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

Carnarvon Water Reserve

Drinking water source protection plan

Carnarvon town water supply

Looking after all our water needs

Water resource protection series
Report WRP 119
June 2010

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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 your tap. It ensures a holistic assessment of risks to water quality 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 bore). This plan helps to do that. Other barriers against contamination include:

- storage of water
- treating the water (e.g. chlorination)
- maintenance of pipes
- testing of water quality.

In Western Australia, the Department of Water protects public drinking water source areas (PDWSAs) by 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 these Acts so that we can apply legislation to protect water quality.

The ADWG outlines 12 elements to protect drinking water. This plan implements element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management). 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 reflecting 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	Previous drinking water source protection plan (1999)	The *Carnarvon Water Reserve water source protection plan* was released by the Water and Rivers Commission in 1999.
2	Conduct stakeholder consultation (December 2009 – May 2010)	Advice sought from key stakeholders using the assessment document as a tool for information and discussion.
3	Prepare draft drinking water source protection plan (January 2010 – May 2010)	Draft protection plan developed taking into account input from stakeholders and any additional advice.
4	Consult key stakeholders (June 2010)	Draft protection plan consultation process with key stakeholders.
5	**Publish final drinking water source protection plan (June 2010)**	**Final protection plan published after considering stakeholder comments. Includes recommendations on how to protect water quality.**

Summary

Carnarvon is a coastal town located 904 km north of Perth at the mouth of the Gascoyne River. It is a regional centre for the lower Gascoyne district containing major industries such as tourism, fisheries and horticulture.

The Carnarvon townsite's water supply is sourced from a borefield that extends for approximately 40 km along the bed and banks of the Gascoyne River (see Section 1.1 and Figure A1). The borefield consists of 60 bores constructed within an unconfined to semi-confined aquifer (see Section 1.3.3) that is vulnerable to contamination. The borefield supplies both the Carnarvon town water supply and an irrigation scheme operated by the Gascoyne Water Cooperative for the horticulture industry.

The town water supply was gazetted as the Carnarvon Water Reserve in 1992 under the *Country Areas Water Supply Act 1947* (WA) and amended in 2007 to exclude horticultural activity and the infrastructure used for a pastoral lease downstream of the borefield.

In 1999 the Water and Rivers Commission (now the Department of Water) prepared the *Carnarvon Water Reserve water source protection plan*. This drinking water source protection plan updates and replaces the 1999 publication.

Changes to the Carnarvon Water Reserve boundary and its Priority 1 (P1) area are not proposed. This plan's water source protection recommendations will achieve the protection of water quality and ensure the continuation of a reliable, safe drinking water supply to consumers in Carnarvon.

1 Drinking water source overview

1.1 Existing water supply system

The Carnarvon townsite's water supply is sourced from a borefield on the Gascoyne River. The borefield begins approximately 20 km upstream of the river's mouth and extends for approximately 40 km, finishing downstream of Rocky Pool (see Figure A1). The borefield is divided, for management purposes, into 10 basins (B–L excluding I) (see Section 1.5.4) and supplies the Carnarvon town water supply and an irrigation scheme operated by the Gascoyne Water Cooperative.

The Carnarvon borefield consists of 60 bores located both in the Gascoyne River and on the river bank. The bores abstract and monitor water from an unconfined to semi-confined aquifer (see Section 1.3.3).

1.2 Water treatment

Raw water for the town water supply is pumped to the Browns Range pump station, where it is disinfected by chlorination and then pumped to the Browns Range high-level and elevated tanks, which serve the reticulation area.

It should be recognised that although treatment and disinfection are essential barriers against contamination, management of the borefield 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 catchment physiography can be divided into two distinct areas: an inland, etched, granitic plain; and the Carnarvon Basin, consisting of the Kennedy Range plateau and a flat coastal plain (Figure A7). The total catchment area is approximately 74 000 km^2.The granitic plain rises to approximately 700 m AHD on isolated peaks, but averages about 400 m AHD and slopes gently to the west to an elevation of about 280 m AHD.

The drainage channels are generally broad and ill-defined by large floodways within very wide valleys. The granitic terrain comprises about three-quarters of the total catchment area and is generally of very low relief (lowest difference in height).The Carnarvon Basin lies westwards from the granitic terrain and is divided into three

broad physiographic zones: a coastal, a transitional and an inland zone (Hocking, Moors & van de Graaff 1987). The coastal zone consists of flat lying, aggrading alluvial to deltaic plains and sand dunes derived from reworked alluvium. The inland zone consists of erosional landforms of dissected duricrust plateaus with greatest relief (greatest difference in height). Some areas, such as the Kennedy Range, are virtually undissected plateaus above 300 m AHD, protected from erosion by an extensive sandplain. The transitional zone lies between the two, and consists of both low-lying constructional and erosional landforms (Dodson, Wade John 2009).

1.3.2 Climate

The region has an arid climate with hot summers and mild winters. Inland climatic conditions are more extreme than those experienced at the coast. January is typically the hottest month in the inland catchment with a mean daily maximum temperature of 41°C. February is typically the hottest month for the coastal area with a mean daily maximum temperature of 33°C. Cooling onshore breezes result in significant temperature gradients near the coast in the summer months. The coolest month for the inland catchment is July: the mean daily maximum temperature for Gascoyne Junction is 23°C, and for Carnarvon it is 22°C.

Most of the annual average rainfall of 233 mm falls in the period between May and July, however the infrequent occurrence of tropical cyclones, decaying cyclones or tropical cloud bands between January and July can produce unusually heavy rainfalls. The second half of the year is normally very dry (BoM 1998).

1.3.3 Hydrogeology

The groundwater in the floodplain sediments is contained within a regional, unconfined to semi-confined aquifer system. The groundwater flow system is heterogeneous (different physical characteristics in different locations) and anisotropic (hydraulic conductivity (K) is different for flow in all directions). It is bound in the west by the saltwater interface at the Indian Ocean. In the east, the aquifer is bound by the Toolunga Calcilutite on the west side of the north-east trending fault at Rocky Pool. However, there is no surface expression of the fault to the south-west of Rocky Pool as the calcilutite is buried beneath the floodplain sediments (Allen 1971). Thus, the aquifer is probably continuous with the alluvium east of Rocky Pool to the south of the Gascoyne River.

The floodplain sediments have been grouped into two distinct aquifers in hydraulic connection with each other, namely the riverbed sand aquifer and the older alluvium aquifer.

The riverbed sand aquifer, consisting of the bed load of the Gascoyne River, is unconfined and contains fresh groundwater. It is filled by surface water from the intermittent river flows, and groundwater stored in the aquifer leaks downwards to recharge the older alluvium aquifer (Allen 1972; Martin 1990b).

The older alluvium aquifer is an unconfined to semi-confined aquifer located directly below the riverbed sand aquifer and contains the bulk of drinking water source that

supplies the Carnarvon town water supply. The older alluvium is considered to be a multi-layered aquifer, with permeable and non-permeable layers containing old riverbed material of coarse gravel to sand in discontinuous channel beds (WRC 2004).

The confining beds consist of alluvial clay overflow material. The older alluvium contains significant volumes of groundwater in comparison with the riverbed sand aquifer. However, away from the Gascoyne River, much of the groundwater in the older alluvium is brackish to saline (1000–6000 mg/L TDS) (Dodson, Wade John 2009).

1.4 Future water supply requirements

Future water supply requirements from the Carnarvon borefield depend on demand from the irrigation scheme and the town water supply, as well as the intermittent flow regimes of the Gascoyne River. For this reason future water supply requirements are difficult to estimate. Predictions for demand and resulting abstraction have been estimated to be more than the licensed allocation of 6 800 000 kL/year. The projected abstraction may be an overestimate because the recorded historical abstraction figures are erratic.

1.5 Existing drinking water source protection

The Carnarvon Water Reserve was amended and proclaimed in 2007 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 address water quality contamination risks.

The Department of Water has delegated powers of monitoring and by-law enforcement to the Water Corporation for some public drinking water source areas (PDWSAs). Please see Section 4.7, Surveillance and by-law enforcement, for more information.

In 1999 the Water and Rivers Commission (now the Department of Water) prepared the *Carnarvon Water Reserve water source protection plan*. This document outlined risks to water quality from land uses and activities in the Carnarvon Water Reserve and proposed water source protection strategies to address those risks. Water source protection strategies included a proposed priority area (see Section 4.3) and protection zones (see Section 4.4) based on existing land uses and tenure within the Carnarvon Water Reserve (Figure A3). This drinking water source protection plan builds on and replaces the1999 publication.

