



Government of Western Australia  
Department of Water

# *Kununurra Water Reserve*

Drinking water source protection review

*Kununurra town water supply*



*Looking after all our water needs*

Water resource protection series  
Report WRP 137  
December 2012



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Cover photograph: Aerial photograph of Kununurra area (by Chris Qiu, using Landgate data).

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## Summary

This drinking water source protection review considers changes that have occurred in and around the Kununurra Water Reserve since completion of the *Kununurra Water Reserve drinking water source protection plan* (Department of Environment 2003). This 2012 review needs to be read alongside the 2003 protection plan which contains more detailed information. Both of these documents are available on our website or by contacting us (see details on the inside cover of this report).

Kununurra is located on the Ord River in the Shire of Wyndham-East Kimberley in northern Western Australia. Kununurra has experienced a period of sustained growth in recent years flowing from increased investment in the Ord River agricultural industry, mining activity and growth of the Kimberley region as a tourist destination (Shire of Wyndham-East Kimberley 2011).

Water is supplied to the town by the Water Corporation from six production bores which draw water from an unconfined, shallow aquifer that is vulnerable to contamination from land and water based activities above it. The wellfield is located in Crown reserve 30211 vested with the Department of Water, on the northern bank of Lake Kununurra east of and adjacent to the M1 Channel (see Figure A2).

This 2012 review document is a snapshot of actions taken since 2003 and it includes an implementation table showing the status of the recommendations made in the 2003 protection plan. Based on the findings updated recommendations have been developed.

The two tables that follow describe the actions taken since 2003 to help protect this important public water supply and some detail about the Kununurra Water Reserve.

The most significant change since 2003 is the 2004 change to the Kununurra Water Reserve boundary and the proposed 2012 change (Figure A1). Both these boundary changes provide for more land use and foreshore development in Kununurra consistent with the Shire of Wyndham East Kimberley's identification of Lily Creek foreshore for future development and their strategic directions report and foreshore use plan (Shire of Wyndham East Kimberley 2010 and 2011).

The limited availability of an alternative public water supply remains the key limiting factor for any new developments within the 2012 proposed Kununurra Water Reserve. Until an alternative water supply is located, approved and developed the 2012 proposed Kununurra Water reserve will continue to be protected to ensure the ongoing availability of a reliable, safe, lower cost drinking water supply to consumers in Kununurra.

The following table shows important actions taken from 2003 to 2012:

Stages in development of drinking water source protection report		Comment
1	<p><i>Kununurra Water Reserve drinking water source protection plan</i> published (Report WRP 51).</p> <p>(2003)</p>	<p>This was an interim plan pending groundwater investigations to the east of the existing water reserve and investigations of alternative water sources. This interim plan proposed a reduction in the overall size of 1970 proclaimed Kununurra Water Reserve.</p> <p>The proposed boundary was proclaimed in 2004 allowing for more land planning and development decisions to be considered along the foreshore downstream of the drinking water supply for Kununurra.</p>
2	<p>Additional drilling, monitoring and modelling undertaken in 2004 proclaimed Kununurra Water Reserve.</p> <p>Public forum held in Kununurra 2005.</p> <p>(2005, 2006)</p>	<p>Results of the 2005–2006 drilling, monitoring and modelling report confirmed that the alluvial deposits of the region function as a fully-connected aquifer system, with recharge being drawn from the lake through the sand and gravel beds.</p> <p>Results and implications communicated to Shire and Council in 2006.</p>
3	<p>Report <i>Kununurra Water Reserve Exploration Drilling Program</i> produced by the Department of Water as Hydrogeological Report Series HR 245.</p> <p>(2007)</p>	<p>This report confirmed that if development in the 2004 proclaimed Kununurra Water Reserve was important, further investigations needed to be undertaken to identify and develop an alternative, safe, drinking water source before any new development occurred.</p> <p>The limited availability of alternative water sources was also identified in the 2003 Interim protection plan.</p>
4	<p><i>Draft Kununurra Water Reserve drinking water source protection plan: consultation and drafting</i> (Report WRP 99)</p> <p>(2009)</p>	<p>The updated plan was publicly consulted but was not completed. It was put on hold pending the outcome of a number of planning initiatives in Kununurra and investigation of an alternative water source.</p> <p>The plan has been superseded by the development of this 2012 drinking water source protection review.</p>



5	<p>Parliamentary Committee Report into recreation activities within public drinking water source areas identified concerns with the approval processes for recreation and tourism proposals in Kununurra.</p> <p>(2010)</p>	<p>The planned development of a strategic directions report and foreshore plan in 2010–2011 was expected to help resolve historic delays in the assessment and approval of recreation, tourism and other development proposals.</p> <p>A coordinated response to proposals has helped as well as some rationalisation of foreshore vesting to the Shire.</p>
6	<p>Development of the Shire of Wyndham East Kimberley <i>Kununurra Strategic Directions Report 2010, and the Lake Kununurra Foreshore and Aquatic Use Plan 2011</i>.</p> <p>(2010, 2011)</p>	<p>The Department of Water confirmed that it would consider a change along the eastern boundary of the 2004 proclaimed Kununurra Water Reserve to achieve the Shire's proposed planning outcomes along waterfront land adjacent to Lily Creek lagoon.</p> <p>The final boundary change was subject to further consultation.</p> <p>These documents have helped in the progress of new proposals as all agencies with responsibilities for drinking water protection and land use planning and development were involved in their development.</p>
7	<p>Water Corporation investigated a proposed alternative location for the Kununurra Water Reserve on packsaddle plains.</p> <p>(2011, 2012)</p>	<p>The high cost and poor water quality of this alternative drinking water source prevented it from being progressed.</p>
8	<p><i>Kununurra Water Reserve drinking water source protection review</i> (Report WRP 137).</p> <p>(2012)</p>	<p>This review reflects the boundary changes proposed along the eastern boundary of the 2004 proclaimed Kununurra Water to allow development in a waterfront location as requested by the Shire.</p> <p>This 2012 proposed Kununurra Water Reserve boundary also reflects discussions held during the development of <i>Shire's Lake Kununurra Foreshore and Aquatic Use Plan</i> of 2011.</p>

