



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

*We're working for
Western Australia.*

An abstract graphic consisting of several intersecting horizontal and vertical lines in teal and white, creating a grid-like pattern that extends across the middle of the page.

Environmental management of groundwater from the Gnangara Mound groundwater resources

Triennial compliance assessment report
July 2018–June 2021

February 2022

Department of Water and Environmental Regulation
8 Davidson Terrace
Joondalup Western Australia 6027
Locked Bag 10 Joondalup DC WA 6919

Phone: 08 6364 7000

Fax: 08 6364 7001

National Relay Service 13 36 77

www.dwer.wa.gov.au

© Government of Western Australia

February 2022

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

ISSN 1033-8950

WT6512

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).

For more information about this report, contact:

Shaan Pawley, Manager Water Allocation Planning.

Disclaimer

This document has been published by the Department of Water and Environmental Regulation. Any representation, statement, opinion or advice expressed or implied in this publication is made in good faith and on the basis that the Department of Water and Environmental Regulation and its employees are not liable for any damage or loss whatsoever which may occur as a result of action taken or not taken, as the case may be in respect of any representation, statement, opinion or advice referred to herein. Professional advice should be obtained before applying the information contained in this document to particular circumstances.

This publication is available at our website www.dwer.wa.gov.au or for those with special needs it can be made available in alternative formats such as audio, large print, or Braille.

Contents

Contents	iii
Summary	1
1 Background	3
1.1 Ministerial Statement no. 819	3
1.2 The Gngangara groundwater system	5
1.3 Allocation limits and licensing	7
2 Rainfall	8
3 Groundwater use	9
3.1 Public water supply entitlements	9
Groundwater replenishment scheme	9
3.2 Private licensed entitlements	10
3.3 Use that is exempt from licensing	10
4 Compliance	15
4.1 Compliance with water level criteria	15
5 Environmental monitoring, management, research and consultation	17
5.1 Environmental monitoring	17
Wetland vegetation	18
Wetland macroinvertebrates and water quality	20
Mound spring macroinvertebrates and water quality	21
Wetland frogs	21
Terrestrial vegetation	21
5.2 Management actions	22
New draft Gngangara groundwater allocation plan	22
Managing public water supply use	22
Managing private licensed use	23
Managing groundwater use exempt from licensing	23
Be Groundwater Wise website	24
Waterwise Perth Action Plan	25
5.3 Research initiatives	25
Impacts of fire on wetland acidity	25
5.4 Consultation	25
Appendices	27
Appendix A — Water level monitoring results for Ministerial sites for the Gngangara Mound Groundwater Resources for 2012–2021	29
Appendix B — Audit tables: Environmental conditions, procedures and commitments for the Gngangara groundwater resources	39
Appendix C — History of Ministerial statements for the Gngangara Mound	51
References	53

Figures

Figure 1	Location of Gnamptara water level criteria sites, public water supply production bores and drawpoints of private licences with larger entitlements	4
Figure 2	Groundwater connectivity of the Leederville (left) and Yarragadee (right) aquifers, with abstraction locations and volumes	6
Figure 3	Annual and average water-year (July–June) rainfall at Perth Airport (BoM site no. 9021)	8

Tables

Table 1	Rainfall, licensed entitlement totals from all aquifers, and compliance summary	2
Table 2	Licensed entitlements and estimates of garden bore use from all aquifers in the Gnamptara groundwater system	12
Table 3	Licensed entitlements from the Superficial aquifer in subareas of the Gnamptara groundwater system	13
Table 4	Summary of non-compliance with water level criteria for Gnamptara groundwater resources for the reporting period	16
Table 5	Sites where wetland vegetation monitoring occurred over the 2018–21 triennial reporting period	18
Table 6	Sites where wetland macroinvertebrate and water quality monitoring occurred over the 2018–21 triennial reporting period	20

Summary

This report describes the Department of Water and Environmental Regulation's compliance with Ministerial conditions and commitments under *Ministerial Statement no. 819 – Gngangara Mound groundwater resources [including East Gngangara Shire of Swan]* for the period 1 July 2018 to 30 June 2021 under Part IV of the *Environmental Protection Act 1986* (Government of Western Australia 2009).

The report presents total licensed groundwater entitlements covered by the *Gngangara groundwater allocation plan* (DoW 2009a) from all aquifers of the Gngangara groundwater system (Figure 1, Table 1). The report also outlines environmental monitoring, management, research and consultation by the department to manage abstraction from the Gngangara groundwater system.

The number of sites across the Gngangara plan area that were non-compliant with absolute minimum or peak water level criteria in *Ministerial Statement no. 819* increased from 12 in 2018–19 to 14 in 2019–20. In 2020–21, 16 sites were non-compliant.

