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

Looking after all our water needs

Nabawa Water Reserve drinking water source protection plan

Nabawa town water supply

Water resource protection series

REPORT NO. 91
June 2008

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June 2008

ISSN 1326-7442 (print)
ISSN 1835-3924 (online)

ISBN 978-1-921508-21-9 (print)
ISBN 978-1-921508-22-6 (online)

Acknowledgements

The Department of Water would like to thank the following for their contributions to this publication: Phyllis Graham (A/Senior Water Resource Planner, Department of Water) – report preparation; Stephen Watson (Program Manager, Department of Water) and Nigel Mantle (A/Branch Manager) – supervision; Fleur Coaker (Environmental Officer, Mid West Gascoyne Region, Department of Water) and Jon Kaub (Environmental Officer, Department of Water) – photographs; Mike Pickering (Catchment Co-ordinator, Mid-West Gascoyne Region, Water Corporation) – report liaison and Lin Ye (GIS officer, Department of Water) – drafting.

For more information about this report, contact the Department of Water officers listed above or send your query to <drinkingwater@water.wa.gov.au>.

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Preface

The Department of Water has prepared this drinking water source protection plan to assess risks to water quality within the Nabawa 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 recommend a risk-based, multiple-barrier approach to protect public drinking water sources. Catchment protection is the first barrier, 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 reserve providing potable water to the Nabawa town supply system. 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.

This plan should be used to guide state and local government land use planning decisions. It should be recognised in the Shire of Chapman Valley's Town planning scheme, consistent with the Western Australian Planning Commission's Statement of Planning Policy No. 2.7–*Public drinking water source policy* (2003). Other stakeholders should use this document as a guide for protecting the quality of water in the gazetted Nabawa Water Reserve.

The stages involved in preparing a drinking water source protection plan are:

Stages in development of a plan		Comment
1	Prepare drinking water source protection assessment.	Prepared following catchment survey and preliminary information gathering. Report published in 2004.
2	Conduct stakeholder consultation.	Advice sought from key stakeholders using the assessment as a tool for information and discussion.
3	Prepare draft drinking water source protection plan.	Draft plan developed taking into account input from stakeholders and any additional advice received.
4	Release draft drinking water source protection plan.	Draft plan released in April 2008 for a six-week public consultation period.
5	**Publish approved drinking water source protection plan.**	**Final plan published after considering advice received in submissions. It includes recommendations on how to protect water quality.**

Summary

Nabawa is located in the Chapman River Valley approximately 35 km north-east of Geraldton in Western Australia (Figure 1). It is a farming town situated within the Shire of Chapman Valley and has a population of about 100 (Water Corporation 2004).

Drinking water at Nabawa comes from the Nabawa Water Reserve. This reserve was proclaimed in 1990 under the *Country Areas Water Supply Act 1947* for the purpose of protecting this source from potential contamination.

A large portion of the Nabawa Water Reserve is zoned rural and is used for cereal cropping and low intensity stock grazing. The remainder of the water reserve is classified as urban and includes two small low density residential areas, a tavern with a petrol station, a primary school, a recreation centre with an oval and the Shire of Chapman Valley's offices and service compound. The native vegetation consists mainly of low acacia scrub and banksia trees.

Groundwater from this water reserve comes from a fractured rock aquifer south-east of town and from alluvium deposits along the Chapman River. It is abstracted by the Water Corporation borefield located approximately 1 km from the town. Raw (untreated) water from the Nabawa bores is disinfected by chlorination prior to supply as drinking water.

This plan recommends that rural and recreation zoned areas in the Nabawa Water Reserve be classified as Priority 2 source protection areas and the remaining urban areas, including the school, tavern and residential areas are classified for Priority 3 source protection. It also recommends establishing wellhead protection zones to protect the water from potential contamination in the immediate vicinity of drinking water bores.

During the preparation of this plan it was recognised that the proclaimed water reserve area, approximately 1.4 km^2, may not correspond to the physical area of land contributing to the recharge of the wellfield. This requires further investigation. This plan recommends that the existing water reserve be redefined and re-proclaimed following a hydrogeological study to ensure adequate protection of the water supply.

This drinking water source protection plan has been developed in consultation with the Water Corporation, Shire of Chapman Valley, landowners and other relevant stakeholders.

1 Drinking water source overview

1.1 Existing water supply system

Nabawa is located in the Chapman River Valley approximately 35 km north-east of Geraldton in Western Australia (Figure 1).

The Nabawa Water Reserve was proclaimed in 1990 under the *Country Areas Water Supply Act 1947* (CAWS Act) for the purpose of protecting the public drinking water source from potential contamination.

The public drinking water to supply Nabawa is obtained from the Water Corporation borefield located less than 1 km south of the town within the Nabawa Water Reserve (Figure 2). The borefield is comprised of three production bores, identified as 8, 10/83 and 5/94. Bore 8 is in alluvium deposits along the Chapman River, while bores 10/83 and 5/94, on the Indialla Spur Road, abstract water from the Noondine Chert, a fractured rock aquifer.

Bores 10/83 and 5/94 are located approximately 15 m apart and cannot be used simultaneously. Bore 10/83 has dried up and bore 5/94 has a reduced rest level and is limited in its pumping capabilities. There is now a greater reliance on bore 8 which was used previously as a stand-by bore.

Water abstracted from the duty bores is pumped to a high level 225 m^3 storage tank located on a hill on the eastern side of the town and supplied by gravity to the distribution system.

The existing bores in the Nabawa Water Reserve are currently providing very low yields so water is brought in by tanker to augment the supply on days with high demand.

1.2 Water treatment

Raw water from the Nabawa bores is disinfected by chlorination prior to supply as drinking water.

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 for protecting water quality. This approach is endorsed by the Australian drinking water guidelines (ADWG) (NHMRC & NRMMC 2004a) and reflects a risk-based, catchment-to-consumer, and multiple-barrier approach for providing safe drinking water to consumers. The combination of catchment protection and treatment delivers a safer drinking water source than either barrier could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The Nabawa area is characterised by the Chapman River drainage system with low hills rising to the east and west of the river. Elevations range from around 210 m Australian Height Datum (AHD) with gentle slopes to the Chapman River at 140 mAHD. The drainage system dissects the landscape, resulting in a gently undulating terrain with ephemeral tributaries. The native vegetation consists mainly of low acacia scrub and banksia trees.

1.3.2 Climate

Nabawa experiences a mild Mediterranean-type climate with hot, dry summers and cool, wet winters. The mean annual rainfall from 1905 to 2007 is 446.7 mm with the highest rainfalls recorded in June and July.

The area has experienced reduced rainfall in recent years. Six of the years since 2000 have recorded annual rainfall well below the long-term mean, with annual means of 182.8 mm and 281.0 mm in 2006 and 2007, respectively. The exceptions were 2003 and 2005 with means of 466.8 mm and 449.5 mm, respectively.

1.3.3 Hydrology

The Nabawa Water Reserve is situated toward the central-eastern edge of the Northampton Complex, a Proterozoic age inlier between the Perth and Carnarvon basins. It is underlain by basement rocks consisting of granulites (metamorphosed sedimentary rocks) which grade eastward through a zone of migmatite (mixed metamorphic and intrusive rocks) to a large intrusive granite along the eastern margin of the complex. These have been intruded by a swarm of north-easterly trending dolerite dykes. In the west the basement rocks are overlain by outliers of Mesozoic sedimentary rocks and along the Chapman River by alluvium up to 15 m in thickness consisting of clay, silt, sand and gravel.

