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

Paraburdoo Water Reserve

Drinking water source protection plan

Paraburdoo town water supply

Looking after all our water needs

Water resource protection series
Report WRP 147
November 2013

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Cover photograph: Photo of Python Pool Paraburdoo (Clint Roberts, Department of Water)

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Summary

The Paraburdoo bore field consists of eleven production bores, ten of which supply drinking water to the Paraburdoo town site, and one to the airport (Figure 5). The bore field stretches approximately 5.7 km north-east from Paraburdoo along a floodplain system that receives drainage from the upper portion of Seven Mile Creek and two tributaries; Tableland Creek and Bellary Creek (Figure 4).

The Paraburdoo bore field draws water from two unconfined aquifers beneath Seven Mile Creek and Bellary Creek. The bore field is owned and operated by Rio Tinto Iron Ore (through Hamersley Iron – as the licensed water service provider).

This plan proposes to establish a water reserve to protect the Paraburdoo bore field and the Tableland and Bellary Creek catchment areas that recharge the aquifers. It recommends management of the water reserve as a Priority 1 (P1) area, and establishes wellhead protection zones (WHPZs) with a 500 m radius around each production bore. The airport and remote communities of Innawonga (Bellary springs) and Wakathuni are recommended to be managed as Priority 3 (P3) areas, including a 300m WHPZ around production bore PAP1 (Figure 5). Due to the unconfined nature of its aquifers, the priority areas and protection zones will help to protect this drinking water source from inappropriate development that could contaminate its water quality.

The major water quality risks to this water reserve include mineral exploration, mining proposals, fuel storage and refuelling, and pastoral activities both upstream of and close to the bore field.

This plan recommends implementation of the *Paraburdoo town bore field risk identification and mitigation assessment* (2011) undertaken by Rio Tinto Iron Ore, and makes further recommendations relating to fuel storage and refuelling practices, mineral exploration and operation, and prevention of stock entering the WHPZs. When implemented, these recommendations will reduce water quality contamination risks.

This plan is consistent with the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2004a) and State planning policy no. 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) and was prepared with the assistance of key stakeholders including Rio Tinto Iron Ore. The following tables show important information about the development of this plan and information about the Paraburdoo Water Reserve.

Table 1 Stages in the development of the Paraburdoo drinking water source protection plan

Stages in development of this plan		**Comment**
1	Prepare drinking water source protection assessment document (October 2010)	Rio Tinto Iron Ore prepared the *Paraburdoo town bore field risk identification and mitigation assessment report*.
2	Conduct stakeholder consultation (March/April 2013)	Advice sought from key stakeholders using the assessment document as a tool for information and discussion. Draft protection plan is prepared.
3	Consult draft drinking water source protection plan (April/May 2013)	Draft protection plan released for a six-week stakeholder consultation period.
4	Publish approved drinking water source protection plan	Final protection plan published after considering submissions. Includes recommendations on how to protect water quality.

Table 2 Key information about the Paraburdoo Water Reserve

Key information about the Paraburdoo Water Reserve	
Local government authority	Shire of Ashburton
Locations supplied	Paraburdoo town site and airport
Aquifer type	Unconfined
Licensed abstraction	9 000 000 kL per year Pilbara Iron Company (Services) Pty Ltd has a licence to take water (no. GWL109318 (12)) for dewatering for mining purposes, dust suppression, ore processing and potable water supply.

Key information about the Paraburdoo Water Reserve	
Number of bores	11 in total: • bore PAP1 supplies water to the airport • bores PTP1 – PTP10 supply the town site • bore PTP9 is currently used for emergency purposes only • bore PTP11 is currently decommissioned and has not been included in this plan.
Bore names and GPS coordinates	PAP1 (airport bore) (E 576690, N 7437044) PTP1 (E 568401, N 7434956) PTP2 (E 568995, N 7435233) PTP3 (E 569261, N 7435338) PTP4 (E 569873, N 7435473) PTP5 (E 570372, N 7435597) PTP6 (E 572116, N 7435980) PTP7 (E574068, N 7435660) PTP8 (E 573290, N 7436146) PTP9 (E 568373, N 7436146) PTP10 (E 574046, N 7435000)
Bore depth range mBGL (metres below ground level)	29 mBGL (PTP5) - 89 mBGL (PTP1)
Size	104,564.72 ha
Date of bore completion	The bore field was commissioned in the 1970s. During the mid- to late-1980s, bores PTP2, PTP3, PTP4, PTP8, PTP9 and PAP1 were upgraded.
Proclamation status	Proclamation will need to be progressed under the *Country Areas Water Supply Act 1947* when this plan is finalised.

1 Overview

1.1 The drinking water supply system

Rio Tinto Iron Ore supplies drinking water to the town of Paraburdoo and the Paraburdoo airport via 11 bores that draw groundwater from an unconfined aquifer.

Ten electrically powered bores with a total capacity of 468 m^3 per hr pump water to a 680 kL collection tank at El Caballo Road, Paraburdoo. Water is then pumped from the collection tank to two 9.1 ML storage tanks located 5 km up-gradient of the town. Water is then gravity-fed via an above-ground pipeline to the town, where it is distributed through 23 km of pipeline. Gas chlorination systems are located at the collection and storage tanks to disinfect the water before supply to consumers.

The Paraburdoo Airport has a separate small system with one electrically powered bore (PAP1) with a capacity of 70 m^3 per hour. Bore PAP1 pumps water through an underground pipe to an 8 m high tank. Water from the tank is treated with chlorine and pumped to the distribution system for the airport facilities.

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

1.2 Water management

1.2.1 Licence to take water

Water resource use and conservation in Western Australia is administered by the Department of Water in accordance with the *Rights in Water and Irrigation Act 1914*. Under this act, the right to use and control water is vested with the Crown. This means that a licence is required for drilling bores and abstracting groundwater (pumping water from a bore, spring or soak) within proclaimed groundwater areas throughout the state. Some exemptions apply such as abstracting water for domestic purposes only.

The Paraburdoo Water Reserve is located within the Pilbara Groundwater Area (and the Ashburton subarea) which is proclaimed under the *Rights in Water and Irrigation Act 1914*. The Pilbara Iron Company (Services) Pty Ltd is licensed by the Department of Water, under the *Rights in Water and Irrigation Act 1914*, to abstract water from the Pilbara Groundwater Area for public water supply.

Pilbara Iron Company (Services) Pty Ltd hold a 5C licence to take 9 000 000 kL of water per year from the Hamersley – Fractured Rock aquifer (licence no. GWL109318 (12)). The licence includes water use for the Paraburdoo town water supply as well as for mining activities.

In 2010 a total of 2 382 808 kL was abstracted from the Paraburdoo bore field. This was significantly higher compared to historical data. The increase in abstraction is due to an increase in demand for town supply and mine processing use.

1.2.2 Water planning

The draft *Pilbara groundwater allocation plan* (Department of Water 2012) provides the Department of Water's proposed approach to regulating and managing the use of groundwater in the Pilbara region. This plan guides water licensing decisions and is used to manage and monitor groundwater resources.

The *Pilbara regional water plan 2010–2030* (Department of Water 2010) sets the overall strategic direction for water resource management in the Pilbara. It identifies priority actions for implementation during the next five years. One of those priority actions is that drinking water source protection plans (DWSPPs) are prepared for all sources across the Pilbara.

DWSPPs have been prepared for the following drinking water sources in the Pilbara region:

- all sources currently used by the Water Corporation which include the Harding Dam Catchment Area, Millstream Water Reserve, Marble Bar Water Reserve, Newman Water Reserve and De Grey Water Reserve
- the Hamersley Iron system that supplies drinking water to Tom Price from the Southern Fortescue and Marandoo Water Reserves
- the West Pilbara Water Supply Scheme drawn from the Bungaroo Water Reserve.

DWSPPs are due for review five to seven years after completion.

The Department of Water has developed the *Western Australian water in mining guideline* (Western Australia 2013) to facilitate good water management practices in mining operations across the state, aiming to achieve the best possible water, environmental and economic management outcomes. Refer to section 1.5.2 for more detail.

1.2.3 Future water needs

Population growth in Paraburdoo is predicted to remain static for the foreseeable future, so water demand is not expected to increase.

1.3 Characteristics of the catchment

1.3.1 Physical environment

The Paraburdoo bore field lies within an east-west trending floodplain system that receives drainage from the upper portion of Seven Mile Creek and two tributaries; Tableland Creek and Bellary Creek. Seven Mile Creek flows in a south-westerly direction away from the town of Paraburdoo and intersects the larger drainage system of the Ashburton River.

Elevations in the bore field range from 420 m AHD in the east near the airport to 386 m AHD Win the west near Paraburdoo. There are low-lying hills to the north and south of the bore field that trend north-west to south-east and show irregular outcropping of the underlying bedrock. Elevations in the surrounding hills are up to 750 m AHD.

The Seven Mile Creek, Bellary Creek and Tableland Creek catchments have been incised by modern drainage and have experienced differential erosion to produce various hills, tablelands, crests and spurs. Colluvial and alluvial materials have formed in valley floors between the hills and ranges. The catchments have complex drainage patterns which reflect the diversity of the underlying geology (Rio Tinto Iron Ore 2011).

