Government of **Western Australia**
Department of **Water and Environmental Regulation**

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Environmental management of groundwater from the Gnangara Mound

Triennial compliance report July 2015–June 2018

May 2020

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May 2020

ISSN 1033-8950

WT6512

FIRST 115827

Acknowledgements

This document was prepared by the Water Allocation Planning Branch with assistance from the Regulation, Water Resource Assessment and Water Information and Modelling branches; and regional operations officers of the Swan–Avon Region (Welshpool office).

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Disclaimer

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1 Summary

This report describes compliance by the Department of Water and Environmental Regulation (the department) with Ministerial conditions and commitments for the Gnangara Mound for the period 1 July 2015 to 30 June 2018 under Part IV of the *Environmental Protection Act 1986 – Ministerial statement no. 819* (Government of Western Australia 2009a).

This report presents total licensed groundwater entitlements covered by the *Gnangara groundwater areas allocation plan* (DoW 2009a) from all aquifers of the Gnangara groundwater system (Figure 1, Table 1, 2 and 3). It also outlines the environmental monitoring, management, research and consultation the department is doing to improve sustainable management of the Gnangara groundwater system.

The department initiated many of these strategies through the *Gnangara groundwater areas allocation plan* (DoW 2009a), which has been a key step in adapting to climate change. The next Gnangara groundwater allocation plan is currently being developed and will outline further strategies to achieve target groundwater levels to maintain the groundwater-dependent environment.

Over the 2015–18 reporting period, the number of sites that were non-compliant with absolute minimum or peak water level criteria in Ministerial Statement No 819 decreased from 18 in 2015–16 to 16 in 2016–17 and to 14 in 2017–18. The improved level of compliance over the reporting period has been supported by a combination of Perth experiencing a period of relatively stable rainfall (in comparison to the 2000s) and two large summer rainfall events in 2017 and 2018 that slowed the groundwater level declines that normally occur in the January to April period.

Public water supply entitlements in 2015–16 and 2016–17 included temporary groundwater licences that were approved for the Integrated Water Supply Scheme under ‘exceptional circumstances’ conditions. The temporary volumes, 10 GL in 2015–16 and 13.5 GL in 2016–17, were required to secure supply to the scheme after very low inflows to our dams by the end of winter in 2015.

Table 1 Rainfall, licensing totals from all aquifers and compliance summary

	2015–16	2016–17	2017–18
Rainfall [1]	602.0 mm	633.6 mm	765.6 mm
Public water supply entitlements	121.31 GL	123.70 GL	110.71 GL
Private licensed entitlements	127.16 GL	128.11 GL	129.44 GL
Estimated garden bore use [2]	36.00 GL	36.00 GL	36.00 GL
No. of non-compliant sites with absolute minimum or peak water level criteria [3]	18 out of 30	16 out of 30	14 out of 30

1 Rainfall figures are for July to June and taken from Perth Airport (BoM site no. 9021).

2 Domestic garden bore use is estimated using data collected through surveys, data from the Australian Bureau of Statistics and records of household use from Water Corporation.

3 For full details of compliance see Table 4 and Appendix A

2 Background

2.1 Ministerial statement no. 819

Ministerial statement no. 819: Gnangara Mound groundwater resources sets environmental water provisions in the form of water level criteria at 30 sites across the Gnangara Mound groundwater resource – 14 wetland sites and 16 terrestrial phreatophytic vegetation sites (Figure 1). Phreatophytic vegetation is vegetation that uses groundwater to meet at least part of its water needs.

The conditions and commitments under *Part IV of the Environmental Protection Act 1986* were first established in 1988 (*Ministerial statement no. 21*) to manage how groundwater was abstracted for public water supply and the expected growth in private licensed use. Since then, the conditions and commitments have been revised several times to remove sites where environmental values have been lost due to causes other than abstraction (Appendix C). These causes include reduced rainfall due to climate change, land clearing and disturbance related to changing land use.

The most recent revision in 2008 resulted in the removal of seven sites and amended water level criteria at three sites. The water level criteria at the current 30 sites represent contemporary environmental water provisions, suitable for protecting significant environmental values of groundwater-dependent ecosystems supported by the Superficial aquifer of the Gnangara groundwater resources.

Since the merging of the Department of Water, Department of Environment Regulation and the Office of the Environmental Protection Authority in July 2017, the Department of Water and Environmental Regulation (the department) has become the proponent of *Ministerial statement no. 819.* To ensure there is no possible apprehension of bias, the department's Director General will not be involved in monitoring compliance with the Statement. The Executive Director, Compliance and Enforcement has been formally delegated to exercise the compliance duties under the *Environmental Protection Act 1986*.

2.2 The Gnangara groundwater system

The Gnangara groundwater system is located on the Swan Coastal Plain. It extends from the Swan River in the south to Moore River and Gingin Brook in the north, and from the coast to close to the Darling Scarp in the east. It covers an area of about 2200 km^2. The system comprises four main aquifers:

- the shallow, unconfined Superficial (watertable) aquifer known as the Gnangara Mound
- the shallow, semi-confined Mirrabooka Aquifer
- the deep, partially-confined Leederville Aquifer
- the deep, mostly-confined Yarragadee Aquifer.

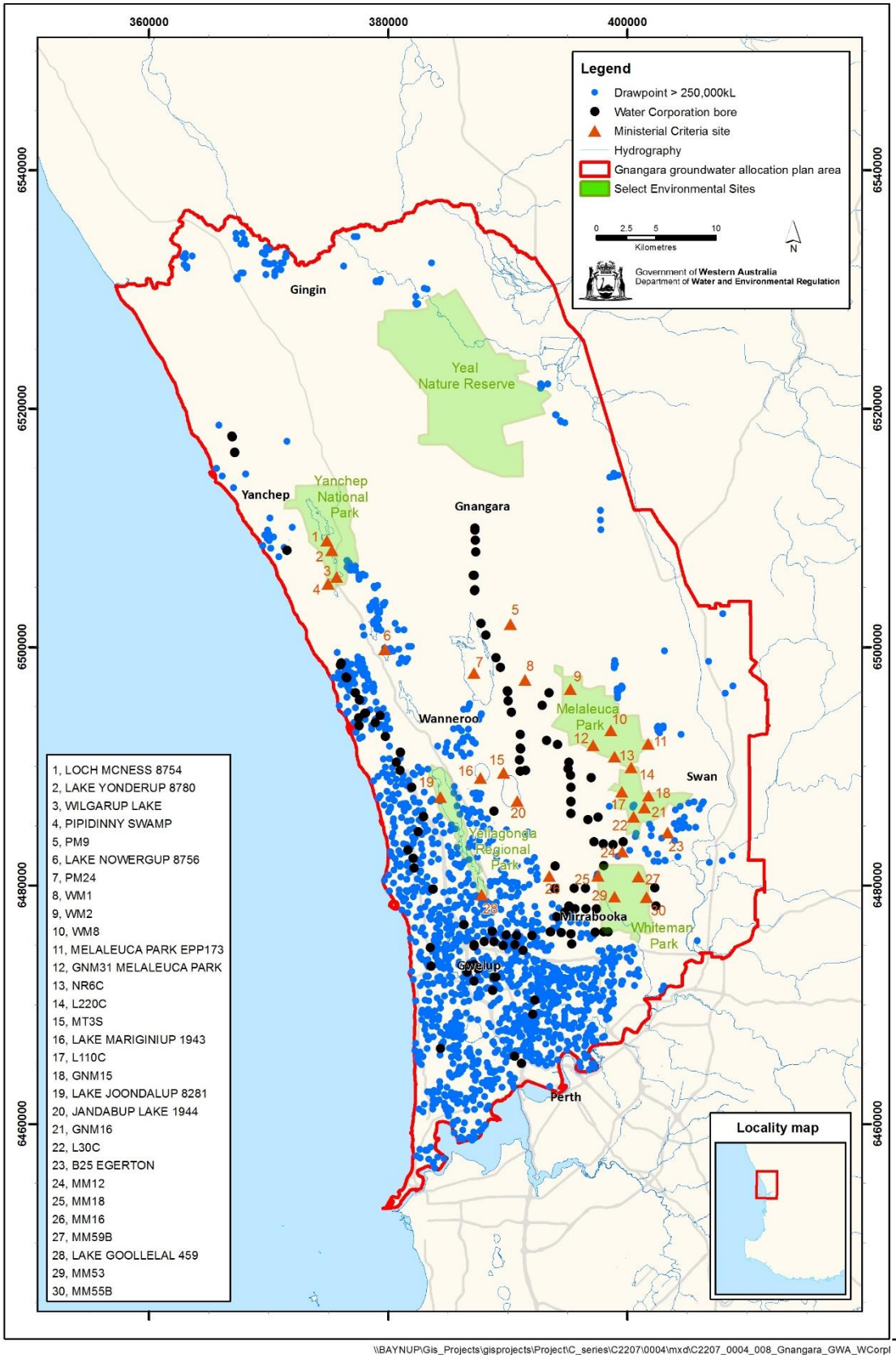

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Figure 1 Location of Gnangara Ministerial sites, public water supply production bores and private licensed drawpoints

The Gnangara groundwater system is now over-allocated and overused. This is a result of:

- groundwater abstraction for public water supply and private use
- climate change (less rainfall and recharge)
- pine plantations limiting recharge to groundwater.

This has resulted in water levels generally declining over the last 40 years which has impacted on important wetlands and other groundwater-dependent ecosystems.

Environmental impacts to ecosystems from groundwater level decline can occur where those ecosystems are directly supported by the regional watertable. In the Gnangara area, the main watertable aquifer is the Superficial aquifer. Impacts can occur by pumping from the Superficial aquifer itself or through abstraction from deeper aquifers where they are directly or indirectly connected to the Superficial aquifer. Such connections exist in the northern half of the Gnangara plan area.

2.3 Allocation limits and licensing

The department uses allocation limits, licensing of groundwater abstraction and monitoring of water levels as the main mechanisms to manage groundwater resources. An allocation limit is the annual volume of water set aside for sustainable consumptive use from a water resource. This usually includes:

- water that is available for licensing
- water we account for that is exempt from licensing, including water used by domestic garden bores
- water we set aside for future public water supply.

Licensing of groundwater associated with managed aquifer recharge (including for the Groundwater Replenishment Scheme – see section 6.2) is managed outside the allocation limit.

Water for the environment is not included as part of the allocation limit either, as it is made up of the water that is left in the groundwater system. It is considered a non-consumptive use. Water is ‘allocated’ to the environment through the setting of water level criteria at high value wetland and bushland sites on the Gnangara groundwater system. The water level criteria are generally set as minimum water levels and represent the groundwater that is required to protect the stated values of a particular ecosystem. The allocation limits are then set to ensure that enough water is left in the system to meet the water level criteria, and therefore to protect the groundwater-dependent values of the ecosystems.

Allocation limits are set following comprehensive assessments of the state of the groundwater resource, hydrogeological capacity of the system, and risks of abstraction to the resource, existing users and the environment. The department applies climate science, hydrogeological modelling and environmental assessments when setting and reviewing allocation limits.

The department is in the process of reviewing allocation limits for the Gnangara groundwater system and establishing pathways for reducing groundwater use.

3 Rainfall

Groundwater is recharged by rainfall. How much groundwater levels rise and fall each year is affected by the amount of rain that falls in the catchment, but also by how it falls (timing, pattern, and intensity). Recharge is also affected by temperature – warmer weather will increase evaporation and allow less rainfall to reach the aquifer.

The climate across south-west Western Australia is changing. There has been a general trend of declining annual rainfall since the mid-1970s. Average temperatures have also risen. CSIRO's investigation of climate change (Bates et al. 2010), as well as relevant global climate change models, predict continued rainfall reduction in the region.

Over the 2015–18 reporting period, rainfall at the Bureau of Meteorology's (BoM) Perth Airport station was below the short and long-term annual averages in two out of the three years (Figure 2). Annual rainfall was 602.0 mm in 2015–16, 633.6 mm in 2016–2017 and 765.6 mm in 2017–18.