Unconfined groundwater occurs in the basement rocks (fractured rock aquifer), Mesozoic sedimentary rocks (sedimentary aquifer) and the alluvium (superficial aquifer). A regional watertable occurs throughout the area and the groundwater is inferred to occur in a flow system controlled by the shape of the Chapman River catchment. The groundwater originates as rainfall recharge in the higher parts of the catchment and moves downslope to discharge via springs and pools into the Chapman River. Groundwater in the area varies from fresh to brackish tending to be more saline in the alluvium along the river. Supplies of groundwater, usually less than 300 kL/day, are obtained at specific sites located in the fractured rock aquifers and the alluvium (Water Corporation 2003).

1.4 Future water supply requirements

In 2004 the five-year projected annual demand, based on growth projections of 0.7 per cent a year, was 23 900 kL. This is now considered slightly too high. Consumption in recent years has varied from 20 303 kL in 2003–04 to 23 161 kL in 2006–07. This is nevertheless considerably less than the current groundwater allocation of 50 000 kL/yr.

There is some doubt about the adequacy of this source due to low rainfall in this area in recent years. The Water Corporation carts water to Nabawa during periods of high demand to supplement the source.

1.5 Protection and allocation

1.5.1 Existing water source protection

The Nabawa Water Reserve was proclaimed in 1990 under the CAWS Act for the purpose of protecting the public drinking water source from potential contamination. The water reserve, which extends over an area of approximately 1.4 km^2, is presented in Figure 2. Recent assessments have determined that this gazetted boundary does not correspond to the physical recharge area of the Nabawa Water Reserve. Section 4.2 provides more information about proposed changes to the water reserve boundary.

All Water Corporation bores in the reserve are sealed and secured in fenced compounds (photographs 1 and 2, Appendix B).

No priority areas for source protection or protection zones have been assigned to the existing water reserve. Nevertheless, the land is currently managed for Priority 2 and Priority 3 source protection.

The department's Water quality protection note–*Land use compatibility in public drinking water source areas* (Department of Water) describes the department's existing drinking water source protection approach and explains priority areas and protection zones. This drinking water source protection plan recommends that priority areas and wellhead protection zones (WHPZs) be assigned.

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* (RIWI Act). Under this Act, the right to use and control surface and groundwater is vested with the Crown. The Act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within proclaimed groundwater areas (except for domestic and stock use).

The Nabawa groundwater resource lies within the Gascoyne Groundwater Area which was proclaimed in 1987 under the RIWI Act.

Under its current Groundwater well licence No. GWL65336(4), the Water Corporation is licensed to draw 50 000 kL of groundwater a year from the Nabawa wellfield for public water supply purposes.

Consumption in recent years is considerably less than the current groundwater allocation and has varied as follows:

2003–04	20 303 kL
2004–05	20 407 kL
2005–06	17 621 kL
2006–07	23 161 kL.

In 2006–07 there were a total of 38 units in Nabawa; 28 of these were domestic units. The term unit refers to points at which water consumption is metered.

