



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

Rockingham—Stakehill groundwater management plan

Looking after all our water needs

Department of Water

Water resource allocation planning series

Report no. 23

November 2008

Department of Water

168 St Georges Terrace

Perth Western Australia 6000

Telephone +61 8 6364 7600

Facsimile +61 8 6364 7601

www.water.wa.gov.au

© Government of Western Australia 2008

November 2008

This work is copyright. You may download, display, print and reproduce this material in unaltered form only (retaining this notice) for your personal, non-commercial use or use within your organisation. Apart from any use as permitted under the *Copyright Act 1968*, all other rights are reserved. Requests and inquiries concerning reproduction and rights should be addressed to the Department of Water.

ISSN 1327-8428 (print)

ISSN 1834-2620 (online)

ISBN 978-1-921549-01-4 (print)

ISBN 978-1-921549-02-1 (online)

For more information about this report, contact:

Kwinana Peel Region

Department of Water

PO Box 454

Kwinana WA 6966

Telephone +61 8 9411 1788

Facsimile +61 8 9419 5897

Contents

Summary	vi
1 Introduction.....	1
1.1 Purpose.....	1
1.2 Objectives	1
1.3 The plan area	1
1.3.1 Location	1
1.3.2 Proclamation of the plan area	3
1.3.3 The plan boundary	3
1.4 Groundwater resource overview	6
1.5 The plan’s socio-economic environment	6
1.6 Water allocation in Western Australia	8
1.6.1 Principles	8
1.7 Legislative and policy framework	10
1.7.1 The role of the Department of Water	10
1.7.2 <i>Rights in Water and Irrigation Act 1914</i>	10
1.7.3 Water reform.....	10
2 Environmental considerations	11
2.1 Sustainable use of water.....	11
2.2 Environmental water provisions	11
2.3 Ecological considerations.....	12
2.3.1 Groundwater-dependent ecosystems	12
2.3.2 Future work to set ecological water requirements.....	18
2.4 Social values.....	18
2.5 Aboriginal cultural values	20
2.5.1 Native Title.....	20
2.6 Water quality	21
2.6.1 Acid sulfate soils	21
2.6.2 Seawater interface.....	22
3 Groundwater use.....	23
3.1 Existing groundwater use.....	23
3.2 Subarea water use	26
3.3 Public drinking-water source areas	28
3.4 Future use	28
3.4.1 Potential water supplies	28
3.4.2 Future demand	28
4 Status of the groundwater resources.....	30
4.1 Monitoring the resource	30
4.2 Monitoring groundwater levels	32
4.2.1 Monitoring program.....	32
4.2.2 Superficial Aquifer.....	32
4.2.3 Rockingham Sand Aquifer	35
4.2.4 Leederville Aquifer	36
4.2.5 Yarragadee Aquifer.....	37
4.3 Monitoring groundwater quality	38
4.3.1 Monitoring program.....	38
4.3.2 Superficial Aquifer.....	38
4.3.3 Rockingham Sand Aquifer	39

4.3.4	Leederville Aquifer	39
4.3.5	Yarragadee Aquifer	39
4.4	Monitoring groundwater use	40
4.4.1	Licensed allocation	40
4.4.2	Authorised unlicensed use	41
4.5	Future monitoring	42
4.6	Groundwater modelling	42
5	Groundwater allocation	43
5.1	Water allocation	43
5.2	Groundwater allocation in the Rockingham—Stakehill area	43
5.2.1	Department position	43
5.2.2	Approach to setting allocation limits	43
5.2.3	Groundwater allocation in the unconfined aquifers	44
5.2.4	Groundwater allocation in the confined aquifers	45
5.3	Impacts of climate variability on water allocation	46
6	Allocation principles and licensing considerations	47
6.1	Allocation approach	47
6.2	Allocation policies	48
6.2.1	Water restrictions for authorised unlicensed use	56
7	Implementation and review	58
7.1	Implementing this plan	58
7.2	Evaluating this plan	59
7.3	Future planning in this area	59
7.4	Reviewing this plan	59
	Appendices	61
	Shortened forms	89
	Glossary	90
	Bibliography	93
	Contributors	97
	Appendices	
	Appendix A — Subarea reference sheets	62
	Appendix B — Hydrogeological cross-section	78
	Appendix C — Wetlands	79
	Appendix D — Processing a licence application	81
	Appendix E — Other plans and legislation to be considered	86

Figures

Figure 1	Location of the plan area	2
Figure 2	Plan boundary and proclaimed areas	4
Figure 3	Groundwater subareas	5
Figure 4	Suburbs and land-use zoning	7
Figure 5	Location of groundwater-dependent ecosystems	14
Figure 6	Historic wetland levels	15
Figure 7	Comparison of wetland levels.....	16
Figure 8	A comparison of lake and bore levels in the Cooloongup subarea.....	17
Figure 9	Location of social and cultural sites	19
Figure 10	Spatial distribution of licensed entitlements from the Superficial Aquifer	25
Figure 11	Warnbro groundwater use	26
Figure 12	Cooloongup groundwater use.....	26
Figure 13	Tamworth Swamp groundwater use	26
Figure 14	Maramanup groundwater use.....	27
Figure 15	Outridge groundwater use	27
Figure 16	Churcher groundwater use	27
Figure 17	Karnup groundwater use	28
Figure 18	Department of Water groundwater monitoring bores.....	31
Figure 19	Superficial Aquifer water levels.....	33
Figure 20	Comparison of Superficial Aquifer water levels and rainfall.....	34
Figure 21	Comparison of groundwater levels in the Maramanup subarea.....	34
Figure 22	Rockingham Sand Aquifer groundwater levels	35
Figure 23	Comparison of groundwater levels in the Churcher subarea	36
Figure 24	Leederville Aquifer groundwater levels	37
Figure 25	Yarragadee Aquifer groundwater levels.....	38
Figure 26	Leederville Aquifer monitoring bore SH1 salinity	39
Figure 27	A comparison of subarea licensed entitlements in the Superficial Aquifer, 1995–2006.....	41
Figure 28	Garden-bore suitability for the plan area.....	57

Tables

Table 1	Wetland water-level behaviour	13
Table 2	Aboriginal sites relating to wetlands in the plan area.....	20
Table 3	Distribution of licensed entitlements between aquifers	23
Table 4	Licensed entitlements by use category.....	24
Table 5	Groundwater allocation in the plan area (kL/yr)	45
Table 6	Licensing policies for the taking and use of groundwater in the Rockingham–Stakehill area.....	48
Table 7	Recommended watering day roster in the plan area	55
Table 8	Implementation actions, timeframes and deliverables	58

Summary

The Department of Water manages and regulates Western Australia's water resources. The department has produced this management plan for the groundwater resources of the Rockingham and Stakehill groundwater subareas (the plan area) to allocate water sustainably for current and future users and to protect groundwater-dependent ecosystems.

Groundwater is an important source of water for private water supplies; however, water is limited. Regional water levels are declining in all aquifers, indicating that private abstraction in many areas has exceeded the sustainable level of allocation. The plan area has a number of significant wetlands, some with national and international protection status. Many of the wetlands are groundwater-dependent, and groundwater abstraction may adversely affect these sensitive environments.

The department has reviewed and set allocation limits for groundwater resources in the plan area (see Summary table, page vii). At present, water is available for allocation in only two subareas of the unconfined aquifers (Superficial and Rockingham Sand). The department will not issue any new entitlements for commercial activities in a subarea where the allocation limit has been reached.

This plan guides groundwater licence assessments and allocations within the plan area. The high level of allocation means that careful management is required to ensure that the quality of and accessibility to groundwater is not compromised. This plan describes an impact management approach to assess new licence applications, which will make best use of the water, and protect existing users and their access to water. New licences will only be approved if there is no unacceptable impact on existing users or the environment.

An aquifer's allocation limit may change if updated information about the sustainable yield becomes available; for example, through the new Perth regional aquifer modelling system (PRAMS). Monitoring of water levels and water-quality trends over time enables adaptive management of the resource, which is also used to review the allocation limit of an aquifer. It is unlikely additional water will become available in the plan area.

The department will, however, support individuals who wish to undertake, at their own expense, hydrogeological investigations to determine if additional groundwater can be taken sustainably from any of the fully allocated aquifers. The department will require investigations of this nature to demonstrate, through flow modelling and ongoing monitoring, that any impacts on social, cultural and ecological values and existing users are acceptable.

The department will encourage water licensees to be more efficient water users and implement water efficiency programs to make the best use of the available resource. The department supports water trading as a market-based opportunity for additional development in fully allocated groundwater systems.

Summary table **Groundwater allocation in the plan area (kL/yr)**

Aquifer	Subarea	Allocation limit ^a	Licensed entitlements ^b	Unlicensed use ^c	Groundwater availability
Superficial	Maramanup	1 956 000	1 289 880	470 000	Limited availability
	Tamworth Swamp	3 485 000	3 163 845	250 000	Limited availability
	Outridge	2 456 000	2 112 770	210 000	Limited availability
Superficial–Rockingham Sand	Churcher West	1 849 000	1 244 700	343 000	Limited availability
	Churcher East	3 672 000	3 820 983	147 000	Fully allocated
	Karnup West	1 200 000	104 115	368 000	Water available
	Karnup East	1 636 000	1 749 245	92 000	Fully allocated
	Cooloongup	272 000	171 900	0	Limited availability
Leederville	Warnbro	7 800 000	1 344 998	830 000	Water available
	Rockingham–Stakehill confined	820 000	1 014 839	0	Fully allocated
Yarragadee	Rockingham–Stakehill confined	0	0	0	No water available
Total		24 874 000	16 021 625	2 710 000	

a The allocation limit is the annual volume of water set aside for licensed and unlicensed use.

b A licensed entitlement is the annual volume of water a licensee is allowed to abstract from a specific aquifer. The licensed entitlement information has been obtained from the department's Water Resource Licensing database (4 July 2008).

c Refers to authorised unlicensed use. Includes garden bores and stock and domestic use.

1 Introduction

1.1 Purpose

The Department of Water has developed the *Rockingham–Stakehill groundwater management plan* (the plan) to guide the management of groundwater resources to achieve:

- sustainable water allocation for current and future groundwater users
- protection of groundwater-dependent ecosystems.

The plan provides the objectives, policies, principles and strategies that will be used to manage the groundwater resources of plan area (see Figure 1, page 2).

The plan area is defined by the plan boundary (see Figure 2, page 4), which includes the groundwater resources of the Rockingham groundwater area and the majority of the Stakehill groundwater subareas (see Figure 3, page 5). For the purpose of this plan, the Rockingham and Stakehill groundwater subareas are referred to as the Rockingham–Stakehill area or the plan area, unless otherwise specified.

1.2 Objectives

The objectives of this plan are to:

- 1 ensure that the groundwater resources are allocated equitably and used sustainably in the long term
- 2 set the rules and policies that will apply in the assessment of licence applications and water resource development proposals, and the issue of groundwater resource entitlements
- 3 set the monitoring requirements for the groundwater resource and its dependent ecosystems.

1.3 The plan area

1.3.1 Location

The plan area is located 30 kilometres south of Perth within the City of Rockingham’s municipal boundary. It covers about 218 square kilometres of the Swan coastal plain and is bounded by the Serpentine River and the Peel main drain to the east and the ocean to the west. In relation to groundwater areas, it is bounded by the Cockburn groundwater area to the north, Serpentine groundwater area to the east, and the South West Coastal and Murray groundwater areas to the south (see Figure 2, page 4).

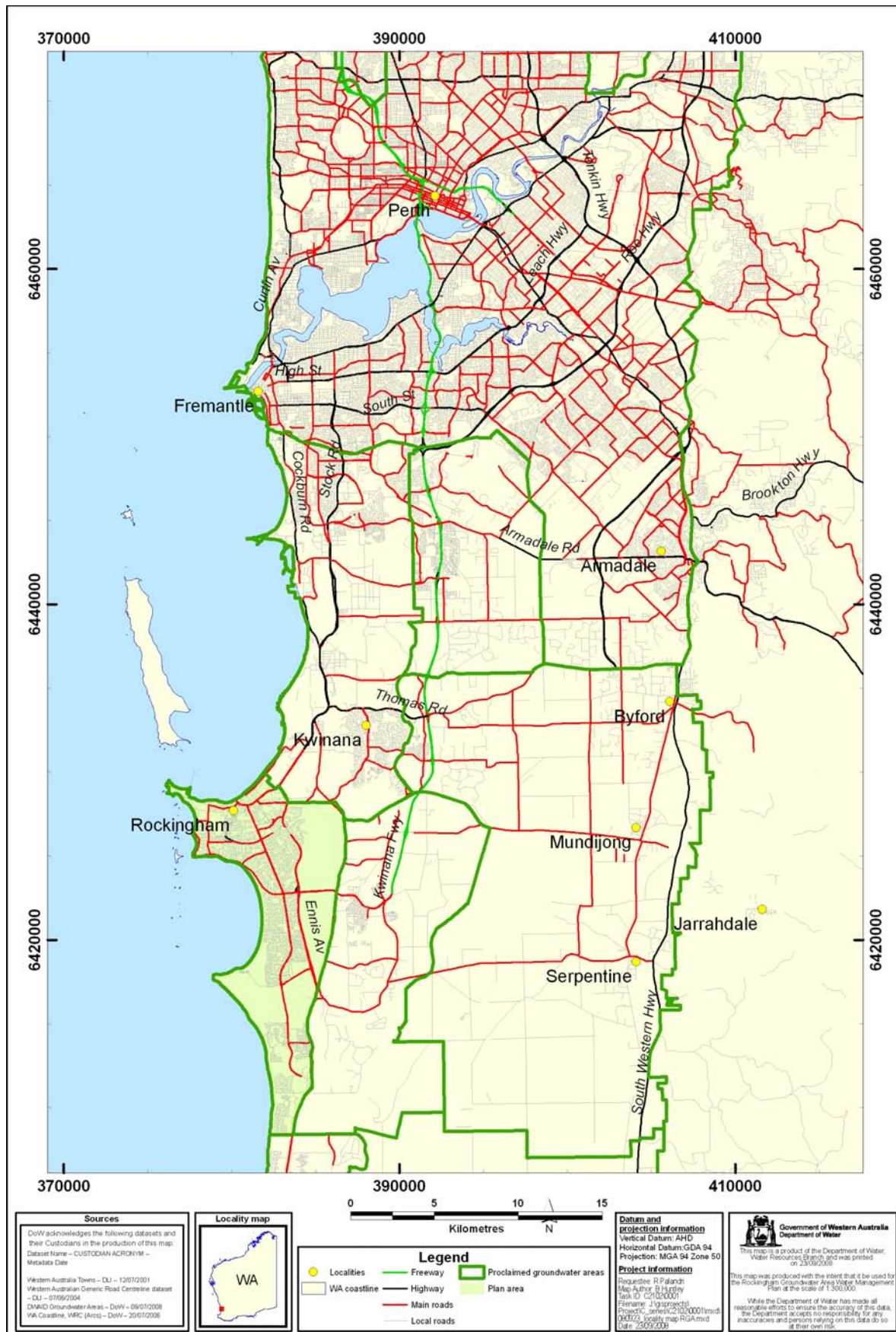


Figure 1 Location of the plan area

1.3.2 Proclamation of the plan area

The Peel groundwater area was proclaimed on 3 May 1985 under the *Rights in Water and Irrigation Act 1914* (the Act). However, this area was much larger and had more varied resources and water use than other groundwater areas. On 30 April 1987, the Water Authority recommended the Peel groundwater area be divided to allow detailed management plans to be adopted in areas where groundwater systems and use were similar (Water Authority of WA 1994). This resulted in the proclamation of the Rockingham and Stakehill groundwater areas on 29 June 1988 under the provisions of the Act. The proclamation authorised the licensing and management of groundwater abstraction to protect the resource for all users.

Groundwater management plans were prepared in 1988 (Cox 1988), 1997 (WRC 1997) and 2000 (JDA 2000, Rockwater 2000), but they were not finalised. In 1995 the Stakehill Groundwater Advisory Committee recommended the Stakehill and Rockingham groundwater areas be combined into one groundwater area, which was subsequently endorsed by the Water Resources Allocation Committee of the Water and Rivers Commission.

This plan has been developed to provide allocation, licensing and policy information for the Rockingham–Stakehill area to provide consistency in decision-making and management. The boundaries of the proclaimed Rockingham, Stakehill and Serpentine groundwater areas will be amended to follow the plan boundary when a statutory water management plan (allocation) is developed for these areas following enactment of the water reform legislation (see Section 1.7.3, page 10).

1.3.3 The plan boundary

All of the existing proclaimed Rockingham groundwater area and the majority of the Stakehill groundwater area sit within the plan area's boundary. The exception is the Keysbrook subarea east of the Serpentine River (see Figure 2, page 4). The plan boundary follows the Karnup Drain and Serpentine River (Thomson 2001), and moves the Keysbrook subarea – formerly the East Karnup subarea (Water Authority of WA 1994) – to become part of the management of the Serpentine groundwater area.

The plan area has been divided into seven subareas to better manage the groundwater resources. They are the Warnbro, Cooloongup, Tamworth Swamp, Maramanup, Outridge, Churcher and Karnup groundwater management subareas (see Figure 3, page 5). Churcher and Karnup have been further split along the boundary of the proclaimed Rockingham and Stakehill groundwater areas for administrative purposes, so that subareas do not cross proclaimed groundwater area boundaries. These subareas have been created to reflect the hydrogeological features and consumptive uses of the water resources. Information about each subarea is provided in Appendix A (page 62).

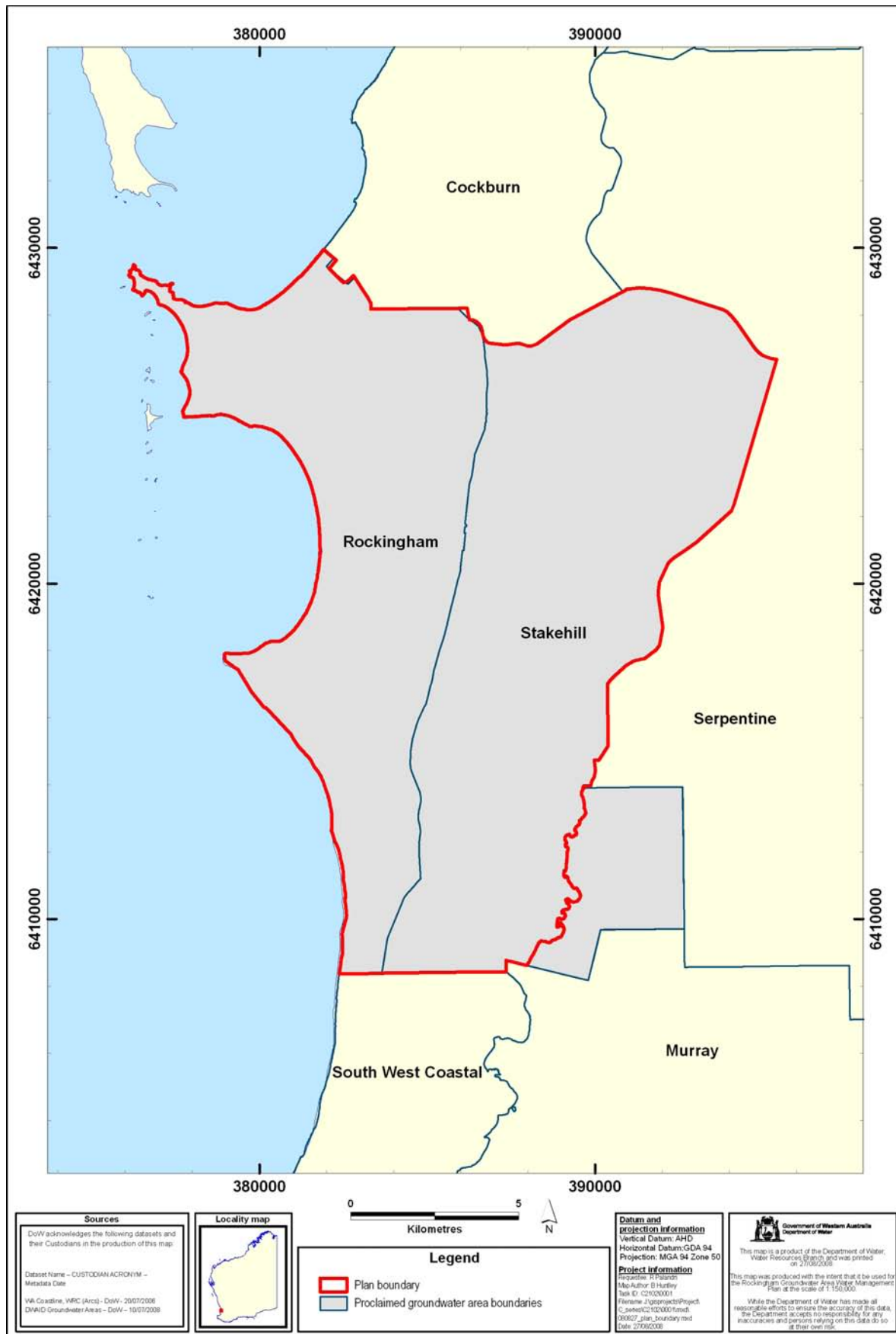


Figure 2 Plan boundary and proclaimed areas

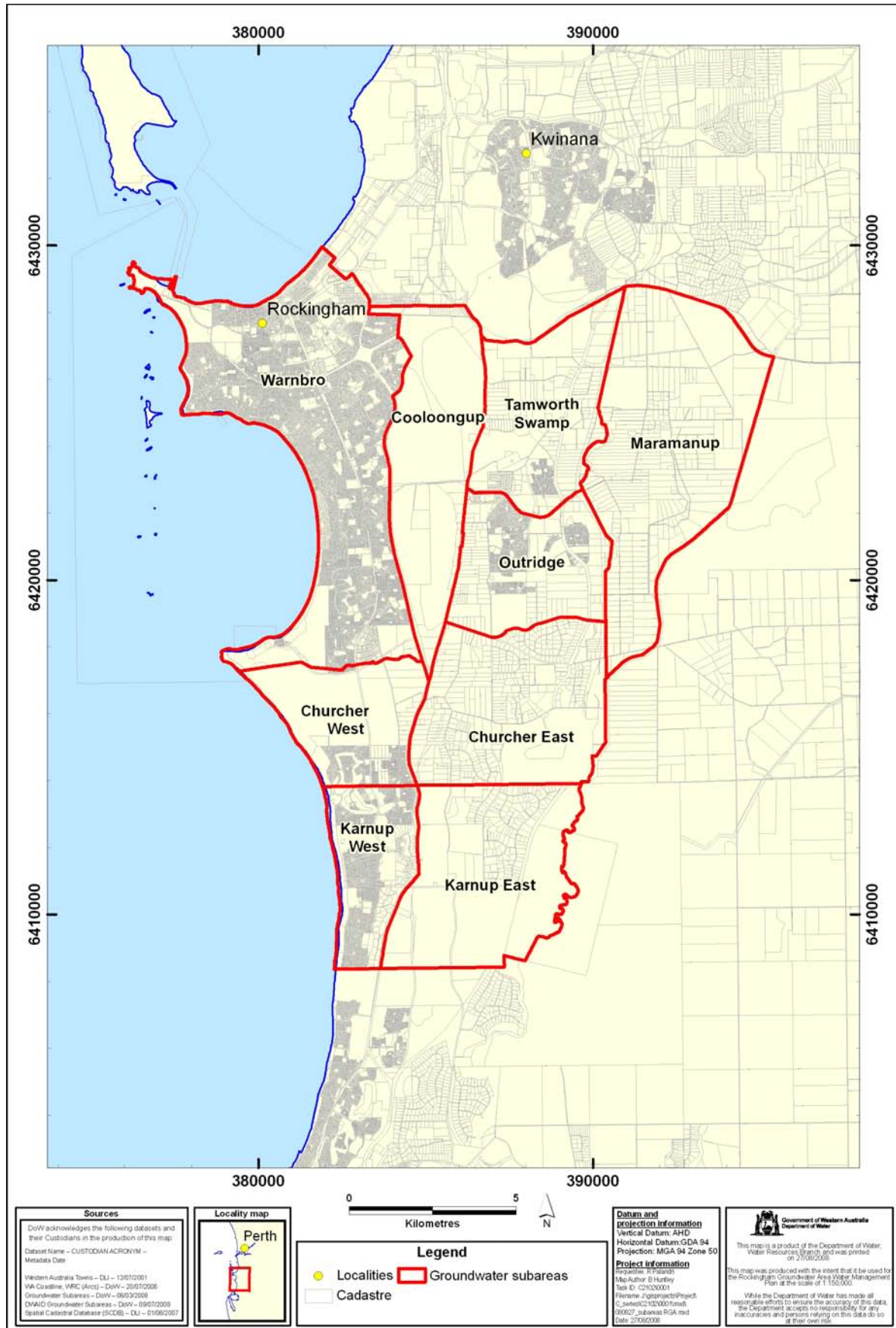


Figure 3 Groundwater subareas

1.4 Groundwater resource overview

The groundwater resources of the Rockingham–Stakehill area consist of unconfined, semi-confined and confined aquifers that exist as separate layered systems. The aquifers are, in order of increasing depth, the unconfined Superficial and Rockingham Sand, the Leederville (semi-confined to confined) and the Yarragadee (confined) aquifers. The Yarragadee Aquifer includes the Yarragadee Formation in the north east of the Baldivis subarea, and the Gage Sandstone and Cattamarra Coal Measures elsewhere in the Rockingham–Stakehill area. For more information on the hydrogeology of the Rockingham–Stakehill area see Appendix A (page 62) and Appendix B (page 78), Lindsay 2004, and Davidson and Yu 2006.

Groundwater abstraction for private use in the Rockingham–Stakehill area draws from both the Superficial and Rockingham Sand unconfined aquifers and the semi-confined Leederville Aquifer, with the majority of groundwater abstraction from the Superficial Aquifer.

Development within the Rockingham–Stakehill area is dependent on groundwater for water supply. However, there is only limited potential for further use of groundwater resources in the area, as allocation of groundwater supplies – particularly from the Leederville and Yarragadee aquifers – has reached the sustainable yield.

1.5 The plan's socio-economic environment

Rockingham is the largest city in Western Australia outside of Perth with a population of 97 000 (City of Rockingham 2007). Rockingham has experienced strong population growth, doubling in the past 14 years (and trebling in the past 20 years). The population is expected to increase by 60 per cent in the next 15 years. Much of the growth is due to urban development along the coastal corridor southwards from the Rockingham city centre.

Land within the Rockingham–Stakehill area is zoned according to the *City of Rockingham Town Planning Scheme No. 2* (DPI 2005) (see Figure 4, page 7). Land west of Mandurah Road is predominantly urban and land east of Mandurah Road is predominantly rural, with areas zoned urban in the Tamworth Swamp and Outridge subareas. Areas zoned parks and recreation include the Cooloongup subarea and other pockets generally containing conservation wetlands. Industries in the Rockingham–Stakehill area include horticulture, floriculture, animal production and extractive industries (sand and lime).

The Department of Water recognises that land-use change in the Rockingham–Stakehill area will impact on water availability and use (see Section 3.4, page 28). Water will be a limiting factor for developments requiring water in the fully allocated parts of the Rockingham–Stakehill area, unless trading of water licences is considered (see Section 6.2, page 48). A list of the land-use planning documents that affect land-use zoning and water management are listed in Appendix E (page 86).