1.3.2 Climate

The Bureau of Meteorology's Paraburdoo Aero site (no. 7185) maintains climate statistics for the Paraburdoo area. The mean maximum temperature is 41.1^{o}C and the mean minimum temperature is 26^{o}C. The mean average annual rainfall is 313 mm (for years 1974 to 2012) and is generally highest in the summer months, with the highest mean average of 78.3 mm occurring in February and the lowest mean average of 3.3 mm occurring in September. High rainfall in the summer months is attributed to tropical cyclonic activity. Flooding may occur over this time and can be enhanced where multiple tropical lows occur within a few weeks of each other.

1.3.3 Hydrogeology

The Paraburdoo bore field draws water from two unconfined aquifers beneath Seven Mile Creek and Bellary Creek. The upper aquifer is comprised of alluvium and weathered bedrock which is collectively 30–70 m thick. The lower aquifer is unweathered and fractured bedrock. In most cases, the top of the screened interval is below the reported base of the alluvium. Bores are generally screened across both the weathered bedrock and the underlying fractured bedrock. The static water level in the bore field is generally less than 6 m below the ground surface.

Similar to other alluvial aquifer systems in the Pilbara, indirect recharge to the upper aquifer occurs by surface run-off and direct infiltration from rainfall. The underlying fractured bedrock aquifer is recharged by vertical leakage from the overlying alluvium and weathered bedrock horizon.

The direction of groundwater flow is from east to west along the path of Bellary and Seven Mile creeks. Discharge is assumed to occur via baseflow to the lower portions of Seven Mile Creek. There are no known areas of perennial surface discharge or water holes within the bore field area.

Water levels in the bore field show short-term responses to production pumping and to stream flow recharge events. As a result, water levels fluctuate annually but tend to return to historic levels. No long-term impacts from pumping have been observed and the water levels generally follow regional trends.

Major recharge events are associated with flooding, two of which occurred in the last ten years. The hydrograph record shows a distinct rise in water levels following the 2004 and 2006 floods, after which water levels gradually declined back to previous levels. It is assumed that major flood events occur in the bore field about once every five years (Rio Tinto Iron Ore 2011).

1.4 How is this drinking water source currently protected?

Rio Tinto Iron Ore undertook a risk identification and mitigation assessment for the Paraburdoo drinking water source and produced the *Paraburdoo Town bore field risk identification and mitigation assessment* in October 2011. This DWSPP is largely based upon that report.

Rio Tinto conducted an internal risk assessment of their Pilbara drinking water supply bore fields in August of 2010. The Paraburdoo town bore field was identified as having a level of risk that significantly exceeded the risk acceptance threshold standards used by Rio Tinto Iron Ore and therefore needed urgent and immediate attention. The high risk level was due to incompatible land use activity close to one or more bores. Rio Tinto made a recommendation to complete a more detailed risk assessment of the bore field infrastructure, aquifer characteristics and land uses to eliminate or reduce this level of risk.

In April 2011, Rio Tinto engaged Parsons Brinckerhoff Australia Pty Ltd to assess and make recommendations to address contamination risks for the Paraburdoo bore field. Using the ADWG's recommended management framework, the project focussed on assessing and identifying the risks to the aquifer from land use activity, aquifer vulnerability, development of mitigation measures and recommendations, costs and contingencies for each option.

Recommended mitigation measures included:

- a comprehensive (monthly) sampling program to monitor hydrocarbons
- a scope of works and consultation regarding the assessment of hydrocarbon contamination below the airport facility
- incorporation of a water source protection mechanism within Rio Tinto Iron Ore's internal approvals system for infrastructure and development proposals

- abandoned cars and rubbish to be removed from the surrounding area of production bore PTP2 (Rio Tinto Iron Ore, 2011).

1.5 Other water management information

1.5.1 Other groundwater bores in the area

Through Pilbara Iron Company (Services) Pty Ltd, Rio Tinto Iron Ore operates drinking water bores in the Paraburdoo Water Reserve. If bores for other purposes (e.g. irrigation, private household use) 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 all bores are appropriately located and constructed to prevent contamination of a public drinking water source. This matter will be assessed through the Department of Water's water licensing process where applicable under the Rights in Water and Irrigation Act 1914. All bores should be constructed in accordance with Minimum construction requirements for water bores in Australia (National Uniform Drillers Licensing Committee 2012).

1.5.2 Western Australia water in mining guideline

This guideline sets out how to meet the Department of Water's regulatory requirements for mining projects. In particular, it draws on the *Rights in Water and Irrigation Act 1914,* policies, water allocation plans and regional experience in water management issues. However, the Department of Water is also responsible for implementing other water management legislation, including the *Country Areas Water Supply Act 1947*, the *Water Agencies Powers Act 1984* and the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909,* and has responsibility for providing advice to other agencies through the state's land-use planning processes.

The guideline provides advice on water management issues that need to be considered in mine planning and the type of information the department may require as part of the licence assessment process. While this guideline focuses mostly on groundwater licence applications, most of its processes are also applicable to applications for surface water licences (Western Australia 2013).

1.5.3 Pilbara water in mining guideline

The *Pilbara water in mining guideline* (Department of Water 2009) sets out how to meet the Department of Water's regulatory requirements for mining projects. The guideline was developed to improve the information available on our regulatory processes with the aim of improving how water is managed across the Pilbara mining industry.

The guideline also recommends that mining operations within PDWSAs recognise the potential impacts of their operations on drinking water sources and develop strategies to protect water quality.

1.5.4 Paraburdoo town bore field risk identification and mitigation assessment

The *Paraburdoo town bore field risk identification and mitigation assessment* (Rio Tinto Iron Ore, 2011) describes the Paraburdoo water supply system, identifies potential hazards to the quality of the groundwater source and provides specific actions to mitigate the risks. It presents a risk assessment that considers the level of risk following field inspections and upgrades the risk assessment previously conducted by Rio Tinto Iron Ore. Operational requirements to implement additional barriers of protection are outlined as risk management measures. A practical approach to implement ongoing management is presented as an additional step in the internal Rio Tinto Iron Ore approvals process.

1.5.5 Indigenous land use agreements

The Hamersley Iron Pty Ltd – Eastern Guruma Indigenous Land Use Agreement (ILUA) (National Native Title Tribunal file no. WI2001/001) covers the northern part of the Paraburdoo Water Reserve. The Hamersley Iron Pty Ltd – Eastern Guruma ILUA validates new and existing activities carried out in relation to large-scale iron ore mining by Hamersley Iron Pty Ltd or the Hamersley Iron Ore Group. The ILUA also covers the granting and exercise of rights under prospecting, exploration and retention licences to Rio Tinto Exploration Pty Ltd in the area. Parties to the ILUA agree that 'new future acts' can be undertaken without negotiation procedures as set out for compliance under the Commonwealth *Native Title Act 1993*. The activities are agreed subject to conditions, including respecting an Aboriginal heritage protocol.

There is also a notice of an application to register an area agreement on the Register of Indigenous Land Use Agreements with Rio Tinto Iron Ore and Yinhawangka People (WI2013/001). This agreement covers 10,140 km^2 and includes the majority of the Paraburdoo Water Reserve.

The Rio Tinto Iron Ore and Yinhawangka Claim Wide Participation Agreement (RTIO and YCWPA) outlines detailed guidance as to the manner in which Rio Tinto Iron Ore can operate in Yinhawangka country. Parties to the RTIO and YCWPA agree that 'new future acts' can be undertaken without negotiation procedures as set out for compliance under the Commonwealth *Native Title Act 1993*. The activities are agreed subject to conditions, including respecting an Aboriginal heritage protocol.

2 Common contamination risks

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

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

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

For more information about water quality in this PDWSA, see section *3: Contamination risks in this drinking water source*.

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

2.1 Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness. These include bacteria, protozoa and viruses. Pathogens can enter drinking water supplies from faecal contamination in the water reserve. In groundwater sources, this occurs indirectly – faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (e.g. *Salmonella*, *Escherichia coli* and cholera), protozoa (e.g. *Cryptosporidium*, *Giardia*) and viruses. Monitoring for the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (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).

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

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

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

When people consume drinking water contaminated with pathogens the consequences 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's water supply was contaminated by a pathogenic strain of *E. coli* and *Campylobacter* (NHMRC & NRMMC 2011).

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

2.2 Physical risks

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

Some physical properties of water such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. Other properties such as iron and dissolved organic matter can affect the colour and smell of water. Although not necessarily harmful to human health, coloured or 'hard' water will not be as appealing to consumers. Salinity can affect the taste of drinking water.

2.3 Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2011). A number of these

chemicals (organic and inorganic) are potentially toxic to humans or are suspected of causing cancer.

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 these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

Hydrocarbons (e.g. fuels and 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.

Drinking water sources can also be contaminated by nutrients (such as nitrogen) from fertiliser, septic systems, and faecal matter from domestic or feral animals that washes through or over soil and into a water source. Nitrate and nitrite (forms of nitrogen) can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2011).

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter drinking water sources and could be harmful to human health.

