Gnangara groundwater areas allocation plan: Evaluation statement 2009–2011

The Gnangara groundwater system is the largest single source of quality fresh water in the Perth region and is vital to our natural and urban environment, social amenity and continuing economic development. The Department of Water is responsible for managing water use across the system.

The department manages allocation of groundwater for use as described in the *Gnangara groundwater areas allocation plan* (DoW 2009a). The plan's purpose is to support use of groundwater, while leaving enough water in the ground to meet other public benefit needs and support future public and private use.

This evaluation reviews our management and the extent to which the objectives of the *Gnangara groundwater areas allocation plan* were met so far. It also describes the status of water allocation and use, water resources and our current management.

This is the first evaluation statement for the *Gnangara groundwater areas allocation plan*. It covers the first two years of plan implementation. The Gnangara groundwater system is complex and management decisions can have serious consequences for many water users, including local governments and agriculture. The department expected it would take two planning periods, of up to seven years each, to return the system to a sustainable balance. It is, therefore, understandable that all objectives were not achieved in the first two years of the this allocation plan.

Progress over the first two years is encouraging. However, the central objective of reducing over-allocation was, in part, delayed by the lowest rainfall year on record occurring in 2009 and 2010. While successful steps were taken to manage impacts on wetlands during this time, the overall allocation was not reduced.

This evaluation statement identifies how we will continue to adapt our management to meet the objectives. It confirms that further management changes, through a second plan, will be needed to continue to progress against objectives.

The objectives of the plan are:

1. Reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the current recharge from rainfall.
2. Optimise the use of water through water use efficiency and demand management measures.
3. Protect groundwater-dependent ecosystems from direct impacts associated with abstraction.
4. Protect the quality of groundwater for public and self-supply from impacts associated with abstraction and land use.
5. Adapt management of the water resource based on the results of monitoring programs and the condition of the resource.

1 Resource status

1.1 Rainfall and recharge

Total rainfall recorded at Perth Airport was 611 mm in 2009 and 456 mm in 2010. Rainfall from 1974 to 2006, before work started on the plan, averaged around 730 mm/yr. The decline in rainfall and consequent decline in recharge since the mid 1970s, and a further decline over the last decade has meant that less water is entering the groundwater system.

1.2 Superficial aquifer

As Perth's average rainfall decreased, water levels at the top of the Gnangara Mound (the main recharge zone) fell by about 0.4 m/yr reaching the lowest water levels on record in 2006. After the plan's release in 2009 the water levels were similar to those recorded in 2006.

The management approach established through the plan was designed for these water levels, but in 2010 there was a further drop. Following the very dry winters of 2006 and 2010, groundwater was used to make up public water supply during the transition to alternative climate-independent sources. In these years additional water generally came from the Superficial aquifer.

Water level data from 48 Superficial monitoring bores are used to represent relative groundwater level change in the Superficial aquifer across the plan area, compared with the highest recent groundwater levels (1997) (Figure 1). The figure highlights the stabilisation of water levels in 2008-10 and then the effect on 2011 levels of the extremely low winter rainfall of 2010, coinciding with an 'exceptional circumstances take' for public supply. It also highlights the effect of consecutive years of low rainfall.

Figure 1 is an average of representative sites. In some areas water levels are stable, but in others, near the top of the Gnangara Mound, they dropped more than the averages shown here. This figure is updated and presented each month on our website.[1] Figure 2 shows long-term change in the watertable derived from site specific hydrographs.

During the past 10 years, water levels continue to fall in the Gnangara Mound's central, northern and eastern areas, with stabilisation and small water level increases under some urban areas. Current thinning and clearing of pine plantations and urban development may be contributing to the stabilisation of water levels observed in some areas surrounding Perth.

[1] See our website under Water resources data, then use the Tools, monitoring and data tab.

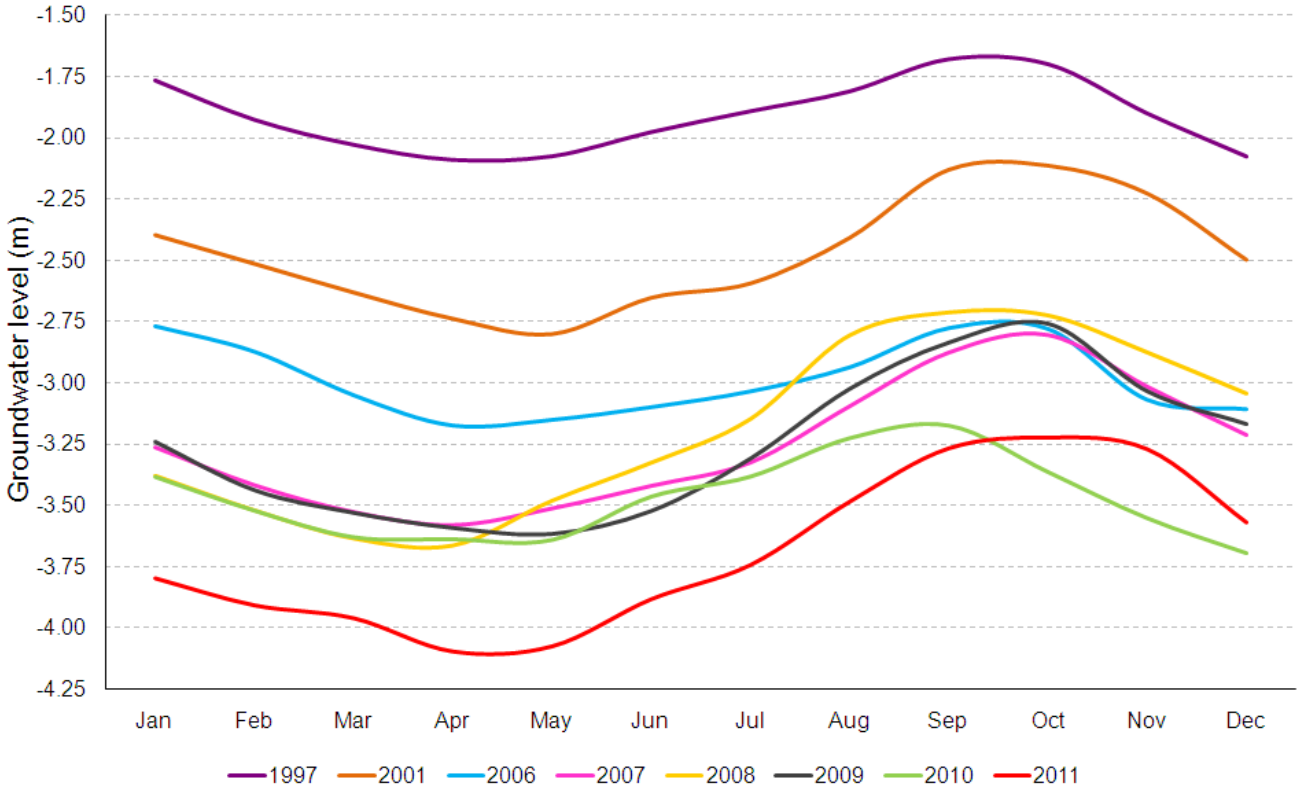

Figure 1 Average groundwater levels of the Gnangara Superficial aquifer, from 1997–2011