This plan recommends that the *Shire of Carnarvon's District Zoning Scheme No. 11* to recognise the gazetted boundary of the Carnarvon Water Reserve as a special control area (special use). The types of development recommended in the Carnarvon

Water Reserve are described in the Department of Water's Water quality protection note (WQPN) no. 25: *Land use compatibility in public drinking water source areas*.

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 Carnarvon groundwater scheme is operated under groundwater well licence no. 55398(4), issued 11 December 2009. The licensed allocation is for 6 800 000 kL a year.

1.6.2 Groundwater recharge from the Gascoyne River, Western Australia

Published in 2009, this report represents a synthesis of groundwater investigations, and water quality and watertable monitoring conducted during the past 30 years. The report establishes the hydrologic, geological and hydrogeological framework for the Gascoyne River floodplain aquifer containing the Carnarvon drinking water source (Dodson, Wade John 2009).

1.6.3 Managing the Groundwater Resources of the Lower Gascoyne River (Carnarvon) WA, Groundwater Management Strategy

Published in 2004, this management strategy was developed to address and resolve issues relating to illegal or unauthorised pumping, splitting of entitlements, prolongations and drought access (implementation of the 2004 strategy is currently being reviewed by the Department of Water [June 2010]).

Its prime goal was to set out management initiatives to ensure water use was optimised, drought security was provided for and key environmental goals were met. The strategy set the basis for the development of a statutory local area water management plan in accordance with the *Rights in Water and Irrigation Act 1914* (WA) (WRC 2004).

The strategy subdivided the water resource into Basin A, where groundwater is abstracted by private bores; and basins B to L – where the public drinking water source area is currently operated by the Water Corporation (in accordance with a licence issued by the Department of Water) and where water is distributed by the Gascoyne Water Cooperative to irrigators.

To protect basins B to L resources, growers drawing water from the scheme are required to install a 150 mm air-gap, or a reduced pressure zone back-flow prevention device to protect the scheme supply from back-flow contamination.

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 groundwater from the Carnarvon Water Reserve for microbiological, health-related and aesthetic (non-health-related) characteristics. 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 groundwater from the Carnarvon Water Reserve from January 2005 to December 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.

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.

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. In 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.

2.2 Health related

Land- and water-based uses and activities within a water reserve can directly affect water quality and treatment.

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.

Contamination of a drinking water source by pesticides (and other chemicals) may also 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).

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).

2.4 Groundwater bores

The Carnarvon Water Reserve is located within the Gascoyne 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 Carnarvon Water Reserve. If bores for other purposes (e.g. irrigation) 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 matter will be considered through the Department of Water's water licensing process 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 Carnarvon Water Reserve is located over Crown reserve and Crown lease land (see Figure A3 and Figure A4). Current land uses and activities are outlined below. This information has been summarised in Table 1 at the end of this section. This 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 water quality protection strategies for key stakeholders to consider.

3.1.1 Crown lease

Pastoral lease

Brickhouse Co. Pty Ltd leases Crown land owned by the Department of Regional Development and Lands.

The main risk to water quality from this pastoral lease is from stock grazing and associated leaching of pathogens into the water from stock faeces. The risk is significant in the water reserve, where stock watering points are located within wellhead protection zones (WHPZs) and production bore casings may not be sealed. Cattle have been observed to congregate in large numbers around stock watering points during the summer months and times of drought, increasing the risk of pathogen contamination.

Additionally, feral goats were observed in large numbers within the water reserve. Feral goats were also observed to congregate around stock watering points during the summer months and times of drought and are also considered to pose a significant risk to water quality.

Mining tenements

A number of mining tenements are held within the Carnarvon Water Reserve. Mining tenements are held for sand mining to extract river sands and gravel from the bed of the Gascoyne River. The tenements consist of prospecting licences (totalling 714 ha) and one mining lease (96 ha).

The mining lease is active and another mining lease is pending. Sand extraction occurs at an approximate rate of 9000 tonnes/year for local use and regional export. The process involves excavating an area covering about 1500 m^2 to a depth of approximately 3 m. Sand mining within the water reserve is conducted through a Department of Mines and Petroleum (DMP) tenement lease. Conditions attached to the tenement ensure that the approved mining operations in the Carnarvon Water Reserve are conducted in a manner that protects the quality of the water resource.

Tenement conditions include:

- no mining being carried out within 50 m of any bore or well or associated equipment located on the water reserve without the written permission of the owner of that bore or well
- no action being taken that will interfere with the natural drainage or adversely affect in quality or quantity the water in any watercourse, dam, waterhole, spring or subterranean source of supply
- no poisonous, noxious or polluting matter being stored on the licence.

The Department of Water has sought an amendment to mining tenement conditions within the Carnarvon Water Reserve from the DMP.

The proposed conditions are consistent with *Statewide policy no. 1: Policy and guidelines for construction and silica sand mining in public drinking water source areas* (1999). The conditions include:

- All sand mining operators are to use dry methods of sand extraction in PDWSAs. No extraction activities shall occur below the watertable.
- All sand mining operations are to maintain a minimum of 3 m of undisturbed profile between the likely future maximum watertable and the proposed final surface level in Priority 1 (P1) areas. The Department of Water may allow this to be reduced to a minimum of 2 m if the proponent can demonstrate there is no risk to the water source and approval from the department is obtained.
- No underground storage tank system for petroleum hydrocarbons shall be installed in P1 areas or WHPZs.
- Elevated storage tanks are permitted in P1 areas, outside of WHPZs. The storage should be undertaken in accordance with the Department of Water's WQPN no. 56: *Tanks for elevated chemical storage.*
- Servicing of mechanical components of machinery involving liquids, such as coolants, hydraulic oils, lubricants or brake fluids (apart from routine maintenance) shall not be undertaken within WHPZs and P1 areas. Routine maintenance should not be conducted in WHPZs.
- The Department of Water requires that all mining operators in priority areas (P1, P2 and P3) have in place a fuel management plan. The plan shall address:
  - fuel spill prevention at fuel storage areas
  - details of fuel transport and refuelling
  - a contingency plan for dealing with fuel spillages
  - a groundwater monitoring program for hydrocarbons.

3.1.2 Crown reserve

There are three Crown reserves within the Carnarvon Water Reserve. Crown reserves 18368 and 693 are owned by the Department of Water and Crown reserve 21350 is owned by the Department of Regional Development and Lands.

Crown reserve 21350 was without a management order when this plan was written. The land use is stated as a stock route, which is located within the Gascoyne River watercourse.

3.1.3 Native title

Native title is a form of land title that recognises the unique ties some Aboriginal groups have to land. Native title exists where Aboriginal people have maintained a traditional connection with their land and waters, since sovereignty, and where acts of government have not removed it.

There is a native title claim within the proclaimed water reserve. This claim is the Gnulli (WAD6161_98).

3.2 Proposed land uses and activities

Rally and racing events

The Gascoyne Dash is an annual off-road vehicle rally that currently operates outside of the gazetted Carnarvon Water Reserve. It has been proposed that the rally route be extended through the water reserve.

Statewide policy no.13: *Policy and guidelines for recreation within public drinking water source areas on Crown land* outlines the Department of Water's position on the compatibility of rallying and racing in PDWSAs on Crown land.

Based on Statewide policy no. 13, an extension of the Gascoyne Dash route through the Carnarvon Water Reserve boundary would not be supported.

It is noted, however, that the Public Administration Standing Committee of the Western Australian parliament is currently reviewing recreation issues in PDWSAs. Statewide policy no.13 is expected to be reviewed after the committee completes its report in September 2010.