This table shows useful information about the Kununurra Water Reserve.

<b>Kununurra Water Reserve</b>	
Local government authority	Shire of Wyndham-East Kimberley
Locations supplied	Kununurra
Aquifer type	Unconfined, shallow aquifer subject to contamination from land and water based activity
Volume of water pumped	During the period 1 April 2010 to 31 March 2011, total abstraction was 1277264 kL  Licensed to take 2 000 000 kL/year
Number of bores	6 production bores currently drilled.  During the water year 1 April 2010 to 31 March 2011, most of the abstraction was from Bore 1/98. Bore 2/69 was not operational - it was kept as an emergency standby bore.
Bore name and GPS coordinates	1/98 (E 470 124 N 8 254 748) 1/89 (E 470 203 N 8 254 480) 1/95 (E 470 138 N 8 254 566) 3/69 (E 470 218 N 8 254 319) 1/70 (E 470 029 N 8 254 583) 2/69 (E 469 982 N 8 254 267)
Date of <i>Kununurra Water Reserve drinking water source protection reports</i>	Drinking water source protection plan published in 2003  Draft drinking water source protection plan consulted in 2009 (this plan was put on hold pending development of strategic direction report for Kununurra and investigations of an alternative water source on packsaddle plains)  Drinking water source protection review published in 2012
Proclamation status	Originally proclaimed in 1970 <i>under the Country Areas Water Supply Act 1947</i>  New boundary proclaimed in 2004 based on 2003 Interim Plan  New boundary proposed based on 2012 review

# 1 Review of Kununurra's drinking water source protection plan

## 1.1 Water reserve boundary, priority areas and protection zones

The Kununurra Water Reserve was originally proclaimed in 1970 under the *Country Areas Water Supply Act 1947*. Following the release of the 2003 Kununurra Water Reserve drinking water source protection plan, a reduced reserve boundary was proclaimed in 2004 to reflect existing land use, allowing for more land planning and development decisions to be considered (see Department of Water's Water quality protection notes (WQPN): no.25: *Land use compatibility in public drinking water source areas* (2004) and no.75: *Proclaimed public drinking water source areas* (2009)).

Since the publication of the *Kununurra Water Reserve Drinking water source protection plan* (Department of Environment 2003) and consultation on the draft *Kununurra Water Reserve Drinking water source protection plan 2009*, additional discussions have been held with the Shire of Wyndham East Kimberley (SWEK), the Department of Planning, LandCorp and Water Corporation, on the regional development aspirations.

Planning documents prepared by the Shire of Wyndham East Kimberley, such as their *Kununurra Strategic Directions* (SWEK 2010) and *Lake Kununurra Foreshore and Aquatic Use Plan* (SWEK 2011), have continued to consider relocation of the existing Kununurra water reserve to release waterfront land for development. The Department of Water has responded by reducing the boundary of the water reserve in the 2003 plan and in this 2012 review to allow for some waterfront development while maintaining the integrity of the reserve.

Figure A1 shows the current 2004 boundary and the new 2012 proposed Kununurra Water Reserve boundary. This water reserve consists mostly of Crown land. The Department of Water will arrange proclamation of the 2012 Kununurra Water Reserve boundary under the *Metropolitan Water Supply Sewerage and Drainage Act 1909/Country Areas Water Supply Act 1947* as recommended in Section 2.2.

The Priority 1 (P1) status of the water reserve reflects the importance of this area for public drinking water supply. A 2007 Department of Water publication (*Kununurra Water Reserve Exploration Drilling Program*) reported results of drilling, monitoring and modelling investigations in the water reserve. This work indicated the vulnerability of this shallow groundwater source and how the shoreline provides an interface between the unconfined aquifer and the lake.

In P1 areas the objective is risk avoidance to protect water quality, and public health, and land use intensification is not recommended to avoid increased contamination risks.

The 2012 proposed Kununurra Water Reserve and its priority areas and protection zones have been determined in accordance with current departmental policy and legislation as applied to more than 100 other public drinking water source areas in Western Australia.

If you require more information on the background to and support for protection of Public Drinking Water Source Areas (PDWSAs), please refer to our WQPN no. 36: *Protecting public drinking water source areas* (2009).

## 1.2 Update on water supply scheme

The Kununurra bore field consists of 6 bores (Figure A3): During the water year 1 April 2010 to 31 March 2011, most of the abstraction was from Bore 1/98. Bore 2/69 was not operational - it was kept as an emergency standby bore.