3 Contamination risks in this drinking water source

3.1 Water quality

Rio Tinto Iron Ore regularly monitors the quality of raw water from the Paraburdoo bore field for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in the PDWSA. An assessment of the drinking water quality once treated is also made against the ADWG. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water, chaired by the Department of Health.

A water quality summary for the Paraburdoo town bore field from January 2010 to September 2012 is presented in Appendix B.

3.2 Land uses and activities

The Paraburdoo Water Reserve is located over Crown land. Current land uses and activities and their risks to the drinking water source are described below. Table 2, at the end of this section, summarises this information in an easy-to-read format. Appendix C displays a more detailed risk assessment, and includes recommended protection strategies to address water quality risks.

3.2.1 Remote communities

The Innawonga (Bellary Springs) and Wakathuni Communities are located within the Parraburdoo Water Reserve. The community layout plans for both communities have been developed with consultation undertaken by the Western Australian Planning Commission that identified various residential land use activities within those communities. Both communities are located in close proximity to tributaries associated with Bellary Creek that recharges the groundwater source utilised by the Paraburdoo drinking water production bores. The recommendations for water source protection planning within the Paraburdoo Water Reserve will serve to protect the water sources used to supply drinking water to both these remote communities.

Wakathuni Community is located within Crown Reserve, Gregory Location 105 on Land Administration Plan 19084. In relation to the Paraburdoo Water Reserve, the community is located approximately 30 km from the closest bore (PAP1). Based on the *Wakathuni Community layout plan report and provisions* published in October 2000, the community includes residential housing, community facilities, sewerage ponds, visitor camping areas and potential drainage into the Bellary Creek (Hames 2000).

Innawonga Community is located within Crown lease 3114/1166. In relation to the Paraburdoo Water Reserve, the community is located approximately 20 km from the closest bore (PAP1). Based on the draft *Innawonga (Bellary Springs) community*

layout plan no.1 – living area (Western Australian Planning Commission 2008) the community includes residential housing, ablutions and a clinic.

3.2.2 Pastoral lease

A major portion of the Paraburdoo Water Reserve lies within a pastoral lease held by Rocklea Station Pty Ltd (owned by Hamersley Iron).

Preventing stock from entering wellhead protection zones (WHPZs) and locating stockyards and watering points appropriately will help to reduce the level of risk of pathogen contamination (see section 5, recommendation 8).

3.2.3 Recreation

There is an existing motocross facility located within the WHPZs. There are no permanent fuel storage facilities. The bikes are fuelled in the parking lot and any maintenance (such as oil changes) is done off-site. The ablution block is a sealed septic system which is pumped out when full and the waste is disposed off-site (Rio Tinto Iron Ore, 2011).

3.2.4 Mining

There are 40 mining tenements within the Paraburdoo Water Reserve (refer to Appendix F). Existing and future mining proposals are considered compatible with conditions within the water reserve, and should be guided by the *Water quality protection guidelines for mining and mineral processing 1–11* and other relevant water quality protection notes published by the Department of Water (refer to Appendix C).

3.2.5 Crown land

Several Crown leases vested with the Department of Lands are located within the Paraburdoo Water Reserve (GE I-213357, 3116-4591, 3116-4585, 3114-1193 and 3114-1166). Two areas of unallocated Crown land are located to the north and south of the water reserve (refer to Figure 2).

3.2.6 Aboriginal sites of significance and native title claims

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* protects all Aboriginal sites in the state.

There are a number of Aboriginal sites of significance within the Paraburdoo Water Reserve (refer to Appendix A, Figure 6).

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

There is one native title claim by the Yinhawangka People (WAD340/2010) that has been accepted for registration within the Paraburdoo Water Reserve.

In addition to the Native Title Claims, there is a Hamersley Iron Pty Ltd – Eastern Guruma Indigenous Land Use Agreement located within the northern section of the water reserve boundary (refer to section 1.5.4 and Appendix C). There is also an application to register an area agreement on the Register of Indigenous Land Use Agreements between Rio Tinto Iron Ore and Yinhawangka People (WI2013/001) that covers the majority of the water reserve.

The Department of Water is committed to working with Aboriginal people in its planning and management activities. The department recognises that native title is an important framework for water management.

Proclamation of the Paraburdoo Water Reserve under the *Country Areas Water Supply Act 1947* will not restrict access to heritage sites or sites of significance for customary practices by the native title claimants and Traditional Owners.

3.3 Possible future contamination risks

Future contamination risks to the Paraburdoo Water Reserve include:

- mineral exploration and mining proposals that do not adhere to best management practice for water source protection
- fuel storage
- continued stock grazing in close proximity to the bore field.

As a result, identified hazards are:

- pathogens associated with cattle faeces, mine campsites, landfill and exploration upstream of the surface and groundwater flow
- nutrients associated with cattle faeces and mine camp landfills
- hydrocarbons and chemicals associated with fuel storage, vehicle and mobile plant refuelling.

Table 3 Summary of potential water quality risks, land use compatibility and best management practices

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance[1]
Airport (upstream of bore field)	Pathogens from aerobic treatment system.	High	The airfield is an existing, approved land use.	WQPN no. 62: *Tanks for underground chemical storage* WQPN no. 56 *Tanks for ground level chemical storage* WQPN no. 68 *Mechanical equipment washdown*
	Hydrocarbons from: • fuel storage • refuelling/ handling • wash down facility • light vehicle fuel storage.	High		
Pastoral activityclose to bore field	Pathogens from cattle faeces. Nutrients from cattle faeces.	High	Pastoral leases are compatible with conditions in P1 areas.	WQPN no. 35: *Pastoral activities within rangelands* WQPN no. 80: *Stockyards*
Mining operations	Pathogens from faecal matter. Hydrocarbons associated with refuelling and storage. Chemicals from various mining operations Nutrients from mine camps and land fill.	High	Mining is compatible with conditions in P1 areas.	WQPG 1–11: *Mining and mineral processing*

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance[1]
Motocross facility	Pathogens from ablution block. Hydrocarbons from fuel spills.	High	Existing motocross track is a non-conforming land use. New motocross facilities are incompatible in P1 areas.	Operational policy no. 13: *Recreation on Crown land in PDWSAs*
Railway line	Hydrocarbons from fuel spills. Chemicals from incidents resulting in spills.	High	Existing, non-conforming land use. New railway line infrastructure is incompatible within P1 areas.	WQPN no. 83: *Infrastructure corridors near sensitive water resources.* WQPN no.10: *Contaminant spills – emergency response*
Roads and tracks	Hydrocarbons from fuel spills.	Medium	Existing sealed roads are acceptable. Unsealed roads need to be managed to control access.	WQPN no. 44: *Roads near sensitive water resources*

[1]Water quality protection notes are available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for *water quality protection notes*.

4 Protecting your drinking water source

4.1 Proclaiming public drinking water source areas

The boundaries of the Paraburdoo Water Reserve include the catchment areas of Seven Mile Creek and its tributaries; Tableland Creek and Bellary Creek (refer to Figure 4). These catchment areas provide indirect recharge to the upper aquifer through surface water run-off and direct infiltration from rainfall. This then supplies the underlying fractured bedrock aquifer through vertical leakage, providing the source of water utilised by the bore field.

In order to protect the quality of the drinking water source, the Department of Water proposes to arrange proclamation of the Paraburdoo Water Reserve. The proclamation process begins with consultation undertaken during the development of this drinking water source protection plan.

Once the water reserve is proclaimed, the Shire of Ashburton should incorporate the PDWSA into their *Town planning scheme no. 7* consistent with State planning policy no. 2.7: *Public drinking water source policy*. PDWSAs are commonly shown in planning schemes as special control areas. This provides guidance for state and local government planning decision-makers and developers.

Proclamation of a PDWSA will not change the zoning of land. All existing, approved land uses and activities in a proclaimed area can continue. However, we recommend that best management practices are employed in PDWSAs to protect the quality of the drinking water source. New developments or expansion of existing land uses or activities need to consider the recommendations in this plan.

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

4.2 Defining priority areas

The protection of PDWSAs relies on statutory and non-statutory measures for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes a system that defines three specific priority areas:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance (e.g. state forest and other Crown land).
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation (e.g. land that is zoned rural).
- Priority 3 (P3) areas have the fundamental water quality objective of risk management (e.g. areas zoned urban, industrial or commercial).

The determination of priority areas is based on the strategic importance of the land or water source including risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For

further detail, please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

The priority areas for the Paraburdoo Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figure 5. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

The Paraburdoo Water Reserve is recommended to be managed as a P1 area. The Department of Water has assigned a P1 area due to the unconfined nature of the aquifer system used as the source for drinking water. This means there is a high risk of contamination within the Paraburdoo Water Reserve and a need for adequate management to protect it. The airport (based on the Shire of Ashburton's Local planning Scheme), Innawonga (Bellary Springs) and Wakathuni Communities are to be managed as P3 areas due to the zoning, community layout plans and existing nature of the land uses. These recommendations are consistent with the Western Australian Planning Commission's Statement of planning policy no. 2.7: *Public drinking water source policy* (2003), as the water reserve is located over Crown lease and unallocated Crown land (refer to figures 2 to 5).