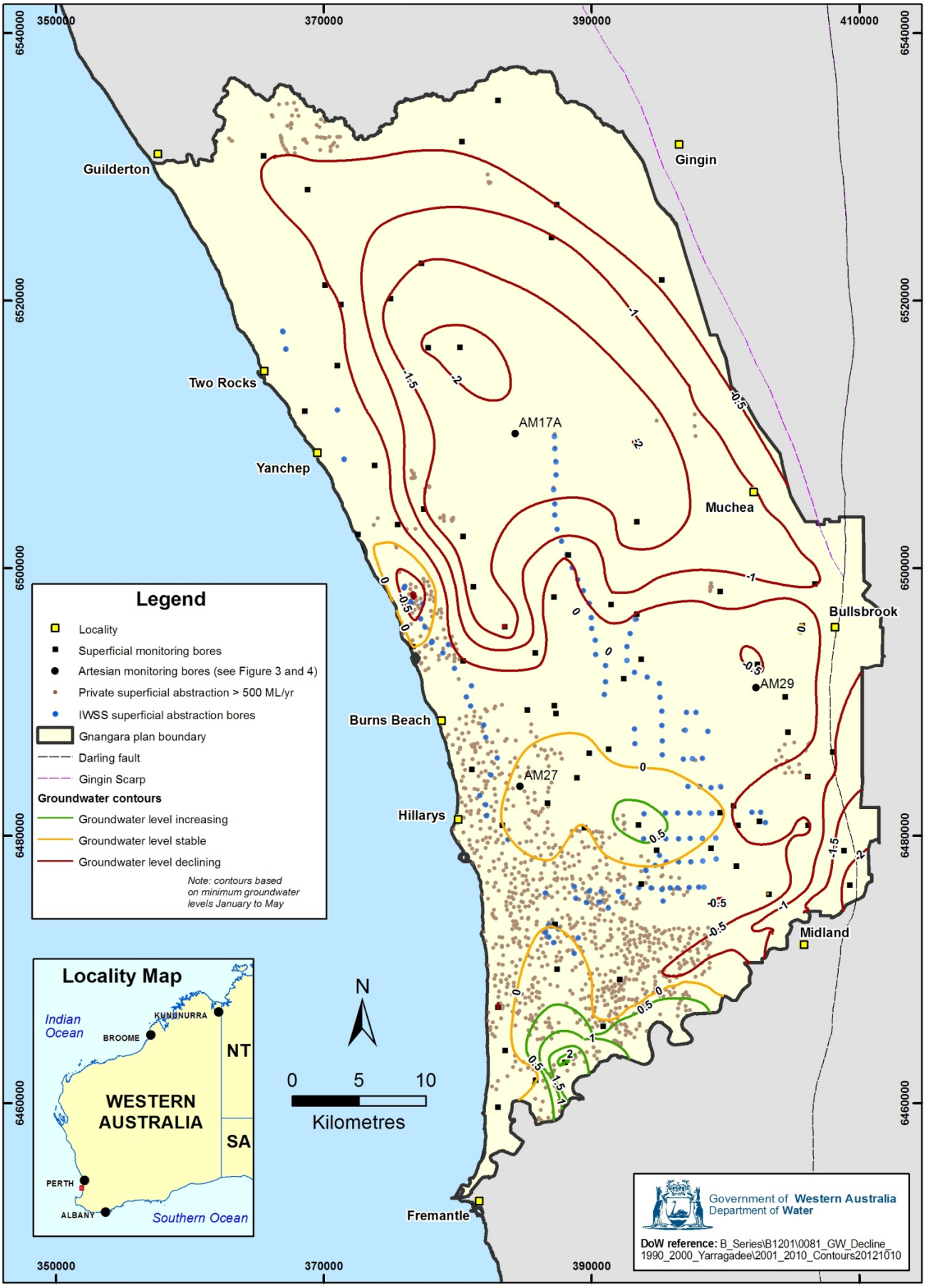

Figure 2 *Change in groundwater level contours for the Superficial aquifer from 2001–10*

Water levels at groundwater-dependent ecosystems monitored through Ministerial statement no. 819 criteria sites

Water levels in the Superficial aquifer fell below the criteria water levels set by Ministerial statement no. 819 at several groundwater-dependent ecosystems, including Loch McNess and Melaleuca Park.

The Department of Water reports to the Office of the Environmental Protection Authority (OEPA) on the conditions and procedures set in Ministerial statement no. 819 for managing groundwater-dependent ecosystems supported by the Gnangara system – see *Environmental management of groundwater from the Gnangara Mound, annual compliance report to the Office of the Environmental Protection Authority July 2010 to June 2011* (DoW 2011a).

A key commitment in the statement is for the department to manage groundwater abstraction to meet environmental water provision criteria set at 30 groundwater-dependent ecosystem sites across the Gnangara Mound where we monitor water levels. These include 14 wetland sites and 16 terrestrial groundwater-dependent vegetation sites. The sites are mainly located:[2]

- around urban wetlands (e.g. Lake Joondalup)
- at permanent deeper wetlands in the northern linear chain where the Superficial aquifer intercepts the coastal dunes (e.g. Yanchep National Park)
- at shallow wetland systems and bushland on the Bassendean Dunes in the east and south-east (e.g. Whiteman Park and Melaleuca Park).

Most sites are in areas where water levels declined between 0.5 and 1.5 mAHD, as shown in Figure 2. Table 1, from the 2010–11 report to OEPA, shows the number of sites that did not comply with water level and other criteria at June 2011.

Table 1 Sites across the Gnangara groundwater areas non-compliant with water level and other criteria for the 2010–11 reporting period (DoW 2011a)

Year	Compliance*				
	Absolute summer minimum		Absolute minimum spring peak	Total**	Other criteria***
	Wetland	Terrestrial			
2008–09	5/14	5/16	4/5	14	4/8
2009–10	7/14	5/16	3/5	13	4/8
2010–11	7/14	7/16	4/5	16	4/8

* *For 2007–09 compliance was reported against Ministerial statement no. 687 with 37 Ministerial criteria sites. For 2009–11 compliance is reported against Ministerial statement no. 819 with 30 Ministerial criteria sites.*

** *The total differs where sites are non-compliant with both the absolute summer minimum and the spring peak water levels.*

*** *Sites can be also non-compliant with other criterion such as where water levels are only allowed to be between the preferred and absolute minimum water levels at a rate of two in six years to replicate natural drying cycles.*

[2] See Figure 6, pg 13, of DoW 2011a for locations of the criteria sites.

1.3 Leederville and Yarragadee aquifers

The partly confined Leederville aquifer and the deeper mostly confined Yarragadee aquifer are measured in terms of pressure expressed as a groundwater level. These aquifers are connected in some areas to the overlying Superficial aquifer, providing pathways for recharge and discharge from the aquifers. Declines in these aquifers are expected with pumping, and are accepted so long as positive pressure is maintained above the top of each aquifer.

Pressure in the Leederville aquifer declined in the early 1990s but remained relatively stable from 1999 until recently. The hydrograph from monitoring bore AM17A (Gnangara confined subarea), which is on the crest of the Gnangara Mound (see Figure 2 for location), shows changes over time (Figure 3). Most Leederville aquifer monitoring bores are showing similar trends across the groundwater area. There is still positive pressure in the Leederville aquifer across most of the area.

Abstraction volumes from the Leederville aquifer were around 20 GL/yr through the late 1980s and early 1990s and doubled in the late 1990s. Total abstraction across the whole Leederville aquifer was almost 60 GL in 2010–11.