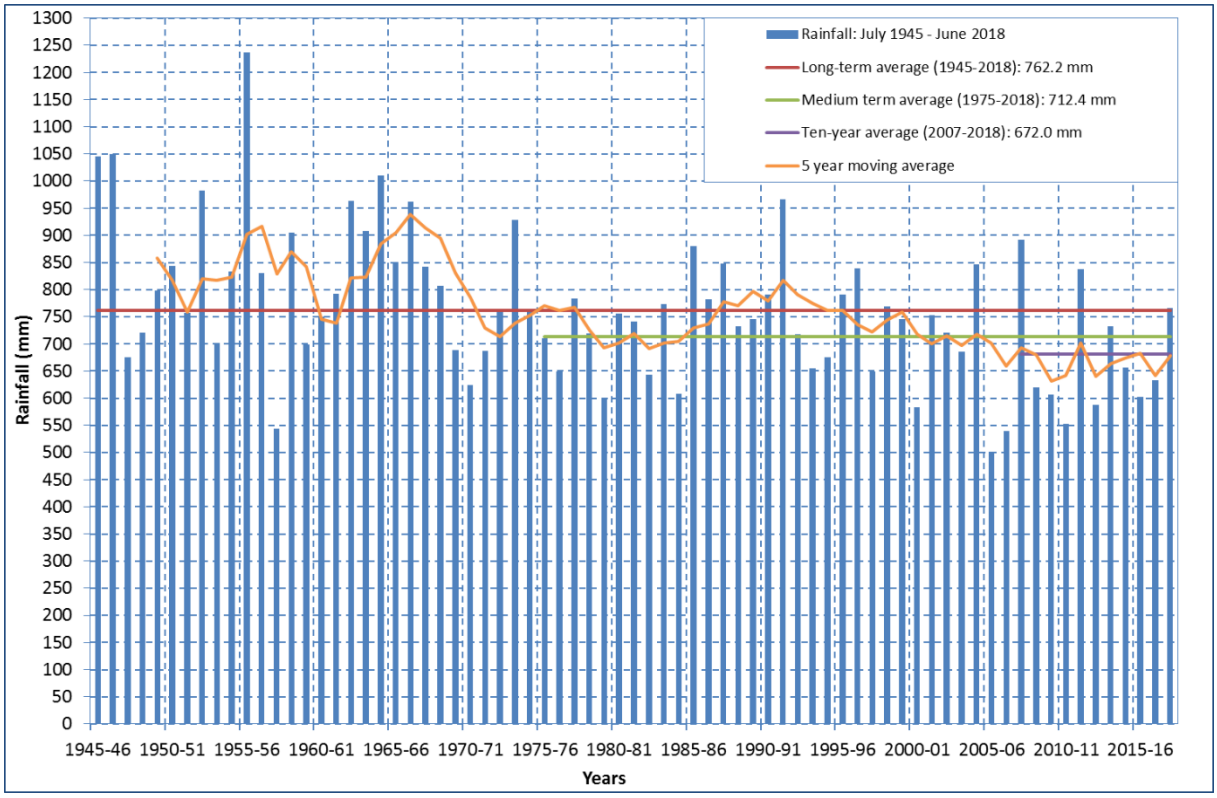

Figure 2 Annual and average water-year (July–June) rainfall at Perth Airport (BoM site no. 9021)

4 Groundwater use

The Gnangara groundwater system is the Perth region's largest source of good quality fresh water. It provides almost half of Perth's public water supply. It also provides water for public open spaces, for local horticulture and viticulture, and for domestic garden bores.

This section summarises licensed entitlements and provides estimates of uses that are exempt from licensing within the Gnangara allocation plan area. Table 2 summarises licensed and exempt use from all aquifers for the three-year reporting period, and Table 3 provides a breakdown of licensed entitlements from the Superficial aquifer for those years for each of the Gnangara plan subareas.

4.1 Public water supply

The department licenses Water Corporation to take groundwater from the Gnangara and Jandakot groundwater systems for Perth's public water supply. Groundwater from these systems forms a crucial component of Perth's Integrated Water Supply Scheme (IWSS). Within the Gnangara system, a small volume of groundwater is licensed for the Woodridge town water supply. This volume does not form part of the Integrated Water Supply Scheme and is licensed separately.

The volume of groundwater licensed for public water supply from all aquifers was 121.31 GL in 2015–16, 123.70 GL in 2016–17 and 110.71 GL in 2017–18. The volumes in the first two years of the reporting period included additional temporary groundwater licences of 10 GL in 2015–16 and 13.5 GL in 2016–17 across the Gnangara and Jandakot systems to secure supply to the scheme because of extremely low inflows into our dams in 2015 (Table 2).

The decision to allocate additional volumes for public water supply was a contingency action after Water Corporation also:

- increased production from desalination plants
- used low dam storage
- brought forward investment in the next stage of groundwater replenishment and investigations into the next water source options
- invested in stronger demand management including their "Drop 2" and "Tap In" media campaigns.

Groundwater Replenishment Scheme

The licensing of groundwater associated with the Groundwater Replenishment Scheme is managed outside the allocation limits set for the Gnangara system so the volumes are reported separately from other volumes licensed for public water supply.

Groundwater Replenishment (GWR) is a form of managed aquifer recharge. GWR currently occurs at Beenyup wastewater treatment plant in Craigie where water is treated to drinking standard and recharged/injected into the Leederville and

Yarragadee aquifers. An equivalent amount of water is then abstracted from aquifers across the Gnangara or Jandakot groundwater systems, and this is subject to a groundwater licence. For administration purposes licensing of the groundwater recovery from GWR is managed outside of the allocation limit.

No groundwater recovery was licensed as part of the GWR scheme in 2015–16 or 2016–17 due to the upgrading of Beenyup Treatment Plant. In 2017-18 13 GL was licensed from the Gnangara system as part of Stage 1 of the GWR scheme. The distribution of GWR recovery between drawpoint locations and aquifers (Table 2) considers IWSS operating constraints while aiming to limit overall impacts to groundwater-dependent ecosystems supported by the Gnangara groundwater system. Only part of the 13 GL licensed in 2017–18 was abstracted due to delays in commissioning the scheme.

Water recharged through Stage 2 of the GWR Scheme will provide broader benefits to the groundwater system including to some dependent ecosystems such as wetlands. The locations of the recharge bores being constructed as part of Stage 2 were chosen based on where the additional groundwater recharge from reinjection would best support environmental objectives.

Once Stage 2 of the GWR scheme is complete its capacity will increase to 28 GL.

4.2 Private licensed use

Groundwater licensed for private use from the Gnangara system mostly comes from the Superficial aquifer. Groundwater abstracted from this aquifer is mainly used for irrigation of public open spaces, agriculture, industry and commercial uses.

Private licensed entitlements have remained relatively steady since the department implemented the *Gnangara groundwater areas allocation plan* (DoW 2009a) which capped private entitlements in most subareas (Table 2).

4.3 Use that is exempt from licensing

The department estimates and accounts for groundwater that is exempt from licensing.

The main types of exempt water use from Gnangara are garden bores used in urban areas and stock and domestic bores used in rural areas where there is no scheme water connection.

In 2014 an estimated total of 36 GL/year was abstracted from about 65,000 garden bores and 4,000 stock and domestic bores.

There is good information on the number of garden bores that are installed in urban areas across Perth. This includes data from on-the-ground surveys by Water Corporation, surveys by the Australian Bureau of Statistics in 2003, 2006 and 2009, and independent phone surveys conducted in 2012, 2016 and 2018.

Average water use per bore was estimated from the department's domestic bore metering project which operated from 2009–2012 and was updated in 2016.

Estimates of exempt use are updated over time as we get new data on rates of instalment and average water use per bore in urban and rural areas.

Table 2 Licensed and garden bore water use from all aquifers in the Gnangara groundwater system, comparing the three years of the triennial reporting period: 2015–16, 2016–17 and 2017–18

Aquifer	Public water supply entitlements [1] GL						Private licensed entitlements GL			Garden bore use exempt from licensing GL		
	Baseline + additional temporary licences [2]			Groundwater replenishment (GWR) [5]								
	2015–16	2016–17	2017–18	2015–16	2016–17	2017–18	2015–16	2016–17	2017–18	2015–16	2016–17	2017–18
Superficial	31.08	32.25	32.20	0.00	0.00	1.00	112.75	113.68	115.61	36.00	36.00	36.00
Mirrabooka [3]	1.30	3.61	2.25	0.00	0.00	0.80	2.32	2.37	3.00	-	-	-
Leederville	40.03	38.82	33.80	0.00	0.00	8.45	11.31	11.28	10.07	-	-	-
Yarragadee	[4] 48.90	[4] 49.02	[4] 42.45	0.00	0.00	2.75	0.68	0.68	0.68	-	-	-
Fractured rock	0	0	0	0	0	0	0.10	0.10	0.09	-	-	-
TOTAL	**121.31**	**123.70**	**110.71**	**0.00**	**0.00**	**13.00** [6]	**127.16**	**128.11**	**129.44**	**36.00**	**36.00**	**36.00**

1 Public water supply volumes include groundwater licensed to Water Corporation for both the Integrated Water Supply Scheme and the Woodridge town water supply.

2 Baseline licence for Gnangara groundwater public water supply entitlements (including MR17) is 110.65 GL. Additional temporary licences were granted in 2015–16 and 2016–17.

3 Mirrabooka and fractured rock aquifer volumes have been previously reported together but have been separated out in this report.

4 Yarragadee volumes include 0.70 GL in 2015–16, 0.95 GL in 2016–17 and 0.85 GL in 2017–18 from bore MR17, which is located outside of the Gnangara plan boundary in the Perth South Groundwater Area.

5 No water was allocated against GWR in 2015–16 or 2016–17 due to the upgrading of Beenyup Treatment Plant.

6 Only part of the 13 GL licensed for groundwater replenishment in 2017–18 was abstracted by Water Corporation due to delays in commissioning the scheme.

Table 3 Licensed entitlements from the Superficial aquifer in subareas of the Gnangara groundwater areas allocation plan

Groundwater area	Subarea	Ministerial criteria site present?	Public water supply entitlements [1] GL						Private licensed entitlements [3] GL		
			Baseline + additional temporary licences			Groundwater replenishment [2]					
			2015–16	2016–17	2017–18	2015–16	2016–17	2017–18	2015–16	2016–17	2017–18
Gingin	Beermullah Plain South	No							2.80	3.30	3.30
	Deepwater Lagoon South	No							3.02	3.08	3.08
	Guilderton South	No	0.03	0.03	0.03				9.87	9.82	7.19
	Lake Mungala	No							2.85	2.84	2.83
Total for Gingin Groundwater Area			**0.03**	**0.03**	**0.03**	**0.00**	**0.00**	**0.00**	**18.54**	**19.04**	**16.39**
Gnangara	Reserve	Yes	0.22	0.28	0.92				1.42	1.42	1.53
	Wanneroo Wellfield	Yes	6.08	6.00	6.52				2.10	2.12	2.37
Total for Gnangara Groundwater Area			**6.30**	**6.28**	**7.43**	**0.00**	**0.00**	**0.00**	**3.53**	**3.54**	**3.90**
Gwelup	Gwelup	No	3.20	3.37	3.55				1.17	1.12	1.09
Total for Gwelup Groundwater Area				**3.37**	**3.55**	**0.00**	**0.00**	**0.00**	**1.17**	**1.12**	**1.09**
Mirrabooka	Ballajura	No	1.80	2.10	2.28	0.00	0.00	0.05	0.89	0.89	1.20
	Beechboro	No							0.32	0.33	0.34
	Henley Brook	No	0.50	0.50	0.50				0.27	0.27	0.25
	Improvement Plan 8	No	1.05	1.05	1.08				0.13	0.27	0.66
	Landsdale	Yes							0.66	0.52	0.50
	Plantation	No							0.36	0.36	0.36
	State Forest	No							1.03	1.03	1.31
	Whiteman Park	Yes	0.15	0.15	0.00				0.60	1.09	1.31
Total for Mirrabooka Groundwater Area			**3.50**	**3.80**	**3.99**	**0.00**	**0.00**	**0.05**	**4.26**	**4.75**	**5.94**
Perth	City of Bayswater	No							1.81	2.45	3.30
	City of Fremantle North	No							0.04	0.05	0.05
	City of Nedlands	No							2.35	2.41	2.36
	City of Perth	No							2.95	2.16	1.72
	City of Stirling	No	2.60	3.82	2.85	0.00	0.00	0.30	7.68	7.65	7.83
	City of Subiaco	No							0.99	0.99	0.99
	Eglinton	No							2.44	2.51	2.94
	Quinns	No	11.00	10.36	9.63	0.00	0.00	0.25	3.67	3.52	2.97
	Shire of Peppermint Grove	No							0.08	0.08	0.08
	Shire of Swan North	No							0.64	0.61	1.52
	Town of Bassendean	No							0.39	0.39	0.39
	Town of Cambridge	No							2.47	2.42	2.39
	Town of Claremont	No							0.70	0.70	0.70
	Town of Cottesloe	No							0.27	0.27	0.27
	Town of Mosman Park	No							0.48	0.48	0.48
	Town of Vincent	No							2.23	0.74	0.77
	Whitfords	Yes	2.92	3.08	3.25			0.40	8.93	8.90	8.85
Total for Perth Groundwater Area			**16.52**	**17.26**	**15.75**	**0.00**	**0.00**	**0.95**	**38.12**	**36.32**	**37.58**
Swan	Bandy Spring	No							0.33	0.33	0.33
	Central Swan	No							1.26	1.24	1.23
	Cockman Bluff	No							1.45	1.39	1.38
	East Swan	No							0.72	0.73	0.72
	Neaves	No							3.20	3.20	3.24
	North Swan	Yes							3.21	3.19	3.22
	Radar	No							1.86	1.86	2.87
	South Swan	No							3.54	3.45	3.55
Total for Swan Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**15.56**	**15.39**	**16.53**
Wanneroo	Adams	Yes							1.08	1.08	1.08
	Carabooda	No							7.91	7.71	8.04
	Carramar	No							1.50	1.50	1.50
	Jandabup	No							0.18	0.18	0.18
	Joondalup	No							0.86	0.84	0.83
	Lake Gnangara	No							6.55	6.50	6.71
	Mariginiup	Yes							4.13	4.05	4.11
	Neerabup	No							2.53	2.57	2.56
	Nowergup	Yes							2.58	2.54	2.71
	Pinjar	Yes							0.58	0.58	0.56
Total for Wanneroo Groundwater Area			**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	**0.00**	**27.90**	**27.56**	**28.28**
Yanchep	Yanchep	Yes	1.47	1.55					3.69	5.96	5.89
Total for Yanchep Groundwater Area			**1.54**	**1.55**	**1.47**	**0.00**	**0.00**	**0.00**	**3.69**	**5.96**	**5.89**
Total for Gnangara groundwater allocation plan area			**31.08**	**32.25**	**32.17**	**0.00**	**0.00**	**1.00**	**112.75**	**113.68**	**115.61**

1 Public water supply information is from both the Water Resources Licensing System (2015–16 and 2016–17) and COMPASS (2017–18) as well as annual reports submitted to the department as a condition of Water Corporation's licences.

