Department of Water
Government of Western Australia

Looking after all our water needs

Bunbury Water Reserve drinking water source protection plan

Bunbury and Dalyellup water supplies

Water resource protection series

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June 2008

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Cover photograph: View of Bunbury, taken by Alana Thorpe.

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Preface

The Department of Water has prepared this draft drinking water source protection plan to assess risks to water quality within the proposed Bunbury Water Reserve and to recommend management strategies to avoid, minimise or manage those risks. The department is committed to protecting drinking water sources to meet public health requirements and ensure the supply of safe, good quality drinking water to consumers.

The *Australian drinking water guidelines* (NHMRC & NRMMC 2004a) recommend a risk-based, multiple-barrier approach to protect public drinking water sources. Catchment protection is the first barrier against contamination, with subsequent barriers implemented at the water storage, treatment and distribution stages of a water supply system. Catchment protection requires an understanding of the catchment, the hazards and hazardous events that can compromise drinking water quality, and development of preventative strategies and operational controls to ensure the safest possible water supply.

This plan details the location and boundary of the drinking water catchment which provides potable water to the Bunbury and Dalyellup town water supplies. It discusses existing and future use of the water source, describes the water supply system, identifies risks and recommends management approaches to address these risks and maximise protection of the water reserve.

State and local government agencies should use this plan to guide land use planning in this water reserve. The water reserve should be recognised in the City of Bunbury's and Shire of Capel's town planning schemes, consistent with the Western Australian Planning Commission's Statement of planning policy No. 2.7 – *Public drinking water source policy*. Other stakeholders should use this document as a guide for protecting the quality of water in the Bunbury Water Reserve.

The stages involved in preparing this drinking water source protection plan were:

Stages in development of a plan		Comment
1	Conduct stakeholder consultation.	Advice sought from key stakeholders using the assessment as a tool for information and discussion.
2	Prepare draft drinking water source protection plan.	Draft plan developed taking into account input from stakeholders and any additional advice received.
3	Release draft drinking water source protection plan.	Draft plan released for a six-week public consultation period.
4	**Publish approved drinking water source protection plan.**	**Final plan published after considering advice received in submissions. Includes recommendations on how to protect water quality.**

Summary

The City of Bunbury is located in the South West Region of Western Australia, approximately 160 km south of Perth, and Dalyellup is located a further 7 km south of Bunbury in the Shire of Capel. The proposed Bunbury Water Reserve extends approximately 12 km along the coast from the centre of Bunbury to south of Dalyellup. Drinking water supply bores in this area are operated by two independent water service providers; Aqwest and Water Corporation, who supply Bunbury and Dalyellup respectively.

Drinking water bores for Bunbury and Dalyellup source water from the Yarragadee aquifer, which is generally unconfined in the vicinity of Bunbury Water Reserve. In some areas (such as in the locality of the Dalyellup bores) clay layers are present and the aquifer is semi-confined. Unconfined sources (and to a certain extent semi-confined sources) are vulnerable to contamination from current, historical and future land uses in the area. Current land uses in the area include urban development (consisting largely of residential and commercial land uses), regional open space, recreation, extractive industries, a wastewater treatment plant and a waste disposal site. Potentially contaminating historical land uses include decommissioned landfill sites and former service stations.

This plan recommends that the Bunbury Water Reserve be gazetted under the *Country Areas Water Supply Act 1947* to help protect the Bunbury and Dalyellup drinking water sources. The water reserve boundary was defined on the basis of the local hydrogeology and hydrology, which determines the potential for contamination. The water reserve has been classified as priority 3 and wellhead protection zones have been designated around each of the bores. Priority 3 areas are declared over land where water supply sources need to coexist with other land uses, such as urban development (as occurs in Bunbury and Dalyellup). These areas are defined to manage the risk of pollution to drinking water sources through adoption of best management practices for land uses and activities within the water reserve.

The plan makes the following major recommendations:

- The water reserve boundary should be gazetted under the *Country Areas Water Supply Act 1947*.
- The water reserve boundary, priority areas, wellhead protection zones and management principles outlined in this plan should be recognised in the Shire of Capel and City of Bunbury town planning schemes and other applicable schemes and strategies.
- Any development proposals that are inconsistent with the water quality protection note – *Land use compatibility in public drinking water source areas* (Department of Environment 2004a) or this protection plan should be referred to the Department of Water for advice and recommendations.

- Best management practices for current and approved land uses within the water reserve should be implemented.
- All potentially contaminated sites within Bunbury Water Reserve should be assessed and remediated (if required) under the *Contaminated Sites Act 2003*.

1 Drinking-water source overview

1.1 Existing water-supply system

Bunbury is located in the South West Region of Western Australia, approximately 160 km south of Perth. The City of Bunbury has a population of approximately 29 700 (Australian Bureau of Statistics 2006). Dalyellup is a major subdivision located approximately 7 km south of Bunbury in the Shire of Capel (Figure 1).

The proposed Bunbury Water Reserve stretches approximately 12 km along the coast from the centre of Bunbury to Five Mile Creek, south of Dalyellup. Drinking water bores within Bunbury Water Reserve are operated by two independent water service providers; Aqwest and Water Corporation.

Aqwest operate a total of 12 production bores, which supply water to the City of Bunbury, Eaton and Australind. Eight of these bores (Irwin 1 and 2, Spencer 1 and 2, Hastie 1 and 2 and Tech 1 and 5) are located within Bunbury Water Reserve. The remaining four bores operated by Aqwest (Skewes 1 and 2, Robinson 3 and Tech 4) are located in the confined area to the east of Bunbury Water Reserve. They will be covered by a future source protection plan and so will not be discussed further in this plan. Hastie 2 and Irwin 2 were not used during 2006–07 due to high levels of iron and total dissolved solids.

The Water Corporation operate two bores within Bunbury Water Reserve (1/99 and 1/05), which supply water to Dalyellup. Bore 1/05 is currently the main production bore, with 1/99 being used as a back-up bore.

All bores operated by Aqwest and Water Corporation are screened within the Yaragadee formation, with depths ranging from as shallow as approximately 34 m to as deep as approximately 270 m. Table 1 provides a summary of the screened depth for each of the production bores within Bunbury Water Reserve. The location of the production bores is shown in Figure 2.

Table 1 Screened depth for drinking water production bores in Bunbury Water Reserve

Water service provider	Bore name	Screened depth (m below ground level)
Aqwest	Hastie 1	123.7–129.5 132.6–151
	Hastie 2	80.6–95.6
	Irwin 1	72.7–84.7
	Irwin 2	73–87
	Spencer 1	34–56
	Spencer 2	53.3–56.3 60.9–82.4
	Tech 1	56.2–71.4
	Tech 5	272–342
Water Corporation	1/99	102.6–144.4
	1/05	202.2–250.4

1.2 Water treatment

Aqwest manage four drinking water treatment plants within Bunbury Water Reserve located next to or near the bores. Treatment includes aeration, dry sand filtration and chlorination.

Water Corporation operates one drinking water treatment plant located adjacent to their production bores. Treatment consists of aeration, clarification, filtration and chlorination.

These processes help to reduce iron, manganese and hardness, which all occur at naturally high levels in the regional groundwater source. Chlorination also provides a disinfection barrier.

It should be recognised that although treatment and disinfection are essential barriers to ensure a safe, good quality drinking-water supply, catchment management is the fundamental first barrier against contaminants for protecting water quality. This approach is endorsed by the *Australian drinking water guidelines* (NHMRC & NRMMC 2004a) and reflects a risk-based, catchment-to-consumer, multiple-barrier approach for providing safe drinking water to consumers. The combination of catchment protection and drinking water treatment delivers a safer drinking water source than either barrier could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The Swan Coastal Plain in the Bunbury region is a flat to gently undulating sand plain. Hills are generally lower than 30 m Australian Height Datum. Numerous shallow drainage lines cross the plain, draining to wetlands and the sea. There are many extensive wetland areas which are hydraulically connected to the superficial aquifer and possibly the Leederville aquifer.

The Swan Coastal Plain terminates at the Darling Scarp to the east and the Whicher Scarp to the south.

1.3.2 Climate

The region has a Mediterranean type climate, with warm dry summers and cool wet winters. The average maximum temperature range is from 17.3 ^{o}C in August and July to 29.6 ^{o}C in February. The average minimum temperatures range from 7.3 ^{o}C in July to 15.5 ^{o}C in February. Average annual rainfall for Bunbury (since 1995) is 727 mm, with the majority of rainfall falling during the months of June and July (Bureau of Meteorology 2008).

1.3.3 Hydrogeology

From the surface, the formations in the Bunbury region are: superficial formations, Leederville Formation, Yarragadee Formation, and the Cockleshell Gully Formation. The Bunbury Basalt unconformably separates the Leederville Formation and the deeper Yarragadee Formation in an area south of Bunbury.

The superficial formations are generally thin (up to 20 m thick) and consist of predominantly sands, forming an unconfined aquifer that is recharged by direct infiltration of rainfall.

The Leederville Formation consists of interbedded sand and shale. The thickness of the formation in the Bunbury Trough ranges from 150 to 200 m. The formation contains a confined aquifer, and also acts to confine the deeper Yarragadee Formation. The Leederville aquifer is absent from an area extending approximately 25 km south of Bunbury (Figure 3).

The Yarragadee Formation consists of weakly consolidated sandstone, siltstone and shale. Sandstone is the dominant lithology, comprising about 70 per cent of the formation. The thickness of the formation ranges from 600 m to 1200 m, and extends to depths of up to 1500 m. The Yarragadee aquifer is generally confined with the exception of where it outcrops in areas of the Blackwood Plateau and in the area south of Bunbury (in the vicinity of Bunbury Water Reserve) where the Leederville Formation and the Bunbury Basalt are absent (Figure 3). Within Bunbury Water Reserve the Yarragadee aquifer is generally unconfined, although in a few places

(such as in the locality of the Dalyellup bores) clay layers are present and the aquifer is semi-confined.