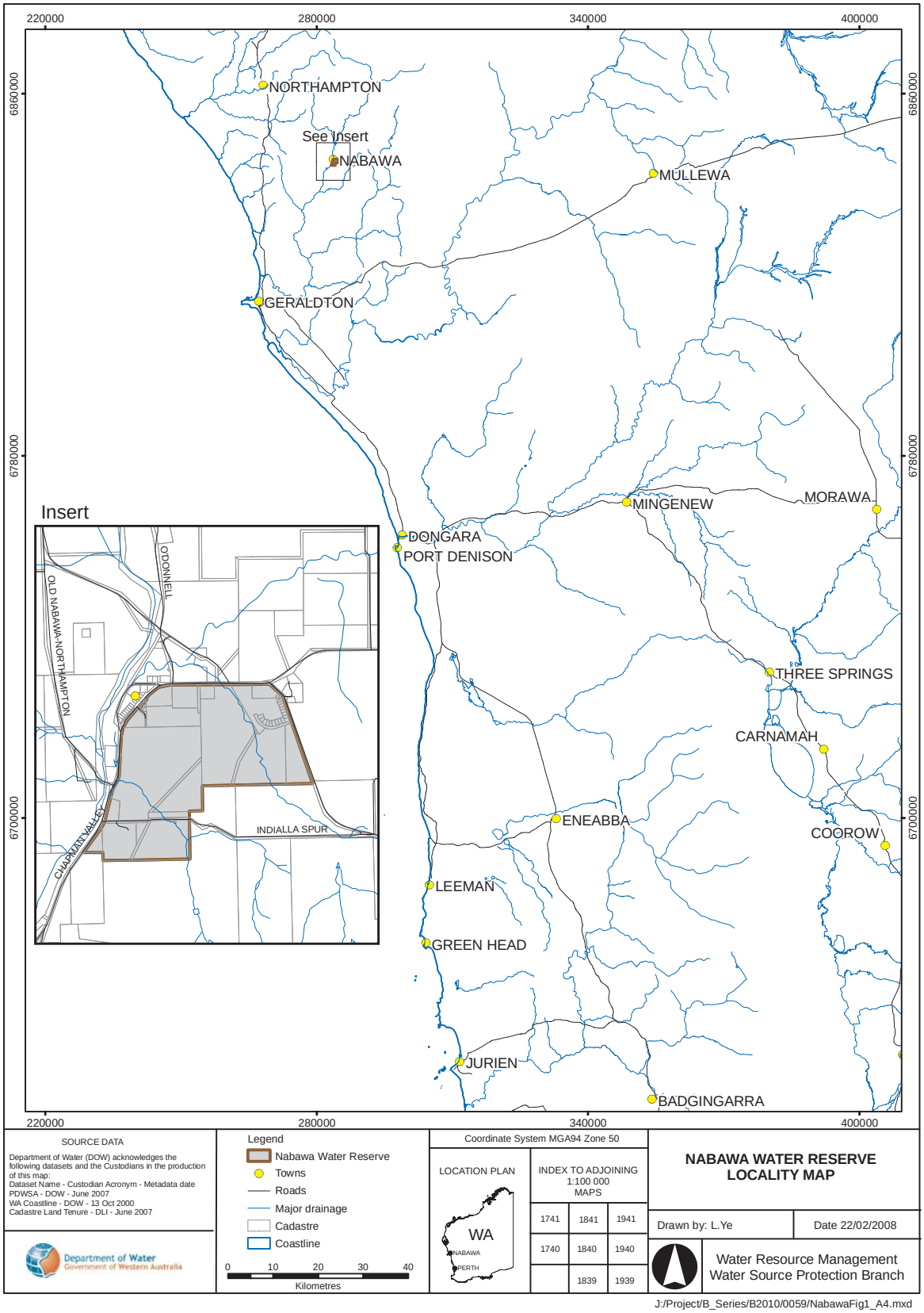

Figure 1 Nabawa Water Reserve locality map

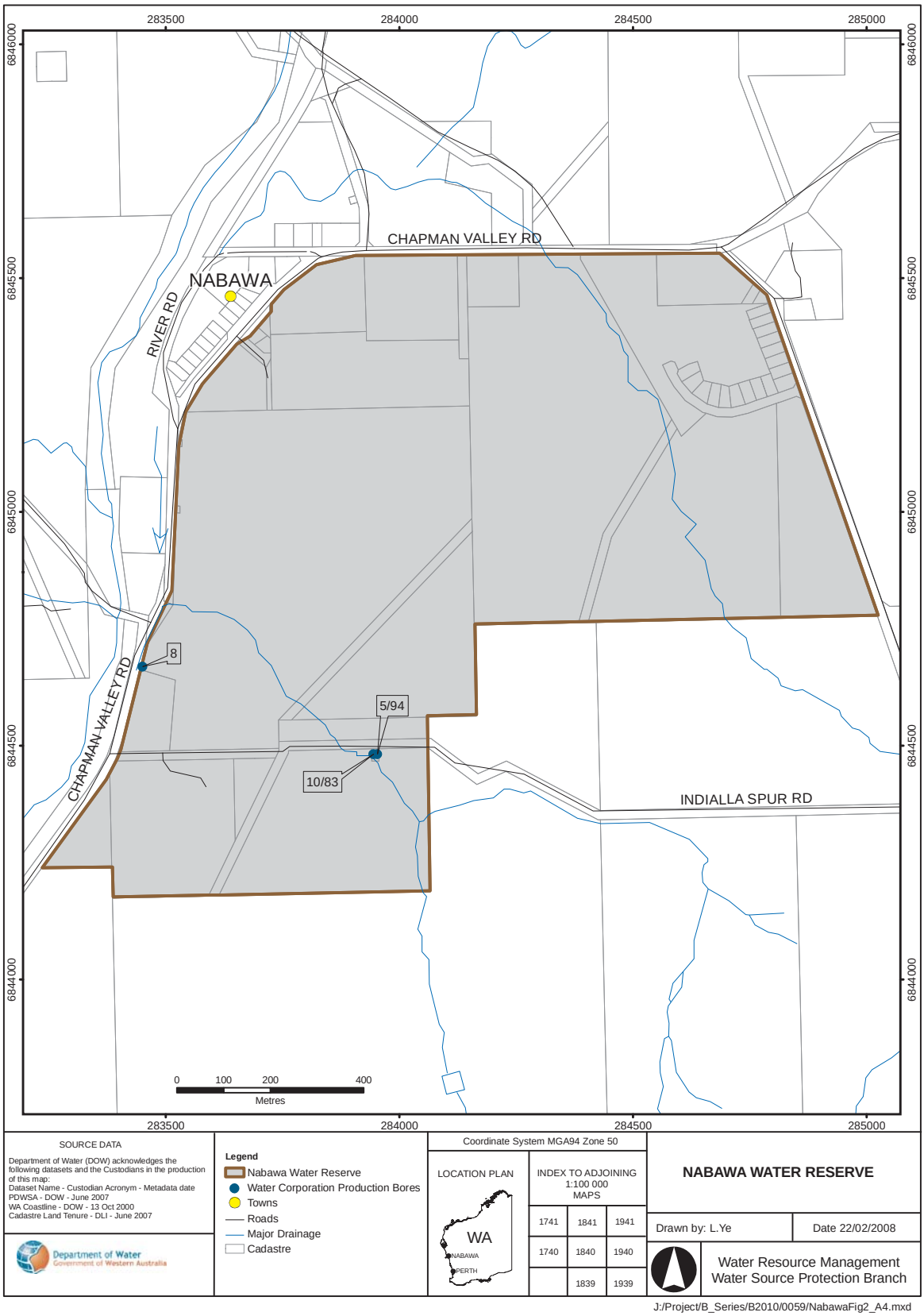

Figure 2 Nabawa Water Reserve

2 Water quality monitoring and contamination risks

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

The Water Corporation regularly monitors the raw water quality from the Nabawa Water Reserve for microbiological contamination, health related and aesthetic (non-health related) characteristics in accordance with the ADWG. 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 Nabawa Water Reserve from February 2003 to February 2008 is presented in Appendix A. For more information on the quality of drinking water supplied to Nabawa, 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.

The groundwater quality in the Nabawa Water Reserve is potentially at risk from activities occurring in the catchment. The bores are located in a rural area and abstract water from an unconfined source. Consequently, the aquifers have the potential for groundwater contamination from fertilisers and agrochemicals. There is also mineralisation in the region and this could affect groundwater quality in the fractured rock aquifer.

It should be recognised that although treatment and disinfection by chlorination are essential barriers used to ensure good quality drinking water, catchment management and water source protection are fundamental first barriers for the protection of water quality. This approach is endorsed by the Australian drinking water guidelines (ADWG) and reflects a multiple barrier, catchment to consumer, risk-based approach for the provision of safe drinking water to consumers.

2.1 Microbiological contaminants

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 (for example, *Salmonella*, *Escherichia coli* and *Cholera*), protozoa (for example, *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 (that is, 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).

Pathogens may enter a water source through activities involving direct contact of people and domestic animals with the main water body or its tributaries (such as fishing, boating and swimming). This primarily occurs through the direct transfer of faecal material (even a very small amount can cause contamination), or indirectly through runoff moving faecal material into the surface water and groundwater.

The ability of pathogens to survive in surface water differs between species. For example, *Salmonella* may be viable for two to three months, *Giardia* may still infect after one month in the natural environment (Geldreich 1996) and *Cryptosporidium* oocysts (cells containing reproductive spores) may survive weeks to months in freshwater (NHMRC & NRMMC 2004a).

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

During the review period of February 2003 to February 2008 there have been no issues with microbiological contamination.

2.2 Health related characteristics

Land use activities within a catchment can directly influence the effectiveness of water treatment. Pathogens can adsorb onto soil particles and may be shielded from the effects of disinfection.

A number of chemicals (organic and inorganic) are of concern in drinking water 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 of mineral deposits or from different land uses (NHMRC & NRMMC 2004b).

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control nematodes, that is, threadworms or roundworms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides may occur as a result of accidental spills, incorrect use or

overuse and 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 from leaching of fertiliser and 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).

Nitrate concentrations are elevated in the Nabawa area due to the natural process of plant decay underground that has occurred over geological time. The Water Corporation has been granted an exemption by the Department of Health from compliance with the nitrate guidelines as there is no alternative water supply in Nabawa. Community health nurses advise carers of infants less than three months to use alternative water sources to prepare bottle feeds.

Hydrocarbons (for example, fuels and oils) are potentially toxic to humans, and harmful by-products may be formed when they are combined with chlorine in water treatment processes. Hydrocarbons can enter a water source from vehicle accidents, refuelling and leakage from storage areas.

2.3 Aesthetic characteristics

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. The ADWG set limits on water quality characteristics to meet the aesthetic requirements of consumers.

Some properties such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. The ADWG also set out aesthetic guidelines for these types of water quality characteristics.

2.4 Groundwater bores

Under the provisions of sections 26D and 5C of the RIWI Act, a licence is required to construct a bore or extract water (unless exempt under the RIWI Exemption and Repeal (Section 26C) Order 2001) within a proclaimed groundwater area. The Nabawa Water Reserve is located within the Gascoyne 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 within a WHPZ 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 other impacts on the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the RIWI Act.