2 No water was licensed for GWR in 2015–16 or 2016–17 due to the upgrading of Beenyup Treatment Plant.

3 For the period 2015–16 and 2016–17 private licensed entitlement data was sourced from the department's Water Resources Licensing System (2015–16 report run on 1 July 2016 and 2016–17 report run on 1 June 2017. The report was run earlier in 2017, due to timing of upgrades to the licensing and reporting systems. The 2017–18 report was run on 1 July 2018 using COMPASS.

Up-to-date figures on water availability are available from the department's website or through the Swan–Avon Regional office.

1 GL = 1 000 000 kL. Figures have been rounded to two decimal places.

5 Compliance

The conditions and commitments that the department is required to comply with from *Ministerial statement no. 819: Gnangara Mound groundwater resources* (Government of Western Australia 2009a) are shown in Appendices A and B (the 'audit tables'). A cornerstone of the *Ministerial statement no. 819* conditions are the water level criteria and biological monitoring conditions set at groundwater-dependent ecosystems across the Gnangara allocation plan area. Information specifically related to these conditions is described below and in section 6.1.

5.1 Compliance with water level criteria

Ministerial statement no. 819 sets water level criteria at 30 sites across the Gnangara Mound (Figure 1). There are 14 wetland sites and 16 terrestrial (phreatophytic) vegetation sites. Some sites have more than one water level criterion and can be non-compliant with multiple criteria. Water level criteria include:

- absolute minimum levels and peak water levels
- preferred minimum water levels – these are set at some wetlands and allow water levels to fall between the 'preferred' level and the absolute minimum level in two out of six years (replicating natural drying cycles). Preferred minimum water levels are referred to as 'other' water level criteria in this report.

Over the 2015–18 reporting period, the number of sites that were non-compliant with absolute minimum or peak water level criteria decreased from 18 in 2015–16 to 16 in 2016–17 and to 14 in 2017–18 (Table 4). Notable changes within the reporting period were:

- In 2016–17 and 2017–18 water levels at Lexia 86 were compliant after falling below the absolute minimum criteria for the first time in 2015–16.
- Levels at Lake Jandabup were compliant in 2016–17 for the first time since 2008–09 but were non-compliant in 2017–18.
- In 2017–18 water levels at Lake Mariginiup were compliant for the first time since 2009-10, and WM2 and WM8 were compliant for the first time since 2011–12 and 2010–11 respectively.

Management and mitigation actions implemented by the department in response to non-compliance are described in Section 6. Details for individual sites can be found in the 'audit tables' in Appendix A.

The improved level of compliance over the reporting period has been supported by a combination of Perth experiencing a period of relatively stable rainfall (in comparison to the 2000s) and two large summer rainfall events in 2017 and 2018 that slowed the groundwater level declines that normally occur over summer and autumn.

Table 4 Summary of non-compliance with Ministerial criteria for the Gnangara groundwater resources

Non-compliant sites[1]				
Absolute minimum or peak water level criteria			Other water level criteria	
Wetlands	**Terrestrial vegetation**	**Total non-compliant**	**Wetlands**	**Total non-compliant**
2015–16				
Loch McNess Lake Yonderup Lake Mariginiup Lake Jandabup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 86 Lexia 186 Melaleuca Park-EPP173 Melaleuca Park-Dampland 78	MM53 MM55B MM59B PM9 WM1 WM2 WM8	18 out of 30	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park-Dampland 78	6 out of 8
2016–17				
Loch McNess Lake Yonderup Lake Mariginiup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park-EPP173 Melaleuca Park-Dampland 78	MM53 MM55B MM59B PM9 WM1 WM2 WM8	16 out of 30	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park-Dampland 78	6 out of 8
2017–18				
Loch McNess Lake Yonderup Lake Jandabup Lake Nowergup Lake Wilgarup Pipidinny Swamp Lexia 186 Melaleuca Park-EPP173 Melaleuca Park-Dampland 78	MM53 MM55B MM59B PM9 WM1	14 out of 30	Lake Joondalup Lake Mariginiup Lake Nowergup Lexia 86 Lexia 186 Melaleuca Park Dampland 78	6 out of 8

1 In the event that a site is non-compliant with both absolute summer minimum and peak water level criteria within the same year, it is only counted as a single incidence of non-compliance i.e. the site is not double-counted. See also Appendix A.

6 Environmental monitoring, management, research and consultation

6.1 Environmental monitoring

Expert environmental consultants undertake environmental monitoring for the department in line with the commitments in *Ministerial statement no. 819: Gnangara Mound groundwater resources* (Government of Western Australia, 2009). The monitoring provides a representative indication of the health of the system and includes:

- wetland vegetation
- wetland macroinvertebrates and water quality
- mound spring macroinvertebrates and water quality
- wetland frogs.

Ecological condition of groundwater-dependent ecosystems is affected by a number of factors of which the water regime is just one. Other factors include fire, insect attack, disease, weed invasion, pollution, and disturbance from changing land use. Similarly, groundwater abstraction is just one factor that can affect the water regime of an ecosystem. Others include changes in rainfall patterns, fire, and land use changes such as urbanisation.

The department uses the results of environmental monitoring to continually improve understanding of the relationship between water levels and ecological condition. The information is also used to manage abstraction at priority locations, reducing abstraction where it is likely to improve ecological condition.

Wetland vegetation

Over the triennial reporting period the condition of wetland vegetation was monitored in spring at the sites listed in Table 5. In addition to Ministerial criteria sites, vegetation monitoring is also carried out at other sites of ecological importance that may be affected by abstraction, such as within Yeal Nature Reserve. Details of the wetland vegetation monitoring can be found in Buller et al. (2016, 2017 and 2018).

Table 5 Sites where wetland vegetation monitoring occurred over the 2015-18 triennial reporting period

	2015-16	2016-17	2017-18
Ministerial criteria sites	Lake Jandabup Lake Mariginiup Loch McNess Lake Yonderup Lake Nowergup Lake Joondalup Melaleuca Park EPP173 Lexia 86	Lake Jandabup Loch McNess Lake Yonderup Lake Nowergup Melaleuca Park EPP173 Lexia 86 Lexia 186	Lake Jandabup Loch McNess Lake Yonderup Lake Nowergup Melaleuca Park EPP173 Lexia 86 Lexia 186
Other sites	Lake Bindiar PM4 Quin Brook Quin Swamp Yeal Lake Lake Muckenburra Lake Bambun Tangletoe Swamp	Lake Bindiar Quin Brook Quin Swamp Lake Bambun	Lake Bindiar Quin Brook Lake Bambun Lake Gwelup

Over the reporting period there were several wetlands at which monitoring showed declining groundwater levels had contributed to declines in canopy condition of overstorey species, and/or the disappearance or decline in condition and abundance of some key wetland species. These wetlands include:

- Loch McNess – declines in groundwater levels since 2004 have contributed to the recent loss of the key wetland macrophyte, *Baumea articulata,* at the transect and declines in health of *Melaleuca rhaphiophylla.*
- Lake Yonderup – lower groundwater levels have contributed to declining condition of *Melaleuca rhaphiophylla* on the transect and recent deaths of mature trees.
- Lake Mariginiup – water level declines since 1997 have contributed to it being one of the poorest sites in terms of wetland vegetation health.
- Lake Nowergup – declines in water levels have led to deaths of mature trees and reduced health of the key wetland macrophyte *Baumea articulata*.
- Melaleuca Park EPP173 – groundwater declines since the mid-2000s have contributed to the wetland species of *Baumea articulata* and *Pericalymma ellipticum* disappearing from the transect.

Over the longer term, most monitored wetlands show declines in canopy condition and species similarity, and a general increase in exotic species cover-abundance.

Wetland macroinvertebrates and water quality

Over the reporting period the sites in Table 6 were surveyed for aquatic macroinvertebrates and water quality.

Table 6 Sites where macroinvertebrate and/or water quality monitoring occurred over the 2015-18 triennial reporting period

	Macroinvertebrates		Water quality	
	Ministerial criteria sites	**Other sites**	**Ministerial criteria sites**	**Other sites**
2015-16	Lake Jandabup Loch McNess Melaleuca Park EPP173 Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup Melaleuca Park EPP173	Yeal Lake	Lake Mariginiup Lake Yonderup Lake Joondalup Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup	Lake Gnangara Lake Gwelup Lake Bambun Yeal Lake
2016-17	Lake Jandabup Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup Melaleuca Park EPP173	Lake Gnangara Lake Bambun	Lake Jandabup Lake Mariginiup Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup Melaleuca Park EPP173	Lake Gnangara Lake Bambun
2017-18	Lake Jandabup Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup Melaleuca Park EPP173	Lake Gwelup Lake Bambun	Lake Jandabup Lake Mariginiup Loch McNess Lake Nowergup Lake Yonderup Lake Goollelal Lake Joondalup Melaleuca Park EPP173	Lake Gnangara Lake Gwelup Lake Bambun

The surveys showed that despite water levels improving at some sites, critically low water levels at Loch McNess, Lake Nowergup, Lake Yonderup, Lake Mariginiup, Lake Jandabup and Melaleuca Park EPP173 continued to contribute to:

- risk of acidification at Lake Jandabup and Lake Nowergup (though acidity results improved at both lakes over the reporting period)
- degradation and loss of aquatic habitat at Loch McNess, Lake Nowergup, Lake Yonderup and Melaleuca Park EPP173
- changes in macroinvertebrate assemblages and loss of key taxa at Loch McNess and Lake Nowergup
- localised extinction of the native fish *Galaxiella nigrostriata* from Melaleuca Park EPP173.

For further details refer to Judd and Horwitz (2016, 2017 and 2018).

Mound spring macroinvertebrates and water quality

Four springs were monitored across the reporting period: Egerton Spring, Edgecombe Spring, Gaston Rd Spring, and Sue's Spring (WRM 2016, 2017 and 2018).

Increased peak groundwater levels in 2016 and 2017 contributed to surface water flow improving at all sites since 2015. Water quality across the triennial period remained relatively stable and of little ecological concern.

The springs continue to support highly diverse assemblages of aquatic and semi-aquatic invertebrates, including several rare, regionally endemic and/or undescribed groundwater-dependent species.

Wetland frogs

Frog populations were monitored using trapping and aural surveys of calling males (Bamford 2016, Bamford & Everard 2017, Bamford & Everard 2018). At some sites a number of species have stopped calling for an extended period, suggesting that these populations have died out. Disappearances from wetlands relate mostly to declining hydroperiods, which can be related to declining groundwater levels. The disappearances are most marked at sites where the impact of falling groundwater has been greatest (e.g. Lexia 86 and Lexia 186).

The monitoring suggests that current groundwater regimes are not sufficient to maintain frog distributions. Unless groundwater levels rise, it is likely that the local distribution of some frog species will contract in the short term (3–5 years), with the greatest declines in the middle and north of the Gnangara area.

Frog assemblages remain intact at some of the urban wetlands, such as Lake Joondalup and Lake Goollelal, where groundwater levels have been relatively stable.

6.2 Management actions

In response to the changes described in section 6.1 and the level of non-compliance identified in this and previous reports, the department has implemented strategies to reduce impacts on environmentally important sites. Many of these strategies are outlined in the *Gnangara groundwater areas allocation plan* (DoW 2009a), including:

- significantly reducing abstraction for public water supply
- increasing licence compliance and enforcement activities
- capping abstraction for private licensed water supply.

The department is also using compliance monitoring and reporting results to support development of a new Gnangara groundwater allocation plan. The plan will include new strategies to return the system to balance and reduce groundwater use in line with climate change.

Managing public water supply

Every water year the department reviews the distribution of Water Corporation's entitlements to assess the potential impact of that year's proposed abstraction strategy on Ministerial criteria sites and other high value ecological features. Wherever possible abstraction is moved away from bores in the environmentally sensitive areas of the Superficial aquifer, and from the deeper Leederville and Yarragadee aquifers where they are connected to the Superficial aquifer. This helps to minimise the impacts of Water Corporation's abstraction on Ministerial criteria sites where water levels are close to or are already exceeding minimum water level criteria.

Groundwater Replenishment Scheme

Increased recycling of Perth's wastewater resources is critical to meet increasing water demands in our growing city without negative impacts to groundwater levels. Stage 1 of the Groundwater Replenishment (GWR) Scheme at Beenyup, with a capacity of 14 GL, was recently commissioned.