Table 1 Land use and potential water quality risks

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Crown leases				
Mining tenements	Hydrocarbons associated with excavation by heavy machinery	High	Mining is compatible with conditions in Priority 1 (P1) areas	Water quality protection guideline series: *Mining and mineral processing* Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in public drinking water source areas* Mining tenement conditions for the protection of water quality on tenement leases occurring in the water reserve Development of fuel management plans for sand mining operations occurring in the water reserve
	Hydrocarbon and other chemical spills from storage and use	Medium		
	Pathogens from human activity	High		
Pastoral lease	Pathogens from animals	Medium	Pastoral leases are acceptable in P1 areas.	WQPN no. 35: *Pastoral activities within rangelands*
	Nutrients from animal excrement	Low		
	Hydrocarbon and other chemical spills from machinery and vehicles	Low		WQPN no. 80: *Stockyards* WQPN no. 96: *Pest animal management in public drinking water source areas* WQPN no. 65: *Toxic and hazardous substances – storage and use*
	Pathogens from animal carcasses and faeces entering unsealed wells	Medium		

Land use/activity	Hazard	Management priority	Compatibility of land use/activity	Best management practice guidance
Roads	Fuel transport and chemical spills and accidents	Low	Existing approved roads are compatible within P1 areas.	WQPN no. 25: *Land use compatibility within public drinking water source areas*
Recreation activities (rallying and racing)	Hydrocarbon and other chemical spills from off-road vehicles	Possible	Rallying and racing is an incompatible land use within WHPZs and P1 areas.	Statewide policy no.13: *Policy and guidelines for recreation within public drinking water source areas* WQPN no. 25: *Land use compatibility within public drinking water source areas*
	Pathogens from public access	Possible		

4 Catchment protection strategy

4.1 Protection objectives

This plan's objective is to ensure reliable, safe drinking water is available to consumers in Carnarvon now and in the future. Existing approved land uses can continue.

4.2 Proclaimed area

As discussed in Section 1.5.1, the Carnarvon Water Reserve is proclaimed under the *Country Areas Water Supply Act 1947* (WA). A review of the 1999 water source protection plan included an assessment of the water reserve's existing boundary.

It has been determined that the existing water reserve boundary is appropriate for the protection of water quality (see Section 1.3.3). The assessment also included updated information on bore locations (see Figure A6).

4.3 Priority areas

The protection of 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:

- P1 areas have the fundamental water quality objective of risk avoidance
- P2 areas have the fundamental water quality objective of risk minimisation
- 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 WQPN no.25: *Land use compatibility in public drinking water source areas*.

The priority areas for the Carnarvon Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and shown in Figure A6. 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*.

The existing P1 area of the Carnarvon Water Reserve (Figure A6) *will be retained for the following reasons:*

- the water source is strategically important because it is the only potable water source for the town of Carnarvon

- the groundwater is vulnerable to contamination from intensive land use as the aquifer is considered to be unconfined, has transmissive course sands and has a shallow depth to groundwater (see Section 1.3.3)
- the area covers the borefield, which is directly recharged by intermittent river flows
- current land uses are compatible with the P1 area for the Carnarvon Water Reserve.

4.4 Protection zones

In addition to priority 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.

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.

As discussed in Section 1.1, the number of bores used in the Carnarvon town water supply has increased to 60, compared with 44 bores identified and mapped in the 1999 water source protection plan. The bore locations have also been amended based on updated information.

The additional 16 bores have been included in the borefield for water source protection management. WHPZs are proposed for these bores. The proposed WHPZs for all 60 bores are shown in Figure A6.

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. As outlined in the WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy* (2003) it is appropriate that the Carnarvon Water Reserve, its priority areas and protection zones be recognised in the *Shire of Carnarvon District Zoning Scheme No. 11*. Any development proposals within the Carnarvon Water Reserve that are 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. These 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;* Statewide policy no. 1*: Policy and guidelines for construction and silica sand mining in public drinking water source areas*; WQPN no. 35: *Pastoral activities within rangelands;* and WQPN no. 80: *Stockyards.*

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 Carnarvon 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 PDWSAs 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 are erected on the boundaries of the 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 Carnarvon 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 Shire of Carnarvon local emergency management committee (LEMC), through the Mid West-Gascoyne emergency management district, should be familiar with the location and purpose of the Carnarvon 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 Carnarvon 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 Carnarvon 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 of this plan identifies potential water quality risks associated with existing land uses in the Carnarvon Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

When this *Carnarvon Water Reserve drinking water source protection plan* is published, an implementation strategy will be drawn up based on the recommendations in this plan and guidance provided in Appendix C.

Table 2 Review of recommendations in the 1999 Carnarvon Water Source Protection Plan

The tasks listed in this table have been taken directly from the 1999 *Carnarvon Water Reserve water source protection plan* and refer to the branches and personnel positions that existed within the agencies at that time. For further information please see the 1999 *Carnarvon Water Reserve water source protection plan*.

Task		Status
Long-term tasks		
1	Proposed water reserve gazetted	*Complete.* The Carnarvon Water Reserve was amended and gazetted in 2007.
2	Incorporation into land management strategies	*Incomplete.* The Carnarvon Water Reserve has not been designated as a special control area or similar within the local planning scheme *(Shire of Carnarvon District Planning Scheme No. 11*).
3	Referral of development proposal: Water and Rivers Commission (now Department of Water) to provide the Shire of Carnarvon with guidelines for referral of development proposals. Referral of development proposals.	*Completed.* *Ongoing.*

4	Erection of signs: • development of guidelines for signage. • determine number and location of signs required. • erect signs.	 *Completed.* *Completed.* *Completed.*
5	Incidents covered by WESTPLAN–HAZMAT in the Carnarvon Water Reserve should be addressed through the following measures: • the Carnarvon LEMC (through the Karratha emergency management district) (now the Mid West-Gascoyne emergency management district) being familiar with the location and purpose of the Carnarvon Water Reserve • the locality plan for the Carnarvon Water Reserve being provided to the fire and rescue services headquarters for the HAZMAT emergency advisory team. • the HAZMAT emergency advisory team receiving water quality protection advice during incidents in the Carnarvon Water Reserve. • personnel dealing with WESTPLAN–HAZMAT incidents in the area given ready access to a locality map of the water reserve and training to understand the potential impacts of spills on the groundwater resource.	 *Completed.Completed.* *Ongoing.* *Ongoing.*
6	Prepare management plan for fuel/oils storage, refuelling and spillages for sand mining operations and submit to the Department of Water. Report spillages to Asset Manager, Carnarvon Business Unit (Water Corporation).	*Incomplete.* A fuel management plan should be prepared by sand mining tenement lessees within the Carnarvon Water Reserve and submitted to the Department of Water. *Ongoing.*
7	Sand mining operator's annual reports to be referred to the Department of Water.	*Ongoing.*
8	Surveillance program: • develop guidelines for the surveillance of water reserves • implement surveillance program.	 *Ongoing.* *Ongoing.*
9	Review of this plan and recommendations.	*Completed.*

5 Recommendations

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

1 Update the 1999 water source protection plan's implementation strategy and include it in 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)

2 The *Shire of Carnarvon's District Zoning Scheme No. 11* should incorporate this plan and reflect the identified Carnarvon Water Reserve boundary, Priority 1 area and protection zones in accordance with the WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy*. (Shire of Carnarvon)

3 All development proposals within the Carnarvon 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, Shire of Carnarvon, proponents of proposals)

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

- the Mid West-Gascoyne LEMC is aware of the location and purpose of the Carnarvon Water Reserve
- the locality plan for the Carnarvon 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 Carnarvon Water Reserve
- personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Carnarvon Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Water Corporation)

5 The existing monitoring program should be maintained to identify any incompatible land uses or potential threats within the Carnarvon Water Reserve. (Department of Water, Water Corporation)

6 Signs located along the boundary of the Carnarvon Water Reserve should be maintained 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 The mining tenement conditions outlined in Section 3.1.1 for the protection of water quality should be considered in all tenement leases over the Carnarvon Water Reserve.