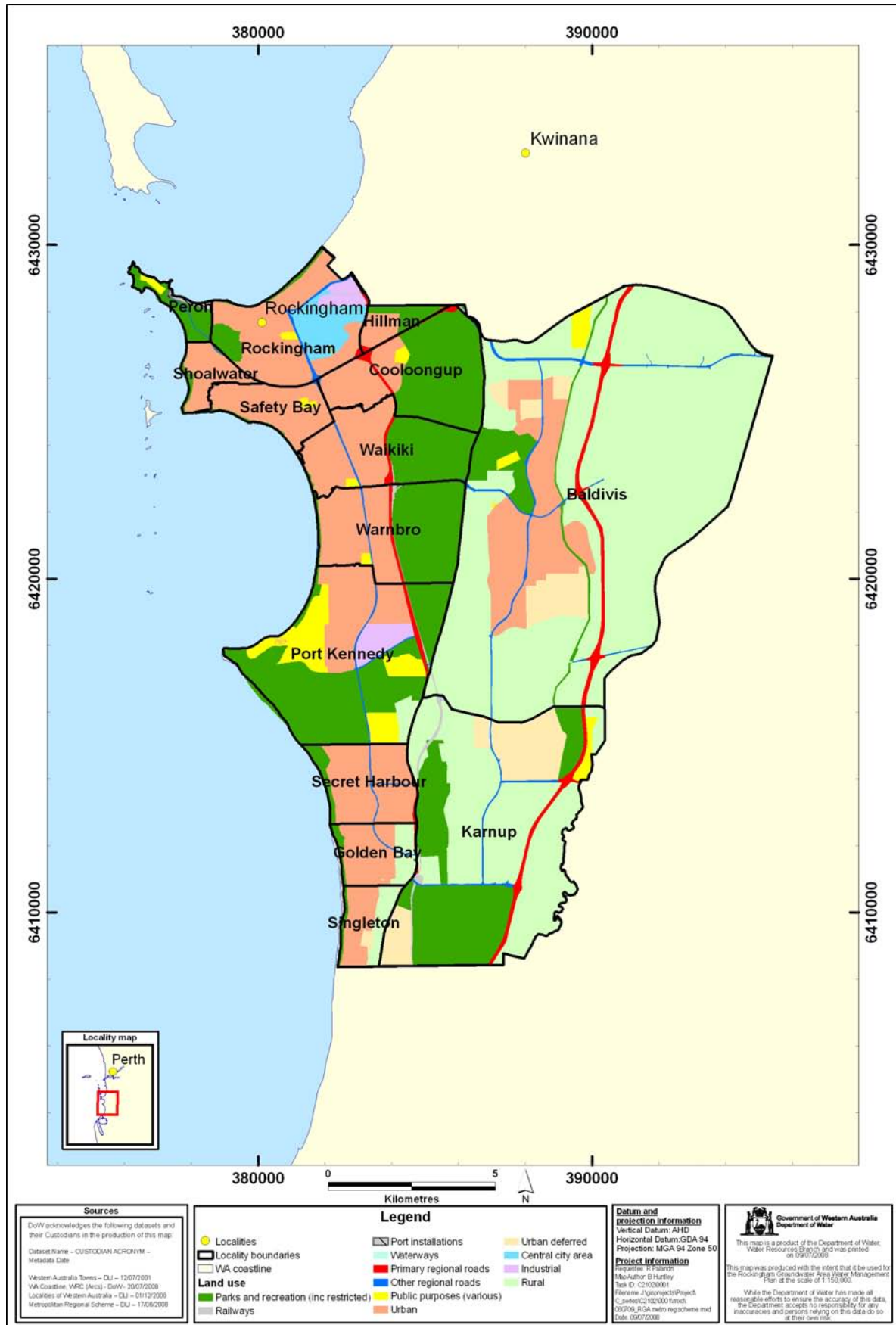


Figure 4 Suburbs and land-use zoning

1.6 Water allocation in Western Australia

The Department of Water is responsible for the allocation and management of water resources in Western Australia. It manages those water resources with input from other government agencies, interested and affected parties and the community. The primary objective of allocation management is to ensure the state's water resources are appropriately managed and used to support sustainable development and conservation of the environment for the long-term benefit of the community. This is achieved through a licensing and water allocation process that ensures water is used efficiently and within sustainable limits.

As part of the water allocation process, the department determines how much water should be set aside for the environment and how the water available for consumptive use should be shared. Water management plans are prepared to formalise the water management objectives in an area, and they range from regional plans that cover a large area to local plans that cover individual surface water or groundwater management areas. Plans identify the water resources and water regimes to be protected and define the water allocation policy for the area in question.

1.6.1 Principles

The water resource management principles adopted in this plan, to be taken into account when considering licensing of groundwater abstraction in the area, are:

- 1 Water use must be sustainable. Allocation decisions must not significantly decrease the rights of future generations to benefit from water resources and they must not lead to unacceptable environmental damage.
- 2 Water use must be productive. When water is diverted from the environment, it should be used productively for the benefit of all Western Australians.
- 3 Water use must be efficient to avoid wastage. Developments planning to use large quantities of groundwater must demonstrate that water conservation has been considered, with appropriate investment in and implementation of water efficiency measures.
- 4 Water use must be consistent with the regional planning and land-use objectives of the region and generate outputs that contribute to environmentally sustainable development.
- 5 The water allocation process will consider impacts on ecological, social, cultural and economic values of the water resource, before it is allocated to consumptive use.
- 6 The allocation of water should be fair and equitable to allow both short-term and long-term planning objectives to be met.
- 7 Natural ecological processes and the biodiversity of water-dependent ecosystems are to be maintained at an acceptable level of risk.

- 8 Where significant effects are likely, individual licensees are responsible for determining potential groundwater pumping impacts on identified local groundwater-dependent ecosystems (GDE) and existing users.
- 9 Community education on groundwater matters and involvement in water planning should continue, as this is essential for sustaining a strong and effective groundwater management effort.

The following national principles (WRC 2000b) have been applied in developing this plan:

- 1 The precautionary principle:

Where there are threats of serious or irreversible environmental damage, the lack of full scientific knowledge and certainty should not be used as a reason for postponing measures to prevent environmental damage.

- 2 Inter-generational equity:

Decision-making processes should effectively integrate both short- and long-term ecological, social, cultural and economic equity considerations.

- 3 Integrated management:

The interrelationships between surface water, groundwater and land use should be managed in an integrated way. In this context, impacts of groundwater abstraction on dependent ecosystems that include surface water regimes and their ecological, social, cultural and economic dependencies need to be managed.

Water management should be integrated with the relevant policies of other government agencies to foster a holistic management approach.

- 4 Adaptive management:

Management tools and policies must be able to respond promptly to increasing knowledge of resource dynamics and their interactions with other ecosystems.

Management tools must also be able to take into account changing community attitudes and perceptions of sustainability.

Adaptive management relates to management of water resources in a cycle of assessment, planning, implementation, monitoring, review and responding to change, including provision for the modification of the management approach to accommodate results of reviews.

1.7 Legislative and policy framework

1.7.1 The role of the Department of Water

The Department of Water implements water allocation decisions and regulates the use of water through the powers assigned to it under the Rights in Water and Irrigation Act 1914 and the Rights in Water and Irrigation Regulations 2000.

1.7.2 *Rights in Water and Irrigation Act 1914*

The *Rights in Water and Irrigation Act 1914* vests the 'right to the use and flow, and to the control, of the water at any time in any watercourse, wetland or underground water source' in the Crown.

The Act requires compulsory licensing of all artesian wells throughout Western Australia. In addition, non-artesian wells within specific areas proclaimed under the Act as groundwater areas require licensing. These areas are proclaimed to ensure equitable allocation between competing users including the environment, and to protect existing and future users in areas of major public, agricultural, industrial or mineral developments. Water taken from non-artesian aquifers for stock and domestic purposes is exempt from licensing, if considered appropriate.

1.7.3 Water reform

Water reform has progressed since the Council of Australian Governments (COAG) 1994 Water Reform Agreement. Changes to water management have been instigated through the Irrigation review final report (Government of Western Australia 2005) and the Government response to a blueprint for water reform in Western Australia (Government of Western Australia 2007).

Western Australia signed the National Water Initiative (NWI) agreement in April 2006, about two years after it was released. The overall objective of the NWI is to provide a 'nationally compatible, market, regulatory and planning based system of managing water resources in rural and urban settings that optimise economic, social and environmental outcomes'. The *Government response* clearly indicates how reforms will be implemented, consistent with the NWI. Western Australia is currently undergoing legislative reform with a new Water Resource Management Bill being drafted, which will replace the *Rights in Water and Irrigation Act 1914*.

2 Environmental considerations

2.1 Sustainable use of water

The long-term management objective for groundwater resources is to achieve sustainable use of those resources.

Any amount of groundwater abstraction will cause alterations to the existing flow regime, which will impact on the groundwater resource to some degree. The extent of this impact will vary and its acceptability will be dependent on the ecological, social and cultural values of the resource. Abstraction that causes continuous long-term declines in groundwater levels is not acceptable and could ultimately have effects that cannot be reversed, such as seawater intrusion, drying of wetlands, exposure of potentially acid-generating soils (acid sulfate soils) and degradation of soil and water quality. They can occur slowly over time – sometimes many years – and these impacts must be recognised and managed.

The sustainable yield is the level of water extraction from a particular system that, if exceeded, would compromise the environmental assets or ecosystem functions of the resource. Sustainable yields for groundwater are determined by assessing information about the water resource, such as water-level trends and water quality. Scientific models may be used to calculate potential yields.

The sustainable yield of an aquifer system may change with the availability of new information. Monitoring of water levels, water-quality trends and ecological monitoring over time enables adaptive management of the resource, which is used to refine how much water is available for allocation.

2.2 Environmental water provisions

The Department of Water is responsible for managing groundwater resources on a sustainable basis. This means that groundwater abstraction must be managed so that impacts on ecosystems that rely on the groundwater are acceptable. The *Statewide policy no. 5 – Environmental water provisions policy for Western Australia* (WRC 2000a) guides the process for determining how much water can be sustainably abstracted and involves the setting of ecological water requirements (EWR) and environmental water provisions (EWP).

Ecological water requirements are the water regimes needed to maintain the ecological values of significant water-dependent ecosystems at a low level of risk. Environmental water provisions are the water regimes provided to the environment as a result of the water allocation limit decision-making process, taking into account ecological, social, cultural and economic values (WRC 2000a).

The environmental water provisions may be less than or greater than the ecological water requirements. However, in cases where some ecological impact is accepted as

a trade-off to meet the requirements of other values, environmental water provisions would allow for more water to be abstracted than the ecological water requirements regime.

At this stage, ecological water requirements have not been determined for the Rockingham–Stakehill area. Some preliminary work has been completed but additional work is required (see Section 2.3.2, page 18).

2.3 Ecological considerations

2.3.1 Groundwater-dependent ecosystems

A preliminary study by JDA Consultant Hydrologists (JDA 2000) identified two types of groundwater-dependent ecosystems (see Figure 5, page 14) within the Rockingham–Stakehill area — wetlands and groundwater-dependent terrestrial vegetation (such as Banksia woodlands). The Banksia woodlands, which are dependent on root access to the Superficial Aquifer, are distributed throughout the Rockingham–Stakehill area. These woodlands have been identified in Perth’s Bushplan (WAPC 1998) as having regionally significant values. There may also be other potential groundwater-dependent ecosystems (GDE) within the Rockingham–Stakehill area such as cave streams and near-shore marine systems.

Wetlands

Numerous seasonal and intermittent wetlands that rely on the availability of water from the Superficial Aquifer are found throughout the Rockingham–Stakehill area. The department identified wetlands in the study area using V & C Semeniuk (1991) in conjunction with Hill et al. (1996) (see Appendix C, page 79). It then considered the following factors:

- 1 the natural and human-use attributes of the wetlands as determined by V & C Semeniuk (1991)
- 2 wetlands with a ‘conservation’ evaluation category (Hill et al. 1996), whether or not they occurred in existing or proposed designated conservation reserves
- 3 wetlands protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy (EPP) 1992 or listed under the Ramsar convention on wetlands as significant (Becher Point Wetlands, August 2000, site no. 5AU054) (The Ramsar convention on wetlands, 2008)
- 4 wetlands most likely to be affected by groundwater abstraction
- 5 wetlands representative of the range of wetlands existing in the study area.

Using the factors described above, the department then chose the following representative wetlands (see Figure 5, page 14) for use in the groundwater allocation process:

- Lake Richmond
- Lake Cooloongup
- Lake Walyungup
- Folly Pool
- Anstey Swamp
- Paganoni Swamp
- Tamworth Hill Swamp
- Becher Suite – Swamp 35
- Becher Suite – Swamp 169.

The Department of Water currently monitors levels in six of the 10 representative wetlands as well as Churcher and Pike swamps (see Table 1 below). Private users also monitor important wetlands where there is the potential for environmental impacts, including the Becher wetlands and Anstey Q wetland. The department has monitored lakes Cooloongup and Walyungup since the 1920s and Lake Richmond since the 1940s, finding that water levels have declined by up to 2 m since monitoring began (see Figure 6, page 15).

Table 1 Wetland water-level behaviour

Wetland	Period of record	Water-level behaviour
Lake Richmond	1945–2005	Up to 0.5 m decline from 1945–75, stable since 1975. Water level below staff gauge (i.e. measurable level) occasionally since mid 1990s.
Lake Cooloongup	1927–2005	Up to 0.5 m decline from late 1920–75, 0.5–1 m decline since 1975. Water level below staff gauge regularly since late 1980s, regularly since mid 1990s.
Lake Walyungup	1927–2005	Decline of 0.5–1 m since 1975. Minimum water level below staff gauge regularly since 2000.
Pike Swamp	1975–2005	Variable levels with greater than 0.5 m decline since 1975. Water level below staff gauge regularly since late 1980s, almost continuously since mid 1990s.
Folly Pool	1974–2005	Variable, but stable levels since 1975. Minimum water level below staff gauge occasionally since mid 1990s.
Churcher Swamp	1975–2005	Variable levels with greater than 0.5 m decline since 1975. Water level below staff gauge regularly since late 1980s, almost continuously since mid 1990s.
Anstey Swamp	1975–2005	Variable levels with 0.5–1 m decline since 1975. Water level below staff gauge regularly since late 1980s, almost continuously since mid 1990s.
Paganoni Swamp	1975–2005	Levels stable until early 1990s, with a decline of 0.5 m since. Minimum water level below staff gauge regularly since 1990.

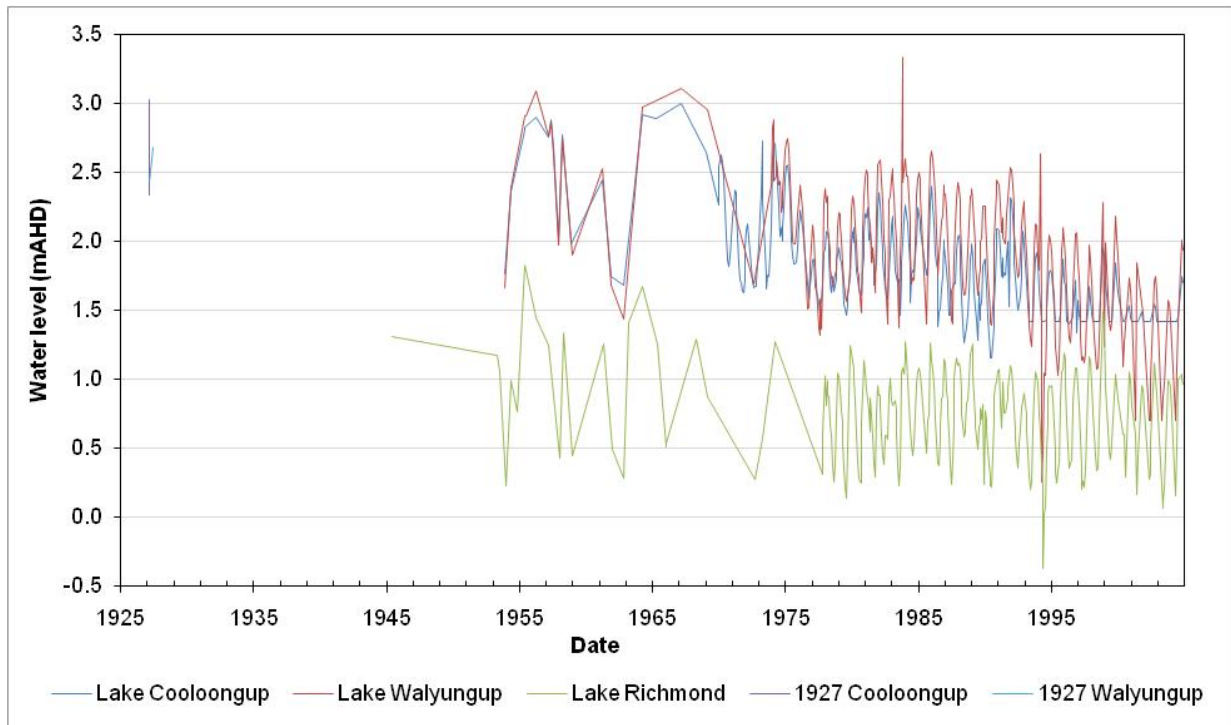


Figure 6 Historic wetland levels

Folly Pool and Lake Richmond show stable water levels since the mid 1970s, with all other wetlands showing a declining trend of 0.5–1 m over the same period. Water levels in all wetlands have been too low to read at some time since the late 1980s, with levels in the Anstey, Churcher and Pike swamps almost continuously below the measurable level since the mid 1990s (indicated by the horizontal lines in Figure 7 on page 16), which makes it difficult to determine accurate trends. Monitoring points in the wetlands should be modified so that low water levels can be measured (see Section 2.3.2, page 18).

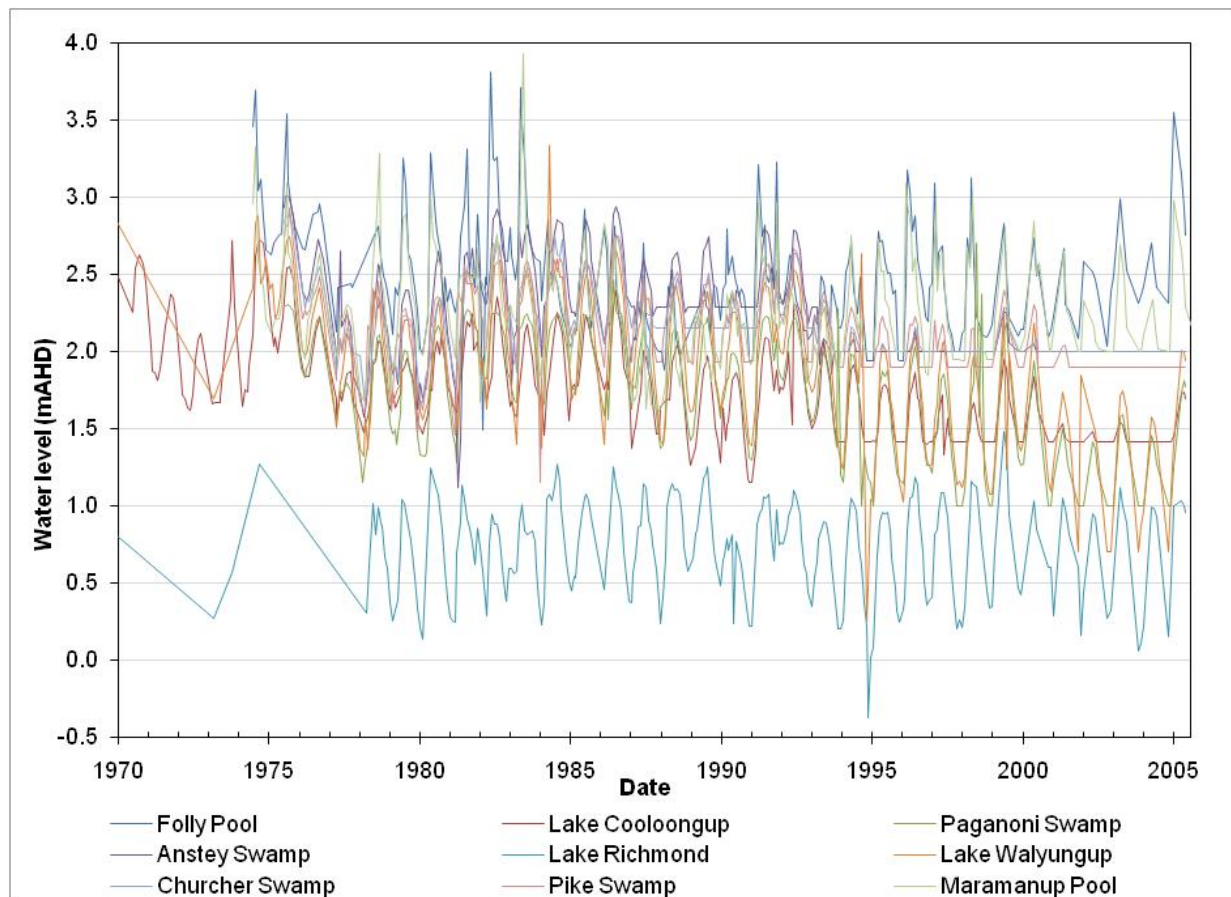


Figure 7 Comparison of wetland levels

A comparison of wetland and bore levels for the Cooloongup subarea (see Figure 8, page 17) shows that groundwater levels (bore) and seasonal fluctuations (lake) are very similar for Lake Cooloongup. The declines in wetland levels are consistent with declines in monitoring bores (see Section 4.2.2, page 32), indicating that the wetlands are connected to the Superficial Aquifer.

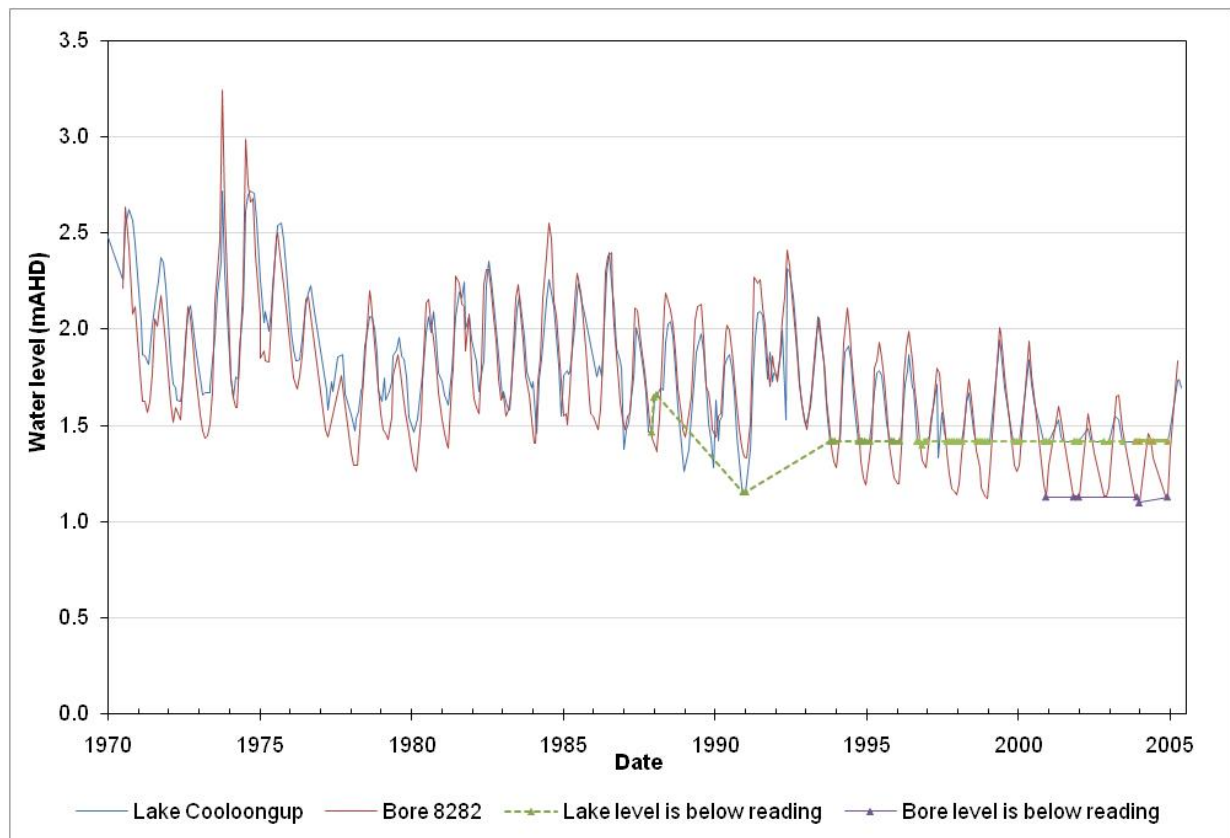


Figure 8 A comparison of lake and bore levels in the Cooloongup subarea

Terrestrial vegetation

JDA (2000) did not set ecological water requirements for terrestrial environments in the Rockingham–Stakehill area, concluding that *Banksia* woodlands are mostly located in areas where the watertable is more than 6 m from the surface and thus not susceptible to decreases in groundwater levels due to increased abstraction.

However, a vegetation stress study conducted on the Gnangara Mound (Water Authority of WA 1992) investigated the cause of stress and deaths of terrestrial vegetation. The study's main conclusion was that vegetation deaths occurred due to low soil moisture and lower water levels after an extended period of below-average rainfall between 1979 and 1991, particularly between 1985 and 1991. The justification for this conclusion was that stressed vegetation and vegetation deaths were observed over several areas of the Gnangara Mound and not just where production wells were abstracting groundwater (JDA 2000).

The study also concluded that groundwater abstraction exacerbates the effects of reduced rainfall recharge and can therefore influence the intensity of tree deaths in an area. Evidence showed that tree deaths had been more concentrated in areas of groundwater abstraction where some trees had apparently compensated for lowered soil moisture by relying on access to groundwater. A decline in groundwater levels beyond where their roots could extend, or that was too rapid for the roots to keep up,

was therefore detrimental to this vegetation (Water Authority of WA 1992). Vegetation that occurs where the depth to groundwater is less than 6 m appears to be adapted to having shallow groundwater near its roots. A lowering of the groundwater table affects this vegetation more than vegetation occurring in areas where the depth to groundwater is greater. Some *Banksia* species are also more susceptible to vegetation stress than others (JDA 2000).

The studies outlined above indicate that more work is required before the department can determine ecological water requirements for the Rockingham–Stakehill area.

2.3.2 Future work to set ecological water requirements

Additional work to be used in future water resource planning for the Rockingham–Stakehill area (see Section 7.1, page 58) includes, but is not limited to:

- reviewing the identification of groundwater-dependent ecosystems (GDE) beyond the scope of JDA (2000) including ecological, social and cultural values
- using the PRAMS groundwater model to assess the level of risk of climate change, abstraction and land-use changes to the ecological values of the GDE
- establishing water regimes to satisfy the management objectives and defining the ecological water requirements
- reviewing existing monitoring and establishing monitoring and reporting relevant to the management objectives.

2.4 Social values

Social values include the aesthetics of wetlands and recreation in and around wetlands. No studies on social values have been done for the Rockingham–Stakehill area. Work to establish these values will be progressed according to priorities for future planning (see Section 7.1, page 58). This information will be used when the allocation limits are next reviewed.

Future work on social values is likely to include the following areas (see Figure 9, page 19):

- Lake Richmond area
- Coo loongup and Walyungup lakes and surrounds
- Port Kennedy area
- Paganoni Swamp and adjacent areas
- Cape Peron Battery complex.

These areas are also identified as priority areas for management in the *Rockingham Lakes regional park area* (DEC 2008).