4.3 Defining protection zones

In addition to priority areas, protection zones are defined in PDWSAs to protect water from contamination in the immediate vicinity of water extraction facilities (i.e. bores or dams). Specific conditions may apply within these zones such as restrictions on the storage of chemicals or prohibition of public access.

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 and they adopt the priority area of the land over which they occur.

Ten production bores within the Paraburdoo Water Reserve will be further protected by 500 m WHPZs and production bore PAP1within the airport will be protected by a 300m WHPZ. The WHPZs have been designated around each production bore due to the unconfined nature of the aquifer used as the source of drinking water. The WHPZs will help to protect Paraburdoo's drinking water source from potential contamination by alerting land use planning decision makers about the risks of inappropriate development within them.

4.4 Planning for future land uses

It is recognised under the Western Australian Planning Commission's *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. As outlined in the WAPC's State planning policy no. 2.7: *Public*

drinking water source policy (2003) it is appropriate that the Paraburdoo Water Reserve, its priority areas and WHPZs are recognised in the Shire of Ashburton's *Town Planning Scheme no. 7* as a special control area. Any development proposals in the Paraburdoo Water Reserve that are inconsistent with advice in our WQPN no.25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, need to be referred to our nearest regional office for advice.

For further information on the integration of land-use planning and water source protection, please refer to our WQPN no.36: *Protecting public drinking water source areas*. This note describes the findings of Parliamentary Committee reviews instrumental in the integration of water quality protection and land use planning in Western Australia. The Parliamentary Committees all advocated protection over a reliance on costly water treatment or the cleanup of contaminated sources required in other parts of the world.

The department's protection strategy for PDWSAs provides for approved developments to continue even if those developments would not be supported under current water quality protection criteria. In these instances, the department can provide advice to landowners or operators on measures they can use to reduce water quality contamination risks (see section *4.5: Using best management practices*).

4.5 Using best management practices

There are opportunities to 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.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and WQPNs. They recommend practices to help managers reduce their impacts upon water quality. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Education and awareness-raising (such as through providing information on signs and publications) are key mechanisms for protecting water quality, especially for people visiting the area.

4.6 Enforcing by-laws and surveying the area

The quality of water in PDWSAs within country areas of the state is protected under the *Country Areas Water Supply Act 1947*. Proclamation of PDWSAs allows 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.

4.7 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Ashburton local emergency management committee (LEMC), through the Pilbara emergency management district, should be familiar with the location and purpose of the Paraburdoo Water Reserve. A locality plan will be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Shire of Ashburton administers the *Bush Fire Act 1954* and is the lead authority for wildfire control management for most of the water reserve. Rio Tinto Iron Ore should have an advisory role to the HAZMAT team for incidents in the Paraburdoo 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 Paraburdoo Water Reserve, noting the location of the WHPZs. These personnel should have an adequate understanding of the potential impacts of spills on this drinking water source.

4.8 Implementing and updating this plan

Table 2 (found at the end of section 3) identifies the potential water quality risks associated with existing land uses in the Paraburdoo Water Reserve that were identified in Rio Tinto Iron Ore's October 2011 report: *Paraburdoo town bore field risk identification and mitigation assessment*. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

Table 3 below shows the implementation measures recommendation from this report and from the Rio Tinto assessment, and shows their current status.

Table 4 Implementation status of the Paraburdoo town bore field risk identification and mitigation assessment

Paraburdoo town bore field risk identification and mitigation assessment			
No.	**Risk identification and mitigation measure**	**Status**	**Mitigation measures and recommendations**
1	Implement a raw water quality monitoring program for bore PAP1.	Implemented	The sampling program consists of a monthly monitoring regime for both pathogen and hydrocarbon contamination. Recommended monitoring is consistent with Department of Health requirements.
2	Initiate a staged environmental assessment of the potential impact beneath the airport complex.	Implemented	Determine the extent to which pathogen and hydrocarbon contamination is present below the airport complex. Soil sampling conducted, results found no contamination.
3	A regular, monthly monitoring regime to assess bore PTP9 for hydrocarbons is warranted, to determine the impact from the up-stream petrol station.	Implemented	The sampling program should be a monthly monitoring regime for both pathogen and hydrocarbon contamination. Recommended monitoring is consistent with Department of health requirements.
4	Ongoing communication with the local council to track and manage the nature of light industrial development is recommended.	Proposed	Development proposals within the Paraburdoo Water Reserve should be referred to the Department of Water (refer to section 5). Develop a reporting and communication strategy for potentially contaminating land uses associated with the light industrial area.

Paraburdoo town bore field risk identification and mitigation assessment			
No.	**Risk identification and mitigation measure**	**Status**	**Mitigation measures and recommendations**
5	It is recommended that the existing use of the motocross facility be observed and managed. This may include discussions with the club coordinators whereby an agreement is made to limit the volume and storage of hydrocarbons or other contaminants on-site.	Proposed	Implement best management practices for water source protection regarding hydrocarbon containment and spills and septic tank management.
6	Regular monitoring of bore PTP9 up-gradient of the wastewater treatment facility where grey water is discharged.	Implemented	The sampling program should be a monthly monitoring regime for both pathogen and hydrocarbon contamination.
7	Ongoing management of the assets is recommended; and measures to address catastrophic spills are covered in detail in the Water Quality Management Manual (Rio Tinto Iron Ore, 2011b).	Proposed	The railway line and the paved Paraburdoo Tom Price Road are existing infrastructure in an area that can be considered to be mixed-use.
8	The car graveyard and other rubbish should be removed immediately as a priority.	Implemented	The car graveyard and rubbish has been removed. Surveillance should be undertaken to monitor illegal dumping and allow for removal of potential contamination sources associated with waste.
9	It is recommended that the cattle trough be moved so that it is a minimum of 300 m downstream away from bore PTP7 and PTP10.	Implemented	This plan further recommends the cattle trough and other stockyards be relocated outside of the WHPZs (500 m radius surrounding production bores).

Paraburdoo town bore field risk identification and mitigation assessment			
No.	**Risk identification and mitigation measure**	**Status**	**Mitigation measures and recommendations**
10	Refurbishment of headworks on production bores PTP5 and PTP6 is recommended.	Implemented	Corroded headworks may provide a window for contamination to enter the aquifer when flooding occurs.

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5 Recommendations

The following recommendations apply to the Paraburdoo Water Reserve. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, the implementation of that recommendation.

1. Arrange proclamation of the Paraburdoo Water Reserve under the *Country Areas Water Supply Act 1947*. (Department of Water)
2. Incorporate the findings of this plan and location of the Paraburdoo Water Reserve (including its P1 and P3 areas and WHPZs) in the Shire of Ashburton's *Town planning scheme no. 7* in accordance with the Western Australian Planning Commission's State planning policy no. 2.7: *Public drinking water source policy*. (Shire of Ashburton)
3. Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C). (Department of Water, Rio Tinto Iron Ore, Yinhawangka People)
4. Refer development proposals within the Paraburdoo Water Reserve that are inconsistent with the Department of Water's WQPN no.25: *Land use compatibility in public drinking water source areas* or recommendations in this plan to the Department of Water regional office for advice. (Department of Planning, Shire of Ashburton, proponents of proposals)
5. Ensure incidents covered by Westplan–HAZMAT in the Paraburdoo Water Reserve are addressed by ensuring that:
    - the Shire of Ashburton LEMC is aware of the location and purpose of the Paraburdoo Water Reserve
    - the locality plan for the Paraburdoo Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
    - Rio Tinto Iron Ore acts in an advisory role during incidents in the Paraburdoo Water Reserve
    - personnel dealing with Westplan–HAZMAT incidents in the area have ready access to a locality map of the Paraburdoo Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Department of Water, Rio Tinto Iron Ore)
6. Erect signs for the Paraburdoo Water Reserve including an emergency contact telephone number. (Rio Tinto Iron Ore)
7. Prepare a catchment management plan for the water reserve, in consultation with the Department of Water's regional office. (Rio Tinto Iron Ore, Department of Water)
8. Prevent stock from entering the WHPZs and other areas that are sensitive to contamination. (Rio Tinto Iron Ore)

9. Update this plan after five to seven years. This may require a new plan if substantial changes have occurred. If not, a drinking water source protection review should be developed. (Department of Water)

