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

Leonora Water Reserve

Drinking water source protection plan

Leonora-Gwalia town water supply

Looking after all our water needs

Water resource protection series
Report WRP 113
June 2010

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Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601
www.water.wa.gov.au

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For more information about this report, contact the Water Source Protection Branch on +61 6364 7600 or drinkingwater@water.wa.gov.au.

Cover photograph: Station Creek weir (Photo: V. Claughton)

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Preface

How do we protect public drinking water source areas?

The Australian drinking water guidelines (ADWG) (NHMRC & NRMMC 2004a) outlines how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a risk-based, multiple-barrier approach. A similar approach is recommended by the World Health Organization in other countries worldwide.

The 'catchment to consumer' framework applies across the entire drinking water supply system, from the water source to the tap. It ensures a holistic assessment of risks to drinking water to maximise the delivery of safe drinking water to consumers.

A risk-based approach means that we look at all the different risks to water quality, and how to address them. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system. The first barrier is protecting the catchment (the whole area from which water flows into the drinking water source). This plan helps to do that. Other barriers against contamination include:

- storage of water to help settle out contaminants
- treating the water (e.g. chlorination) to remove contamination
- maintenance of pipes
- monitoring of water quality.

As water treatment practices evolve, many people think that we no longer need to protect the catchment because we can 'engineer out the risks'. Nothing could be further from the truth (Krogh et. al 2008). Recent research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That's why this drinking water source protection plan is important. It's about protecting the catchment's water quality now and in the future.

In Western Australia, the Department of Water protects public drinking water source areas (PDWSAs) by using the law; putting the ADWG into practice; writing plans, policies and guidelines; and providing input into land-use planning.

The *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA) allow us to protect water. We proclaim PDWSAs under one of these Acts so that we can apply the legislation to protect water quality.

The ADWG outlines 12 elements to protect drinking water. We implement element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management) by writing drinking water source protection plans. Plans have been, or are being written for all PDWSAs

around the state. They give an overview of a drinking water source and outline the risks to water quality and how to address them. Our regional offices work with the community, other government agencies and landowners to put the recommendations into practice.

We also define special areas within PDWSAs: priority areas and protection zones. There are three different priority areas, each assigned a certain level of risk to water quality. Protection zones surround drinking water extraction points, so that the most vulnerable areas may be protected from contamination. Under legislation, some activities are restricted in protection zones.

If you would like more information about how we protect drinking water in Western Australia, go to <http://drinkingwater.water.wa.gov.au>.

The following table outlines the stages involved in the preparation of this drinking water source protection plan:

Stages in development of a plan		**Comment**
1	Prepare draft drinking water source protection plan. (2000 and 2004)	Prepared after catchment survey, information gathering and assessment of risks to water quality.
2	Conduct stakeholder consultation. (October to April 2010)	Advice sought from key stakeholders using the assessment document as a tool for information and discussion.
3	**Publish approved drinking water source protection plan.** (June 2010)	Final protection plan published after considering stakeholder feedback. Includes recommendations on how to protect water quality. Proclamation of proposed public drinking water source area can now occur.

Summary

Leonora and Gwalia are located approximately 830 km north-east of Perth on the Goldfields Highway. Leonora is a service centre for the mining, exploration and pastoral industries in the area while Gwalia is a historical mining town restored for tourism. The Leonora-Gwalia township supports a population of approximately 1 500 people.

The Leonora-Gwalia town water supply is drawn from the Station Creek wellfield operated by the Water Corporation. The wellfield draws water from a shallow, unconfined, fractured rock aquifer that is vulnerable to contamination from land uses in the recharge area. Raw water from the Station Creek wellfield is treated to reduce scaling caused by hardness and disinfected using chlorine. In 2004 a reverse osmosis plant was brought online to reduce naturally occurring high levels of salinity, nitrate and hardness in the water.

The Leonora Water Reserve was proclaimed in 1990 under the *Country Areas Water Supply Act 1947* (WA) to protect the water source. The water reserve covers the recharge area for the Station Creek wellfield and the surface water catchment for Station Creek. This plan proposes a reduction of the existing water reserve to exclude the catchment area for Jasper Flats, which is no longer considered a likely future water source for Leonora.

Potential risks to drinking water quality in the remaining water reserve include contamination from mining and mineral exploration activities, pathogens from livestock on pastoral leases, and hydrocarbons from fuel storage and theft in bore compounds. Open historic wells near production bores and abandoned drill holes throughout the water reserve may allow direct contamination of the aquifer.

The following strategies are recommended to protect water quality within the Leonora Water Reserve:

- All land within the proposed Leonora Water Reserve should be managed for Priority 1 source protection.
- The source/s of pathogens identified in raw water samples should be further investigated. The findings should be used to implement appropriate protection strategies to reduce pathogen contamination risk-levels.
- Open historic wells near production bores should be capped or backfilled. The seals on capped wells should be periodically checked and maintained.
- The boundary of the water reserve should be reviewed for the next update of this plan. That review should consider future drinking water source planning and investigate the broader impact of the surface water catchment on the Station Creek wellfield and any proposed production bores.

1 Drinking water source overview

1.1 Existing water supply system

The Leonora-Gwalia town water supply is sourced from the Station Creek wellfield, located approximately 12 km north of Leonora (Figure A1). The wellfield is operated by the Water Corporation.

There are 12 production bores and 17 monitoring bores in the Station Creek wellfield (Figure A2). The production bores are generally located along Station Creek in fenced and locked compounds (Figure D1). All the production bores are constructed of slotted PVC casing, varying in depth from approximately 30 to 70 m (Figure D2). The bore pumps are powered by diesel generators with self-bunded above-ground fuel tanks (Figure D3). Water is abstracted from between 6 and 70 m below ground level and pumped to a collector tank adjacent to the Station Creek pump station. From the pump station the water is transferred to the Mount George storage tank about 8 km north of Leonora.

1.2 Water treatment

Approximately half the water from the Mount George storage tank is treated at a reverse osmosis plant located about 3 km west of Leonora. The plant was brought online in 2004 to reduce naturally occurring high levels of salinity, nitrate and hardness in the town water supply. The remaining water bypasses the desalination plant and is dosed with Calgon to reduce scaling caused by hardness. The two streams of treated water are blended, chlorinated to disinfect the water and then stored in the desalination treated water tank. Water is pumped from this tank to the Leonora and Gwalia town reticulations and the local Buttress and Gwalia tanks.

It should be recognised that although treatment and disinfection are essential barriers against contamination, management of the wellfield is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed by the *National water quality management strategy: Australian drinking water guidelines 6,* 2004 (ADWG) (NHMRC & NRMMC 2004a) and reflects a risk-based, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver more reliable, safe and lower-cost drinking water to consumers than either approach could achieve individually.

1.3 Catchment details

1.3.1 Physiography

The area has a low to moderate relief with elevations ranging from about 360 to 480 m AHD. A prominent range of hills extends north-north-west from south of

Leonora, rising approximately 60 m above the surrounding plain. Surface drainage flows to the south-west, toward and into Lake Raeside.

1.3.2 Climate

The climate is semi-arid with hot, dry summers and cold to mild winters. Rainfall averages 234 mm per year and is generally confined to intense events associated with tropical cyclones during the summer months and frontal systems in the winter months. The average potential evaporation at Leonora is approximately 2 000 mm per year.

1.3.3 Hydrogeology

Leonora lies in the Eastern Goldfields Province within the Archaean Yilgarn Craton. The Station Creek wellfield is located in the Malcolm Greenstone Belt which comprises mainly volcanics and sedimentary rocks (Griffin 1990). The greenstones are generally deeply weathered, usually 50 to 70 m but may be up to 100 m, and are concealed by a layer of younger deposits. Lake deposits and peripheral Aeolian deposits occur in the Lake Raeside area.