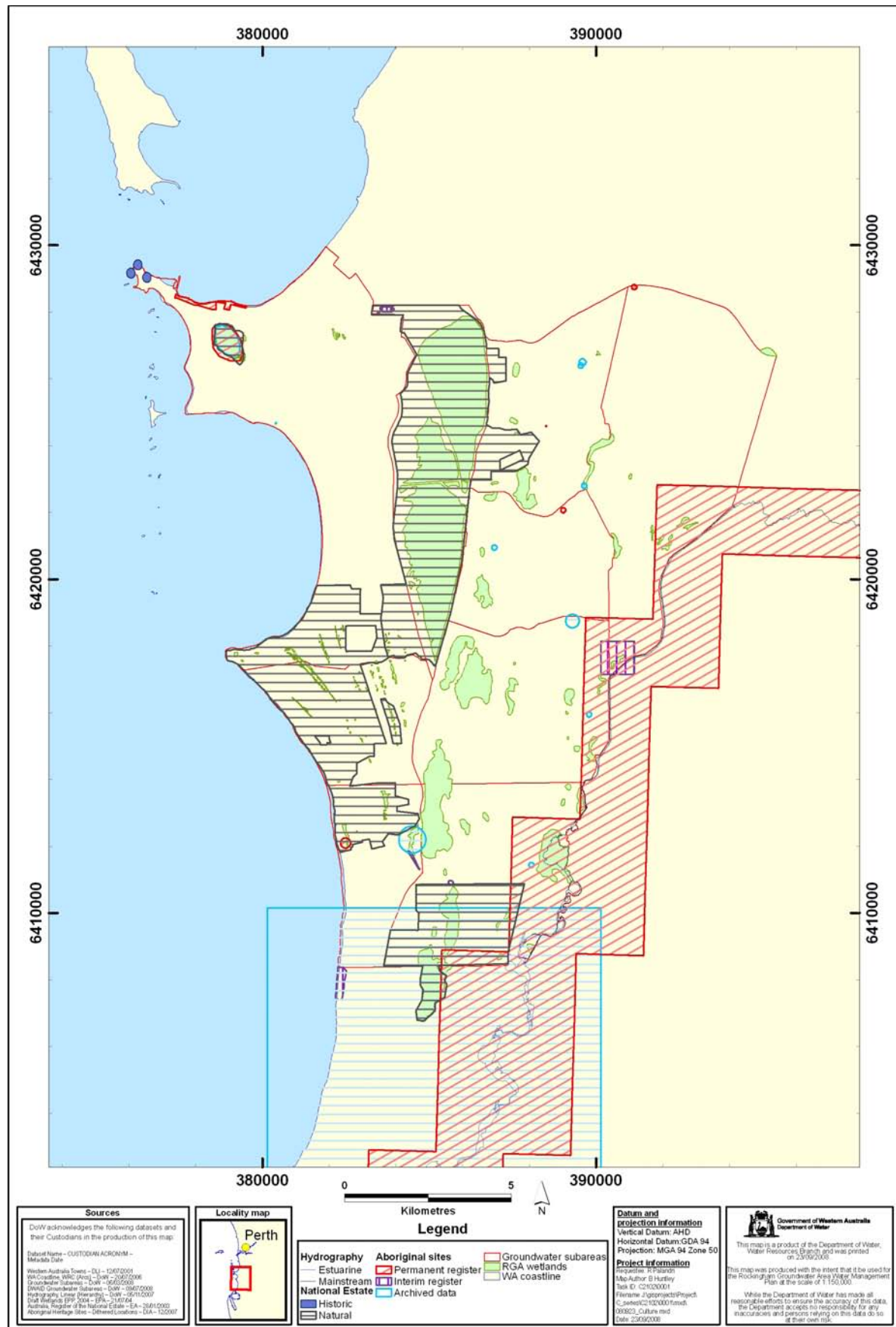


Figure 9 Location of social and cultural sites

2.5 Aboriginal cultural values

Aboriginal sites have been found at several locations within the study area, which have both ethnographic and archaeological significance (V & C Semeniuk 1991). It is common for significant Aboriginal sites and artefacts to exist within 500 m of wetlands, as the Indigenous occupants established their camps and lived around these areas. Sufficient Aboriginal artefacts have been found within the study area to warrant further detailed survey work. There is some possibility that subsurface artefact material may be present throughout the Rockingham–Stakehill area. The most likely places are around swamps, and in sandhills or ridges (JDA 2000).

There are 29 sites of Aboriginal significance within the Rockingham–Stakehill area (see Table 2 below and Appendix A on page 62). These include water bodies such as Lake Amarillo, Folly Pool, Lake Richmond and the Serpentine River. Local Aboriginal tradition is that Waugal, a dreaming ancestor, created the Serpentine River (O'Connor et al. 1989), which runs along the south-eastern boundary of the Rockingham–Stakehill area. The Waugal is important as it represents the life and spirit of water. As well as having mythological and spiritual significance, water bodies and other sites are significant because of historical use, access and habitation. These factors must be considered when managing water resources.

Table 2 Aboriginal sites relating to wetlands in the plan area

Site name	Approximate wetland location	Site type ^a
Rotary Park, Rockingham	Altered wetland	Mythological
Safety Bay	Altered wetland	Burial
East Rockingham industrial area	East Rockingham wetlands	Camp, trees
Golden Bay Turtle Swamp	Turtle Swamp	Hunting place
Stakehill Burial	North Paganoni	Burial
Gas pipeline 82	Tamworth Hill	Artefacts
Karnup	CALM Reserve and Beenyup Pool	Artefacts
Folly Pool	Folly Pool	Artefacts
Coomers Camp	Northern Palusplain Swan River Suite	Camp

^a Mythological sites often link natural features to the Aboriginal account of the formation of the world (V & C Semeniuk 1991)

2.5.1 Native Title

The native title claimant in the Rockingham–Stakehill area is Gnaala Karla Booja (ref WAG6274_98 registered on 17 September 1998, updated 30 June 2004). Native title is an important social and cultural matter and needs to be considered in conjunction with water resource development proposals.

Notification under the *Native Title Act 1993* (Cwlth) is not required where:

- native title has been extinguished by a prior grant of an exclusive tenure (e.g. freehold land, residential leases, commercial leases, exclusive agricultural and exclusive pastoral leases, conditional purchase leases and war service settlement [perpetual] leases)
- water use is consistent with the purpose of the tenure (e.g. water use in relation to a mining tenure is for mining-related purposes)
- the taking of water is within the purpose of a reserve or within the statutory powers enabling the management of the reserve (e.g. Crown Reserve)

or

- the licence is a renewal, re-grant, re-making or an extension of term of a previous licence granted before 23 December 1996

and

- the licence is for the same term as the previous licence.

If the proposal does not comply with any of the above points, then the Department of Water will advise the native title claimant and the proponent in writing and request comment on the proposal by the claimant. It may be useful for proponents with major operations to negotiate an agreement with native title claimants before submitting a groundwater licence application.

2.6 Water quality

2.6.1 Acid sulfate soils

Acid sulfate soils are naturally occurring soils that contain iron sulfides, predominantly as pyrite. These soils are not harmful when undisturbed, but the exposure of the pyrite to air by the drainage, dewatering (water-level declines by pumping groundwater) or excavation of soil, can generate substantial amounts of sulfuric acid and lead to a deterioration in groundwater quality. Discharge of acidic water into waterways and wetlands can cause fish kills and loss of aquatic biodiversity.

Infiltration of acidic water may contaminate groundwater with acid, metals and other contaminants that are toxic to humans and other biota. Lowering of pH in soil, water or water bodies can change community composition of dependent biota whereby acid-tolerant species are favoured, and those that are intolerant disappear from that environment. In effect, the impact will lead to the deterioration of groundwater quality.

Particular areas of concern include estuaries, floodplains and wetlands. More detail and updated information on acid sulfate soils are available from the Department of Environment and Conservation's website <www.dec.wa.gov.au> Management and protection > Land > Acid Sulfate Soils > or Planning Bulletin 64, which is available on the Western Australian Planning Commission website <www.wapc.wa.gov.au> Publications > Planning and bulletins > Planning Bulletin 64 Acid Sulfate Soils >.

2.6.2 Seawater interface

A potential limitation for groundwater abstraction in the Rockingham–Stakehill area is the need to maintain the seawater interface and prevent seawater being drawn inland and up into the freshwater aquifer (upconing). Groundwater abstraction from the watertable aquifer near the coast must be limited to minimise the risk of the existing seawater interface moving inland. Regular monitoring and management of bores is encouraged to prevent upconing and saline water intrusion, which would result in deterioration of the freshwater aquifer.

Where the watertable aquifer is accessed, the installation of multiple-spaced bores with low-flow pumps is recommended – to spread the draw and minimise the potential water-level decline. The department will provide advice on the location of the bores and whether monitoring is required.

3 Groundwater use

3.1 Existing groundwater use

The main aquifer used as a water resource in the Rockingham–Stakehill area is the Superficial Aquifer (96 per cent of all licensed entitlements). The Churcher subarea also has a small number of licensed entitlements in the Rockingham Sand Aquifer, while all subareas except for Cooloongup have licensed entitlements in the Leederville Aquifer (see Table 3 below).

Table 3 Distribution of licensed entitlements between aquifers

Licensed entitlements ^a per subarea (%)							
Aquifer	Warnbro	Cooloongup	Tamworth Swamp	Maramanup	Outridge	Churcher (East and West)	Karnup (East and West)
Superficial	95	100	97	86	97	96	98
Rockingham Sand	0	0	0	0	0	0.2	0
Leederville	5	0	3	14	3	4	2
Total	100	100	100	100	100	100	100

^a Data calculated using information from the Water Resource Licensing database (8 September 2006)

There is a range of allocation volumes in the Rockingham–Stakehill area (see Figure 10, page 25), with the larger allocations for the service sector, mining/industrial and larger agriculture and horticulture properties. The smaller allocations represent use by special rural zone properties.

The service sector (irrigation of public open space, golf courses etc.) and irrigation/horticulture categories are the two highest groundwater users within the Rockingham–Stakehill area (see Table 4, page 24). Other major users include agriculture/aquaculture in the Maramanup subarea, and mining/industrial in the Cooloongup and Tamworth Swamp subareas.

There is also a large amount of authorised unlicensed use (as per the Rights in Water and Irrigation Exemption and Repeal [section 26C] Order 2001) from the unconfined aquifers (Superficial and Rockingham Sand), which is used for domestic gardens and non-intensive stock and domestic purposes.

Table 4 Licensed entitlements by use category

Licensed entitlements ^a per subarea (%)							
Use	Warnbro	Cooloongup	Tamworth Swamp	Maramanup	Outridge	Churcher (East and West)	Karnup (East and West)
Public water supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture/aquaculture	1.0	0.0	5.3	22.8	6.3	5.5	14.0
Domestic, garden and stock	1.0	0.0	3.2	10.0	4.5	7.4	8.4
Irrigation/horticulture	0.0	8.4	51.3	63.6	49.3	60.5	55.5
Mining/industrial	4.6	26.8	34.0	0.1	20.3	2.2	8.9
Service sector	93.4	64.8	6.2	3.4	19.6	24.3	13.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a Data calculated using information from the Water Resources Licensing database (8 December 2005)

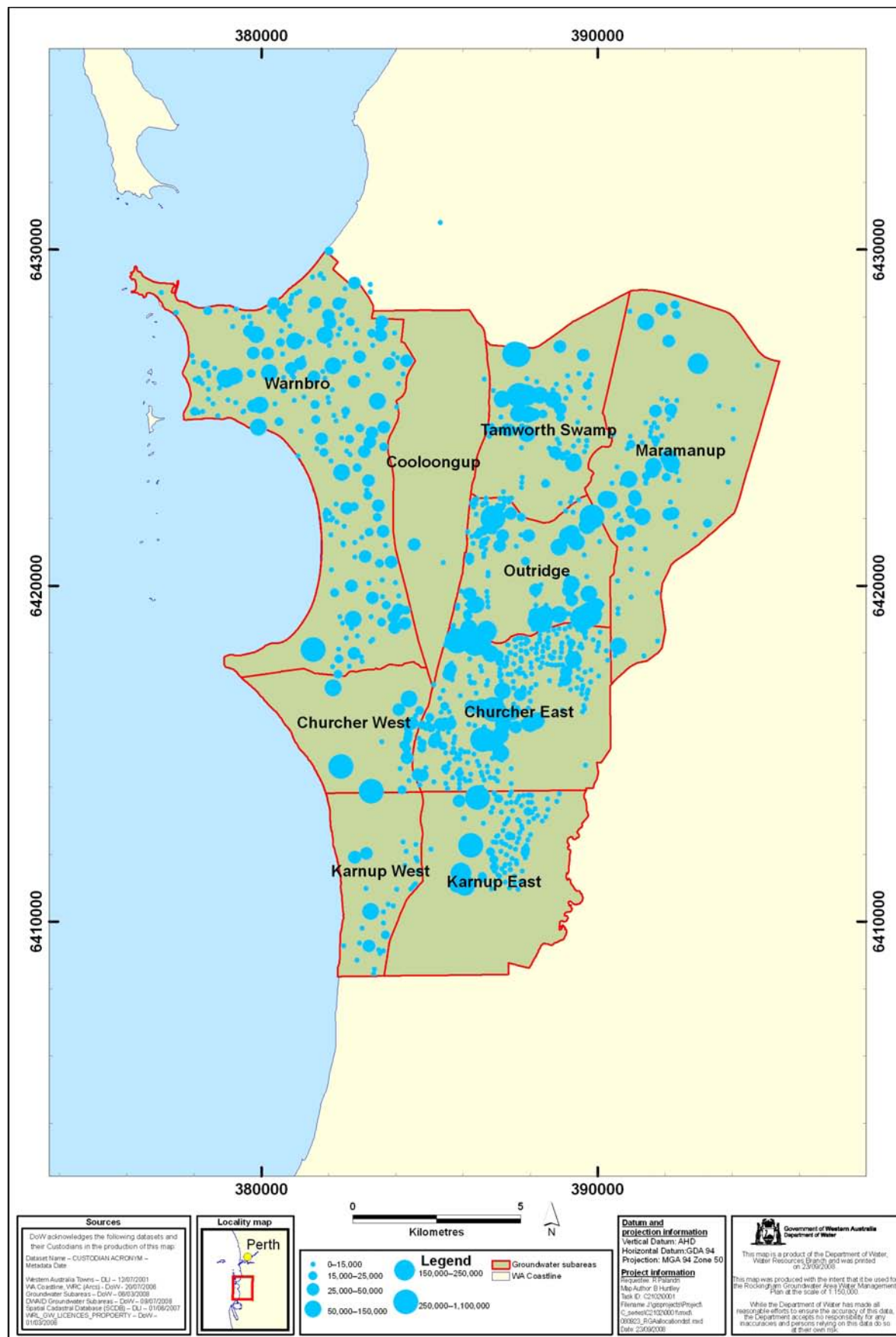


Figure 10 Spatial distribution of licensed entitlements from the Superficial Aquifer

3.2 Subarea water use

Warnbro

The Warnbro subarea draws water mainly from the Superficial Aquifer. The service sector uses most of that water due to the high level of urban land use in the subarea (Figure 11).

The Warnbro subarea also draws water from the Leederville Aquifer – only 225 000 kL/yr – solely for the service sector.

The mining and industrial category uses water for dewatering, dust suppression, earthwork and construction. In the domestic, garden and stock category, most of the licences are for general irrigation of lawns and gardens.

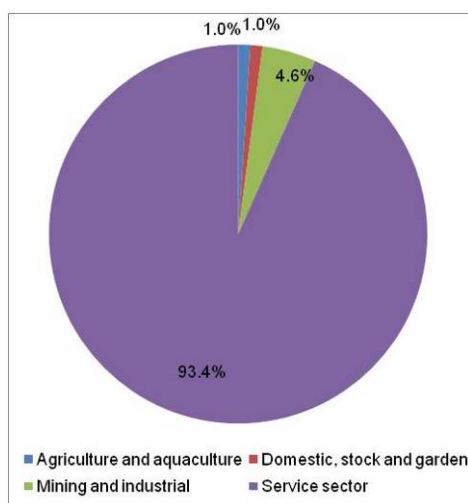


Figure 11 Warnbro groundwater use

Cooloongup

The Cooloongup subarea draws water only from the Superficial Aquifer.

This subarea is covered by extensive wetlands – Cooloongup and Walyungup lakes. The total water use in the subarea is very low as a consequence of limited access.

The predominant use is the service sector, mostly for golf course irrigation. There is a short term, non-renewable licensed use for the clean up of contaminated water for mining and industry (Figure 12).

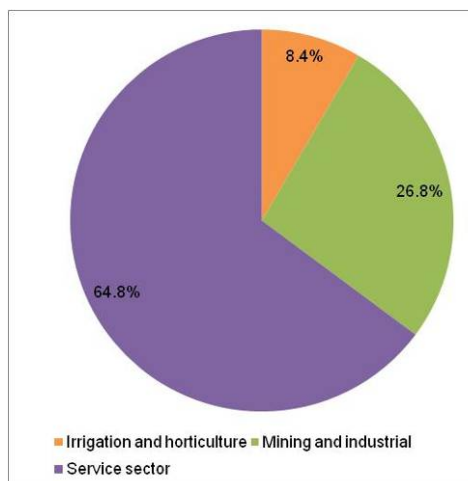


Figure 12 Cooloongup groundwater use

Tamworth Swamp

The Tamworth Swamp subarea draws water mainly from the Superficial Aquifer. The water is predominantly used to irrigate fruit and vegetables and for mining purposes (Figure 13). Other uses include irrigation of pasture, stock watering and domestic purposes.

The service sector uses the small amount of water abstracted from the Leederville Aquifer to irrigate parks and gardens.

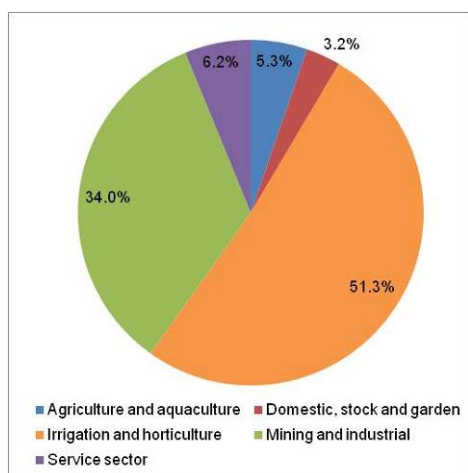


Figure 13 Tamworth Swamp groundwater use

Maramanup

The Maramanup subarea draws water mainly from the Superficial Aquifer. The water is predominantly used to irrigate pasture and fruit and vegetables (including hot houses) and for stock watering (Figure 14). Other uses include marron farming and domestic purposes.

The Superficial Aquifer’s water quality is poor (saline) in most areas, so water is drawn from the Leederville Aquifer to meet stock, domestic and garden requirements.

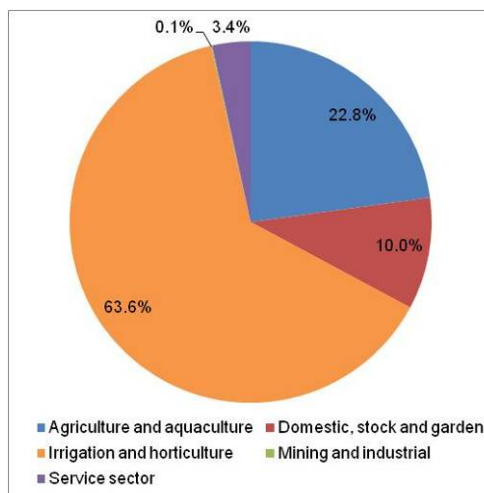


Figure 14 Maramanup groundwater use

Outridge

The Outridge subarea draws water mainly from the Superficial Aquifer. The water is used to irrigate pasture, fruit and vegetables and some vineyards. (Figure 15). Other uses include mineral ore processing, irrigation of public open spaces, general agricultural purposes, and water for domestic, stock and garden use.

A limited amount of water is drawn from the Leederville Aquifer.

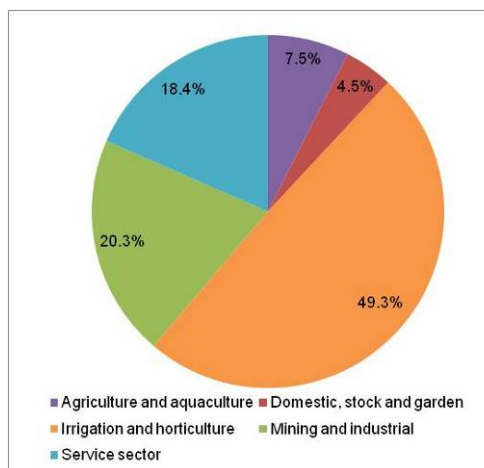


Figure 15 Outridge groundwater use

Churcher

The Churcher subarea (East and West) draws water mainly from the Superficial Aquifer. The water is used to irrigate pasture, fruit and vegetables and vineyards (Figure 16). Other uses include stock watering, public open spaces, lawns, gardens, and golf courses

There are over 350 licenses for domestic, garden and stock use. Many of these domestic requirements are associated with larger properties that use water for other purposes or abstract water from the Leederville Aquifer.

The Leederville Aquifer is used for pasture production, industrial purposes and domestic requirements.

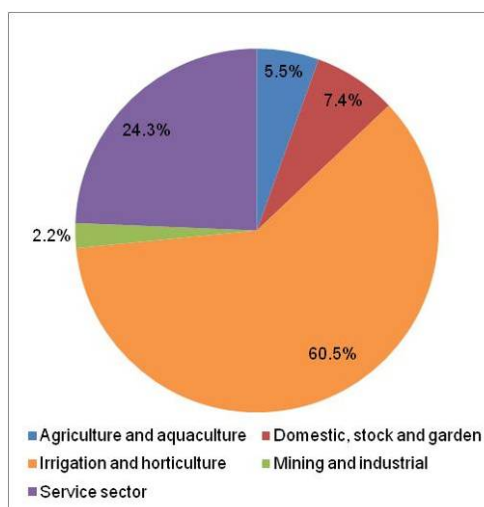


Figure 16 Churcher groundwater use

Karnup

The Karnup subarea (East and West) draws water mainly from the Superficial Aquifer. The water is used to irrigate orchards, vineyards and other produce, as well as for stock watering (Figure 17). Other uses include plant nurseries; public open spaces and recreation areas; dust suppression, earthwork and construction; as well as turf farming.

A limited amount of water is drawn from the Leederville Aquifer.

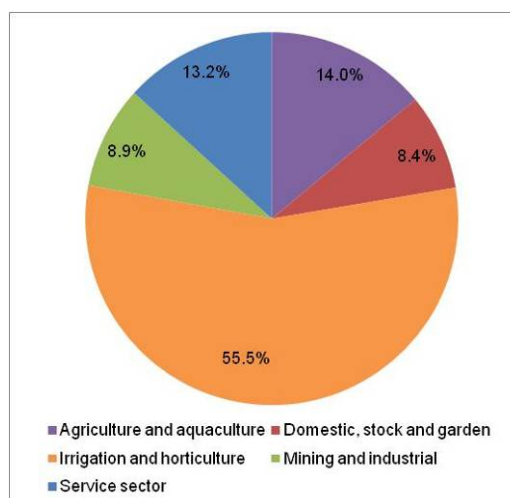


Figure 17 Karnup groundwater use

3.3 Public drinking-water source areas

There are no public drinking-water source areas in the Rockingham–Stakehill area.

3.4 Future use

Groundwater in the Rockingham area is close to fully allocated. Most future developments requiring water will need to look into alternative sources or purchase groundwater through water licence trading (see Section 6.2, page 48).

3.4.1 Potential water supplies

There is limited scope for identification of additional groundwater supplies in the Rockingham–Stakehill area. Since the 1980s, groundwater investigations in this part of the Perth basin have identified most of the available groundwater resources. A review of the Perth metropolitan area's groundwater resources (see Section 4.6, page 42) will give a better understanding of the impact of groundwater abstraction.

3.4.2 Future demand

It is expected that demand for the groundwater resources in the Rockingham–Stakehill area will grow, although the pattern of use is changing as the area, particularly the west, becomes urbanised. Population growth will continue to increase in and around the Rockingham–Stakehill area due to expanding urbanisation and infrastructure development such as the Perth to Mandurah Railway and the Perth to Bunbury Highway. Although water use for horticulture and agriculture may decrease as urban development continues, water for irrigation (such as public open space and golf courses) and demand for domestic use (which is exempt) is likely to increase.

In the Warnbro subarea, the government is looking into development options for a proposed marina near Point Peron. In the southern portion of the Warnbro subarea

and the coastal part of Churcher subarea at Port Kennedy (where existing development includes residential, the Lark Hill Regional Sporting & Equestrian Complex and the Port Kennedy Golf Course), there is a proposal to build another golf course and coastal development – both of which would require water.

South of Port Kennedy is Secret Harbour, which has existing residential and commercial developments and a golf course. This area is also growing, and all allocations for groundwater are new, as previously there was no land use requiring groundwater licences.

The groundwater resources in the Port Kennedy and Secret Harbour areas are under pressure due to intense development and the potential for seawater intrusion. As a result, the department needs to carefully assess new applications in these areas.

In the Outridge subarea, Baldivis is also experiencing increasing residential development. There may be a reduction in water allocation as old, larger licences for intensive use such as horticulture are replaced by new developments. However, not all areas had licences issued, and there is likely to be an increase in domestic use of groundwater throughout all the Rockingham–Stakehill subareas. The Rockingham area has the greatest percentage of domestic garden bores within the metropolitan area (A Kern, pers. comm., October 2005) and this groundwater use is likely to continue.

See Figure 3, page 5, for groundwater subareas and Figure 4, page 7, to locate the suburbs mentioned above.

4 Status of the groundwater resources

4.1 Monitoring the resource

The Department of Water monitors groundwater to understand the groundwater systems and the impacts of factors such as pumping, climate variability and land-use change. Groundwater monitoring provides information on the changes that occur in groundwater levels, groundwater quality and groundwater abstraction. Unlike surface-water resource assessment, groundwater resources are indirectly determined from the analysis of this data, and from an understanding of the hydrogeology and geology of an area. This department uses this information to assess how the groundwater resource is responding, and to determine a sustainable management regime.

The Department of Water maintains a monitoring bore network to monitor groundwater levels and quality in the Rockingham–Stakehill area, with bores drilled in the Superficial, Rockingham Sand, Leederville and Yarragadee aquifers (see Figure 18, page 31). Details of monitoring bores in each subarea of the Rockingham–Stakehill area are provided in Appendix A (page 62).

The Department of Water stores data from monitoring bores in the Water Information Network (WIN) database. In the Rockingham–Stakehill area, there are two main series of groundwater monitoring bores: the Artesian Monitoring (AM series) bores and the Lake Thomson (T series) bores. In the Cooloongup subarea there is also one bore from the Lakes and Wetlands series (Lakes and Wetlands Bore 8282), which is drilled into the Superficial Aquifer (Figure 18, page 31). The T series are drilled into the Superficial and Rockingham Sand aquifers (unconfined aquifers) and the AM series are drilled into the Leederville and Yarragadee aquifers (semi-confined and confined aquifers).

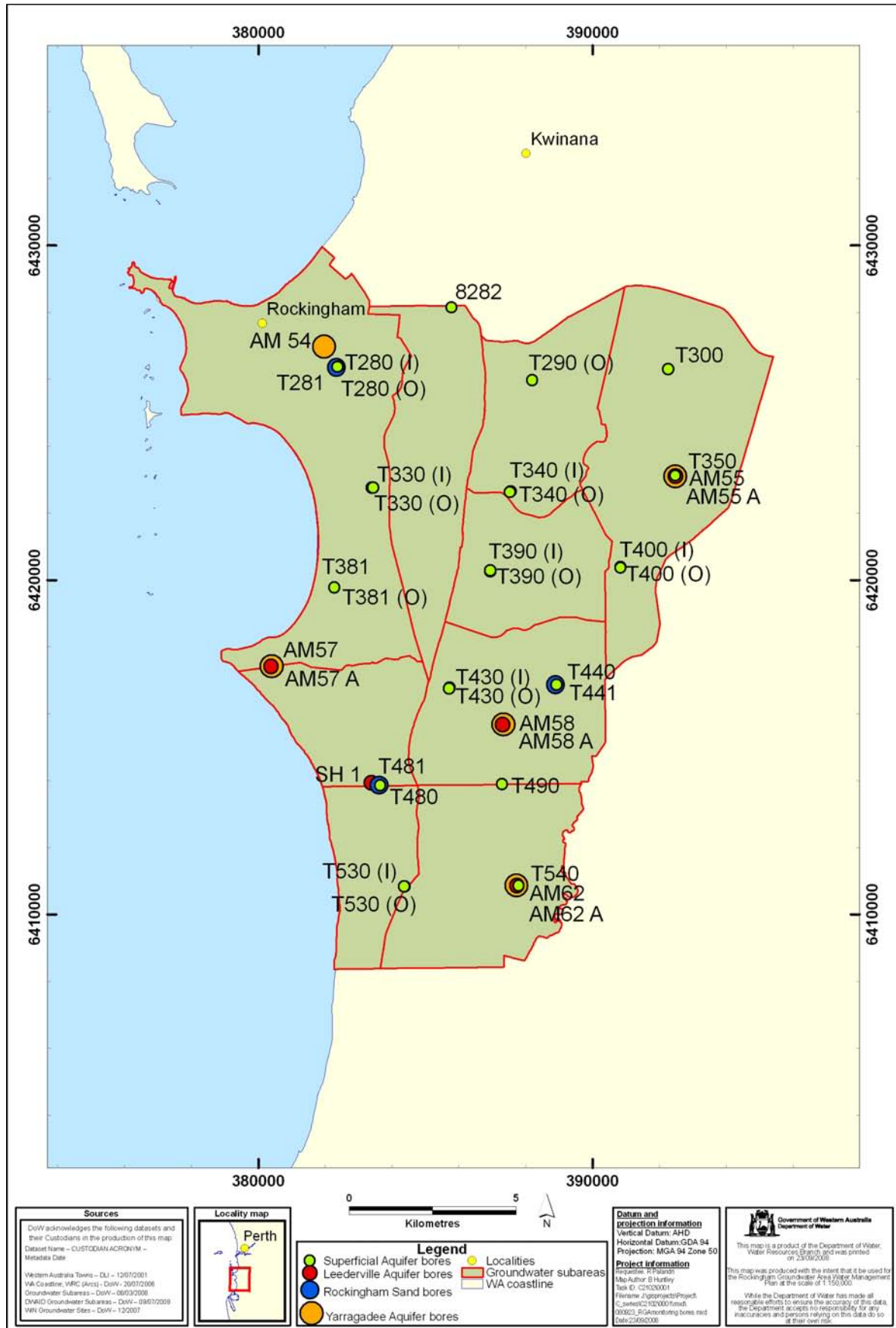


Figure 18 Department of Water groundwater monitoring bores

4.2 Monitoring groundwater levels

4.2.1 Monitoring program

The earliest water-level measurements in the Rockingham–Stakehill area monitoring bores are from 1975, except for the Lakes and Wetlands Bore 8282, which has been monitored since 1970. The water levels in the T series (unconfined aquifers) are generally recorded twice a year to coincide with seasonal maximum and minimum water levels, with the exception of bores T350, 8282 and T540. The water levels in bores T350 and T540 are recorded monthly. The Lakes and Wetlands Bore 8282 was recorded monthly for most years until 2000, when it was reduced to six readings per year (between April and December).