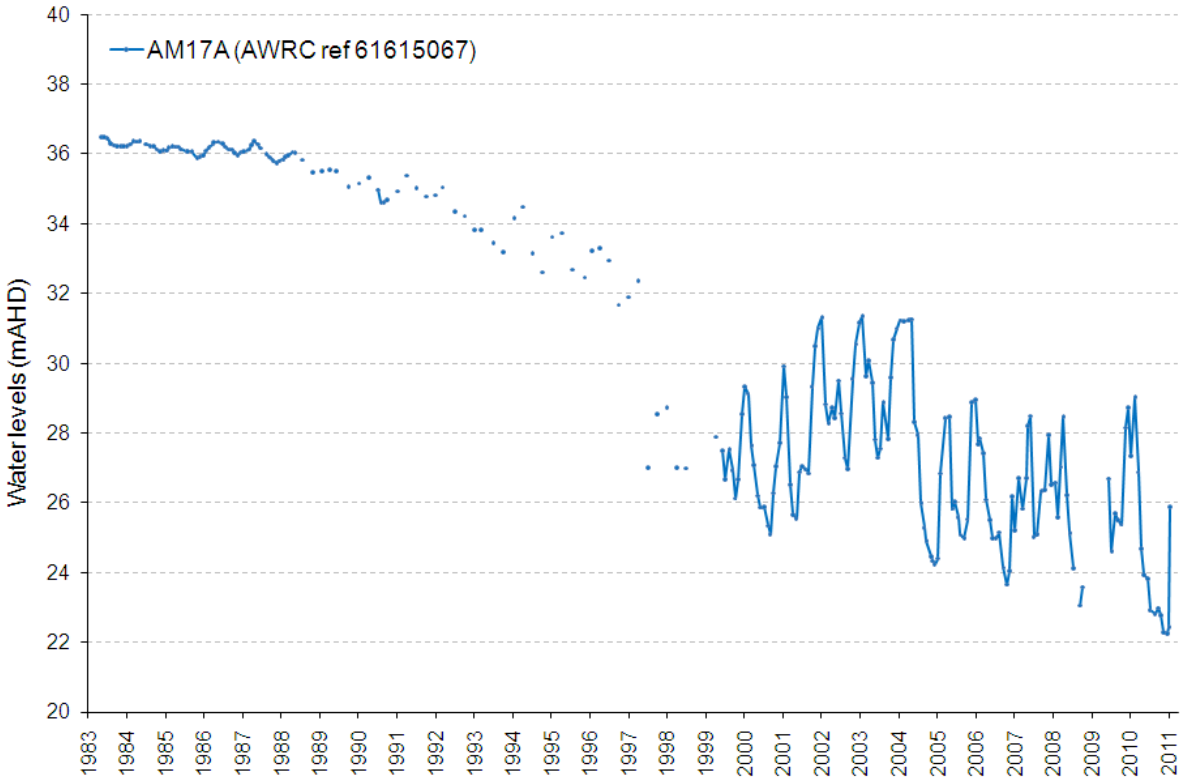

Figure 3 Leederville aquifer water level changes (AM17A)

Substantial declines in pressure in the Yarragadee are evident from the late 1990s to early 2000s (25–45 mAHD) (Figure 4), but pressure is still maintained above the top of the aquifer.

Monitoring bore AM27 on the coast (Perth North confined subarea) and AM29 on the eastern edge (Swan confined subarea) of the mound show the changes across the plan area in a general east to west cross-section in the Yarragadee aquifer (see Figure 2 for location). Most Yarragadee aquifer monitoring bores are showing similar trends across the groundwater area, with greater falls in pressure towards the coast. Between the 1990s and

2000s abstraction from the Yarragadee aquifer increased from around 24 GL/yr up to almost 55 GL/yr.

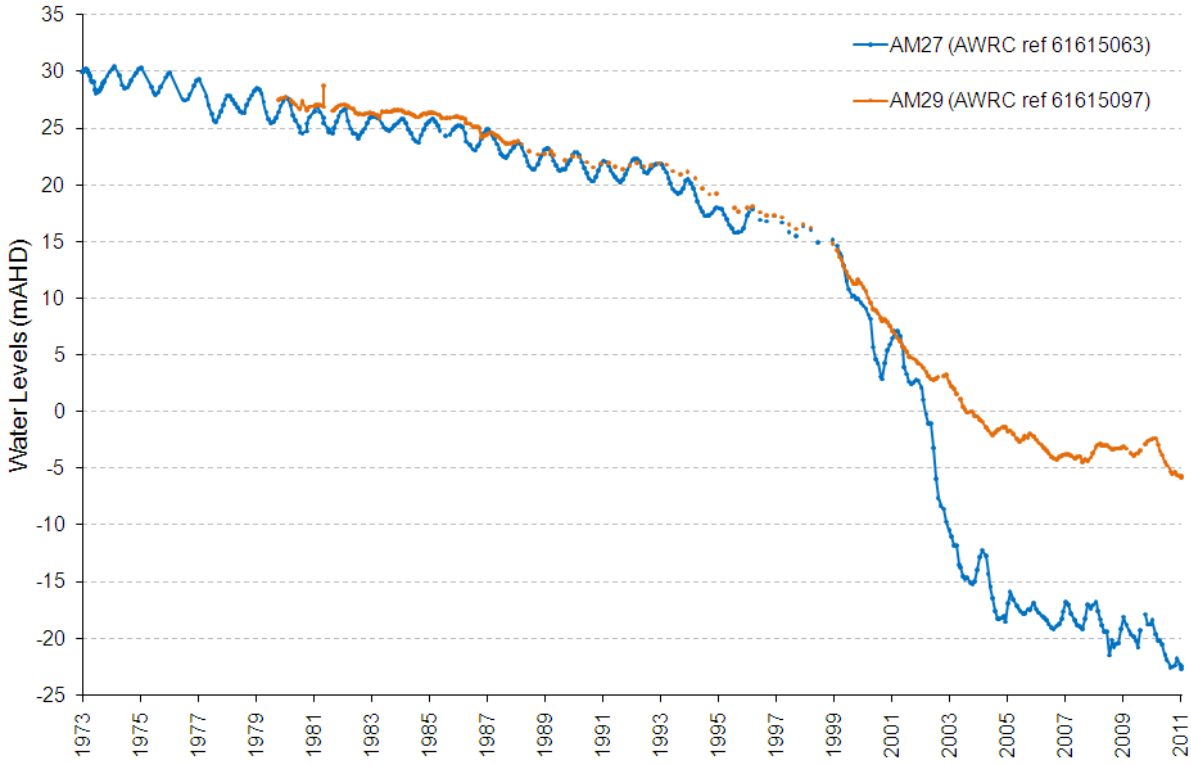

Figure 4 Yarragadee aquifer water level changes (AM27 and AM29)

2 Allocation status

2.1 Changes in allocation status

The 2009 plan recognised that in many areas more groundwater was being used than was being replaced by rainfall and recharge and that the previous allocation limits were too high for the changed climate. The plan reduced allocation limits[3] to cap use. Where groundwater declines were most severe, new allocation limits were set lower than the total of licensed entitlements and recovery of unused entitlements implemented.

The allocation status across the Gnangara plan area is shown in Table 2. Generally, the highest value, or most in-demand resources, in the plan area are close to fully allocated or over-allocated, with the majority in the Superficial aquifer. Thirty four per cent of the 79 groundwater resources[4] in the plan area are classified and managed as over-allocated. No new water is issued in these resources and through management of licences there is a focus on efficiency, compliance and the recouping of unused entitlements.

[3] Allocation limits are expressed in gigalitres (GL) per year and in this plan are the annual volume of water set aside for licensed use from a water resource. Post 2009 plans include small-scale unlicensed use within the allocation limit.

[4] For administrative purposes the five aquifers of Gnangara plan area are divided and identified as 79 different resources within 59 subareas of eight groundwater management areas.