The Cockleshell Gully Formation is about 1500 m thick and is composed of interbedded sandstone and grey shale. It is the oldest unit with groundwater potential. The aquifers in this formation are confined.

The Leederville Formation is recharged by direct infiltration of rainfall on the Blackwood Plateau, where the formation outcrops.

The Yarragadee Formation is recharged by direct infiltration of rainfall where the formation outcrops on the Blackwood Plateau (Department of Water 2008). This is considered to be in the Nannup area. The aquifer is also recharged by leakage from the overlying Leederville aquifer south of the Whicher Scarp. However, even over large areas the leakage rates are likely to be low, due to the extensive clay units through the Leederville Formation. Some recharge also occurs through the superficial formations between Bunbury and Capel.

The regional groundwater flow in the Leederville and Yarragadee aquifers is to the north west changing to more westerly as you go further north. Carbon dating indicates that water in the Yarragadee aquifer is in the order of 40 000 years old (Thorpe 1994).

1.4 Future water supply requirements

Due to aesthetic water quality issues (high total dissolved solids and iron) in bores close to the coast and predicted increases in demand, Aqwest will be looking to develop new production bores to the east of Bunbury (outside of the proposed Bunbury Water Reserve), where the aquifer is confined. New bores to the east of Bunbury are expected to replace the existing coastal bores within the next five years.

Water Corporation is currently looking to develop a third production bore in order to meet predicted increases in demand. This is expected to be located further inland (within the water reserve boundary) from the existing bores in order to avoid potential salinity issues.

1.5 Protection and allocation

1.5.1 Existing water source protection

Bunbury Water Reserve is not currently proclaimed under the *Country Areas Water Supply Act 1947*.

Current measures that are undertaken by Water Corporation and Aqwest to ensure water source protection include fencing of the bore compounds, bore maintenance and water quality monitoring.

1.5.2 Current allocation licence

Water resource use and conservation in Western Australia is administered by the Department of Water in accordance with the *Rights in Water and Irrigation Act 1914*. Under the act, the right to use and control surface and groundwater is vested with the Crown. This act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within proclaimed groundwater areas.

The Bunbury Groundwater Area was proclaimed in 1975. The draft *South West groundwater areas water management plan – allocation* (Department of Water 2008) provides guidance on the abstraction and use of groundwater resources within proclaimed South West groundwater areas (including Bunbury Groundwater Area).

Abstraction details for each water utility in Bunbury Groundwater Area are detailed in Table 2.

Table 2 Allocation licences for public drinking water supply

Water utility	Supply	Sub area	Licensed allocation (ML/year)	Extraction during 06/07 (ML/year)
Aqwest	City of Bunbury	South Bunbury[a]	4400	2140
		East Bunbury[b]	4800	4626
Water Corporation	Dalyellup	Gelorup–Stratham	1000	1043

[a]Includes Hastie 1 and 2, Irwin 1 and 2 and Spencer 1 and 2
[b]Includes Robertson 3, Skewes 1 and 2 and Tech 1, 4 and 5