Groundwater levels (potentiometric head levels) in the AM series (confined aquifers) are recorded monthly, an increase from twice a year since 2000. The frequency was increased to monitor water levels more closely and to provide data for hydrogeological modelling of the Perth basin.

4.2.2 Superficial Aquifer

Data from Superficial Aquifer monitoring bores show seasonal variations in water levels from winter highs to summer lows (Figure 19, page 33). Monitoring bores indicate that in some areas, water levels have declined by up to 1 m in winter and 1.5 m in summer since the 1970s (see Appendix A, page 62). The winter declines are most pronounced in the Tamworth Swamp and Churcher subareas (1 m), and to a lesser degree in the Cooloongup, Outridge and Karnup subareas (0.5–0.7 m). Winter levels have been relatively stable in the Warnbro subarea (as a result of urbanisation) and the Maramanup subarea (due to the small abstraction from the shallow Superficial Aquifer, with summer declines of up to 0.5 m). The declines in water levels are generally consistent with Superficial Aquifer's level of use (Table 5, page 45), except for Cooloongup, which has a low level of use.

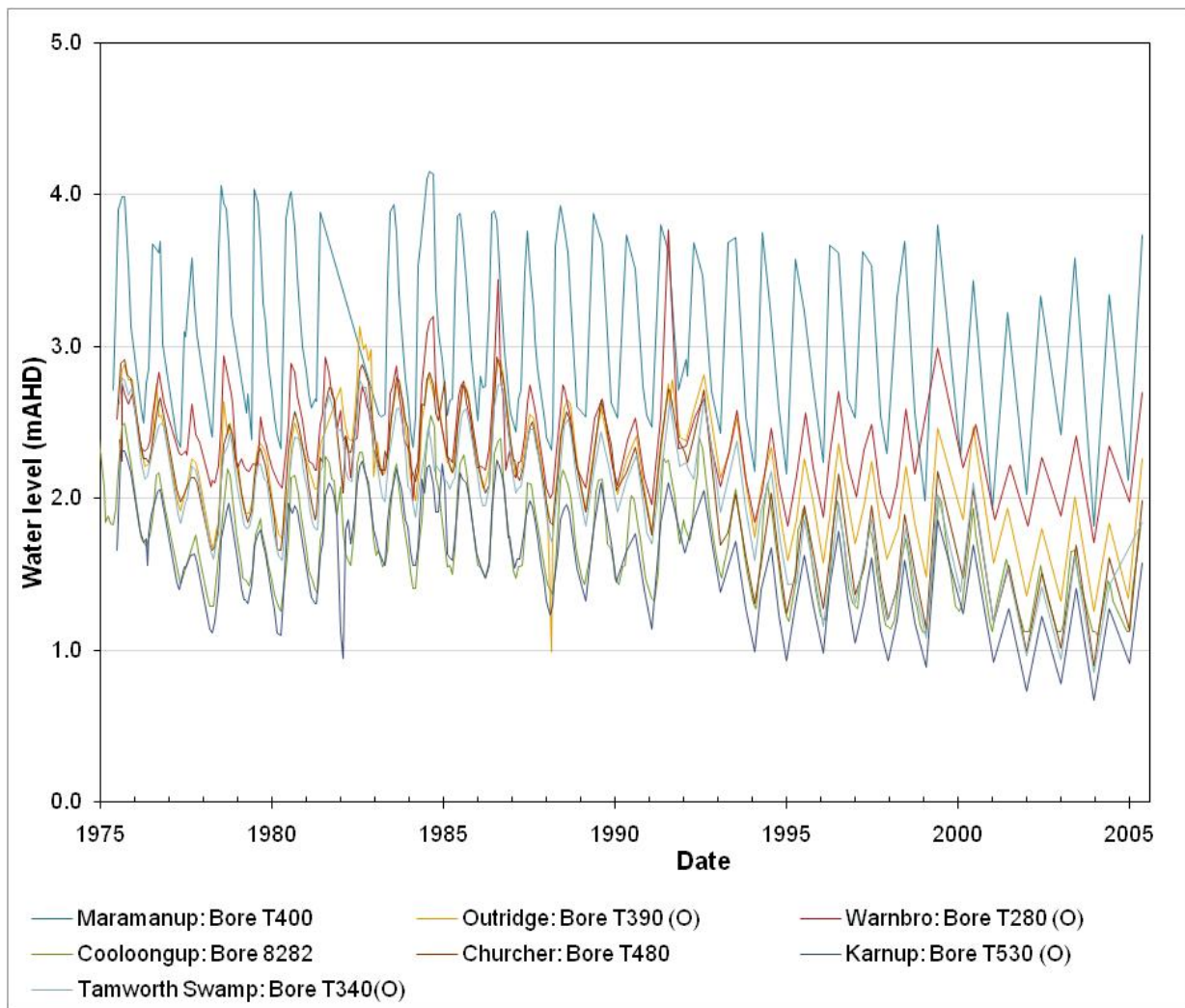


Figure 19 Superficial Aquifer water levels

The fluctuation of groundwater levels in the Lake and Wetlands Bore 8282 (Figure 20, page 34) in the Cooloongup subarea is representative of Superficial Aquifer bores in the Rockingham–Stakehill area. Bore 8282 has shown a decline in winter and summer water levels of approximately 0.5 m over the period of record. Since 1970, the annual variation in water level has reflected rainfall, as shown by the plot of cumulative deviation from the mean (CDFM) of the long-term rainfall average at Rockingham post office (Figure 20, page 34). The hydrograph also shows a seasonal variation in groundwater level of 0.5–1 m, between the summer low and winter high, which has been relatively consistent over the period of record.

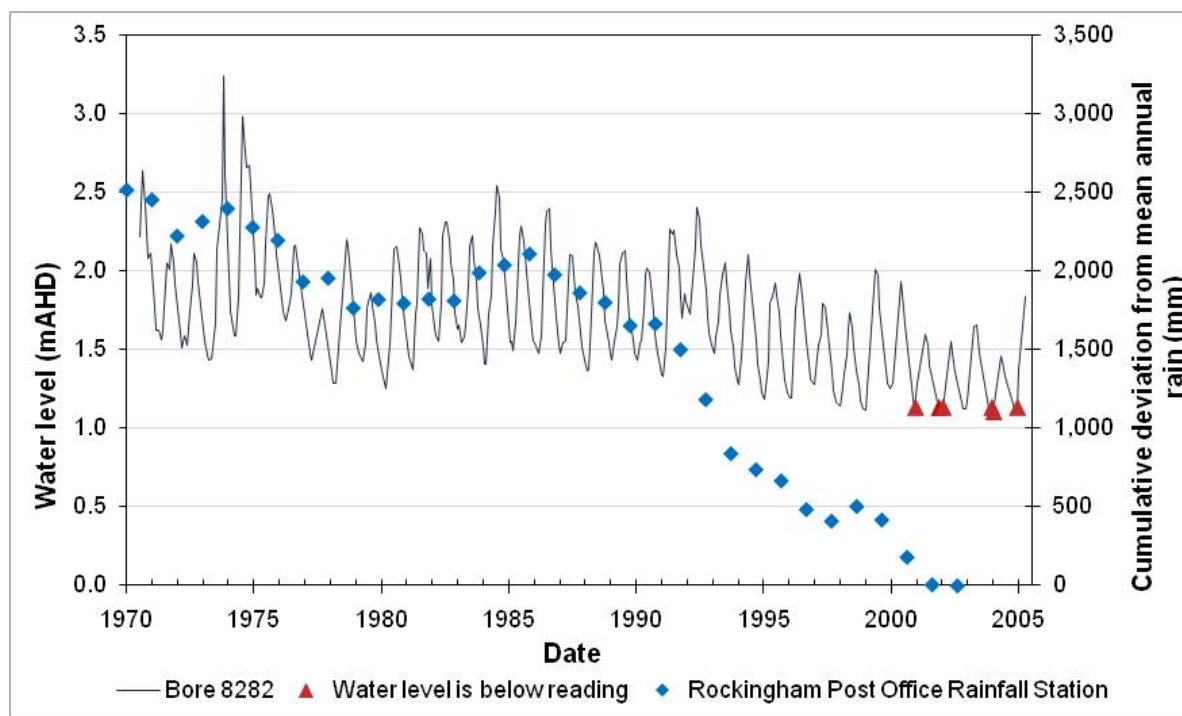


Figure 20 Comparison of Superficial Aquifer water levels and rainfall

A comparison of levels in bores in the Maramanup subarea – drilled in the same vicinity in the Superficial, Leederville and Yarragadee aquifers – shows the relative change in groundwater levels (Figure 21 below). From 1982 (the common period of record), the declines in the Superficial, Leederville and Yarragadee aquifers are approximately 0.5 m, 2 m and 15 m respectively.

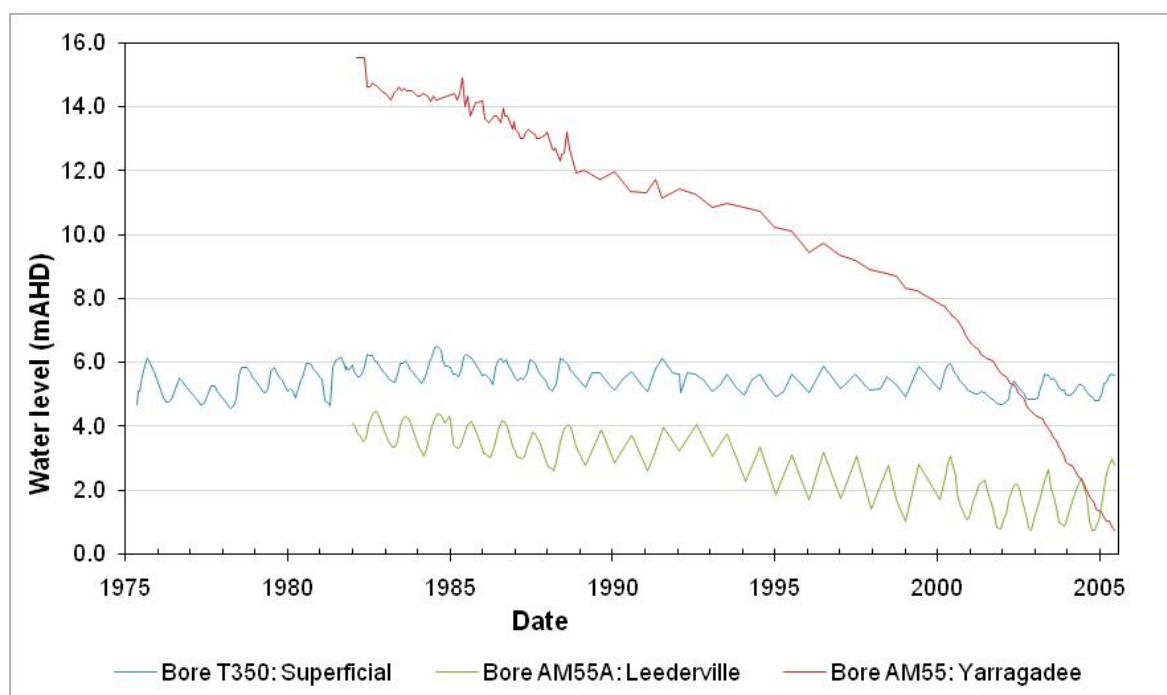


Figure 21 Comparison of groundwater levels in the Maramanup subarea

4.2.3 Rockingham Sand Aquifer

There are only three monitoring bores in the Rockingham Sand Aquifer in the Rockingham–Stakehill area. They are T281 in the Warnbro subarea, and T441 and T481 in the Churcher subarea. As for the Superficial Aquifer, the water-level declines in the Warnbro subarea are less than the Churcher subarea, where they are up to 1 m (Figure 22 below). Although the summer levels in the Warnbro subarea have been relatively stable, the seasonal variation in levels has decreased due to the decline in winter levels (0.5 m). Bore T481 has shown a large fluctuation in winter levels but is relatively stable, whereas summer levels have declined by about 0.7 m (see Appendix A, page 62). Monitoring data for the Rockingham Sand and Superficial aquifers show similar responses (Figure 23, page 36), which suggest a connection.

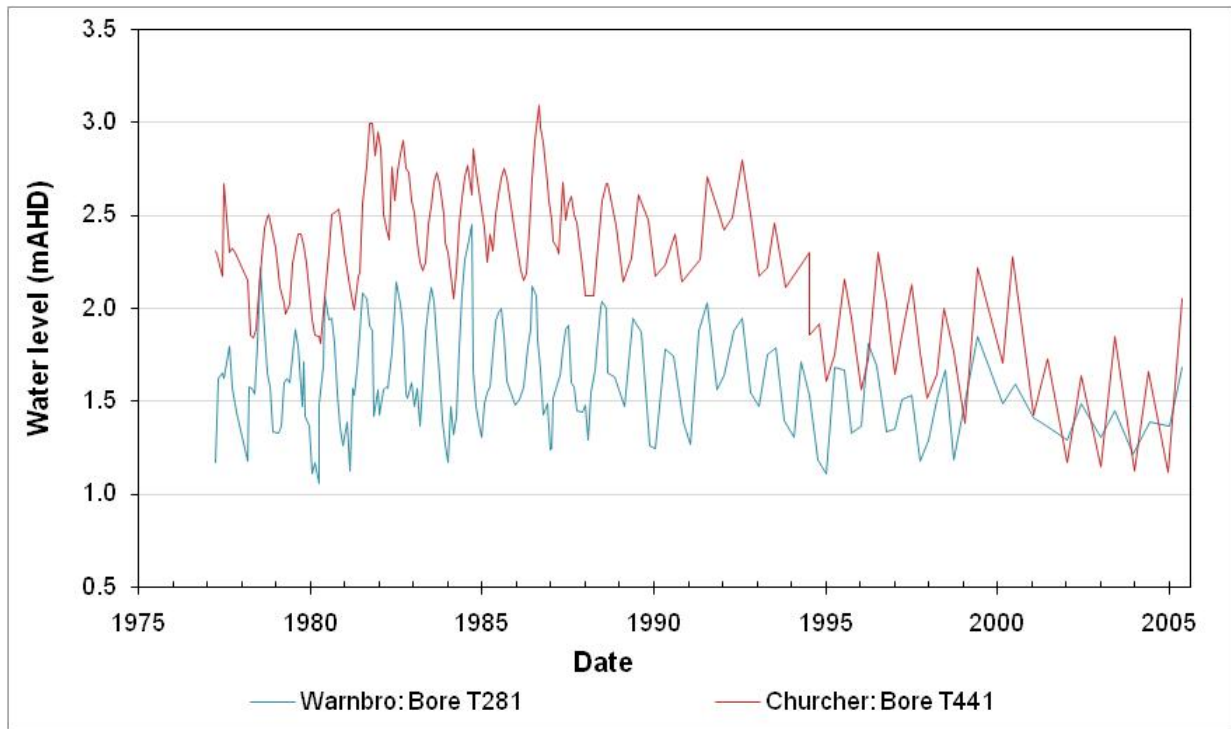


Figure 22 Rockingham Sand Aquifer groundwater levels

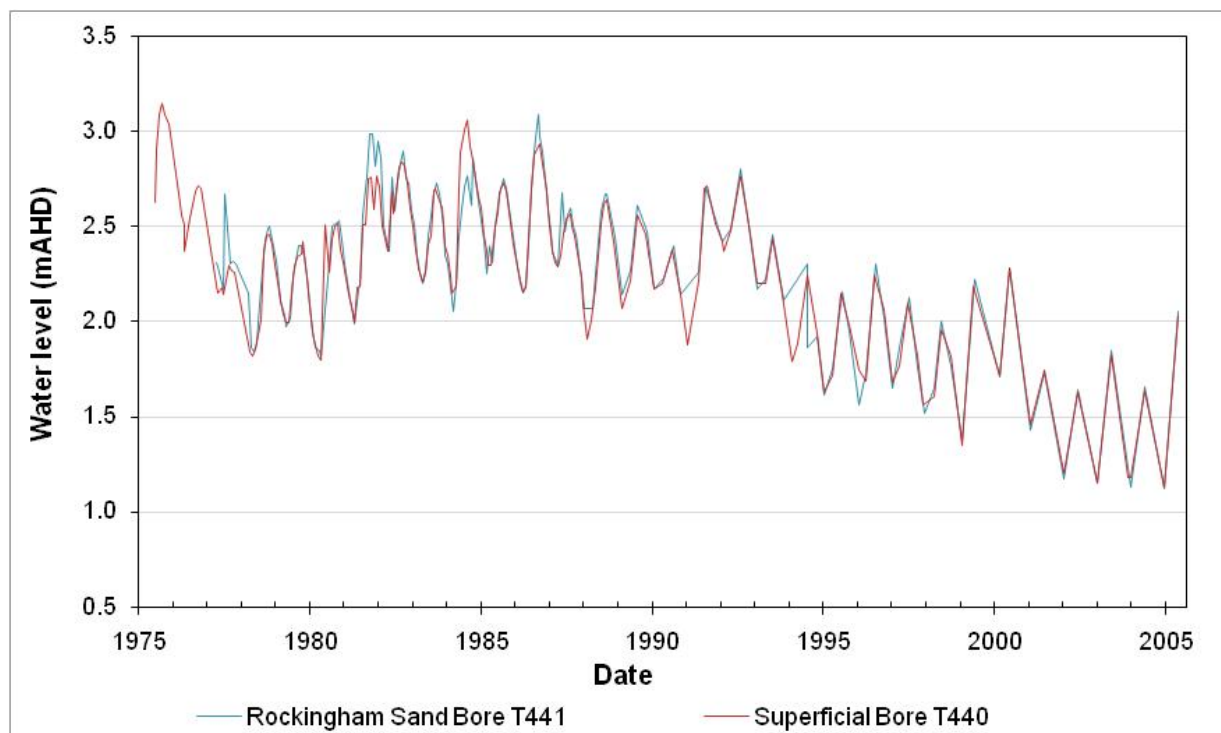


Figure 23 Comparison of groundwater levels in the Churcher subarea

4.2.4 Leederville Aquifer

There are five monitoring bores in the Leederville Aquifer. They are located in the Warnbro (AM57A), Maramanup (AM55A), Churcher (AM58A, SH1) and Karnup (AM62A) subareas. All monitoring bores have shown a decline in water levels of up to 2 m in winter and 2.8 m in summer since the 1980s (see Appendix A, page 62). Seasonal fluctuations have increased due to high rates of abstraction in the summer irrigation season in all bores except for AM57A in the Warnbro subarea (see Figure 24, page 37).

Over at least part of the Rockingham–Stakehill area, groundwater flows in the Leederville Aquifer are to the north or east towards areas of high abstraction in the Serpentine groundwater area, and towards the centre of the Perth metropolitan area. Increased rates of discharge from the Leederville Aquifer to the Rockingham Sand and Superficial aquifers may also be contributing to the decline in water levels in the aquifer (Rockwater 2000). This may explain the water-level declines in the Karnup subarea, because abstraction is minimal there.

The wide extent of the effects of abstraction supports the recommendation by Lindsay (2004) that groundwater be managed on a management area scale rather than on a subarea scale (see Section 5.2, page 43).

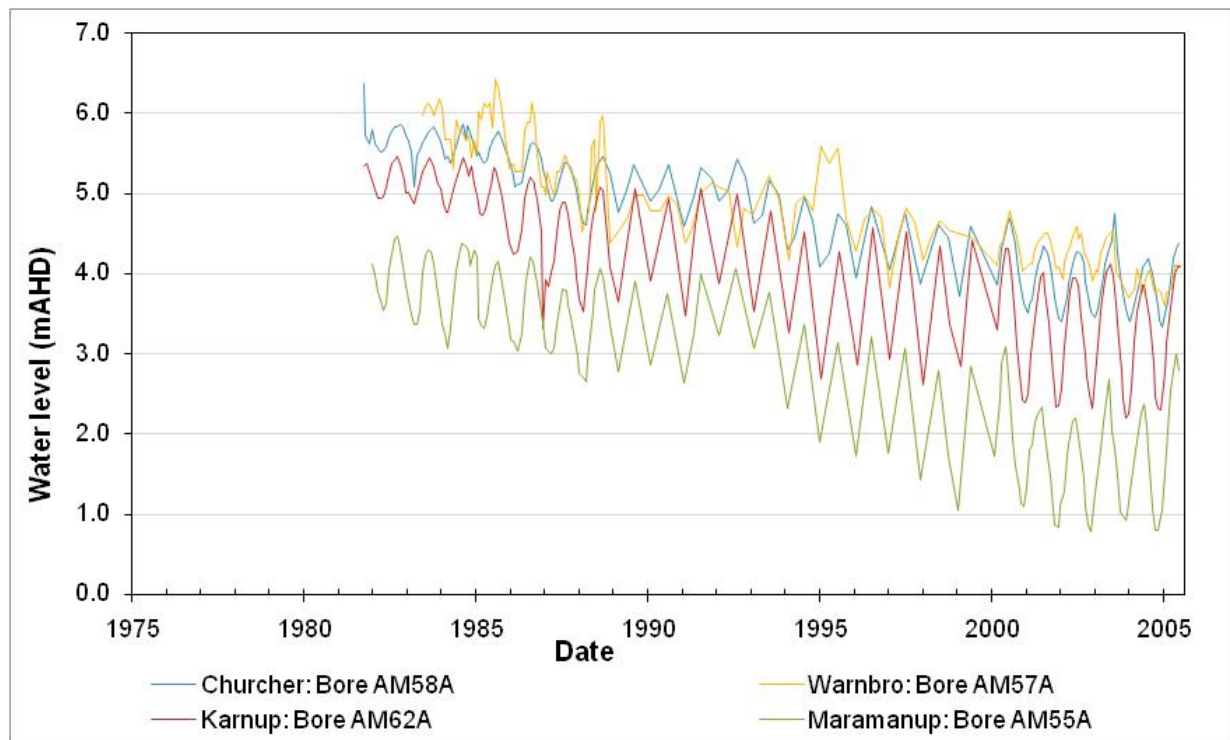


Figure 24 Leederville Aquifer groundwater levels

4.2.5 Yarragadee Aquifer

There are five monitoring bores in the Yarragadee Aquifer. They are located in the Warnbro (AM54, AM57), Maramanup (AM55), Churcher (AM58) and Karnup (AM62) subareas. All monitoring bores have shown declines in water levels during the past 25–30 years (see Appendix A, page 62). The declines range from 7 m since 1977 in the Karnup subarea to 15 m since 1982 in the Maramanup subarea (see Figure 25, page 38).

All bores have shown a significant decline in water levels since 2000. The water level in Bore AM55 declined from 15.5 mAHD in 1982 to 7.7 mAHD in 2000 (or 0.4 m/year), however from 2000–05 it declined 7 m to 0.7 mAHD (or 1.3 m/year), more than three times the rate of the previous 18 years.

Groundwater levels in the Yarragadee Aquifer appear to be affected by abstraction from production bores in neighbouring groundwater areas, as there are no known production bores in the Yarragadee Aquifer in the Rockingham–Stakehill area. This reflects a regional lowering of water levels. The aquifer is effectively confined by the South Perth Shale throughout the groundwater area (see Appendix B, page 78) and consequently, the effects of pumping are transmitted north to south over long distances.



Figure 25 Yarragadee Aquifer groundwater levels

4.3 Monitoring groundwater quality

Groundwater quality in the Rockingham–Stakehill area has the potential to be affected by pumping, seawater intrusion and disturbance of acid sulfate soils. Regular groundwater monitoring provides data for the analysis of water-quality trends. This analysis is used to assist water resource management programs.

4.3.1 Monitoring program

Information on salinity trends is limited: Bore SH1 is the only bore in the Rockingham–Stakehill area with more than five salinity measurements. Most of the salinity measurements were taken in the mid 1980s, with the most recent taken in 1991. To read about licensees' involvement in monitoring, see Section 6.2 on page 50.

4.3.2 Superficial Aquifer

Salinity has been measured in all subareas except Coo loongup. The most recent salinity measurements were taken in the mid 1980s. At the time, the water quality ranged from fresh to moderately saline. The freshest water was measured in the Warnbro subarea (fresh to marginal), with the most saline (up to moderately saline) measured in the Maramanup subarea (see Appendix A, page 62).

4.3.3 Rockingham Sand Aquifer

Salinity measurements for the three monitoring bores in the Rockingham Sand Aquifer (in the Warnbro and Churcher subareas) were taken in 1977 (see Appendix A, page 62). At the time, the water quality was fresh to marginal (<700 mg/L TDS). Since then, there has been no change in salinity, or the position of the seawater interface in the aquifer (Rockwater 2000).

4.3.4 Leederville Aquifer

Salinity has been measured in bores in the Warnbro, Maramanup, Churcher and Karnup subareas, generally up to the late 1980s. The water quality has been marginal (<1000 mg/L) for all bores except SH1 in the Churcher subarea, which has had measurements up to 1150 mg/L TDS since 1986 (Figure 26 below). The seven years of data (1984–91) is not long enough to determine any trends.

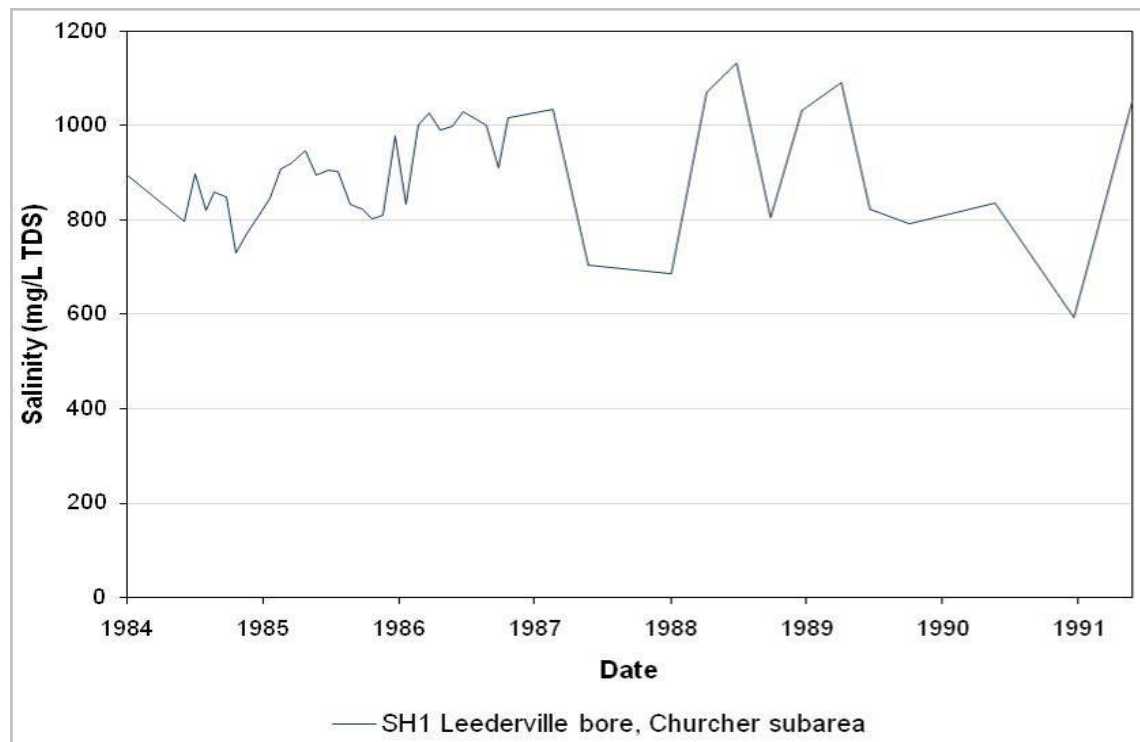


Figure 26 Leederville Aquifer monitoring bore SH1 salinity

4.3.5 Yarragadee Aquifer

Salinity has been measured in bores in the Warnbro, Maramanup, Churcher and Karnup subareas up to the late 1980s. The water quality has been brackish (1000–2000 mg/L TDS) for all bores except those in the Warnbro subarea, with salinity measurements of about 2500 mg/L TDS.