Table 2 Summary allocation status for the Gnangara groundwater areas, 2009–11

Year	Aquifer	Number of resources by allocation category				
		Total	Category 1 0–30% allocated	Category 2 31–70% allocated	Category 3 71–100% allocated	Category 4 >100% allocated
June 2009	Superficial, Mirrabooka and fractured rock	*64*	9	9	28	18
	Leederville	*8*	0	0	2	6
	Yarragadee	*7*	2	0	2	3
Total		***79***	**11**	**9**	**32**	**27**
June 2010	Superficial, Mirrabooka and fractured rock	*64*	8	10	28	18
	Leederville	*8*	0	0	2	6
	Yarragadee	*7*	2	0	2	3
Total		***79***	**10**	**10**	**32**	**27**
Dec. 2011	Superficial, Mirrabooka and fractured rock	*64*	9	14	23	18
	Leederville	*8*	0	0	2	6
	Yarragadee	*7*	2	0	2	3
Total		***79***	**11**	**14**	**27**	**27**

2.2 Changes in water use

At the end of June 2011, the total volume licensed across approximately 3580 water licences was 280 GL. Table 3 shows the total water licensed in the last two water accounting years.

Table 3 Summary of total water licensed (private and public water supply) by aquifer for the Gnangara groundwater areas (between 2009 and 2011, GL/yr)

Aquifer	Total water licensed	
	2009–10	**2010–11**
Superficial and fractured rock	143.4	161.3
Mirrabooka	3.3	6.5
Leederville	47.0	61.2
Yarragadee	40.9	50.9
TOTAL	**234.6**	**279.9**

The volume of water allocated annually for public water supply, private licensed use and estimated garden bore use across each aquifer is shown in Table 4. The total of licensed and unlicensed use to June 2010 was approximately 270 GL/yr and in June 2011 was approximately 307 GL/yr.

Table 4 Summary of changes in water allocated across the Gnangara plan area (1 June each year, GL/yr)

Aquifer	Public water supply		Private water supply		Garden bore supply*	
	2009–10	2010–11	2009–10	2010–11	2009–10	2010–11
Superficial and fractured rock	32.8	48.3	110.6	113.1	35.0	27.2
Mirrabooka	0.9	4.2	2.4	2.3	0	0
Leederville	35.5	48.1	11.6	13.1	0	0
Yarragadee	40.3	50.2	0.7	0.7	0	0
Total	**109.4**	**150.8**	**125.2**	**129.1**	**35.0**	**27.2**

** Garden bore supply is estimated using data collected through surveys and Australian Bureau of Statistics and Water Corporation household use data and is not licensed.*

Data are sourced from our water resource licensing database. Data for the tables above were extracted from our licensing system on 1 June each year.

The amount of water licensed does change over time. For up-to-date water availability in all resources contact the Swan Avon regional office in Perth or see our water register <www.water.wa.gov.au/ags/WaterRegister>.

2.3 Changes in water use – public water supply

The plan revised the variable groundwater abstraction rule (VGAR) to start to move away from sustained high groundwater use in years when there was little inflow to reservoirs. The plan established the annual groundwater allocation for the Integrated Water Supply Scheme (IWSS) as between 105 GL/yr and 145 GL/yr, retaining a provision for up to 165 GL in exceptional circumstances. The plan also established that the allocation would fall to an average of 110 GL/yr in 2012, follow commissioning of the Southern Seawater Desalination Plant.

Most of this groundwater comes from the Gnangara system and about 10 GL/yr comes from the Jandakot system. The amount abstracted varies from year to year depending on the amount of water available in the IWSS reservoirs and, to an increasing extent, from desalination.

IWSS abstraction from Gnangara in 2009–10 was 109 GL and in 2010–11 was 151 GL. This followed a record low inflow to the reservoirs in the winter of 2010. Under the exceptional circumstances rule (Section 5.4.1, pg 57 of the plan) the Water Corporation were authorised to take more than 145 GL of groundwater for the IWSS (combined Gnangara and Jandakot).

This higher abstraction was granted for the 2010–11 year as the criteria set in the allocation plan were met:

- Water Corporation secured 4 GL from alternative (contingency) water supplies by maximising take from the Perth Seawater Desalination Plant
- additional demand management measures were put in place including the Water Corporation's Target 60 L campaign, the shower head exchange program and a winter sprinkler ban
- abstraction from the Superficial aquifer was managed in line with environmental sensitivity rules set for the IWSS by the department.

The licensed and use data in Table 5 are sourced from our water resource licensing database and verified against data submitted by the Water Corporation as part of its licence reporting requirements. Annual licensed entitlements for public water supply were determined using the VGAR (Table 5). All bores abstracting water for public water supply are metered.

Table 5 Water licensed and used for the IWSS for 2009–11 water accounting years from the Gnangara groundwater areas (GL/yr)

Aquifer	2009–10		2010–11	
	Water licensed for the IWSS from Gnangara	Actual metered use	Water licensed for the IWSS from Gnangara	Actual metered use
Superficial	32.8	32.1	48.3	48.2
Mirrabooka	0.9	0.9	4.2	4.2
Leederville	35.5	*35.8	48.1	48.1
Yarragadee	40.3	*40.6	50.2	50.1
TOTAL	**109.4**	**109.3**	**150.8**	**150.6**

**The volume exceeded for individual bore quotas was due to variation between planned and actual bore production rates. This was resolved by the Water Corporation.*

2.4 Changes in water use – private use

Since the plan was released the volume licensed for private use across each aquifer changed as a result of unused entitlements being recouped, improved water use efficiency and land use change. The actual volume used by licensees can be determined through compliance surveys and meter readings.

Meters are generally required on all new and existing licences over 0.5 GL/yr (500 000 kL/yr). Additionally there are 1269 government-owned meters installed on privately owned and licensed bores drawing between 0.005 GL/yr (5000 kL/yr) and 0.5 GL/yr. Licensees use metering data to manage their water use and evaluate efficiency measures. As more metering data are collected and analysed, we use them to:

- compare actual water use to groundwater level changes
- compare actual water use to licensed use
- focus on efficiency and compliance
- identify where enforcement action is required.

Data collected from samples of government-owned meters during 2009–10 and 2010–11 show that total metered use was below licensed entitlements. The proportion of entitlements used increased in 2010–11 after the very dry winter of 2010 (Table 6).

Incidents of over-abstraction for the samples increased from 15 to 22 per cent over the reporting period. These incidents are followed up through our licensing compliance and enforcement program and the first prosecutions were completed.

Table 6 Annual water use summary for state-owned water meters sampled from the Gnangara groundwater areas for 2009–11 water accounting years

Sample	2009–10	2010–11
Total licensed entitlement (GL/yr)	25.5	24.4
Total metered abstraction (GL/yr)	16.0	21.3
Entitlement used (as %)	62.7%	87.1%
Sample size (number of meters)	876	790
Sample size (number of licences)	669	608
Under abstraction (number of licences)	543	435
At entitlement (number of licences)	25	37
Over-abstraction (number of licences)	101	136

2.5 Changes in water use – garden bore use

Estimates of garden bore use were considered when setting allocation limits for the 2009 allocation plan, but were not included in the allocation limit.[5] The government updated the 2007 water efficiency measures legislation for garden bores in November 2011 under the Water Agencies (Water Use) By-laws 2010. The by-laws led to a three-day-a-week sprinkler schedule in the summer months and a total winter sprinkler ban for backyard bore users – reducing overall garden bore use.

According to Australian Bureau of Statistics and Water Corporation data, in June 2011 there were an estimated 67 200 garden bores in the plan area. Through survey information on current use from individual bores, we estimated total garden bore use in 2010–11 as 27.2 GL/yr (compared with 35 GL/yr for the previous year).

3 Management status

3.1 Managing to the objectives

Objective 1 Reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the current recharge from rainfall

To manage the system more sustainably for all users, the plan introduced new allocation limits in line with recent recharge and moved away from managing around a longer-term average. The intent was to cap use in higher-risk areas and begin to focus on necessary changes in efficiency and infrastructure. See Table 4 for water use details.

Private water supply:

- In fully allocated or over-allocated areas no new water licences were issued (except for temporary or short-term dewatering purposes). New allocation limits served to cap use in the higher-risk areas where groundwater levels showed significant decline and where impacts between users and on wetlands were evident.