Appendices

Appendix A — Figures

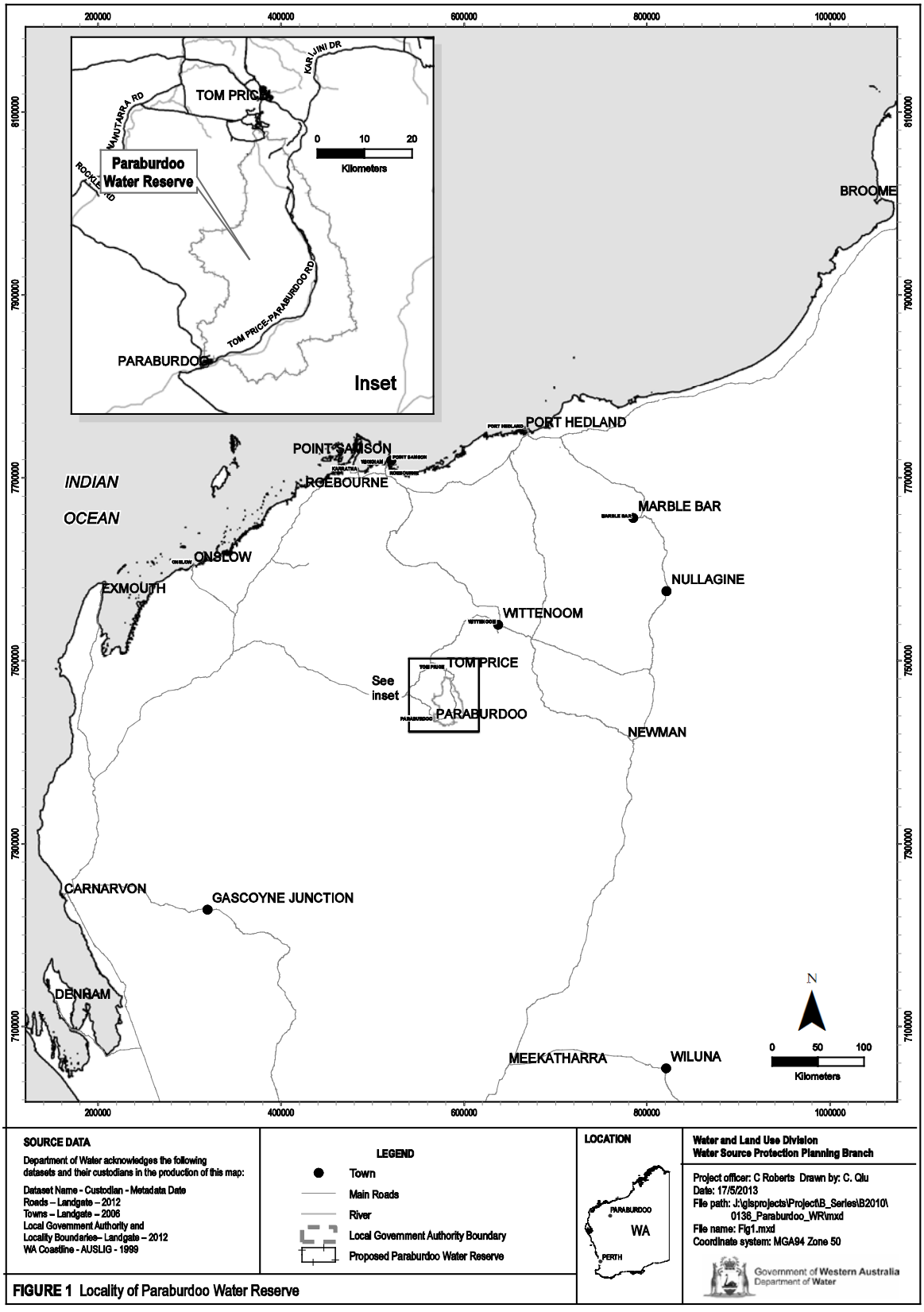


FIGURE 1 Locality of Paraburdoo Water Reserve

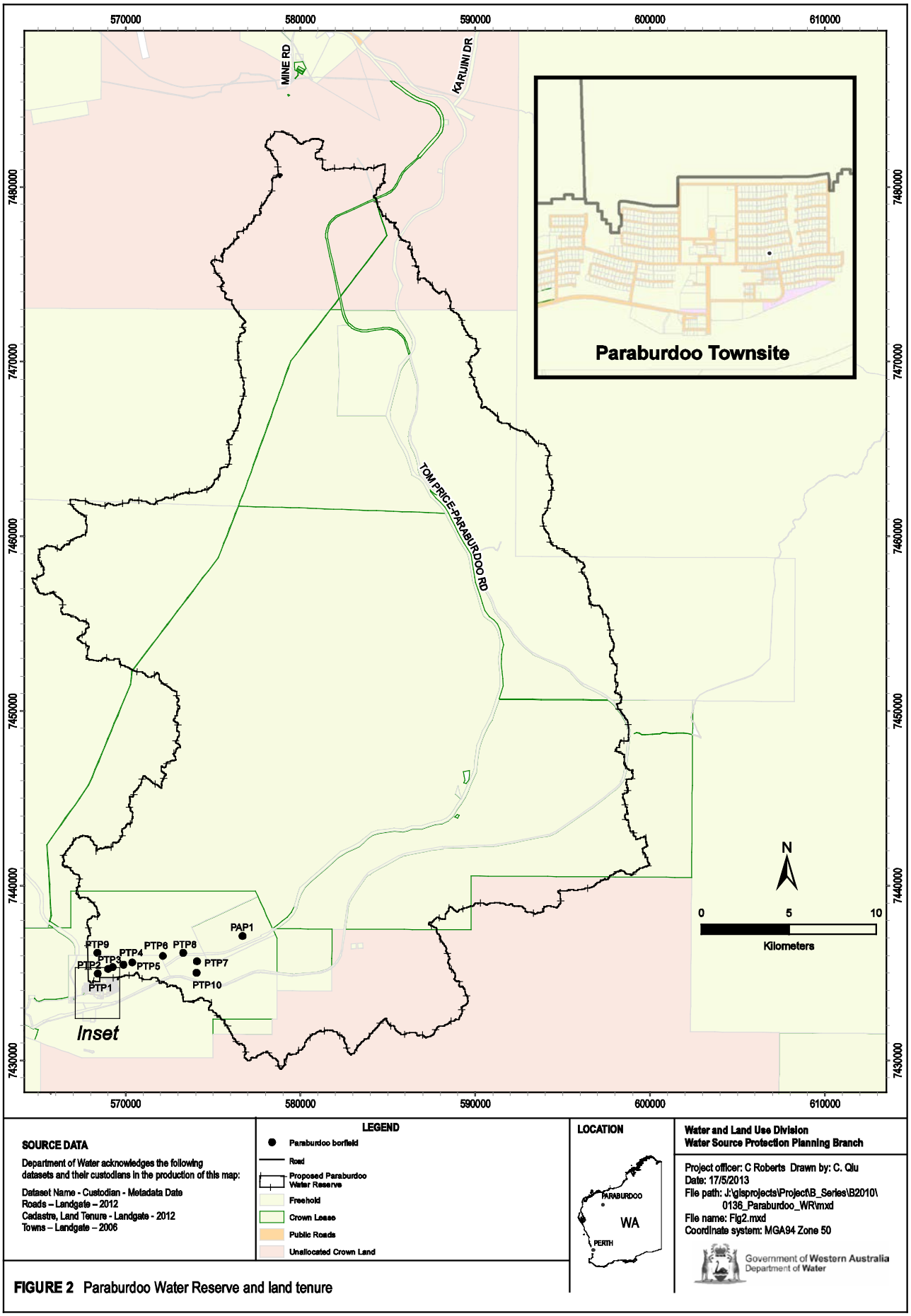
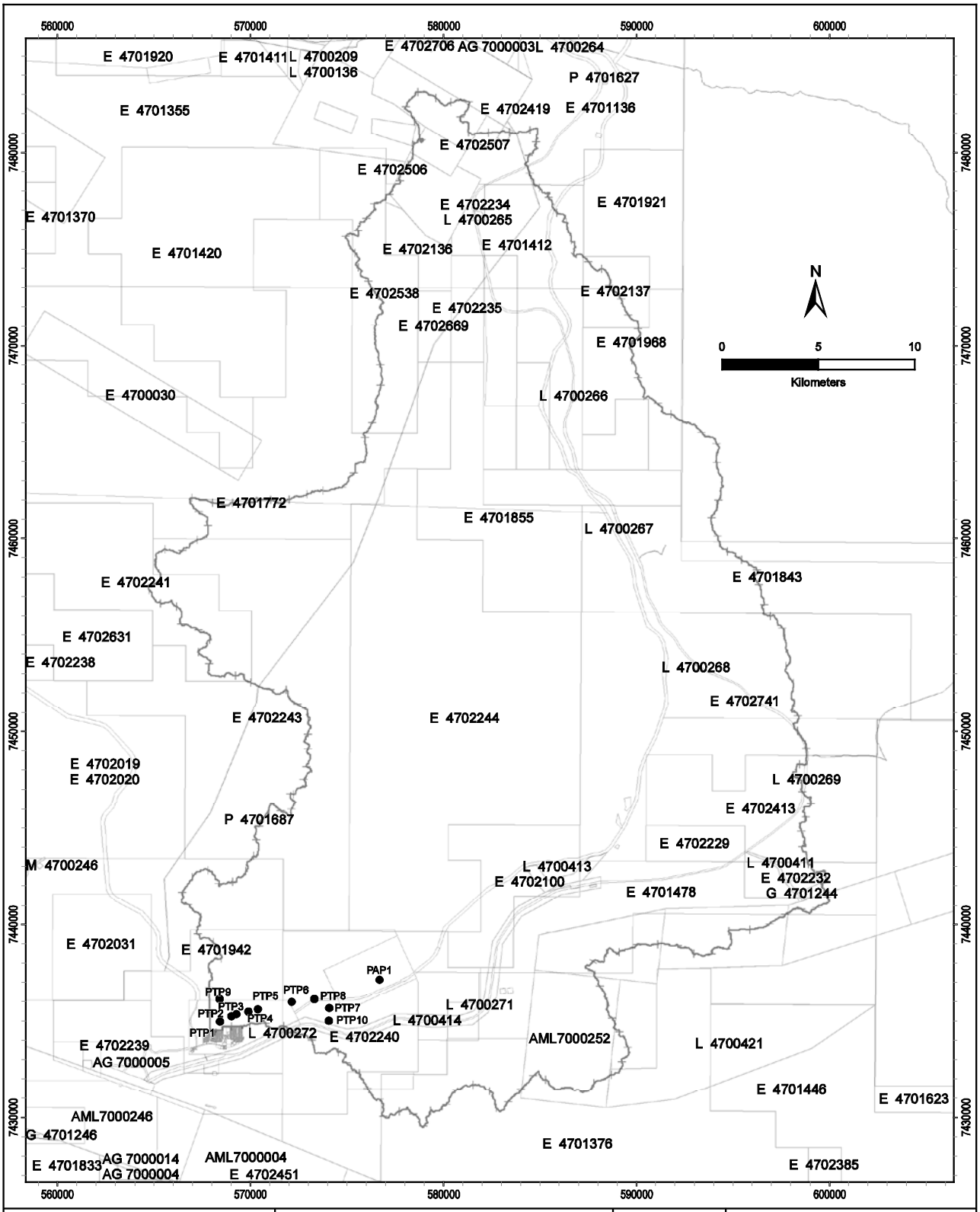