4.4 Monitoring groundwater use

Bore metering enables accurate monitoring of actual use (abstraction), while water-use surveys provide estimates of use. Large licensees in the Rockingham–Stakehill area are required to monitor groundwater use and levels as part of their licence conditions. In general, large allocations above 500 000 kL/year are metered, although metering is requested on a number of smaller allocations, including new developments requiring water (e.g. public open space).

The Department of Water conducts water-use surveys to assess all licence renewals and randomly check compliance. This information is entered and stored in the department's Water Resource Licensing (WRL) database.

4.4.1 Licensed allocation

As at July 2008, the total annual licensed entitlements in the Rockingham–Stakehill area was approximately 16.0 million kL, of which 15 million kL was allocated from the Superficial Aquifer. During the past 10 years, the total annual licensed entitlements has increased by approximately 5.4 million kL or 40 per cent.

Licensed entitlements for the Superficial Aquifer increased during the period 1995–2005 for the Churcher, Karnup and Warnbro subareas (Figure 27, page 41). All three subareas are experiencing residential development along the west coast. Wetlands cover most of the Coo loongup subarea, which is reflected in the consistently low level of licensed entitlements. The number of licensed entitlements in the Maramanup and Outridge subareas has decreased since 2000, although the current licensed entitlements for the Maramanup subarea have more than doubled since 1995. The current level of allocation in the Outridge and Tamworth Swamp subareas is similar to the level of allocation in 1995.

All subareas in the Rockingham–Stakehill area have shown a decrease in licensed entitlements from 2005–06. This is a result of increased urbanisation and subdivision, as the area moves away from rural to semi-rural land use.

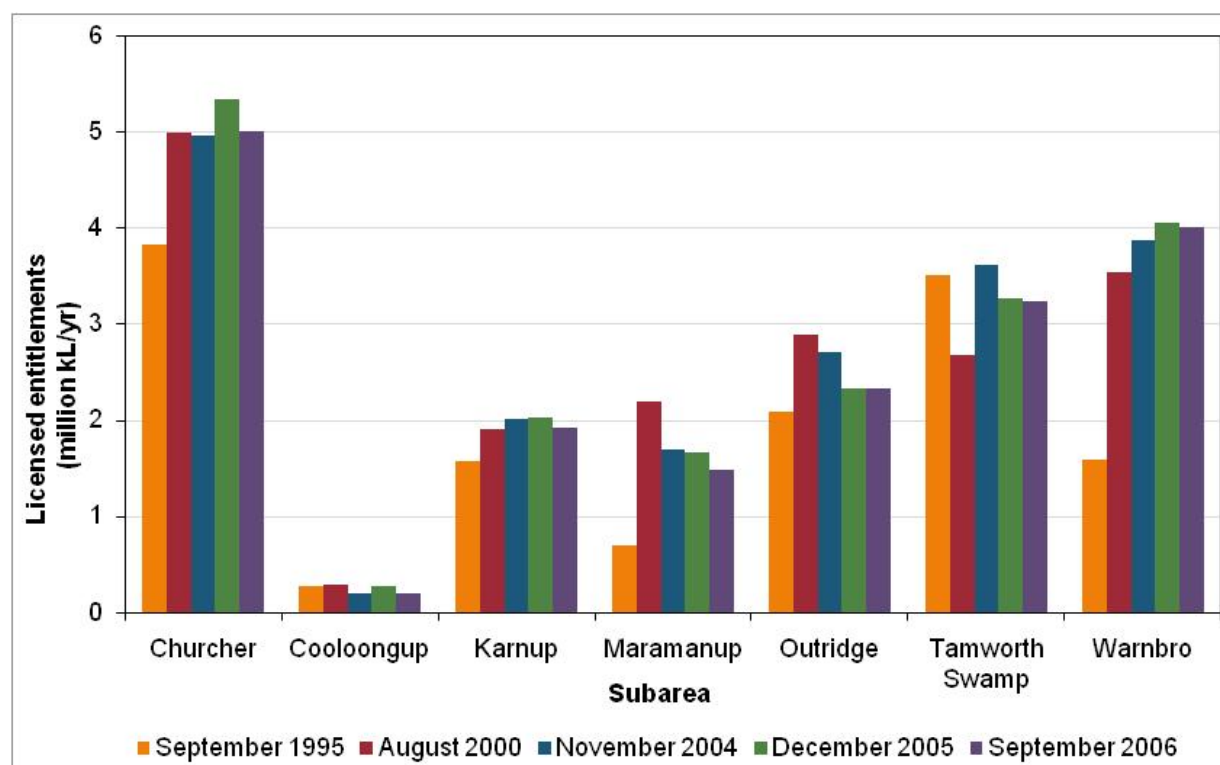


Figure 27 A comparison of subarea licensed entitlements in the Superficial Aquifer, 1995–2006

4.4.2 Authorised unlicensed use

Groundwater use from domestic garden bores (which do not legally require licences) needs to be considered when determining the total amount of abstraction and the groundwater available for consumptive and industrial use. This use has been estimated on a regional basis and incorporated into the PRAMS regional groundwater model (see Section 4.6, page 42).

A 1995 bore-ownership survey of 16 133 households indicated that 76 per cent of properties in the Rockingham area had garden bores, compared with the average of 36 per cent for the Perth region. For suburbs in the Rockingham–Stakehill area including Rockingham, Safety Bay and Shoalwater, the growth in bore ownership from 1995–2000 was estimated to be 23 per cent; while for Cooloongup, Port Kennedy, Secret Harbour, Waikiki and Warnbro, the growth was estimated to be 43 per cent (JDA 2000). This is consistent with the growth of residential developments along the coast, particularly in the Warnbro subarea, which contains all the suburbs listed above, except for Secret Harbour.

Garden bore (unlicensed) use in the Perth region is also continuing to grow, especially in the Rockingham–Stakehill area. From February 2003 – October 2005 more than 2000 new domestic bores were installed in the Rockingham–Stakehill area (A Kern, pers. comm., October 2005).

Of the 10 suburbs with the most new domestic bores, five are located in the Rockingham–Stakehill area. They include Port Kennedy (rank 1), Rockingham (rank 3), Waikiki (rank 5), Warnbro (rank 7) and Secret Harbour (rank 8).

4.5 Future monitoring

Groundwater monitoring programs should be reviewed and modified to include the following:

- review resourcing options for establishing an improved groundwater monitoring network including partnership with industry
- establish monitoring objectives to guide monitoring activities
- regular water level and quality monitoring (at least quarterly readings in the Superficial Aquifer)
- establish monitoring bores in all aquifers in each subarea
- establish monitoring bores near all representative groundwater-dependent ecosystems
- survey domestic bores to estimate unlicensed use for subareas in the Rockingham–Stakehill area.

4.6 Groundwater modelling

The Department of Water and the Water Corporation have developed a regional groundwater model – PRAMS (Davidson and Yu 2006) – to better understand groundwater resources in the Perth metropolitan region. This model is an interactive and predictive tool for quantitative water resource assessment. It is being used to evaluate different management and development scenarios, evaluate impacts of land- and water-use options on the environment, and to determine sustainable water resource management options.

PRAMS has been used to assess groundwater availability, particularly rainfall recharge and aquifer yields based on various climate scenarios. The model considers both licensed and unlicensed use (domestic bores) to account for total water use. The department has used results from PRAMS to make allocation decisions for the Rockingham–Stakehill area (see Section 5.2, page 43).

5 Groundwater allocation

5.1 Water allocation

The Department of Water is responsible for determining how much water should be available for consumptive use and how much should remain in the system for the environment. The department sets allocation limits, which are the maximum groundwater volumes for a particular management area that are available for abstraction annually. Allocation limits consider the sustainable yield (see Section 2.1, page 11) and are set to ensure the annual abstraction regime does not have unacceptable impacts on the groundwater resource (quantity and quality), its dependent ecosystems (wetlands, terrestrial vegetation, river base flow) and its dependent social and cultural values.

5.2 Groundwater allocation in the Rockingham–Stakehill area

5.2.1 Department position

Groundwater resources are an important source of water for private water supplies in the Rockingham–Stakehill area; however, water is limited. The department supports the efficient use of groundwater and aims to make best use of the water while protecting key environmental values.

5.2.2 Approach to setting allocation limits

The department set allocation limits for the Rockingham–Stakehill area using a range of information including:

- sustainable yield calculations and modelling results
- hydrogeological information and monitoring data (bores and wetlands)
- licensed entitlements (current and historic)
- unlicensed garden-bore use
- environmental and social information
- regional knowledge
- existing relevant policies.

Allocation limits for the Rockingham–Stakehill area make up the annual volume of water set aside for licensed and unlicensed use for a particular management area. Groundwater available for future allocation and use in the Rockingham–Stakehill area is water not yet assigned to existing licences or for unlicensed stock and domestic use.

5.2.3 Groundwater allocation in the unconfined aquifers

Management objectives

The unconfined aquifers are used for abstraction and support environmental features such as wetlands and native vegetation (see Section 2.3, page 11). Consumptive use (licensed and unlicensed) is high in the Superficial Aquifer and declines in water levels are evident in many areas (see Section 4.2, page 32). Management objectives for the subareas include:

- preventing further water-level declines in the aquifers
- minimising degraded water quality from seawater intrusion and acid sulfate soils
- protecting the high ecological values of the wetlands.

Management response

The unconfined aquifers (Superficial and Rockingham Sand) are connected and it is difficult to distinguish between them. For the purposes of this plan, the aquifers will be jointly managed where both are present (Table 5, page 45).

The department limits the water available for allocation to achieve the management objectives above. In areas where impacts on the resource are acceptable, water is made available. In areas where use is high and impacts on the resource are unacceptable, the water is fully allocated. Water may become available if older licences are relinquished and/or it can be shown that proposed developments will not have an unacceptable impact on the resource.

The allocation limit for the Cooloongup subarea has been set at 272 000 kL/yr (existing licensed entitlements), which means it is fully allocated because of existing use. The subarea is almost totally covered by discharge lakes (Cooloongup and Walyungup), which do not provide any recharge to the area for potential abstraction. It is also possible that some bores in the subarea are actually accessing the deeper aquifers. The management approach will be to prevent further use and eliminate use over time through the natural attrition of licences — existing licences will not be reallocated.

Table 5 Groundwater allocation in the plan area (kL/yr)

Subarea	Aquifer	Allocation limit ^a	Licensed entitlements ^b	Unlicensed use ^c	Groundwater availability
Maramanup	Superficial	1 956 000	1 289 880	470 000	Limited availability
Tamworth Swamp	Superficial	3 485 000	3 163 845	250 000	Limited availability
Outridge	Superficial	2 456 000	2 112 770	210 000	Fully allocated
Churcher West	Superficial – Rockingham Sand	1 849 000	1 244 700	343 000	Limited availability
Churcher East	Superficial – Rockingham Sand	3 672 000	3 820 983	147 000	Fully allocated
Karnup West	Superficial – Rockingham Sand	1 200 000	104 115	368 000	Water available
Karnup East	Superficial – Rockingham Sand	1 636 000	1 749 245	92 000	Fully allocated
Cooloongup	Superficial – Rockingham Sand	272 000	171 900	0	Limited availability
Warnbro	Superficial – Rockingham Sand	7 800 000	1 344 998	830 000	Water available
Rockingham–Stakehill confined	Leederville	820 000	1 014 839	0	No water available
	Yarragadee	0	0	0	No water available
TOTAL		24 874 000	16 021 625	2 710 000	

a The allocation limit is the annual volume of water set aside for licensed and unlicensed use.

b Licensed entitlements from the Water Resource Licensing database (4 July 2008).

c Refers to authorised unlicensed use. Includes estimates of garden bores and stock and domestic use.

5.2.4 Groundwater allocation in the confined aquifers

Management objectives

The management objectives for the Leederville and Yarragadee aquifers are to minimise use and reduce any likely adverse long-term impacts to the aquifer. The Leederville Aquifer extends throughout the Rockingham–Stakehill area, however, it reduces to a thickness of about 50 m (Outridge, Tamworth Swamp and Maramanup subareas). Historically, abstraction from the Leederville Aquifer has only been permitted if proponents can show that the water quality from the unconfined aquifers is not suitable or yields are insufficient. Consumptive use of the aquifer is high, with over one million kilolitres allocated to licensed entitlements as at July 2008 (Table 5 above) and declines in water levels are evident (see Section 4.2, page 32).

There are currently no licensed allocations in the Yarragadee Aquifer (Table 5 above). As the aquifer is more than 250–350 m below ground, bore drilling is too expensive for the size of the developments in the Rockingham–Stakehill area at present. Although there is no licensed abstraction in the aquifer, the aquifer has shown large declines both locally and regionally, confirming that abstraction impacts are transmitted over wide areas (Lindsay 2004). Management objectives for the

Yarragadee Aquifer are being addressed through other management plans for the Perth metropolitan region, where groundwater from the aquifer is accessed.

Management response

The plan sets allocation limits for the confined aquifers by groundwater area, rather than for subareas, as abstraction impacts are transmitted over wide areas. The aquifers will be managed according to the Policy on Accessing the Leederville and Yarragadee Aquifers in Perth (DoW 2006).

The allocation limit for the Leederville Aquifer has been set at 90 per cent of current licensed entitlements (at July 2008), consistent with other groundwater areas in the Perth metropolitan region. This means the aquifer is over-allocated and no more licences will be issued.

The allocation limit for the Yarragadee Aquifer is 0 kL/year, as a result of large water-level declines from abstraction in surrounding areas. This means that no water is available from the aquifer.

5.3 Impacts of climate variability on water allocation

The groundwater yield from an aquifer is dependent on a number of factors including the extent of rainfall recharge and the amount of water lost through evaporation and taken up by plants (evapotranspiration). Climate change that causes a sustained decline in rainfall and increased temperatures could lead to reduced groundwater recharge and more evaporation and evapotranspiration. Alternatively, a long-term shift to wetter years could have the opposite effect.

As climate variability has a direct impact on the groundwater available for allocation, groundwater use needs to be adapted to prevailing climatic conditions. Failure to adapt poses a risk to the sustainability of the groundwater resource and its dependent ecosystems, and the long-term security of groundwater supply for users.

The climate has been drier in the south-west of Western Australia (including Perth) since the 1970s, compared with the long-term average, due to reduced rainfall (IOCI 2002). This was taken into account when the department set allocation limits for the Rockingham–Stakehill area. The PRAMS model was run using a range of climate scenarios (see Section 4.6, page 42) and the scenario related to the period 1975–2003 was used for the Rockingham–Stakehill area.

The drying climate and current abstraction regime has affected how much groundwater is available for future use in the Rockingham–Stakehill area. It is also possible that allocation limits may need to be revised if the drying trend continues and this may influence the way that water is allocated and used in the future.

6 Allocation principles and licensing considerations

Water allocation planning involves deciding how much water can be taken for consumptive use while leaving enough water in the environment to meet ecological, social and cultural needs. The aim of water allocation planning is to identify where water is or is not available; and if it is available, how it can be obtained and used. Planning also identifies ecological objectives and sets out how the environmental impacts of water use will be monitored and managed. Planning decisions about how much water can be used are informed by science and by community needs. The management of water is delivered through licensing of water abstraction.

The focus for allocation principles and licensing considerations in the Rockingham–Stakehill area is to make best use of the water, protect key ecological values of wetlands and groundwater-dependent ecosystems and prevent adverse long-term impacts to the aquifers. Only limited water is available in the unconfined aquifers and the Leederville Aquifer is over-allocated. The department also supports water trading as a market-based opportunity for further development in fully allocated groundwater subareas.

The area covered by the Rockingham–Stakehill area is proclaimed under the *Rights in Water and Irrigation Act 1914* and access to groundwater is subject to licensing under Part III of the Act. All statewide policies endorsed by the Department of Water apply in this plan. A list of statewide departmental policies, guidelines and notes are available from the department's website <www.water.wa.gov.au Policies>.

The policies and protocols for managing current licensees or applicants requesting access to the groundwater resources in the Rockingham–Stakehill area are outlined below. They apply to all aquifers and will remain current until this plan is amended by the department or replaced by another plan. Licensing of groundwater resources in the Rockingham–Stakehill area is administered by the department's Kwinana–Peel Region, Kwinana office.

6.1 Allocation approach

Water allocation in Western Australia is currently based on the 'first-in first-served' approach. Using this approach, the department assesses licence applications in the order they are received, and issues entitlements up to the allocation limit for a particular management area and aquifer.

The department's policy is to licence water use up to the allocation limits: only where there is an immediate need, and where efficient water use can be demonstrated. The department will support applicants who wish to undertake, at their own expense, hydrogeological investigations to determine if additional groundwater can be taken sustainably from any of the fully allocated aquifers. The department will require any

investigation of this nature to demonstrate, through flow modelling and ongoing monitoring, that any impacts on social, cultural and ecological values and existing users are acceptable.

Under extenuating circumstances, applications for small volumes of water (including domestic water supply) from the Leederville Aquifer will be considered in accordance with the department's *Policy on Accessing the Leederville and Yarragadee Aquifers in Perth* (DoW 2006).

6.2 Allocation policies

Allocation policies are the procedures and rules that the department requires to ensure that water is allocated according to the *Rights in Water and Irrigation Act 1914*. Allocation policies provide a structure for assessing and issuing licences. The following policies also aim to allocate groundwater in the Rockingham–Stakehill area in line with ecological, social, cultural and economic considerations. The following policies apply to all groundwater resources in the Rockingham–Stakehill area.

The policies have been sorted into two areas: general licensing protocols and rules (see Appendix D, page 81) and licensing policies for groundwater in the Rockingham–Stakehill area (see Table 6 below). Appendix D emphasises important sections of the Act and statewide policies that apply to groundwater licensing and management. Table 6 details the additional licensing information and policies for groundwater applications in the Rockingham–Stakehill area.

Table 6 Licensing policies for the taking and use of groundwater in the Rockingham–Stakehill area

Policy group		Policy detail	
1	Allocating water		
1.1	Allocation approach	1.1.1	Groundwater licences in the Rockingham–Stakehill area will be allocated on a ‘first-in first-served’ basis, subject to the provision of all required information.
		1.1.2	Assigned water (licensed entitlements and unlicensed stock and domestic use) must not exceed the allocation limit for the respective management subarea and aquifer.
1.2	Issuing groundwater licences		The department issues groundwater well licences if the applications, once assessed, conform to all appropriate departmental policies and <i>Rights in Water and Irrigation Act 1914</i> requirements.
1.3	Licence approval process		The department will assess licence applications according to the requirements of the <i>Rights in Water and Irrigation Act 1914</i> and the <i>Rights in Water and Irrigation Regulations 2000</i> .
1.4	Increasing an existing licensed entitlement		An application to increase an existing licensed entitlement will be treated as a new application for additional water.

Policy group		Policy detail	
2	Licensee responsibilities		
2.1	Application requirements	2.1.1	It is the applicant's responsibility to provide any requested information to enable the department to complete the assessment of their licence application.
		2.1.2	All applicants required to provide the department with additional information following submission of their application must comply with Statewide policy no. 17 – Timely submission of required further information (DoW 2007b).
2.2	Renewal of groundwater licences	2.2.1	It is the licence holder's responsibility to make an application to extend the term of the existing licence before the expiry date.
		2.2.2	If a licensee has not abided by all the licence conditions in a fully allocated subarea, the licence is unlikely to be renewed without demonstrated extenuating circumstances.
		2.2.3	In fully allocated areas, licensees must not allow their licences to expire as the department cannot guarantee that the licence will be renewed if the water is not available.
		2.2.4	The renewal of an expired licence in a fully allocated area may have more stringent conditions placed upon it.
3	Licensing rules and requirements		
3.1	Licensed water use	Groundwater abstraction from any aquifer in the Rockingham–Stakehill area must be licensed as per the <i>Rights in Water and Irrigation Act 1914</i> . Exemptions may apply for some water use activities (see Policy 5.1).	
3.2	Bore construction and groundwater licensing	3.2.1	When a new application is received for a new bore, the licences will be issued in two parts: <ul style="list-style-type: none"> • issue of a 26D licence for the construction of the bore • issue of a 5C licence only after a valid borehole log and completion details, or Form L – Particulars of completed borehole, has been received from the proponent and the aquifer has been identified. • <i>National guidelines on minimum construction requirements for water bores in Australia edition 2</i> (Land and Water Biodiversity Committee, 2003) provides guidance regarding the construction, cement grouting and abandonment of bores. <www.water.wa.gov.au Licensing and Industry support, Licensing, Publications>
		3.2.2	The construction or alteration of a bore/s (either artesian or non-artesian) requires a 26D licence under the <i>Rights in Water and Irrigation Act 1914</i> .
		3.2.3	Licensees are required to submit information to the department regarding bore construction on the prescribed form within one month of bore completion (s.26E, <i>Rights in Water and Irrigation Act 1914</i>).
		3.2.4	Bore logs are to be submitted to the department by the proponent for every new or altered bore.

Policy group	Policy detail
	3.2.5 All licences issued to construct and alter bores shall be advised that a certified driller must construct bores.
3.3 Cement grouting	<p>3.3.1 Bores screened within the confined aquifers, below the bottom of the unconfined aquifers, must be pressure-cement grouted.</p> <p>3.3.2 The casing of collapsed or abandoned bores must be sealed, at the owner's expense, in accordance with <i>Minimum construction requirements for water bores in Australia edition 2</i>.</p>
3.4 Monitoring program	All new groundwater licences may be required to prepare a monitoring program, undertake regular monitoring and submit the results to the department, in accordance with Statewide policy no. 19 – Hydrogeological reporting associated with a groundwater well licence (DoW 2007b)
3.5 Recouping unused water entitlements	The department may reduce unused portions of licensed entitlements in accordance with Statewide policy no. 11 – Management of unused water entitlements (WRC, 2003a).
3.6 Metering	<p>3.6.1 All new groundwater licences may be subject to a condition requiring installation and maintenance of department-approved flow meters to measure abstraction.</p> <p>3.6.2 Licensees are required to read their meters monthly and submit the information to the department within 14 days of the end of the water year (e.g. by 14 July each year). This information includes the location and pumping schedules from each bore and the volume of groundwater pumped from each bore at the end of the month.</p> <p>3.6.3 It is the responsibility of licensees to ensure that the water pumped is of a quality to be metered to prevent damage to the meter. The department may at any time require a meter to be tested by the licensee.</p>
3.7 Water auditing	The regular self-auditing of water usage by licensees is encouraged with the aim of minimising wastage and increasing water use efficiency.
3.8 Staged developments	<p>3.8.1 All applications for new developments will be assessed as per Statewide policy no. 9 – Water licensing – Staged developments (WRC 2003b).</p> <p>3.8.2 A detailed development plan and timetable stipulating the proposed activity, the area of development and the timeframe for each stage of development must accompany all new or amended licence applications.</p>
3.9 Development plans and operating strategies	<p>3.9.1 The department may require the development and implementation of an operating strategy where:</p> <ul style="list-style-type: none"> • the taking of water may impact on the environment • the volume of water to be taken is significant (>100 000 kL/yr) • the water resource requires stringent management • water is abstracted from several sources or from a number of bores and requires careful management • in the opinion of the department, it is necessary in order to fulfil the requirements of the <i>Rights in Water and Irrigation Act 1914</i>.

Policy group	Policy detail
	<p>3.9.2 Operating strategies will be applied according to the Statewide policy no. 10 – Use of operating strategies in the water licensing process (WRC 2004).</p> <p>Operating strategies are applicable to any licensed entitlement where additional information is needed to ensure any potential impacts from taking groundwater are identified and managed.</p> <p>Operating strategies are to be developed by the licensee and submitted to the department. All actions and commitments in the strategy are to be measurable and appropriate for the purpose of taking the water. If the operating strategy is not appropriate the department will return it to the proponent for further work, so it is best to discuss the contents with the department as early as possible.</p> <p>The department will use information submitted in the operating strategy to develop licence conditions and/or additional monitoring/measurement requirements in the operating strategy or as a condition on the licence.</p>
3.10 Hydrogeological investigations	<p>In certain circumstances, proponents of a proposal may be required to submit to the department a hydrogeological report in accordance with Statewide policy no. 19 – Hydrogeological reporting associated with a groundwater well licence (DoW 2007b).</p> <p>This information is used in assessing the possible local and regional impacts of the proposed abstraction on the hydrology, environment and other groundwater users in support of a groundwater well licence application.</p> <p>The report is to be prepared by a competent groundwater professional and is to be completed at the applicant's expense.</p>
3.11 Water conservation and efficiency	<p>3.11.1 Groundwater should be used efficiently and in accordance with best management practices and irrigation methods.</p> <p>3.11.2 A water conservation and efficiency plan (WCEP) should be developed for all large licensed entitlements (>500 000 kL/a) and all industrial and public amenities licensed to use groundwater in the Rockingham–Stakehill area.</p> <p>3.11.3 A WCEP is to be developed in accordance with Statewide policy no. 16 – Policy on water conservation and efficiency plans: achieving water use efficiency gains through water licensing (DoW 2008). The WCEP may be used to develop licence conditions and monitoring requirements.</p>
3.12 Fit for purpose	<p>3.12.1 Where possible, operations that could use lower-quality water should be matched with appropriate lower-quality sources. In areas of limited groundwater availability, alterations to proposals (i.e. alternative irrigation infrastructure) can allow the use of lower-quality water such as high nutrient, saline or recycled water to avoid the cost of purchasing water on a trading market.</p> <p>3.12.2 If alternative supplies such as recycled, drainage, desalinated or reinjected water (managed aquifer recharge) are part of a proposal, contact the department as early as possible to discuss any management or licensing issues.</p>

Policy group	Policy detail
3.13 Transferring (trading) water entitlements	<p>In a fully allocated system, new water users are able to access water through a transfer (trade) of a licensed entitlement(s). An application for a transfer (trade) will be assessed by the department in accordance with the requirements of the <i>Rights in Water and Irrigation Act 1914</i> and relevant policies.</p> <p>Potential impacts to dependent ecosystems and existing users will also be considered. A transfer (trade) of a licensed entitlement can occur only with the approval of the department.</p> <p>The ability to transfer (trade) water entitlements is detailed in Statewide policy no. 6 – Transferable (tradeable) water entitlements in WA (WRC 2001). This enables a licence holder to transfer (trade) all or part of their licensed entitlement to take water to another licensed water user.</p> <p>Transferring (trading) licensed entitlements is a market-based instrument that can be used to:</p> <ul style="list-style-type: none"> • reallocate scarce water resources to uses with higher economic benefit • achieve more efficient use of water resources • allow the water industry to respond to changing conditions • assist regional development.
3.14 Dewatering	<p>3.14.1 All dewatering activities that are not exempt under the Rights in Water and Irrigation Exemption (Dewatering) (section 26C) Order 2005 must be licensed, including the discharge of the wastewater into the environment.</p> <p>3.14.2 Where a licence is required for dewatering, an operating strategy may be requested by the department to address the impacts of the dewatering proposal. The following information must also be submitted with the licence application:</p> <ul style="list-style-type: none"> • detailed project description • proposed start date and duration of project • the need for, extent and details of dewatering required, including the proposed methodology for abstraction • description of how the wastewater will be treated and disposed of; and likely rate and volume of dewatering. <p>3.14.3 Depending on the volume and duration of dewatering, monitoring and contingencies may be required. If the dewatering activity is for an extended duration (> 1 year) or has the potential to impact on existing use or the environment, additional information may be required. This may include:</p> <ul style="list-style-type: none"> • submission of an acid sulfate soil management plan (as per policy 4.4) • a hydrogeological investigation (as per policy 3.9). This may include a local area groundwater model developed to determine the extent of the groundwater draw down. • water reuse or disposal methods and associated monitoring (as per policy 4.3). <p>In these instances additional information will be required in the operating strategy. This includes the location and number of monitoring bores for water level and quality measurements.</p>

Policy group	Policy detail
	<p>3.14.4 Groundwater monitoring bores should be installed with water levels and quality measured on a regular basis to determine if dewatering is influencing the background levels (pre-dewatering). The department will advise the licensee when monitoring is required.</p> <p><i>Dewatering exemptions</i></p> <p>3.14.5 The Rights in Water and Irrigation Exemption (Dewatering) (section 26C) Order 2005 applies to all parts of the State that are proclaimed areas for the purposes of Section 26B of the Act. Sections 5C and 26B (3) to (6) of the Act do not apply in relation to a non-artesian well if:</p> <ul style="list-style-type: none"> • the only water that is able to be taken from the well is from the watertable aquifer • the water is taken from the well at a pump rate of less than five litres per second over a period of less than seven days • the water taken from the well is taken for the purposes of dewatering.
4 Environmental policies	
<p>4.1 Wetlands and groundwater-dependent ecosystems</p>	<p>4.1.1 Groundwater management in the Rockingham–Stakehill area will recognise statutory environmental protection criteria for:</p> <ul style="list-style-type: none"> • Ramsar wetlands • wetlands of national and international importance • declared rare flora and fauna (Wildlife Conservation Act 1950) • Swan coastal plain lakes (EPP lakes) • bushland reserves. <p>4.1.2 If significant impacts are likely, then the applicant will need to provide an assessment of the water-level regime required to maintain the groundwater-dependent ecosystems (GDE) at a low level of risk, including advice on how abstraction will be managed to protect the environmental values.</p> <p>4.1.3 If an applicant’s abstraction regime is likely to have significant impacts on local GDE or other values, such as connected surface-water systems, then the department may require site-specific work to be done on the value concerned, such as:</p> <ul style="list-style-type: none"> • more accurate mapping and identification of the GDE • a values and condition assessment of the GDE • determination of ecological water requirements for the GDE • setting of water-level criteria at representative GDE and associated monitoring bores • monthly monitoring of water levels, including baseline levels • annual monitoring of biological condition • reporting to the department on water-level trends, trends in biological condition, the relation between the two and compliance with water-level criteria • triggers and associated management actions, including switching off production bores if criteria were likely to be breached.