The monitoring program for the Kununurra production bores is set out in the Water Corporation's 2011 *Kununurra Water Resource Management Operations Strategy* (WRMOS).

Raw water from the water reserve is pumped to a 1000 m<sup>3</sup> clear water tank after being disinfected with chlorine. A transfer pump station then pumps disinfected groundwater through the reticulation and to storage tanks in town. The aquifer material, of coarse sand and gravel, acts as a natural filtration system, which obviates the need for additional filtration prior to the treatment process.

The current Water Corporation licence expires in 2016.

## 1.3 Water quality information

The Water Corporation has provided updated water quality information for the Kununurra bore field. This is shown in Appendix B.

## 2 Implementation of Kununurra's drinking water source protection plan

### 2.1 Status of previous recommendations

This table outlines recommendations from the 2003 plan and their current status.

	<b><u>Description in 2003 plan</u></b>	<b><u>Status</u></b>	<b><u>Comment</u></b>
1	The Kununurra Water Reserve boundary should be amended as shown in Figures 4 and 5.	Completed	Boundary amended and proclaimed in 2004. Current 2012 review proposes additional amendment to reflect consultation with the Shire of Wyndham East Kimberley (SWEK), Water Corporation, Department of Planning and LandCorp; and hydrogeological review.
2	The Town Planning Scheme should recognise the Kununurra Drinking Water Source Protection Plan and only support land uses compatible with the assigned priority classification. Planning strategies within the proposed new Water Reserve should incorporate the management principles outlined in the Water and Rivers Commission's <i>Land Use Compatibility in Public Drinking Water Source Areas</i> (Appendix 1) (WRC 2004) and reflect the Priority 1 classification given to the Water Reserve. This recommendation is consistent with the proposed <i>Public Drinking Water Source Policy</i> (WAPC 2004).	Ongoing	The Shire of Wyndham East Kimberley Town Planning Scheme (TPS) no. 7 of 18 April 2011 (updated to 12/04/11) does not recognise the Kununurra Water Reserve as a special control area nor show the protection zone. Map 7 shows a portion of the Kununurra Water Reserve (Crown reserve 30211) as a Public Purposes Reserve denoted for water supply.  The ongoing need to reflect the new Kununurra Water Reserve as a special control area in the Shire of Kununurra TPS will be carried forward into the 2012 updated recommendations.

	<u>Description in 2003 plan</u>	<u>Status</u>	<u>Comment</u>
3	All development proposals in the Water Reserve that are likely to impact water quality and are not consistent with the Department's published Policy, Guidelines, Water Quality Protection Notes or other documents should be referred to the Department of Environment.	Completed	Guidelines have been provided through the Department of Water's water quality protection note series.  Development proposals are referred to the Kimberley Region office of the Department of Water. The ongoing need to refer development proposals will be carried forward into the 2012 updated recommendations.
4	All new proposed activities for Lake Kununurra should be referred to the Department of Environment for comment. (2012 Note: This agency no longer exists; the Department of Water is the responsible agency.)	Completed	This 2012 proposed Kununurra Water Reserve boundary reflects discussions held during the development of the Shire's Lake Kununurra Foreshore and Aquatic Use Plan of 2011.
5	Signs should be erected along the boundaries of the Water Reserve to define the reserve and promote public awareness of the need to protect water quality for drinking water purposes.	Completed	Signs should be maintained.

	<b><u>Description in 2003 plan</u></b>	<b><u>Status</u></b>	<b><u>Comment</u></b>
6	<p>Incidents covered by WESTPLAN – HAZMAT in the Kununurra Water Reserve should be addressed through the following measures:</p> <ul style="list-style-type: none"> <li>• The Kununurra Local Emergency Management Advisory Committee (through the Broome Emergency Management District) being familiar with the location and purpose of the Kununurra Water Reserve.</li> <li>• The locality plan for the Kununurra Water Reserve being provided to the Fire and Rescue Services headquarters for the HAZMAT Emergency Advisory Team.</li> <li>• The Department advising the HAZMAT Emergency Advisory Team during incidents in the Kununurra Water Reserve.</li> <li>• 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.</li> </ul>	Completed	Emergency response protocols have since changed to the jurisdiction of HAZMAT and the local emergency management committee.

	<u>Description in 2003 plan</u>	<u>Status</u>	<u>Comment</u>
7	Surveillance should be undertaken on a periodic basis to identify any incompatible land uses or potential contaminant threats within the Water Reserve. Inspect existing land uses in the Water Reserve, such as the caravan park, to investigate and confirm action for groundwater protection.	Completed	<p>Water Corporation and the Department of Water undertake surveillance within the water reserve; and Water Corporation reports any issues to the Department of Water. Water Corporation undertakes water quality monitoring within the water reserve in accordance with the Australian drinking water guidelines and interpretations agreed to with the Department of Health. This will continue to be a 2012 recommendation.</p> <p>Kununurra Water Reserve is not currently delegated to the Water Corporation. A recommendation to formally delegate this source will be made in the 2012 updated recommendations.</p>
8	If the wellfield needs to be extended to the east in the future, further detailed groundwater modelling should be undertaken. Irrespective of this modelling, a monitoring program should be established to determine the extent of any contaminant movement that might threaten the water quality of the wellfield. Monitoring of production wells should include scanning for pesticides, pathogens and nutrients as possible contaminants from Lake Kununurra, the wastewater treatment plant, KLTP, the stormwater drain and the alleged decommissioned landfill. Observation bores should also be installed between the production bores, KLTP and the reported decommissioned landfill and monitored regularly.	Completed	<p>See Department of Water (2007) which reported: The results of a drilling program in 2005 and subsequent updating of the groundwater model confirmed the existence of the aquifer across the water reserve. The findings were communicated with the Shire of Wyndham East Kimberley.</p> <p>Water quality monitoring is also ongoing – the above work was a one-off project.</p>