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

Appendices

Appendix A Figures

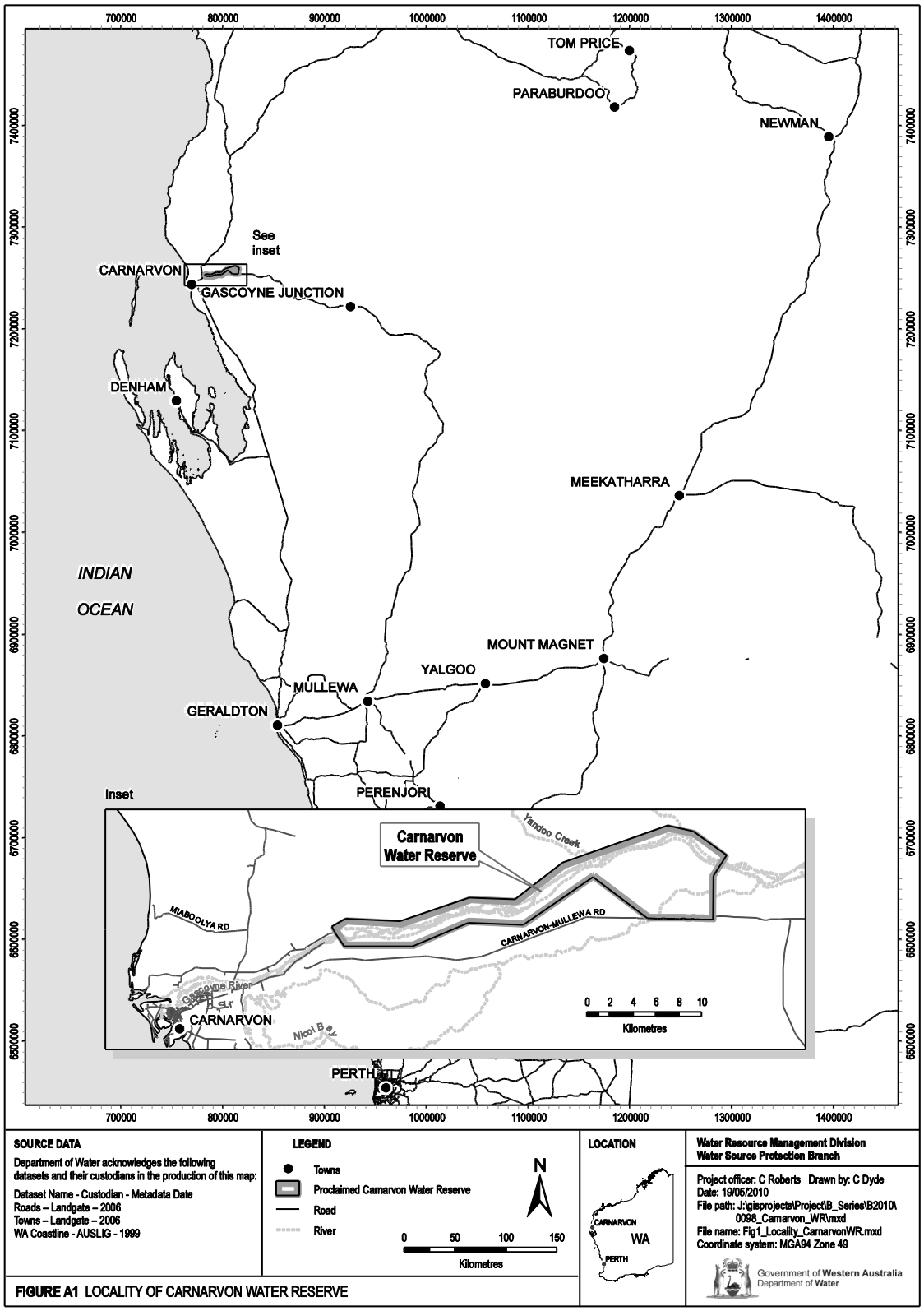
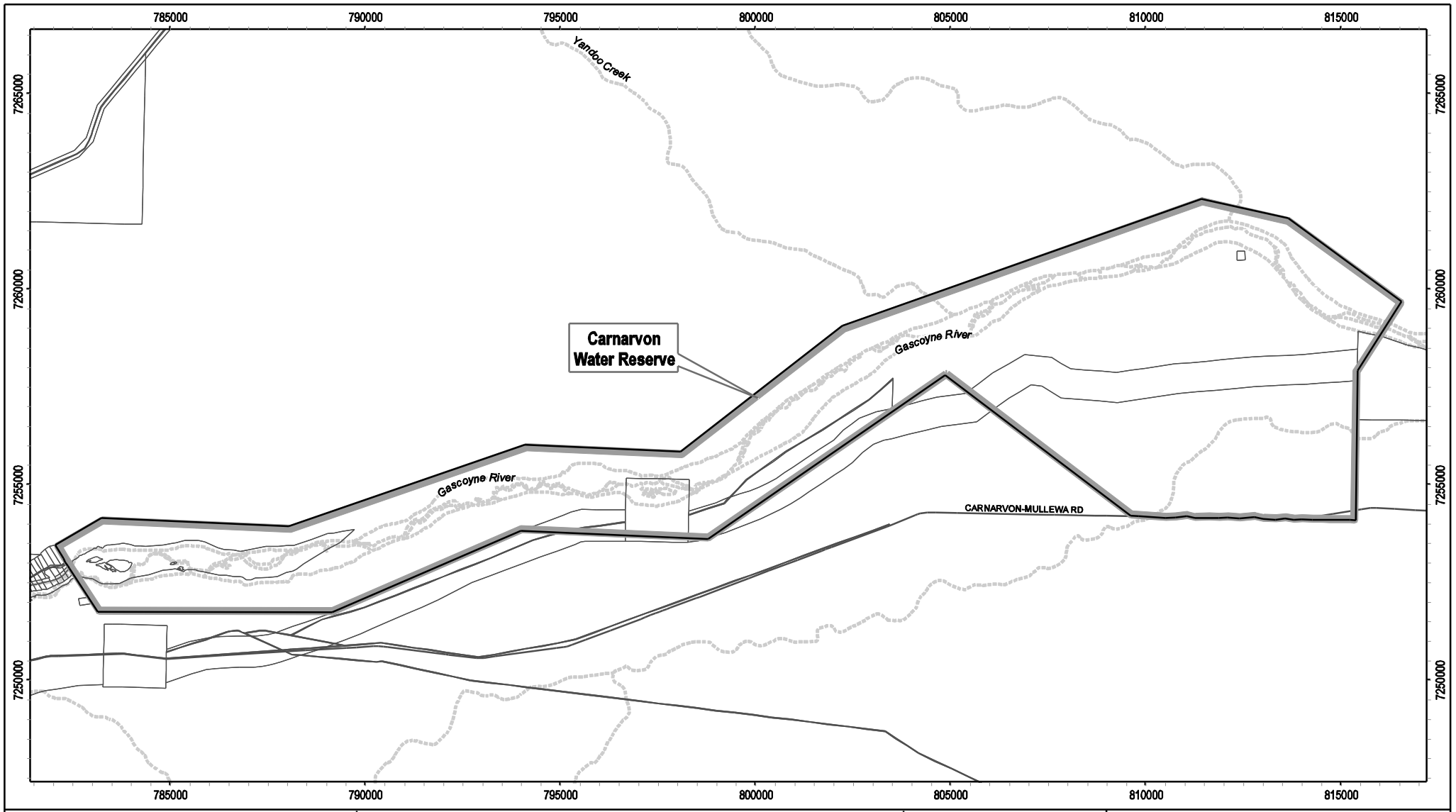


FIGURE A1 LOCALITY OF CARNARVON WATER RESERVE



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 – 2006
Cadastre - Landgate - 2009