The Station Creek aquifer forms part of the Lake Raeside palaeodrainage system. Groundwater is abstracted from both shallow sedimentary rocks and fractured bedrock. The depth to groundwater varies between 6 and 11 m.

Recharge is derived from infiltration of rainfall and runoff associated with high rainfall events. The amount of recharge is generally small due to low rainfall and high evaporation. Recharge is greatest where permeable sediments occur at the surface in the Station Creek area.

Regional groundwater flow in the sediments is slow and generally to the south-west towards Lake Raeside. Movement of groundwater within the fractured rock is controlled by the geological structure and outflow may be restricted, causing increased salinity. Discharge occurs by evapotranspiration and possibly by leakage of groundwater to palaeochannel sediments beneath the Lake Raeside area. Consequently, groundwater can range from potable in the recharge areas to hypersaline in the discharge areas, with salinity increasing in the direction of groundwater flow.

Due to the shallow, unconfined nature of the aquifer, the groundwater is considered vulnerable to contamination from land uses in the recharge area.

1.4 Future water supply requirements

Annual growth in water consumption is expected to be less than 0.5 per cent and town growth is expected to be slow for the foreseeable future. Actual water demand depends on the extent of mining activities in the region. The Water Corporation estimates that water demand will not exceed the current allocation by 2015–16.

The Water Corporation has identified several future water source options. The most likely option is an extension of the existing Station Creek wellfield between the Station Creek pumping station and the Mount George storage tank. Other options include artificial storage and recovery through the injection of water into the aquifer at Station Creek. The diversion of surface water into the Jasper Flats mine pit is now considered an unlikely future water source.

1.5 Existing drinking water source protection

The Leonora Water Reserve was proclaimed in 1990 under the *Country Areas Water Supply Act 1947* (WA) for the purpose of public drinking water source protection. 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.

In 2000 the Water and Rivers Commission prepared the *Leonora Water Reserve draft drinking water source protection plan* (Water and Rivers Commission 2000a). This document outlined risks to water quality from land uses and activities in the Leonora Water Reserve. This drinking water source protection plan builds on and replaces the draft plan.

Current measures undertaken by the Water Corporation for drinking water source protection within the Leonora Water Reserve include water quality monitoring, fenced and locked bore compounds (Figure D1), installation of self-bunded fuel storage tanks with anti-theft devices (Figure D3), water treatment and surveillance of the water reserve.

1.6 Department of Water management

1.6.1 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* (WA). Under this Act, the right to use and control surface water and groundwater is vested with the Crown. The Act requires licensing of groundwater abstraction (pumping water from a bore, spring or soak) within groundwater areas proclaimed under the Act and all artesian wells throughout the state.

The Leonora Water Reserve is located in the Goldfields Groundwater Area which was proclaimed in 1990 under the *Rights in Water and Irrigation Act 1914* (WA). The Water Corporation is licensed by the Department of Water to draw up to 600 000 kL per year for public water supply purposes.

2 Water quality monitoring and contamination risks

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

The Water Corporation regularly monitors the quality of raw water from the Leonora Water Reserve for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in the water reserve. An assessment of the drinking water quality once treated is also made against the ADWG to ensure safe, good quality drinking water is available to consumers. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health.

A water quality summary for the Leonora Water Reserve from July 2004 to June 2009 is presented in Appendix B. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at <www.watercorporation.com.au> What we do > Water quality > Water quality publications > Water quality annual report 2008-09.

Contamination risks relevant to drinking water sources are described below.

2.1 Microbiological

Pathogens are types of microorganisms that are capable of causing disease. These include bacteria, protozoa and viruses. In water supplies, pathogens that can cause illness are commonly found in the faeces of humans and domestic animals (such as dogs and cattle).

A number of pathogens 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. *E. coli* counts are a way to measure these pathogens and provide an indication of faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (e.g. humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water. The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 to 4.3 per cent of people are infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

When people (while fishing, marroning, swimming or the like) or domestic animals come into contact with a body of water, pathogens may enter that water source. 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 water.

The ability of pathogens to survive in surface water also differs between species. 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 fresh water (NHMRC & NRMMC 2004a).

When people consume drinking water contaminated with pathogens the effects vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and sometimes even death. During 2000, seven people died in Walkerton, Canada, because the town water source and supply was contaminated by a pathogenic strain of *E. coli* and campylobacter (NHMRC & NRMMC 2004b). Where possible, avoiding the introduction of pathogens into a water source is the most effective way to protect public health.

Pathogens have been frequently detected in raw water samples from production bores and water storage tanks in the Leonora Water Reserve. The Water Corporation is investigating the source of the pathogens and has instigated a project to seal existing bore headworks and water storage tanks.

2.2 Health related

Land- and water-based uses and activities within a catchment can directly affect water quality and treatment. For example, off-road driving contributes to erosion and the uprooting of vegetation which can increase turbidity in water. This increased turbidity can subsequently reduce the effectiveness of treatment processes (such as disinfection).

Erosion results in the mobilisation of soil particles that are released into the air and tributaries, increasing the turbidity of the main water body. Pathogens can absorb onto these soil particles and may be shielded from the effects of disinfection. Increased turbidity also impacts on other environmental constituents: it smothers riparian vegetation and reduces the transfer of light within the water column, which in turn affects plant growth.

Chemicals attached to suspended material, such as soil particles, can occur in drinking water sources. This may occur as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2004a). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural 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, incorrect use or leakage from storage

areas. In such cases, the relevant authorities should be notified promptly and the spill cleaned up.

Drinking water supplies can also be contaminated by nutrients (such as nitrogen) from fertiliser applications, faulty septic systems, leach drains and from domestic animal faecal matter that washes through or over soil and into a water source. Nitrate and nitrite can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2004a).

Naturally occurring nitrate concentrations in raw water from the Leonora Water Reserve exceed the ADWG health value. After the raw water is treated, however, nitrate concentrations are well below the ADWG health value for the town water supply.

Hydrocarbons (e.g. fuels, oils) are potentially toxic to humans, and harmful chemical by-products may be formed when they are combined with chlorine during the water-treatment process. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

2.3 Aesthetic

Impurities in drinking water can affect its aesthetic qualities, including its appearance, taste, smell and feel. Such impurities are not necessarily hazardous to human health; for example, cloudy water with a distinctive odour or strong taste is not necessarily harmful to health, while clear, pleasant-tasting water may still contain harmful microorganisms (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 ADWG sets aesthetic water quality criteria to meet the aesthetic requirements of consumers and to protect water supply infrastructure (such as pipes).

The raw water from the Leonora Water Reserve is characterised by naturally occurring hardness and salinity at concentrations exceeding the ADWG aesthetic values. Treatment of the raw water results in substantially reduced levels of hardness and salinity in the town water supply.

2.4 Groundwater bores

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

The Water Corporation operates drinking water bores in the Leonora Water Reserve. If bores for other purposes (e.g. irrigation, mining) are drilled near a public drinking water supply bore, they can cause contamination of the drinking water source. For example, a poorly constructed private bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

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

The Leonora Water Reserve is located over Crown reserve and Crown lease. Current land uses and activities are outlined below. This information has been summarised in Table 1 at the end of this section. The table also identifies the recommended management priorities for different hazards. Appendix C of this plan uses data in Table 1 and this section to recommend protection strategies for key stakeholders to consider.

3.1.1 Drill holes

A large number of abandoned and open drill holes in the water reserve present potential pathways for direct contamination of the aquifers through surface water flows.

