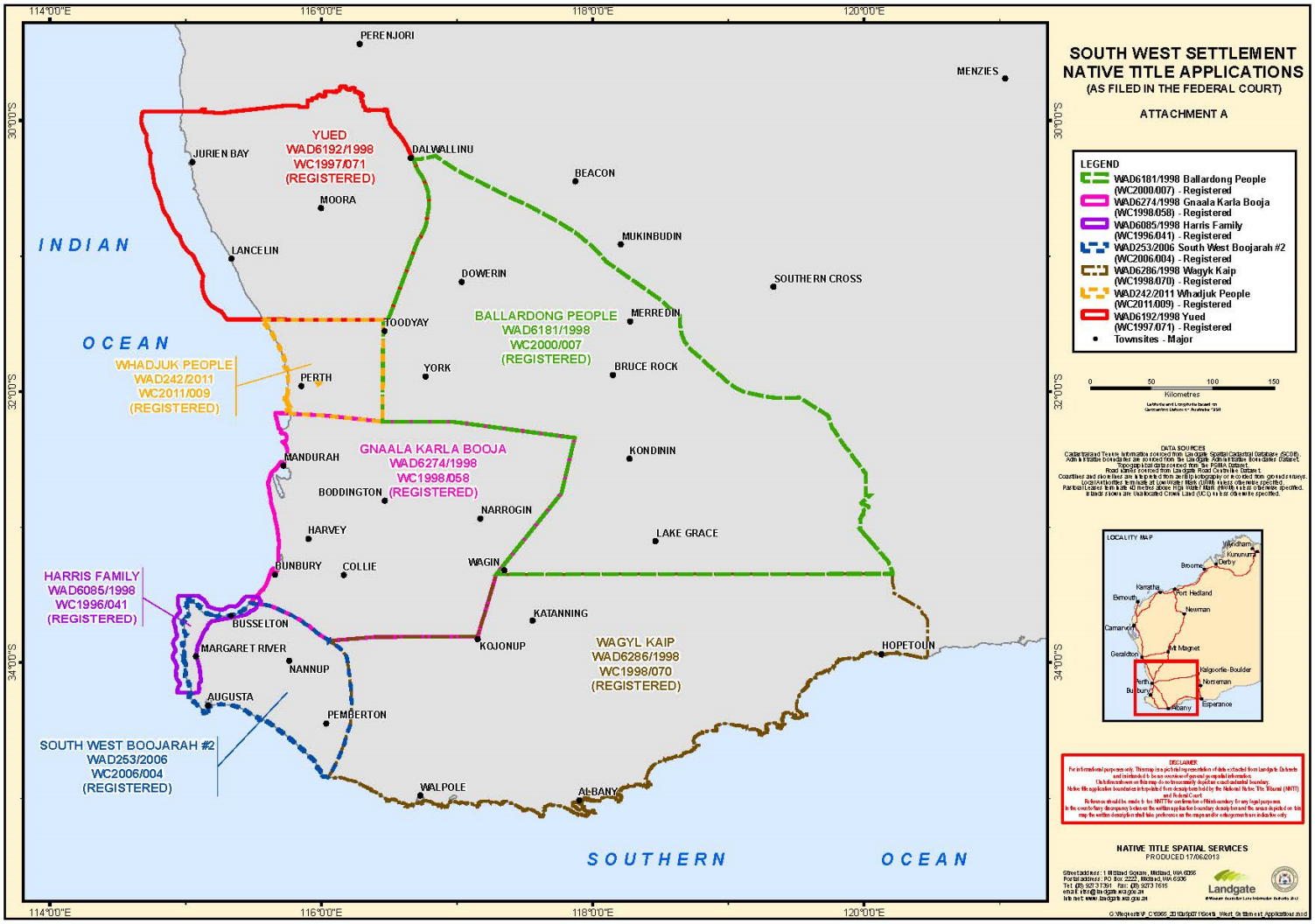


*Figure A5 South West Native Title Agreement area (source: Department of Premier and Cabinet)*

# Appendix B — Water quality data

**The water quality data in this appendix has been provided by the Shire of Manjimup.**

The following data represents the quality of raw water from the Windy Harbour bores. 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.

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 Windy Harbour, please contact the Shire of Manjimup.