[5] For other allocation plans developed after the Gnangara plan, use from small-scale stock and domestic bores exempt from licensing is estimated and is a component of the allocation limit.

- We prioritised fully allocated and over-allocated areas for licence management (compliance, metering, efficiency and recouping of unused water entitlements). The department's new compliance unit targets the highest risk areas of Gnangara.
- After 2009–10, the last year of the government funded metering program, 1273 state owned meters were installed on licensed bores across 971 medium volume licences on Gnangara.
- The 2009 plan's allocation limits represented a target reduction in private abstraction of 10 to 13 per cent, depending on location. The plan did not initiate any recoup of used water entitlements.

Public water supply:

- The annual IWSS allocation for Gnangara was reduced from a 'normal' year maximum of 155 GL/yr to 135 GL/yr until 2012, with provision to take up to 20 GL of additional water following years of exceptionally low inflow to dams (exceptional circumstances provision).
- In 2009–10, when less groundwater was needed for the IWSS, abstraction from the superficial aquifer was reduced to just over 30 GL (compared to approximately 45 GL in the previous year).
- To continue the shift to a better balance between abstraction and recharge, the VGAR, which was used to determine the Water Corporation's annual IWSS abstraction, has been replaced with a new five year average abstraction of 110 GL (from existing bores). This change applies to abstraction from 2012–13 onward, and coincides with the first stage of the Southern Seawater Desalination Plant becoming fully operational.
- To shift towards more sustainable use of groundwater for public water supply, we worked with the Water Corporation and other agencies to advise government on future water supply source options.

Garden bore supply:

- The plan recognises that efficient use of water from garden bores reduces demand on the IWSS and is appropriate in some areas. A map showing suitable areas is available on our website. A water licence is not required for garden bores.

Objective 2 Optimise the use of water through water use efficiency and demand management measures

The plan triggered more effective use of the available water through limiting water available for allocation and by supporting key efficiency actions.

Private water supply:

- We worked with local governments to improve water use efficiency. Of the 18 local government authorities that use water from Gnangara system, 15 completed and implemented a water conservation strategy.
- The Department of Water and the Water Corporation accredited seven local governments under the International Council for Local Environmental Initiatives (ICLEI) Waterwise council program.
- DoW met with horticultural water users twice a year to promote efficiency, and has funded a project to focus on ideal water an nutrient practices at Carabooda.

- We use and maintain the 2005–10 government-funded metering program to collect metering data, understand patterns of use and support efficiency improvements, as well as for compliance. The program maintains and monitors 1273 meters on bores for licences of 5000 to 500 000 kL/yr in the Gnangara plan area. Together with privately collected metering data, this will provide consistent and comparable data for reporting on private use.
- To facilitate water trades as a way to optimise water use, we updated our water trading policy (*Operational policy 5.13 – Water entitlement transactions for Western Australia,* DoW 2010) and listed a web-based register of licensees. Our water efficiency policy guides licensees in developing a water conservation efficiency plan.

Public water supply:

- The department supported the Water Corporation's demand management program, and required further demand management measures to be implemented as part of the exceptional circumstances criteria, before agreeing that more than 135 GL/yr can be pumped from the Gnangara Mound.

Garden bore supply:

- The government updated the 2007 water efficiency measures legislation for garden bores in November 2011 under the Water Agencies (Water Use) By-laws 2010. This limits their use to three days a week over summer and applies a total ban on use during winter.
- A new garden bore use guideline was developed that emphasised water conservation and efficiency. An updated garden bore suitability map is now accessible on the Perth Groundwater Atlas <www.water.wa.gov.au/idelve/gwa> and in *Operational policy 5.17 – Metropolitan domestic garden bores* (DoW 2011b).

Objective 3 Protect groundwater-dependent ecosystems from direct impacts associated with abstraction

The plan introduced improved management of abstraction around groundwater-dependent ecosystems to better protect them in a drying climate. Carefully managed groundwater-dependent ecosystems, particularly those lower in the landscape, can support ecological and social values – even in a drying climate.

Private water supply:

- Lower allocation limits in the highest-risk areas were used to prevent further effects of abstraction.
- In high-risk areas we use an environmental risk map to guide licence assessments and manage licence conditions so that pumping impacts are minimised where possible.
- Ecological and groundwater investigations and modelling to support more precise management of abstraction in sensitive areas was completed, and will be used to inform the next plan.

Public water supply:

- Abstraction for the IWSS is redistributed to the lower-risk areas each year using an environmental sensitivity classification (ESC) system for production bores. This guides the volume and location of the draw away from the most environmentally sensitive areas. This system was used to classify more than 50 public water supply

bores and abstraction from each was revised to reduce impacts on the criteria sites listed under Ministerial statement no. 819.

- Monitoring of water level and ecological health against Ministerial criteria at 30 sites continued, and compliance was reported to the OEPA annually. The data are used to inform how the bore ESC system is applied.

Objective 4 Protect the quality of groundwater for public and self-supply from impacts associated with abstraction and land use

The quality of groundwater for public water supply is protected by public drinking water source protection areas and their associated management. The plan provides local licensing policies for how water quality is protected for private or self-supply water users.

Private water supply:

- The effects of private use on water quality (acid sulfate soils and salinity) are managed through licence conditions and compliance and by allocation limits.

Public water supply:

- We maintained the highest level of public drinking water source protection for Gnangara, with no significant changes to the water source protection zones. These zones are designed to protect current and future public drinking water from impacts on quality associated with land use change and groundwater use.
- All advice on land development and/or land use referrals was made in accordance with *Statement of planning policy 2.7: Public drinking water source policy* (WAPC 2003).
- In some parts of the public drinking water source protection areas, if additional water is thought to be available for sustainable use, it is generally reserved to support future demand for public water supply in these areas – subject to assessment.

Garden bore supply:

- Garden bores are not encouraged in unsuitable areas due to the risk of acid sulfate soils, poor water quality or low yields. These areas are identified on our website: <http://www.water.wa.gov.au/Managing+water/Domestic+garden+bores/Sprinkler+rorost/Perth+and+Mandurah/default.aspx>.

Land use:

- We work with other government agencies on development proposals to minimise effects on water quality as a result of increased demand.
- The *Better urban water management* (WAPC, 2008) framework is used to advise local government authorities and other land development agencies on managing water quality in urban areas to minimise the effects of drainage and stormwater on shallow groundwater in the plan area.

Objective 5 Adapt management of the water resource based on the results of monitoring programs and the condition of the resource

Our adaptive management is based on:

- licensing data and allocation status classification that is used to focus compliance (see Chapter 1 above)
- monitoring data that is used to inform management decisions and research priorities (see Chapter 2 above)
- management responses to triggers set in the plan (see Section 3.2, Table 7)
- annual assessment of public water supply abstraction (see Section 1.3).

3.2 Response to management triggers

To maintain a focus on active management, the plan sets triggers for management actions. Actions taken to resolve management triggers set in the plan are presented in Table 7.