A padlocked, capped bore operated by Main Roads Western Australia occurs near production bore 1/89. The bore is not currently in use but may provide water for road construction projects in the future.

3.1.2 Mining tenements

Most of the water reserve is covered by mining tenements and gold mining has previously occurred at several sites within the proposed water reserve (Figure A4). No active mines are operating in the water reserve but exploration activities are ongoing. New mines are being developed outside the water reserve's eastern edge.

Mineral exploration

Exploration drilling through the alluvial sediments and into the fractured rock beneath presents a potential contamination risk through direct application of drilling fluids and oils into the aquifer. Other risks include fuel and oil spills around the drilling rig and infiltration of contaminants from drilling fluid sumps.

Mining activities

Contamination risks posed from potential mining activities include:

- tailings storage facility management
- workshop and process-plant liquid and solid waste management
- mechanical servicing of plant and equipment
- storage of chemicals
- stormwater management
- acid rock drainage management
- dewatering discharge

- mine-pit rehabilitation.

3.1.3 Pastoral leases

The Leonora Water Reserve includes land used for dry grazing on pastoral leases (Clover Downs and Tarmoola stations, Figure A3). Fenced bore compounds prevent livestock gathering around production bores, however livestock have unrestricted access to wellhead protection zones and Station Creek. The Station Creek weir is used as a livestock watering point (Figure D4). Livestock grazing can cause nutrient and pathogen contamination from faecal material, particularly where grazing occurs near production bores, open drill holes or where livestock have direct contact with surface waterbodies that may be connected with the underlying aquifer.

3.1.4 Recreation

Authorised recreation

Authorised recreation in the water reserve includes the Station Creek site of the Darlot Loop adventure drive. The site has an unsealed road and car park, picnic tables and information boards near production bore 1/89. Evidence of camping was observed at the site (Figure D5). The recreation site may pose risks to water quality arising from fuel leaks and spills and pathogens from human activities. There is also a fenced but open historic well adjacent to the car park which provides a potential pathway for direct contamination of the aquifer through accidental or deliberate actions by people. Unmarked roads and tracks from the car park allow unauthorised vehicle access further into the water reserve and onto the usually dry Station Creek bed.

Unauthorised recreation

Unauthorised off-road driving, camping and hunting are known to occur in the water reserve. Off-road driving was evident in the dry Station Creek bed near production bore 1/89. Picnicking and swimming are known to occur at the Station Creek weir (Figure A4) which may be connected to the underlying aquifer. Risks to water quality from unauthorised recreation in the water reserve are pathogens from human activity and fuel leaks or spills from vehicles.

3.1.5 Roads and tracks

The Goldfields Highway traverses the Leonora Water Reserve in close proximity to the Station Creek wellfield. The highway is a major route for the transport of fuel, metals, chemicals and other potentially contaminating materials. While the highway is down-gradient of the wellfield, road accidents and fuel or chemical spills near the wellfield are potential contamination risks to groundwater.

The numerous unsealed roads throughout the water reserve pose risks from hydrocarbon or chemical spills and leaks from vehicles. They also allow unauthorised access to Station Creek and the production bores. Unauthorised vehicle use in the

water reserve is associated with off-road driving, unauthorised recreation activities, camping, hunting, fuel theft and vandalism of water supply infrastructure.

3.1.6 Station Creek wellfield

Fuel storage

The fuel storage tanks for the diesel generators are self-bunded and located within the bore compounds, which minimises the risk of fuel leakage. There is a risk of spillage occurring when the tanks are refilled or maintained. A diesel spill occurred near bore 35/91 in 2006. The contaminated soil was excavated and refilled with clean river sand. Monitoring of the site indicated that the groundwater was not contaminated.

The bore compounds are fenced and locked, and the fuel storage tanks are equipped with anti-theft devices. However, vandalism and attempted fuel theft continue to occur in the wellfield. These activities may result in spillage or leakage of fuel and subsequent contamination of groundwater.

Historic wells

Historic wells near production bores 1/89, 1/87, 2/87 and 32/91 are potential pathways for direct contamination of the aquifer. The wells have historic value and cannot be filled in or capped and sealed without permission from the Heritage Council of Western Australia. The historic wells near bores 1/87 and 2/87 were previously capped but have been damaged and are now inadequately sealed (Figure D6).

3.1.7 Aboriginal sites of significance

Aboriginal sites of significance are those areas that Aboriginal people value as important and significant to their cultural heritage. The sites are significant because they link Aboriginal culture and tradition to place, land and people over time. These areas form an integral part of Aboriginal identity and the heritage of Western Australia. The *Aboriginal Heritage Act 1972* (WA) protects all Aboriginal sites in the state.

There are 22 Aboriginal sites of significance within the proposed boundary of the Leonora Water Reserve (Figure A4). Those sites are Leonora-Leinster 01 (W00612), Saw Pit Well (W00357), Saw Pit Creek, Oasis (W01559), Whistler Field Site 2, Crabhole Swamp, Pig Well Bore 3 (W01787), Whistler Field Site 1, Pig Well Bore 2 (W01786), Mt George (W00518), Pig Well (W00355), Makata (W01998), Saw Pit Well (near) (W01430), Station Creek (W00627), Snell's Turnoff (hills), Mt Davis Range, Sandy Soak North, Creek Crossing 1 (W00630), Mount Davis Breakaway, Mulla Soak/Sandy Soak (W00075), Sandy Soak South (W00628) and Sandy Soak Quarry (W00629).

3.2 Proposed land uses and activities

Land uses and activities are not expected to change within the Leonora Water Reserve in the short term. Pastoral activities are expected to continue and further mineral exploration and mining activities may occur within the water reserve. There are currently no mining projects being developed within the water reserve.

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Abandoned drill holes				
Drill holes (abandoned and open drill holes)	Fuels, chemicals and metals from surface water flows and the accidental or deliberate actions of people	Medium	N/A	Infilling or sealing of disused drill holes
	Pathogens and nutrients from surface water flows contaminated by faecal matter from humans, livestock, pests or native fauna	High		
Mining tenements				
Mining activities	Chemicals and metals from the mining process and wastes	Medium	Mining is compatible with conditions in a Priority 1 (P1) area	Water quality protection guideline series: *Mining and mineral processing*
	Fuels and oils from machinery and vehicles	Medium		
	Pathogens, nutrients and chemicals from on-site waste disposal and human activities	Medium		
	Turbidity and metals from vegetation removal, ineffective site management or construction activities	Low		

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Mineral exploration	Fuel or chemical contamination from drilling activities Fuel or chemical spills from machinery Fuel storage Pathogens from human activities	Medium Medium Medium Medium	Mining is compatible with conditions in a P1 area	Water quality protection guideline series: *Mining and mineral processing*
Pastoral leases				
Pastoral activities	Fuel or chemical spills from vehicles and machinery Herbicides and pesticides Pathogens from faecal matter	Low Low High	Compatible with conditions in a P1 area Incompatible in wellhead protection zones	Water quality protection note (WQPN) no. 35: *Pastoral activities within rangelands;* Statewide policy no. 2: *Pesticide use in public drinking water source areas*
Recreation				
Recreation – authorised (Darlot Loop adventure drive)	Fuel and oil spills from vehicles Pathogens from human activities Chemicals, fuels or pathogens through accidental or deliberate contamination of the unsealed historic well	Medium Medium Medium	N/A	
Recreation – unauthorised (off-road vehicles, camping and hunting)	Fuel and oil spills from off-road vehicles Pathogens from human activities and animal carcasses	Medium Medium	N/A	

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Recreation – unauthorised (swimming at Station Creek weir)	Pathogens from direct contact with waterbody	Medium	N/A	
Roads and tracks				
Roads and tracks	Hydrocarbon spills and leaks from vehicles	Medium	Existing roads and tracks are acceptable	WQPN no. 44: *Roads near sensitive water resources*
Station Creek wellfield				
Fuel storage	Hydrocarbon leaks and spills due to vandalism/theft Hydrocarbon leaks and spills during refilling	Medium Low	Water supply infrastructure is compatible with conditions in a P1 area	WQPN no. 60: *Tanks for mobile fuel storage in public drinking water source areas*
Historic wells	Pathogens, nutrients, hydrocarbons or chemicals from surface water flows and accidental or deliberate actions of people	High	N/A	Infilling or sealing disused wells

4 Catchment protection strategy

4.1 Protection objectives

This plan's objective is to protect water quality in the Leonora Water Reserve to ensure safe drinking water for consumers in Leonora and Gwalia, while recognising the rights of existing approved land uses to continue. The Leonora Water Reserve should be managed to improve the quality of raw water abstracted from the aquifer by identifying and managing potentially contaminating land uses and activities.