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

Land use and tenure in the Nabawa Water Reserve are shown in Figure 3 and outlined below. There is potential for contamination of the Nabawa wellfield from these existing land uses. Further details on the existing land uses, their potential water quality risks and management considerations are outlined in Table 1.

3.1.1 Crown Land

Crown reserve

There is one crown reserve, number 24313 lot 10396 (2.7 ha), located on Chapman Valley Road within the water reserve. Land uses include a primary school and grassed areas. The school is located within 900 m of the production bores.

The water quality in the Nabawa Water Reserve is potentially at risk from these land uses by pathogen contamination from the septic system as well as the risk of nutrient and herbicide contamination from maintaining the grassed areas.

3.1.2 Private land

Rural

A large portion (125.8 ha, 88 per cent) of the Nabawa Water Reserve is zoned rural and is used for cereal cropping and low intensity stock grazing. The water quality in the Nabawa Water Reserve is potentially at risk from rural activities within the reserve. This includes pathogen and nutrient contamination from animal excrement and septic systems as well as the risk of nutrient and herbicide contamination from fertiliser application, weed control and the dumping of chemical containers.

Unsealed, poorly constructed boreholes provide a direct route for contamination of the aquifer with pathogens from nearby septics and contamination from land uses at the surface. There is a private residence on lot 28 Chapman Valley Road, located within 40 m of production bore 8, and a domestic bore, in unknown condition, less than 10 m from the production bore. These are located within the WHPZ and are incompatible with the risk avoidance strategy used to protect water sources within a WHPZ.

Observation bores are located less than 100 m from bores 5/94 and 10/83. There is the potential for direct contamination of the aquifer by removing the bore caps.

There is the potential for direct contamination of the aquifers with chemicals from a large collection of empty, broken and possibly unrinsed pesticide containers close to bore 8 on lot 1 Indialla Spur Road (Photograph 3, Appendix B).

The water quality in the Nabawa Water Reserve is potentially at risk from indiscriminate dumping close to bore 8 on lot 1 Indialla Spur Road in a disused gravel quarry. Items dumped include car bodies, used car batteries, tyres, green waste, fencing wire and metal drums (Photograph 4, Appendix B). The open gates provide easy access to the public, enabling illegal dumping.

Urban

The remainder of the water reserve is classified as urban (14.7 ha, 10 per cent) and includes a small low density residential area, a tavern with petrol station. Public facilities including a recreation centre with an oval and the Chapman Valley Shire offices and service compound are located between 600 and 800 m from the production bores.

The water quality in the Nabawa Water Reserve is potentially at risk from land uses such as pathogen contamination from domestic activities including animals and septic systems as well as the risk of nutrient and herbicide contamination from gardening. There is also a potential risk of hydrocarbon contamination from the petrol station.

3.2 Proposed land uses and activities

Land use classifications and activity levels within the Nabawa Water Reserve are not expected to change in the foreseeable future.

This plan recognises the right of existing approved land uses to continue to operate. However, new land uses and expansion or intensification of existing land uses may compromise the quality of the drinking water source. Future land use activities should be consistent with Department of Water's Water quality protection note–*Land use compatibility in public drinking water source areas* and Statement of Planning Policy No. 2.7–*Public drinking water source policy*.

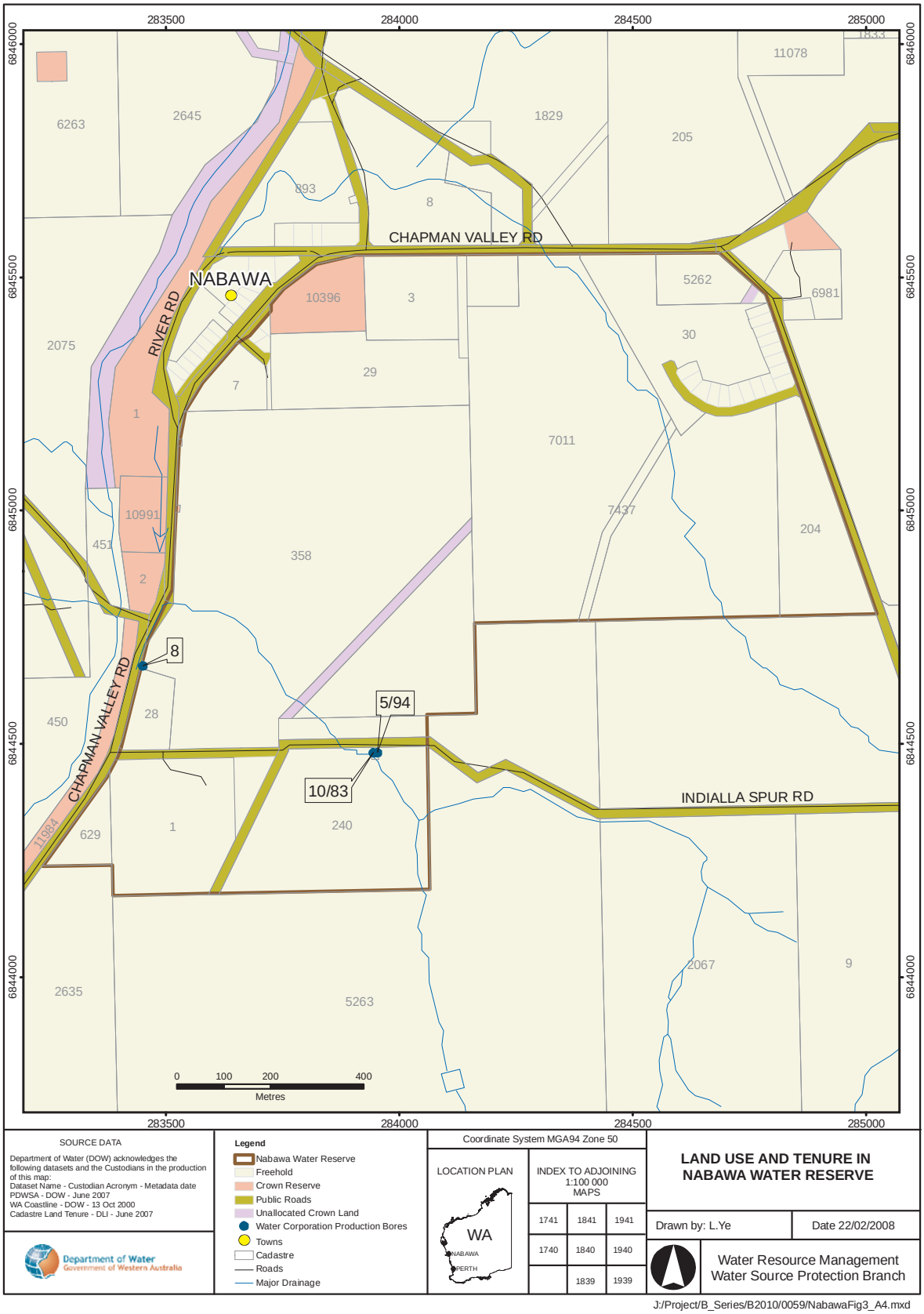

Figure 3 Land use and tenure in Nabawa Water Reserve

Table 1 Land use, potential water quality risks and recommended protection strategies