Table 7 Summary of triggers reached and our response, 2009–11

Trigger	Status	Management response
Groundwater resources within a subarea are 70–100% allocated.	There are 27 resources at C3 with 70–100% of the limit allocated in December 2011 (Table 1).	Areas which are classified category 3 and 4 are targeted for management, including compliance, metering, efficiency and recouping of unused water entitlements. Recoup of unused water entitlements and recovery of unused licences in C3 resources resulted in five resources shifting from more than 70% allocated to less than 70% allocated between June 2009 and December 2011.
Groundwater resources within a subarea are 100% allocated.	One resource became fully allocated in 2011.	Once allocation limits are reached new licences are not normally issued, and trading or efficiency measures are encouraged.
Groundwater resources within a subarea are > 100% allocated.	The number of resources classified as over-allocated (C4) in the plan area did not change during the reporting period.	The amount of over-allocation was reduced in eight category 4 resources in the Superficial aquifer. This was not enough to reduce them to below the allocation limit.
The Water Corporation requests more than 145 GL (135 GL from Gnangara) for public water supply.	The application was considered against exceptional circumstances criteria.	The Water Corporation abstracted 152 GL from Gnangara in the 2010–11 water accounting year for public water supply (Table 5). The ESC system is applied to each of the Water Corporation's production bores. The system ranks the risks of abstraction from production bores on groundwater-dependent ecosystems (see DoW 2011a). The ESC system was used to manage the volume and location of the draw away from environmentally sensitive areas as much as possible. Work to advise on new source options continues.

Trigger	Status	Management response
Declining groundwater levels due to reductions in rainfall recharge.	2010 winter rainfall was one of the lowest on record for Perth. The lowest water levels on record were recorded in the Superficial aquifer.	A review of current allocation limits in the Superficial aquifer, in resources where water levels are declining, has been initiated (see Section 5.1).
The department does not meet the environmental water provisions set as criteria (under Ministerial statement no. 819).	Water levels did not meet the criteria set and the department was non-compliant at: • 13 out of 30 sites in 2008–09 • 14 out of 30 sites 2009–10 • 16 out of 30 sites 2010–11 (DoW 2011a)	Non-compliance was reported to OEPA as required. The ESC system was applied to minimise the effects of abstraction on groundwater-dependent ecosystems from IWSS bores. This reduced abstraction from environmentally sensitive public supply bores by approximately 7 GL in 2010–11 compared with 2006–07. Work to support better management in a drying climate was progressed including: • understanding how to manage abstraction to support groundwater-dependent ecosystem ecology in a drying climate • supporting decision making to limit abstraction impacts on groundwater-dependent ecosystems. This ongoing non-compliance has triggered work on a replacement plan. Applying ESC system principles to private abstraction will be addressed through the planning process.

3.3 Implementation actions

The plan is implemented using three main tools:

- managing to the allocation limits for each resource
- applying licence conditions to facilitate efficiency and manage local impacts
- monitoring of groundwater levels and groundwater use.

Additional complementary actions are identified in the plan to aid implementation and improve how we meet the objectives over time. In the plan we committed to 20 actions and our progress towards implementing them is listed in Table 8.

Table 8 Summary of progress towards actions for implementing the plan

No	Action in plan	Status	Work undertaken
Actions to support meeting Objective 1 (reduce abstraction to match recharge)			
8	Review allocation limits in this plan and revise if necessary.	Ongoing	Consistent with the plan a review of allocation limits in the Superficial aquifer was completed as a result of this evaluation. In subareas where there are declining water levels and there is limited to no demand, the water available for licensing (the general component of the allocation limit) has been reduced by 10% consistent with reduced rainfall and recharge.
14	Continue to make an allocation decision for the IWSS and release in October each year.	Met	See Section 3.1, objectives 1 and 2.

No	Action in plan	Status	Work undertaken
Actions to support meeting Objective 2 (improve efficiency)			
10	Continue to work with government to develop other demand measures to reduce garden bore use in addition to the three-day restrictions.	Met	See Section 3.1, Objective 2.
11	Continue to work with local government authorities to assess the implementation of their water conservation plans.	Met	See Section 3.1, Objective 2.
12	Develop statewide policy on managing new water that may become available through managed aquifer recharge.	Met	We developed *Operational policy 1.01 – Managed aquifer recharge in Western Australia* (DoW 2011c). We are continuing to work with the Water Corporation to maximise benefits and minimise impacts of managed aquifer recharge.
13	Continue to implement the Gnangara Mound metering program across the Gnangara groundwater system, subject to external funding.	Met	See Section 3.1, Objective 2.
15	Continue to inform government decisions on demand management and restrictions to reduce abstractions for the IWSS.	Met	See Section 3.1, Objective 2
16	Continue to review the Water Corporation's contingency source program and advise government as required.	Met	We provided advice to government to expand the Southern Seawater Desalination Plant, maximise use of the Perth Seawater Desalination Plant and support the groundwater replenishment trial.
Actions to support meeting Objective 3 (protect groundwater-dependent ecosystems)			
6	Continue to implement wetland site management including supplementation (artificial maintenance) where appropriate and engage other organisations as required.	Ongoing	We artificially maintained Lake Nowergup as required by the Minister for Environment – see *Perth shallow groundwater systems investigation: Lake Nowergup* (DoW 2011d). Lake levels failed to reach minimum spring peaks and vegetation health declined significantly because groundwater levels were lower, even with supplementation. As a condition of its licence the Water Corporation continued to artificially maintain lake levels at Lake Jandabup and the required minimum levels were met. The Department of Environment and Conservation (DEC), as part of its conservation management, continued artificial maintenance programs at the Yanchep caves. Supplementation will be discontinued where it is no longer effective in maintaining ecosystem health.
17	Continue to report compliance to the EPA.	Met	See Section 3.2, Table 7.

No	Action in plan	Status	Work undertaken
Actions to support meeting Objective 4 (water quality)			
3	Work with DEC to update the current acid sulfate soils risk map, and review procedures for addressing identified ASS risks when licensing.	Partially met	DEC updated the trigger thresholds for acid sulfate soil risk in the plan area, which we use in our licensing assessment process.
4	Continue to implement public drinking water source protection through statutory referrals.	Met	See Section 3.1, Objective 4.
5	Continue to respond to development referrals regarding proposed land uses and impacts on water quality.	Met	See Section 3.1, Objective 4.
Actions to support meeting Objective 5 (adaptive management)			
1	Complete an annual resource assessment report.	Met	An interim resource assessment was completed in 2010 and is summarised in Chapter 1 above. A more detailed regional-scale assessment will be available after PRAMS is revised in 2013.
2	Continue to implement an appropriate research and investigation program.	Met	Scientific work during the past decade was driven by the need to plan for a drying climate and to have more precise management at a local scale. During the reporting period we completed the following investigative work on the Gnangara groundwater system: • mapping of eco-hydrological communities on the Gnangara Mound • detailed hydrogeological investigations at lakes Nowergup, Yonderup and McNess, Lexia wetlands and Tangletoe Swamp, as well as regional investigations of the North Gnangara area • development of local area models for lakes Nowergup, Mariginiup and Bindiar and Lexia wetlands • upgrade of PRAMS to the next version • improved estimates of garden bore use. Copies of the reports from these projects are available on our website or by contacting us.
7	Develop and implement an integrated annual management review and response framework for the Gnangara system.	In progress, partially met	Our response to where management needs changing is shown in Table 11and will inform business planning in each evaluation cycle.
9	Review groundwater area and subarea boundaries.	Deferred	Not yet initiated: will now be completed as part of the next plan.
18	Continue to improve and rationalise the environmental monitoring program.	Met	The environmental monitoring program was reviewed and revised in 2010. Annual monitoring is carried out for all key indicator sites and was reduced to three-yearly for all other sites. Additional sites were added in the northern Gnangara area.

No	Action in plan	Status	Work undertaken
19	Continue to implement the approved groundwater monitoring program.	Met	See Chapter 1.
	Enter groundwater monitoring data into the department's water information network database.		See Section 1.2.
20	Produce and publicly release the annual evaluation statement.	Met	This is the first evaluation statement for the plan.

4 Evaluation against the objectives

To evaluate whether the plan's objectives are being met we assess the performance indicators, management triggers and actions identified in the plan. We rated our performance using the following system:

Code	Description
	71 to 100 per cent of performance indicators or objectives met
	40 to 70 per cent of performance indicators or objectives met
	Less than 40 per cent of performance indicators or objectives met

4.1 Performance indicators

The plan sets out performance indicators to measure whether our management approach is achieving the objectives. An evaluation of the management approach for each performance indicator is presented in Table 9.