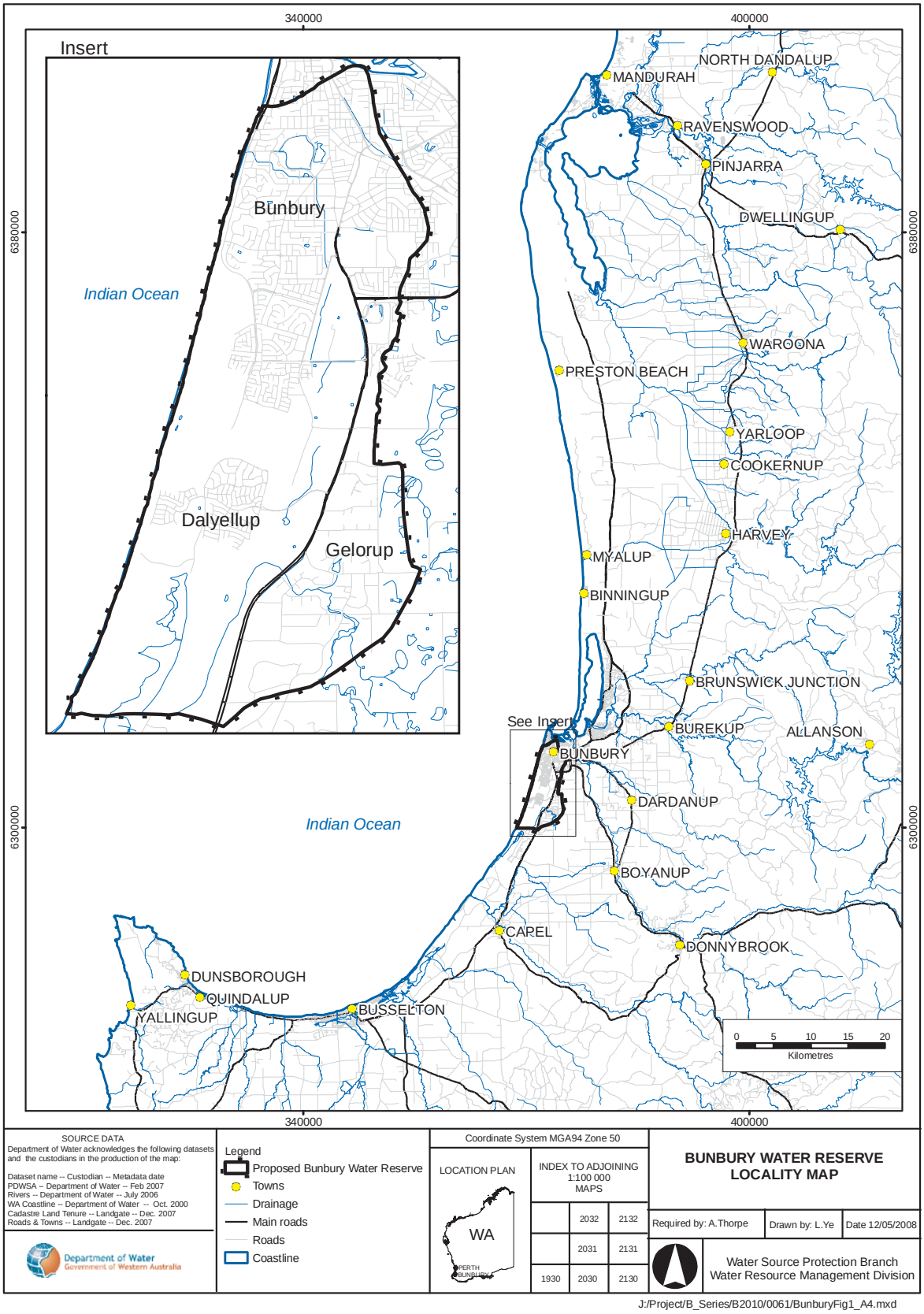

Figure 1 Proposed Bunbury Water Reserve locality map

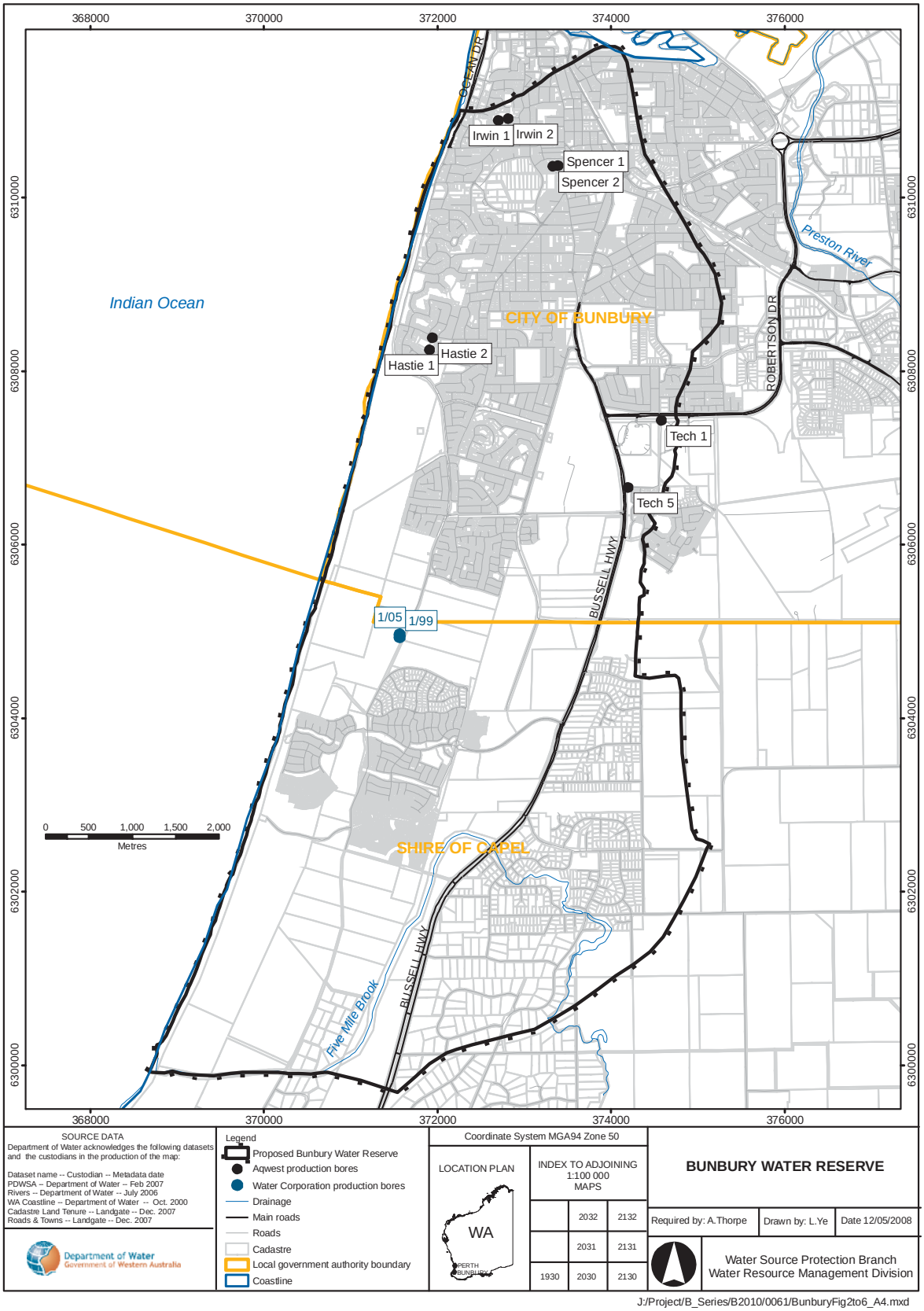

Figure 2 Proposed Bunbury Water Reserve

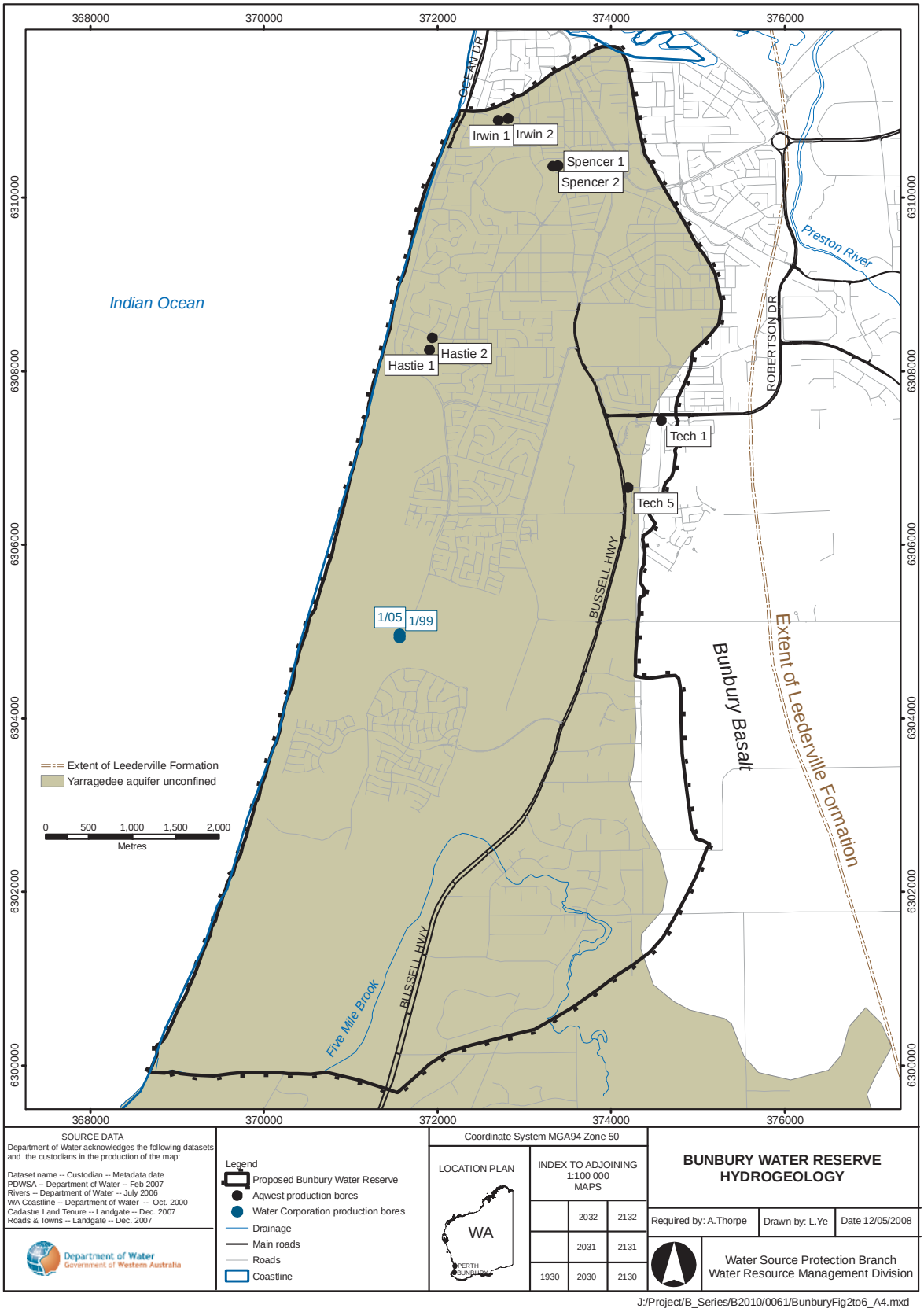

Figure 3 Hydrogeology of the Bunbury region

2 Water quality monitoring and contamination risks

A wide range of factors can impact on water quality and therefore affect the provision of safe, good quality, aesthetically acceptable drinking water to consumers.

The Water Corporation and Aqwest regularly monitor the quality of raw water from the Bunbury wellfield for microbiological contamination, and health related and aesthetic (non-health related) characteristics in accordance with the *Australian drinking water guidelines* (NHMRC & NRMMC 2004a). Monitoring results are reviewed by an intergovernmental committee, chaired by the Department of Health, called the Advisory Committee for the Purity of Water.

A water quality summary for the Dalyellup and Bunbury wellfields is presented in Appendices A and B respectively. For more information on water quality from Water Corporation bores, see the Water Corporation's most recent *Drinking Water Quality Annual Report* at <www.watercorporation.com.au > Water > Water quality > Latest report > Drinking water quality annual report. For more information on water quality from Aqwest bores, see Aqwest's most recent quarterly report at <www.aqwest.wa.gov.au> > Customers > Water quality > Aqwest's quarterly annual performance.

Contamination risks relevant to the Bunbury Water Reserve are described below.

2.1 Microbiological

Pathogens are types of micro-organisms that are capable of causing diseases. These include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness are mostly found in the faeces of humans and domestic animals.

There are a number of pathogens that are commonly known to contaminate water supplies worldwide. These include bacteria (e.g. *salmonella*, *Escherichia coli* and *cholera*), protozoa (e.g. *cryptosporidium*, *giardia*) and viruses. *Escherichia coli* counts are a way of measuring these pathogens and are an indicator of faecal contamination.

Pathogen contamination of a drinking water source is influenced by the existence of pathogen carriers (i.e. humans and domestic animals such as dogs or cattle), their transfer to and movement in the water source and the ability of the pathogen to survive in the water. The percentage of humans in the world that carry various 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 effect on people consuming drinking water that is contaminated with pathogens varies considerably, ranging from mild illness (such as stomach upset or diarrhoea)

to death. In 2000 in Walkerton, Canada seven people died due to contamination of the town water source and supply by a pathogenic strain of *Escherichia coli* and *campylobacter* (NHMRC & NRMMC 2004b). Preventing the introduction of pathogens into the water source is the most effective barrier in avoiding this public health risk.

2.2 Health related

A number of chemicals (organic and inorganic) in drinking water are of concern from a health perspective because they are potentially toxic to humans. Chemicals usually occur in drinking water sources attached to suspended material, such as soil particles, and may result from natural leaching from mineral deposits or overlying land uses (NHMRC & NRMMC 2004b).

Pesticides include agricultural and household chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides and other chemicals may occur as a result of accidental spills and/or incorrect use, overuse or leakage from storage areas. In such cases, prompt action is required to notify relevant authorities and clean up the spill.

Nutrients (such as nitrogen) can enter drinking-water supplies as a result of leaching from fertiliser application septic tanks, and from faeces of domestic animals (such as cattle grazing on the land). Nitrate and nitrite (ions of nitrogen) can be toxic to humans at high levels, with infants less than three months old being most susceptible (NHMRC & NRMMC 2004a).

Hydrocarbons (e.g. fuels, oils) are potentially toxic to humans, and harmful by-products may be formed when they are combined with chlorine in the water treatment process. Hydrocarbons can occur in water supplies due to vehicle accidents, spills during refuelling and leakage from storage areas.

2.3 Aesthetic

Impurities in drinking water can affect the aesthetic qualities of water such as its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, water that is cloudy and has a distinctive colour may not be harmful (NHMRC & NRMMC 2004b).

Iron and dissolved organic matter can affect the colour and appearance of water and salinity can affect the taste.

Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes.

The *Australian drinking water guidelines* (NHMRC & NRMMC 2004a) set out aesthetic guidelines to meet the aesthetic requirements of consumers and to protect water infrastructure.

2.4 Groundwater bores

Under the provisions of sections 26D and 5C of the *Rights in Water and Irrigation Act 1914*, a licence is required to construct a bore or extract water (unless exempt under the *Rights in Water and Irrigation Exemption and Repeal* (Section 26C) Order 2001) within a proclaimed groundwater area. The Bunbury Water Reserve is located within the Bunbury Groundwater Area.

Any bores drilled near to a public drinking water supply bore have the potential to contaminate the drinking water source. For example, a poorly constructed bore may introduce contaminants through surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer. If a public drinking water source bore is being used nearby, it may abstract some of the contaminated water.

It is important to ensure that any bores are appropriately located and constructed in order to prevent contamination and any other effects on the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914.*

All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Minimum Bore Specifications Committee 2003).