Policy group	Policy detail
	<p>This information will be used in assessing the licence application. The information may also be used in developing the licence conditions and an operating strategy (as per policy 3.8.1 and 3.8.2).</p> <p>4.1.4 All newly constructed (licensed) bores should be drilled at least 200 m away from the defined (protected under statutory legislation) wetland boundary, preferably down-gradient of the groundwater flow. A maximum of 5000 kL/yr annual allocation may be issued within 500 m of the defined wetland boundary.</p>
4.2 Cultural sites	All applicants are required to meet any statutory requirements under the State's <i>Aboriginal Heritage Act 1972</i> or the Australian Government's <i>Native Title Act 1993</i> , where applicable.
4.3 Water quality	<p>If a licensee is required to monitor groundwater quality then any identified increase to the trigger levels set in the licence conditions must be reported to the department within seven days.</p> <p>The department will provide advice to the licensee and may require pumping from this source to be restricted until the water-quality levels return to the baseline conditions. This may include amendment of licence conditions, increased monitoring and remediation.</p>
4.4 Acid sulfate soils	<p>When an application is submitted for a large project, which occurs in an area of high risk of generating acidic water or soils, applicants must prepare appropriate documentation to support their application. This may include an acid sulfate soil management plan. These applications to take water will not be granted until appropriate management arrangements are approved by the Department of Environment and Conservation. For more information on acid sulfate soils please see: www.dec.wa.gov.au/management-and-protection/acid-sulfate-soils/index.html</p>
4.5 Contaminated sites	<p>Applications to take water from an identified contaminated site will not be considered unless appropriate management arrangements are approved by the relevant authorities (including Department of Environment and Conservation and the Department of Health). For more information on contaminated sites please see: www.dec.wa.gov.au/pollution-prevention/contaminated-sites/index.html.</p>
4.6 Environmental impact assessment	<p>4.6.1 As part of the licence assessment process, the licensing officer will set the level of assessment based on the level of risk. A proposal with a high level of risk to the environment may require assessment under the <i>Environmental Protection Act 1986</i>.</p> <p>If a project requiring groundwater is submitted where the scale or scope means that it cannot be fully considered under this plan and the <i>Rights in Water and Irrigation Act 1914</i>, the proposal may be referred to the Environmental Protection Authority (EPA) for assessment.</p> <p>The department will provide the EPA with advice. EPA approval of a proposal does not guarantee approval of the water licence. The department must still assess the groundwater-licence application and incorporate EPA advice where relevant.</p>

Policy group	Policy detail						
	4.6.2 All groundwater licence applications must comply with relevant environmental legislation as well as the policies and rules stated in this plan.						
5 Authorised unlicensed water use							
5.1 Exemption order for stock, domestic and garden use	<p>Under the <i>Rights in Water and Irrigation Exemption and Repeal (section 26C) Order 2001</i>, groundwater abstraction in the Rockingham–Stakehill area is exempt from licensing from the Superficial Aquifer for the following purposes only:</p> <ul style="list-style-type: none"> • fire fighting • watering cattle or other stock, other than those being raised under intensive conditions • watering an area of lawn or garden that does not exceed 0.2 ha • other ordinary domestic uses. 						
5.2 Water-use restrictions	<p>Irrigation of gardens, lawns and recreational areas from all bores is restricted to between the hours of 6 pm and 9 am all year round (Water Agencies [Water Use] Bylaws 2007). Domestic bore owners from Perth to Mandurah may only water their gardens using a bore three days a week (see Table 7).</p> <p>Table 7 Recommended watering day roster in the plan area</p> <table border="1" data-bbox="496 1037 1321 1160"> <thead> <tr> <th data-bbox="496 1037 903 1081">House or lot number</th> <th data-bbox="903 1037 1321 1081">Watering day</th> </tr> </thead> <tbody> <tr> <td data-bbox="496 1081 903 1126">Odd numbers (1, 3, 5, 7, 9)</td> <td data-bbox="903 1081 1321 1126">Monday, Wednesday, Friday</td> </tr> <tr> <td data-bbox="496 1126 903 1160">Even numbers (2, 4, 6, 8, 0)</td> <td data-bbox="903 1126 1321 1160">Tuesday, Thursday, Saturday</td> </tr> </tbody> </table>	House or lot number	Watering day	Odd numbers (1, 3, 5, 7, 9)	Monday, Wednesday, Friday	Even numbers (2, 4, 6, 8, 0)	Tuesday, Thursday, Saturday
House or lot number	Watering day						
Odd numbers (1, 3, 5, 7, 9)	Monday, Wednesday, Friday						
Even numbers (2, 4, 6, 8, 0)	Tuesday, Thursday, Saturday						
5.3 Water quality for domestic supply	<p>The department encourages the use of lower-quality water to reduce pressure on scheme water.</p> <p>If groundwater is extracted for private drinking-water supplies, it is advisable to filter, treat and test the water according to public health advice available from the Department of Health, Water Quality branch.</p> <p>The department also provides guidance for drinking water through water quality protection notes <www.water.wa.gov.au Water quality, Publications>. The <i>Australian Drinking Water Guidelines 2004</i> (Australian Government 2004) and the <i>Australian Fresh and Marine Water Quality Guidelines</i> (ANZECC & ARMCANZ 2000) also provide information on relevant drinking-water quality criteria.</p>						
6 Compliance							
6.1 Water-use surveys	Site inspections and water-use surveys may be undertaken to assess compliance of licensed activities.						
6.2 Compliance with licence conditions	Failure to comply with a condition on a licence may result in the department taking enforcement action.						

6.2.1 Water restrictions for authorised unlicensed use

Domestic and stock water demand is acknowledged as a priority for all landholders in areas where no reticulated water supply exists. Domestic and stock bores are currently exempt from licensing requirements from the unconfined aquifers only (see policy 5.1). However, domestic garden bores are only acceptable in the areas delineated green in Figure 28 on page 57.

Garden bores are a better alternative to scheme water for gardens, but groundwater still needs to be used responsibly. Anyone found using garden-bore sprinklers between 9 am and 6 pm, or in the Perth region on their non-allocated day, can be fined \$100, although offenders will first be given a written warning.

Exemptions to the rules

- If you are establishing a new lawn, you may water with sprinklers during the day for the **first 28 days**.
- Neighbours sharing a bore are able to use it **either** according to the dates allocated to their lot number **or** on the same day of their neighbour's allocated watering days (but not both).

If you need more information about the new water restrictions for garden bores, call 1800 508 885 and select option 2 or call the Waterwise Helpline on 13 10 39.

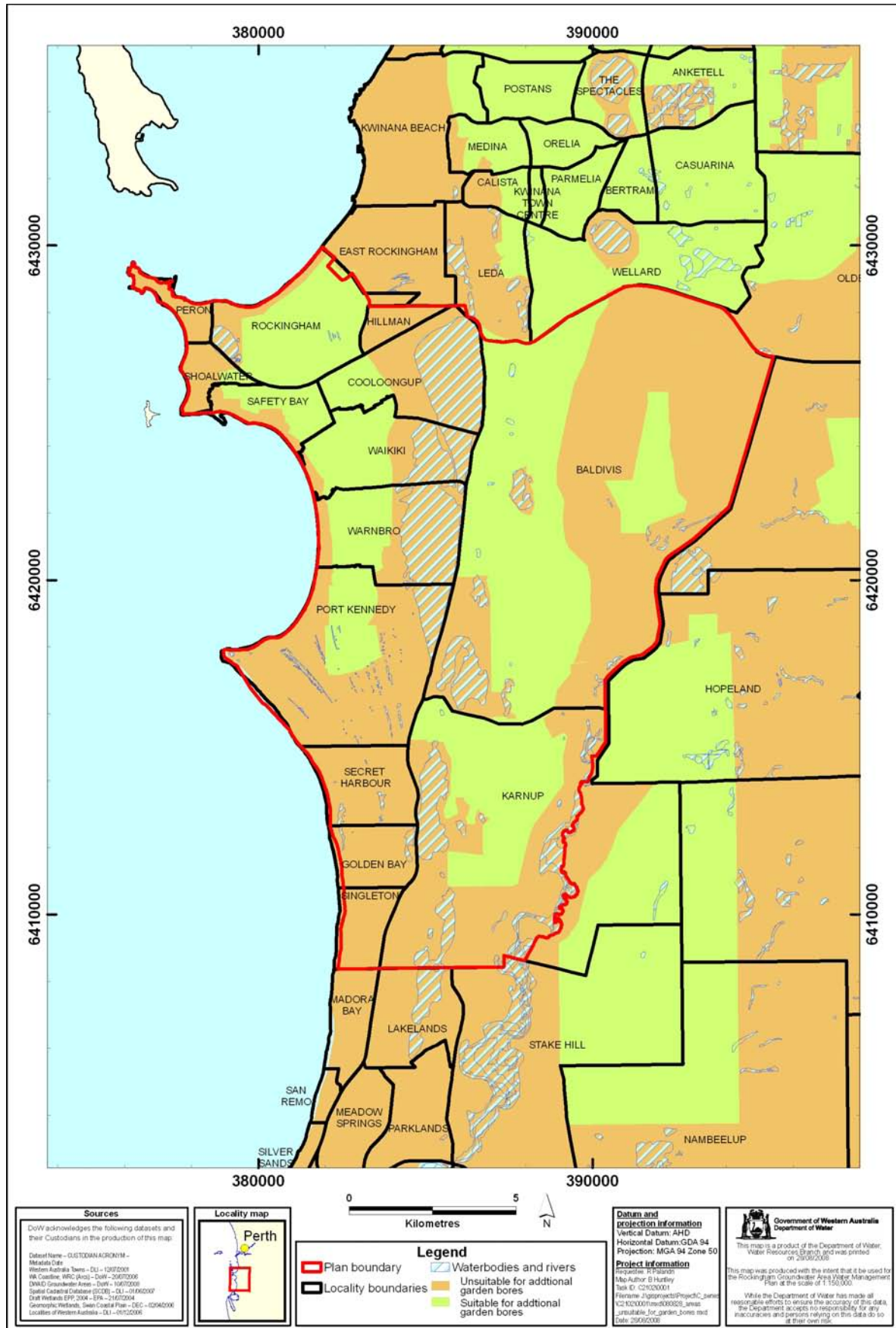


Figure 28 Garden-bore suitability for the plan area

7 Implementation and review

This Section describes how the Department of Water will implement, evaluate and review this plan to ensure the successful management of the Rockingham–Stakehill area’s water resources.

7.1 Implementing this plan

Actions required to implement this plan are summarised in Table 8 below. Responsibility for the actions rests with various sections of the department.

Table 8 Implementation actions, timeframes and deliverables

Action	Deliverables and timelines
Review the location of bores and draw points and identify which aquifer they are drawing from.	<i>2010–11</i> : Any local area specific information will be reported in the annual evaluation statement and a full review completed by 2010–11.
Update current acid sulfate soils risk map through review of existing information in the Rockingham–Stakehill area.	The Department of Water will work with the Department of Environment and Conservation to achieve this deliverable over the next three years.
Undertake domestic garden-bore surveys to account for unlicensed use.	Domestic garden-bore surveys are undertaken periodically, as required by the regional office. Information from rebate schemes is also used during this process. Any surveys completed will be reported in the annual evaluation statement.
Finalise the drilling investigation reports for the Lake Thompson bore series.	<i>2009</i> : As part of the monitoring review, the department will complete any outstanding drilling investigation reports.
Review current groundwater monitoring program, including an appropriate monitoring program for groundwater-dependent ecosystems and improving existing regional monitoring.	<i>2008–2009</i> : Statewide monitoring program review. <i>2009–2011</i> : Any monitoring required will be reported in the Kwinana–Peel regional monitoring program.
Amend boundaries of the proclaimed Rockingham, Stakehill and Serpentine groundwater areas to reflect the Rockingham–Stakehill area boundary.	<i>2011–2012</i> : The boundaries will be formally amended when the statutory water management plan (allocation) for the Rockingham–Stakehill area is completed.
Prepare an annual evaluation statement (see Section 7.2, page 59).	Annual evaluation statement produced and available on the Department of Water’s website.
Determine ecological water requirements for groundwater-dependent ecosystems and review allocation limits.	<i>2009–2011</i> : A report on the ecological water requirements of the Kwinana–Peel Region will be released when investigations are completed. This information will be used to review the allocation limits before the development of the statutory water management plan (allocation) in 2012.

7.2 Evaluating this plan

The department will release an evaluation statement for this plan annually. The statement will identify:

- the status of all actions required by the plan
- whether the management objectives are being met
- if any required responses have been triggered by changes in the condition or availability of the water resources.

The evaluation statement will be used to provide information on the status of the groundwater resources in terms of quantity and quality, as observed to the end of the water accounting year (1 July – 30 June), and identify any emerging issues relevant to the access and use of the groundwater resources in the Rockingham–Stakehill area.

The evaluation statement will include details on:

- the current level of licensed entitlements compared with the allocation limits set in this plan
- groundwater abstraction (from metering and water-use surveys) compared with the licensed entitlements
- the effectiveness of the management responses in meeting the management objectives of this plan
- a summary of the monitoring program (water-level trends, water quality).

7.3 Future planning in this area

A number of actions have been identified through the preparation of this plan which are beyond the scope of the current plan. It is the responsibility of the department to coordinate and prioritise the necessary work so that these actions are addressed in future plans. Any new issues that arise during the implementation of this plan will also be addressed in future plans and reported in the annual evaluation statement.

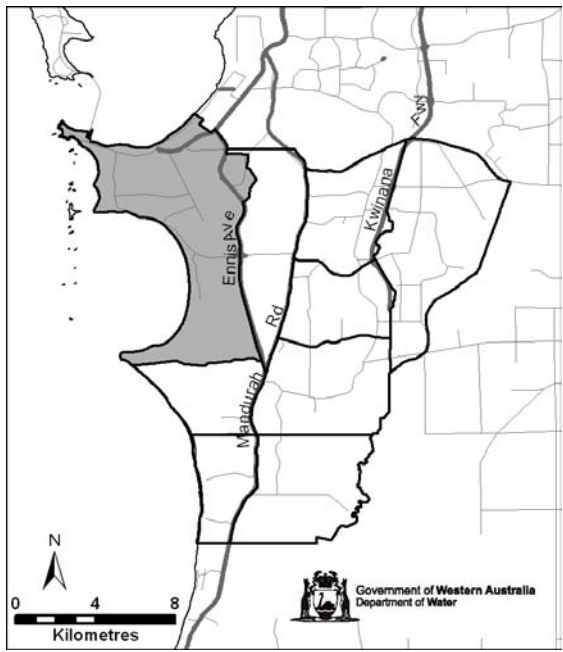
7.4 Reviewing this plan

Every year this plan will be evaluated through the evaluation statement. The statement may identify that the plan is still adequate for managing groundwater into the next year, or it may recommend that the plan be reviewed. A plan review will generally take place if the plan is not meeting its objectives or new information is available.

If no prior review is required, this plan will be reviewed and developed into a statutory water management plan (allocation) under the new water reform legislation by the end of 2011. Western Australia is currently updating and reviewing its legislation for the state's water resources. Any significant changes in legislation that may affect this plan will be noted and the necessary changes made.

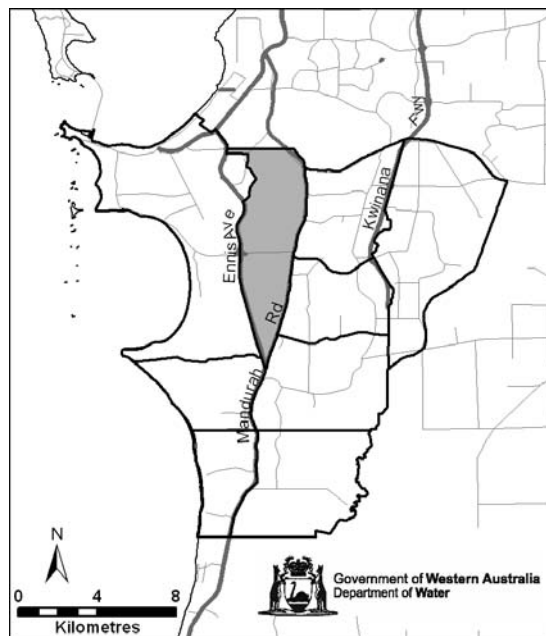
Appendices

Appendix A – Subarea reference sheets

Warnbro	
Subarea description	
Area	47.1 km ²
Proclamation	Rockingham groundwater area
Shire	City of Rockingham
Land and water use	<ul style="list-style-type: none"> The land use in the Warnbro subarea is mainly residential, with some other land uses such as public open space and nature conservation. Groundwater is mainly for use as irrigation water for public open spaces and recreational areas (including golf courses, ovals etc.); industry (5%); general agriculture (1%); and for households, stock and gardens (mainly for irrigation of lawns). Land use is unlikely to change as it is already heavily urbanised.
	
Key issues	<p>There is a seawater interface at the coast, so increased pumping near the coast may cause the interface to move inland. Low pumping rates are necessary.</p> <p>New water is only available from the unconfined aquifers (Superficial and Rockingham Sand). Low potential acid sulfate soil risk.</p>
Hydrogeology	
Aquifer	Description
Superficial	<p>The water table is shallow (about 2 m AHD) and the unconfined aquifer is up to 30 m thick, mainly consisting of clay limestone and sand. Recharge is mainly through infiltration of rainfall.</p> <p>Groundwater flow discharges into Lake Richmond, into the ocean and into the Rockingham Sand Aquifer through downward leakage.</p> <p>Seawater interface occurs along the coast, with groundwater salinity generally between 500–1000 mg/L TDS.</p>
Rockingham Sand	<p>Semi-unconfined aquifer located about 30–35 m below ground surface with a maximum depth of about 130 m.</p> <p>Recharge inferred to occur through the infiltration of rainfall, from the downward leakage of the Safety Bay Mound, and from lateral inflow from the Leederville Aquifer in the east.</p> <p>Discharges into the ocean over a seawater wedge that extends 7–8 km inland.</p> <p>Groundwater above the seawater interface varies in salinity from 250–700 mg/L TDS.</p>

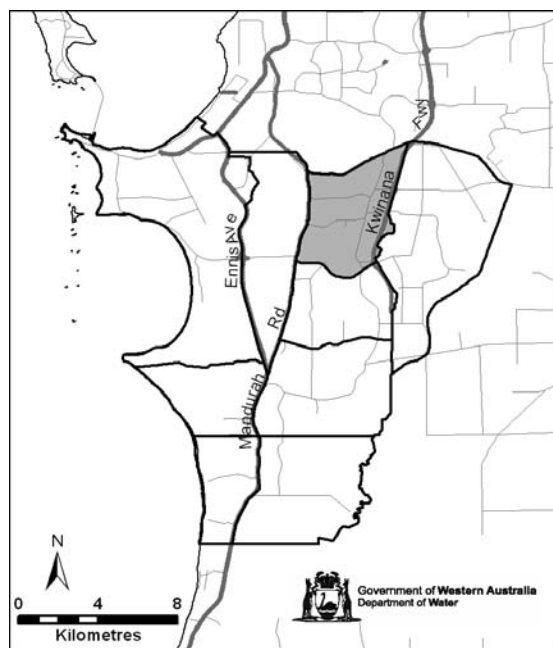
Warnbro				
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T280 (O)	Winter: stable; summer: decline (0.5m)	1975–2005	560 (1975)
	T280 (I)	Winter: stable; summer: decline (0.5m)	1976–2005	560 (1976)
	T330 (O)	Winter: stable; summer: decline (0.5m)	1975–2005	367 (1986)
	T330 (I)	Stable	1976–2005	450 (1981)
	T381	Stable	1997–2005	No data
	T381 (O)	Stable	2000–2005	No data
Rockingham Sand	T281	Winter: decline (0.5m); summer: stable	1977–2005	440 (1977)
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial–Rockingham Sand	7 800 000	1 344 998	830 000	Yes
Sites of significance				
Ecological sites	<p>There are four EPP wetlands in this subarea, including Lake Richmond and Becher Wetlands. The Becher Point wetlands are also a Ramsar-listed wetland area (listed in 2000, site no 5AU054).</p> <p>There are four Threatened Fauna sites recognised by the Department of Environment and Conservation, which consist of mammals and birds.</p> <p>There are 39 Threatened Ecological Communities in the Warnbro subarea, which are located around Lake Richmond, Port Kennedy and Point Becher.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Warnbro subarea are the Rotary Park of Rockingham and the Lake Richmond wetland (both permanent register). These sites are significant due to their relevance to man-made structures, fishing and mythology.</p> <p>The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	<p>There are three National Estate areas in the Warnbro subarea: Lake Richmond area, Port Kennedy area, Lake Cooloongup and Lake Walyungup and surrounds.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Warnbro subarea. Also see Appendix D on page 81 for licence process and assessment information.</p>				

Cooloongup				
Subarea description				
Area	22.0 km ²			
Proclamation	Rockingham groundwater area			
Shire	City of Rockingham			
Land and water use	<ul style="list-style-type: none"> The land use in the Cooloongup subarea is mainly conserved natural water bodies, with water used for the irrigation of public open space and a golf course. The Superficial Aquifer is the only licensed aquifer in the Cooloongup subarea. It is fully allocated and the licensed entitlements are predominantly for the service sector and industry use. Land use is unlikely to change as it is reserved as natural conserved water bodies. 			
Key issues	<p>High potential acid sulfate soil risk. The subarea is covered mostly by groundwater discharge lakes. Following finalisation of the pending licence applications all aquifers will be fully allocated, so no new groundwater is available. The management approach in this area is to prevent further use and eliminate use over time through natural attrition of licences — existing licenses will not be reallocated and trading is not permitted.</p>			
Hydrogeology				
Aquifer	Description			
Superficial	The water table is shallow (about 2 m AHD) and the unconfined aquifer is about 20 m thick, mainly consisting of clay limestone. Recharge is mainly through infiltration of rainfall. Groundwater flow discharges into Lake Cooloongup and Lake Walyungup, and into the Rockingham Sand Aquifer through downward leakage. Groundwater salinity is generally between 1000–2000 mg/L TDS.			
Rockingham Sand	The Rockingham Sand Aquifer is a semi-unconfined aquifer located about 30–35 m below ground surface with a maximum depth of about 130 m. Recharge occurs through the infiltration of rainfall, from the downward leakage of the Safety Bay Mound, and from lateral inflow from the Leederville Aquifer in the east. Discharges west of the subarea to the ocean. Groundwater above the seawater interface varies in salinity from 250–700 mg/L TDS.			
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	8282	Winter and summer: decline (0.5m)	1970–2005	No data
Rockingham Sand	No bores	No data	No data	No data

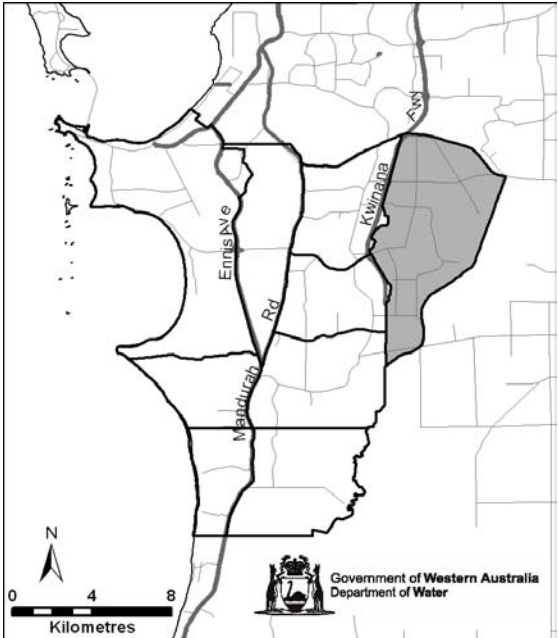


Cooloongup				
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial–Rockingham Sand	272 000	171 900	0	Limited availability
Sites of significance				
Ecological sites	<p>EPP wetlands in the Cooloongup subarea are Cooloongup Lake, Walyungup Lake, and Ennis Avenue/Walyungup Lake.</p> <p>There are nine Threatened Ecological Communities (TEC) in the Cooloongup subarea, which are associated with the wetlands that take up most of the area. Within the TEC there are five threatened bird sites and a mammal site, which are in need of monitoring for their protection.</p> <p>The majority of the Cooloongup subarea is classified as geomorphic wetlands, due to the presence of large wetlands.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Cooloongup subarea are scarred and modified trees on the northern boundary (interim register). This site has ceremonial, mythological, historical and many other reasons for its significance. The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	<p>There is one natural area of National Estate, which is lakes Cooloongup and Walyungup and surrounds, near Mandurah Road.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Cooloongup subarea. Also see Appendix D on page 81 for licence process and assessment information.</p>				

Tamworth Swamp				
Subarea description				
Area	19.2 km ²			
Proclamation	Stakehill groundwater area			
Shire	City of Rockingham			
Land and water use	<ul style="list-style-type: none"> Land use in the Tamworth Swamp subarea is mainly residential, with some manufacturing. The main groundwater source used in the Tamworth Swamp subarea is the Superficial Aquifer. It is used for horticulture (mainly growing vegetables – 46% of total allocation) and mining (34% from the one licence). Groundwater is also used for pasture (7%), general agriculture (5%), household, stock and gardens (3% – mainly irrigation of gardens), the service sector (3%), and industry (2%). Land-use change is likely with semi-rural areas changing to urban as Settlers Ridge development expands. 			
Key issues	The Superficial Aquifer is close to fully allocated, so groundwater availability is limited. Moderate to low potential acid sulfate soils risk. Further urbanisation may impact on groundwater availability.			
Hydrogeology				
Aquifer	Description			
Superficial	<p>The water table is shallow (about 2m AHD) and the unconfined aquifer is about 20 m thick, mainly consisting of clayey limestone.</p> <p>Recharge is mainly through infiltration of rainfall.</p> <p>Groundwater flow discharges into Lake Cooloongup, into the ocean and through downward leakage into the Rockingham Sand Aquifer.</p> <p>Groundwater salinity generally between 1000–2000 mg/L TDS.</p>			
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T290 (O)	Winter and summer: decline (1m and 1.3m)	1975–2005	1150 (1983)
	T340 (O)	Winter and summer: decline (1m and 1.3m)	1975–2005	770 (1986)
	T340 (I)	Winter: stable; summer: decline (0.7m)	1975–2005	1630 (1986)

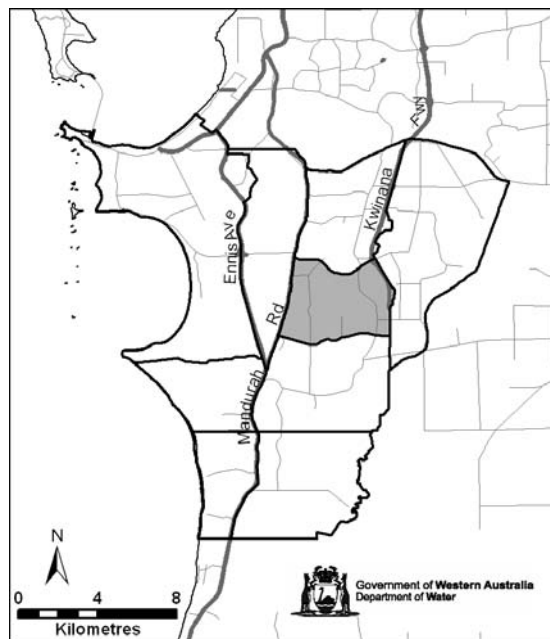


Tamworth Swamp				
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial	3 485 000	3 163 845	250 000	Limited
Sites of significance				
Ecological sites	<p>There are six EPP wetlands in the Tamworth Swamp subarea including Kerosene Lane Swamp, Spot Swamp, Tamworth Hill Swamp and Hollow Swamp.</p> <p>There are no identified threatened or rare biota in the subarea.</p>			
Cultural sites	<p>The Aboriginal site of significance in the Tamworth Swamp subarea is the Baldivis Road South area (archived data) due to the artefacts found there.</p> <p>The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	<p>There is one natural area of National Estate, which is lakes Coo loongup and Walyungup and surrounds, near Mandurah Road.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Tamworth Swamp subarea. Also see Appendix D on page 81 for licence process and assessment information.</p>				

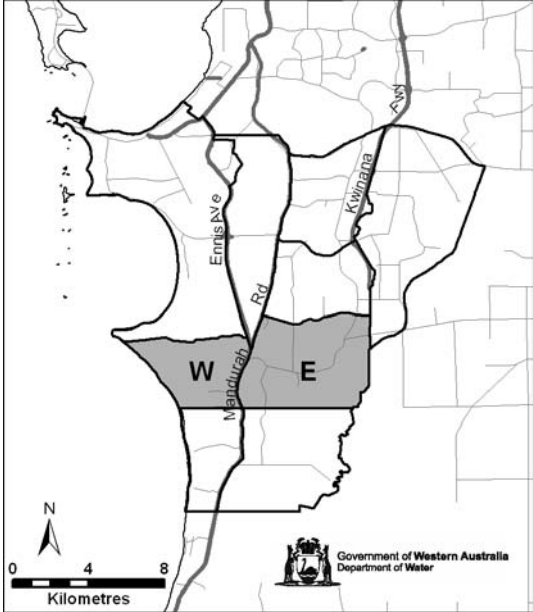
Maramanup				
Subarea description				
Area	36.9 km ²			
Proclamation	Stakehill groundwater area			
Shire	City of Rockingham			
Land and water use	<ul style="list-style-type: none"> The land use in the Maramanup subarea is mainly residential, with some intensive horticulture. The main aquifer used in the Maramanup subarea is the Superficial Aquifer and it is mostly used for pasture production (45% of total allocation), general agriculture (24%), and horticulture (19%). Groundwater is also used for households, stock and gardens (7%) and the service sector (4%). Land use may change from rural to semi-rural and urban with the construction of the Perth to Bunbury Highway. 			
				