Water recharged through Stage 2 of the GWR scheme (scheduled to be fully commissioned by the end of 2019) will provide broader benefits to the groundwater system including to connected wetlands. The locations of the recharge bores being constructed in Wanneroo and Neerabup as part of Stage 2 were selected following a detailed study by the department. Of all the groundwater recharge locations investigated, the sites chosen were found to best meet environmental objectives of improving water levels in target areas. Once Stage 2 of the GWR scheme is complete its capacity will increase by 14 GL to a total of 28 GL.

Managing private licensed use

The department monitors private licensed use through on-ground compliance inspections, meter audits, water use surveys and standard checks as part of the

licence renewal process. Through this work the department verifies that groundwater use is within licensed entitlements and that site activities are authorised.

Over the reporting period the department conducted compliance monitoring on 875 licensees taking water from the Gnangara groundwater system. A total of 66 incidents of alleged non-compliance were detected, with 42 of these relating to alleged exceedance of annual water entitlements. The department's response to these alleged non-compliances ranged from educational letters and warning notices, to statutory direction and infringement notices.

When prioritising licence compliance and enforcement activities the department considers the conditions and commitments set in *Ministerial statement no. 819*. This includes expanding the scope of our licensing compliance plan to include areas potentially affecting non-compliant Ministerial sites.

The department also manages private licensed use of groundwater in other ways, by continuing to work with:

- local governments, urban developers, schools, golf clubs, and other large groundwater users, to improve water use efficiency, reduce demand for groundwater, and assess water needs and supply options
- Water Corporation as our partner in the Waterwise Council program, to encourage the participation of local councils in a program which began in 2009 and now includes all but one of the 16 urban local councils across Gnangara as endorsed Waterwise Councils
- peak bodies, as well as directly with horticulturalists to focus on improving water use efficiency, compliance with licence conditions, and options to reduce total water use in the future.

Managing groundwater use exempt from licensing

Responsible and efficient use of domestic garden bores as a fit-for-purpose source of water helps reduce use of highly treated drinking water from scheme supply for the purpose of irrigating lawns and gardens. Garden bores not only reduce demand on the scheme, but spread the impacts of water abstraction through localised pumping of small volumes across many thousands of drawpoints, rather than the alternative of pumping large volumes from distant public supply bores and importing the water to urban areas.

The use of urban garden bores and so-called 'stock and domestic' bores is managed under the provisions of the *Water Agencies (Water Use) By-Laws 2010*. These by-laws specify a number of permanent sprinkler restrictions that apply to Area 3 Perth / Mandurah which covers the majority of the Gnangara groundwater allocation plan area.

The following permanent sprinkler restrictions have applied to garden bores since 2010:

- Total winter sprinkler ban between 1 June and 31 August (unless extended by the Minister due to low rainfall).

- Use limited to once per day, three times a week according to roster days between 1 September and 31 May each year.
- Daytime sprinkler ban between 9am and 6pm.

These sprinkler restrictions are generally supported by the community, helping to preserve groundwater resources and encourage water use efficiency in garden irrigation. Failure to adhere to restrictions can result in an infringement being issued.

The department guides where new bores can be installed without increasing the risk of impacting the quality of the water resource or environmentally sensitive areas, such as wetlands. The department's garden bore suitability map was updated in 2011.

6.3 Research initiatives

The department, together with research partners, has completed a number of major projects that are helping us develop the new Gnangara groundwater allocation plan, and direct management efforts to the areas that will show the most benefit from changes to abstraction.

Perth Regional Aquifer Modelling System

The department is using the recently updated Perth Region Aquifer Modelling System (PRAMS) to examine the interactions between climate, land use and groundwater abstraction for the new Gnangara groundwater allocation plan. The results of PRAMS modelling scenarios are a critical input into decision making for the new plan as it allows us to compare the likely outcomes of a range of possible management actions, including different scales of reductions to groundwater use, and consider their implications for the groundwater system.

Future climate tool

The department uses a future climate tool to better project how rainfall might respond under a range of likely future climate scenarios. The peer-reviewed tool was built using global circulation models that perform well in Western Australia and provides robust, up-to-date, and defensible climate science for our decision making.

A report outlining how the department developed the climate tool is available on the department's website – *Selection of future climate projections for Western Australia* (DoW 2015b). The department is using the climate tool in the modelling to develop the new Gnangara groundwater allocation plan.

Perth Region Confined Aquifer Capacity project

The Perth Regional Confined Aquifer Capacity study used robust and established science coupled with innovative research, to improve understanding of the deep Leederville and Yarragadee aquifers in the Perth region. Key findings of the study that have supported planning include:

- Abstraction from deep aquifers is limited mainly by connection to the Superficial aquifer and impacts to groundwater-dependent ecosystems supported by the Superficial aquifer
- Redistribution and reduction of deep aquifer abstraction would help rebalance the Gnangara groundwater system
- Groundwater replenishment can have many benefits for the whole system – reinjection in optimal locations can support deep aquifer pressures and allow full recovery of reinjected water while reducing leakage from the Superficial aquifer and helping recover levels at high value groundwater-dependent ecosystems.

The department is continuing work to better understand the deep aquifers of Gnangara with a drilling program at Kings Park to examine the vertical connection of the deeper aquifers with the Superficial aquifer in the area.

Causes of historic water level decline at Loch McNess and Lake Nowergup

Lake Nowergup and Loch McNess are two highly valued wetlands where falling water levels have led to drying and significant declines in ecological health. The department recently completed a study that looked at apportioning the causes of water level declines at both of these important lakes. These studies are informing the development of the new Gnangara plan.

At Loch McNess the department found that watertable decline to 2012 to the east of the lake was predominantly caused by abstraction for public water supply from the Leederville Aquifer, with the remaining watertable decline attributed to decreasing rainfall. To the west of the lake, declines were attributed to abstraction from the Superficial aquifer and to climate (Kretschmer and Kelsey 2016).

The study at Lake Nowergup ranked the contribution of climate and groundwater abstraction to watertable changes at the lake since 1973. The study showed that local Superficial aquifer use for horticulture had the greatest impact on lake levels, followed by reduced rainfall, then Leederville Aquifer pumping from Quinns and Pinjar borefields (Global Groundwater 2015).

Smarter solutions for recycled water

In a changing climate, we must be smart about how we use our finite supplies of water. Recycled water that has been suitably treated may be an option where no more groundwater is available.

The department is working with local government and industry to prepare for a future with less groundwater by assessing the applicability and cost of locally appropriate options for sustainable, efficient and secure water supplies that enable their future viability and growth.

6.4 Consultation

There has been extensive stakeholder consultation over the reporting period as we continue developing the new Gnangara groundwater allocation plan. The department has focussed on working with water users, their industry reference groups and other government agencies to find practical pathways to bring the system back into balance and prepare for a future with less groundwater availability.

The department has held over 100 stakeholder meetings and workshops with stakeholders across water use sectors. In particular we have worked closely with Water Corporation, local governments, agricultural organisations and environmental groups. This consultation has followed three phases:

- Science update – beginning in 2016 we shared the latest science and research with stakeholders, including groundwater modelling of the past effects and future projections of groundwater abstraction and climate.
- Licensing strategy – we've listened to the suggestions of representatives from the major water use sectors and taken careful note of their concerns around reduced groundwater availability.
- Option assessment – from late 2017 onwards our discussions with representatives of the major water use sectors, other agencies and groups with an interest in Gnangara groundwater planning, focused on potential water allocation options and underlying licensing approaches.

As part of keeping licence holders and the wider community informed, in May 2018 the department released the brochure *Our groundwater future in Perth: Securing Gnangara groundwater and adapting to climate change* (DWER 2018) and published a new Gnangara groundwater website <gnangara.dwer.wa.gov.au>.

The brochure introduces the general context for allocation planning for the Gnangara system and was included in letters sent to all 2100 Gnangara groundwater licence holders in May 2018. These letters notified licence holders that Gnangara planning work was underway and that the new plan may propose changes to groundwater licences.

Appendices

Appendix A — Water level monitoring results for Ministerial sites for the Gnangara Mound Groundwater Resources for 2007–2018

Bold text refers to compliance with water level criteria and other criteria. **Black bold text** indicates sites compliant with water level and other criteria. **Red bold text** indicates sites non-compliant with water level criteria. **Blue bold text** indicates sites non-compliant with other criteria.