3 Land-use assessment

3.1 Existing land uses and activities

Table 3 describes the proposed management strategies for the following land uses and activities which occur in Bunbury Water Reserve. Figures 4 and 5 show the land tenure and location of activities described.

3.1.1 Regional open space

The *Greater Bunbury Regional Scheme* (Western Australian Planning Commission 2007) designates a number of areas within the Bunbury Water Reserve as being reserved for regional open space. These areas have been defined to "protect the natural environment, provide recreational opportunities, safeguard important landscapes and provide for public access" (Western Australian Planning Commission 2007).

The major areas of regional open space within the water reserve are:

- Maidens Reserve
- Shearwater Tuart Forest
- South Dalyellup Reserve
- Five Mile Brook Reserve
- Big Swamp Reserve

These areas can act as buffer zones to the bores from the surrounding urban development.

3.1.2 Urban

The majority of land within the water reserve is zoned urban or urban deferred in the *Greater Bunbury Regional Scheme* (Western Australian Planning Commission 2007).

Residential land is the major land use in the water reserve. Most of the urban area within Bunbury Water Reserve is connected to deep sewer, with the exception of some small pockets within Bunbury and a larger residential area in Gelorup (to the east of Dalyellup wellfield). In these areas wastewater is disposed via conventional septic tank systems. Wastewater disposal in septic tank systems poses a risk to the drinking water source due to potential nutrient and pathogen contamination. Other potential risks to water quality from residential areas include nutrient and chemical contamination from the use of fertilisers and pesticides on gardens and hydrocarbon contamination from fuel and oil use, storage and spills.

There is also a commercial area within the water reserve, which includes businesses such as car and caravan sale yards, mechanical servicing workshops, large retail outlets, drycleaners and shopping centres. Some commercial activities can pose a risk to drinking water sources due to the potential for leaks and spills of fuels, oils and chemicals.

There are seven operating fuel stations within the water reserve, as well as a number of former service stations (some with remaining underground storage tanks). Due to the large volumes of fuel stored in underground storage tanks at service stations, these facilities pose a high risk of the drinking water source becoming contaminated with hydrocarbons if there are any leaks or spills.

Other urban land uses within the water reserve include approximately 14 primary and secondary schools, part of the Edith Cowan University Campus, two caravan parks, numerous motels and a hospital. There is also an industrial laundry located in Gelorup along the Bussell Highway. The facility no longer operates as a laundry and is now only a receival and distribution depot. Whilst in operation wastewater from the laundry was partially recycled and irrigated on-site.

Bunbury will continue to expand on several fronts, particularly southwards through Dalyellup where there are additional areas of urban deferred land designated under the *Greater Bunbury Regional Scheme* (Western Australian Planning Commission 2007) to both the east and south of the Dalyellup wellfield. Development of at least one commercial centre and a middle school is planned for Dalyellup. Urban development can pose a risk to the water source when acid sulfate soils are disturbed. Acid sulfate soils are soils or sediment which contain iron sulfides and generally occur in low lying areas under waterlogged or highly reducing conditions. Exposure to air (e.g. through dewatering, excavation and drainage works associated with urban development) can cause the sulfides in the soil to oxidise, releasing sulfuric acid and iron into the soil and groundwater. Aluminium, nutrients and heavy metals (such as arsenic) can then also be released from the soil matrix by the acid (Department of Environment 2003). Acid sulfate soil risk areas have been identified within the Bunbury Water Reserve (Western Australian Planning Commission 2006a).

3.1.3 Special rural

The area south of Watkins Road, within the Bunbury Water Reserve is designated for special rural purposes in the *Shire of Capel Town Planning Scheme* (Department for Planning and Infrastructure 2007). The area is not connected to reticulated sewerage schemes and stables and equestrian activities are present on some lots. Shire of Capel planning controls within this area include:

- Minimum lot size of 2 ha.
- No more than one dwelling per lot.

- Clearing of vegetation requires council approval.
- 2 m vertical clearance is required between the base of a leach drain and the highest known water table.

A vineyard and winery is also identified in the *Shire of Capel Town Planning Scheme* (Department for Planning and Infrastructure 2007) within a special rural area. It is designated for subdivision and strata titling with the aim of developing a cooperative agricultural project. Uses designated as being permitted on the strata lots include a winery, one dwelling and one manager's house, sale of wine and agricultural products, tasting of wine and grazing of livestock (if it is incidental to the predominant use of the lot). Other uses that may be permitted, subject to council approval, include; a licensed restaurant, chalets and/or guesthouse (maximum of seven units), a caretaker's house and accommodation for full-time staff (Department for Planning and Infrastructure 2007). Strata lots in this area are approximately 2 ha in size.

Risks to the drinking water supply from the special rural areas include pathogen and nutrient contamination from septic tank systems and animals (e.g. horses and livestock) and nutrient and chemical contamination from the use of fertilisers and pesticides.

3.1.4 Recreation

The Hay Park Regional Recreation Centre consists of approximately 44 ha of sporting fields, as well as the South West Sports Centre, which contains swimming pools and indoor sporting facilities. In addition to the Hay Park centre there are also a number of other playing fields, e.g. football grounds, located within the water reserve. Potential contamination risks from parks and playing fields include nutrient and chemical contamination from the use of fertilisers and pesticides.

The Bunbury Turf Club and the Bunbury Trotting Club Course are located north east of Hay Park. Horse racing events are held at the Bunbury Turf Club from 1 November until late April each year. The trotting track is used year-round for horse training and events. Potential water quality risks from these facilities includes pathogen and nutrient contamination as a result of horse faeces and nutrient and chemical contamination from the use of fertilisers and pesticides on the tracks.

3.1.5 Extractive industry

Three basalt quarries are located east of Gelorup, one of which is located within Bunbury Water Reserve. Quarries have the potential to cause hydrocarbon contamination from leaks and spills of fuels and oils stored on-site or from any wastewater discharged from the site. The Department of Environment and Conservation licenses the quarries under Part V of the *Environmental Protection Act 1986*. Under this licence the proponents must meet conditions relating to quality of any water discharged from the premises and the storage and disposal of hydrocarbons.

3.1.6 Waste disposal

The Water Corporation operates the City of Bunbury wastewater treatment plant. The treatment plant is located on the coast approximately 530 m west (and downstream) of the existing production bores. The plant treats wastewater from the sewered properties within the City of Bunbury and Dalyellup. Approximately 6 ML of wastewater is treated daily on site to produce biosolids and tertiary quality treated wastewater. An upgrade to the wastewater treatment plant is planned in order to increase the plant's capacity and replace older treatment facilities. Historically, disposal of the treated wastewater was by ground infiltration in the surrounding foredune system. However, since June 2002, wastewater has been discharged via a 1.7 km deep ocean water outlet. Potential risks from this site include pathogen and nutrient contamination from solid waste ponds and historical wastewater disposal practices. The facility is licensed by the Department of Environment and Conservation under Part V of the *Environmental Protection Act 1986*.

Millennium Inorganic Chemical's solid waste disposal site is located south of the Bunbury wastewater treatment plant, approximately 1 km south west of the existing production bores. Solid waste from the company's titanium dioxide plant is disposed of in two interdunal depressions. Solid waste consists of a mixture of aluminium, calcium, chloride, chromium, iron, manganese, sulfur, titanium, vanadium and other trace elements. Potential risks from this site include heavy metal, hydrocarbon and radiation contamination. The facility is licensed by the Department of Environment and Conservation under Part V of the *Environmental Protection Act 1986*, with conditions relating to groundwater monitoring for a range of contaminants. The company are also required to monitor radiation, which is regulated by the Radiological Council of Western Australia. The waste disposal facility is expected to close in January 2010.

There are several former landfill sites located within the proposed water reserve; two within the Big Swamp Reserve, one at the end of Mangles Street, one near College Grove and one along Harewoods Road in Dalyellup. Landfills can cause groundwater contamination from a range of contaminants including pathogens, nutrients, hydrocarbons and heavy metals and their effects can be extensive and long-lived.

3.2 Proposed land uses and activities

Water Corporation proposes to irrigate playing fields and parks within Bunbury Water Reserve (such as Hay Park Regional Recreational Centre) with treated wastewater in the future. Irrigation with treated wastewater is compatible with conditions (related to the quality and quantity of water irrigated) in priority 3 areas.