Table 9 Status of the performance indicators against the objectives (obj.) of the plan

Performance indicator	Obj.	Evaluation
Change in groundwater levels better reflects change in recharge	1 and 5	• Change in groundwater levels is caused by reduced recharge as well as increased abstraction. While recharge has decreased markedly, abstraction has reduced only slightly. • Annual and seasonal rainfall was lowest on record for 2010, affecting recharge. • Allocation and use remains relatively high (tables 2 and 4). • Lowest-ever-recorded water levels in most areas of the Superficial aquifer (Figure 1). • Water levels in the confined aquifers continue to decline (figures 3 and 4).
Impacts of abstraction on groundwater-dependent ecosystems decreases	3 and 5	• Increase in number of breaches at criteria sites under Ministerial statement no. 819 in 2010–11 compared with previous years: 13 out of 30 sites were non-compliant in 2009 and 16 out of 30 sites were non-compliant in 2011 (DoW 2011a).
Actual use is less than or equal to the licensed entitlement volume	1, 2 and 5	• Metered data from both private and government bores show that individually, most licensees are using less than their licensed entitlement. • Some users are over-abstracting (see Section 2.4).

Performance indicator	Obj.	Evaluation
Licensees comply with licence conditions (and operating strategies)	3 and 4	• Most licensees complied with their licences. • 63 registered surveys (57 in the Superficial aquifer) were completed in 2009–10 and 61 registered surveys (53 in the Superficial aquifer) in 2010–11. • No direction notices were issued. • Four infringement notices were issued in 2010–11 to non-compliant licensees.
Over-allocated resources are recovered	1, 2, 3 and 4	• The number of over-allocated resources remained the same between 2009 and 2011 (Table 2). • In one Leederville and eight Superficial aquifer resources we reduced the amount of over-allocation but did not return them to below the allocation limit. • Where over-allocation increased it was for temporary short-term dewatering or to meet the public water supply demand under the exceptional circumstances rule.

4.2 Evaluation against the objectives

An evaluation of our performance in meeting the plan's objectives is given in *Table* 10. The evaluation of each objective uses all of the information presented in this statement.

Table 10 Evaluation against objectives

Objectives	Assessment	Evaluation
1 Reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the current recharge from rainfall	Ongoing, not met	While abstraction was capped, rainfall and recharge continued to decline. Rainfall in the 2001–10 period was approximately 10% lower than the rainfall used to inform the allocation plan (1976–2006). Groundwater levels in the Superficial aquifer fell and total abstraction did not substantially change. The volume licensed to private users in the Superficial aquifer was 3 GL lower between 2009 and 2011 (tables 4 and 6) via efficiency, removal of unused allocations and increased compliance. However, the volume licensed in the Superficial aquifer for public water supply increased by 15.5 GL in 2010–11 in response to the exceptional circumstances rules being triggered in 2010 (Table 5). Metering data shows that total water use is less than the total volume of licensed entitlements, and that use increases in drier years. Through new efficiency measures – the three-day-a-week summer watering restrictions (bores) and the permanent winter sprinkler ban – estimated domestic garden bore use in the Gnangara area was reduced from 35 GL/yr (800 kL/yr/bore) to 27 GL/yr (400 kL/yr/bore). The current holding pattern was insufficient to achieve a better balance between recharge and abstraction. Total abstraction remained at almost 300 GL in 2011. In line with reducing average public water supply abstraction from 2012, in accordance with the plan, there is now a need to scope for reducing private abstraction through the next plan (see Section 5.1).

	Objectives	Assessment	Evaluation
2	Optimise the use of water through water use efficiency and demand management measures	Ongoing, partially met	The draft *Gnangara sustainability strategy* (DoW 2009b) set a target of 20% water use efficiency gain. This was partially met through: • the state government establishing a permanent two-day-a-week sprinkler roster through the Water Agencies (Water Use) By-laws 2010, which reduced scheme water demand in Perth • the Water Corporation implementing several programs to reduce demand management and improve water use efficiency for public water supply, particularly the IWSS sprinkler restrictions and the Target 60 L program • an expanded metering program resulting in on-farm efficiency improvements • winter sprinkler ban and three-day-a-week roster in summer for garden bore users, reducing the estimated take of water by half • implementation of water conservation plans to improve water use efficiency in local government areas.
3	Protect groundwater-dependent ecosystems from direct impacts associated with abstraction	Ongoing, not met	While abstraction in the vicinity of sensitive groundwater-dependent systems was reduced where possible, this was countered by low recharge and regional scale declines in water levels. In 2010–11, 16 out of 30 criteria sites under Ministerial statement no. 819 were non-compliant (see Table 6, DoW 2011a). This was an increase of two sites compared with 2009–10. Artificial maintenance at Lake Nowergup and Yanchep Caves was continued, but is under review. Low rainfall and reduced recharge during the reporting period contributed to the number of non-compliant sites. Public water supply abstraction from environmentally sensitive bores was reduced by approximately 7 GL in 2010–11 compared with the previous driest year of 2006–07. Private licensed water abstraction near wetlands is assessed and managed in accordance with an environmental risk map to minimise the impacts of abstraction on wetlands.
4	Protect the quality of groundwater for public and self-supply from impacts associated with abstraction and land use	Met	The highest level of public drinking water source protection remains in place for Gnangara, with no significant changes to the protection zones. Any significant adverse effects on water quality from proposed developments were prevented. Acid sulfate soils remain a primary concern, particularly with the continuing declining trend in groundwater levels. There were some reports of localised declining water quality associated with historical fertiliser use in the plan area's north. This did not affect the amount of water abstracted for private use, but reduced take from the Superficial aquifer for the purpose of public water supply.

	Objectives	Assessment	Evaluation
5	Adapt management of the water resource based on the results of monitoring programs and the condition of the resource	Ongoing, partially met	We adapted our response to increased demand for public water supply by applying the ESC system to limit impacts on groundwater-dependent ecosystems. We will be managing future take to the 2012 target of an average of 110 GL/yr from existing infrastructure. We focused management of private abstraction on compliance and efficiency in fully allocated and over allocated areas. Management of use did not keep pace with declining water levels, given the number of dry years and the rapidly growing demand since the plan was in place. We identified several actions we can take to improve our management of the Gnangara system based on this evaluation process (see Section 5).
	Score:	**2/5**	

5 Response to this evaluation

5.1 Adapting our management

This evaluation showed that objectives 1 and 3 were not met, despite managing in accordance with the plan. Meeting these objectives was made more difficult by the critically dry conditions in 2010.

Since developing the plan, and through this evaluation, we have identified several management responses to improve performance against the plan's objectives. The responses are listed below in Table 11.

They will be progressively implemented over the next evaluation period. The response to this evaluation is in addition to completing outstanding and ongoing implementation actions, and our day-to-day licensing and regulatory activities.

The information gathered and assessed during this evaluation indicates that objectives 1 and 3 will not be met by this plan, and as such a replacement plan will be initiated in 2013.

Table 11 Management response to the 2009–11 evaluation against the objectives (obj.)

Obj.	What did the evaluation tell us?	Response
1	Allocation limits need to be updated. The allocation limits in the plan were set in 2007, and were based on rainfall experienced between 1974 and 2006. We are now using the 2001–10 rainfall period for Gnangara groundwater modelling (~10% annual rainfall reduction). The use of reduced rainfall recharge estimates is supported by recent climate change work for south-west Western Australia which shows a consistent declining trend in rainfall.	Allocation limits in the Superficial aquifer across all subareas have been reduced to account for continuing declines in rainfall and recharge. Consistent with the plan the water available for licensing (the general component of the allocation limit) has been reduced by 10%. It should be noted that further reductions to allocation limits are likely in the future. These reductions will be made as part of the next plan scheduled for completion in 2016. Public water supply reserve volumes will be reassessed and removed/reduced as part of the next allocation planning process. Garden bore usage will be accounted for as part of next allocation planning process.