FIGURE 2 Paraburdoo Water Reserve and land tenure



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2012
Cadastre - Landgate - 2012
Towns – Landgate – 2006
Mining Tenemen – DOIR – 2013

LEGEND

- Paraburdoo borfield
- Paraburdoo Water Reserve
- Mining Tenements

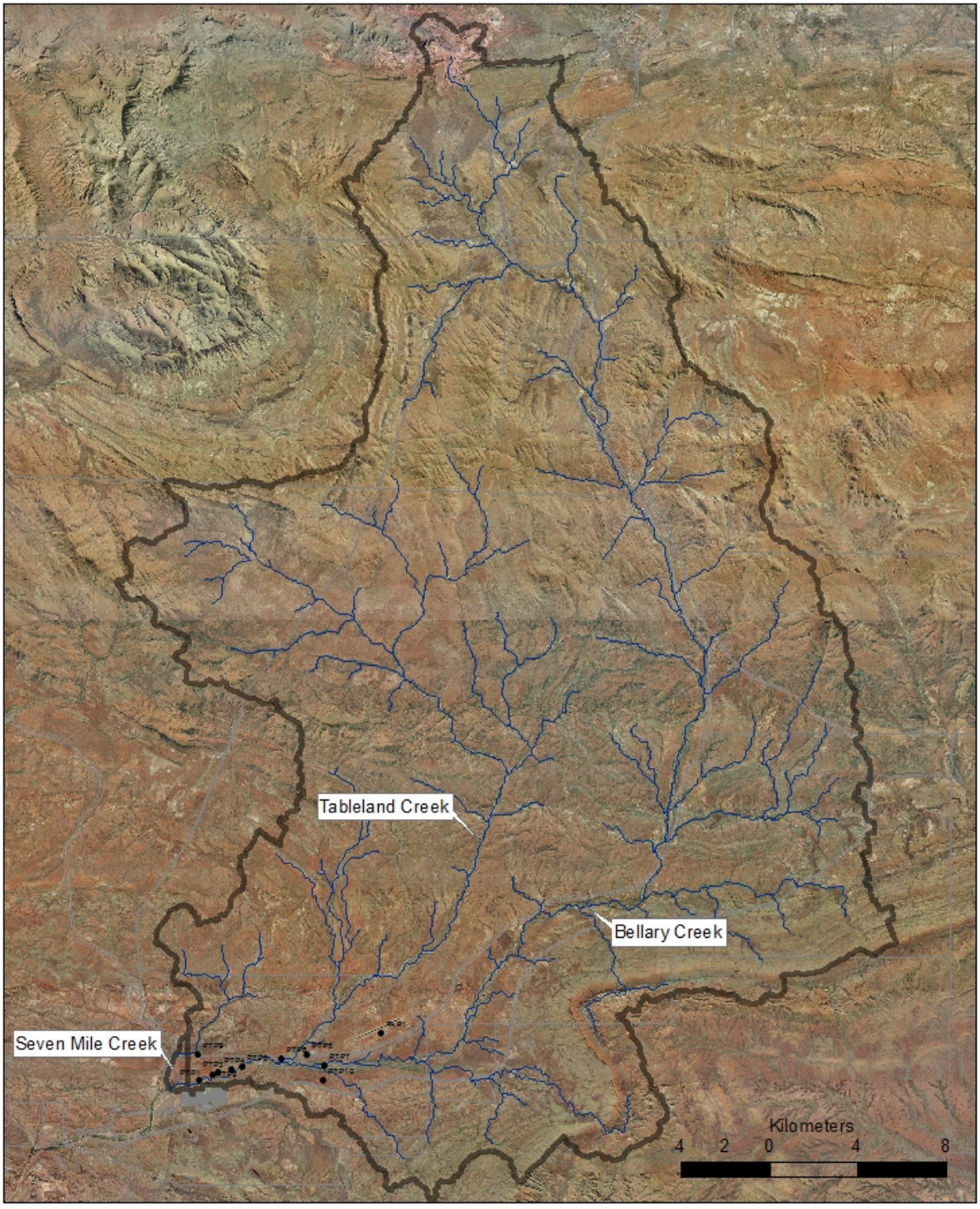
LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: C Roberts Drawn by: C. Qiu
Date: 17/5/2013
File path: J:\gisprojects\Project\B_Series\B2010\0136_Paraburdoo_WR\mxd
File name: Fig3.mxd
Coordinate system: MGA94 Zone 50

Government of Western Australia
Department of Water

FIGURE 3 Mining tenements in the Paraburdoo Water Reserve



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - MetadataDate
Roads – Landgate – 2006
Towns – Landgate – 2006
Cadastre Land Tenure - Landgate - 2009

LEGEND

- Paraburdoo borfield
- Rivers and Tributaries
- Paraburdoo Water Rerserve
- Cadastre

N

LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: C ROBERTS Drawn by: C ROBERTS
Date: 01/03/2013
File path:
File name:
Coordinate system: MGA94 Zone 50