4.2 Proclaimed area

The proposed boundary of the water reserve includes the Station Creek wellfield, the surrounding recharge area of the surficial aquifer and the surface water catchment area for Station Creek (Figure A5).

The existing Leonora Water Reserve includes the Jasper Flats surface water catchment because this was the preferred future source of public drinking water at the time of proclamation (Figure A2). The proposed boundary of the Leonora Water Reserve now excludes the surface water catchment for Jasper Flats as it is no longer considered a likely future water source.

The boundary of the water reserve should be reviewed for the next update of this plan as more information becomes available. The review should consider future drinking water source planning, as per advice from the Water Corporation. The broader impact of the surface water catchment on the Station Creek wellfield, and any proposed production bores, should be investigated with a view to protecting areas of hydrological significance to the drinking water source.

4.3 Priority areas

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

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation
- Priority 3 (P3) areas have the fundamental water quality objective of risk management.

The determination of priority areas is based on the strategic importance of the land or water source, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to the Department of

Water's Water quality protection note (WQPN) no. 25: *Land use compatibility in public drinking water source areas*.

The priority areas for the Leonora Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure A5. The department's WQPN no. 25: *Land use compatibility in public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

All land within the Leonora Water Reserve is classified as P1 for the following reasons:

- Water from this source constitutes a strategic supply to the Leonora-Gwalia town water supply so it should be afforded the highest feasible level of protection.
- Existing land uses on the Crown reserve and Crown lease are considered compatible with P1 source protection objectives.

4.4 Protection zones

In addition to P1, P2 and P3 areas, protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. Specific conditions may apply within these zones such as restrictions on the storage of chemicals.

Wellhead protection zones (WHPZs) are generally circular (unless information is available to determine a different shape or size), with a 500 m radius around each production bore in a P1 area and a 300 m radius around each production bore in P2 and P3 areas. WHPZs do not extend outside the boundary of the water reserve.

A circular WHPZ with a radius of 500 m is defined around each of the 12 production bores in the wellfield, as shown in Figure A5. Land-use activities within the WHPZs, such as mining and pastoral activities, will need to be managed to avoid contamination risks in the immediate vicinity of the production bores.

4.5 Land-use planning

It is recognised under the Western Australian Planning Commission's (WAPC) *State planning strategy* (1997) that appropriate protection mechanisms in statutory land-use planning processes are necessary to secure the long-term protection of drinking water sources. Any development proposals within the proposed Leonora Water Reserve that is inconsistent with advice in the Department of Water's WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, should be referred to the Department of Water for advice.

For further information on the integration of land-use planning and water source protection, please refer to the Department of Water's WQPN no. 36: *Protecting public drinking water source areas*.

The department's protection strategy for PDWSAs provides for lawfully established and operated developments to continue despite those facilities posing a potential level of risk to water quality that would not be accepted for new developments. The department will provide advice to landowners/operators on measures to improve these facilities and reduce water quality contamination risks.

4.6 Best management practices

There are opportunities to significantly reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the Department of Water will continue to encourage the adoption of best management practices for various land uses.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and water quality protection notes. They outline the recommended practices to ensure the protection of water quality and can thus help managers reduce any detrimental effects of their operations. Such guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include the Water quality protection guideline series: *Mining and mineral processing*, WQPN no. 35: *Pastoral activities within rangelands* and WQPN no. 65: *Toxic and hazardous substances: storage and use,* each of which are listed in this plan's References.

Education and creating awareness (e.g. signage and information) are also key mechanisms for protecting water quality, especially for people visiting the area. A brochure will be produced once this plan is finalised, describing the Leonora 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 water in public drinking water source areas within country areas of the state is protected under the *Country Areas Water Supply Act 1947* (WA). Proclamation of PDWSAs 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, to be an important mechanism to protect water quality.

Signs will be erected on the boundaries of this water reserve to educate and advise the public about activities that are prohibited or regulated. This plan recommends that surveillance and by-law enforcement for the Leonora Water Reserve be delegated to the Water Corporation.

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 Leonora local emergency management committee (LEMC), through the Goldfields-Esperance emergency management district, should be familiar with the location and purpose of the Leonora Water Reserve. A locality plan should be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Water Corporation should have an advisory role to the HAZMAT team for incidents in the Leonora 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 Leonora 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 proposed Leonora Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

Following publication of the *Leonora Water Reserve drinking water source protection plan*, an implementation strategy will be drawn up based on the recommendations in Appendix C.

5 Recommendations

The following recommendations apply to the proposed Leonora Water Reserve. The bracketed stakeholders are those expected to have an interest in the relevant recommendation being implemented.

1 The boundary of the proposed Leonora Water Reserve should be amended under the *Country Areas Water Supply Act 1947* (WA). (Department of Water)

2 Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C) showing responsible stakeholders and planned timeframes. (Department of Water, applicable stakeholders)

3 All development proposals within the proposed Leonora Water Reserve that are inconsistent with the Department of Water's Water quality protection note no. 25: *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 of Planning, Department of Mines and Petroleum, Shire of Leonora, proponents of proposals)

4 Incidents covered by WESTPLAN–HAZMAT in the proposed Leonora Water Reserve should be addressed by ensuring that:

- the Leonora LEMC is aware of the location and purpose of the Leonora Water Reserve
- the locality plan for the Leonora Water Reserve is provided to the FESA headquarters for the HAZMAT emergency advisory team
- the Water Corporation acts in an advisory role during incidents in the Leonora Water Reserve
- personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Leonora Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Water Corporation)

5 The Department of Water should delegate responsibility for monitoring and enforcement measures within the proposed Leonora Water Reserve to the Water Corporation. (Department of Water, Water Corporation)

6 Signs should be erected along the boundary of the proposed Leonora 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, Department of Water)

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

8 The source/s of pathogens in raw water samples from production bores and storage tanks should be further investigated. The findings should be used to implement appropriate protection strategies to reduce pathogen contamination risk-levels. (Water Corporation, Department of Water)

9 The open historic wells near the production bores should be capped or backfilled. The existing caps and sealing should be periodically checked and maintained. (Water Corporation, Heritage Council of Western Australia)

10 The boundary of the water reserve should be reviewed for the next update of this plan. The review should consider future drinking water source planning, as per advice from the Water Corporation. The broader impact of the surface water catchment on the Station Creek wellfield, and any proposed production bores, should be investigated with a view to protecting areas of hydrological significance to the drinking water source. (Department of Water, Water Corporation)