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Private land – general rural					
Cereal cropping and sheep grazing	The potential risks associated with cereal cropping and sheep grazing are: • ***Nutrients*** from sheep excrement and fertiliser application • ***Herbicides*** from weed control • ***Pathogens*** from sheep excrement • ***Hydrocarbons and chemicals*** from fuel and chemical spills.	Medium Medium Medium Low	The aquifers are shallow and unconfined. All Water Corporation bores are sealed and secured in fenced compounds. Observation bores are located less than 100 m from bores 5/94 and 10/83 with the potential for cap removal and direct contamination of the aquifer. Sheep excrement is a potential source of *Cryptosporidium*, *Giardia* and *E. coli.*	• Sealed production bores • Fenced borefield compounds • CAWS Act by-laws • Water quality monitoring.	• Establish wellhead protection zones. • Encourage landholders to undertake best management practices according to the relevant Water quality protection note– *Agriculture–dryland crops near sensitive water resources*. • Use pesticides in accordance with Statewide Policy No. 2–*Pesticide use in public drinking water Source areas (*2000) and Department of Health PSC88–*Use of herbicides in water catchment areas* (2007). • Ensure landholders comply with the Department of Health Code of Practice–Disposal of Pesticide residues from pesticide spray applications (2001) when disposing of chemical containers. • Landholder to inform relevant agency of any spills or accidents in the catchment with the potential to contaminate the water reserve. • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Residences Septic systems and domestic activities • Animals • Gardening • Vehicle maintenance Domestic bores	The potential risks associated with residences are: • ***Pathogens*** from septic systems and animals • ***Nutrients*** from septic systems, animals and fertilisers • ***Pesticides*** from pest control • ***Hydrocarbons and chemicals*** from vehicle maintenance, fuel and chemical spills. • ***Pathogens*** from septic systems and animals • ***Nutrients*** from septic systems, animals and fertilisers • ***Hydrocarbons and chemicals*** from vehicle maintenance, fuel and chemical spills.	Medium Medium Low Low **High** Medium Medium	The aquifers are shallow and unconfined. All Water Corporation bores are sealed and secured in fenced compounds. There is a private residence located within 40 m of bore 8 on lot 28. A domestic bore in unknown condition is located less than 10 m from production bore 8. Unsealed, poorly constructed boreholes provide a direct route for contamination of the aquifer with pathogens from nearby septics and from surface contaminant sources.	• Sealed production bores • Fenced borefield compounds • CAWS Act by-laws • Water quality monitoring.	• Establish wellhead protection zones. • Encourage landholders to undertake best management practices according to the relevant Water quality protection note– *Wastewater treatment-onsite domestic systems.* • Use pesticides in accordance with Statewide Policy No. 2–*Pesticide use in public drinking water source areas (*2000). • Inspect private bore on lot 28 Chapman Valley Road and reseal if necessary. • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Farm infrastructure	The potential risks associated with farm infrastructure are: • ***Hydrocarbons*** from bulk fuel storage.	Low	Leaks and spills from unbunded bulk fuel storages have the potential to contaminate the fractured rock aquifers.	• Water quality monitoring.	• Establish wellhead protection zones. • Encourage landholders to undertake best management practices according to the Water quality protection note–*Tanks for elevated chemical storage.* • Landholder to inform relevant agency of any spills or accidents with the potential to contaminate the water reserve.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Rubbish dumping	The potential risks associated with rubbish dumping are: • ***Pesticides/Herbicides*** from empty chemical container dumping • ***Heavy metals*** from car bodies, wire and used drums.	**High** Low	There is indiscriminate rubbish dumping within 300 m of bore 8 on lot 1, where car bodies, used car batteries, tyres, green waste, fencing wire and metal drums are dumped. A large collection of empty, broken and possibly unrinsed, herbicide containers is located just south of Indialla Spur Road on lot 1. There is the potential for direct contamination of the aquifers with pesticides from this source.	• CAWS Act by-laws • Litter Act 1979 • Water quality monitoring.	• Establish wellhead protection zones. • Ensure landholders comply with the Department of Health Code of Practice–*Disposal of Pesticide Residues from Pesticide Spray applications* (2001) when disposing of chemical containers. • Encourage landholders to undertake best management practices according to the relevant Water quality protection note–*Land use compatibility in Public Drinking Water Source Areas.* • Close the gates of lot 1 to discourage unauthorised and illegal dumping. • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Private land – Urban					
Residences Septic systems and domestic activities • Animals • Gardening • Vehicle maintenance	The potential risks associated with residences are: • ***Pathogens*** from septic systems and animals • ***Nutrients*** from septic systems, animals and fertilisers • ***Pesticides*** from pest control • ***Hydrocarbons and chemicals*** from vehicle maintenance, fuel and chemical spills.	Medium Low Low Low	There are two small residential areas located approximately 1 km from the bores. Density is low.	• CAWS Act by-laws • Water quality monitoring.	• Encourage landholders to undertake best management practices for existing, proposed or upgrades to on-site waste treatment systems according to the relevant Water quality protection note–*Wastewater treatment–onsite domestic systems.* • Department of Water to be involved in Nabawa townsite development planning with the Shire of Chapman Valley. • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Commercial activities • Petrol station • Tavern	The potential risks associated with commercial activities are: • ***Hydrocarbons and chemicals*** from bulk fuel storage, fuel and chemical spills • ***Pathogens*** from septic systems • ***Nutrients*** from septic systems.	Low Medium Low	There is one tavern and petrol station in the reserve, located approximately 1 km from the bores. The fuel storage tanks are less than eight years old and would comply with AS 1940 *The Storage and handling of flammable and combustible liquids*, which includes the requirement for secondary containment.	• Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992(Depart-ment of Consumer and Employment Protection) • Water quality monitoring.	• Operated fuel outlet in accordance with Water quality protection note– *Service stations*. • Encourage landholders to undertake best management practices according to the relevant industry guidelines and Water quality protection note–*Rural restaurants, cafés* and *taverns near sensitive water resources*. • Landholder to inform relevant agency of any spills or accidents with the potential to contaminate the water reserve.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Public Facilities • Recreation (Centre and Oval) • Civic (Shire Office)	The potential risks associated with public facilities are: • ***Pathogens*** from septic systems and animals • ***Nutrients*** from septic systems and animals • ***Nutrients*** from fertilisers use • ***Pesticides*** from pest control.	Medium Low Medium Low	The recreation centre, oval and shire offices are located between 600 and 800 m from the production bores. The shire no longer stores bulk fuel on site. Fertiliser and pesticide usage is expected to be low.	• CAWS Act by-laws • Water quality monitoring.	• Encourage landholders to undertake best management practices for existing, proposed or upgrades to on-site waste treatment systems according to the relevant Water quality protection note–*Wastewater treatment–onsite domestic systems.* • Use pesticides in accordance with Statewide Policy No. 2–*Pesticide use in public drinking water source areas (*2000) and Department of Health PSC88–*Use of Herbicides in water catchment areas* (2007). • Encourage landholders to undertake best management practices and prepare a nutrient and irrigation management plan, refer to Water quality protection note–*Nutrient and irrigation management plans.* • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Reserves					
Crown reserve • School	The potential risks associated with the school are: • ***Pathogens*** from septic systems • ***Nutrients*** from septic systems • ***Nutrients*** from fertilisers use • ***Pesticides*** from pest control.	Medium Low Medium Low	A primary school is located on crown reserve, number 24313, approximately 800 m from a production bore. Fertiliser and pesticide usage is expected to be low.	• CAWS Act by-laws • Water quality monitoring.	• Encourage landholders to undertake best management practices for existing, proposed or upgrades to on-site waste treatment systems according to the relevant Water quality protection note–*Wastewater treatment–onsite domestic systems.* • Use pesticides in accordance with Statewide Policy No. 2–*Pesticide use in public drinking water source areas (*2000) and *Department of Health PSC88–Use of Herbicides in water catchment areas* (2007). • Encourage landholders to undertake best management practices and prepare a nutrient and irrigation management plan, refer to Water quality protection note–*Nutrient and irrigation management plans.* • By-law enforcement.