Rainfall at Perth Airport BoM station over the triennial reporting period was 662 mm in 2018–19, 562 mm in 2019–20 and 658 mm in 2020–21. Rainfall was well below the long-term (75 year) average of 760 mm and was similar to the short term (10 year) average of 652 mm (Table 1 and Figure 3).

Public water supply entitlement volumes, licensed to the Water Corporation primarily for the Integrated Water Supply Scheme (IWSS), remained similar across the reporting period (Table 1). We continued to work with the Water Corporation to distribute groundwater abstraction for public water supply in response to groundwater level trends and to move abstraction away from non-compliant sites (Table 1).

Over the reporting period, the volumes of water licensed, injected and abstracted as part of Water Corporation's groundwater replenishment scheme for the IWSS increased with the expansion of the scheme to stage 2 (Table 1).

Private licensed entitlements across the Gngangara Superficial aquifer reduced slightly over the triennial reporting period (Table 1).

Table 1 *Rainfall, licensed entitlement totals from all aquifers, and compliance summary*

	2018–19	2019–20	2020–21
Rainfall ¹	662.0 mm	562.0 mm	658.0 mm
Public water supply entitlements (IWSS baseline licences, Town of Woodridge and Moore River South development) ²	111.47 GL	111.59 GL	112.52 GL
Public water supply entitlements (IWSS groundwater replenishment) ³	13.30 GL	13.30 GL	27.15 GL
<i>Injected (actual)</i>	<i>3.59 GL</i>	<i>12.74 GL</i>	<i>15.24 GL</i>
<i>Abstracted (actual)</i>	<i>1.24 GL</i>	<i>9.42 GL</i>	<i>12.33 GL</i>
Private licensed entitlements	131.59 GL	127.86 GL	127.38 GL
Estimated garden bore and stock and domestic use ⁴	36.00 GL	36.00 GL	36.00 GL
No. of sites non-compliant with absolute minimum or peak water level criteria ⁵	12 out of 30 ⁶	14 out of 30	16 out of 30

1 Rainfall figures are for July to June (water year) and are measured at Perth Airport (BoM site no. 9021).

2 In 2018–19 this consists of 110.65 GL licensed to the Water Corporation for the IWSS (including 0.85 GL for bore MR17), 0.16 GL for Woodbridge town supply (Superficial and Leederville) and 0.69 GL for the Moore River South development (Leederville).

In 2019–20 this consists of 110.77 GL licensed to the Water Corporation for the IWSS (including 0.83 GL for bore MR17), 0.13 GL for Woodbridge town supply and 0.69 GL for the Moore River South development.

In 2020–21 this consists of 111.7 GL licensed to the Water Corporation for the IWSS (including 0.78 GL for bore MR17), 0.13 GL for Woodbridge town supply and 0.69 GL for the Moore River South development.

3 For full details of GWR entitlements, injection and abstraction see section 3.1 and Table 2. Licensed entitlements for GWR increased in 2020–21 with the expansion of stage 2 of the scheme.

4 Garden bore and stock and domestic use is from the Superficial aquifer only. It is estimated using data collected through surveys, data from the Australian Bureau of Statistics and records of household use from the Water Corporation.

5 For full details of compliance with absolute minimum or peak water level criteria see Table 4 and Appendix A.

6 Melaleuca Park Dampland 78 was incorrectly reported as being non-compliant with absolute summer minimum water levels in 2018–19 due to a water level reporting error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

To rebalance the Gngangara groundwater system in response to climate change, the Department of Water and Environmental Regulation released the *Draft Gngangara groundwater areas allocation plan* (DWER 2021) for public comment in November 2021. The draft plan, developed over five years with extensive consultation with stakeholders, provides water users with certainty of on-going supply and helps ensure the long-term environmental sustainability of the Gngangara system.

The draft plan proposes new strategies towards improving environmental outcomes for ecosystems that are dependent on the Gngangara system. Following a three-month public comment period, and the Environmental Protection Authority's assessment of proposed changes to environmental conditions, the plan will be finalised in 2022.

Public submissions on the draft plan close on 28 February 2022.

1 Background

1.1 Ministerial Statement no. 819

Ministerial Statement no. 819: Gngangara Mound groundwater resources (Government of Western Australia 2009) establishes the environmental conditions and commitments associated with the allocation of groundwater from the Gngangara groundwater resources north of Perth for public and private use. As the proponent, the Department of Water and Environmental Regulation (the department) must comply with and report on the conditions to the Environmental Protection Authority each year.

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

Some of the key conditions in *Ministerial Statement no. 819* are environmental water provisions set as water level criteria at 30 representative sites across the Gngangara groundwater resources – 14 wetland sites and 16 terrestrial phreatophytic vegetation sites (Figure 1). Phreatophytic vegetation uses groundwater to meet at least part of its water needs. On the Swan Coastal Plain, native vegetation that occurs within 10.5 m depth to groundwater is considered likely to be phreatophytic.