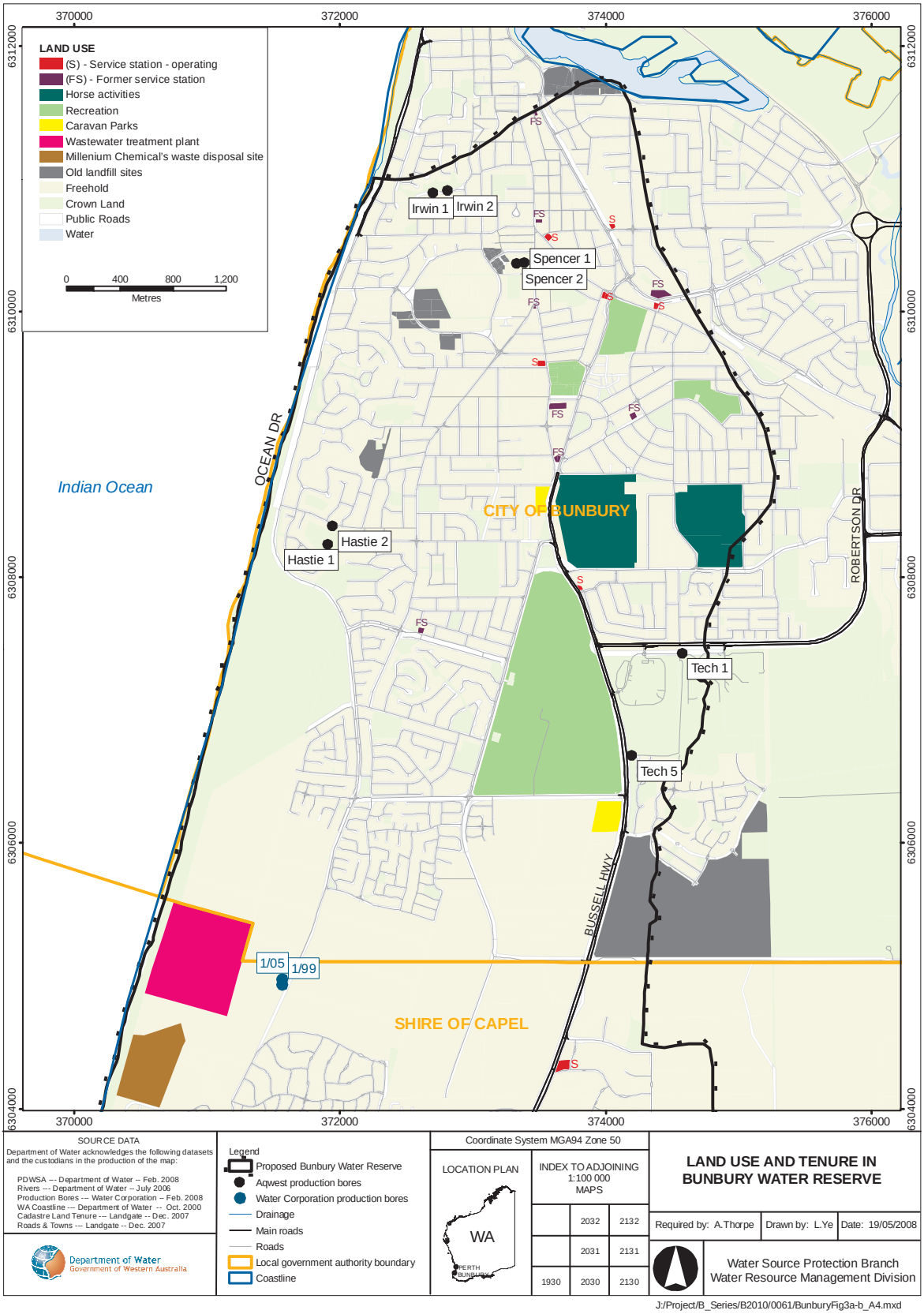

Figure 4 Land use and tenure in Bunbury Water Reserve, City of Bunbury

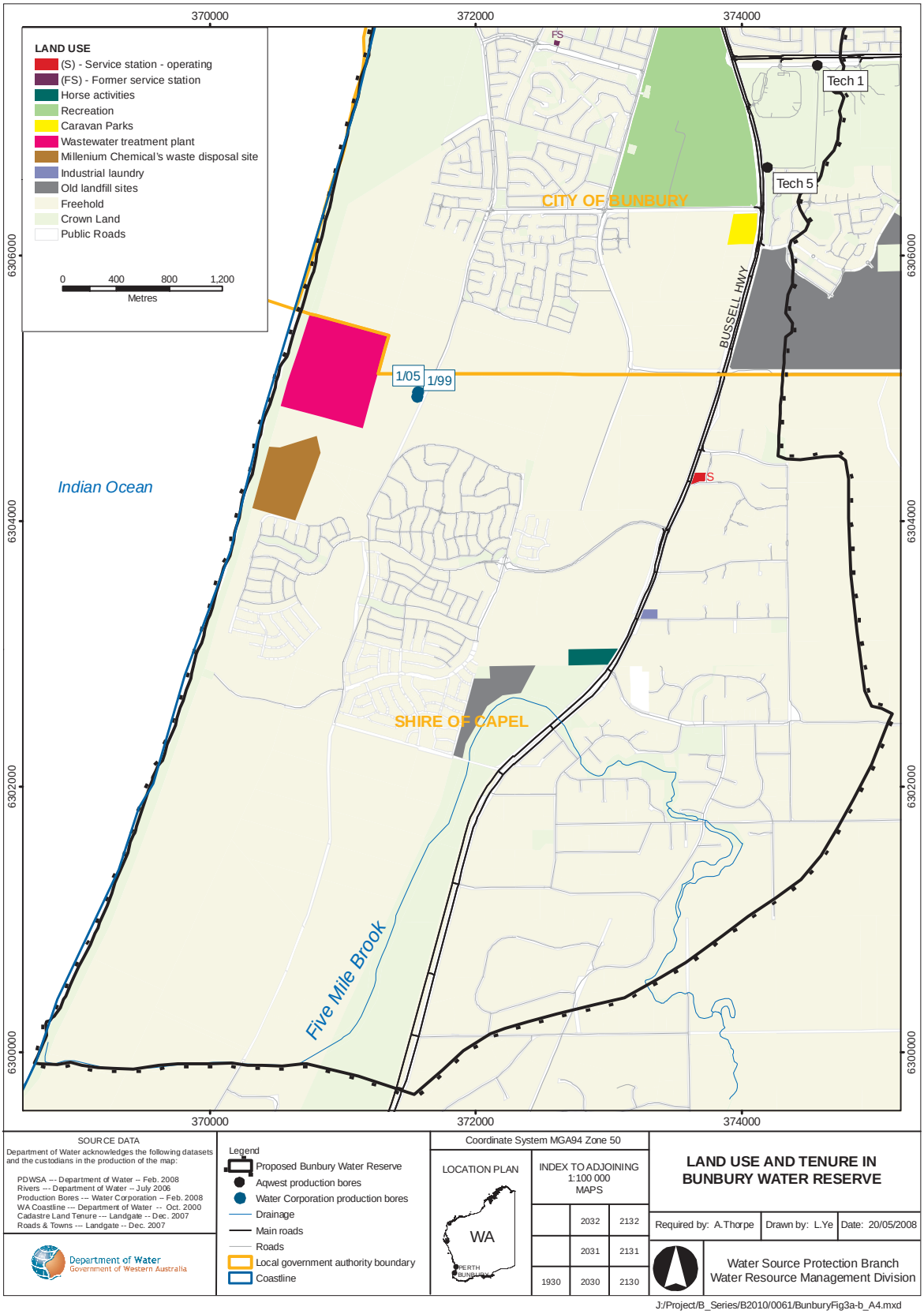

Figure 5 Land use and tenure in Bunbury Water Reserve, Shire of Capel

Table 3 Land use, potential water quality risks and recommended strategies

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Urban					
Residential	Nutrient contamination from septic tank systems and fertiliser use.	Medium	Most residential areas in Bunbury are now connected to deep sewer. Some pockets within Bunbury and a larger area in Gelorup still use conventional septic systems for wastewater disposal. The Gelorup residential area has a minimum lot size of 0.4ha. New residential development is likely to occur near Dalyellup wellfield. Acid sulfate soil (ASS) risk areas have been identified within the Bunbury Water Reserve (WAPC 2006a).	• Monitoring of water quality from production bores. • Infill sewerage program. • City of Bunbury planning approval requires provision of deep sewerage. • Planning guidance provided in Planning Bulletin 64–*Acid sulfate soils* (WAPC 2006a).	• Undertake community education regarding water quality protection and best management practices. • If residential development involves dewatering or drainage works an investigation should be undertaken in accordance with *Draft Identification and Investigation of Acid Sulfate Soils* (DoE 2006). • Where disturbance of ASS is proposed an ASS management plan should be prepared and referred to the Department of Environment and Conservation (DEC). Best management practices as recommended in *Treatment and management of disturbed acid sulfate soils* (DoE 2004b) should be followed.
	Pathogen contamination from septic tank systems.	Medium			
	Chemical contamination from use of household chemicals and pesticides.	Low			
	Hydrocarbon contamination from fuel and oil storage and spills.	Low			
	Acidity and heavy metals from dewatering and drainage works during development of new residential areas.	Medium			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Special rural areas: • Gelorup; south of Watkins Road • Vineyard and Winery.	Nutrients from animal faeces (e.g. horses), septic tanks and fertiliser use.	Low	The special rural area is currently unserviced and wastewater is disposed via septic tank systems. There are a number of stables and equestrian activities in this area. The minimum lot size for Gelorup special rural area is 2 ha. Strata lots within the vineyard subdivision are also approximately 2 ha in size.	• Monitoring of water quality from production bores. • Shire of Capel planning and development controls. • Depth of Dalyellup bores.	• Undertake community education regarding water quality protection and best management practices. • Follow best management practices for vineyard and management as recommended in the Water quality protection guideline (WQPG). *Environmental management guidelines for vineyards* (WRC *et al.* 2001) and Water quality protection note (WQPN) *Wineries and distilleries* (Department of Water 2006k). • Any restaurants proposed within the vineyard and winery special rural area should follow best management practices as recommended in the WQPN *Rural restaurants, cafes and taverns near sensitive water resources* (Department of Water 2006e).
	Pathogens from animal faeces and septic tanks.	Medium			
	Chemicals from use of household chemicals and pesticides.	Low			
	Hydrocarbon contamination from fuel and oil storage and spills.	Low			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Commercial development	Hydrocarbons from fuel and oil leaks and spills.	Medium	Numerous commercial activities exist within the water reserve, including car and caravan sale yards, drycleaners, shopping centres. The majority of the commercial area has been connected to deep sewer as part of the sewer infill program.	• Monitoring of water quality from production bores. • Infill sewerage program. • Connection to deep sewerage is required through the planning approval process. • *Environmental Protection (Unauthorised Discharges) Regulations 2004* and *(Controlled Waste) Regulations 2001*.	• Undertake community education regarding water quality protection and best management practices promoted in the relevant WQPNs e.g. *Mechanical servicing and workshops* (Department of Water 2006b). • A risk assessment of the commercial premises within Bunbury Water Reserve should be undertaken.
	Chemicals from leaks or spills.	Medium			
	Pathogens from septic systems.	Medium			
	Nutrients from septic systems.	Medium			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Service stations	Hydrocarbons from fuel and oil leaks and spills.	High	There are currently seven operating service stations within Bunbury Water Reserve, as well as a number of others that have now ceased operation. Underground storage tanks still remain at some former service station sites. The closest operating service station is approximately 770 m from the Spencer bores. There is a former service station site approximately 340 m from the Spencer bores.	• Monitoring of water quality from production bores.	• New and existing service stations to follow best management practices as recommended in the WQPN's *Service stations* (Department of Water 2006f), *Tanks for underground chemical storage* (Department of Water 2006i and *Tanks for elevated chemical storage* (Department of Water 2006h). • Any new fuel storage tanks should be double-lined and contain a leak detection system. • Follow best management practices recommended in the WQPN *Tanks – closure of underground chemical storage* (Department of Water 2006g) following closure of service stations. • Current and previous service station sites should be assessed and remediated (if required) under the *Contaminated Sites Act 2003.*
	Heavy metals from leaks and spills.	High			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Recreation					
Hay Park recreation area and other parks and playing fields	Nutrients from fertiliser use.	Medium	Hay Park Recreational Area consists of approximately 44ha of sporting fields and the South West Sports Centre (which includes swimming pools). In addition there are a number of football ovals and other playing fields within the water reserve.	• Monitoring of water quality from production bores.	• Follow best management practices as recommended in the WQPG *Environmental Guidelines for the establishment and maintenance of turf and grasses areas* (WRC & DEP 2001) and the WQPN *Swimming pools* (DoE 2005). • Pesticide use should be in accordance with Statewide Policy No. 2 – *Pesticide use in Public Drinking Water Source Areas* (WRC 2000a) and Circular No: PSC88 – *Use of herbicides in water catchment areas* (DoH 2007).
	Chemicals from pesticide application and aquatic centre.	Medium			
Carey Park Race Course and Bunbury Trotting Club Course	Nutrients from animal faeces and fertiliser use.	Medium	Racing occurs at the race course for approximately five months of the year and is used for training all year around. The trotting track is used for racing year-around.	• Monitoring of water quality from production bores.	• Follow best management practices as recommended in the WQPGs *Environmental Guidelines for horse facilities and activities* (WRC *et al.* 2002) and *Environmental Guidelines for the establishment and maintenance of turf and grasses areas* (WRC & DEP 2001). • Pesticide use in accordance with Statewide Policy No. 2 – *Pesticide use in Public Drinking Water Source Areas* (WRC 2000a) and Circular No: PSC88 – *Use of herbicides in water catchment areas* (DoH 2007).
	Pathogens from animal faeces.	Medium			