*Table 1: Raw-water quality monitoring results from Windy Harbour's bores*

| Windy Harbour Reticulated Water Supply<br>Annual Chemical Source (raw) Water Sampling Results | | | | | |
|---|---|---|---|---|---|
| Category | Characteristic | ADWG Guidline Value | | 16 November 2015 Annual Source Bore 2 | 16 November 2016 Annual Source Bore 2 |
| | | Health | Aesthetic | WH RESULT Converted to mg/L | WH RESULT Converted to mg/L |
| Micro-organisms | Thermotolerant coliforms (or E. coli) | 98% nil | | est <1 | est <1 |
| Other Inorganic Chemicals | Arsenic | 0.01 | | 0.001 | 0.001 |
| | Barium | 2 | | 0.033 | 0.055 |
| | Boron | 4 | | 0.037 | 0.07 |
| | Iodide **(bi-annual)** | 0.5 | | | 0.1 |
| | Mercury | 0.001 | | 0.00005 | 0.00005 |
| | Molybdenum | 0.05 | | 0.001 | 0.001 |
| | Selenium | 0.01 | | 0.001 | 0.001 |
| | Silver **(bi-annual)** | 0.1 | | | 0.001 |
| | Uranium **(bi-annual)** | 0.017 | | | 0.0005 |
| | Zinc **(bi-annual)** | | 3 | 0.033 | |
| Organic Compounds Industrial Hydrocarbons 1 (other than disinfection by-products) **(bi-annual)** | Benzene | 0.001 | | | 0.0002 |
| | Chlorobenzene | 0.3 | 0.01 | | 0.001 |
| | Dichlorobenzenes 1,2-dichlorobenzenes | 1.5 | 0.001 | | 0.0005 |
| | Dichlorobenzenes 1,3-dichlorobenzenes | | 0.02 | | 0.001 |
| | Dichlorobenzenes 1,4-dichlorobenzenes | 0.04 | 0.0003 | | 0.0002 |
| | Dichlorethanes 1,1-dichloroethane | | | | 0.0005 |
| | Dichlorethanes 1,2-dichloroethane | 0.003 | | | 0.002 |
| | Dichlorethenes 1,1-dichloroethene | | | | 0.001 |
| | Dichlorethenes 1,2-dichloroethene | 0.03 | | | 0.0005 |
| | Dichloromethane (methylene chloride) | 0.004 | | | 0.004 |
| | Epichlorohydrin | 0.0005 | | | 0.0002 |
| | Ethylbenzene | 0.3 | 0.003 | | 0.001 |
| | Ethylenediamine tetraacetic acid (EDTA) | 0.25 | | | 0.08 |
| | Hexachlorobutadiene | 0.0007 | | | 0.0003 |
| | Nitrilotriacetic acid (NTA) | 0.2 | | | 0.05 |
| | Styrene (vinylbenzene) | 0.03 | 0.004 | | 0.001 |
| | Trichlorobenzenes (total) | 0.03 | 0.005 | | 0.001 |
| | 1,1,1 Trichloroethane | | | | 0.002 |
| | Vinyl Chloride | 0.0003 | | | 0.0001 |
| Organic Compounds Industrial Hydrocarbons 2 (other than disinfection by-products) | Organotins dialkyltins **(bi-annual)** | | | | 0.000002 |
| Organic Compounds (other than disinfection by-products) **(bi-annual)** | Tetrachloroethene (Perchloroethylene, tetrachloroethylene) | 0.05 | | 0.0005 | 0.001 |
| | Trichloroethene (TCE) | | | | 0.001 |
| Radiological Characteristics **(2-5 yearly)** | Gross Alpha | 0.1 Bq/l | | | |
| | Gross Beta | 0.5 Bq/l | | | |

Since this table was produced, additional water quality data has become available for April–June 2017. The pH is 7.65 (meeting the ADWG aesthetic guideline value of 6.5–8.5), true colour is 30 HU (exceeding the ADWG aesthetic value of 15) and turbidity is 1.8 NTU (less than the ADWG aesthetic value of 5).

# Appendix C — Photographs

*Figure C1 Windy Harbour Water Reserve (looking east with pump stations in view)*

*Figure C2 Pump station no. 1*

*Figure C3 Fence surrounding bore compound of Pump station no. 1 (Pump station no. 2 has similar fencing)*

*Figure C4 Pump station no. 2*


*Figure C5 Shed housing Pump station no. 2 (Pump station no. 1 has a similar shed)*

*Figure C6 Water storage tanks*


*Figure C7 Chlorine storage at Pump station no. 1*

*Figure C8 D'Entrecasteaux Drive adjacent to Windy Harbour's drinking water bores*

# Appendix D — Typical contamination risks in groundwater sources

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

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

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

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

### *Microbiological risks*

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

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

In groundwater sources, this occurs indirectly. Faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (for example *Salmonella*, *Escherichia coli* and cholera), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. Monitoring for

the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water.

The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 to 4.3 per cent of people are infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

The survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and inactivation rate) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature and pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, some reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1000–1600 m in channelled limestone
- 250–408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

Unlike chemicals, which dissipate and dilute when they enter a water source, pathogens can multiply under the right conditions, increasing the likelihood of contamination. Therefore it is important to understand both the surface water and groundwater systems to be able to protect the drinking water source from pathogens.

Given the wide variety of pathogens, their behaviour in the environment and the potential consequences of consuming contaminated water, the most effective way to protect public health and reduce water treatment costs is to avoid the introduction of pathogens into a water source.

### *Physical risks*

Turbidity is the result of soil or organic particles becoming suspended in water. Increased turbidity can result in cloudy or muddy-looking water, which is not aesthetically appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens and chemicals can attach 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.