Government of Western Australia
Department of Water

FIGURE 4 Paraburdoo Water Reserve encompassing the catchment areas

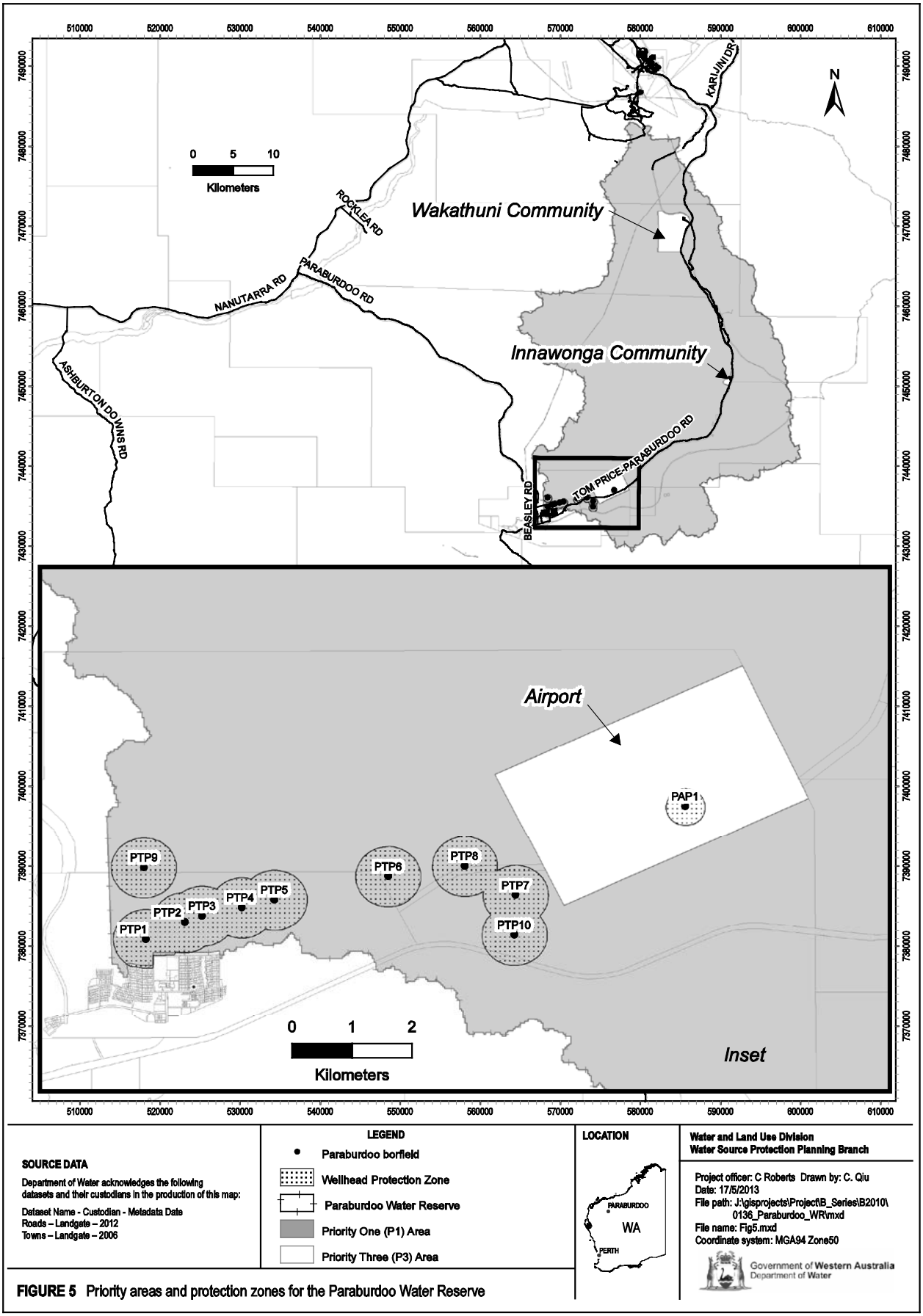


FIGURE 5 Priority areas and protection zones for the Paraburdoo Water Reserve

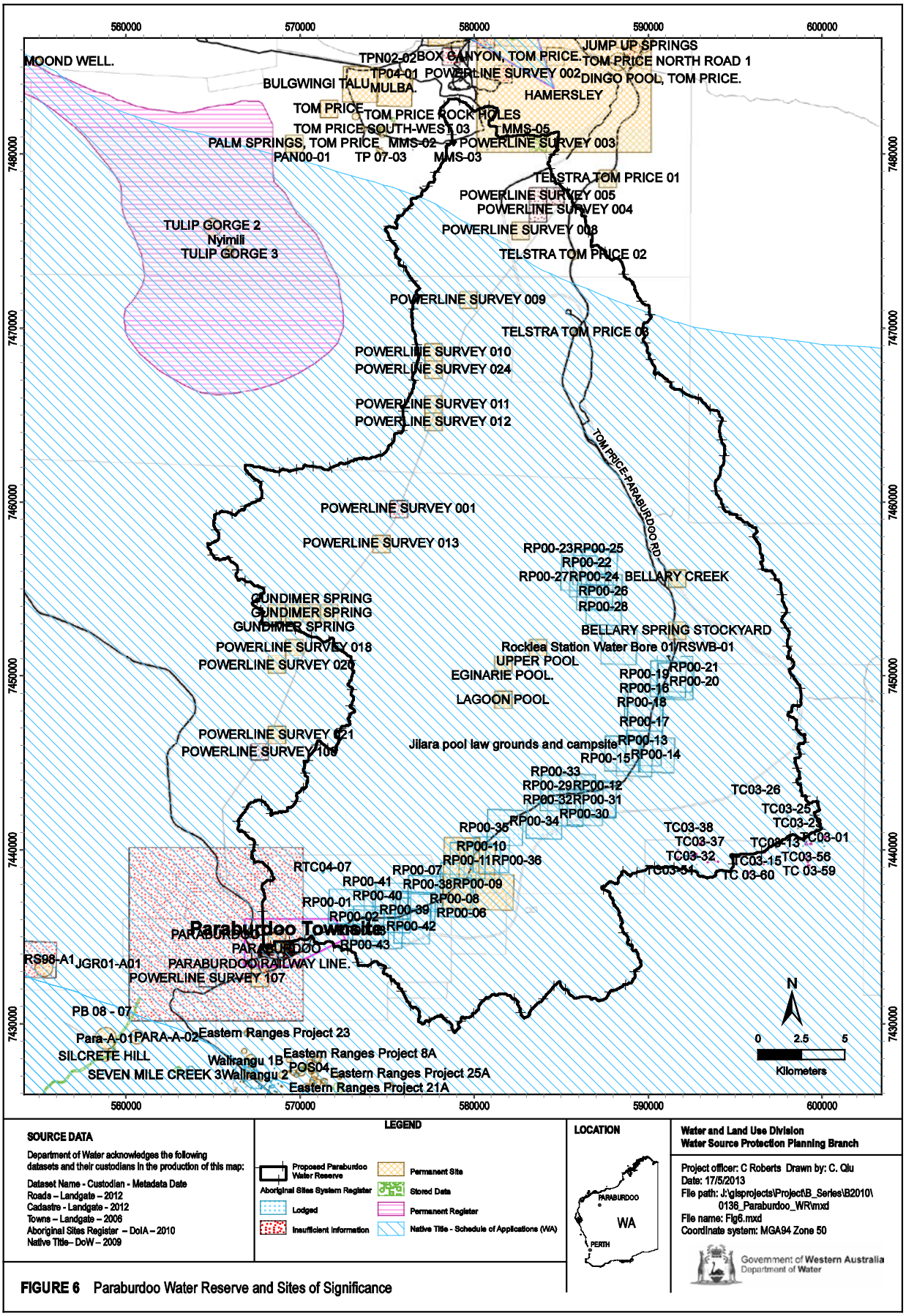


FIGURE 6 Paraburdoo Water Reserve and Sites of Significance

Appendix B — Water quality data

The information provided in this appendix has been supplied by Hamersley Iron Pty Ltd.

As the licensed water service provider for Paraburdoo, Rio Tinto Iron Ore, through Hamersley Iron Pty Ltd has monitored the raw (source) water quality from the Paraburdoo bore field in accordance with the requirements of the *Australian drinking water guidelines* (ADWG) (NHMRC & NRMMC 2011) and interpretations agreed to with the Department of Health. This data shows the quality of water in the public drinking water source area (PDWSA). The raw water is monitored regularly for:

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

The following data represents the quality of raw water from the Paraburdoo Water Reserve. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in bold and italics to give an indication of potential raw-water quality issues associated with this source. The values are taken from ongoing monitoring for the period January 2010 to December 2012.

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG.

Aesthetic characteristics

The aesthetic quality analyses for raw water from the Paraburdoo Water Reserve are summarised in the following table.

Aesthetic detections for Paraburdoo Water Reserve

Parameter	**Units**	**ADWG aesthetic guideline value***	**Paraburdoo Water Reserve**	
			Range	**Median**
Aluminium (acid soluble)	mg/L	0.2	< 0.001	< 0.001
Chloride	mg/L	250	24	140
Colour (true)	TCU	15	< 1	< 1

Parameter	Units	ADWG aesthetic guideline value*	Paraburdoo Water Reserve	
			Range	Median
Hardness as $CaCO_3$	mg/L	200	90	**417**
Iron unfiltered	mg/L	0.3	0.02	0.007
Manganese unfiltered	mg/L	0.1	< 0.005	< 0.005
Sodium	mg/L	180	20	130
Sulfate	mg/L	250	25	97
Turbidity	NTU	5	1	0.35
pH measured in laboratory	no units	6.5–8.5	***0.6***	7.4

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

Health-related chemicals

Raw water from the Paraburdoo Water Reserve is analysed for chemicals that are harmful to human health, including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health-related parameters that have been detected in the source are summarised in the following table.

Health-related detections for the Paraburdoo Water Reserve

Parameter	Units	ADWG health guideline value*	Paraburdoo Water Reserve	
			Range	Median
Barium	mg/L	0.7	0.017	0.004
Boron	mg/L	4	0.06	0.39
Manganese unfiltered	mg/L	0.5	< 0.005	< 0.005
Nitrite as nitrogen	mg/L	3	0.06	0.03
Sulfate	mg/L	500	25	97

* 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 2011).

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

Microbiological contaminants

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

A detection of *E. coli* in raw water abstracted from any bore may indicate contamination of faecal material through ingress into the bore, or recharge through to the aquifer (depending on aquifer type).

During the reviewed period, positive *E. coli* counts were recorded in 10 per cent of raw water samples. PAP1 resulted in a 50 MPN/100mL detection which resulted in immediate isolation and super chlorination, which reduced the *E. coli* counts below the guideline level.

There was no detection of *E. coli* in the reticulated water supplies.