Table A 1 Wetland sites

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
Lake Goollelal	6162517			26.2*	26.0	Max	27.2	27.4	27.4	27.2	27.1	27.2	27.3	27.2	27.1	27.3	27.3	Compliance: **Compliant with absolute summer minimum and other criteria.**
						Min	26.5	26.7	26.6	26.4	26.5	26.5	26.5	26.6	26.4	26.8	26.9	
Loch McNess	6162564				6.95	Max	6.94	6.85	6.80	6.64	6.43	6.40	6.39	6.25	6.25	6.25	6.25	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The lake has been non-compliant since 2002–03 and lake levels have fallen rapidly since 2006. The staff gauge at the lake is now dry. Ecological condition: Long-term monitoring has shown declines in the health of *Melaleuca rhaphiophylla*; changes in species composition to more terrestrial species and increases in abundance of exotic species. Declines in groundwater levels have also contributed to the loss of the key wetland macrophyte *Baumea articulata* at the transect and the degradation and loss of aquatic habitat for macroinvertebrates. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that a groundwater level of 5.27 mAHD at bore BH-LM2 (AWRC ref. 61640108) would meet the minimum groundwater requirements of wetland vegetation. The department is using levels at BH-LM2 to better relate groundwater levels to the ecological condition of vegetation. The minimum groundwater level at the bore did not meet the minimum groundwater requirement of wetland vegetation over the reporting period and continued to decline over the period. Detailed findings and recommendations from the investigation can be found in the Loch McNess report (DoW 2011a). The department completed a study into the cause of rapidly declining levels in Loch McNess (Kretschmer & Kelsey, 2016). This study improved our understanding of the hydrogeology of the lake and surrounding areas, including the Yanchep Caves nearby. Based on the findings of the study the department has: • reduced Superficial aquifer abstraction in the Yanchep National Park • ceased the Yanchep Caves supplementation trial • reduced public supply abstraction from the Leederville Aquifer in the Pinjar borefield.
						Min	**6.63**	**6.61**	**6.45**	**6.25**	**6.17**	**6.10**	**6.25**	**6.25**	**6.07**	**6.25**	**6.25**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum			2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
		Pref	Abs	Pref	Abs													
Lake Yonderup	6162565				5.9	Max	5.9	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The lake has been non-compliant since 2007–08 and the minimum water levels in 2015–16 and 2017–18 were the lowest on record. Ecological condition: Water level declines have contributed to reduced condition of *Melaleuca rhaphiophylla* and recent deaths of mature trees. They are also contributing to the degradation and loss of aquatic habitat for macroinvertebrates. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that a groundwater level of 5.48 mAHD at bore YDP_SC (AWRC ref. 61611840) would meet the minimum groundwater requirements of wetland vegetation (DoW 2011b). The minimum groundwater level at this bore did not meet the minimum groundwater requirement of wetland vegetation over the reporting period. Given the location of Lake Yonderup just to the south of Loch McNess, the department's management actions following the study into the cause of declining levels at Loch McNess, also aim to benefit levels at Lake Yonderup.
						Min	**5.8**	**5.8**	**5.8**	**5.7**	**5.7**	**5.6**	**5.6**	**5.6**	**5.5**	**5.6**	**5.5**	
Lake Joondalup	6162572 (Staff 8281)			16.2*	15.8	Max	16.8	17.0	17.0	16.8	16.8	16.8	17.1	17.0	16.9	17.1	17.3	Compliance and trends: **Compliant with absolute summer minimum criterion.** **Non-compliant with other criterion.** The lake has been non-compliant with the preferred minimum since 1998–99. Lake levels have been relatively stable since 1998 and the minimum level in 2014–15 was above the preferred minimum for the first time since 2005–06. Levels were above the preferred minimum in 2016–17 and 2017–18. The staff gauge dries at around 16.0 mAHD and cannot be used to determine compliance with the absolute summer minimum criteria when lake levels fall below this level. Investigations have suggested an alternative monitoring bore to the existing criteria bore 8281 may be more appropriate for determining compliance with criteria levels. Ecological condition: Long-term monitoring has shown declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that groundwater levels at bore JP20C (AWRC ref. 61610629) more closely reflect trends in lake levels than the current criteria bore and that this bore should be used to measure water level criteria. The minimum groundwater level at this bore increased over the reporting period.
						Min	16.0 **4/6 yr**	16.2 **4/6 yr**	16.2 **4/6 yr**	16.0 **4/6 yr**	16.0 **4/6 yr**	16.0 **4/6 yr**	16.2 **4/6 yr**	16.3 **4/6 yr**	16.1 **4/6 yr**	16.5 **4/6 yr**	16.6 **4/6 yr**	
	61610661 (Bore 8281)					Max	18.5	18.7	18.9	18.7	18.6	18.6	19.0	18.9	18.7	19.0	19.2	
						Min	17.9	18.1	18.3	17.9	18.0	18.0	18.2	18.3	18.1	18.5	18.6	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum			2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
		Pref	Abs	Pref	Abs													
Lake Mariginiup	6162577 (Staff 1943)	42.1*	41.5			Max	**41.4**	41.5	41.5	**41.3**	**41.2**	**41.1**	**41.3**	**41.3**	**41.1**	**41.4**	41.5	Compliance and trends: **Non-compliant with absolute spring peak criterion in 2 out of 3 years of the reporting period.** Peak levels increased over the reporting period and were compliant with the absolute spring peak criterion in 2017–18 for the first time since 2009–10. Water levels were above 41.5 mAHD before being rounded to one decimal place. **Non-compliant with other criterion.** Water levels have not reached the preferred spring peak since 1994. Ecological condition: Groundwater declines have contributed to the lake being one of the poorest sites in terms of vegetation health. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that: • bore MS10 (AWRC ref. 61610685) should be used to measure water level criteria when the lake is dry using a revised level of 41.1 mAHD • the newly installed bore MGP_C (AWRC ref. 61611440) should be used to relate changes in the watertable to wetland vegetation condition. Detailed findings and recommendations from the investigation can be found in Searle et al. (2010). The department is using MGP_C to better relate groundwater levels to the condition of wetland vegetation. Minimum levels at bores MS10 and MGP_C improved marginally over the reporting period. Water levels at Lake Mariginiup are expected to increase in the future due to increasing urbanisation of the catchment and a corresponding decrease in groundwater abstraction from agricultural land uses.
						Min	41.2 **4/6 yr**	41.2 **4/6 yr**	41.3 **4/6 yr**	41.1 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	41.0 **4/6 yr**	
	61610685 (Bore MS10)					Max	41.0	41.3	41.1	40.8	40.9	40.8	41.0	41.2	40.8	41.1	41.1	
						Min	40.2	40.2	40.2	40.0	40.1	40.1	40.1	40.2	40.0	40.4	40.4	
Lake Jandabup	6162578 (Staff 1944)	44.7*	44.2		44.3	Max	44.7	44.8	44.8	44.5	44.7	44.6	44.7	44.7	44.6	44.7	44.8	Compliance and trends: **Compliant with absolute spring peak criterion.** **Non-compliant with absolute summer minimum criterion in 2 of the 3 years of the reporting period.** 2016–17 was the first time the site had been compliant with water level criteria since 2008–09. Water Corporation supplements lake levels to meet the absolute spring peak water level criterion and to prevent the lake from acidifying. Recently, levels have been relatively stable and the supplementation has been successful in preventing the lake from acidifying. Ecological condition: Long-term vegetation monitoring has shown declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. The risk of acidification is still high if water levels decline, however, Lake Jandabup water levels are expected to increase in the future due to increasing urbanisation of the catchment and a corresponding decrease in groundwater abstraction from agricultural land uses. Management and mitigation: Work completed as part of the Perth shallow groundwater systems investigation found that bore JB12B (61610764) should be used to relate groundwater levels to the ecological condition of vegetation on the transect. The minimum level at JB12B remained relatively stable over the reporting period.
						Min	**44.1**	44.3	**44.2**	**44.1**	**44.2**	**44.1**	**44.2**	**44.2**	**44.1**	44.3	**44.2**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum													
		Pref	Abs	Pref	Abs		2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
Lake Nowergup	6162567 (Staff)	17.0*	16.8			Max	17.2 **4/6 yr**	**16.5** **4/6 yr**	**16.5** **4/6 yr**	**16.2** **4/6 yr**	**16.1** **4/6 yr**	**16.0** **4/6 yr**	**16.0** **4/6 yr**	**16.0** **4/6 yr**	**16.0** **4/6 yr**	**16.0** **4/6 yr**	**16.0** **4/6 yr**	Compliance and trends: **Non-compliant with absolute spring peak criterion.** Lake levels have been non-compliant in most years since 1996 despite water levels being supplemented and artificially maintained by the department. **Non-compliant with other criterion.** Ecological condition: Water levels have led to the deaths of mature trees and declines in the abundance of the key wetland macrophyte *Baumea articulata*. Low water levels are also contributing to the risk of acidification. Management and mitigation: From work completed as part of the Perth shallow groundwater systems investigation, Searle, Hammond and Bathols (2010) recommends to: • continue the supplementation regime • revise the spring peak criteria to 16.2 mAHD, which should be done gradually from the 2009 peak of 16.5 mAHD • use groundwater levels at bore LN2-89 (AWRC ref. 61611247) to relate changes in the watertable to wetland vegetation condition. The department is using bore LN2-89 to better relate groundwater levels to condition of wetland vegetation. Minimum levels at bore LN2-89 have been declining since 2009 but stabilised over the reporting period. The department recently studied the causes of groundwater level declines at Lake Nowergup. The study showed that local Superficial aquifer use for horticulture had the greatest impact on lake levels, followed by reduced rainfall, then Leederville Aquifer pumping from Quinns and Pinjar borefields (Global Groundwater 2015). This study is informing development of the new Gnangara allocation plan.
						Min	16.5	16.2	16.0	16.0	15.9	16.0	16.0	16.0	16.0	16.0	16.0	
Lake Wilgarup	6162623 (Staff)	6.10	5.65	4.8	4.5	Max	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	**6.00 dry**	Compliance and trends: **Non-compliant with absolute spring peak criterion.** The lake has been dry since 1998. **Non-compliant with absolute summer minimum criterion.** Groundwater levels have declined since 1998 and have been non-compliant with the absolute minimum criteria since 2006–07. Management and mitigation: Given the location of Lake Wilgarup just to the east of Loch McNess, the department's management actions following the study into the cause of declining levels at Lake Wilgarup, also aim to benefit levels at Lake Wilgarup.
						Min												
	61618500 (Bore)					Max	4.77	4.77	4.64	4.47	4.38	4.31	4.41	4.29	4.21	4.34	4.29	
						Min	**4.18**	**4.08**	**4.02**	**3.80**	**3.84**	**3.83**	**3.82**	**3.79**	**3.66**	**3.88**	**3.75**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum			2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
		Pref	Abs	Pref	Abs													
Pipidinny Swamp	6162624 (Staff)	2.70	2.40		1.6	Max	**2.1**	**2.1**	**2.0**	**2.0**	**1.6**	**1.8**	**2.2**	**1.9**	**1.6**	**2.0**	**2.0**	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The department could not confirm compliance with the absolute summer minimum criteria from 2004 to 2010 because levels below 2.0 mAHD could not be measured at the staff gauge at the swamp. In 2010, the department fixed an extra staff gauge plate to measure to 1.0 mAHD. **Non-compliant with absolute spring peak criterion.** Spring peak levels have been non-compliant since 2005–06. Management and mitigation: A new bore – PIP_C (AWRC ref. 61610764) – was installed as part of the Perth shallow groundwater system investigation (Searle 2009). Levels at this bore are well correlated with the staff gauge and can be used to measure compliance with absolute summer minimum criteria when the staff gauge dries. Levels have been relatively stable at the bore since it was installed in 2009.
						Min	2.0	2.0	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	
Lexia 86 (GNM16)	61613215			47.3*	47.0	Max	48.2	48.4	48.2	47.7	47.9	47.6	47.8	47.7	47.3	47.7	47.9	Compliance and trends: **Non-compliant with absolute summer minimum criterion in 1 of the 3 years of the reporting period.** 2015–16 was the first and only year that the site was non-compliant with absolute summer minimum water levels. **Non-compliant with other criterion.** Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Lexia 86. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
						Min	47.4	47.3	47.3	47.1	47.2	47.0	47.0 **4/6 yr**	47.0 **4/6 yr**	**46.9** **4/6 yr**	47.1 **4/6 yr**	47.1 **4/6 yr**	
Lexia 186 (GNM15)	61613214			47.5*	47.2	Max	47.5	47.6	47.5	47.0	47.1	46.9	47.2	47.1	46.7	47.0	47.3	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant with the absolute summer minimum water level criteria since 1997. The spring peak in 2015–16 was the lowest on record. Levels increased in 2016–17 and 2017–18. **Non-compliant with other criterion.** Minimum water levels have not been above the preferred summer minimum criteria since 1995. Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Lexia 186. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
						Min	**46.9** **4/6 yr**	**46.8** **4/6 yr**	**46.8** **4/6 yr**	**46.5** **4/6 yr**	**46.5** **4/6 yr**	**46.5** **4/6 yr**	**46.6** **4/6 yr**	**46.5** **4/6 yr**	**46.3** **4/6 yr**	**46.5** **4/6 yr**	**46.6** **4/6 yr**	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
		Spring peak		End of summer minimum			2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
		Pref	Abs	Pref	Abs													
Melaleuca Park EPP173	6162628 (Staff)				50.2	Max	51.1	51.0	51.0	50.5	50.7	50.6	50.9	50.7	50.4	50.8	51.0	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant with absolute summer minimum criterion since1995. The spring peak in 2015–2016 was the lowest on record. Water levels were still declining as of June 2017. Ecological condition: Groundwater declines have contributed to wetland species *Baumea articulata* and *Pericalymma ellipticum* disappearing from the wetland. Declines have also contributed to the degradation and loss of aquatic habitat for macroinvertebrates. The native fish *Galaxiella nigrostriatal* has also become locally extinct. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including Melaleuca Park EPP173. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
						Min	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	
	61613213 (Bore GNM14)					Max	50.7	50.9	50.5	49.5	50.0	49.7	50.3	50.1	49.3	50.2	50.3	
						Min	**49.1**	**48.9**	**48.9**	**48.6**	**48.8**	**48.7**	**48.8**	**48.7**	**48.5**	**49.0**	**# 48.8**	
Melaleuca Park Dampland 78 (GNM31)	61613231			65.4*	65.1	Max	66.0	66.0	65.9	65.5	65.3	65.2	65.3	65.2	64.9	65.1	65.2	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The rate of decline in groundwater levels increased from 2009–10 and the minimum level in 2016-17 was the lowest on record. **Non-compliant with other criterion.** Ecological condition: Long-term monitoring has shown reduced frog numbers, declines in canopy condition, changes in species composition to more terrestrial species and increases in abundance of exotic species. Management and mitigation: A cluster of bores were installed adjacent to GNM31 as part of the Perth shallow groundwater systems investigation (Searle 2009).
						Min	66.0	65.6	65.5	65.1	65.1	**64.9**	65.1 **4/6 yr**	**64.9** **4/6 yr**	**64.7** **4/6 yr**	**64.7** **4/6 yr**	**65.0** **4/6 yr**	
Egerton Spring (B25)	61618607				39.29	Max	40.03	40.22	40.15	40.01	40.05	40.04	40.17	40.12	39.97	40.10	40.20	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels have been compliant since 2003 and have risen over the past 10 years in response to increased localised recharge associated with the surrounding urban development.
						Min	39.54	39.72	39.72	39.49	39.70	39.69	39.73	39.79	39.58	39.84	39.84	

* Water levels are allowed to fall between the preferred minimum and absolute minimum for two out of six years to replicate natural drying cycles.

The minimum water level reported is the minimum water level recorded during the 2015–16, 2016–17 and 2017–18 water years. As of June, water levels were still declining.