	<u>Description in 2003 plan</u>	<u>Status</u>	<u>Comment</u>
9	Government should consider possible alternative drinking water sources and provide advice on the environmental, social, and economic implications of developing those sources which could then allow land adjacent to Lake Kununurra to be further developed.	Ongoing	<p>An investigation program of alternative sites was recommended by an Inter-Agency Working Group, and was subsequently developed by consultants appointed by LandCorp. The cost of this program was initially estimated to be in excess of \$1 million (Department of Water 2007).</p> <p>The existing 2003 and proposed 2012 protection reports recognise there are aspirations to relocate the water reserve, but advise an examination of the costs and benefits of all relocation options is required to best advise government of the benefits.</p> <p>The Department of Water will continue to maintain protection of the existing water reserve, given it is the sole water source for the town and risk from contamination.</p>
10	The reported decommissioned landfill should be verified and cleaned up if it exists so that the water quality of future bores in that area is not threatened. Possible impacts from the decommissioned landfill and the stormwater drain should be taken into consideration during development of a future wellfield in the eastern part of the reserve.	Completed	The area of the reported decommissioned landfill is not included in the water reserve boundary proposed in this review.

	<u>Description in 2003 plan</u>	<u>Status</u>	<u>Comment</u>
11	Existing boat launching facilities on Lake Kununurra within the water reserve should be reviewed (to look at opportunities to minimise potential impacts and expansion, or for relocation outside the Water Reserve) and vehicle access rationalised to restrict uncontrolled access to the Water Reserve area. This could include closure of unnecessary tracks. Development of any new boating facility on or adjacent to the proposed Kununurra Water Reserve is not supported due to the risk of contamination of Kununurra's drinking water. The litter issue on the foreshore and inland within the Water Reserve should be addressed.	Completed	Commercial boating facilities have been established downstream, outside the P1 area (see the SWEK's 2011 <i>Lake Kununurra Foreshore and Aquatic Use Plan</i> of 2011). With increasing commercial and recreational boating the expansion of this facility needs to be progressed.  The M1 channel has been fenced off.  Recreational activities should be guided by the Department of Water's 2012 <i>Recreation within public drinking water source areas on Crown land</i> (Operational policy series Report 13).
12	A full review of this protection plan should be undertaken after five years, or sooner if an alternative public drinking water source area (PDWSA) is established.	Completed	Undertaken through the preparation of this 2012 review document.

## 2.2 Consolidated recommendations

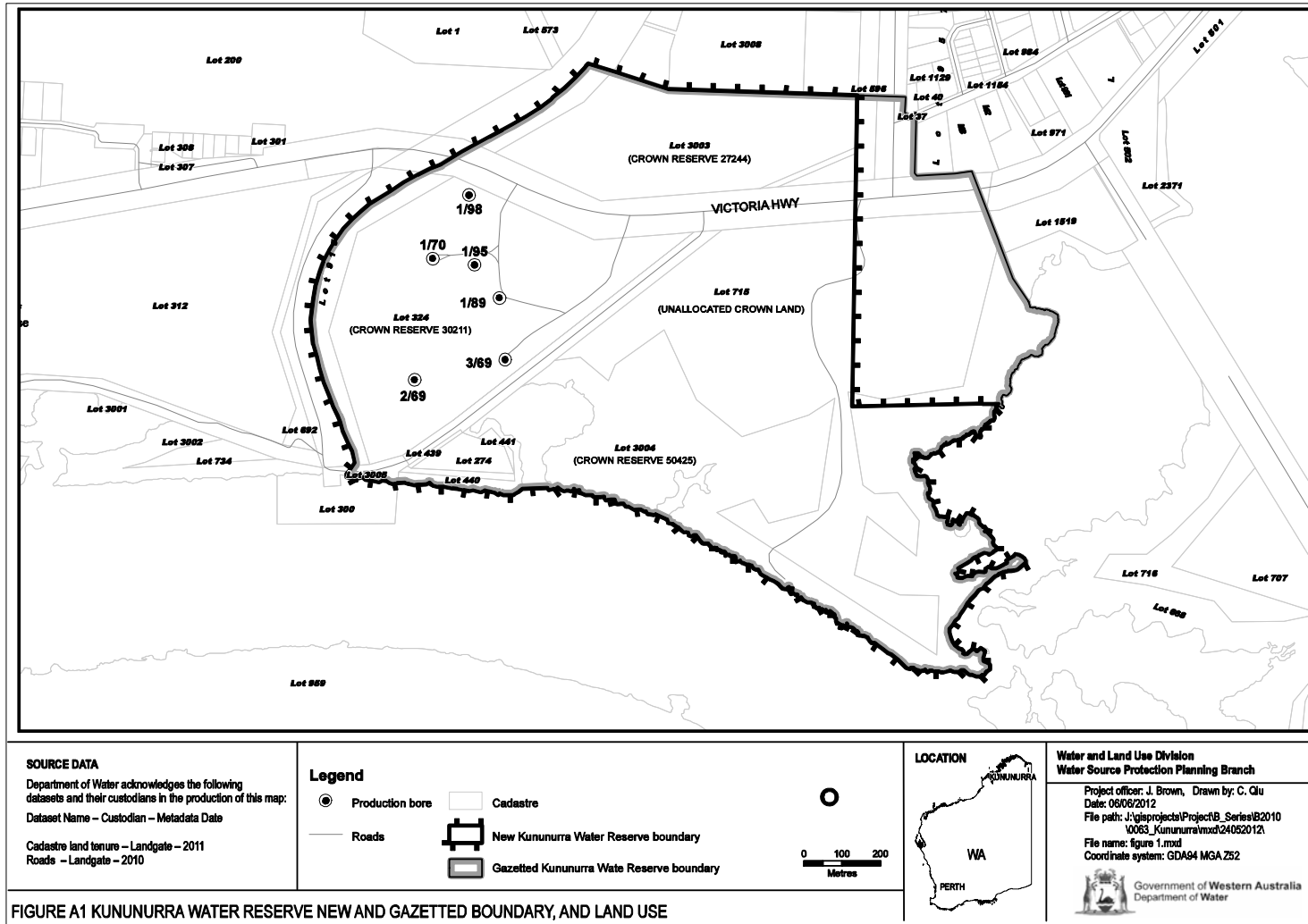
The following recommendations apply to the Kununurra Water Reserve. The bracketed stakeholders are those expected to have an interest in implementing the relevant recommendation.