LEGEND

- Proclaimed Carnarvon Water Reserve
- Cadastre
- Roads
- River

N

0 1 2 3 4 5
Kilometres

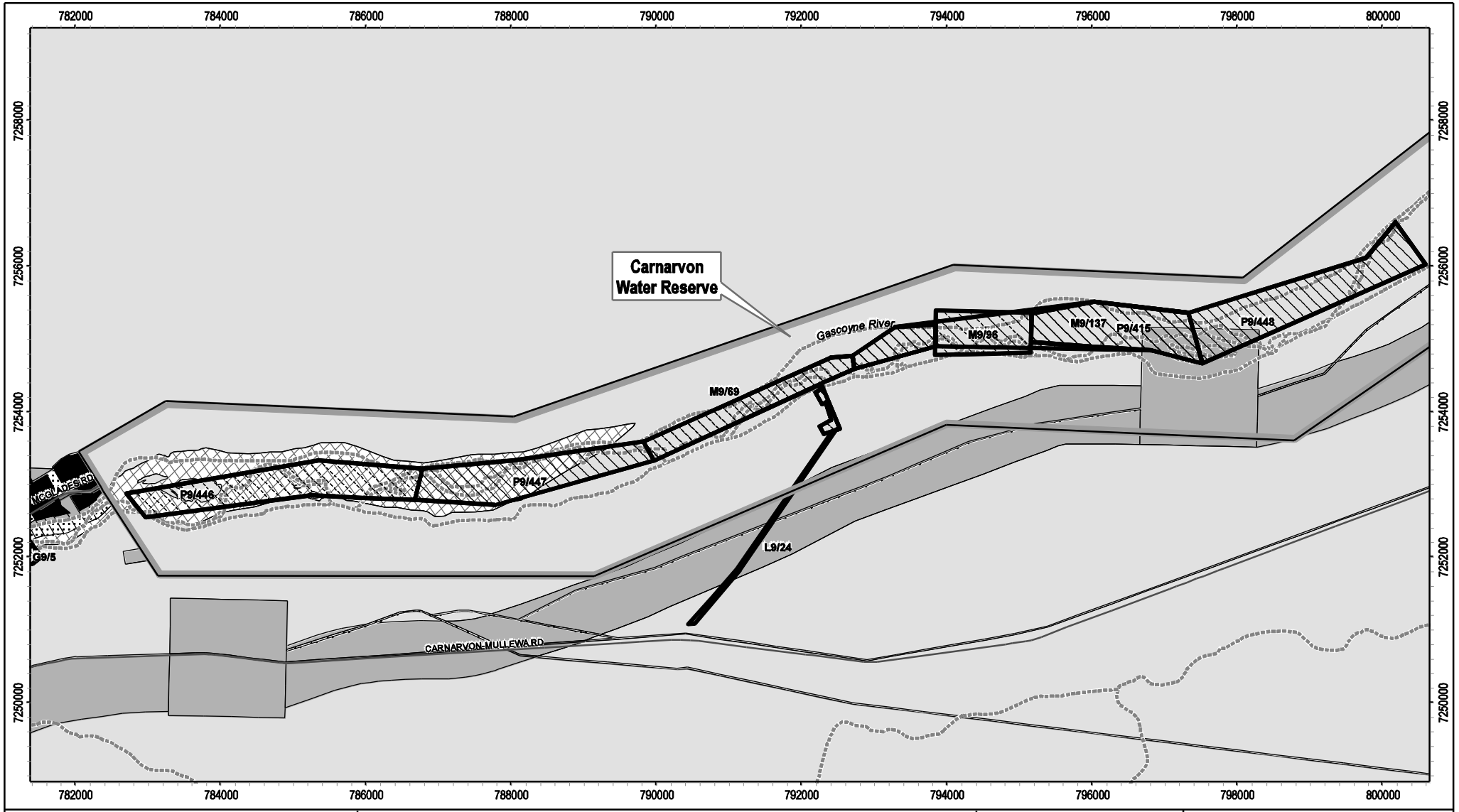
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: C Roberts Drawn by: C Dyde
Date: 03/06/2010
File path: J:\gisprojects\Project\B_Series\B2010\0098_Carnarvon_WR\mxd
File name: Fig2_Cadastre_CarnarvonWR.mxd
Coordinate system: MGA94 Zone 49

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

FIGURE A2 CARNARVON WATER RESERVE BOUNDARY



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 – 2006
Cadastre, Land Tenure - Landgate - 2009
Mining Tenement Data - Dept. of Industry and Resources - 2010

LEGEND

- Proclaimed Carnarvon Water Reserve
- Mining Tenements
- Roads
- River

Cadastre, Land Tenure

- Crown Lease
- Crown Reserve
- Freehold
- Unallocated Crown Land
- Water
- Public Roads

N

0 500 1,000 1,500 2,000
Metres

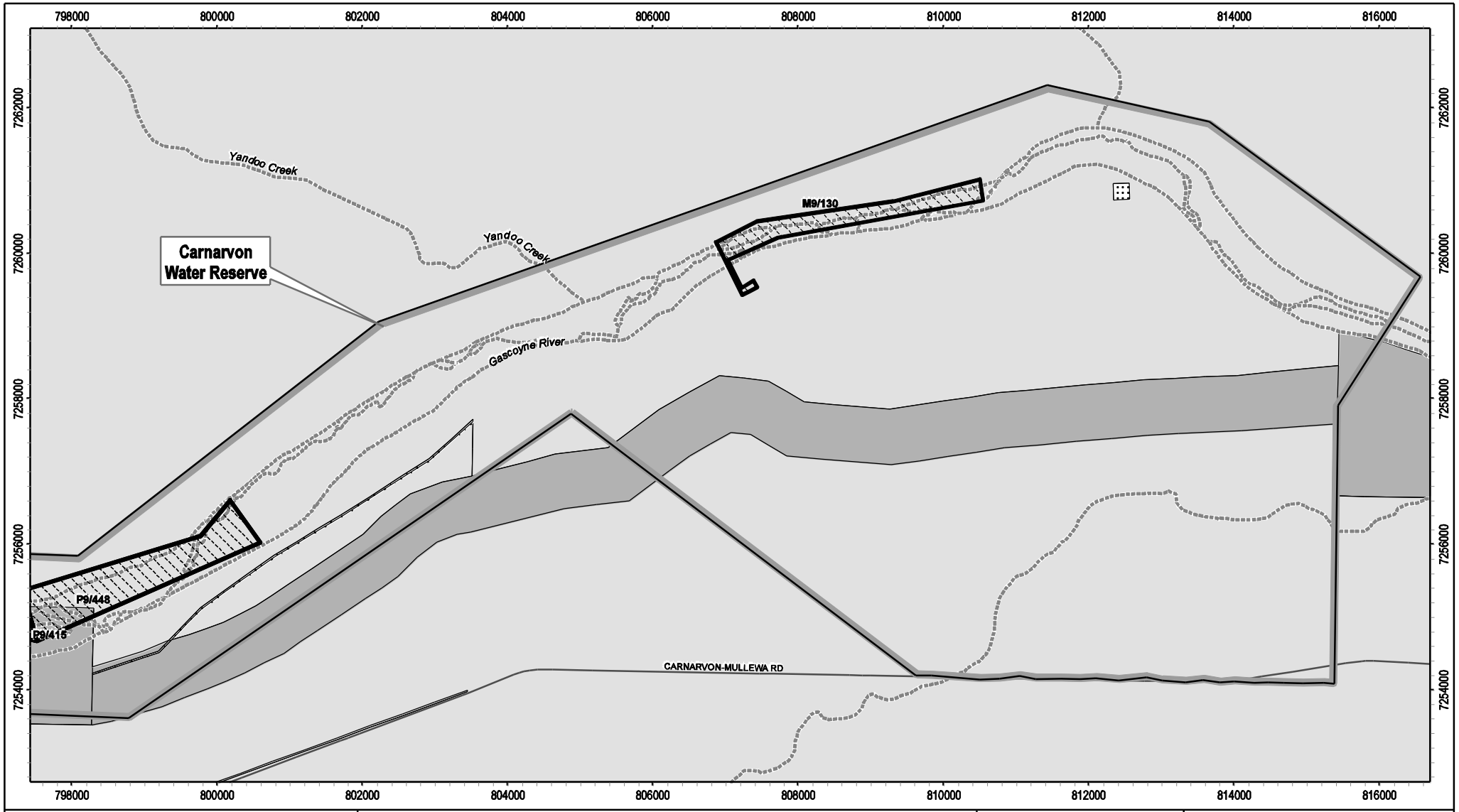
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: C Roberts Drawn by: C Dyde
Date: 03/06/2010
File path: J:\gisprojects\Project\B_Series\B2010\0098_Carnarvon_WR\mxd
File name: Fig3_LandTenure_CarnarvonWR_West.mxd
Coordinate system: MGA94 Zone 49

Government of Western Australia
Department of Water

FIGURE A3 LAND USE, ACTIVITIES AND TENURE IN THE CARNARVON WATER RESERVE - WEST



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 – 2006
Cadastre, Land Tenure - Landgate - 2009
Mining Tenement Data - Dept. of Industry and Resources - 2010

LEGEND

- Proclaimed Carnarvon Water Reserve
- Mining Tenements
- Roads
- River

Cadastre, Land Tenure

- Crown Lease
- Crown Reserve
- Freehold
- Unallocated Crown Land
- Water
- Public Roads