Key issues	The Superficial Aquifer is close to fully allocated, so groundwater availability is limited. The clayey nature of the soils means that water quality and poor transmission are issues for abstraction. Moderate to high acid sulfate soils risk.			
Hydrogeology				
Aquifer	Description			
Superficial	<p>The water table is shallow (about 3 m AHD) and the unconfined aquifer is about 20 m thick, mainly consisting of clay limestone.</p> <p>Recharge is mainly through infiltration of rainfall and is limited due to the geology of the soil. Groundwater flow discharges into Lake Coo loongup, into the ocean and into the Rockingham Sand aquifer through downward leakage.</p> <p>Groundwater salinity is generally marginal to brackish between 1000–2000 mg/L TDS.</p>			
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T300	Stable	1975–2005	4050 (1980)
	T350	Winter: decline (0.5m); summer: stable	1975–2005	187 (1986)
	T400 (O)	Winter: stable; summer: decline (0.5m)	1975–2005	1910 (1986)
	T400 (I)	Winter: stable; summer: decline (0.5m)	1976–2005	2320 (1986)

Maramanup				
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial	1 956 000	1 289 880	470 000	Yes
Sites of significance				
Ecological sites	<p>There are seven EPP wetlands recognised in the Maramanup subarea. The area is mainly multiple-use geomorphic wetland palusplain (Hill et al. 1996).</p> <p>The main watercourse in the Maramanup subarea is the Serpentine River, which flows along its eastern boundary. The Folly River also runs through the area as a drain, along with other drains that run through the area.</p> <p>There is one threatened bird species in the Maramanup subarea.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Maramanup subarea are mainly the Serpentine River (permanent register), and the Folly Pool site (archived data).</p> <p>The Serpentine River is significant for its mythology and ceremonial importance, and the Folly Pool for its artefacts.</p> <p>The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	There are no National Estate or Heritage places in the Maramanup subarea.			
Other information				
Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Maramanup subarea. Also see Appendix D on page 81 for licence process and assessment information.				

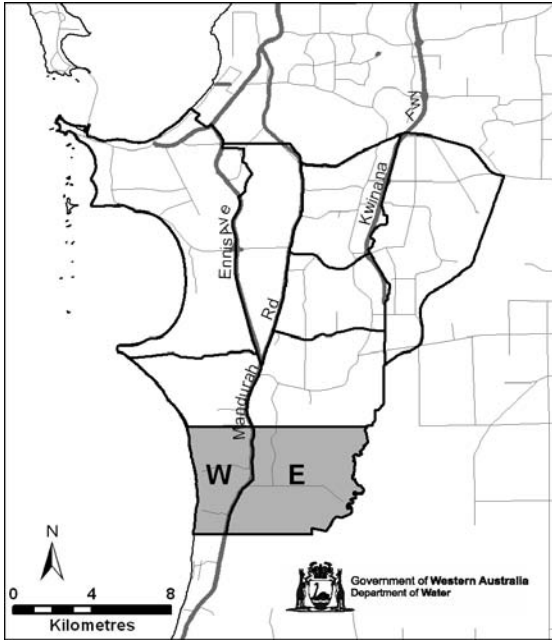
Outridge				
Subarea description				
Area	16.4 km ²			
Proclamation	Stakehill groundwater area			
Shire	City of Rockingham			
Land and water use	<ul style="list-style-type: none"> • The land use in the Outridge subarea is mainly residential, with some plantation forestry, irrigated perennial horticulture and services (recreation and culture). • A wide range of groundwater uses is present in the Outridge subarea, with main uses for horticulture (35% of total allocation – mostly for growing vegetables); the service sector (20% – mostly for irrigation of public open spaces), mining (17%); and pasture (13%). • Groundwater is also used for general agriculture (6%), households, stock and gardens (4%), industry (3%), and viticulture (2%). • Land-use change is likely with semi-rural areas changing to urban as Settlers Ridge development expands. 			
Key issues	The Superficial Aquifer is close to fully allocated, so groundwater availability is limited. Further urbanisation may impact on groundwater availability.			
Hydrogeology				
Aquifer	Description			
Superficial	<p>The water table is shallow (about 2 m AHD) and the unconfined aquifer is about 25 m thick, mainly consisting of clayey limestone. Groundwater is recharged mainly through infiltration of rain. Groundwater flow discharge occurs radially to the coast, into the Serpentine River, Lake Walyungup and through downward leakage into the Rockingham Sand Aquifer.</p> <p>Salinity varies between 500–1000 mg/L TDS; some areas associated with wetlands exceed 1000 mg/L TDS.</p>			
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T390 (O)	Winter and summer: decline (0.6m and 1m)	1975–2005	960 (1986)
	T390 (I)	Winter and summer: decline (0.6m and 1m)	1976–2005	430 (1986)



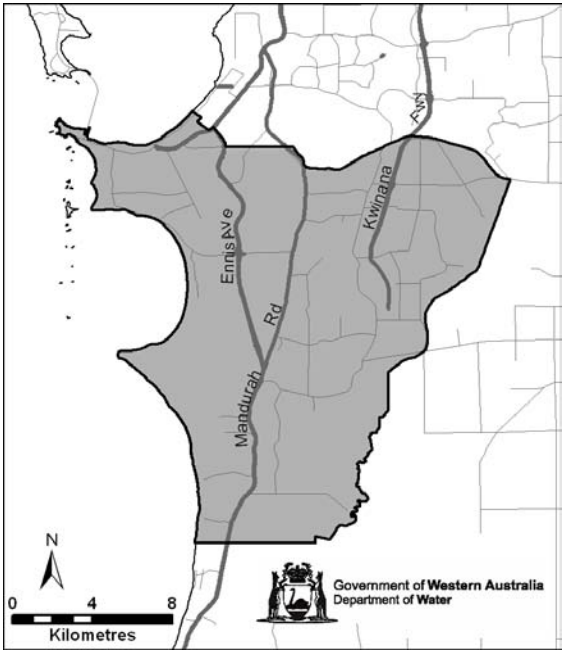
Outridge				
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial	2 456 000	2 112 770	210 000	Limited
Sites of significance				
Ecological sites	<p>There are three EPP wetlands in the Outridge subarea including Outridge Swamp and Fount Swamp.</p> <p>There is one threatened bird species in the Outridge subarea.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Outridge subarea are at Baldivis: Baldivis Road and Eighty Road. These sites are significant due to the artefacts found there.</p> <p>The Native Title claim in the area is the Gnaala Karla Booja Claim.</p>			
Social sites	<p>There are no National Estate or Heritage places in the Outridge subarea.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Outridge subarea. Also see Appendix D on page 81 for licence process and assessment information.</p>				

Churcher (East and West)	
Subarea description	
Area	40.0 km ²
Proclamation	Rockingham and Stakehill groundwater areas
Shire	City of Rockingham
Land and water use	<ul style="list-style-type: none"> • Land use in the Churcher subareas is mainly residential, services, conserved natural water bodies, grazing and improved pastures, with some mining, irrigated perennial horticulture and cropping land-use present. • The main aquifer used in the Churcher subareas is the Superficial Aquifer. It is used for horticulture (49% of total allocation – mainly vegetables and other uses such as orchards, avocados and olive trees), the service sector (23%), and pasture (23%). • A small amount of groundwater is used from the Rockingham Sand Aquifer (West) for households, stock and gardens (35%); pasture (33%); and horticulture (32%).
	 <p style="text-align: center;">W = Churcher West E = Churcher East</p>
Key issues	There is a seawater interface at the coast (Churcher West), so increased pumping near the coast may cause the interface to move inland. The subarea has significant ecological features (Churcher West). Further water demand is also limited by Churcher West being predominantly part of the National Estate and Churcher East predominantly rural and special rural zoning. All aquifers are fully or over-allocated, so no new groundwater is available.
Hydrogeology	
Aquifer	Description
Superficial	The water table is shallow (about 2 m AHD) and the unconfined aquifer is about 25 m thick, mainly consisting of clayey limestone and sand. Recharge is mainly through infiltration of rainfall. Groundwater flow discharge occurs radially to the coast, into the Serpentine River, Lake Walyungup and through downward leakage into the Rockingham Sand Aquifer. Groundwater flow also contributes to water levels in wetlands such as the Becher wetlands and Stakehill, Anstey and Churcher swamps. Seawater interface occurs along the coast, with groundwater salinity generally between 500–1000 mg/L TDS.
Rockingham Sand	Semi-unconfined aquifer located about 30–35 m below ground surface with a maximum depth of about 130 m. Recharge inferred to occur through the infiltration of rainfall, from the downward leakage of the Safety Bay Mound, and from lateral inflow from the Leederville Aquifer in the east. Discharges into the ocean over a seawater wedge that extends 7–8 km inland. Groundwater above the seawater interface varies in salinity from 250–700 mg/L TDS.

Churcher (East and West)				
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T480	Winter and summer: decline (1m and 1.5m)	1975–2005	330 (1980)
	T430 (O)	Winter and summer: decline (0.8m and 0.7m)	1975–2005	1130 (1986)
	T430 (I)	Winter: stable; summer: decline (0.7m)	1977–2005	780 (1986)
	T490	Winter and summer: decline (1m and 1m)	1975–2005	1560 (1978)
	T440	Winter and summer: decline (1m and 1m)	1975–2005	310 (1986)
Rockingham Sand	T441	Winter and summer: decline (0.6m and 1m)	1977–2005	690 (1977)
	T481	Winter: stable; summer: decline (0.7m)	1977–2005	300 (1977)
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial–Rockingham Sand (East)	3 672 000	3 820 983	147 000	No – over allocated
Superficial–Rockingham Sand (West)	1 849 000	1 244 700	343 000	Limited
Sites of significance				
Ecological sites	<p>There are 13 EPP wetlands across the Churcher subareas. These include Stakehill Swamp, Churcher Swamp, Secret Swamp-Peelhurst, Point Becher Wetland, Lark Hill and Surf Road. The Serpentine River is the main watercourse in the area, and runs along the eastern boundary of the Churcher subareas.</p> <p>There are 29 Threatened Ecological Communities in the Churcher subareas, which are mainly associated with the Point Becher wetland areas. One taxon of Threatened Fauna (a mammal) has been identified in the Churcher subareas, which is associated with Anstey Swamp.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Churcher subareas are Sixty-eight Road, Baldivis and the Serpentine River. These are significant due to artefacts and ceremonies and mythology respectively. The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	<p>The subarea is part of the Natural Heritage Trust Metro Regional Area. There is one natural area of National Estate in the Churcher West subarea, which is the Port Kennedy Area. There are no National Heritage places in the subarea.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Churcher East and West subareas. Also see Appendix D on page 81 for licence process and assessment information.</p>				

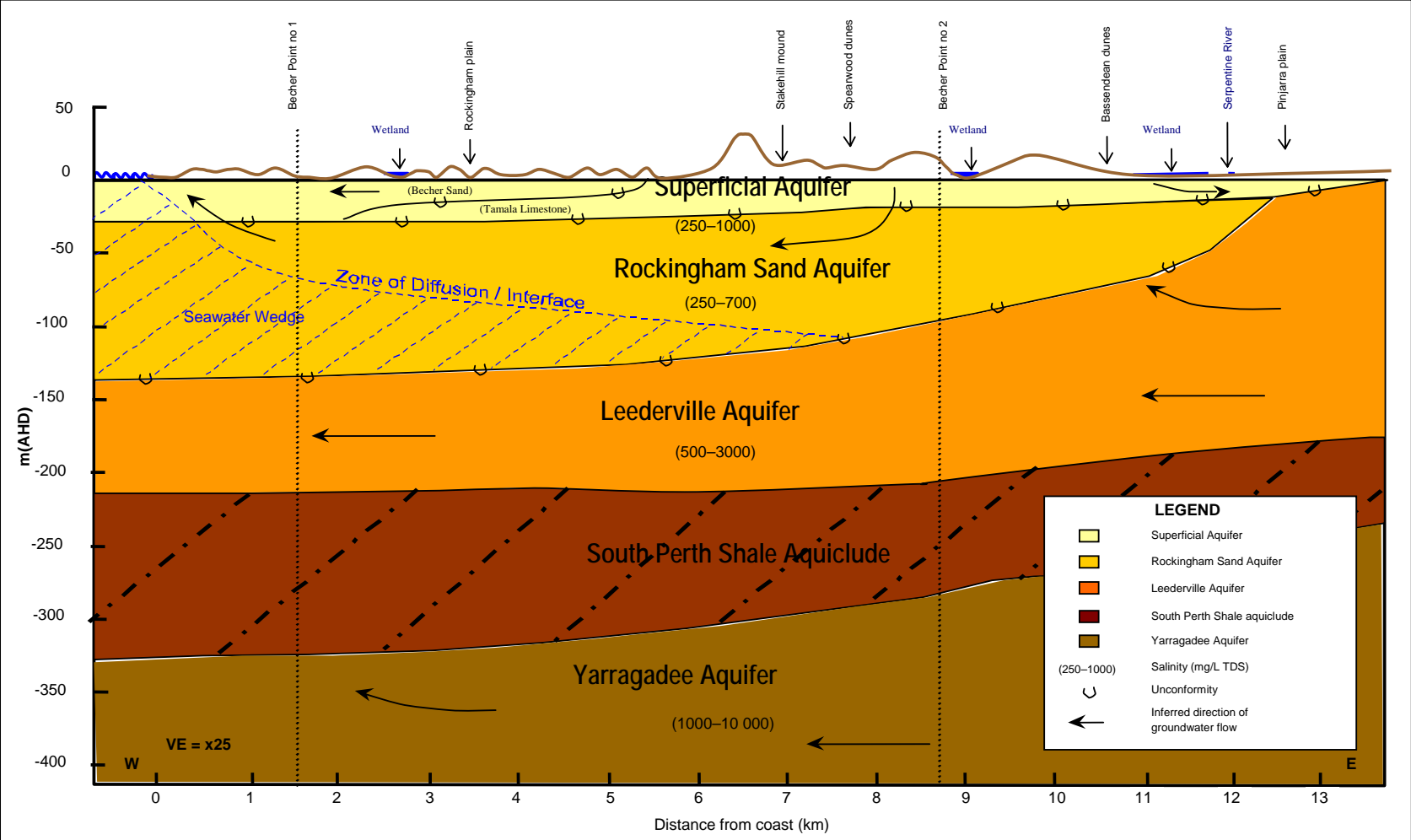
Karnup (East and West)	
Subarea description	
Area	37.2 km ²
Proclamation	Rockingham and Stakehill groundwater areas
Shire	City of Rockingham
Land and water use	<ul style="list-style-type: none"> The Karnup subareas contain a mix of residential and agricultural land uses such as dryland cropping, and fruit and vegetable production. A conserved natural water body also exists in the subarea. This subarea only draws from the Superficial Aquifer at present, mainly for horticulture (41% of total allocation), general agriculture (14%), the service sector (13% – mainly recreational and public open spaces), and pasture (11%). Groundwater is also used for industry (9%), households, stock and gardens (8%), and viticulture (3%).
	 <p>W = Karnup West E = Karnup East</p>
Key issues	<p>There is a seawater interface at the coast, so increased pumping near the coast may cause the interface to move inland.</p> <p>Groundwater is only available in the unconfined aquifers (Superficial and Rockingham Sand) in the Karnup West area and the Superficial Aquifer in the Karnup East subarea.</p>
Hydrogeology	
Aquifer	Description
Superficial	<p>The water table is shallow (about 2 m AHD) and the unconfined aquifer is about 25 m thick, mainly consisting of clayey limestone and sand. Recharge is mainly through infiltration of rainfall.</p> <p>Discharge occurs west to the coast and east into the Serpentine River, through downward leakage into the Rockingham Sand Aquifer and through evapotranspiration from wetlands such as the Anstey and Paganoni swamps.</p> <p>Seawater interface occurs along the coast, with groundwater salinity generally between 500–1000mg/L TDS.</p>
Rockingham Sand	<p>Semi-unconfined aquifer located about 30–35 m below ground surface with a maximum depth of about 130 m.</p> <p>Recharge inferred to occur through the infiltration of rainfall, from the downward leakage of the Safety Bay Mound, and from lateral inflow from the Leederville Aquifer in the east.</p> <p>Discharges into the ocean over a seawater wedge that extends 7–8 km inland. Groundwater above the seawater interface varies in salinity from 250–700 g/L DS.</p>

Karnup (East and West)				
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Superficial	T530 (O)	Winter and summer: decline (0.7m and 1m)	1975–2005	1220 (1978)
	T530 (I)	Winter: stable; summer: decline (0.6m)	1977–2005	1460 (1977)
	T540	Winter and summer: decline (0.7m and 1m)	1975–2005	160 (1986)
Rockingham Sand	-	none	-	-
Allocation and water availability (as at July 2008) (kL/yr)				
Aquifer	Allocation limit	Licensed water entitlements	Estimated exempt water use	Available water
Superficial–Rockingham Sand (East)	1 636 000	1 749 245	92 000	No
Superficial–Rockingham Sand (West)	1 200 000	104 115	368 000	Yes
Sites of significance				
Ecological sites	<p>There are 15 EPP wetlands in the Karnup subareas including Anstey Q Swamp, Anstey Swamp, Fletcher Road Swamp, Small Swamp, Zed Swamp and Woodlands Road Golden Bay wetland.</p> <p>There is one Declared Rare Flora species found in the Karnup East subarea, present at the wetland in the south-east corner of the subarea.</p> <p>There are nine Threatened Ecological Communities present in the Karnup subarea, which are associated with Anstey Q wetlands and swamps, Point Becher wetlands, and Woodlands Road Golden Bay wetland.</p> <p>There is one endangered fauna species in the Karnup East subarea, which is listed by the Department of Environment and Conservation as Threatened Fauna.</p> <p>The main watercourse in the area is the Serpentine River, which flows along the eastern border of the Karnup subarea.</p>			
Cultural sites	<p>The Aboriginal sites of significance in the Karnup subarea are the Serpentine River, Golden Bay Turtle Swamp, Golden Bay camp 2, Lake Amarillo, and the Stake Hill Burial. These are important for their artefacts, ceremonial and mythological significance.</p> <p>The Native Title claim in the area is the Gnaala Karla Booja claim.</p>			
Social sites	<p>There are two National Estate places in the Karnup subarea that are listed for natural purposes: Port Kennedy Area and Paganoni Swamp and adjacent areas, near Paganoni Road.</p>			
Other information				
<p>Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Karnup East and West subareas. Also see Appendix D on page 81 for licence process and assessment information.</p>				

Rockingham–Stakehill confined		
Subarea description		
Area	218.8 km ²	
Proclamation	Rockingham and Stakehill groundwater areas	
Shire	City of Rockingham	
Land and water use	<ul style="list-style-type: none"> • The Rockingham–Stakehill confined subarea covers the whole of the Rockingham and Stakehill groundwater areas. • The Leederville Aquifer is predominantly used for irrigation of public open space, industrial use and pasture production; with limited use for horticulture, general agriculture, and household, stock and gardens. • The Yarragadee Aquifer is not used in this groundwater area. 	
Key issues	The Leederville and Yarragadee aquifers are over-allocated and no new water is available for licensing.	
Hydrogeology		
Aquifer	Description	
Leederville	Warnbro, Churcher and Karnup subareas	Confined to semi-confined aquifer that occurs about 130 m below ground surface, with a thickness of about 70 m.
	Cooloongup subarea	Semi-confined aquifer that occurs about 50–130 m below ground surface (minimum 70 m thick).
	Tamworth Swamp, Maramanup and Outridge subareas	Semi-confined aquifer that occurs at depths from 20–50m below ground surface (about 200 m thick).
	<p>Recharge occurs outside the Rockingham GWA, east of Serpentine River. Discharge occurs into the Rockingham Aquifer and west of the subarea to the ocean.</p> <p>Groundwater salinity is mainly 500–1000 mg/L TDS except in the north where it is up to 3000 mg/L TDS, with salinity generally increasing towards the coast where the salt-water interface exists.</p>	
Yarragadee	<p>The Yarragadee Aquifer is a confined aquifer that is confined beneath the South Perth Shale at a depth of 250–350 m below ground surface. Recharge occurs outside of the Rockingham groundwater area along the eastern edge of the Swan coastal plain. Discharge is inferred to occur offshore.</p> <p>Groundwater salinity ranges from about 1000–10 000 mg/L TDS to about 500 m below the base of the South Perth Shale, with the seawater interface likely to occur well offshore.</p>	

Rockingham–Stakehill confined				
Groundwater monitoring				
Aquifer	Monitoring bore	Water-level behaviour	Period of record	Salinity (mg/L TDS) (year)
Leederville	AM57A	Winter and summer: decline (2m and 2.5m)	1983–2005	810 (1989)
	AM62A	Winter and summer: decline (1.3m and 2.6m)	1981–2005	619 (1984)
	AM58A	Winter and summer: decline (2m and 2.5m)	1981–2005	840 (1989)
	SH1	Winter and summer: decline (1.6m and 2.1m)	1984–2005	1052 (1991)
Yarragadee	AM54	Decline (12m)	1981–2005	2760 (1984)
	AM57	Decline (9m)	1977–2005	2430 (1989)
	AM62	Decline (7m)	1980–2005	1830 (1984)
	AM58	Decline (12m)	1977–2005	1750 (1989)
Allocation and water availability (as at July 2008)				
Aquifer	Allocation limit (kL/yr)	Licensed water entitlements (kL/yr)	Estimated exempt water use (kL/yr)	Available water
Leederville	820 000	1 014 839	0	No
Yarragadee	0	0	0	No
Sites of significance				
Ecological sites	There are currently no identified sites of ecological significance in the plan area that rely on the Leederville or Yarragadee aquifers.			
Cultural sites	There are currently no identified sites of cultural significance in the plan area that rely on the Leederville or Yarragadee aquifers.			
Social sites	There are currently no identified sites of social significance in the plan area that rely on the Leederville or Yarragadee aquifers.			
Other information				
Refer to Section 6.2 on page 47 for the policies and rules that are applicable to the Rockingham–Stakehill confined aquifers subarea. Also see Appendix D for licence process and assessment information.				

Appendix B – Hydrogeological cross-section



From Rockwater, 2000

Figure B1 Hydrogeological cross-section

Appendix C – Wetlands

Wetlands within the study area boundary were identified from Semeniuk (1991) in conjunction with Hill et Al. (1996). Wetlands within the Rockingham–Stakehill area classified under any of the following headings were summarised (see Table C1 below) in:

- monitored by the Department of Water
- Environmental Protection (Swan coastal plain lakes) Policy 1992 (Environmental Protection Authority, 1999)
- Conservation Category (Hill et Al. 1996)

Table C1 Summary of classified wetlands within the study area

Wetland name/no.	Geomorphic setting	Suite ¹	DoW monitored	EPP lakes	Hill et al. 1996 category ²	Hill et al. 1996 map ref	Selected for EWR
Lake Cooloongup	Quindalup Dunes	Q1	x	x	C	2033 II NW 15	Y
Lake Richmond	Quindalup Dunes	Q1	x	x	C	2033 III NE 1	Y
Walyungup Lake	Quindalup Dunes	Q1	x	x	C	2033 II NW 14	Y
Anstey Q Swamp	Quindalup Dunes	Q2		x	C	2033 III NE 16	
Becher Wetlands	Quindalup Dunes	Q2			C	2033 III NE	Y
CC116S	Pinjarra Plains	R2		x	R	2033 II SW 67	
CC119S	Pinjarra Plains	R2		x	R	2033 II SW 62	
CC120S	Pinjarra Plains	R2		x	R	2033 II SW 121	
CC123S	Pinjarra Plains	R2		x	C	2033 II SW 117	
CC125S	Pinjarra Plains	R2		x	R	2033 II SW 60	
Folly Pool	Pinjarra Plains	R2	x		R	2033 II NW 45	Y
Maramanup Pool	Pinjarra Plains	R2	x		R	2033 II NW 46	
Beenyup Pool	Pinjarra Plains	R4		x	C	2033 II SW 61	
Anstey Swamp	Spearwood Dunes	S4	x	x	C	2033 II SW 32	Y
Baldivis Swamp	Spearwood Dunes	S4		x	C	2033 II NW 24	
Churcher Swamp	Spearwood Dunes	S4	x	x	C	2033 II SW 54	
Deerpark	Spearwood	S4		x	M	2033 II	

Wetland name/no.	Geomorphic setting	Suite ¹	DoW monitored	EPP lakes	Hill et al. 1996 category ²	Hill et al. 1996 map ref	Selected for EWR
Swamp	Dunes					SW 42	
Fletcher Swamp	Spearwood Dunes	S4		x	C	2033 II SW 41	
Hidden Swamp	Spearwood Dunes	S4		x	C	2033 II SW 123	
Kerosene Lane Swamp	Spearwood Dunes	S4		x	C	2033 II NW 32	
Outridge Swamp	Spearwood Dunes	S4		x	C	2033 II NW 21	
Paganoni	Spearwood Dunes	S4	x	x	C	2033 II SW 35	Y
Pike Road Swamp	Spearwood Dunes	S4	x		R	2033 II NW 22	
Small Swamp	Spearwood Dunes	S4		x	C	2033 II SW 48	
StakeHill Swamp East	Spearwood Dunes	S4		x	C	2033 II NW 17	Y
Tamworth Hill Swamp	Spearwood Dunes	S4		x	C	2033 II SW 33	Y

Notes:

1 Q1 Coo loongup Suite, Q2 Becher Suite, Q3 Peelhurst Suite, R2 Swan River Suite, R4 Goegrup Suite, S4 Stakehill Suite (Semeniuk, 1991)

2 C = Conservation, R = Resource Enhancement, M = Multiple Use, NA = Not Assessed (Hill et al. 1996)

Of the 26 wetlands listed within the Rockingham–Stakehill area, 18 are classified as Conservation Category wetlands and all but four are protected under the *Environmental Protection (Swan coastal plain lakes) Policy 1992* (Environmental Protection Authority, 1999). The policy prohibits unauthorised filling, mining, drainage into or out of, and effluent discharge into specific wetlands identified in the policy. Wetlands identified in this policy have the highest level of protection under the Environmental Protection Act. There is one Ramsar-listed wetland (Point Becher). The ecological values of these wetlands are becoming increasingly important as similar habitats throughout the area are being impacted.