Land use / activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Roads	The potential risks associated with roads are: • ***Hydrocarbons and chemicals*** from fuel and chemical spills from vehicles and machinery.	Low	Bore 8 is located within metres of the sealed Chapman Valley Road which is not within the currently gazetted Nabawa Water Reserve. Bores 10/83 and 5/94 are located next to Indialla-Spur Road, a rural access gravel road. Road usage is low and accidents are rare, reducing the potential for contamination.	• Local Fire and Emergency Services Authority (FESA) HAZMAT response • Water quality monitoring.	• Establish wellhead protection zones. • Ensure road siting, construction and management complies with the Department of Water's Water quality protection note–*Roads in sensitive environments*. • Ensure contingency plans are in place for any spills of hydrocarbons or chemicals resulting from accidents. • Ensure stormwater management does not direct water towards the bores. • Erect signs along the boundary of the Nabawa 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. • Consider Chapman Valley Road road reserve and crown reserves 31509 (lot 10991) and 43025 (lots 2 and 11984), located adjacent to Chapman Valley Road, as part of the wellhead protection zones for management purposes.

4 Catchment protection strategy

4.1 Protection objectives

The objective of water source protection is to preserve water quality at its current level and where practical, achieve an improvement, so as to provide safe drinking water to Nabawa.

This plan recognises the right of existing approved land uses to continue to operate within the Nabawa Water Reserve.

The department will encourage non-conforming land uses to adopt best management practices to minimise the risk to the water resource.

4.2 Proclaimed area

The Nabawa Water Reserve was proclaimed in 1990 under the CAWS Act for the purpose of protecting the public drinking water source from potential contamination.

By-laws created under this Act enable the Department of Water to control potentially polluting activities, regulate land use, inspect premises and take the necessary steps to prevent or clean up pollution.

During the preparation of this plan it was recognised that the proclaimed water reserve area, approximately 1.4 km^2, may not correspond to the physical area of land contributing to the recharge of the wellfield. This requires further investigation. This plan recommends that the existing water reserve be redefined and re-proclaimed following a hydrogeological study to ensure adequate protection of the water supply.

4.3 Priority areas

The protection of public drinking water source areas (PDWSAs) relies on statutory measures available in water resource management and land use planning legislation. The department's policy for the protection of PDWSAs includes three risk management based priority areas:

- Priority 1 source protection areas have the fundamental water quality objective of risk avoidance.
- Priority 2 source protection areas have the fundamental water quality objective of risk minimisation.
- Priority 3 source protection areas have the fundamental water quality objective of risk mitigation.

The determination of priority areas and protection zones over land in a PDWSA is based on:

- the strategic importance of the land or water source
- the local planning scheme zoning
- form of land tenure
- existing approved land uses or activities.

For further detail, please refer to the department's Water quality protection note– *Land use compatibility in public drinking water source areas*.

To date priority areas for protection have not been assigned to the Nabawa Water Reserve.

The priority areas for the Nabawa Water Reserve have been determined in accordance with the department's policy to ensure consistency with the current framework for public drinking water source protection. These priority areas reflect the strategic importance of the water source and town planning scheme land zonings and land tenure. They were determined in consultation with local government, landholders and other key stakeholders. The priority areas for the Nabawa Water Reserve are outlined below and shown in Figure 4.

All rural and recreation zoned land is classified for Priority 2 (P2) source protection. This classification is appropriate for the following reasons.

- Water from this source will supply drinking water to the Nabawa town so it should be protected.
- Land is either privately owned and zoned rural, or owned by the shire and zoned recreation or rural, so the compatible development rights are recognised.
- Existing land uses in these areas can be managed for P2 source protection objectives with the implementation of best management practices.

The remainder of the water reserve is classified for Priority 3 (P3) source protection. This classification is appropriate.

- Nabawa's water supply sources need to co-exist with these other existing land uses: residential, community, recreation, school, hotel and service station.
- Compatible development rights are recognised.
- Existing land uses are considered compatible with P3 protection objectives.

In P2 and P3 priority areas there is a strong reliance on landowners, developers, regulators and other users to be aware of the drinking water resource and risks, and to adopt and implement best management practices to help protect the drinking water source.

Existing, lawfully established but non-conforming land in the P2 and P3 priority areas are allowed to continue and land users will be encouraged to adopt environmentally responsible/best practice land use methods.

4.4 Protection zones

Wellhead protection zones (WHPZs) are defined around groundwater abstraction bores to protect the water from contamination in the immediate vicinity of drinking water production bores.

WHPZs in P2 priority areas are set at a 300 m radius around each public water supply production bore within the Nabawa Water Reserve. The WHPZs will not extend outside the boundary of the water reserve, as shown in Figure 4.

There is a strong reliance on landowners, developers, regulators and other users in the WHPZs to be aware of the drinking water resource and risks, and to adopt and implement best management practices to help protect the drinking water source.

Existing, lawfully established land uses in WHPZs are allowed to continue and land users will be encouraged to adopt environmentally responsible/best practice land use methods.