Table A 2 Terrestrial phreatophytic vegetation sites

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)											Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
				2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
MM16	61610835	38.8	Max	39.4	39.8	39.9	39.4	39.6	39.6	40.1	40.2	40.1	40.3	40.7	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have shown a general rising trend since 2011.
			Min	38.8	39.0	39.0	**38.6**	38.9	39.0	39.2	39.5	39.3	39.5	39.8	
MM18	61610918	38.6	Max	39.3	40.0	39.8	39.3	39.5	39.6	39.9	40.0	39.6	40.0	40.2	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have shown a general rising trend since 2011.
			Min	38.8	39.0	39.0	38.7	38.9	39.0	38.6	39.2	39.1	39.2	39.4	
MM53	61610493	33.3	Max	33.9	34.1	33.9	33.3	33.8	33.6	34.0	34.0	33.5	33.7	34.0	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Minimum levels generally declined from 2005 to 2011 but have stabilised in recent years. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park, with the intention of reducing abstraction impacts at sites in the area, including MM53. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**33.2**	**33.1**	**33.0**	**32.8**	**33.0**	**33.0**	**32.8**	**33.1**	**32.9**	**33.1**	**33.1**	
MM55B	61610559	29.5	Max	30.6	31.0	30.8	30.1	30.3	30.3	30.5	30.5	30.3	30.4	30.6	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Minimum and maximum water levels have stabilised since 2011.
			Min	**29.4**	**29.4**	**29.3**	**29.0**	**29.3**	**29.2**	**29.2**	29.7	**29.2**	**29.4**	**29.5**	
MM59B	61611025	36.3	Max	36.4	36.8	36.6	36.0	36.1	36.2	36.3	36.3	36.0	36.1	36.4	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have generally declined since 2000 but have stabilised since 2011. Water levels were still declining as of June 2018. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer from bores located close to Whiteman Park with the intention of reducing abstraction impacts at sites in the area, including MM59B. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**35.8**	**35.8**	**35.7**	**35.3**	**35.5**	**35.5**	**35.5**	**35.6**	**35.4**	**# 35.5**	**35.6**	
MT3S	61610745	43.0	Max	44.7	44.9	44.8	44.3	44.4	44.2	44.6	44.5	44.3	44.6	44.9	Compliance and trends: **Compliant with absolute summer minimum criterion.** Water levels generally declined between 1992 and 2011 but have increased over the last several years.
			Min	43.9	44.0	43.9	43.5	43.6	43.5	43.7	43.7	43.6	44.0	44.1	
NR6C	61610982	58.5	Max	59.7	60.0	60.1	59.9	59.7	59.3	59.7	59.5	59.1	59.5	60.0	Compliance: **Compliant with absolute summer minimum criterion.** Water levels generally declined after 1992 and in 2015–16 they were the lowest on record. There has since been a rising trend and in 2017–18 the site recorded the highest maximum water levels since 2009–10.
			Min	59.1	59.2	59.4	58.9	59.0	58.7	58.9	59.0	58.7	58.8	59.0	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)		Water levels (mAHD)										Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
				2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
PM9	61610804	56.3	Max	56.3	56.1	55.9	55.9	55.0	54.8	55.0	54.7				Compliance and trends: **Non-compliant with absolute summer minimum criterion.** The bore is not currently being monitored due to safety issues associated with its location in a rifle range. The department is looking to resolve this issue by installing a logger at the bore and monitoring it remotely. Maintenance in 2016 also impacted on water levels recorded at the site. Water levels have declined since 1996 and were first non-compliant in 2006–07. Water levels at the site are now greater than 10.5m depth to groundwater, and it is unlikely vegetation in the vicinity is accessing groundwater. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including PM9. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**55.8**	**55.6**	**55.4**	**54.9**	**54.8**	**54.4**	**54.3**	**54.1**[#]	**51.8**			
PM24	61610697	40.5	Max	42.7	43.0	42.5	42.1	42.4	42.0	42.1	42.3	42.1	42.2	41.6	Compliance: **Compliant with absolute summer minimum criterion.** Water levels have generally declined since 1998 but have stabilised since 2011.
			Min	41.3	41.2	41.2	41.0	41.1	41.1	41.1	41.3	41.0	41.4	41.0	
WM1	61610833	55.7	Max	55.6	55.7	55.4	54.8	54.8	54.4	54.7	54.4	54.5	55.1	55.6	Compliance and trends: **Non-compliant with absolute summer minimum criterion.** Water levels have been non-compliant since 2001–02 and have generally declined since 2005. However there has been a rising trend over the three-year reporting period and in 2017–18 the site recorded the highest maximum water levels since 2007–08. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound, with the intention of reducing abstraction impacts at sites in the area, including WM1. The department reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	**55.0**	**54.9**	**54.8**	**54.4**	**54.3**	**54.1**	**54.2**	**54.1**	**54.1**	**54.3**	**54.7**	
WM2	61610908	66.5	Max	67.5	67.6	67.5	66.9	66.8	66.4	66.7	66.5	66.6	67.2	67.3	Compliance and trends: **Non-compliant with absolute summer minimum criterion in 2 of the 3 years of the reporting period.** In 2017–18 this site was compliant for the first time since 2010–11. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including WM2. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	67.0	66.9	66.9	66.5	**66.4**	**66.1**	**66.2**	**66.1**	**66.3**	**66.4**	66.7	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)		Water levels (mAHD)										Comments on compliance during the reporting period (1 July 2015 – 30 June 2018)
				2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	
WM8	61610983	64.8	Max	65.4	65.5	65.4	65.5	64.9	64.7	65.0	64.8	64.3	64.7	65.2	Compliance and trends: **Non-compliant with absolute summer minimum criterion in 2 of the 3 years of the reporting period.** In 2017–18 this site was compliant for the first time since 2009–10. Management and mitigation: The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gnangara Mound with the intention of reducing abstraction impacts at sites in the area, including WM8. The department also reviews public water supply abstraction annually, considering water level trends and criteria compliance.
			Min	65.1	65.1	65.1	**64.7**	**64.7**	**64.4**	**64.7**	**64.3**	**64.1**	**64.1**	64.9	
MM12	61610989	42	Max	43	43	43	43	43	43	43	43	43	43	43	Compliance and trends: **Compliant with absolute summer minimum criterion.** Levels have generally risen since 2011.
			Min	42	43	43	42	42	43	43	43	43	43	43	
L30C	61611010	47.2	Max	48.6	48.7	48.9	48.1	48.2	47.8	47.9	48.0	47.7	47.9	48.1	Compliance: **Compliant with absolute summer minimum criterion.** Levels generally fell from 2005 to 2016. Water levels were still declining as of June 2018.
			Min	48.0	48.2	48.1	48.0	47.7	47.5	47.5	47.7	47.3	47.3	# 47.6	
L110C	61611011	55.7	Max	57.7	57.8	57.7				57.4	57.6	57.4	57.6	57.8	Compliance: **Compliant with absolute summer minimum criterion.** Levels have generally fallen since 1999. Minimum levels could not be measured at the Ministerial criteria bore between March 2010 and July 2013 because of a blockage. Water levels were still declining as of June 2018.
			Min	57.2	57.5	57.5				57.1	57.3	57.1	57.1	# 57.3	
L220C	61611018	52.2	Max	53.7	53.5	53.6	52.8	53.2	52.8	53.1	53.9	53.4	53.8	54.1	Compliance: **Compliant with absolute summer minimum criterion.** Levels have generally fallen since 1991 and the 2015–16 was the lowest on record. Water levels were still declining as of June 2018.
			Min	52.7	52.6	52.6	52.3	52.4	52.1	52.3	53.1	52.8	53.1	# 53.2	

The minimum water level reported is the minimum water level recorded during the 2017–18 water year. As of June 2018, water levels were still declining.

Note: Observed water levels have been rounded to the same number of decimal places as shown in Table 1 and 2 on Ministerial Statement No. 819.

Appendix B — Audit tables: Environmental conditions, procedures and commitments for the Gnangara groundwater resources

Proponent: Department of Water and Environmental Regulation (formerly Department of Water)