	Chemicals from pesticide application.	Medium			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Extractive industry					
Basalt quarry	Hydrocarbons from fuel and oil leaks and spills.	Low	Activities consist of extraction of basalt crushing and screening of the extracted basalt and stockpiling of the material. The facility is licensed by the DEC with conditions relating to the quality of water discharged from the site and storage and disposal of hydrocarbons.	• Monitoring of water quality from production bores. • DEC licence requirements under the *Environmental Protection Act 1947.* • Depth of Dalyellup bores.	• Follow best management practices as recommended in the WQPN *Extractive industries within Public Drinking Water Source Areas* (WRC 2000b). • Department of Water to liaise with DEC regarding the proponent's compliance to the licence conditions and water quality monitoring results.
Waste disposal					
Millennium Inorganic Chemical solid waste disposal site	Heavy metals	Medium	Waste from Millennium Inorganic Chemical's titanium dioxide plant is disposed in interdunal depressions. The waste disposal site is downstream of current production bores. The waste is a mixture containing aluminium, calcium, chloride, chromium, iron, manganese, sulphur, titanium, vanadium and other trace elements.	• Monitoring of water quality from production bores and bores at the disposal site. • DEC licence requirements under the *Environmental Protection Act 1947*. • Regulation of radiation by the Radiological Council of WA.	• Department of Water to liaise with DEC regarding the proponent's compliance to the licence conditions and water quality monitoring results. • On closure the site should be assessed and rehabilitated (where necessary) under the *Contaminated Sites Act 2003.*
	Salinity	Medium			
	Hydrocarbons	Medium			
	Radiation from the disposed material.	Medium			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Wastewater treatment plant	Nutrients	Medium	Wastewater was historically disposed in interdunal depressions near the treatment facility. The treatment plant is downstream of current production bores. All wastewater is now disposed via a deep ocean outfall.	• Monitoring of water quality from production bores and treatment plant monitoring bores. • DEC licence requirements under the *Environmental Protection Act 1947*. • Depth of Dalyellup bores.	• Department of Water to liaise with DEC regarding the proponent's compliance to the licence conditions and water quality monitoring results. • Water quality monitoring should be undertaken between the wastewater treatment plant and drinking water bores.
	Pathogens	High			
Landfills (ceased operation)	Nutrients	High	There are six sites known to have been used as landfills within Bunbury Water Reserve. All sites have now ceased to be used for this function, with the most recent landfill closing in 1995. More recent landfills were capped with clay as part of post-closure management: however, this is unlikely to have occurred for older landfills. Some landfills have been rehabilitated.	• Monitoring of water quality from production bores. • Old Gelorup landfill was capped with clay following closure. • Some rehabilitation has occurred at certain sites.	• Sites should be assessed and rehabilitated (where necessary) under the *Contaminated Sites Act 2003.*
	Pathogens	High			
	Heavy metals	High			
	Hydrocarbons	High			

Land use or activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Other					
Roads	Hydrocarbons from accidents or spills.	Low	Bulk haulage and major traffic occurs along Bussell Highway. Being an urban area there are a large number of local roads within the water reserve. The Local Emergency Management Committee responds to spills and accidents.	• Monitoring of water quality from production bores. • Sealed bores and fenced bore compounds. • The bore adjacent to the Bussell Highway is >270 m deep. • Local Emergency Management Committee response.	• Continue water quality monitoring program and the Local Emergency Management Committee response. • Follow best management practices recommended in the WQPN *Roads near sensitive water resources* (Department of Water 2006d). • Signage to indicate the water reserve boundary and emergency contact number should be installed. • Road drainage should be directed away from the bores.
	Chemicals from accidents or spills.	Low			

4 Catchment protection strategy

4.1 Protection objectives

The objective of this plan is to protect the drinking water source in the interest of providing safe, good quality drinking water to the residents of Bunbury and Dalyellup.

4.2 Proclaimed area

The proposed Bunbury Water Reserve (Figure 2) encompasses the unconfined area of the Yarragadee aquifer to the north and extends east to the surface drainage divide. The boundary then follows the north side of the proposed Bunbury bypass highway and Five Mile Brook south of Dalyellup. This area will be gazetted under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking source. Gazettal of this area enables the *Country Areas Water Supply Act 1947* by-laws to be applied to potentially polluting activities within the Bunbury Water Reserve.

4.3 Priority areas

Priority areas are designated based on the strategic importance of the water source, its zoning, ownership and existing approved land uses. Further information on the priority classification system and detail on the compatibility of land uses and activities within each of the priority areas is provided in the Water quality protection note – *Land use compatibility in public drinking water source areas* (Department of Environment 2004a).

Given the range of existing land uses and zoning of the land, the proposed water reserve has been classified as priority 3 (P3) (Figure 6). P3 areas are defined to manage the risk of pollution to drinking water sources (through the use of best management practices) in areas where water supply sources need to coexist with other land uses such as residential, commercial and light industry. Land uses which are considered to have significant pollution potential are nonetheless opposed or constrained. If the water source were to become significantly contaminated, then additional treatment or an alternative water source may be required.

The P3 classification for Bunbury is justified based on the following criteria:

- Majority of the land within Bunbury Water Reserve is identified for urban or future urban land uses under the *Greater Bunbury Regional Scheme* (Western Australian Planning Commission 2007), which is consistent with a P3 classification.
- Alternative water resources are available in the confined aquifer to the east of the proposed water reserve.

4.4 Protection zones

Wellhead protection zones (WHPZs) are circular areas defined around each bore (500 m radius in P1 areas and 300 m radius in P2 and P3 areas) in order to protect the drinking water source from contamination in the immediate vicinity of the bores. Within these zones, by-laws may prohibit, restrict or approve defined land uses and activities to prevent water source contamination or pollution. Special conditions, such as restrictions on storage and use of chemicals, may apply within these zones. The WHPZs do not extend outside the water reserve boundary. WHPZs for Bunbury wellfield consist of a 300m radius around each of the bores and are shown in Figure 6. Where possible, development within WHPZs should be avoided in order to minimise the risk of contamination. Future production bores drilled within the water reserve should preferably be located in an area where there is limited development in a 300 m radius WHPZ.