N

0 500 1,000 1,500 2,000
Metres

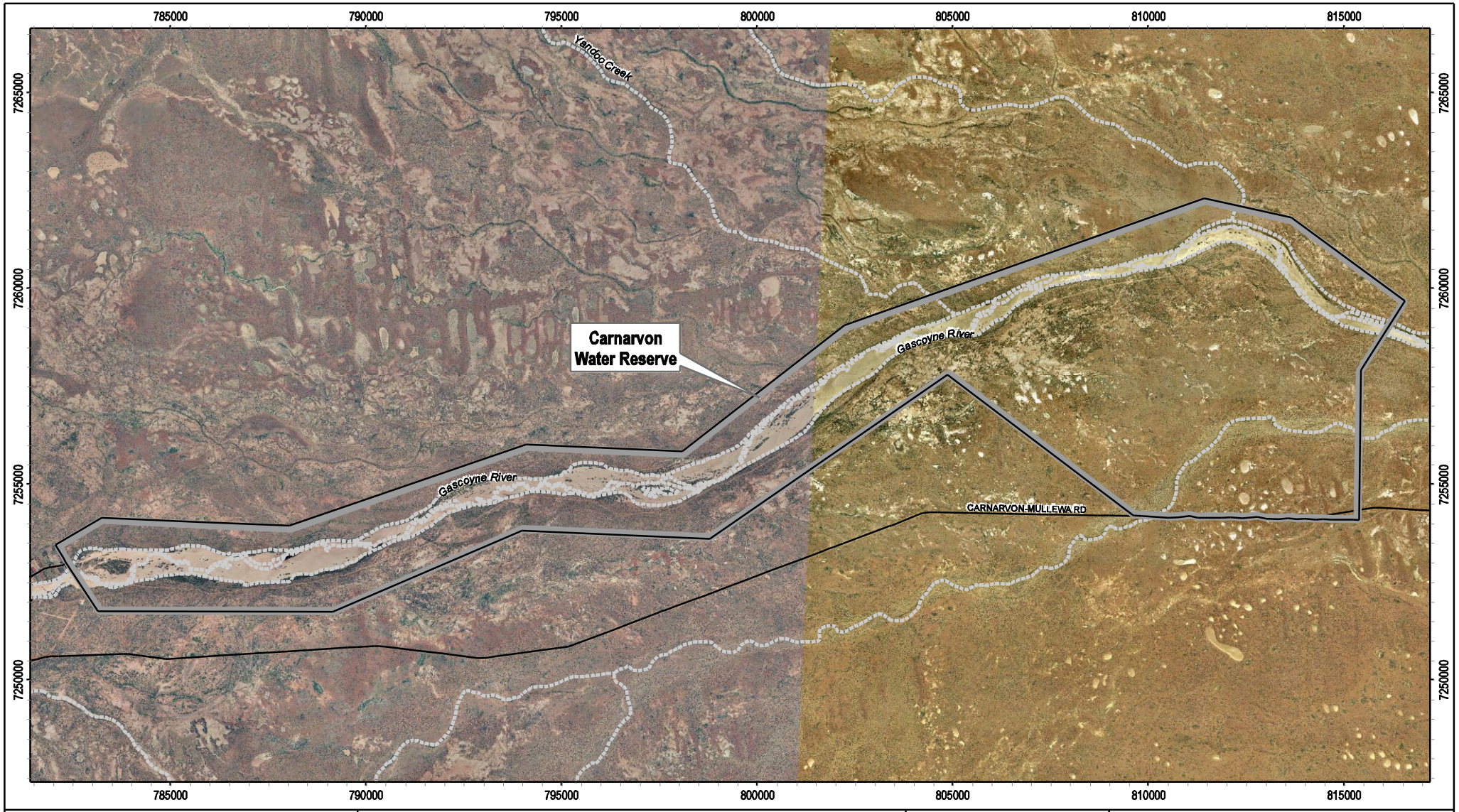
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: C Roberts Drawn by: C Dyde
Date: 03/06/2010
File path: J:\gisprojects\Project\B_Series\B2010\0098_Carnarvon_WR\mxd
File name: Fig3_LandTenure_CarnarvonWR_East.mxd
Coordinate system: MGA94 Zone 49

Government of Western Australia
Department of Water

FIGURE A4 LAND USE, ACTIVITIES AND TENURE IN THE CARNARVON WATER RESERVE - EAST



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 – 2006
Aerial Photography - Landgate -
Carnarvon 50cm - 2007 (West)
Doorawarrah 1.4m - 2002 (East)

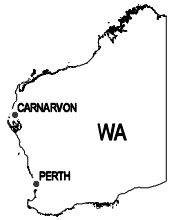
LEGEND

Proclaimed Carnarvon Water Reserve
Roads
River

N

0 1 2 3 4 5
Kilometres

LOCATION

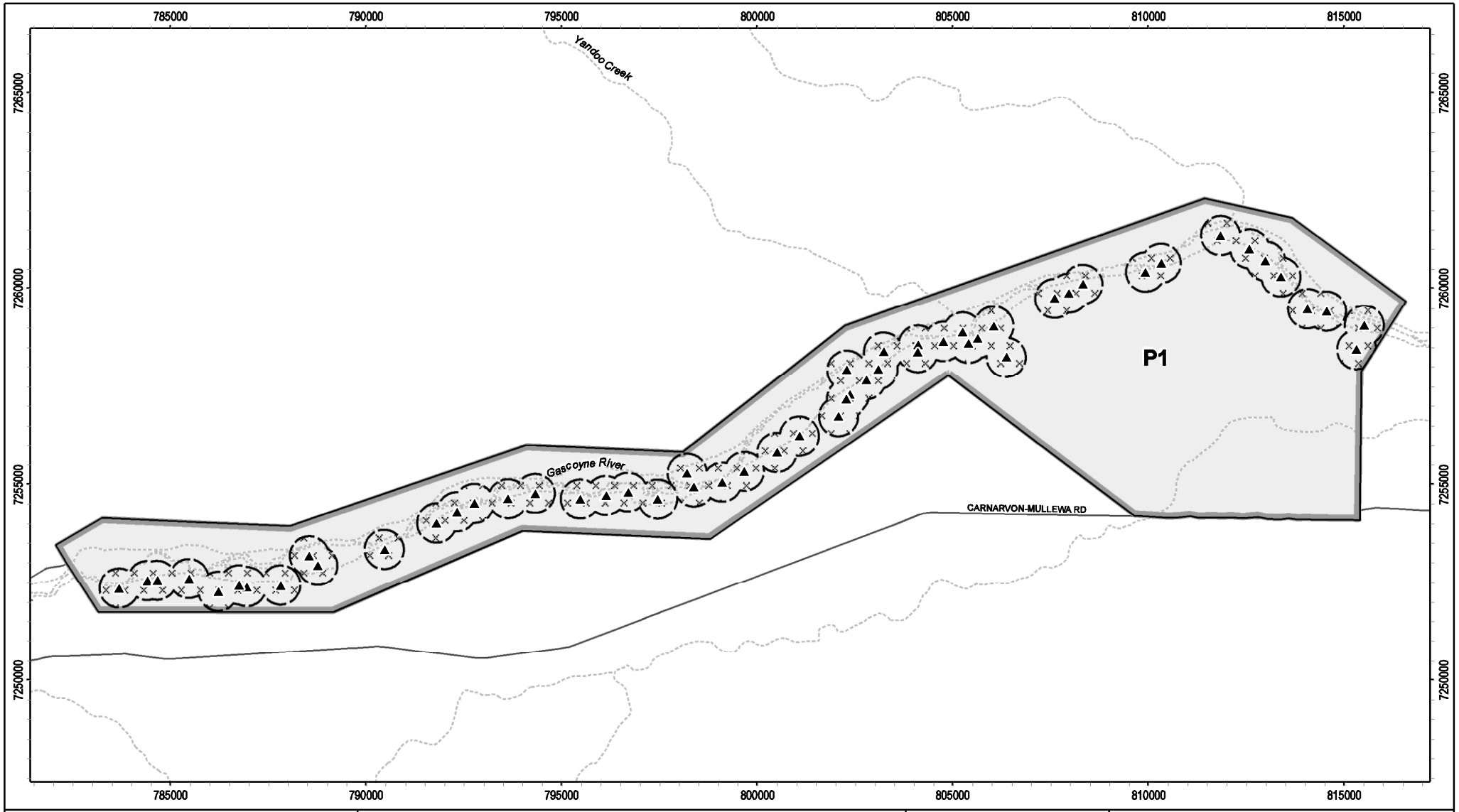


Water Resource Management Division
Water Source Protection Branch

Project officer: C Roberts Drawn by: C Dyde
Date: 03/06/2010
File path: J:\gisprojects\Project\B_Series\B2010\0098_Carnarvon_WR\mxd
File name: Fig4_Aerial_CarnarvonWR.mxd
Coordinate system: MGA94 Zone 49