Obj.	What did the evaluation tell us?	Response
	The strategies used to reduce the amount of water taken from the Gnangara system were not sufficient to align abstraction with recharge from rainfall. This confirms the need to continue to adjust abstraction to a more sustainable balance, particularly where this can maintain environmental, water quality or water security benefits for the longer term. An updated and more targeted strategy for reducing over-allocation and use in key areas is needed.	Any significant reductions to existing water entitlements will be progressed through the next allocation planning process. Areas where adjusting abstraction would achieve benefits for the groundwater system, *in situ* public and environmental values and/or longer-term water security will be identified through current research as part of next allocation planning process. Economic and social criteria will also be considered to determine where reductions in use are appropriate. Through the next allocation planning process, and in consultation with stakeholders, we will develop a recovery approach to support the recouping of water entitlements in these identified areas.
	The scheduled 2012 reduction in the average volume of public water supply abstraction to a target of 110 GL/yr (from current infrastructure), and shifting away from increased groundwater take in very dry years, is still necessary. The VGAR, which uses groundwater to 'buffer' dry years, is only effective to manage variation around a steady average rainfall. In a declining rainfall trend it results in sustained high groundwater abstraction, compounding the effects of low recharge on the groundwater system.	Water Corporation licences were changed to a new base of 120 GL/yr from Gnangara and Jandakot. The VGAR will be replaced with a target average of 120 GL/yr of groundwater. Annual groundwater take will align with our ESC system for abstraction bores and it will target low-impact areas of the Gnangara system and other sources to meet demand (e.g. reservoirs). Alternative sources and further demand management are being considered as options to replace additional take of groundwater after very dry years. In the interim a modified exceptional circumstances provision (triggered at 120 GL/yr) will still be needed.
2	Trading, water use efficiency gains, reduced demand and use of alternative water sources (e.g. water recycling) are increasingly important alternatives to the current level, or any additional level of groundwater abstraction.	We will continue work with local government authorities, other agencies and urban developers to reduce demand, optimise use of scarce water and identify alternative options for meeting water demand for urban expansion, particularly for public open parkland. The initial priority for this work is the North west urban growth corridor, in partnership with the City of Wanneroo. With the water supply senior officers group we will continue to advise the government on future water supply options and timing.
1, 2 & 3	Water use in over-allocated areas was not recovered back to allocation limits. The metering data, which confirm under-use of entitlements in some areas, show a high risk to the water resource is posed if full use is achieved. Metering data show some water users are taking more than their licensed entitlement.	We will continue to recoup unused entitlements to manage risk. We will continue to focus our compliance activities in high-use and high-environmental-risk areas and follow up with enforcement action where over-use is identified through metering data and compliance surveys.

Obj.	What did the evaluation tell us?	Response
3	In 2010 groundwater levels in the Superficial aquifer reached their lowest levels on record. This resulted in the highest number of non-complaint Ministerial criteria sites since monitoring began. In addition to this, the exceptional circumstances rule was triggered for an increased take to meet public water supply demand in 2010. The ESC system for public water supply abstraction and the environmental risk mapping for private abstraction were applied, but were not enough to minimise the number of criteria sites breached.	We will use research to identify which groundwater-dependent ecosystems can survive in a drying climate and which ones can transition to a drier eco-hydrological state with appropriate management. This will guide how abstraction can be managed to increase the opportunity for wetland resilience, while still providing for public and private water needs. Investigate the linkage between abstraction and impacts on criteria sites such as Loch McNess and Lake Nowergup. Reduce abstraction in high-value target areas through a next plan (see response to Objective 1). Update the environmental risk map used in licensing to reflect up-to-date understanding and research findings.
5	While plan actions were largely implemented these need to be sustained over a much longer period to meet objectives 1 and 3. The evaluation shows areas where current management can be improved and where a new plan is required to progress water resource management in the Gnangara groundwater areas into the future (see Section 5.2).	In addition to carrying out the responses identified, we will focus scientific work on: • developing local area models for priority groundwater-dependent ecosystems • improving our understanding of the northern and coastal regions of the Gnangara Mound via saltwater interface monitoring and identifying the connection between the Superficial aquifer and the underlying Yarragadee and Leederville aquifers.
	There is still enough positive pressure (above the top of the aquifer) for the Leederville and Yarragadee aquifers to sustain current abstraction. Taking more water from these aquifers may be a viable way to reduce impacts on the Superficial aquifer. This includes looking at offsetting this with managed aquifer recharge and other risk management.	A program to investigate confined aquifer capacity and connectivity is being scoped. In parallel, the department and the Water Corporation will develop a confined aquifer abstraction strategy. This will include the rules for impact and risk management, and a strategy on the mitigation of impacts through managed aquifer recharge.

5.2 Future planning

The 2009 *Gnangara groundwater areas allocation plan* was a first step in updating our groundwater management in the context of high demand for water in a drier climate. The 2009 plan delivered critical improvements in how the groundwater system is managed. Specifically it made the contentious decision to cap any further increases in groundwater allocation, set management actions to reduce the impacts of abstraction in the Superficial aquifer, and provided a basis to meet growth in demand through efficiency gains and new supply options.

Private abstraction from developed areas was essentially capped. At the same time a staged reduction (with provision for exceptional circumstances) and redistribution (to limit impacts on the Superficial aquifer) of public water supply abstraction was initiated.

The 2009 plan identified that it would need to be reviewed in 2012 (after new legislation) and replaced with a new allocation plan if necessary. The review provided by this

evaluation shows that a new plan is needed to take the next step to maintaining a viable multi-benefit resource for the longer term. The new plan will focus on the framework and tools to better meet objectives 1 and 3. As this will need significant negotiation and consensus on the future state of the Gnangara system and the actions to achieve it, a formal planning process is appropriate.

Initiating work on the next phase of the *Gnangara groundwater areas allocation plan* is a 2013 business priority for the Department of Water. A project schedule for the new plan will be developed in 2013, with the purpose and outcomes clarified and agreed with key stakeholders. We will report on this in the next evaluation statement.

Work to improve management under the current plan (Table 11) is continuing in parallel with preliminary work for the next plan. The new plan is now scheduled for 2016.

5.3 Other actions

The technical work done for the draft *Gnangara sustainability strategy* (DoW 2009b) informs a manageable transition to a drier future through environmental, land and water planning. This and more recent work will support the 2016 groundwater allocation plan in establishing the pathway to a water balance that reflects ongoing declines in recharge.

The department will continue working with:

- local government and planning authorities to reduce the reliance on shallow groundwater through urban and open space design and water use efficiency
- the Water Corporation to maintain the shift towards a reduced reliance on shallow groundwater for Perth's water supply
- the Department of Agriculture and Food to maintain and progress the effective use of water for urban horticulture.

These processes will occur ahead of, and in parallel with, the allocation planning process.

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Legislation

Rights in Water and Irrigation Act 1914

Water Agencies (Water Use) By-laws 2010

Database

Department of Water, Perth Groundwater Atlas, <www.water.wa.gov.au/idelve/gwa>.

Shortened forms

DEC	Department of Environment and Conservation
DoW	Department of Water
ESC	environmental sensitivity classification
IWSS	Integrated Water Supply Scheme
OEPA	Office of the Environmental Protection Authority
PRAMS	Perth Regional Groundwater Modelling System
VGAR	variable groundwater abstraction rule

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 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)