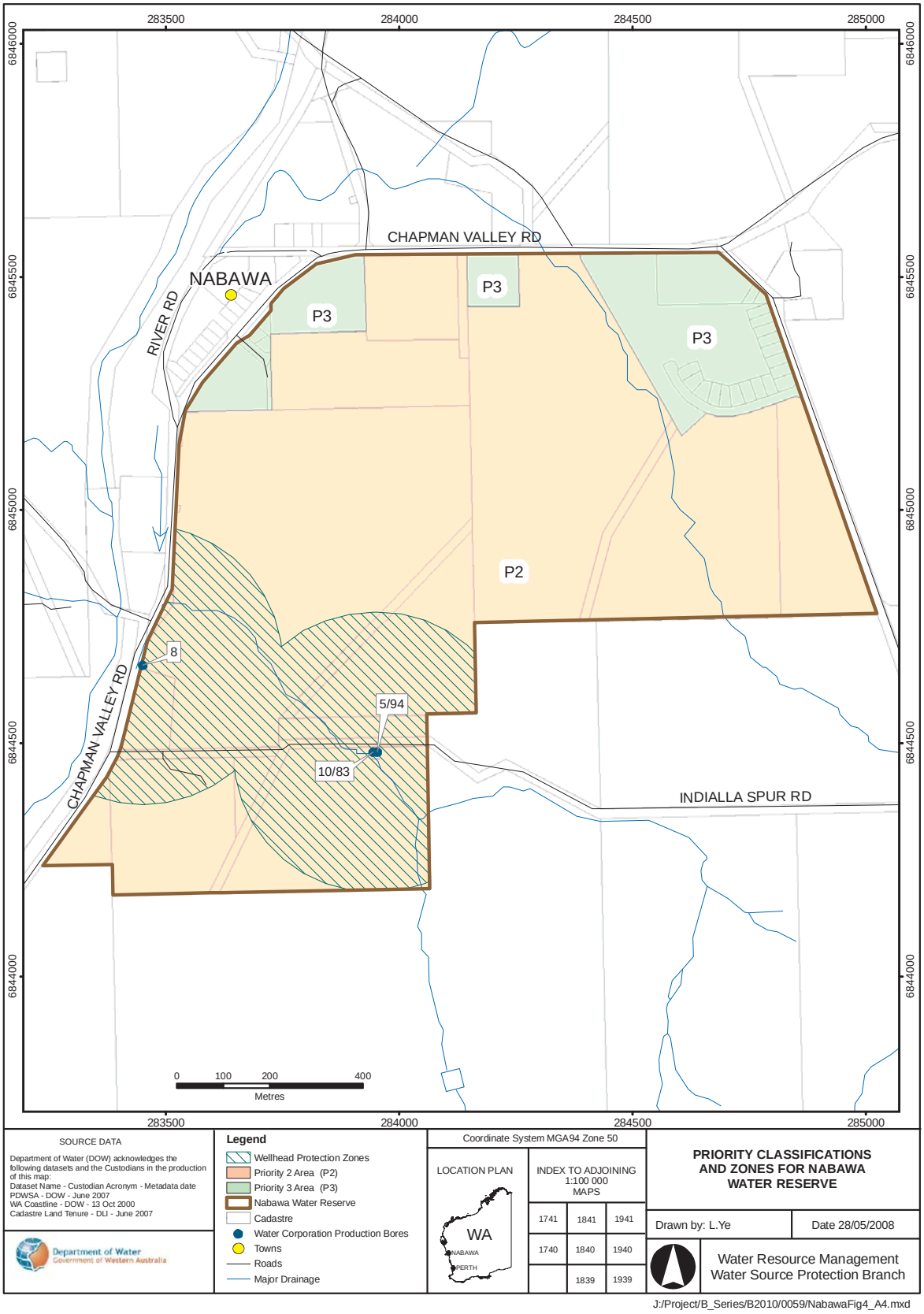

Figure 4 Priority classifications and zones for Nabawa Water Reserve

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 Nabawa Water Reserve, priority classifications and wellhead protection zones be recognised in the Shire of Chapman Valley town planning scheme. Any development proposals within the Nabawa Water Reserve that are inconsistent with advice within the Department of Water's Water quality protection note–*Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water.

The department's protection strategy for PDWSA 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/operators on measures to improve these facilities or processes to lessen the level of water contamination risk.

In critical areas close to water sources, the department may make an offer 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 for many land uses in the form of industry codes of practice, environmental guidelines or Water quality protection notes. These have been developed in consultation with stakeholders such as industry groups, producers, state government agencies and technical advisers. Examples include:

- Department of Health Code of Practice–*Disposal of pesticide residues from pesticide spray applications* (2001)
- Department of Health PSC88–*Use of herbicides in water catchment areas* (2007)
- Statewide Policy No. 2–*Pesticide use in public drinking water source areas* (2000)

- Water quality protection note–*Agriculture–dryland crops near sensitive water resources* (Department of Water)
- Water quality protection note–*Rural restaurants, cafés and taverns near sensitive water resources* (Department of Water)
- Water quality protection note–*Wastewater treatment–onsite domestic systems* (Department of Water).

These are listed in the references section of this document. The guidelines help managers to reduce the risk that their operations may cause unacceptable water quality impacts. They are recommended as best practice for water quality protection.

Education and awareness (for example, signage and information) are key mechanisms for water quality protection, especially for those people visiting the area who are unfamiliar with the Nabawa Water Reserve. A brochure will be produced describing the Nabawa 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 CAWS Act. 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 PDWSAs, as an important mechanism to protect water quality.

Signs are erected around PDWSA boundaries to educate the public and to advise of activities that are prohibited or regulated. This plan recommends that the delegation of surveillance and by-law enforcement to the Water Corporation be continued.

4.8 Emergency response

Escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Chapman Valley Local Emergency Management Committee through the Mid West–Gascoyne Emergency Management District should be familiar with the location and purpose of the Nabawa Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the Hazardous Materials (HAZMAT) Emergency Advisory Team. Water Corporation should have an advisory role to any HAZMAT incident in the Nabawa Water Reserve.

Personnel who deal with WESTPLAN–HAZMAT (Western Australian Plan for Hazardous Materials) incidents within the area should have access to a map of the Nabawa Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this water resource.

4.9 Implementation of this plan

Table 1 identifies the potential water quality risks associated with existing land uses in the Nabawa Water Reserve and recommends protection strategies to minimise these risks.

Following publication of the final Nabawa water reserve drinking water source protection plan, an implementation strategy will be drawn up based on the recommendations in Table 1. It will describe timeframes for the recommended protection strategies and identify stakeholders with an interest in the strategies. This is reflected in the recommendations section of this plan.

5 Recommendations

1 The Shire of Chapman Valley Town planning scheme should incorporate this plan and reflect the identified Nabawa Water Reserve boundary, Priority 2 and 3 areas and wellhead protection zones in accordance with Statement of Planning Policy No. 2.7–*Public drinking water source policy* (*Shire of Chapman Valley*).

2 Prepare an implementation strategy including the recommended protection strategies as detailed in Table 1: *Land use, potential water quality risks and recommended protection strategies* showing responsible stakeholders and planned timeframes (*Department of Water in consultation with applicable stakeholders*).

3 Carry out hydrogeological investigation of the Nabawa Water Reserve and amend the boundary of the water reserve consistent with the findings from that work (*Department of Water*).

4 All development proposals within the Nabawa Water Reserve that are inconsistent with the Department of Water's Water quality protection note–*Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations (*Department for Planning and Infrastructure, Shire of Chapman Valley, Proponents of proposals*).

5 Incidents covered by the Western Australian Plan for Hazardous Materials in the Nabawa Water Reserve should be addressed through the following.

- The Shire of Chapman Valley Local Emergency Management Committee should be aware of the location and purpose of the Nabawa Water Reserve.
- The locality plan for the Nabawa Water Reserve is provided to the Fire and Rescue headquarters for the Hazardous Materials Emergency Advisory Team.
- The Water Corporation provide an advisory role during incidents in the Nabawa Water Reserve.
- Personnel dealing with Western Australian Plan for Hazardous Materials incidents in the area have ready access to a locality map of the Nabawa Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality (*Department of Water; Water Corporation*).

6 The existing surveillance program should be maintained to identify any incompatible land uses or potential threats within the Nabawa Water Reserve (*Water Corporation*).

7 Signs should be erected along the boundary of the Nabawa 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*).

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

Appendices

Appendix A Water quality

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

The Water Corporation has monitored the raw (source) water quality from Nabawa borefield in accordance with the Australian drinking water guidelines (ADWG) and interpretations agreed to with the Department of Health. The raw water is regularly monitored for:

a. aesthetic characteristics (non-health related)

b. health related characteristics:

- health related chemicals
- microbiological contaminants.