Government of Western Australia
Department of Water

FIGURE A5 CARNARVON WATER RESERVE - AERIAL PHOTOGRAPHY AND OTHER LAND USE INFORMATION



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 – 2006

LEGEND

- Production bores
- Wellhead protection zone (500m)
- Proclaimed Carnarvon Water Reserve
- Roads
- River

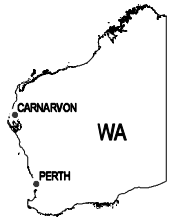
Priority area

- P1 - Priority one

N

0 1 2 3 4 5
Kilometres

LOCATION

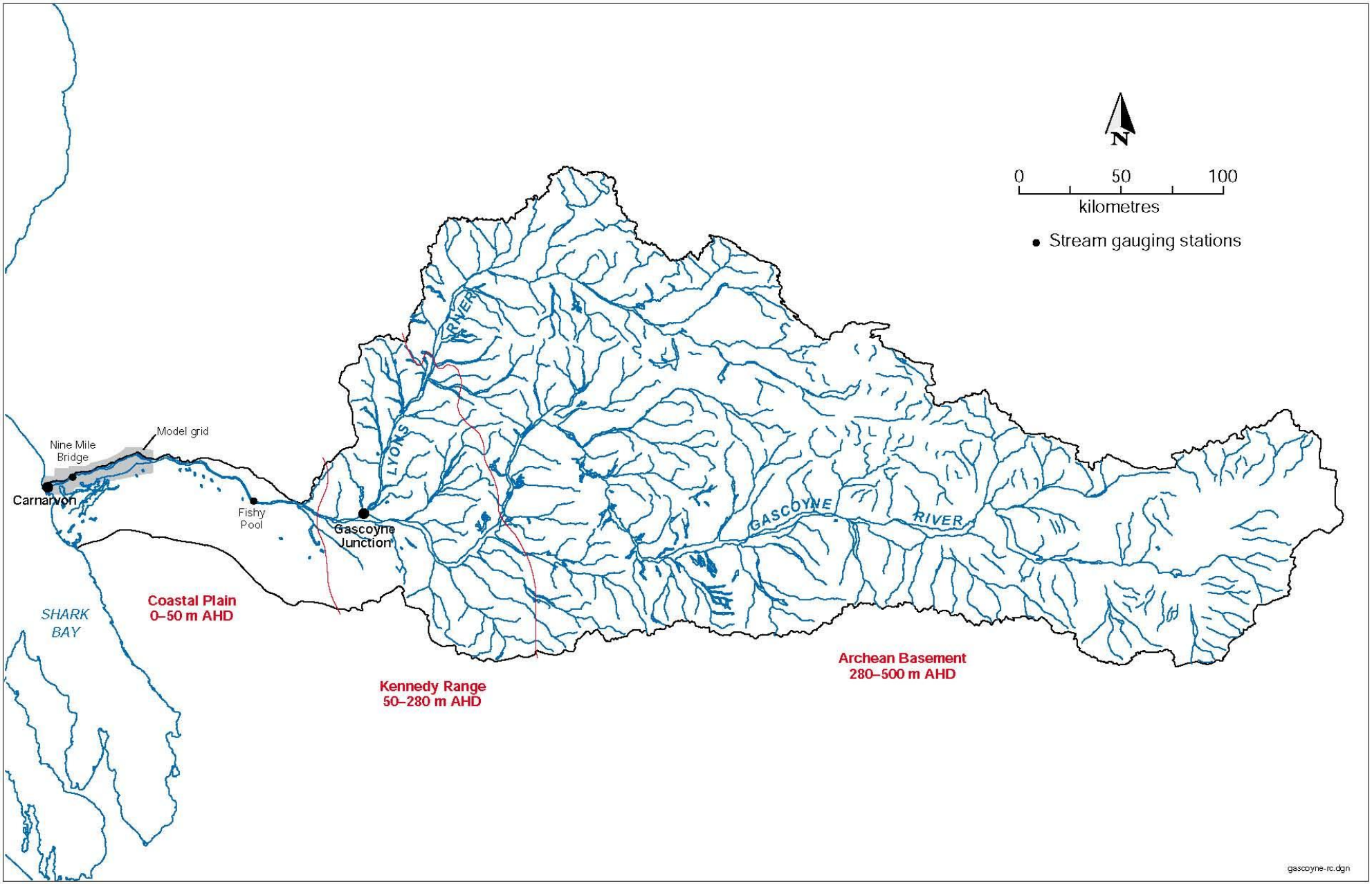


Water Resource Management Division
Water Source Protection Branch

Project officer: C Roberts Drawn by: C Dyde
Date: 03/06/2010
File path: J:\gisprojects\Project\B_Series\B2010\0098_Carnarvon_WR\mxd
File name: Fig5_Priority_CarnarvonWR.mxd
Coordinate system: MGA94 Zone 49

Government of Western Australia
Department of Water

FIGURE A6 PROCLAIMED BOUNDARY, PRIORITY AREAS AND PROTECTION ZONES FOR CARNARVON WATER RESERVE


N
0
50
100
kilometres
Stream gauging stations
LYONS RIVER
GASCOYNE RIVER
Model grid
Nine Mile Bridge
Carnarvon
Fishy Pool
Gascoyne Junction
SHARK BAY
Coastal Plain
0–50 m AHD
Kennedy Range
50–280 m AHD
Archean Basement
280–500 m AHD
gascoyne-rc.dgn

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 Carnarvon borefield in accordance with the Australian Drinking Water Guidelines (ADWG) and interpretations agreed to with the Department of Health. The raw water is regularly monitored for:

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

The following data represents the quality of raw water in Carnarvon borefield. 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. Results that exceed the 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 and water treatment, to name a few, exist downstream of the raw water to ensure it meets the requirements of the ADWG. For more information on the quality of drinking water supplied to Carnarvon, refer to the most recent Water Corporation drinking water quality annual report at <www.watercorporation.com.au/W/waterquality_annualreport.cfm>.

Aesthetic-related characteristics

Aesthetic water quality analyses for raw water from Carnarvon borefield are summarised in Table 3.

The values are taken from ongoing monitoring for the period January 2005 to December 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 3 Aesthetic-related detections for Carnarvon borefield

Parameter	Units	ADWG aesthetic guideline value*	Carnarvon borefield raw water SP	
			Range	Median
Chloride	mg/L	250	28–275	110
Colour – True	TCU	15	<1–1	<1
Hardness as $CaCO_3$	mg/L	200	27–291	129
Iron unfiltered	mg/L	0.3	<0.003 – 0.88	<0.003
Sodium	mg/L	180	23–180	76
Total filterable solids by summation	mg/L	500	117–905	455
Turbidity	NTU	5	<0.1–22	<0.1
pH	NOUNIT	8.5	6.86–9.57	7.76

* 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 Carnarvon is analysed for health-related chemicals including inorganics, heavy metals and pesticides. Health-related water quality parameters that have been measured at detectable levels in the source between January 2005 and December 2009 are summarised in Table 4. Any parameters that have on occasion exceeded the ADWG are shaded.

Table 4 Health-related detections for Carnarvon borefield

Parameter	Units	ADWG health guideline value*	Carnarvon borefield raw water SP	
			Range	Median
Sulfate	mg/L	500	16–105	47
Arsenic	mg/L	0.007	<0.002–0.013	0.007
Fluoride	mg/L	1.5	0.1– 3	0.4

* 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).

Microbiological contaminants

Microbiological testing of raw water samples from Carnarvon borefield is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water.

A detection of *Escherichia 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 January 2005 to December 2009, positive *Escherichia coli* counts were recorded in 4.4 per cent of samples with no samples being higher than 20 MPN/100ml. Carnarvon borefield abstracts water from an unconfined aquifer and, as such, can be susceptible to ingress of contaminants to the aquifer. The data suggests this happens infrequently and treatment is present to deal with this.