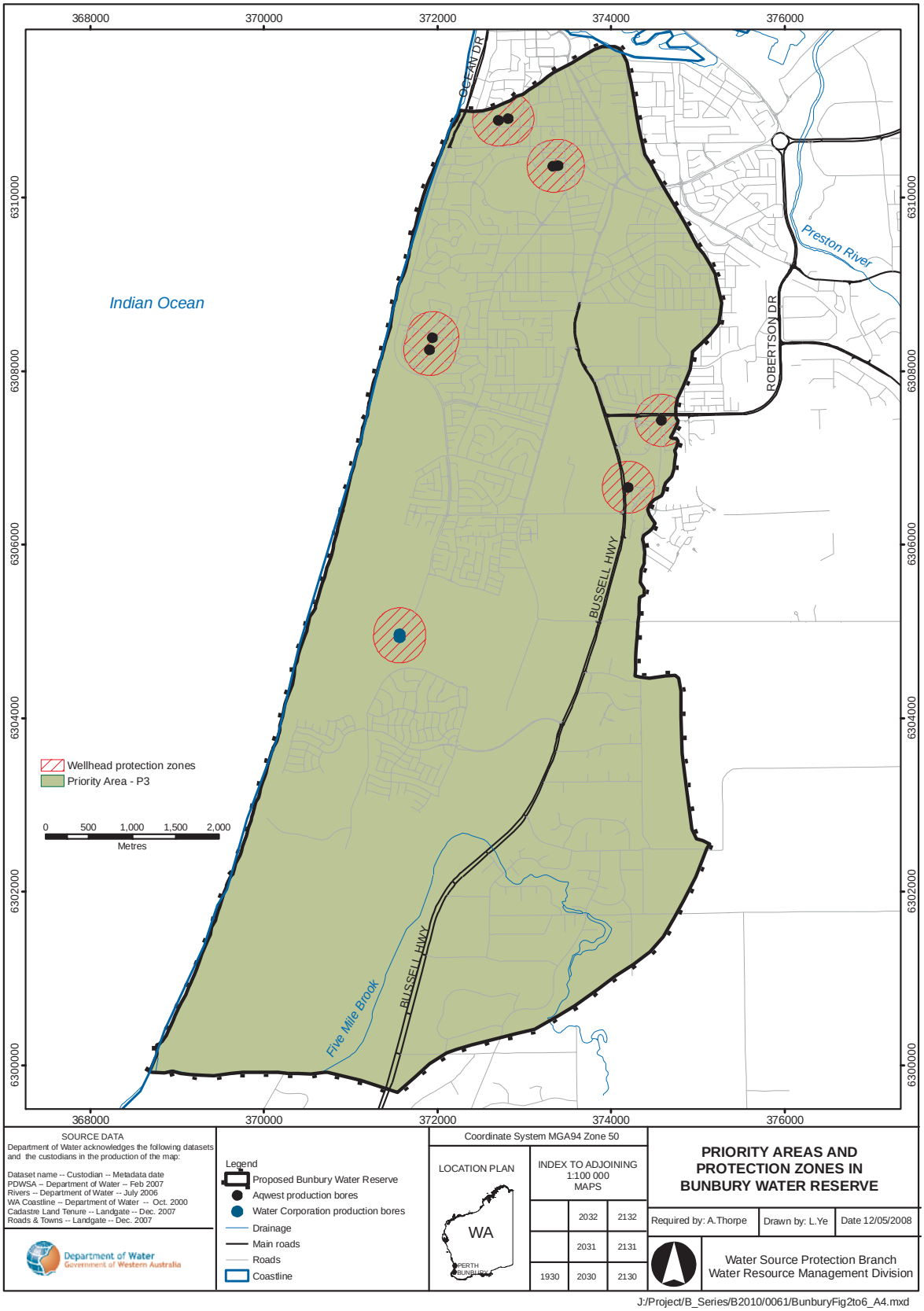

Figure 6 Priority areas and protection zones for the proposed Bunbury Water Reserve

4.5 Land-use planning

It is recognised under the *State Planning Strategy* (Western Australian Planning Commission 1997) that the establishment of appropriate protection mechanisms in statutory land-use-planning processes is necessary to secure the long-term protection of drinking water sources. As outlined in Statement of Planning Policy No. 2.7 – *Public Drinking Water Source Policy* (Western Australian Planning Commission, 2003) it is appropriate that the Bunbury Water Reserve, priority areas and protection zones be recognised in the City of Bunbury and Shire of Capel town planning schemes. Any development proposals within the Bunbury Water Reserve that are inconsistent with advice within the Water quality protection note – *Land use compatibility in public drinking water source areas* (Department of Environment 2004a) or recommendations in this plan, should be referred to the Department of Water.

The department's protection strategy for public drinking water source areas provides for lawfully established and operated developments to continue despite their location or facilities posing a level of risk to water quality which would not be accepted for new developments. The department may negotiate with landowners and operators on measures to improve these facilities or processes to lessen the level of water contamination risk.

In critical areas close to production bores, the department may negotiate to purchase land or development rights where the level of contamination risk is considered significant enough to have the potential to compromise the quality of water resources.

4.6 Best management practices

There are opportunities to significantly reduce risks to water quality by carefully considering design and management practices. The adoption of best management practices for land uses will continue to be encouraged to help protect water quality. On freehold land, the Department of Water aims to work with landowners to achieve best management practices for water quality protection by providing management advice.

There are guidelines available in the form of industry codes of practice, environmental guidelines or water quality protection notes for many land uses. These have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include *Service stations, Extractive industries near sensitive waters, Environmental management guidelines for horse facilities and activities*, *Environmental guidelines for the establishment and maintenance of turf and grassed areas* and *Roads near sensitive water resources* which are listed in the references section of this document. The guidelines help managers reduce the risk of their operations impacting on water quality. They are recommended as best practice for water quality protection.

Education and creating awareness (e.g. signage and information) are key mechanisms for protecting the quality of water, especially for those people visiting the area who are unfamiliar with the Bunbury Water Reserve. A brochure will be produced, describing the Bunbury Water Reserve, its location and the main threats to water quality. This brochure will be available to the community and will inform people in simple terms about the drinking water source and the need to protect it.

4.7 Surveillance and by-law enforcement

The quality of public drinking water sources within country areas of the state is protected under the *Country Areas Water Supply Act 1947*. Declaration of these areas allows existing by-laws to be applied to protect water quality.

The Department of Water considers by-law enforcement, through surveillance of land-use activities in public drinking water source areas, as an important mechanism to protect water quality.

Signs are erected within public drinking water source areas to educate the public and to advise of activities that are prohibited or regulated. This plan recommends delegation of surveillance and by-law enforcement to the water service providers.

4.8 Emergency response

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The City of Bunbury and Shire of Capel's Local Emergency Management Committee, through the South West Emergency Management District should be familiar with the location and purpose of the Bunbury Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the Hazardous Materials Emergency Advisory Team. Water Corporation, Aqwest and Department of Water should have an advisory role to any Hazardous Materials incident in the Bunbury Water Reserve.

Personnel who deal with hazardous material incidents within the area should have access to a map of the Bunbury Water Reserve. These personnel should have an adequate understanding of the potential effects of spills on this water resource.

4.9 Implementation of this plan

Table 3 identifies the potential water quality risks associated with existing land uses in the Bunbury Water Reserve and recommends protection strategies to minimise these risks.

Following publication of the final Bunbury Water Reserve drinking water source protection plan, an implementation strategy will be drawn up based on the recommendations in Table 3 and section 5. It will describe timeframes for the recommended protection strategies and identify responsible stakeholders.

5 Recommendations

The following recommendations apply to the whole of Bunbury Water Reserve. The bracketed agencies have a direct interest in implementation of the relevant recommendation.

1 The boundary of the Bunbury Water Reserve should be proclaimed under the *Country Areas Water Supply Act 1947* (Department of Water).

2 Prepare an implementation strategy (including the recommended protection strategies as detailed in Table 3: Land use, potential water quality risks and recommended strategies of this plan) showing responsible stakeholders and planned time frames (Department of Water in consultation with applicable stakeholders).

3 The City of Bunbury and Shire of Capel town planning schemes should incorporate this plan and reflect the identified Bunbury Water Reserve boundary, priority 3 area and protection zones in accordance with Statement of Planning Policy No. 2.7 – *Public Drinking Water Source Policy* (City of Bunbury, Shire of Capel).

4 All development proposals within the Bunbury Water Reserve that are inconsistent with the Water quality protection note – *Land use compatibility in public drinking water source areas* (Department of Environment 2004a) or recommendations in this plan should be referred to the Department of Water for advice and recommendations (Department for Planning and Infrastructure, City of Bunbury, Shire of Capel, proponents of proposals).

5 Incidents covered by the Western Australian Plan for Hazardous Materials in the Bunbury Water Reserve should be addressed by ensuring that:

- the South West Local Emergency Management Committee should be aware of the location and purpose of the Bunbury Water Reserve
- the locality plan for the Bunbury Water Reserve is provided to the fire and rescue headquarters for the Hazardous Materials Emergency Advisory Team
- Water Corporation, Aqwest and Department of Water provide an advisory role during incidents in the Bunbury Water Reserve
- personnel dealing with Western Australian Plan for Hazardous Materials incidents in the area have ready access to a locality map of the Bunbury Water Reserve and information to help them recognise the potential effects of spills on drinking water quality (Department of Water, Aqwest, Water Corporation).

6 Pursuant to Section 13(1) of the *Water and Rivers Commission Act 1995*, the Department of Water should consider delegating responsibility for surveillance and enforcement of the Bunbury Water Reserve to the water service providers (Department of Water, Water Corporation, Aqwest).

7 Signs should be erected on bore compounds and in strategic locations within Bunbury Water Reserve to define the location and promote awareness of the need to protect drinking water quality. Signs should include an emergency contact telephone number (Water Corporation, Aqwest, Department of Water).

8 All potentially contaminated sites within Bunbury Water Reserve should be assessed and remediated (if required) under the *Contaminated Sites Act 2003* (Landowners, Department of Environment and Conservation, Department of Water).

9 A review of this plan should be undertaken after five years (Department of Water).

Appendices

Appendix A: Water quality – Dalyellup bores

The information provided in this appendix was prepared by the Water Corporation.

The Water Corporation has monitored the raw (source) water quality from Dalyellup wellfield in accordance with the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2004a) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

- aesthetic characteristics (non-health related)
- health related characteristics including
  - health related chemicals
  - microbiological contaminants.