Appendix D – Processing a licence application

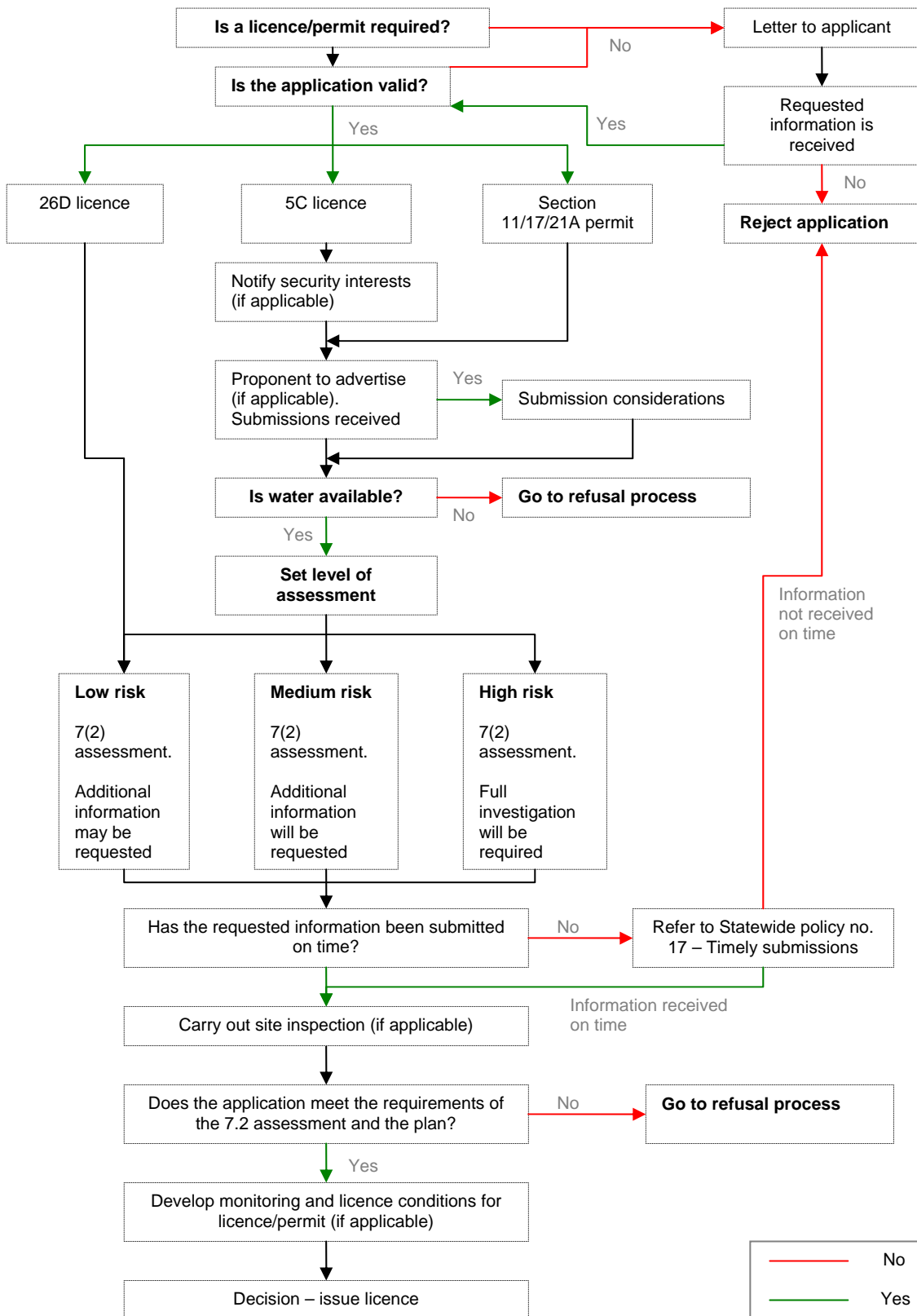


Figure D1 Flow chart for processing a licence application

Protocols for groundwater allocation

Application for a groundwater well licence

The process of assessing a groundwater licence application commences when an application for a groundwater well licence is submitted to the Department of Water on the prescribed form, in accordance with Schedule 1, clause 4 of the *Rights in Water and Irrigation Act 1914*.

An application is required when the bore (well) is defined as artesian under s. 26A of the *Rights in Water and Irrigation Act 1914* or the property upon which a non-artesian bore is to be situated lies within a groundwater area proclaimed under s. 26B of the *Rights in Water and Irrigation Act 1914*. Stock and domestic use in the Rockingham–Stakehill area, from a non-artesian bore, is exempt from a licence to take groundwater (5C licence).

Under these circumstances, an applicant must gain approval in the form of a licence to construct or alter a well (26D licence) to commence constructing, enlarging, deepening, altering or drawing groundwater from any bore (see Table 6, page 48). A person in breach of these requirements, or found to be in contravention of a licence condition, may incur a fine.

Licence approval process

The legislative requirements for assessing applications are stated in the *Rights in Water and Irrigation Act 1914* and the Act's Regulations. Applications for licences made under Division 2 of schedule 1 of the *Rights in Water and Irrigation Act 1914* will be accepted by the department and either granted or refused at the discretion of the department in accordance with clause 7(1). In exercising that discretion, the department is to have regard to all matters that it considers relevant in accordance with clause 7(2).

In an urgent situation where a new or replacement bore, or alteration to a bore, is required to minimise loss of production, the department will consider 26D licence applications in priority. The applicant would need to make the department aware that the construction work is critical. This applies to 26D licence applications only. Applications to amend 5C licences would need to be treated on an 'as received' basis for equity reasons.

Issue of groundwater licences

Licences are issued when the department's assessment process has been satisfied. A licence entitlement is not an implied guarantee that the quantity (and quality) of water will always be available.

The department may issue a groundwater exploration licence for a period up to 12 months. Licences for exploration purposes (issued under s. 26D of the *Rights in Water and Irrigation Act 1914*) allow applicants to construct bore(s), investigate whether there is sufficient water available to meet the requirements of their

development plan and determine any likely impacts caused by pumping. This is particularly important where licensees are contemplating purchasing an entitlement on the trading market in a fully allocated area. The department gives no guarantee that a licence to take water (under s. 5C of the *Rights in Water and Irrigation Act 1914*) will be issued at the completion of the investigation.

The department's Kwinana–Peel Region can approve and issue a groundwater well licence directly if the assessment has considered all matters required in Schedule 1 clause 7(2), adequate water is available, and the assessment indicates that the taking of water is consistent with the departmental policies and does not adversely affect the environment or other users.

Refusal of groundwater licences

The department may make a decision to refuse a licence after undertaking an assessment in accordance with the requirements of Schedule 1 clause 7(2), if the taking of water is inconsistent with policies or plans applying in the area, or if it may cause significant adverse impacts to the aquifer, environment or existing users.

Applications must be refused if the department considers that an applicant would not be willing or able to comply with terms, conditions and restrictions included in a licence. A licence must also be refused if the department is not satisfied that the applicant has the resources, including financial, to carry out the activity, or if a person has a prior conviction under the *Rights in Water and Irrigation Act 1914*.

Appeals relating to groundwater licences

Applicants aggrieved by a departmental decision relating to a refusal of a licence or transfer of entitlement, or the period for which a licence is granted or any condition or restriction in a licence, may apply to the State Administrative Tribunal (SAT) for a review of the decision. Further details can be found in s. 26GG of the *Rights in Water and Irrigation Act 1914*.

Compliance and monitoring of resources and licences

Given the high level of allocation in the Rockingham–Stakehill area, compliance and monitoring are very important for management. Site inspections and water-use surveys may be undertaken periodically to assess compliance of in situ development with licensed activities. Unused entitlements are managed in accordance with the department's Statewide policy no. 11 – Management of unused licensed water entitlements (WRC 2003a).

Action will be taken to address overuse and non-compliance with the terms of the licence on a case-by-case basis depending on the circumstances of the non-compliance.

Reallocation of entitlements

Where existing entitlements remain, either wholly or partly, unused for a significant period of time or the applicant proposes to reduce their allocation, then the water may be recouped as per the department's Statewide policy no. 11 – Management of unused licensed water entitlements (WRC 2003a). Recouped water may become available for reallocation to consumptive use or to the environment.

Renewal of existing licences

Groundwater licences to take water are valuable documents that should be kept in a safe place and not allowed to expire. The department will endeavour to notify licence holders in advance of expiry; however, it is the licence holder's responsibility to make an application to extend the term of the existing licence before the expiry date.

Generally, when a licence to take water is due to expire, and the licensee has abided by all the licence conditions, the licence will normally be extended for a further period. However, if an application for a licence to take water expires or the licensee has not abided by all the licence conditions, there is no guarantee that the term of the licence will be extended automatically.

The licensee will need to show why the term and conditions of the licence in its entirety should be extended or the licensee may need to apply for a new licence. If a licensee has not abided by all the licence conditions in a fully allocated subarea, the licence is unlikely to be extended without demonstrated extenuating circumstances.

Applications for increasing an existing entitlement

Existing licensees may require additional groundwater to expand operations, which will require an amendment to their licence. The proposed increased abstraction will require assessment to ensure that the taking of water is consistent with departmental policies and does not adversely affect the environment or other users.

Rights in Water and Irrigation Exemption and Repeal (section 26C) Order 2001

The Order is made by the Lieutenant-Governor and deputy of the Governor in Executive Council under s. 26C of the Act.

Citation

This order may be cited as the Rights in Water and Irrigation Exemption and Repeal (section 26C) Order 2001.

Application

This order applies to all parts of the state that are proclaimed areas for the purposes of s. 26B of the Act, other than:

- the Albany groundwater area
- that part of the Gascoyne groundwater area in the North-West Cape north of south latitude 22.5 degrees.

Exemptions from sections 5C and 26B(3) to (6)

Sections 5C and 26B (3) to (6) of the Act do not apply in relation to a non-artesian well if:

- the only water that can be taken from the well is from the watertable aquifer
- water taken from the well is used only in accordance with clause 4.

Use of water

- 1 Water taken from a well referred to in Clause 3 may be used for:
 - fire fighting
 - watering cattle or other stock, other than those being raised under intensive conditions as defined in s. 21(4) of the Act
 - watering an area of lawn or garden that does not exceed 0.2 ha, subject to subclauses (2) and (3)
 - other ordinary domestic uses.
- 2 A lawn or garden is not to be watered by use of a sprinkler at any time during the hours of 9 am to 6 pm. Watering is restricted to three days per week.

Subclause (2) does not apply in respect of a lawn for a period of 28 days from when the lawn was planted. In this instance the times must be registered with the Department of Water by calling 1800 508 885 and selecting option 2 or calling the Waterwise Helpline on 13 10 39.

Appendix E – Other plans and legislation to be considered

Plans to be considered

Plan	Consideration	Department
State water plan 2007	Strategic direction	DoW
Perth–Peel regional water plan	Strategic direction, Perth to Peel community issues, overarching water management issues	DoW
Better managing the urban water cycle – the urban drainage initiative (2007)	Urban water drainage and management for better urban design	DoW
Baldivis-Karnup drainage water management plan [Draft]	Water management plan for drainage in the Baldivis-Karnup area	DoW
Better urban water management	Urban water management for public amenities and urban design	DPI
City of Rockingham town planning scheme no 2 (2005)	Town planning scheme for the City of Rockingham	DPI
Metropolitan region scheme (2007)	Statutory planning scheme for land use	WAPC
South West corridor structure plan (1993)	Land-use zoning and planning	WAPC
Peel–Harvey catchment natural resource management plan (2005)	Natural resource management plan for the Peel-Harvey catchment area	PHCC

DoW = Department of Water

DPI = Department of Planning and Infrastructure

PHCC = Peel–Harvey Catchments Council

WAPC = Western Australian Planning Commission

Legislation to be considered

Commonwealth legislation

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- *Commonwealth Environmental Protection and Biodiversity Act 1999*
- *National Environmental Protection Council Act 1994*
- *Natural Heritage Trust Act of Australia 1997*
- *National Water Commission Act 2004*
- *World Heritage Properties Conservation Act 1995*

State legislation

- *Aboriginal Heritage Act 1972*
- *Conservation and Land Management Act 1984*
- *Contaminated Sites Act 2003*
- *Country Areas Water Supply Act 1947*
- *Environmental Protection Act 1986, amendment 1998*
- *Environmental Protection Regulations 1987*
- *Heritage of Western Australia Act 1990*
- *National Trust of Australia (WA) Act 1964*
- *Native Title (State Provisions) Act 1999*
- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Rights in Water and Irrigation Act 1914, Regulations 2000*
- *Soil and Land Conservation Act 1945, Regulations 1992*
- *State Administrative Tribunal Act 2004*
- *Town Planning and Development Act 1928*
- *Water Agencies (Powers) Act 1984*
- *Water and Rivers Commission Act 1995*
- *Waterways Conservation Act 1976*
- *Western Australian Planning Commission Act 1985*
- *Wildlife Conservation Act 1950, Regulations 1970*

Shortened forms

AHD	Australian height datum
AM series	Artesian Monitoring bores
EWP	environmental water provision
EWR	ecological water requirement
GDE	groundwater-dependent ecosystem
PRAMS	Perth regional aquifer modelling system
T series	Thomson’s Lake series
TDS	total dissolved salts

Volumes of water

Volumes of water are measured in litres. Different volumes of water are referred to in this document.

One litre	1 litre	1 litre	(L)
One thousand litres	1 000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 Megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 Gigalitre	(GL)

Glossary

Abstraction	The permanent or temporary withdrawal of water from any source of supply, so that it is no longer part of the resources of the locality.
Allocation limit	The amount of water set aside for annual licensed and unlicensed use.
Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water. Usually described by whether they consist of sedimentary deposits (sand and gravel) or fractured rock. Aquifer types include unconfined, confined and artesian.
Artesian aquifer	A confined aquifer in which the hydraulic pressure will cause water to rise in a bore or spring above the land surface. If the pressure is insufficient to cause the well to flow at the surface, it is called a sub-artesian aquifer.
Australian height datum (AHD)	The datum used for the determination of elevations in Australia. The determination used a national network of benchmarks and tide gauges, and set mean sea level as zero elevation.
Confined aquifer	An aquifer lying between confining layers of low permeability strata (such as clay, coal or rock) so that the water in the aquifer cannot easily flow vertically.
Domestic use	The use of a water resource that is not for commercial purposes.
Ecological values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of those systems.
Ecological water requirements (EWR)	The water regimes needed to maintain the ecological values of water-dependent ecosystems at a low level of risk.
Entitlement	The quantity of water that a person is entitled to take on an annual basis in accordance with the <i>Rights in Water and Irrigation Act 1914</i> or a licence.
Environmental water provisions (EWP)	The water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social, cultural and economic impacts. They may meet in part or in full the ecological water requirements.
Evaporation	The vaporisation of water from a free water surface above or below ground level, normally measured in millimetres.
Evapotranspiration	The loss of water to the atmosphere by evaporation and by transpiration through living organisms.
Groundwater	Any underground water, including water that percolates from the ground surface into a well or other works.
Groundwater area	An area of land that overlies a particular water resource, or resources, that has been proclaimed under the <i>Rights in Water and Irrigation Act 1914</i> , for the purposes of controlling, through licensing, the construction of water wells and the taking and use of the water resource(s).
Groundwater-dependent ecosystems (GDE)	An ecosystem that is partially or fully dependent on groundwater for its sustained existence.

Hectare (ha)	10 000 square metres or 2.47 acres.
Kilolitre (kL)	1000 litres or 220 gallons.
Leakage	The flow of water from one aquifer to another.
Licence	A 5C licence is a right that allows the licence holder to 'take' water from a watercourse, wetland or underground source. Under the provisions of s.5C, unless a person holds a licence, any unauthorised taking of water is prohibited except where a person has another right to do so (i.e. a 'riparian right').
Policy	Refers to a guideline that is not directly supported by any legislation but has been adopted by the department as its guideline.
Potentiometric level	An imaginary surface representing the total head of groundwater and defined by the level (surface) to which water will rise in a well.
Precautionary principle	Taking a cautious approach to development and environmental management decisions when information is uncertain, unreliable or inadequate.
Priority use	The current or future uses for a water resource that have priority over other potential uses because of their regional significance to the community.
Public water supply reserve (PWS)	A volume of groundwater that has been reserved for town water supply purposes (drinking water for human consumption) and, where appropriate, to satisfy the water requirements for developments of state significance under State Agreements to which the <i>Government Agreements Act 1979</i> applies.
Recharge	The downward movement of water, usually expressed as a percentage of rainfall, that contributes to the groundwater resources of an aquifer system.
Salinity	The measure of total soluble salt (i.e. mineral constituents in water). Water resources are classified on the basis of salinity in terms of total dissolved salts (TDS) or total soluble salts (TSS). Measurements are usually milligrams per litre (mg/L) or parts per thousand (ppt).
Staff gauge	A marked plate situated in a water body to provide a direct measure of the water level.
Subarea	A subdivision within a surface or groundwater area, defined for the purpose of managing the allocation of groundwater resources.
Surface water	An open body of water such as a stream, lake or reservoir.
Sustainability	Meeting the needs of current and future generations through integration of environmental protection, social advancement and economic prosperity.
Sustainable yield	The volume of water abstracted from a source that can be sustained on a long-term basis without exceeding the rate of replenishment.
Throughflow	The flow of water within an aquifer.
Transferable (tradable) water entitlement	The ability to transfer or trade a water entitlement, or a part thereof, to another person within a common water resource.

Unconfined aquifer	An aquifer nearest the surface, having no overlying confining layer. The upper surface of the groundwater within the aquifer is called the watertable. An aquifer containing water with no upper non-porous material to limit its volume or to exert pressure.
Water conservation	The management of water use to achieve and maintain an appropriate level of water-use efficiency.
Water efficiency	The minimisation of water use through adoption of best management practices.
Water regime	A description of the variation of flow rate in surface water or water level in groundwater over time; it may also include a description of water quality.
Water reserve	An area proclaimed under the <i>Metropolitan Water Supply Sewerage and Drainage Act</i> or <i>Country Areas Water Supply Act</i> to allow the protection and use of water on or under the land for public water supplies.
Watertable	The groundwater surface of an unconfined aquifer at which pressure is equal to atmospheric pressure.
Well	An opening in the ground made or used to obtain access to underground water. This includes soaks, wells, bores and excavations.
Wellfield	A group of wells to monitor or withdraw groundwater, including for scheme supply.
Wetland	A permanent or seasonal lake, swamp or permanently waterlogged soils or inundated land.

Bibliography

- Agriculture and Resource Management Council of Australia and New Zealand, and the Australian and New Zealand Environment and Conservation Council – see ANZECC & ARMCANZ.
- ANZECC & ARMCANZ 1995, *Guidelines for groundwater protection in Australia*, Commonwealth of Australia, Canberra.
- 2000a, *Australian Guidelines for water quality monitoring and reporting*, Commonwealth of Australia, Canberra.
- 2000b, *The Australian and New Zealand guidelines for fresh and marine water quality, paper no. 4*, Commonwealth of Australia, Canberra.
- Australian Government 2004, *Australian Drinking Water Guidelines 6*, National Health and Medical Research Council and National Resource Management Ministerial Council, Government of Australia, Canberra.
- City of Rockingham 2007, *Annual report 2006–2007*, City of Rockingham, Rockingham.
- Cox, JW 1988, 'Rockingham groundwater area groundwater allocation plan' in possession of Water Allocation Planning section, Department of Water, Government of Western Australia, Perth.
- Davidson, WA and Yu, X 2006, *Perth region aquifer modelling system – PRAMS – Hydrogeology and groundwater modelling*, Hydrogeology report no. 202, Department of Water, Government of Western Australia, Perth.
- DEC – see Department of Environment and Conservation
- Department of Environment and Conservation 2008, *Rockingham Lakes regional park area*, Department of Environment and Conservation website, viewed on 3 September 2008, <www.dec.wa.gov.au>
- Department for Planning and Infrastructure 2005, *City of Rockingham Town Planning Scheme No. 2*, Government of Western Australia, Perth.
- 2007, *Better urban water management*, prepared by Essential Environmental Services for the Department of Planning and Infrastructure, Department of Water, Western Australian Local Government Association and Federal Department of Environment, Water, Heritage and the Arts, Perth.
- Department of Premier and Cabinet 2007, *State water plan*, Government of Western Australia, Perth.

Department of Water 2006, *Policy on accessing the Leederville and Yarragadee Aquifers in Perth*, Department of Water, Government of Western Australia, Perth.

— 2007a, *Better managing the urban water cycle – the urban drainage initiative*, Department of Water, Government of Western Australia, Perth.

— 2007b, *Hydrogeological reporting associated with a groundwater well licence*, Statewide policy no. 19, Department of Water, Government of Western Australia, Perth.

— 2007c, *Timely submission of required further information*, Statewide policy no. 17, Department of Water, Government of Western Australia, Perth.

— 2008, *Policy on water conservation and efficiency plans – Achieving water use efficiency gains through water licensing*, Statewide policy no. 16, Department of Water, Government of Western Australia, Perth.

DoW – see Department of Water.

DPI – see Department for Planning and Infrastructure.

Environmental Protection Authority 1999, *Review of the environmental protection (Swan coastal plain lakes) policy 1992*, EPA, Government of Western Australia, Perth.

EPA – see Environmental Protection Authority.

Froend, R, Loomes, R, Horwitz, P, Bertuch, M, Storey, A & Bamford, M 2004, *Study of ecological water requirements on the Gnangara and Jandakot mounds under Section 46 of the Environmental Protection Act – Task 2: Determination of ecological water requirements*, prepared for Water and Rivers Commission, Government of Western Australia, Perth.

Government of Western Australia 2005, *State water strategy: Irrigation review final report*, Irrigation Review Steering Committee, Government of Western Australia, Perth.

— 2006, *A blueprint for water reform in Western Australia: Final advice to the Western Australian Government*, Water Reform Implementation Committee, Government of Western Australia, Perth.

— 2007, *Government response to a blueprint for water reform in Western Australia*, Government of Western Australia, Perth.

Hill, AL, Semeniuk, CA, Semeniuk, V & Del Marco, A 1996, *Wetlands of the Swan coastal plain volume 2b, Wetland mapping, classification and evaluation, wetland atlas*, prepared for the Water and Rivers Commission and the

Department of Environmental Protection, Government of Western Australia, Perth.

IOCI – see Indian Ocean Climate Initiative

Indian Ocean Climate Initiative 2002, *Climate variability and change in south west Western Australia*, IOCI Panel, Perth.

JDA Consultant Hydrologists 2000, 'Rockingham groundwater allocation plan' in possession of Water Allocation Planning section, Department of Water, Government of Western Australia, Perth.

A Kern, Senior Hydrogeologist, Department of Water, pers. comm., October 2005 regarding domestic bore use — including new bore rebate figures from the Water Corporation.

Land and Water Biodiversity Committee 2003, *Minimum construction requirements for water bores in Australia*, Edition 2, National Minimum Bore Specifications Committee, Natural Resources, Mines and Energy, Queensland Government, Canberra.

Lindsay, RP 2004, *Confined aquifer allocations in the Perth metropolitan area*, Hydrogeology report no 229, Department of Environment, Government of Western Australia, Perth.

Mayer, X, Ruprecht, J & Bari, M 2005, *Stream salinity status and trends in south-west Western Australia, salinity and land use impacts series*, report no SLUI 38, Department of Environment, Government of Western Australia, Perth.

O'Connor, R, Quatermaine, G & Bodney, C 1989, *Report on an investigation into Aboriginal significance of wetlands and rivers in the Perth–Bunbury region*, publication no 2/90, Western Australian Water Resources Council, Western Australia, Perth.

Peel Harvey Catchments Council 2005, *Peel–Harvey catchment natural resource management plan* prepared by Land Assessment Pty Ltd, Mandurah.

Rockwater Pty Ltd 2000, 'Rockingham groundwater management plan – Appendix 1: resource characteristics, and determination of sustainable yield' in possession of Water Allocation Planning section, Department of Water, Government of Western Australia, Perth.

The Ramsar convention on wetlands, 2008, The Ramsar convention on wetlands, viewed on 28 August 2008, <www.ramsar.org>.

Thomson, Y 2001, 'Review of groundwater management areas in the Perth region', in possession of the Department of Water, Government of Western Australia, Perth.

V & C Semeniuk Research Group 1991, 'Wetlands of the City of Rockingham – their classification, significance and management', unpublished report to the City of Rockingham and the WA Heritage Committee.

WAPC – see Western Australian Planning Commission.

Water and Rivers Commission 1997, 'Rockingham groundwater area management plan', in possession of Water Allocation Planning section, Department of Water, Government of Western Australia, Perth.

— 2000a, *Environmental water provisions policy for Western Australia*, Statewide policy no. 5, Water and Rivers Commission, Government of Western Australia, Perth.

— 2000b, *Western Australia water assessment 2000 – Water availability and use*, Water and Rivers Commission, Government of Western Australia, Perth.

— 2001, *Transferable (Tradeable) water entitlements in WA*, Statewide policy no. 6, Water and Rivers Commission, Government of Western Australia, Perth.

— 2003a, *Management of unused licensed water entitlements*, Statewide policy no. 11, Water and Rivers Commission, Government of Western Australia, Perth.

— 2003b, *Water licensing – staged developments*, Statewide policy no. 9, Water and Rivers Commission, Government of Western Australia, Perth.

— 2004, *Use of operating strategies in the water licensing process*, Statewide policy no. 10, Water and Rivers Commission, Government of Western Australia, Perth.

Water Authority of Western Australia 1992, *Gnangara Mound vegetation stress study – results of investigations*, report no WG127, Water Authority of Western Australia, Government of Western Australia, Perth.

— 1994, 'Stakehill groundwater management plan', Water Authority of WA, in possession of Water Allocation Planning section, Department of Water, Government of Western Australia, Perth.

Western Australian Planning Commission 1993, *South West corridor structure plan*, Government of Western Australia, Perth.

— 1998, *Perth's Bushplan, keeping the bush in the city*, Government of Western Australia, Perth.

— 2007, *Metropolitan regional scheme*, Government of Western Australia, Perth.

WRC – see Water and Rivers Commission.

Contributors

Binh Anson:	Senior Engineer, Groundwater Assessment
Sally Bowman:	Program Manager, Water Allocation Planning
Alan Cook:	Program Manager, Kwinana Peel Region
Kym Erickson:	Program Manager, Kwinana Peel Region
Trevor Haig:	Senior Hydrogeologist, Groundwater Assessment
Brenden Huntley	Water Planning Officer, Water Allocation Planning
Laz Leonhard:	Senior Hydrogeologist, Kwinana Peel Region
Andy McCrea:	Senior Research Officer, Allocation Policy
Rebecca Palandri	Water Planning Officer, Water Allocation Planning
Emily Said:	Water Planning Officer, Water Allocation Planning
Wen Yu:	Senior Hydrogeologist, Groundwater Assessment