The following data is representative of the quality of raw water in Nabawa borefield. In the absence of specific guidelines for raw water quality, the results have been compared with ADWG values set for drinking water, which define the quality requirements at the customer's tap. Results that exceed ADWG have been highlighted to give an indication of potential raw water quality issues associated with this source.

It is important to appreciate that this raw water data does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of ADWG. For more information on the quality of drinking water supplied to Nabawa, refer to the most recent Water Corporation drinking water quality annual report at <http://www.watercorporation.com.au/W/waterquality_annualreport.cfm?uid=2377-9937-9579-7091>.

Aesthetic characteristics

Aesthetic water quality analyses for raw water from Nabawa borefield are summarised in Table 2.

The values are taken from ongoing monitoring for the period February 2003 to February 2008. All values are in milligrams per litre (mg/L) unless stated otherwise. Any water quality parameters that have been detected are reported; those that have on occasion exceeded the ADWG are highlighted.

Table 2 Aesthetic parameters detections for Nabawa borefield

Parameter	Units	ADWG Aesthetic guideline value*	Range of monitored values min-max med			
			Nabawa Bore 10/83 SP	Nabawa Bore 5/94 SP	Nabawa Bore 8 SP	Nabawa Raw Source SP
Aluminium unfiltered	mg/L	na	<0.008 <0.008	<0.008 <0.008	<0.008–0.01 <0.008	<0.008–57 0.011
Chloride¥	mg/L	250	170–205 195	210–250 240	180–270 205	195–240 225
Colour–True	TCU	15	<1 <1	<1 <1	<1–2 <1	<1–3 <1
Conductivity at 25 ºC	mS/m	na	85–101 97.1	96–115 105	92.1–140 105	92–125 102.5
Hardness as $CaCO_3$¥	mg/L	200	98–109 102	104–139 134	96–148 111	102–126 105
Iron unfiltered	mg/L	0.3	0.05–0.44 0.1975	<0.003 <0.003	<0.003–0.01 <0.003	<0.003–0.5 0.008
Manganese unfiltered	mg/L	0.1	0.006–0.014 0.01	<0.002–0.028 <0.002	<0.002 <0.002	<0.002–0.022 <0.002
pH	no unit	6.5-8.5	6.34–6.68 6.465	6.38–6.87 6.46	6.86–6.99 6.91	6.45–6.92 6.665
Sodium¥	mg/L	180	120–145 135	155–170 160	160–225 170	155–200 175
Sulphate¥	mg/L	250	38–57 56	55–72 61	59–79 72	68–76 76
TFSS¥	mg/L	500	544–600 569.5	646–684 673	695–888 724	651–791 733
Turbidity	NTU	5	0.4–5.6 0.95	<0.1–0.2 0.1	<0.1–0.3 <0.1	<0.1–2.6 <0.1

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

¥ Water quality data observed from five or less sampling occasions from the raw source.

Note: Water quality data for bores was provided from five or less sampling occasions for all parameters except conductivity.

Health related characteristics

Health parameters

Raw water from Nabawa borefield is analysed for health related chemicals including inorganics, heavy metals and pesticides. Health related water quality parameters that have been measured at detectable levels in the source between February 2003 and

February 2008 are summarised in Table 3. Any parameters that have on occasion exceeded the ADWG are highlighted.

Table 3 Health related detections for Nabawa borefield

Parameter	Units	ADWG Health Guideline Value*	Range of Monitored Value Min-Max Med			
			Nabawa Bore 10/83 SP	Nabawa Bore 5/94 SP	Nabawa Bore 8 SP	Nabawa Raw Source SP
Barium†	mg/L	0.7	-	-	-	0.025 0.025
Boron†	mg/L	4	-	-	-	0.2–0.22 0.21
Fluoride	mg/L	1.5	-	-	-	0.45–0.8 0.525
Nitrate as nitrogen	mg/L	11.29	-	-	-	<0.002–10 8.2
Nitrite as nitrogen	mg/L	0.91	-	-	-	<0.002–0.008 <0.002
Nitrite plus nitrate as N†	mg/L	11.29	6.3–11.5 8.9	4.2–10.5 9.6	9.2–10.5 10	7.8–8.1 8

* 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 & ARMCANZ 1996).

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

Microbiological contaminants

Microbiological testing of raw water samples from Nabawa borefield 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 of February 2003 to February 2008, no positive *Escherichia coli* detections were recorded.

Appendix B Photographs

Photograph 1 Water Corporation Bore 8 in a locked compound

Photograph 2 Water Corporation bores 5/94 and 10/83 in a locked compound

Photograph 3 Dumping of chemical containers within the wellhead protection zone

Photograph 4 Dumping within the water reserve

Glossary

abstraction	the pumping of groundwater from an aquifer, or the removal of water from a waterway or water body
adsorb	to accumulate (liquids or gases) on the surface
ADWG	the Australian drinking water guidelines, outlining acceptable criteria for the quality of drinking water in Australia
aesthetic guideline	a water quality criterion in the ADWG associated with acceptability of water to the consumer, for example, appearance, taste and odour (NHMRC & NRMMC 2004a)
AHD	Australian Height Datum; the height of land in metres above mean sea level, for example +0.026 m at Fremantle
allocation	the quantity of water permitted to be abstracted by a licensee, usually specified in kilolitres per year (kL/yr)
ANZECC	Australian and New Zealand Environment Conservation Council
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
borefield	a group of bores to monitor or withdraw groundwater
catchment	the area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater
conductivity	electrical conductivity; estimates the volume of total dissolved solids (TDS) or the total volume of dissolved ions in a solution (water) corrected to 25 °C. Measurement units include milliSiemens per metre and microSiemens per centimetre.
effluent	the liquid, solid or gaseous wastes discharged by a process, treated or untreated
fractured rock aquifer	an aquifer where groundwater is present in the fractures, joints, solution cavities, bedding planes and zones of weathering

	igneous, metamorphic and deformed sedimentary rocks. Fractured rock aquifers they are highly susceptible to contamination from land use activities when they crop out or sub-crop close to the land surface
ha	hectare (a measure of area)
HAZMAT	hazardous materials
health guideline	a water quality criterion in the ADWG 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, for example fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons
hydrology	the scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere
kL	kilolitre (1 000 litres) or one cubic metre
km	kilometre (1 000 metres)
km^2	square kilometre (a measure of area) or one million square 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 and can pollute groundwater and waterways.
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
mm	millimetre
mS/m	milliSiemens per metre, a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity

NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units, 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.
oocysts	the spore phase of certain organisms, such as *Cryptosporidium* and *Toxoplasma*, which can survive for lengthy periods outside a host and is very resistant
pathogen	a disease producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses
pesticides	collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms
pH	a logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below 7 indicates an acidic solution and above 7 indicates an alkaline solution.
pollution	Water pollution occurs when waste products or other substances (for example, 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
PDWSA (Public Drinking Water Source Area)	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 or

	fractured rock 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.
spore	a small, usually single-celled reproductive body that is highly resistant to desiccation and heat and is capable of growing into a new organism, produced especially by certain bacteria, fungi and algae
TCU	true colour units (a measure of degree of colour in water)
TFSS	total filterable solids by summation.
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
wastewater	water that has been used for some purpose and would normally be treated and discarded; usually contains significant quantities of pollutants
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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