Period: 1 July 2015 to 30 June 2018

Table B 1 Ministerial conditions and procedures

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 1-1	Implementation	The proponent shall implement the proposals as documented in "Section 46 Review of Environmental Conditions on Management of the Gnangara and Jandakot Mounds – Stage 1 Proposal for Changes to Conditions" (August 2004), as modified and documented in Environmental Protection Authority Bulletin 1155.	Implement proposals given in EPA Bulletin 1155 and *Ministerial Statement No. 819*.	Compliance report	Minister for the Environment		Overall		**Partly compliant.** Partly compliant with most Ministerial conditions – refer to the 'status' column of this table. Further amendments are likely to be proposed in the next Gnangara groundwater allocation plan.
819: M 2-1	Proponent commitments	The proponent shall implement the environmental management commitments, as revised in May 2009, and documented in schedule 1 of Statement No. 819, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority (EPA).	Implement commitments given in Schedule 1 of EPA Bulletin 1324 and *Ministerial Statement No. 819*.	Compliance report	Minister for the Environment	EPA	Overall		**Partly compliant.** Compliant with most proponent commitments – refer to the 'status' column of this table.
819: M 3-1	Proponent nomination and contact details	The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the *Environmental Protection Act 1986* is responsible for the implementation of the proposal until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person as the proponent for the proposal.	Adhere to conditions, procedures and commitments given in EPA Bulletin 1324 and *Ministerial Statement No. 819*. Maintain responsibility for implementation of proposal.	Letter notifying the Chief Executive Officer of the Office of the Environmental Protection Authority (OEPA) of any change in proponent details. Compliance report.	Minister for the Environment	EPA	Overall		**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.
819: M 3-2	Proponent nomination and contact details	If the proponent wishes to relinquish the nomination, the proponent shall apply for the transfer of proponent and provide a letter with a copy of this statement endorsed by the proposed replacement proponent that the proposal will be carried out in accordance with this statement. Contact details and appropriate documentation on the capability of the proposed replacement proponent to carry out the proposal shall also be provided.	Follow procedure given in 'action'.	Letter notifying the Chief Executive Officer of any change in proponent details.	Minister for the Environment		Overall		**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.
819: M 3-3	Proponent nomination and contact details	The nominated proponent shall notify the Chief Executive Officer of the EPA of any change of contact name and address within 60 days of such change.	Follow procedure given in 'action'.	Letter notifying the Chief Executive Officer of any change in proponent details.	CEO		Overall	60 days of change	**Partly compliant.** The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 4-1 1	Compliance audit and performance review	The proponent shall prepare an audit program and submit compliance reports to the EPA which address: • evidence of compliance with the conditions and commitments.	Detail in annual/triennial reports. Compliance report will include: • evidence of compliance with the conditions and commitments.	Audit program	CEO		Overall	Annually	**Compliant.** Summarised in sections 5 and 6 of this report and the 'status' column of this table.
819: M 4-1 2	Compliance audit and performance review	The proponent shall prepare an audit program and submit compliance reports to the EPA which address: • the performance of the environmental management plans and programs.	Detail in annual/triennial reports. Compliance report will include: • the performance of the environmental management plans and programs.	Compliance report	CEO			Annually	**Compliant.** Environmental management plans and programs are ongoing and include: 1. The *Gnangara groundwater areas allocation plan* was released in November 2009 (DoW 2009a). The plan has been evaluated regularly to assess whether objectives are being achieved. The evaluation statements are available on the department's website. 2. The next Gnangara groundwater allocation plan will include new strategies to work towards meeting the following objectives: • reduce the total volume of water abstracted from the Gnangara system towards a level that better reflects the recharge from rainfall due to climate change. • protect groundwater-dependent ecosystems from impacts associated with abstraction.
819: M 4-2 1	Compliance audit and performance review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the EPA, which address: • compliance with the conditions.	The performance review will address: • compliance with the conditions.	Compliance report	CEO		Overall	By 1 December each year and more detailed reports by 1 February every three years.	**Compliant.** Refer to 819: M 4-1 2. Compliance with conditions can found in the 'status' column of this table.
819: M 4-2 2	Compliance audit and performance review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the EPA, which address: • the achievement of environmental objectives set for the proposal.	The performance review will address: • the achievement of environmental objectives set for the proposal.	Compliance report	CEO		Overall	By 1 December each year and more detailed reports by 1 February every three years.	**Compliant.** Evidence of achievement of the objectives is given by the 'evidence' and 'status' columns of this table.
819: M 4-2 3	Compliance audit and performance review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the EPA, which address: • stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed.	The performance review will address: • stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed.	Compliance report	CEO		Overall	By 1 December each year and more detailed reports by 1 February every three years.	**Compliant.** The *Gnangara groundwater areas allocation plan* was released in November 2009. The accompanying *Gnangara groundwater areas allocation plan: statement of response* (DoW 2009b) sets out how we responded to issues raised by the public to finalise the plan and how we are working towards managing these issues in implementing the plan. Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015a). These statements evaluated the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website. A summary of consultation that has occurred to date as part of the new Gnangara groundwater allocation plan is contained within this report.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 4-2 4	Compliance audit and performance review	The proponent shall submit a performance review report by 1 December each year and more detailed reports by 1 February every three years, to the requirements of the EPA, which address: • proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal.	The performance review will address: • proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal.	Compliance report	CEO		Overall	By 1 December each year and more detailed reports by 1 February every three years.	**Compliant.** Sections 6.2 and 6.3 describes the department's management actions and research initiatives to limit impacts of abstraction on groundwater-dependent ecosystems.
819: M 4-3	Compliance audit and performance review	The proponent shall make the reports required by condition 4-2 publicly available, to the requirements of the Chief Executive Officer of the EPA.	Available on Department of Water and Environmental Regulation's website.	Reports made available on the Department of Water (now Department of Water and Environmental Regulation) website.	CEO		Overall	After EPA acknowledg-ement letter being received. Department of Water and Environmental Regulation website.	**Compliant.** The following Gnangara compliance reports have been formally audited or commented on by the then Department of Environmental Conservation (DEC) or the then OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a). The following Gnangara compliance reports have not been formally audited or commented on, but can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b) • 2010–11 annual (DoW 2011d) • 2009–12 triennial (DoW 2013a) • 2012–13 annual (DoW 2014a) • 2013–14 annual (DoW 2014b) • 2012–15 triennial (DoW 2016) • 2015–16 annual (DoW 2017) • 2016–17 annual (DWER 2017).
819: M 4-4	Compliance audit and performance review	The proponent shall report any breach or anticipated breach of the environmental criteria set out in tables 1 and 2 or environmental objectives to the Chief Executive Officer immediately it becomes evident to the proponent.	Report in regular summaries sent to the Chief Executive Officer.	Letter to the Chief Executive Officer reporting non compliances with water level and other criteria as required. Compliance report.	CEO		Overall	Immediately as it becomes evident.	**Compliant.** The department reports annually to the EPA on non-compliance with criteria water levels and other criteria.
819: M 5-1	Management of the water resource	The proponent shall base decisions affecting the management of groundwater resources of the Gnangara Mound on the concept of sustainable yield of resources and maintenance of ecological systems in accordance with the objectives of the State Conservation Strategy (1987).	Base decision on the concept of sustainable yield of resources and maintenance of ecological systems in accordance with the State Conservation Strategy (1987). Present relevant material in annual/triennial compliance reports.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department used the concept of sustainable yield and PRAMS modelling to calculate allocation limits for the *Gnangara groundwater areas allocation plan* (DoW 2009a). The department recognises that sustainable yield has diminished because recharge has decreased since the plan was released and is reassessing allocation limits for Gnangara resources as part of the development of the new Gnangara groundwater allocation plan.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 5-2	Management of the water resource	The proponent shall subject to review, every three years, the basis for groundwater management decisions, including groundwater allocations and licences, and the criteria specified for conservation of the environment and the groundwater resource of the Gnangara Mound, to the requirements of the Environmental Protection Authority on advice of DBCA (formerly Department of Parks and Wildlife (DPaW)).	Present relevant material in annual/triennial reports. Refer draft groundwater management planning reports to the EPA and the DBCA for comment. Make compliance reports publicly available (on the Department of Water and Environmental Regulation's website).	Compliance report. Draft groundwater management documents sent to DBCA/EPA for comment. Reports made available on Department of Water (now Department of Water and Environmental Regulation) website.	EPA	DBCA	Overall	Subject to regular review every three years.	**Compliant.** The department's water licensing policies are the 'basis for groundwater management decisions'. We regularly review these policies (e.g. state-wide policies are reviewed every 5 years). The *Gnangara groundwater areas allocation plan* provides the foundation for water allocation decisions on the Gnangara Mound. We have issued two evaluation statements for the 2009 plan (DoW 2013b; DoW 2015a). These statements evaluate the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website. The draft *Gnangara sustainability strategy* (Government of Western Australia 2009b) showed how other factors (e.g. land uses) relate to water management decisions on the Gnangara Mound. The following Gnangara compliance reports have been formally audited or commented on by the then DEC or the then OEPA and can be found on the department's website: • 2003–06 triennial (DoW 2007) • 2006–07 annual (DoW 2008a) • 2006–09 triennial (DoW 2010a). The following Gnangara compliance reports have not been formally audited or commented on, but can also be found on the department's website: • 2007–08 annual (DoW 2009c) • 2009–10 annual (DoW 2010b) • 2010–11 annual (DoW 2011d) • 2009–12 triennial (DoW 2013a) • 2012–13 annual (DoW 2014a) • 2013–14 annual (DoW 2014b) • 2012–15 triennial (DoW 2016) • 2015–16 annual (DoW 2017) • 2016–17 annual (DWER 2018).
819: M 6-1	Groundwater allocation	The proponent shall ensure that the allocation of water to public and private users and the operation of the Pinjar Stages 1, 2 and 3, Wanneroo, Mirrabooka, and Lexia Groundwater Schemes comply with environmental water provisions.	Licensed allocations not to exceed allocation limits for Groundwater Area sub-areas.	Compliance report	Minister for the Environment		Overall		**Compliant.** As outlined in the *Gnangara groundwater areas allocation plan 2009*, adding the Southern Seawater Desalination Plant to the Integrated Water Supply Scheme triggered a change in how we allocate groundwater for public water supply. In line with the plan, from 2012–13 Water Corporation's baseline groundwater allocation from Gnangara and Jandakot for the Integrated Water Supply Scheme has been reduced from 145 GL to 120 GL per year (from existing infrastructure). The department recognises that it is non-compliant with approximately half of the environmental water provision criteria for the Gnangara groundwater resources proposal, and that, in line with climate change, further management strategies are required in order to reduce pressure on groundwater-dependent ecosystems, including reducing groundwater abstraction. The new Gnangara groundwater allocation plan will outline proposed strategies to help bring Gnangara groundwater resources back into balance.
819: M 7-1	Groundwater-dependent ecosystems	The proponent shall ensure that the integrity of all groundwater-dependent ecosystems (GDE) located on the Gnangara Mound that may be impacted as a result of groundwater abstraction are protected, to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Comply with EPA Bulletin No. 1324 *and Ministerial Statement No. 819*. Undertake a monitoring program to measure integrity of GDEs.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** Section 6.1 and Appendix C describe the department's environmental monitoring program (in line with the commitments in *Ministerial Statement No. 819*). Sections 6.2 and 6.3 describe department management and research initiatives to limit impacts of abstraction on groundwater-dependent ecosystems.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 8-1	Groundwater availability	The proponent shall widely publish by the end of October each year the limits on groundwater availability for the Gnangara Mound.	Detail limits on availability on the Department of Water's website.	Allocation limits made available on the Department of Water (now Department of Water and Environmental Regulation) website. Current water availability figures can be obtained from the department's Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>	Minister for the Environment		Overall	End of October each year	**Compliant.** Current water availability figures are constantly changing. Up-to-date figures are available by contacting the department's Swan–Avon regional office or through the water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>
819: M 8-2	Groundwater availability	The proponent shall update annually the figures published according to the requirements of condition 8-1, with the emphasis on those areas of high allocation relative to sustainable yield of the groundwater resource so that limits to use and development can be clearly seen by all interested parties. The updated figures shall also be widely published.	Detail limits on availability relative to sustainable yield (allocation limits) published on the Department of Water and Environmental Regulation's website.	Allocation limits made available on the Department of Water (now Department of Water and Environmental Regulation) website. Current water availability figures can be obtained from Swan Avon regional office or through the department's water register: <www.water.wa.gov.au/maps-and-data/maps/water-register>	Minister for the Environment		Overall	End of October each year	**Compliant.** Current water availability figures are constantly changing. Up-to-date figures are available by contacting the department's Swan Avon regional office or through the water register: < www.water.wa.gov.au/maps-and-data/maps/water-register>
819: M 9-1	Water conservation	The proponent shall actively encourage further reduction in public and private water demand in accordance with the State Water Strategy (2003) and other water conservation initiatives.	Engage in activity that supports water conservation.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department has worked with local governments to investigate conceptual water supply and demand management options for North East Corridor urban expansion and Swan Valley agriculture, North Wanneroo agriculture and Western Suburbs Regional Organisation of Councils greenspaces. A cross-agency Waterwise Perth strategy has been initiated to help transition Perth becoming a leading water wise city. The strategy advocates responsible and sustainable use of water from all sources, including groundwater, and well-designed private and public green spaces are key to making the most of Perth's limited water resources. The Waterwise Council Program, a partnership program between the department and Water Corporation, fosters a cooperative working relationship with local government agencies to build demand management capability and improve water efficiency, climate resilience and liveability in their operations and their communities. An advertising campaign has been developed to enhance garden bore owners' awareness of groundwater as a limited resource and to encourage waterwise use of garden bores.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 10-1 1	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • clarification of the relationship between groundwater level and rainfall under conditions of declining long-term rainfall.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The department used PRAMS modelling to examine the relationship between rainfall and groundwater levels as climate changes as part of our review of allocation limits for the new Gnangara allocation plan.
819: M 10-1 2	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** As part of the development of the next Gnangara allocation plan, the department used the PRAMS groundwater model to simulate groundwater levels under various pines, land use and climate scenarios. Through the Perth shallow groundwater system investigations we have improved our understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction. We are using the investigation's outcomes to better relate water levels to ecological condition at groundwater-dependent ecosystems. The department commissioned Dr Bea Sommer and Professor Ray Froend of Edith Cowan University to develop a model for determining ecological risk to groundwater-dependent vegetation across the Gnangara groundwater system as climate changes. The model is based on 30 years of ecological and hydrological monitoring data. It has been an important management tool for assessing the impact of future land and water use scenarios and for reviewing allocation limits for the new Gnangara allocation plan.
819: M 10-1 3	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara Mound.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The department is using PRAMS modelling to improve understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnangara system. Reductions to both public and private abstraction are being modelled to evaluate storage gains in the Superficial aquifer at 2030. These scenarios are informing the allocation limit review for the new Gnangara allocation plan. The Perth Regional Confined Aquifer Capacity study used robust and established science coupled with innovative research to improve our understanding of the deep Leederville and Yarragadee aquifers in the Perth region. See Section 6.3 for key findings. Perth shallow groundwater system investigations have improved the department's understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction. The department is using the investigation's outcomes to limit abstraction impacts on groundwater-dependent ecosystems.

Audit code	Subject	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: M 10-1 4	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • clarification of the relationship between groundwater level and wetland water levels and wetland water quality • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • clarification of the relationship between groundwater level and wetland water levels and wetland water quality.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The department has conducted hydrogeological studies at a number of sites across the Gnangara groundwater system as part of the Perth shallow groundwater systems investigation. To date, ten reports have been completed and are available on the department's website. These reports examine relationships between wetland hydrogeology, chemistry and ecosystem function to provide a basis for improved management strategies that limit abstraction impacts.
819: M 10-1 5	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep Caves • to the requirements of the Minister for the Environment on advice of the EPA and the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in the understanding of the relationship between groundwater level and water levels in the Yanchep Caves.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Partly compliant.** Water quality and macroinvertebrate monitoring in the Yanchep Caves ceased in 2013–14 because of low water levels. Building on the work of the shallow groundwater system investigation, the department recently completed a study on the cause of rapidly declining levels in Loch McNess in Yanchep National Park (Kretschmer and Kelsey 2016). This study improved our understanding of the hydrogeology of Loch McNess and surrounding areas, including the nearby caves. We continue to monitor groundwater levels in relation to cave levels and have made management changes that aim to improve levels in the caves. We have worked with Water Corporation to reduce public water supply abstraction near the Yanchep National Park and further reductions are proposed. Reductions in abstraction, both public and private, and removal of pine plantations to the east will assist in improving groundwater levels in the vicinity of the Yanchep Caves.
819: M 10-1 6	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes: • improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnangara Mound • to the requirements of the Minister for the Environment on advice of the EPA the DBCA (formerly DPaW).	Engage in research projects to address this issue, which includes: • improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnangara Mound.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		**Compliant.** The conservation value of wetlands is a prime responsibility of the Department of Biodiversity, Conservation and Attractions (formerly DPAW). The department does research and monitoring to determine how conservation values are supported by groundwater and how abstraction can be managed to limit impacts on these values.
819: M Proced-ure 1		Where a condition states "to the requirements of the Minister for the Environment on advice of the EPA", the EPA will prepare the written notice to the proponent.	The EPA to provide written notice to the proponent (Department of Water now Department of Water and Environmental Regulation).		Minister for the Environment		Overall		Not the responsibility of the Proponent (Department of Water and Environmental Regulation).
819: M Proced-ure 2		The EPA may seek advice from other agencies or organisations, as required, in order to provide its advice.	The EPA to seek advice as required.		EPA	Other agencies as required.	Overall		Not the responsibility of the Proponent (Department of Water and Environmental Regulation).
819: M Proced-ure 3		Where a condition lists advisory bodies, it is expected that the proponent will obtain the advice of those listed as part of its compliance reporting to the Chief Executive Officer of the EPA.	Department of Water and Environmental Regulation liaises with advisory body as required.	Liaison with advisory body in compliance report.	EPA	Agencies listed as part of compliance reporting.	Overall		**Compliant.** Refer to commitments: • 2,4,6,8,21 = DBCA (formerly DEC) • 21 = FPC. Although specific feedback was not sought on each separate condition, advice on relevant issues was obtained as part of the comprehensive, interagency network that formed part of the draft *Gnangara Sustainability Strategy*. Also, both the FPC and the then DEC and made public submissions to the *Gnangara groundwater areas water management plan: draft for public comment* (DoW 2008b), which dealt with similar issues as the conditions.