Appendices

Appendix A Figures

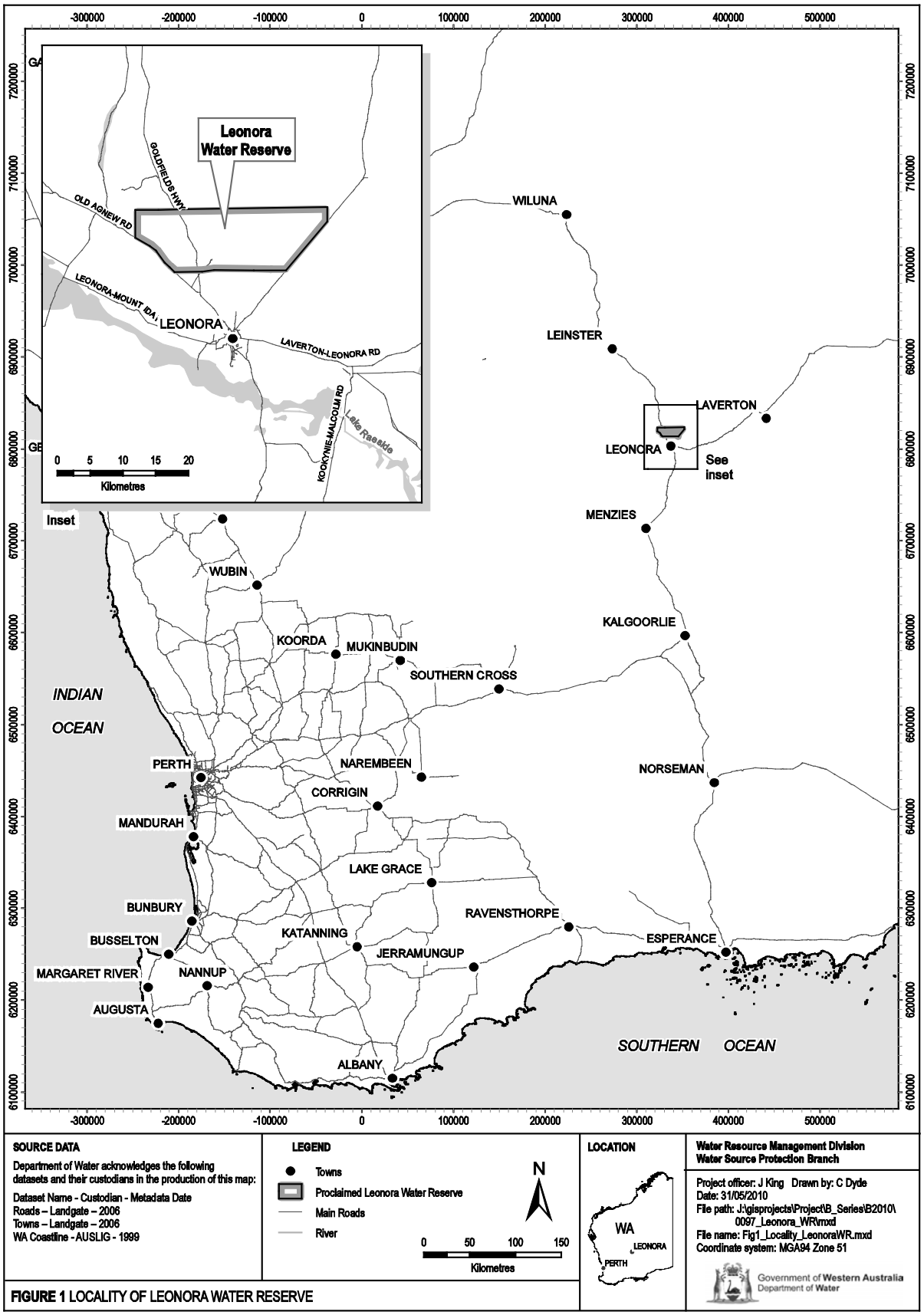

FIGURE 1 LOCALITY OF LEONORA WATER RESERVE

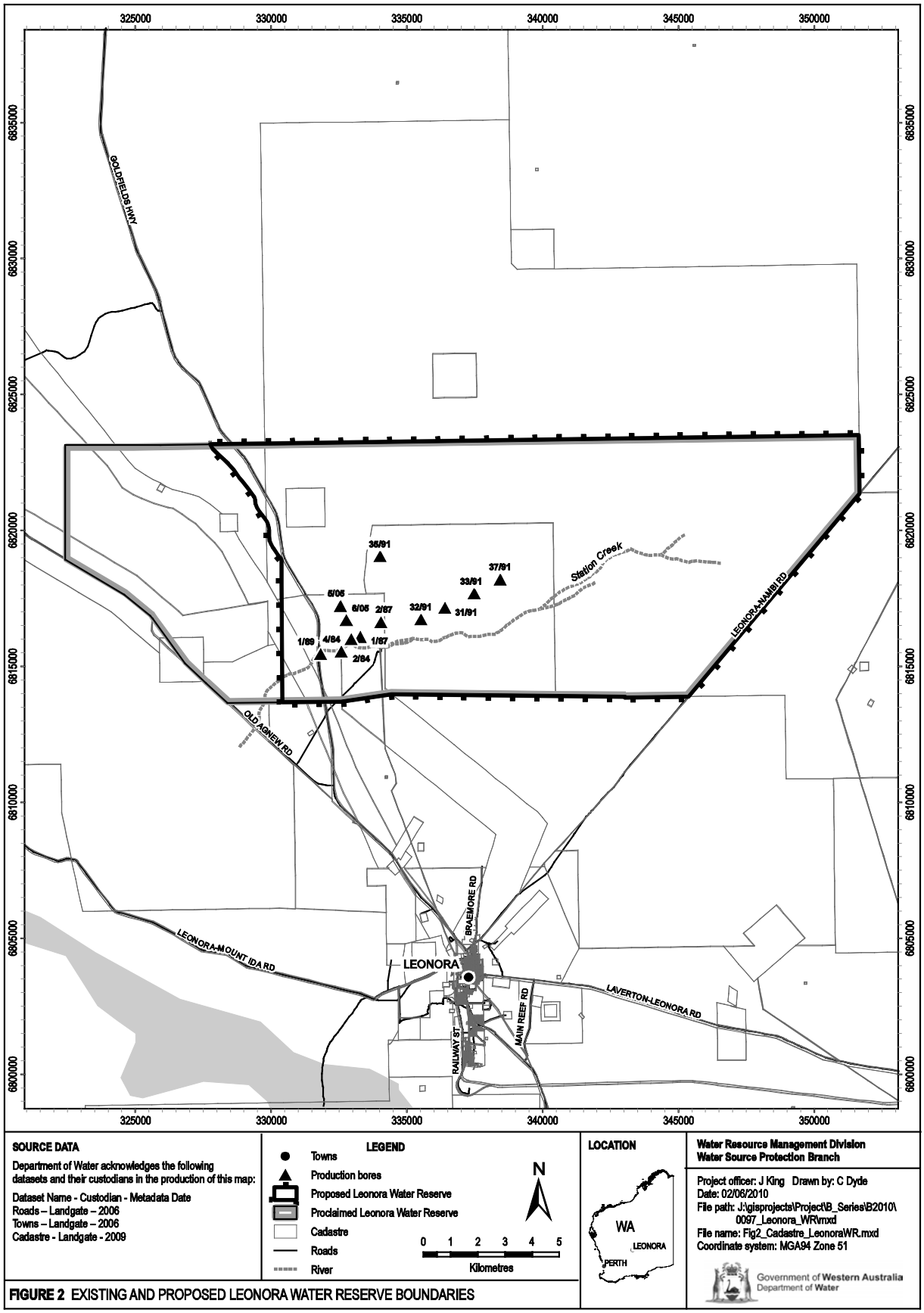

FIGURE 2 EXISTING AND PROPOSED LEONORA WATER RESERVE BOUNDARIES

FIGURE 3 LAND USE ACTIVITIES AND TENURES IN THE PROPOSED LEONORA WATER RESERVE

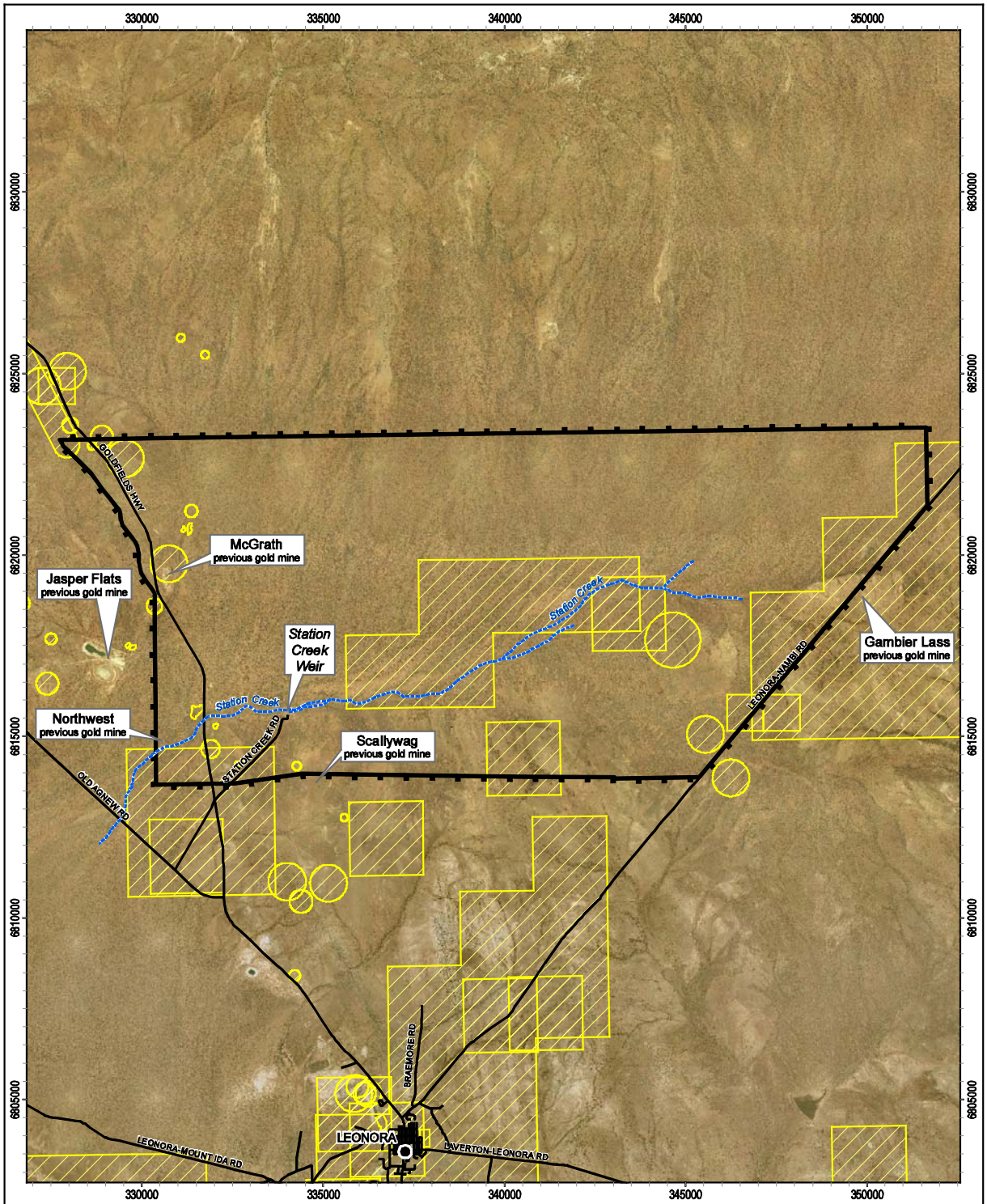

FIGURE 4 AERIAL PHOTOGRAPHY AND LAND USES IN THE PROPOSED LEONORA WATER RESERVE

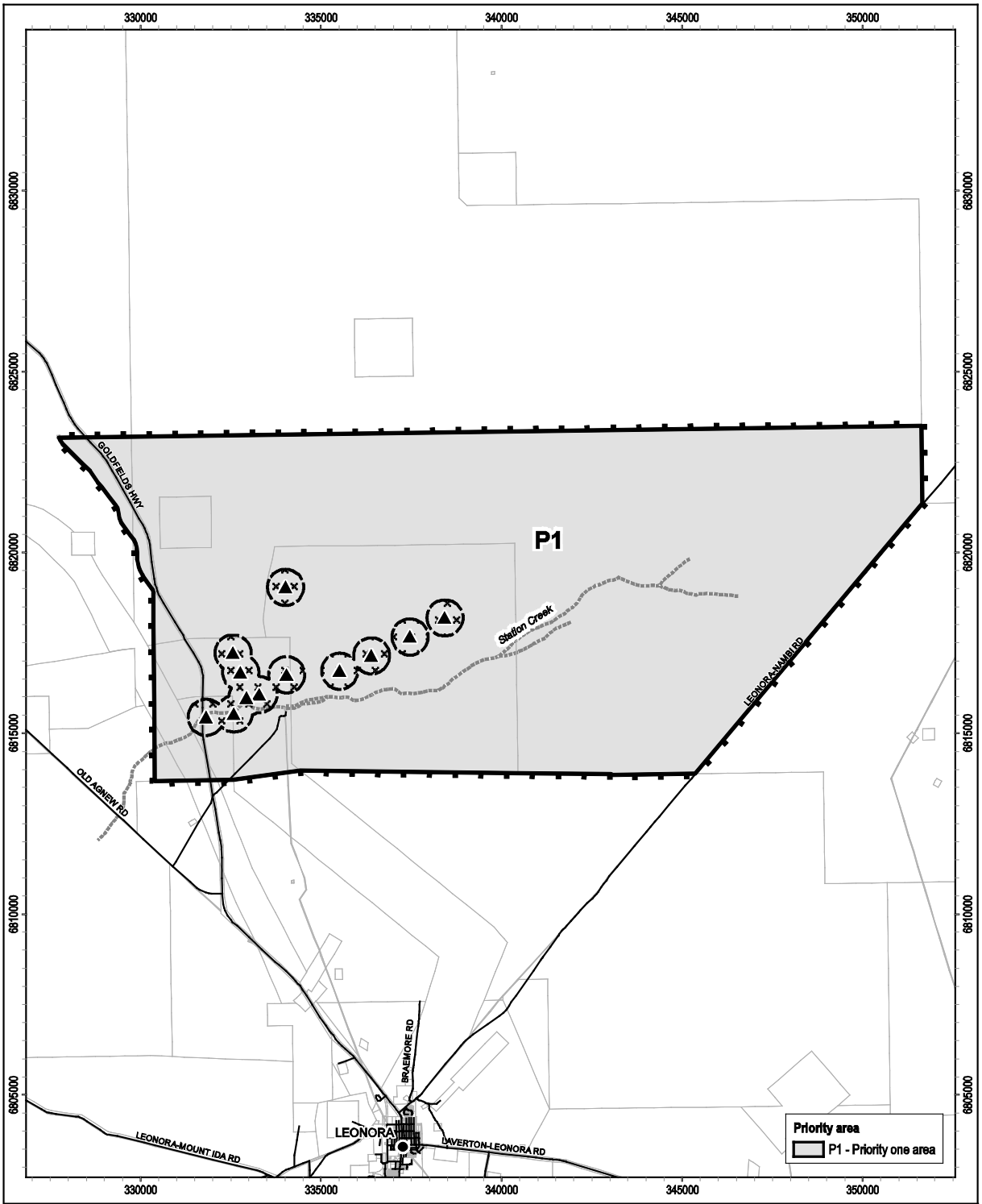

FIGURE 5 PROPOSED BOUNDARY, PRIORITY AREA AND PROTECTION ZONES FOR LEONORA WATER RESERVE

Appendix B Water quality data

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

The Water Corporation has monitored the raw (source) water quality from Leonora in accordance with the *National water quality management strategy: Australian drinking water guidelines 6, 2004* (ADWG) (NHMRC & NRMMC 2004a) and interpretations agreed to with the Department of Health. The raw water is regularly monitored for:

a. aesthetic-related characteristics (non-health related)

b. health-related characteristics
   - health-related chemicals
   - microbiological contaminants

Following is data representative of the quality of raw water in Leonora. In the absence of specific guidelines for raw water quality, the results have been compared with ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Results that exceed ADWG 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, water treatment and disinfection, to name a few, 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 Leonora refer to the most recent Water Corporation drinking water quality annual report at <www.watercorporation.com.au> Publications > Water quality > Water quality annual report.

Aesthetic-related characteristics

Aesthetic water quality analyses for raw water from Leonora are summarised in Table B1.

The values are taken from ongoing monitoring for the period July 2004 to June 2009. 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 shaded.

Table B1 Aesthetic-related detections for Leonora

Parameter	Units	ADWG aesthetic guideline value*	Leonora	
			Range	Median
Aluminium unfiltered	mg/L	na	<0.008 - 0.036	<0.008
Chloride	mg/L	0–250	290–460	370
Colour – True	TCU	0–15	<1–3	<1
Conductivity at 25 C	mS/m	na	170–290	215
Hardness as $CaCO_3$	mg/L	0–200	319–450	372
Iron unfiltered	mg/L	0–0.3	<0.003–0.141	<0.003
Manganese unfiltered	mg/L	0–0.1	<0.002–0.006	<0.002
pH	NOUNIT	6.5–8.5	7.37–8.18	7.56
Sodium	mg/L	0–180	270–340	295
Sulphate	mg/L	0–250	155–250	190
TFSS	mg/L	0–500	1300–1560	1420
Turbidity	NTU	0–5	<0.1–2.4	<0.1

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

Health-related characteristics

Health parameters

Raw water from Leonora is analysed for health-related chemicals including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related water quality parameters that have been measured at detectable levels in the source between July 2004 and June 2009 are summarised in Table B2. Any parameters that have on occasion exceeded the ADWG are shaded.

Table B2 Health-related detections for Leonora

Parameter	Units	ADWG health guideline value*	Leonora	
			Range	Median
Boron†	mg/L	0–4	1.4–1.8	1.6
Manganese unfiltered	mg/L	0–0.5	<0.002–0.006	<0.002
Nitrite plus nitrate as N	mg/L	0–11.29	0.07–23	12
Sulphate	mg/L	0–500	155–250	190

* A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHRMC & ARMCANZ 1996).

† Results based on three or less samples

Microbiological contaminants

Microbiological testing of raw water samples from Leonora is currently conducted on a weekly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water. A detection of *E. coli* in raw water abstracted from any bore may indicate contamination of faecal material through ingress in the bore or recharge through to the aquifer (depending on aquifer type).

During the reviewed period of July 2004 to June 2009, positive *E. coli* counts were recorded in 46.8 per cent of samples. This figure includes subsequent response and investigative sampling associated with *E. coli* detections. Insufficient sealing of bore headworks has been identified as an issue. A project to standardise the design of new bore headworks and seal existing bore headworks where detections have occurred will take place during the 2009–10 and 2010–11 financial years.

Appendix C Land use, potential water quality risks and recommended protection strategies

This table was prepared from data in Section 3 of this plan.

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Abandoned drill holes					
Drill holes (abandoned and open drill holes)	Fuels, chemicals and metals from surface water flows and the accidental or deliberate actions of people Pathogens and nutrients from humans, livestock, pests and native fauna	Medium High	There are a large number of abandoned drill holes. There is the potential for direct contamination of the aquifer. Frequent pathogen detections in raw water sampling.	• Water quality monitoring • Water Corporation surveillance • Water treatment	• Continue to investigate source/s of pathogen detections in raw water sampling • Investigate options to locate and seal or backfill unused drill holes, particularly those near production bores
Mining tenements					
Mining activities	Chemicals and metals from the mining process and wastes Fuels and oils from machinery and vehicles Pathogens and	Medium Medium Medium	There are currently no active mines in the water reserve. Gold mining has occurred at several sites in the water reserve.	• Water quality monitoring • State Agreement Act • Emergency response procedures	• Adherence to Department of Water mining and mineral guidelines • Spills of contaminants should be cleaned up and any contaminated

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	chemicals from on-site waste disposal Turbidity, metals from vegetation removal, ineffective site management or construction activities	Low			soil disposed of at an approved facility • Chemicals should not be stored in wellhead protection zones (WHPZs) • Adherence to relevant water quality protection notes including WQPN no. 65: *Toxic and hazardous substances – storage and use*; WQPN no. 10: *Contaminant spills – emergency response*; and WQPN no. 28: *Mechanical servicing and workshops*
Mineral exploration	Fuel or chemical contamination from drilling activities Fuel or chemical spills from machinery Fuel storage Pathogens from human	Medium Medium Medium	Mining tenements are subject to licensing by the Department of Mines and Petroleum (DMP). An administrative agreement to manage mining activities to protect public drinking water	• Water quality monitoring • DMP tenement licence conditions	• Adherence to Water quality protection guideline series: *Mining and mineral processing* • Compliance with tenement licence conditions

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	activity	Medium	sources areas is in place between DMP and the Department of Water.		
Pastoral leases					
Pastoral activities	Fuel or chemical spills from vehicles and machinery Herbicides and pesticides Pathogens from faecal matter	Low Low High	Livestock have unrestricted access to WHPZs, Station Creek and direct contact with the Station Creek weir. Frequent pathogen detections in raw water sampling. The creek may recharge the underlying aquifer. Production bores are located close to the creek downstream of the weir.	• Water quality monitoring • Fenced bore compounds • Water treatment	• Adherence to WQPN no. 35: *Pastoral activities within rangelands* • Continue to investigate source/s of pathogen detections in raw water sampling • Consider excluding livestock from the Station Creek weir and sump; and provide alternative livestock watering point/s in more suitable locations
Recreation					
Recreation – authorised (Darlot Loop adventure drive)	Fuel and oil spills from vehicles Pathogens from human activity Chemicals, fuels or	Medium Medium	An open historic well, road, car park and picnic area are near bore 1/89. The site is infrequently flooded by Station Creek.	• Water quality monitoring • Fenced bore compounds • Water Corporation	• Signage advising that the Leonora Water Reserve is present and promoting protection of drinking water quality