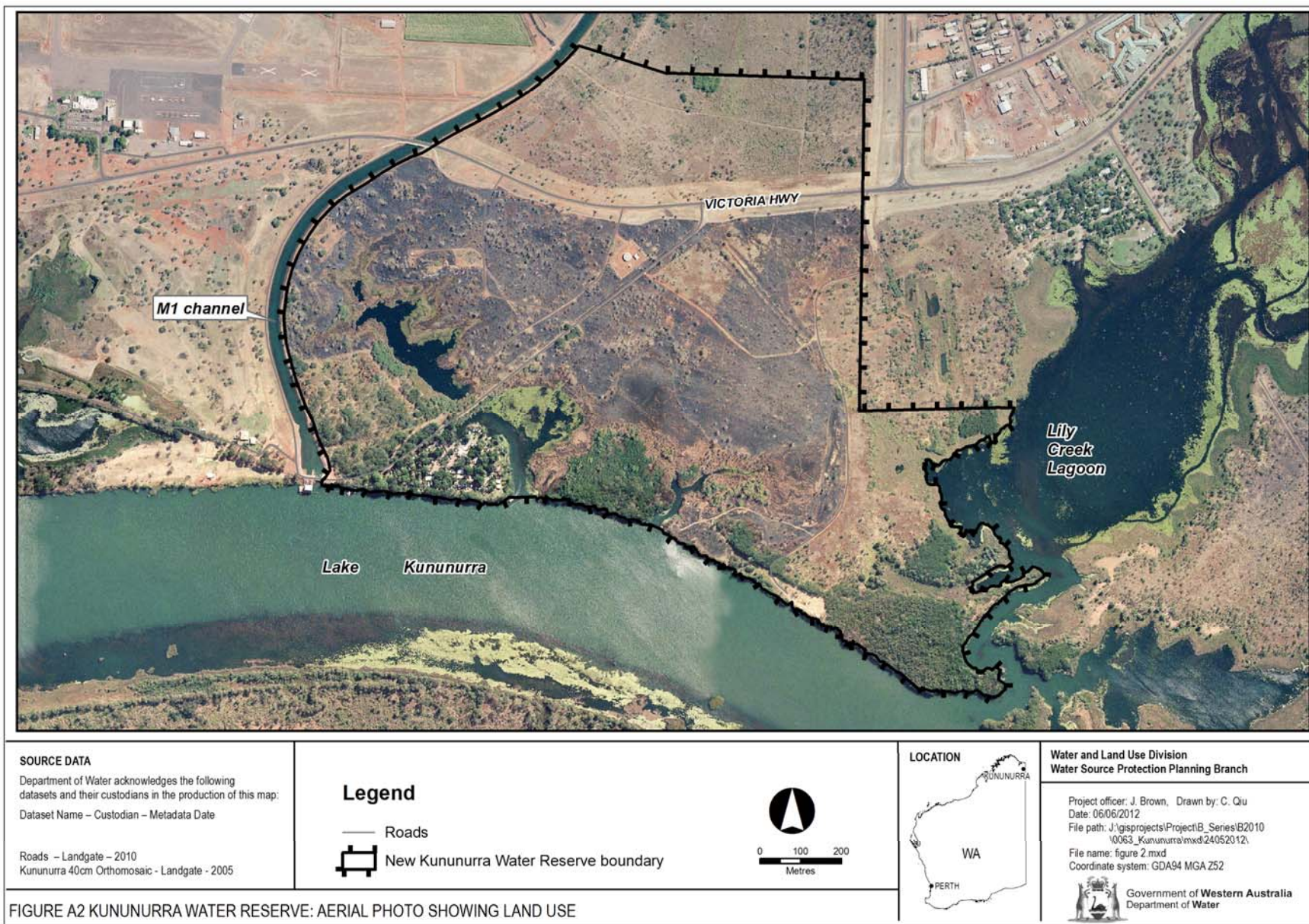
- 1 The modified boundary of the Kununurra Water Reserve should be proclaimed under the *Country Area Water Supply Act 1947*. (Department of Water)
- 2 The Shire of Wyndham East Kimberley town and local planning schemes should incorporate this plan and reflect the identified Kununurra Water Reserve boundary, priority 1 area and wellhead protection zones (see Figure A3) in accordance with *Statement of planning policy 2.7: Public drinking water source policy*. (Shire of Wyndham East Kimberley)
- 3 All development proposals within the Kununurra Water Reserve that are inconsistent with the Department of Water's water quality protection note: *Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations. (Department of Planning; Shire of Wyndham East Kimberley; proponents of proposals)