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

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Remote Communities					
Sewerage and ablution facilities	Pathogens from sewerage spills/ incidents	Medium	• Sewerage ponds and ablution facilities are located at a minimum 20km distance.	• water quality monitoring • on-site water disinfection	WQPN no. 89: *Remote drinking water sources – self-supplied Indigenous communities.*
Landfills	Chemicals from landfill leachate	Medium	• Landfill facilities are located at a minimum 20km distance.	• water quality monitoring • on-site water disinfection	
Pastoral lease					
Stock grazing	Pathogens from animal faeces and decaying cattle	High	• Stock are prevented from entering WHPZs.	• water quality monitoring	WQPN no. 35: *Pastoral activities within rangelands*

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Nutrients from animal faeces and decaying cattle	High	• Bores are cased, with raised and sealed headworks. • Water supply is chlorinated.	• on-site water disinfection	WQPN no. 96: *Pest animal management in PDWSAs*.
Mineral exploration and mining					
Vehicle and fuel tanker access and operation	Hydrocarbons from spills, leaks and incidents	Medium	• No refuelling occurs in the bore field. • Annual monitoring for hydrocarbons.	• water quality monitoring	WQPN no.10: *Contaminant spills – emergency response* WQPN no. 44: *Roads near sensitive water resources.*
	Chemicals from spills, leaks and incidents	Medium			
Vehicle wash down and servicing	Hydrocarbons from spills, leaks and incidents	Medium	• No vehicle wash down occurs in the bore field. • No refuelling occurs in the bore field.	• water quality monitoring	WQPN no.10: *Contaminant spills – emergency response*. WQPN no. 28: *Mechanical servicing and workshops* WQPG no. 07: *Mechanical*

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Chemicals from spills, leaks and incidents	Medium	• No workshops are located in the water reserve.		*servicing.*
Exploration	Hydrocarbons from leaks, spills and refuelling during drilling activities	Medium	• Operating standards for drilling are adhered to. • Operating control procedures are in place. • Bunded areas for storing chemicals and hydrocarbons are required.	• water quality monitoring	Department of Mines and Petroleum's *Guidelines for the protection of surface and groundwater resources during exploration.*
	Pathogens entering inadequately sealed drill holes	High		• water quality monitoring	Department of Mines and Petroleum's *Guidelines for the protection of surface and groundwater resources during exploration.*
	Nutrients entering inadequately sealed drill holes	Medium			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Radioactive material from geophysical equipment leaks	Medium			
Ore extraction	Hydrocarbons from machinery associated with drill and blast operations	Medium	• Current groundwater quality monitoring program in place. • Chemical approval process and National Pollution Inventory (NPI) audits are already required.	• water quality monitoring	WQPG 1–11: *Mining and mineral processing* Administrative Agreement between Department of Mines and Petroleum and the Department of Water for mining referrals under the *Mining Act 1978.*
	Nutrients associated with ammonia nitrate fuel oil (ANFO) explosives during blasting operations	Medium			
	Chemical spills from storage failure	Low			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Rail	Hydrocarbons associated with spills and incidents.	Medium	• Current groundwater quality monitoring program in place.	• water quality monitoring	WQPN no.10: *Contaminant spills – emergency response* WQPN no. 83*: Infrastructure corridors near sensitive water resources*
	Chemical spills	medium			
Bore field					
Cyclonic activity	Nutrients transported to bore field through floods	Low	• Bores are sealed. • Bore head design is elevated. • Bore field is turned off while water subsides. • Cyclone management plan is in place.	• water quality monitoring • cyclone management plan	National Minimum Bore Specification Committee's *Minimum construction requirements for water bore in Australia.*
	Pathogens transported to bore field from floods	High			
Monitoring activities	Pathogens from human interaction within WHPZs	Medium	• There is limited potential for access because the	• water quality monitoring	WQPN no.10: *Contaminant spills – emergency response* WQPN no. 30: *Groundwater*

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Nutrients from human interaction within WHPZs	Medium	headworks are fenced and locked.		*monitoring bores* National Minimum Bore Specification Committee's *Minimum construction requirements for water bores in Australia.*
	Hydrocarbons from vehicles	Medium	• Vehicle Health, Safety and Environment (HSE) standards, driving policies and procedures are in place.		
Airport bore (PAP1)					
Fuel storage	Hydrocarbons from fuel storage leaks	High	• Implement regular water quality sampling regime for the early detection of hydrocarbon contamination.	• water quality monitoring	WQPN no. 68: *Wash down of mechanical equipment* WQPN no. 28 *Mechanical servicing and workshops* WQPN no. 62*: Tanks for underground storage*
Fuel depot	Hydrocarbons from fuel storage leaks	High			

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Refuelling facilities	Hydrocarbons from fuel spills	High	• Investigate capacity for fuel storage flooring area. • Located within the WHPZ for PAP1 • Upstream of groundwater flow direction, however may be within PAP1's area of influence. • Implement mitigation measures as recommended in the the Paraburdoo Town Bore field risk identification and mitigation assessment.		WQPN no.10: *Contaminant spills – emergency response* WQPN no. 30: *Groundwater monitoring bores.* WQPN no. 61: Tanks for ground level chemical storage.

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
Toilet facilities	Pathogens migrating from septic and grey water system	High	• Implement mitigation measures as recommended in the the *Paraburdoo Town Bore field risk identification and mitigation assessment*.	• water quality monitoring	WQPN no. 70*: Wastewater treatment – on-site domestic systems.*
Recreation					
Horse riding	Pathogens from horse manure	High	• Existing horse stables are located within the P1 area. Recommend management practices to avoid pathogen contamination risk.	• water quality monitoring	WQPG no. 13: *Environmental guidelines for horse facilities and activities.*
Motocross facility	Hydrocarbons from fuel spills and refuelling	Medium	• Facility is located within the WHPZ.	• water quality monitoring	WQPN no. 100: *Motor sport facilities near sensitive waters* WQPN no. 70*: Wastewater*

Land use/activity	Potential water quality risks		Consideration for management	Current preventive measures	Recommended protection strategies
	Hazard	**Management priority**			
	Chemicals from tyre storage	High			*treatment – on-site domestic systems.*
	Pathogens from ablution block	High			

Appendix D — Mining tenements

Tenement ID	Holder name
AML70/4	HAMMERSLEY IRON PTY LTD
AML70/252	MOUNT BRUCE MINING PTY LTD
E47/1136	FORTESCUE METALS GROUP LTD
	TALISMAN MINING LTD
E47/1376	AQUILA STEEL PTY LTD
	AQUILA RESOURCES LTD
	AMCI (IO) PTY LTD
	WESTIRON PTY LTD
E47/1412	AQUILA STEEL PTY LTD
	AQUILA RESOURCES LTD
	AMCI (IO) PTY LTD
	WESTIRON PTY LTD
E47/1478	HAMERSLEY IRON PTY LTD
E47/1772	FMG PILBARA PTY LTD
E47/1843	FMG PILBARA PTY LTD
E47/1855	FMG PILBARA PTY LTD
E47/1921	E 4701921
E47/1942	BROCKMAN EXPLORATION PTY LTD
E47/1968	CHRYSALIS RESOURCES LTD
E47/2100	HAMERSLEY IRON PTY LTD
E47/2136	ATLAS IRON LIMITED
E47/2137	FMG PILBARA PTY LTD

Tenement ID	Holder name
E47/2229	FMG PILBARA PTY LTD
E47/2232	HAMERSLEY IRON PTY LTD
E47/2234	FMG PILBARA PTY LTD
E47/2235	FMG PILBARA PTY LTD
E47/2240	FMG PILBARA PTY LTD
E47/2241	FMG PILBARA PTY LTD
E47/2243	FMG PILBARA PTY LTD
E47/2244	FMG PILBARA PTY LTD
E47/2413	GIRALIA RESOURCES PTY LTD
E47/2507	FMG PILBARA PTY LTD
E47/2538	FMG PILBARA PTY LTD
E47/2669	HAMERSLEY IRON PTY LTD
E47/2741	BALDOCK FE PTY LTD
G47/1244	HAMERSLEY IRON PTY LTD
L47/265	HAMERSLEY IRON PTY LTD
L47/266	HAMERSLEY IRON PTY LTD
L47/267	HAMERSLEY IRON PTY LTD
L47/268	HAMERSLEY IRON PTY LTD
L47/270	HAMERSLEY IRON PTY LTD
L47/271	HAMERSLEY IRON PTY LTD
L47/411	HAMERSLEY IRON PTY LTD
L47/413	HAMERSLEY IRON PTY LTD
L47/414	HAMERSLEY IRON PTY LTD

Tenement ID	Holder name
L47/421	HAMERSLEY IRON PTY LTD
P47/1687	SPENCER, PAUL GEOFFREY
	FOERS, STEVEN DAVID

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
GL	gigalitre
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km^2	square kilometre
LEMC	local emergency management committee
Ltd	limited
m	metres
mBGL	metres below ground level
mg/L	milligrams per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PDWSA	public drinking water source area
PSC 88	Public sector circular number 88
Pty	proprietary

TCU	true colour units
WAPC	Western Australian Planning Commission
Westplan–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPN	water quality protection note

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Adsorb	Adsorb means to accumulate on the surface of something.
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 2011).
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 or formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6*, 2011 (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).
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.
Bore	A bore is a narrow, lined hold 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.
Drinking water source protection report	This is a report on water quality hazards and risk levels within a public drinking water source area that includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.
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.

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. Fractures 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 2011).
Hectare	A measurement of area, equivalent to 10 000 square metres.
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Hydrogeology	The 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.
Microbe	A microorganism, usually one of vegetable nature, a germ. Also known as a bacterium, especially one causing illness.
Most probable number	Most probable number is a measure of microbiological contamination.
Nephelometric	Nephelometric turbidity units are a measure of turbidity in water.

turbidity units

Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Point source pollution	Pollution originating from a specific localised source, e.g. sewage or effluent discharge; industrial waste discharge.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated run-off) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Porosity	The state of quality of a material to be porous – that is permeable by water.
Public drinking water source area	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*.
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.
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.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
True colour units	True colour units are a measure of degree of colour in water.
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. This is also known as a superficial aquifer.
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* 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 is referred to as the watertable.
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 is usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination threats in the nearby area.
Western Australian hazardous materials emergency management scheme	This is now known as Westplan–HAZMAT.

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