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
	pathogens from vandalism of the unsealed historic well	Medium	Unmarked roads provide easy access into the water reserve and onto the Station Creek bed.	surveillance • Fencing around the historic well	• Signage to prohibit driving on unmarked tracks • Liaise with the Heritage Council of WA to receive permission to cap or fill the historic well
Recreation – unauthorised (off-road vehicles, camping and hunting)	Fuel and oil spills from off-road vehicles Pathogens from human activity and animal carcasses	Medium Medium	Unauthorised off-road vehicle use, camping and hunting occur in the water reserve.	• Water quality monitoring • Fenced bore compounds • Water Corporation surveillance	• Signage advising that the Leonora Water Reserve is present and promoting protection of drinking water quality
Recreation – unauthorised (swimming and picnicking at Station Creek weir)	Pathogens from direct contact with waterbody	Medium	Swimming in Station Creek may cause direct contamination of the waterbody. The creek is potentially connected to the underlying aquifer. Production bores are located close to the creek downstream of the weir. Frequent pathogen detections in raw water sampling.	• Water quality monitoring • Water Corporation surveillance • Signage prohibiting aquatic activities	• Signage advising that the Leonora Water Reserve is present and promoting protection of drinking water quality • Continue to investigate source/s of pathogen detections in raw water sampling • Consider options to restrict access to the Station Creek weir

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Roads and tracks					
Roads and tracks	Hydrocarbon spills and leaks from vehicles Spills of fuels, chemicals, metals and other contaminants on the highway	Medium Low	The Goldfields Highway is a major transport route. The highway is approximately 100 m down-gradient of a production bore. There are numerous unsealed roads and tracks throughout the water reserve. Production bores are easily accessible from the tracks.	• Water Corporation surveillance • Water quality monitoring • HAZMAT emergency response	• Signage advising that the Leonora Water Reserve is present and promoting protection of drinking water quality • Consider restricting or deterring access to the water reserve
Station Creek wellfield					
Fuel storage	Hydrocarbon leaks and spills during refilling	Low	Self-bunded fuel storage tanks are used in all bore compounds and the pumping station.	• Self-bunded fuel storage tanks • Trained operators applying best practices • Water Corporation surveillance • Water quality monitoring	• Continue best management practices and monitoring

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	Management priority			
Fuel storage (theft)	Hydrocarbon leaks and spills due to vandalism/theft	Medium	Vandalism and fuel theft occur despite locked bore compounds. The installed anti-theft devices may discourage vandalism and theft in the long-term.	• Self-bunded fuel storage tanks with anti-theft devices • Fenced and locked bore compounds • Water Corporation surveillance • Water quality monitoring • Maintenance of fuel storage tanks	• Signage advising that the Leonora Water Reserve is present and promoting protection of drinking water quality • Signage advising of anti-theft devices on fuel tanks and the risks to drinking water quality from vandalism
Historic wells	Pathogens, nutrients, hydrocarbons or chemicals from surface water flows and accidental or deliberate actions of people	High	The open historic wells are near the production bores. Direct contamination of the aquifer is possible. Previously capped historic wells have damaged seals and caps and are no longer adequately sealed. Frequent pathogen detections in raw water sampling.	• Water quality monitoring • Water treatment • Water Corporation surveillance	• Liaise with the Heritage Council of WA to receive permission to cap or backfill the historic wells • Maintain adequate seals on capped historic wells • Continue to investigate source/s of pathogen detections in raw water sampling

Appendix D Photographs

Figure D1 Fenced and locked production bore compound (Photo: J. King)

Figure D2 Sealed production bore inside shed (Photo: J. King)

Figure D3 Self-bunded fuel storage tank with anti-theft device (Photo: J. King)

Figure D4 Pooling water immediately downstream of the Station Creek weir with numerous animal tracks (Photo: V. Claughton)

Figure D5 *Station Creek site of the Darlot Loop adventure drive showing unauthorised camping near the production bore* (Photo: J. King)

Figure D6 *Historic well within bore compound with damaged capping and seals* (Photo: J. King)

List of shortened forms

ADWG	*Australian drinking water guidelines*
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mS/m	millisiemens per metre
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PSC 88	public sector circular number 88
PDWSA	public drinking water source area
TCU	true colour units
TDS	total dissolved solids
TFSS	total filterable solids by summation
WHPZ	wellhead protection zone
WESTPLAN–HAZMAT	Western Australian plan for hazardous materials

Glossary

Abstraction The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.

Australian drinking water guidelines The *National water quality management strategy: Australian drinking water guidelines 6, 2004* (NHMRC & NRMMC 2004a) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).

Aesthetic guideline value The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, e.g. appearance, taste and odour (NHMRC & NRMMC 2004a).

Australian height datum Australian height datum is the height of land in metres above mean sea level. For example, the AHD is +0.026 m at Fremantle.

Allocation The quantity of water that a licensee is permitted to abstract is their allocation, usually specified in kilolitres per annum (kL/a).

Aquifer An aquifer is a geological formation or group of formations able to receive, store and transmit significant quantities of water.

Bore A bore is a narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).

Bore field A group of bores to monitor or withdraw groundwater is referred to as a bore field (also see *wellfield*).

Catchment The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.

Colony forming units Colony forming units are a measure of pathogen contamination in water.

Effluent Effluent is treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.

Electrical conductivity This estimates the volume of TDS or the total volume of dissolved ions in a solution (water) corrected to 25ºC. Measurement units include millisiemens per metre and microsiemens per centimetre.

Fractured rock	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 are highly susceptible to contamination from land-use activities when aquifers crop-out or sub-crop close to the land surface.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 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.
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.
mg/L	A milligram per litre (0.001 grams per litre) is a measurement of a total dissolved solid in a solution.
Millisiemens per metre	Millisiemens per metre is a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water, which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.

Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
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* (WA) and the *Country Areas Water Supply Act 1947* (WA).
Recharge	Recharge is the action of water infiltrating through the soil/ground to replenish an aquifer.
Recharge area	An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
True colour units	True colour units are a measure of degree of colour in water.

Total dissolved solids	Total dissolved solids consist of inorganic salts and small amounts of organic matter that are dissolved in water. Clay particles, colloidal iron and manganese oxides, and silica fine enough to pass through a 0.45 micrometer filter membrane can also contribute to total dissolved solids. Total dissolved solids comprise sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate (and nitrite) and phosphate (NHMRC & NRMMC 2004a).
Total filterable solids by summation	Total filterable solids by summation is a water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO_4 equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO_2 (silicon oxide). It is used as a more accurate measure than total dissolved solids (TDS). The higher the value, the more solids that are present and generally the saltier the taste.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconfined aquifer	An aquifer 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	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	A water reserve is an area proclaimed under the *Country Areas Water Supply Act 1947* (WA) or the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater is referred to as the watertable.
Weir	A dam built across a river or stream to raise the surface water level

Wellfield	A wellfield is a group of bores located in the same area used to monitor or withdraw groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
Wellhead protection zone	A wellhead protection zone (WHPZ) is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.

References

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Department of Health 2007, *Use of herbicides in water catchment areas*, Circular no: PSC 88, February 2007, Department of Health, Perth.

Department of Water various dates, Water quality protection guideline series: *Mining and mineral processing*, Department of Water, Perth, available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for water quality protection guidelines.

Department of Water various dates, Water quality protection note – *various titles*, Department of Water, Perth, available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for water quality protection notes;

– WQPN no. 10: *Contaminant spills – emergency response*

– WQPN no. 25: *Land use compatibility in public drinking water source areas*

– WQPN no. 28: *Mechanical servicing and workshops*

– WQPN no. 35: *Pastoral activities within rangelands*

– WQPN no. 36: *Protecting public drinking water source areas*

– WQPN no. 44: *Roads near sensitive water resources*

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Department of **Water**
168 St Georges Terrace, Perth, Western Australia
PO Box K822 Perth Western Australia 6842
Phone: 08 6364 7600
Fax: 08 6364 7601
www.water.wa.gov.au

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