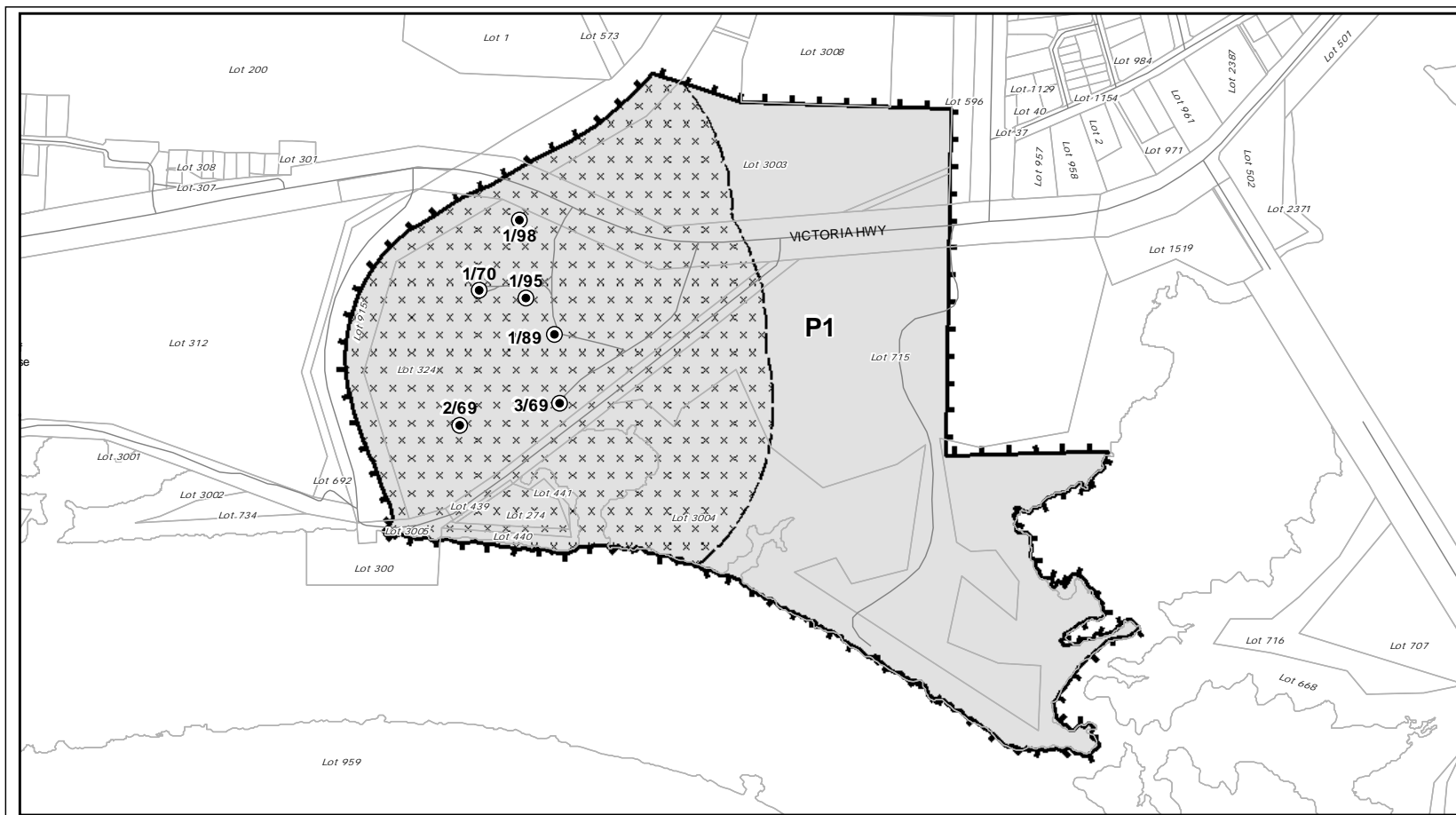
- 4 Surveillance and by-law enforcement for the Kununurra Water Reserve should be formally delegated to Water Corporation. (Department of Water; Water Corporation)
- 5 Incidents covered by WESTPLAN–HAZMAT in the Kununurra Water Reserve should be addressed by ensuring that:
  - the Shire of Wyndham East Kimberley’s LEMC is aware of the location and purpose of the Kununurra Water Reserve
  - the locality plan for the Kununurra Water Reserve is provided to the Fire and Rescue headquarters for the HAZMAT Emergency Advisory Team
  - the Water Corporation and the Department of Water provide an advisory role during incidents in the Kununurra Water Reserve
  - personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Kununurra Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.(Department of Water; Water Corporation; Shire of Wyndham East Kimberley)
- 6 The existing monitoring, surveillance and signage programs should be maintained to identify any incompatible land uses or potential threats within the Kununurra Water Reserve. Signage identifying the reserve should also signify the prohibition of illegal camping within the reserve, and include an emergency contact telephone number (Department of Water; Water Corporation)
- 7 It is recommended that the Department of Health’s *Use of herbicides in water catchment areas* (PSC 88) is used to guide herbicide use in the Kununurra Water Reserve. (Shire of Wyndham East Kimberley, Department of Health, Discovery Holiday Parks Lake Kununurra)
- 8 Best management practices, in accordance with Department of Water’s water quality protection notes, should be undertaken with respect to the management of potential contamination from gardening and landscaping, vehicles and vehicle maintenance, recreation and workshops etc. within the Discovery Holiday Parks Lake Kununurra. (Discovery Holiday Parks Lake Kununurra)
- 9 An implementation plan should be prepared for the recommended protection strategies detailed in Table 1 of this plan, with key stakeholders, and planned timeframes. (Department of Water; applicable stakeholders)
- 10 Review this plan after five years, or if an alternative location borefield is created. (Department of Water)