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**			
Pastoralist	Pathogens from grazing livestock and feral goats Nutrients from animal excrement Hydrocarbon and other chemical spills from machinery and vehicles Pathogens from animal carcasses and faeces entering unsealed wells.	Medium Low Low Medium	Cattle, sheep and feral animals on pastoral lease are attracted to stock watering points during summer months. Some stock watering points are located within WHPZs.	Water quality monitoring Water quality monitoring	WQPN 58: *Above-ground chemical storage tanks in public drinking water source areas.* WQPN no. 35: *Pastoral activities within rangelands* WQPN no. 80: *Stockyards* Stock watering points located within WHPZs should be identified and relocated outside of the WHPZs

Land use/activity	Potential water quality risks		Consideration for management	Current preventative measures	Recommended protection strategies
	Hazard	**Management priority**			
Mining leases contained in the water reserve.	Hydrocarbons from fuel spills from storage and mechanical servicing Hydrocarbons from heavy machinery excavation Pathogens from human activity	Medium High High	Current mining activity is estimated at 9000 tonnes a year. Current tenement conditions apply to all mining tenements within the Carnarvon Water Reserve. The Department of Water has sought new conditions relating to water quality protection from the Department of Mines and Petroleum (DMP) for mining tenements occurring in the Carnarvon Water Reserve.	Water quality monitoring Current mining tenement lease conditions (see Section 3.1.1)	Ensure adherence to the water quality protection guideline series: *Mining and mineral processing*. Ensure both compliance with the current DMP mining tenement conditions and endorsements and inclusion of requested tenement conditions. Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in public drinking water source areas.*

Appendix D Photographs

Figure D1 Carnarvon production bore [Beatrice Franke, Department of Water]

Figure D2 Stock watering points [Nigel Mantle, Department of Water]

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
BoM	Bureau of Meteorology
CA	catchment area
CFU	colony forming units
DEC	Department of Environment and Conservation
EC	electrical conductivity
GL	gigalitre
ha	hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
km^2	square kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
ML	megalitre
mm	millimetre
MPN	most probable number
mSv	millisievert

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
RPZ	reservoir protection zone
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 waterbody.
Adsorb	Adsorb means to accumulate on the surface of something. For example, microorganisms can absorb onto soil particles.
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).
Allocation	The quantity of water that a licensee is permitted to abstract is their allocation, usually specified in kilolitres per annum (kL/a).
Anisotropic	Having different properties in different directions. For example, an aquifer with variations in hydraulic conductivity horizontally and vertically, or different grain sizes in all directions.
Aquifer	An aquifer is a geological formation or group of 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, 2004* (NHMRC & NRMMC 2004a) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's References).
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 hole drilled into the ground to monitor or draw groundwater (also called a well).
Borefield	A group of bores to monitor or withdraw groundwater is referred to as a borefield (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.
Confined aquifer	An aquifer that is confined between non-porous rock formations (such as shale and siltstone) and therefore contains water under pressure.
Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.

Diffuse source	A diffuse source of pollution originates from a widespread non-specific area (e.g. urban stormwater runoff, agricultural infiltration) as opposed to a particular point source (see *point source pollution*).
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).
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.
Intermittent	Recurrent streams, lakes or springs; showing water only part of the time.
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.
Millisievert	A millisievert is a measure of annual radiological dose, with a natural dose equivalent to 2 mSv/yr.

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.
Most probable number	Most probable number is a measure of microbiological contamination.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
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.
Perched	An unconfined aquifer, often ephemeral or seasonal, perched on top of an impermeable horizon near the land surface and separated from deeper groundwater by an unsaturated zone.
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 runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
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).
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.
Relief	*Physical Geography;* the departure of the land surface in any area from that of a level surface.
Reservoir	A reservoir, dam, tank, pond or lake that forms part of any public water-supply works.
Reticulation	A network of pipes which conveys services through a town or building.
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Semi-confined aquifer	A semi-confined or leaky aquifer is saturated and bounded above by a semi-permeable layer and below by a layer that is either impermeable or semi-permeable.
Stormwater	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
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.

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.
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.
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

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) & Australian and New Zealand Environment and Conservation Council (ANZECC) 1996, *Draft rural land uses and water quality – A community resource document*, ARMCANZ & ANZECC, Canberra.

Allen, AD 1971, 'Cretaceous-Holocene stratigraphy and structure lower Gascoyne River, Carnarvon Basin', Western Australia Geological Survey, *Annual report 1971*, p 22-25.

Allen, AD 1972, *Results of the investigation into groundwater resources along the lower Gascoyne River for Carnarvon irrigation and town water supplies*, Western Australia Geological Survey, Record 1972/9.

Bureau of Meteorology 1998, *Gascoyne Murchison* climate survey, Department of the Environment and Heritage, Commonwealth of Australia.

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 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.

Department of Water & Department of Health 2008, *Risks from pathogenic micro-organisms in public drinking water source areas*, Department of Water, Perth, available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for our advisory brochures relevant to drinking water.

Dodson, Wade John 2009, *Groundwater recharge from the Gascoyne River, Western Australia,* Hydrogeological record series HG 32, Department of Water, Perth.

Geldreich, EE 1996, 'Pathogenic agents in freshwater resources', *Hydrological Processes*, vol. 10, pp. 315-333.

Government of Western Australia 1914, *Rights in Water and Irrigation Act*, reprinted under the *Reprints Act 1984* as at 1 February 2008, available <www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_844_homepage.html>.

Government of Western Australia 1947, *Country Areas Water Supply Act*, reprinted under the *Reprints Act 1984* as at 14 April 2008, available <www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_208_homepage.html>.

Government of Western Australia 2007, *State water plan 2007*, Department of the Premier and Cabinet, Perth, available <www.water.wa.gov.au> Publications > Find a publication > A-Z browse.

Hrudey, SE & Hrudey, EJ 2004, Safe drinking water – Lessons from recent outbreaks in affluent nations, IWA Publishing, London.

Hocking, RM., Moors, HT & van de Graaff, JE 1987, *Geology of the Carnarvon Basin Western Australia,* Western Australia Geological Survey, Bulletin 133.

Krogh, M, Davison, A, Miller, R, O'Connor, N, Ferguson, C, McClaughlin, V & Deere, D 2008, *Effects of recreational activities on source protection areas – literature review*, Water Services Association of Australia, Melbourne.

National Health and Medical Research Council (NHMRC) & Natural Resource Management Ministerial Council (NRMMC) 2004a, National Water Quality Management Strategy: *Australian drinking water guidelines*, Australian Government, Canberra, available <www.nhmrc.gov.au/publications/synopses/eh19syn.htm>.

NHMRC & NRMMC 2004b, W*ater made clear – a consumer guide to accompany the Australian drinking water guidelines 2004,* Australian Government, Canberra, available <www.nhmrc.gov.au/publications/synopses/eh19syn.htm>.

National Minimum Bore Specifications Committee 2003, *Minimum construction requirements for water bores in Australia,* 2nd edn, Land and Water Biodiversity Committee, Queensland, available <www.water.wa.gov.au> Publications > Find a publication > A-Z browse.

Martin, MW 1990b, Groundwater resources of the older alluvium, Gascoyne River, Carnarvon, Western Australia*,* Western Australia Geological Survey*,* Hydrogeology report no. 1990/21 (unpublished).

State Emergency Management Committee 2005, Policy statement no. 7: *Western Australian emergency management arrangements,* Government of Western Australia, Perth.

Water and Rivers Commission 2000, Statewide policy no. 2: *Pesticide use in public drinking water source areas*, Water and Rivers Commission, Perth, available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for our policies.

Water and Rivers Commission 2003, Statewide policy no. 13: *Policy and guidelines for recreation within public drinking water source areas on Crown land*, Water and Rivers Commission, Perth, available <http://drinkingwater.water.wa.gov.au> and scroll down to the link for our policies.

Water Corporation 2006, *SG097 Source protection operations manual*, Water Corporation, Perth.

Western Australian Planning Commission 1997, *State planning strategy*, Government of Western Australia, Perth, available <http://www.planning.wa.gov.au/Plans+and+policies/Publications/52.aspx>.

Western Australian Planning Commission 2003, Statement of planning policy no.2.7: *Public drinking water source policy*, Government Gazette Western Australia, 10 June 2003, pp. 2077-82, Government of Western Australia, Perth, available <http://www.planning.wa.gov.au/Plans+and+policies/Publications/149.aspx>

Western Australian Planning Commission 2006, State planning policy no.2.9: *Water resources*, Government Gazette Western Australia, 19 December 2006, pp. 5707-22, Government of Western Australia, Perth, available <http://www.planning.wa.gov.au/Plans+and+policies/Publications/1281.aspx>

World Health Organization 2004, *Guidelines for drinking-water quality – Volume 1 – Recommendations*, 3rd edn, World Health Organization, Geneva, available <www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html>.

WRC 2004. *Managing the groundwater resources of the Lower Gascoyne River (Carnarvon) WA – groundwater management strategy*, Water and Rivers Commission, Perth.

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