Table B 2 The proponent's (Department of Water) environmental management conditions

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 1	Gnangara Mound allocations	Sustainable use of groundwater from the Gnangara Mound (Superficial aquifer).	Manage public and private groundwater abstraction to meet objectives and Environmental Water Provisions (EWP) criteria presented in tables 1 and 2 (*Ministerial Statement No. 819*).	Meet objectives and EWPs criteria presented in tables 1 and 2 (*Ministerial Statement No. 819*).	Compliance report	Minister for the Environment		Overall		**Partly compliant.** Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnangara Mound.
819: P 2	Management objectives and Criteria	To provide for ongoing adaptive management.	Management objectives, criteria and water allocation limits will be regularly reviewed and amended as information becomes available to provide for ongoing adaptive management.	Regularly review management objectives, criteria and water allocation limits. Best examined in triennial reports, which also review long-term trends (most recent triennial for Gnangara: 2006-09).	Compliance report	Minister for the Environment	DBCA	Overall		**Compliant.** Gnangara plan evaluation statements were completed in 2013 and 2015 (DoW 2013b; DoW 2015a). These statements evaluated the department's management of Gnangara groundwater resources against the Gnangara plan objectives since its release. The evaluation statements are available on the department's website. The most recent review of Ministerial conditions and commitments for the Gnangara mound are outlined in the 2007 *Review of Ministerial Conditions on the groundwater resources of the Gnangara Mound* (DoW 2008c) and confirmed in *Ministerial Statement No. 819*. The department is reviewing the management objectives and allocation limits of Gnangara resources as part of the development of the new Gnangara allocation plan.
819: P 3	Yanchep Caves	To minimise environmental and/or significant impact.	Continue to develop catchment strategies to minimise change in hydrological regime within the caves of Yanchep National Park. Monitor water levels and cave fauna.	Interact with state and local agencies to coordinate land and water development activity to promote objective. Incorporate water level and fauna monitoring of caves in the Department of Water and Environmental Regulation's Gnangara Mound monitoring program.	Compliance report	Minister for the Environment	DBCA	Overall		**Partly compliant.** Water levels in Yanchep Caves have been declining for a number of years and accessible caves are now dry. We can no longer gain access to a number of the caves above because of safety concerns. This informed the decision to discontinue macroinvertebrate and water quality monitoring at Yanchep Caves. Monitoring of surrounding Superficial aquifer groundwater bores is ongoing. Building on the work of the shallow groundwater system investigation, the department recently completed study on the cause of rapidly declining levels in Loch McNess in Yanchep National Park (Kretschmer and Kelsey 2016). Working with DBCA, the department has reduced local abstraction in the Yanchep National Park and has also made changes to public water supply abstraction to limit impacts on the caves (see section 6).
819: P 4	Strategic drainage plans	To minimise environmental and/or significant impact.	Prepare strategic drainage plans for the study area including options for management of higher water levels in lakes Joondalup, Goollelal, Mariginiup, and Jandabup.	Prepare strategic drainage plans for the study area.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department assesses water management strategies and plans against our legislation, policies and guidelines to ensure that: • water management opportunities and issues are addressed at the appropriate planning and design stages of urban development and • proposed urban development does not result in adverse impacts to water resources and the environment. During the reporting period the department advised the Department of Planning, Land and Heritage that the East Wanneroo Structure Plan area will require a Drainage and Water Management Plan.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 5 1	Research and investigation program	Improving understanding of: • groundwater-environmental relationships on the Swan Coastal Plain; • the associated management requirements, and • potential management techniques.	Prepare a research and investigation program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The research and investigation program will be prepared with the objective of improving understanding of: • groundwater – environmental relationships on the Swan coastal plain; • the associated management requirements, and • potential management techniques; • and will incorporate all relevant aspects of research and investigation work currently committed to under Ministerial statements 438 and 496.	Prepare a research and investigation program.	Submit research and investigation program to the EPA for approval. Compliance report.	EPA	DBCA	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** The department, together with research partners, is focussing management effort on the areas that will show the most benefit from changes to abstraction. This work is informing the new Gnangara allocation plan: • The department has updated the Perth Regional Aquifer Modelling System (PRAMS). • The department has completed the Perth Regional Confined Aquifer Capacity project (PRCAC) that investigated the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (or managed aquifer recharge). • The Perth shallow groundwater system investigation is complete with reports available on the department's website. These studies improved our understanding of the interrelationships between wetlands and the Superficial aquifer and the complex, superimposed impacts of climate change, land use and abstraction. • For the new Gnangara allocation plan, we have used a tool developed by Edith Cowan University to assess the risk of impacts to groundwater-dependent vegetation under different water, land use and climate scenarios. A previous research and investigation program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of Gnangara Triennial report 2003–06 (DoW 2007). The audit of 2003–06 and 2006–07 compliance reports agreed that the commitment could be 'cleared' upon confirmation from the DEC.
819: P 5 2	Research and investigation program	Administrative	Implement the research and investigation program to the satisfaction of the EPA.	Make part of annual Departmental work program.	Compliance report	EPA	DBCA	Overall		**Compliant.** The department uses outcomes from the research and investigation program to develop management strategies based on scientific data, to promote the sustainable use of the groundwater resources of the Gnangara system.
819: P 5 3	Research and investigation program	To provide for ongoing up-to-date adaptive management.	Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Incorporate review in Triennial reporting in 6-year intervals.	Triennial compliance report	EPA	DBCA	Overall	Every six years (coincide with triennial reports)	**Compliant.** The department's research and investigation program is constantly evolving. The current program includes modelling of climate, land use and abstraction scenarios using the Perth Regional Aquifer Modelling System.
819: P 6 1	Environmental monitoring program	To enable evaluation of the environmental impact of groundwater abstraction from the Gnangara Mound (Superficial aquifer).	Prepare an environmental monitoring program for submission to the EPA for review and subsequent finalisation of the program to the satisfaction of the EPA. The monitoring program will include: • monitoring of groundwater levels in all relevant aquifer systems; • relevant wetland water levels and water quality; • condition of vegetation and fauna associated with groundwater-dependent ecosystems • cave water levels.	Prepare an environmental monitoring program.	Submit monitoring program to the EPA for approval. Compliance report.	EPA	DBCA	Overall	Within four months of a revised statement being issued following the 2004 Stage 1 section 46 review	**Compliant.** A letter was sent to the Director General of the then DEC in December 2009, seeking advice and input on amendments to the environmental monitoring program. The previous environmental monitoring program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of the Gnangara triennial report 2003–06 (DoW 2007). The audit of 2006–07 compliance report agreed commitment could be 'cleared' upon confirmation from the then DEC. Although this requirement has been satisfied technically (the monitoring program was prepared), the department does not seek a 'clearance' of this commitment as the program is constantly evolving and being modified. The new Gnangara groundwater allocation plan will include an updated monitoring program.
819: P 6 2	Environmental monitoring program	Administrative	Implement the approved environmental monitoring plan to the satisfaction of the EPA.	Make part of annual departmental work program.	Compliance report	EPA	DBCA	Overall		**Compliant.** (see P 6 1)

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 6 3	Environmental monitoring program	To provide for ongoing up-to-date adaptive management.	Review and revise the program every six years (coinciding with triennial reports), to the satisfaction of the EPA.	Incorporate review in Triennial reporting in 6-year intervals.	Triennial compliance report	EPA	DBCA	Overall	Every six years (coincide with triennial report)	**Compliant.** A review of the environmental monitoring program was completed in June 2009 with the ecologists who complete the monitoring on the department's behalf. We made a number of amendments. Although the action states that a review must be compiled in triennial reports every 6 years, the ecological monitoring program undergoes regular revisions as required. Recent revisions were made in 2010 and 2013 and have been previously reported. The department is reviewing environmental objectives and monitoring as part of developing the new Gnangara allocation plan.
819: P 7	Development advice	Integrated land and water resource planning for enhanced water resource management.	Continue to provide advice to the City of Wanneroo, the Department of Planning, Lands and Heritage (DPLH) (formerly Department of Planning and Infrastructure), DBCA (formerly DEC) and other relevant agencies on the impact of land use on groundwater resources.	Liaise with the City of Wanneroo, the DPLH, DBCA and other relevant agencies.	Compliance report	Minister for the Environment	City of Wanneroo, DBCA and other relevant agencies	Overall		**Compliant.** The department assesses land use proposals with potential water resource issues that are referred to it from local and state government agencies.
819: P 8	Gnangara inter-agency technical advisory group	Integrated land and water resource planning for enhanced water resource management.	Convene and provide ongoing executive support for an inter-agency technical advisory group for water resources planning and management issues on the Gnangara Mound. The group will consider planning and management issues in the context of recommendations of the Select Committee on Metropolitan Development and Groundwater Supplies.	Provide executive duties for the Gnangara Coordinating Committee. Provide executive duties for the Gnangara Consultative Committee (see P 9).	Compliance report. See P 9.	Minister for the Environment		Overall		**Compliant.** (See P 9)
819: P 9	Community consultation	Useful forum for information exchange and advice.	Continue to chair and provide support for the Gnangara Consultative Committee as an ongoing forum for information exchange and advice.	Chair and provide support for the Gnangara Consultative Committee.	Compliance report	Minister for the Environment		Overall		**Partly compliant.** While there is no formal Gnangara Consultative Committee, the department continues to consult with a range of stakeholders on Gnangara as required. To develop the new Gnangara allocation plan, we are consulting extensively with water users on how to adjust to climate change. A summary of the consultation is outlined in this report.
819: P 10	Vegetation protection	Limit environmental impact – tree deaths.	Limit potential for tree deaths around production wells to 100 metres radius for normal (average) climate conditions and within 200 metres to extreme conditions.	Considered in Water Corporation operating strategy.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department has classified each public water supply bore based on its proximity to environmentally sensitive areas and use these classifications to distribute public supply abstraction to limit impacts at groundwater-dependent ecosystems.
819: P 11	Lake Nowergup supplementation	Protect environmental values.	Should EWPs in Lake Nowergup not be met by November, artificial supplementation will be used until the EWP is reached.	Operate Lake Nowergup artificial maintenance facility if EWPs not met by end of November until EWP is reached.	Compliance report	Minister for the Environment		Overall		**Non-compliant.** Supplementation of water levels continues to occur at Lake Nowergup all year round, but water levels continue to be non-compliant.
819: P 12	Reporting	Assessment of environmental impact(s) from groundwater abstraction for public water supply.	Require Water Corporation to submit yearly production plans as part of the operating strategy and to report on compliance with environmental commitments made in the operating strategy.	Water Corporation to submit annual production summary and report on compliance with environmental commitments defined in operating strategy.	Compliance report	Minister for the Environment		Overall		**Compliant.** The department requires and reviews annual bore abstraction plans from Water Corporation to ensure that abstraction is distributed to limit impacts on groundwater-dependent ecosystems. Water Corporation also submits annual water monitoring summaries that report on compliance with environmental commitments made in its operating strategy.

Audit code	Subject	Objective	Action	How	Evidence	Require-ment of	On advice from	Phase	When/ Where	Status
819: P 13	Vegetation protection	To minimise environmental and/or significant impact.	Establish additional monitoring wells in those areas where suitable wells do not exist to monitor groundwater levels under phreatophytic vegetation.	Review monitoring program and recommend construction of additional monitoring wells as required.	Compliance report	Minister for the Environment		Overall		**Cleared.** A similar commitment from previous statement 438: P 2 was stated as 'cleared' by the former Department of Environmental Protection's Environmental Audit Branch on 28/10/1997 (refer to Appendix 7 of the Gnangara 2000–03 triennial compliance report). However, the department is continuing work in this area. The department completed a management area review (McHugh and Bourke 2007) that summarised the current monitoring and management issues facing wetlands on the Gnangara and Jandakot groundwater mounds and identified the information and data required to address these issues. The review recommended sites to be included in the Perth shallow groundwater systems investigation, prioritised based on ecological significance, management issues and geomorphic setting. As part of the investigation, we redesigned and upgraded existing monitoring infrastructure and installed new monitoring networks at ecologically important sites.
819: P 14	East Gnangara wetlands	Offset environmental impact with environmental benefit.	Require Water Corporation to implement its 2001 wetland mitigation strategy and subsequent approved revision and report to the DoW on implementation.	Require information in Water Corporation annual production summary and report on compliance with environmental commitments defined in operating strategy.	Compliance report	Minister for the Environment		Overall	Prior to the commissioning of the Lexia scheme	**Partly compliant.** The department has discussed this issue with Water Corporation. Consistent with the study on biodiversity values on the Mound (as part of the draft *Gnangara sustainability strategy*) and other investigations outlined in the status against commitment 819: P 5 1, the department and Water Corporation have agreed to review and develop an environmental benefit program to offset the impacts seen on wetlands in the next phase of planning for the Gnangara Mound.

Appendix C — History of Ministerial statements for the Gnangara Mound

The importance of managing abstraction from the Gnangara Mound to protect groundwater-dependent ecosystems was formally recognised in the late 1980s. The Environmental Protection Authority (EPA) proposed conditions on Gnangara groundwater abstraction in 1986 when the Gnangara Mound water resources environmental review and management program was released (WAWA 1986). The conditions, released in March 1988 under Statement 021, included Ministerial water level criteria based on environmental knowledge at the time. These were considered reasonable by the former Water Authority of WA to maintain key elements of the environment. These Ministerial criteria accounted for expected groundwater abstraction for the region, expected land use changes, and historical rainfall variations.

In 1995, the WAWA reviewed Ministerial water level criteria (WAWA 1995). The review highlighted that climate was an important factor affecting groundwater levels, and the difficulty of predicting future groundwater levels given the uncertainty of future climatic conditions.

In 2001, in response to land-use changes and lower rainfall, the EPA endorsed a two-stage approach to review the Ministerial conditions and commitments for the Gnangara and Jandakot mounds under section 46 of the *Environmental Protection Act 1986*. The first stage was for the then Department of Water (former Department of Environment) to review Ministerial conditions and commitments on Gnangara and Jandakot based on existing knowledge (DoE 2005). This review led to *Statement No. 687* for Gnangara (Government of Western Australia 2005a) and *Statement No. 688* for Jandakot (Government of Western Australia 2005b).

In 2007, the then Department of Water conducted a further review of Ministerial conditions and commitments on Gnangara (DoW 2008c). The purpose of this review was to refine Ministerial criteria to the sites with significant ecological value and where abstraction is the main factor influencing groundwater levels. This review led to the *EPA Bulletin 1324* in May 2009, with recommendations to the Minister for Environment on the proposed changes. *Statement No.819* for Gnangara (Government of Western Australia 2009a) was released later that year containing the consolidated and refined conditions and commitments.

The second stage of the Section 46 review was proposed as a more comprehensive review to improve management of public and private abstraction and to incorporate ecological information from work underway at the time. This work has been overtaken by more recent investigations into the shallow groundwater systems and ecological responses to climate. We will use this work to focus management effort on areas that will show the most benefit from changes to abstraction. The intent of the stage two review will be covered by the new Gnangara groundwater allocation plan.

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