# Appendices

## Appendix A – Figures







**SOURCE DATA**  
 Department of Water acknowledges the following datasets and their custodians in the production of this map:  
 DatasetName - Custodian - Metadata Date  
 Cadastre land tenure - Landgate - 2011  
 Roads - Landgate - 2010

**Legend**

- Production bore
- New Kununurra Water Reserve boundary
- Roads
- Protection Area - P1
- Cadastre
- Wellhead protection zone

0 100 200  
 Metres



**Water and Land Use Division  
 Water Source Protection Planning Branch**

Project officer: J. Brown, Drawn by: C. Qiu  
 Date: 06/06/2012  
 File path: J:\gis\projects\Project\B\_Series\B2010\0063\_Kununurra\mxd\24052012  
 File name: figure 3.mxd  
 Coordinate system: GDA94 MGA Z52

**Government of Western Australia  
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FIGURE A3 KUNUNURRA WATER RESERVE NEW BOUNDARY, PRIORITY AREA AND WELLHEAD PROTECTION ZONES

## Appendix B – Water quality data

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

The Water Corporation has monitored the raw (source) water quality from Kununurra in accordance with the requirements of the Australian Drinking Water Guidelines, 2004 (ADWG) and interpretations agreed to with the Department of Health. This data shows the quality of water in the catchment. The raw water is regularly monitored 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 Kununurra 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. 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 July 2007 to June 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.

For more information on the quality of drinking water supplied to North West Region refer to the most recent Water Corporation drinking water quality annual report at <[watercorporation.com.au](http://watercorporation.com.au)> What we do > Water quality > Water quality publications > Most recent *Drinking water quality annual report*.

### Aesthetic

The aesthetic water quality analyses for raw water from Kununurra Borefield are summarised in the following table.

*Aesthetic detections for Kununurra Borefield*

Parameter	Units	ADWG aesthetic guideline value*	Kununurra Borefield Raw water sample point	
			Range	Median
Chloride	mg/L	250	17 - 23	21
True Colour	TCU	15	<1 - 1	<1
Hardness as CaCO <sub>3</sub>	mg/L	200	160 -160	160
Iron Unfiltered	mg/L	0.3	<0.003 – 0.008	<0.003
Sodium	mg/L	180	37 - 40	38
Total filterable solids by summation	mg/L	600	429 – 437	433.5
Turbidity	NTU	5	<0.1 – 0.1	<0.1
pH	N/A	8.5	7.37 – 7.84	7.58

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

## Health related

*Health-related chemicals*

Raw water from Kununurra Borefield 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 Kununurra Borefield*

Parameter	Units	ADWG health guideline value*	Kununurra Borefield Raw water sample point	
			Range	Median
Barium <sup>+</sup>	mg/L	0.7	0.15 – 0.15	0.15
Boron <sup>+</sup>	mg/L	4	0.5 – 0.5	0.5
Copper <sup>+</sup>	mg/L	2	<0.002 – 0.007	<0.002
Manganese Unfiltered	mg/L	0.5	<0.002 – 0.018	0.004
Molybdenum <sup>+</sup>	mg/L	0.05	0.0006 – 0.0008	0.0007
Nitrite plus nitrate as N	mg/L	11.29	<0.002 – 0.038	0.004
Radon - 222 <sup>+</sup>	Bq/L	100	1.74 – 1.74	1.74
Selenium <sup>+</sup>	mg/L	0.01	<0.003 – 0.003	<0.003
Sulphate	mg/L	500	1.5 -1.5	1.5
Uranium <sup>+</sup>	mg/L	0.02	0.002 – 0.003	0.0025



\* 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, 2004).

† The 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.

+ Parameter has been sampled two times or less in reporting period.

### *Microbiological Contaminants*

Microbiological testing of raw water samples from Kununurra Borefield Raw water sample point is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals.

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

During the review period, positive *Escherichia coli* counts were recorded in 3.4% of samples.