Following is data representative of the quality of raw water from Dalyellup wellfield. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG (NHMRC & NRMMC 2004a) values set for drinking water, which defines the quality requirements at the customer's tap. Results that exceed the ADWG (NHMRC & NRMMC 2004a) have been shaded to give an indication of potential raw-water quality issues associated with this source.

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 (NHMRC & NRMMC 2004a). The values are taken from ongoing monitoring for the period May 2003 to May 2008.

Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG (NHMRC & NRMMC 2004a) are shaded.

For more information on the quality of drinking water supplied to Dalyellup refer to the most recent Water Corporation *Drinking Water Quality Annual Report* at <www.watercorporation.com.au> > Water > Water quality > Latest report > Drinking Water Quality Annual Report.

Aesthetic characteristics

Aesthetic water quality analyses for raw-water from Dalyellup wellfield are summarised in the following table.

Aesthetic detections for Dalyellup wellfield

Parameter	Units	ADWG aesthetic guideline value*	Dalyellup Bore 1/05 SP		Dalyellup Bore 1/99 SP	
			Range	Median	Range	Median
Chloride	mg/L	250	72†	72†	150 – 200	160
Colour	TCU	15	<1 – 2	<1	<1 – 6	<1
Conductivity at 25°C	mS/m	–	43 – 47	44	63 – 92	68
Hardness as $CaCO_3$	mg/L	200	61†	61†	81 - 101	82.5
Iron unfiltered	mg/L	0.3	9.5 – 11	10	20 – 35	27
Manganese unfiltered	mg/L	0.1	0.22 – 0.26	0.24	0.065 – 0.18	0.1085
pH	No unit	6.5 – 8.5	6.55 – 6.77	6.61	5.77 – 9.36	6.27
Sodium	mg/L	180	49†	49†	72 - 93	74
Sulphate	mg/L	250	14†	14†	15 - 17	16
Total filterable solids by summation	mg/L	500	307†	307†	372 - 451	393.5
Turbidity	NTU	5	23 – 85	70	7.4 – >400	90

* An aesthetic guideline value is the concentration or measure of a water quality characteristic that is associated with good quality water (NHMRC & NRMMC 2004a).

† Water quality data observed from three or less sampling occasions.

Health related characteristics

Health parameters

Raw water from Dalyellup is analysed for health related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters are summarised in the following table.

Health related detections for Dalyellup wellfield

Parameter	Units	ADWG Health Guideline Value*	Dalyellup Bore 1/05 SP		Dalyellup Bore 1/99 SP	
			Range	Median	Range	Median
Antimony†	mg/L	0.003	–	–	<0.002 – 0.002	<0.002
Arsenic	mg/L	0.007	<0.002 - 0.003	<0.002	<0.002 – 0.003	0.002
Barium	mg/L	0.7	0.055 0.1	0.06	0.04 – 0.11	0.095
Boron	mg/L	4	0.03 - 0.05	0.04	<0.02 – 0.05	0.03
Mercury	mg/L	0.001	<0.0005	<0.0005	<0.0005 – 0.0008	<0.0005
Nitrate as nitrogen†	mg/L	11.29	0.01	0.01	–	–
Nitrite as nitrogen†	mg/L	0.91	–	–	<0.002 – 0.021	0.006
Tributylin oxide†	ug/L	1	–	–	<0.002 – 0.003	0.002

* 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 2004a).

† Water quality data observed from three or less sampling occasions.

Microbiological contaminants

Microbiological testing of raw-water samples from Dalyellup wellfield is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw-water from warm-blooded animals. A detection of *Escherichia coli* in raw water abstracted from any bore may indicate possible contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period, positive *Escherichia coli* was not detected in any samples collected from the borefield.

Appendix B: Water quality – Bunbury bores

The information provided in this appendix was prepared by Aqwest.

Aqwest has monitored the raw (source) water quality from Bunbury wellfield in accordance with the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2004a) and interpretations agreed to with the Department of Health. The raw water is monitored regularly for:

- aesthetic characteristics (non-health related)
- health related characteristics including
  - health related chemicals
  - microbiological contaminants.

Following is data representative of the quality of raw water from Aqwest's wellfield. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG (NHMRC & NRMMC 2004a) values set for drinking water, which defines the quality requirements at the customer's tap. Results that exceed the ADWG(NHMRC & NRMMC 2004a) have been shaded to give an indication of potential raw-water quality issues associated with this source.

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(NHMRC & NRMMC 2004a). The values are taken from ongoing monitoring for the period 1 July 2006 to 30 June 2007.

Water quality parameters that have on occasion have exceeded the ADWG (NHMRC & NRMMC 2004a) are shaded.

For more information on water quality from Aqwest bores, see Aqwest's most recent quarterly report at <www.aqwest.wa.gov.au> > Customers > Water quality > Aqwest's quarterly annual performance.

Aesthetic characteristics

Aesthetic water quality analyses for raw-water from Dalyellup wellfield are summarised in the following table.

Aesthetic-related detections for available analyses from Aqwest production bores

Parameter	Units	ADWG Health Guideline Value[a]	Aqwest borefield raw water Data from 2006-07 GLOS report[b]	
			Range	Median
Chloride	mg/L	250	30 – 160	99
Hardness as $CaCO_3$	mg/L	200	57 – 110	92
Iron unfiltered	mg/L	0.3	0.6 – 25	7
Manganese unfiltered	mg/L	0.1	0.05 – 2.8	0.2
pH	mg/L	6.5 – 8.5	6.4 – 8.4	7.2
TDS	mg/L	500	240 – 480	320

[a] NHMRC & NRMMC 2004a

[b] Rockwater 2007

[c] Several anomalous values for TDS and iron have been excluded from the data

Health related characteristics

Health parameters

Raw water from Bunbury wellfield is analysed for health related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters are summarised in the following table.

Health related detections for available analyses from Aqwest production bores

Parameter	Units	ADWG Health Guideline Value[a]	Aqwest borefield raw water Data from 2006-07 GLOS report[b]	
			Range	Median[c]
Barium	mg/L	0.7	0.064 – 0.3	0.18
Boron	mg/L	4	0.03 – 0.08	0.05
Manganese unfiltered	mg/L	0.5	0.05 – 2.80	0.02
Mercury	mg/L	0.001	0.0001[d]	0.0001[d]
Tetrachloroethene	mg/L	0.05	0.0021[d]	0.0021[d]

[a] NHMRC & NRMMC 2004a

[b] Rockwater 2007

[c] Analysis results below the detection limit are not included.

[d] Only one value recorded above the detection limit.

Appendix C: Photographs

Photo 1 Water Corporation production bore 1/05

Photo 2 Residential area in Dalyellup

Photo 3 Commercial area, Bunbury

Photo 4 Bunbury wastewater treatment plant

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
ADWG	The *Australian drinking water guidelines*, outlining acceptable criteria for the quality of drinking water in Australia.
Aesthetic guideline	A water-quality criteria in the *Australian drinking water guidelines* associated with acceptability of water to the consumer e.g. appearance, taste and odour (NHMRC & NRMMC, 2004).
AHD	Australian Height Datum is the height of land in metres above mean sea level. For example, this is +0.026 m at Fremantle.
Allocation	The quantity of water permitted to be abstracted by a licencee, usually specified in kilolitres per annum (kL/a).
Aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand.
Bore	A narrow, lined hole, also known as a well, drilled to monitor or draw groundwater.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.
DEC	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment (DoE) and the Department of Conservation and Land Management (CALM).
Effluent	The liquid, solid or gaseous wastes discharged by a process, treated or untreated.
ha	Hectare (a measure of area).
HAZMAT	Hazardous materials.

Health guideline	A water-quality criteria in the *Australian drinking water guidelines* associated with human health that, based on present knowledge, does not result in any significant risk to the consumer over a lifetime of consumption (NHMRC & NRMMC 2004a).
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 study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
kL	Kilolitre (1 000 litres) or one cubic metre.
km	Kilometre (1 000 metres).
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.
LEMC	Local Emergency Management Committee.
m	Metres.
mg/L	Milligram per litre (0.001 grams per litre) as a measurement of a total dissolved solid in a solution.
mL	Millilitre
ML	Megalitre (1 000 000 litres = one million litres).
mm	Millimetre.
NHMRC	National Health and Medical Research Council.
NRMMC	Natural Resource Management Ministerial Council.
NTU	Nephelometric turbidity units are a measure of turbidity in water.
Nutrients	Minerals dissolved in water, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) which provide nutrition (food) for plant growth. Total nutrient levels include the inorganic forms of an element plus any bound in organic molecules.

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 seven indicates an acidic solution and above seven indicates an alkaline solution.
Pollution	Water pollution occurs when waste products or other substances, e.g. effluent, litter, refuse, sewage or contaminated runoff, change the physical, chemical, biological or thermal properties of the water, adversely affecting water quality, living species and beneficial uses.
PSC 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
Public Drinking Water Source Area (PDWSA)	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*.
Recharge	Water infiltrating 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.
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, industrial or irrigation use.
Semi-confined aquifer	A semi-confined or leaky aquifer is saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable.
Stormwater	Rainwater which has run off the ground surface, roads, paved areas etc, and is usually carried away by drains.

TCU	True colour units (a measure of degree of colour in water).
TDS	Total dissolved solids: a measurement of ions in solution, such as salts in water.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Unconfined aquifer	An aquifer in which the upper surface of water is lower than the top of the aquifer itself. The upper surface of the groundwater within the aquifer is called the watertable.
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	The physical, chemical and biological measures 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.
Wellfield	A group of bores to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater. A wellhead protection zone (WHPZ) is usually declared around wellheads in drinking water areas to protect the water source from contamination.
WESTPLAN HAZMAT	Western Australian Plan for Hazardous Materials.

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