Research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That's why this drinking water source protection report is important. We should not forget that ultimately it's about safeguarding your health by protecting water quality now and for the future.

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

In Western Australia, the Department of Water and Environmental Regulation 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 PDWSAs.

An important step in maximising the protection of water quality in PDWSAs is to define their boundaries, priority areas and protection zones to help guide land use planning and to identify where legislation applies. Our Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a) describes how we do this. It is available www.dwer.wa.gov.au.

There are three different priority areas. The objective of priority 1 (P1) areas is risk avoidance – ensuring there is no degradation of the water quality (for example over Crown land). The objective of priority 2 (P2) areas is risk minimisation – maintaining or improving water quality (for example over rural-zoned land). The objective of priority 3 (P3) areas is risk management – maintaining the water quality for as long as possible (for example, urban- or commercial-zoned land). Protection zones surround drinking water abstraction bores and surface water reservoirs so that the most vulnerable areas are protected from contamination.

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

With approximately 130 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 Environmental Regulation) 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 read our Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a). You can also contact the Department of Water and Environmental

Regulation’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 Department of Water and Environmental Regulation*

| **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 program has resulted in the development of four Western Australian Planning Commission state planning policies (SPPs), recognising the importance of PDWSAs for the protection of water quality and public health:

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

This integrated program relies upon a risk assessment process based on 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* |
| **AHD** | Australian height datum |
| **ANZECC** | Australian and New Zealand Environment Conservation Council |
| **HACCP** | hazardous analysis and critical control points |
| **ILUA** | Indigenous land use agreement |
| **NHMRC** | National Health and Medical Research Council |
| **NRMMC** | Natural Resource Management Ministerial Council |
| **P1, P2, P3** | priority 1, priority 2, priority 3 |
| **PDWSA** | public drinking water source area |
| **WALCO** | Western Agricultural Lime Company |
| **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. |
| **HU** | hazen units | A measure of colour in water. |
| **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. |
| **mm** | millimetres | A measure of length. |
| **NTU** | nephelometric turbidity units | A measure of turbidity 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 year (kL/y). |
| **Aquifer** | A geological formation or group or formations able to receive, store and transmit significant quantities of water. |
| **Australian drinking water guidelines** | The *National water quality management strategy: Australian drinking water guidelines 6* (ADWG; NHMRC & NRMMC 2011) outlines acceptable criteria for the quality of drinking water in Australia (see *References*). |
| **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). |
| **Catchment** | The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater. |
| **Constitute** | Define the boundaries of any catchment area or water reserve by Order in Council under the *Country Areas Water Supply Act 1947* or by Proclamation under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*. |
| **Contamination** | A substance present at concentrations exceeding background levels that presents – or has the potential to present – a risk of harm to human health, the environment, water resources or any environmental value. |
| **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. |
| **Hydrogeology** | The branch of geology that deals with the occurrence, distribution and effects of groundwater. It is the study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality. |
| **Leaching/ leachate** | The process by which materials such as organic matter and mineral salts are washed out of a layer of soil or dumped material by being dissolved or suspended in percolating rainwater. The material washed out is known as leachate. Leachate can pollute groundwater and waterways. |
| **Nutrients** | Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth. |
| **Pathogen** | A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. |
| **Permeability** | Also referred to as hydraulic conductivity, this is the ability of a rock or soil unit to transmit fluids. Its magnitude depends on the size of the pore spaces (see porosity) and the degree to which they are interconnected. |
| **Pesticides** | Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms. |
| **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. |
| **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*. |
| **Priority 1, 2 and 3** | Three different priority areas are assigned within PDWSAs to guide land use decisions. The objective of priority 1 (P1) areas is *risk avoidance*, priority 2 (P2) areas is *risk minimisation* and priority 3 (P3) areas is *risk management*. |
| **Recharge** | The action of water infiltrating through the soil/ground to replenish an aquifer. |
| **Recharge area** | An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface. |
| **Runoff** | Water that flows over the surface from a catchment area, including streams. |
| **Scheme supply** | Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation. |
| **Semi-confined aquifer** | A leaky aquifer, saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable. |
| **Superficial aquifer** | Shallow (near to the surface) aquifers which are easily recharged and can be readily accessed by bores. |
| **Treatment** | Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment. |
| **Turbidity** | The cloudiness or haziness of water caused by the presence of fine suspended matter. |
| **Unconfined aquifer** | An aquifer where the upper boundary is the watertable and therefore is in contact with the atmosphere through the pore spaces in the unsaturated zone. Typically (but not always) it is the shallowest aquifer at a given location. |
| **Water quality** | Collective term for the physical, aesthetic, chemical and biological properties of water. |

| | |
|---|---|
| **Water reserve** | An area proclaimed under the *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* for the purposes of protecting a drinking water supply. |
| **Watertable** | The upper saturated level of the unconfined groundwater. |
| **Wellhead** | The top of a well (or bore) used to draw groundwater. |
| **Wellhead protection zone** | Usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination risks. |
| **Westplan–HAZMAT** | State emergency management plan for hazardous materials emergencies. |

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