## Appendix C – Photographs



**Figure D1** *Kununurra Water Reserve as viewed from the north-west. The M1 channel visible in the foreground is next to the western boundary of the water reserve. Lily Creek Lagoon in the background forms part of the eastern boundary. The Kununurra Airport and golf course in the foreground are not within the water reserve boundary. (Photographer: Stephen Watson)*



**Figure D2** *Recreational facilities in Discovery Holiday Park Lake Kununurra (Photographer: Stephen Watson)*



*Figure D3 Aerial view towards the south-west corner of Kununurra Water Reserve. In the background: Kona Inlet from Lake Kununurra is visible, as well as the nearby Discovery Holiday Park Lake Kununurra. (Photographer: Stephen Watson)*

## List of shortened forms

<b>ADWG</b>	<i>Australian drinking water guidelines</i>
<b>ANZECC</b>	Australian and New Zealand Environment Conservation Council
<b>ARMCANZ</b>	Agriculture and Resource Management Council of Australia and New Zealand
<b>B<math>\mu</math>/L</b>	becquerel per litre
<b>DEC</b>	Department of Environment and Conservation
<b>HAZMAT</b>	hazardous materials
<b>kL</b>	Kilolitre
<b>mg/L</b>	milligram per litre
<b>NHMRC</b>	National Health and Medical Research Council
<b>NRMMC</b>	Natural Resource Management Ministerial Council
<b>NTU</b>	nephelometric turbidity units
<b>P1</b>	priority 1
<b>P2</b>	priority 2
<b>P3</b>	priority 2
<b>PSC 88</b>	public sector circular number 88
<b>PDWSA</b>	public drinking water source area
<b>SWEK</b>	Shire of Wyndham-East Kimberley
<b>TPS</b>	Town Planning Scheme
<b>TFSS</b>	total filterable solids by summation
<b>WAHMEMS</b>	Western Australian hazardous materials emergency management scheme
<b>WESTPLAN-HAZMAT</b>	Western Australian plan for hazardous materials
<b>WHPZ</b>	wellhead protection zone
<b>WQPN</b>	water quality protection note

# Glossary

<b>Abstraction</b>	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
<b>Aesthetic guideline value</b>	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).
<b>Allocation</b>	The quantity of water that a licensee is permitted to abstract is their allocation, usually specified in kilolitres per annum (kL/a).
<b>Aquifer</b>	An aquifer is a geological formation or group or formations able to receive, store and transmit significant quantities of water.
<b>Australian drinking water guidelines</b>	The <i>National water quality management strategy: Australian drinking water guidelines 6, 2011</i> (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).
<b>Becquerel</b>	The becquerel is the International System of Units' unit of radioactivity.
<b>Bore</b>	A bore is a narrow, lined hold drilled into the ground to monitor or draw groundwater (also called a well).
<b>Bore field</b>	A group of bores to monitor or withdraw groundwater is referred to as a bore field (also see <i>wellfield</i> ).
<b>Catchment</b>	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
<b>Department of Environment</b>	Department name no longer in use - see next entry.
<b>Department of Environment and Conservation</b>	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.
<b>Drinking water source protection plan</b>	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.
<b>Health guideline value</b>	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).

<b>Hydrocarbons</b>	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.
<b>Hydrogeology</b>	The study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
<b>mg/L</b>	A milligram per litre (0.001 grams per litre) is a measurement of a total dissolved solid in a solution.
<b>Nephelometric turbidity units</b>	Nephelometric turbidity units are a measure of turbidity in water.
<b>Nutrients</b>	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
<b>Pathogen</b>	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as <i>Escherichia coli</i> ), protozoa (such as <i>Cryptosporidium</i> and <i>Giardia</i> ) and viruses.
<b>Pesticides</b>	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
<b>pH</b>	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.
<b>Pollution</b>	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.
<b>Public drinking water source area</b>	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> and the <i>Country Areas Water Supply Act 1947</i> .
<b>Public sector circular number 88</b>	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.
<b>Recharge</b>	Recharge is the action of water infiltrating through the soil/ground to replenish an aquifer.
<b>Recharge area</b>	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.

<b>Stormwater</b>	Rainwater that has run off the ground surface, roads, paved areas etc., and is usually carried away by drains.
<b>Total filterable solids by summation</b>	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 <sub>4</sub> equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO <sub>2</sub> (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.
<b>Treatment</b>	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
<b>Turbidity</b>	The cloudiness or haziness of water caused by the presence of fine suspended matter.
<b>Unconfined aquifer</b>	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.
<b>Wastewater</b>	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
<b>Water quality</b>	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.
<b>Water reserve</b>	A water reserve is an area proclaimed under the <i>Country Areas Water Supply Act 1947</i> or the <i>Metropolitan Water Supply, Sewerage and Drainage Act 1909</i> for the purposes of protecting a drinking water supply.
<b>Watertable</b>	The upper saturated level of the unconfined groundwater is referred to as the watertable.
<b>Wellfield</b>	A wellfield is a group of bores located in the same area used to monitor or withdraw groundwater.
<b>Wellhead</b>	The top of a well (or bore) used to draw groundwater is referred to as a wellhead.
<b>Wellhead</b>	A wellhead protection zone is usually declared around wellheads in public drinking water source areas to protect the groundwater from

**protection zone** 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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