The conditions and commitments on Gngangara groundwater resources were first established in 1988 under Part IV of the *Environmental Protection Act 1986* and since then they have been revised several times to include additional criteria sites or 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 water level criteria at the current 30 sites have been developed to protect the important environmental values of groundwater-dependent ecosystems from significant impact caused by water use from the Gngangara system.

The new draft Gngangara groundwater allocation plan proposes further changes to water level criteria. The proposed changes will be assessed by the Environmental Protection Authority under section 46 of the *Environmental Protection Act 1986* in 2022.

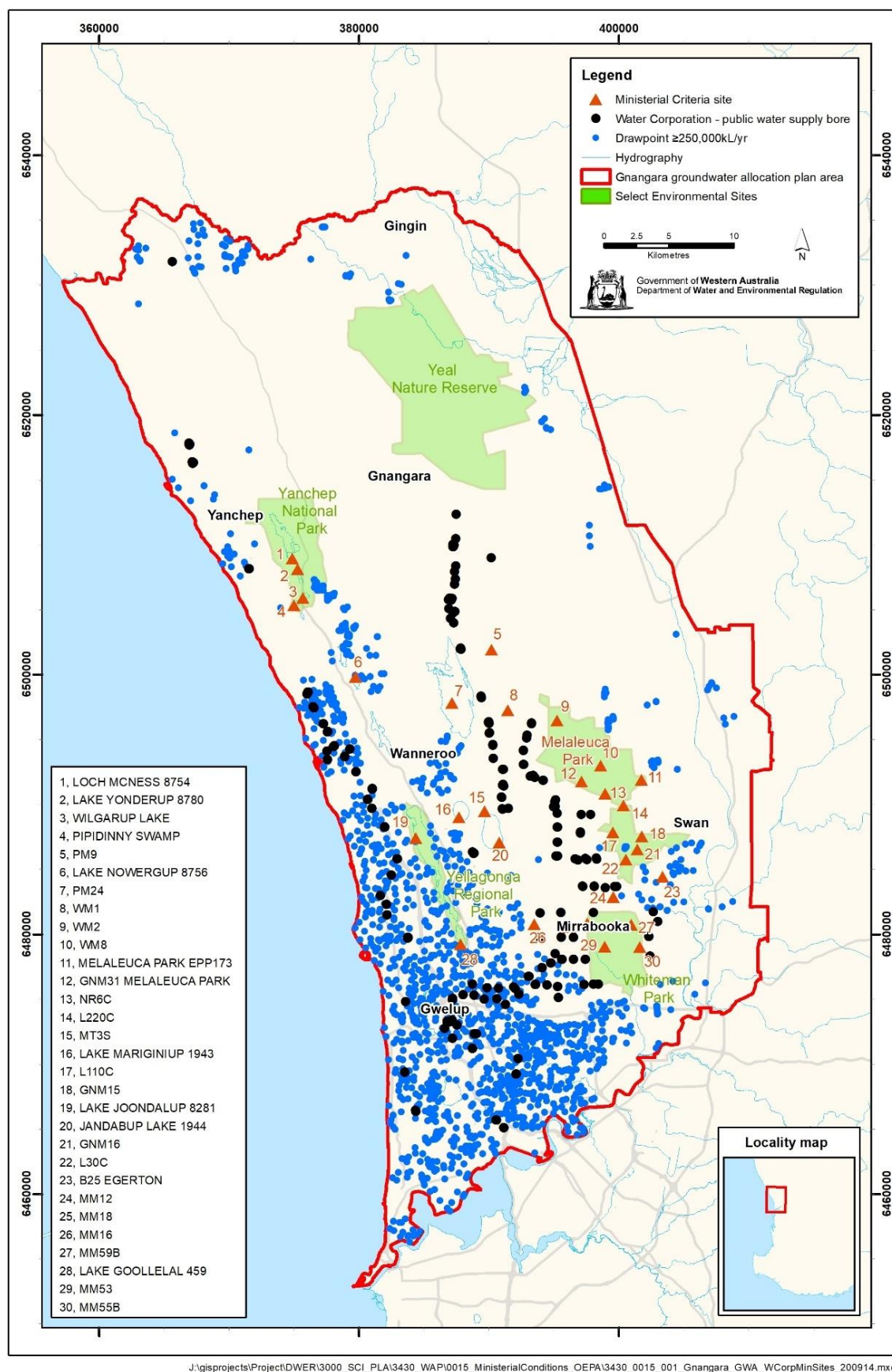


Figure 1 Location of Gnangara water level criteria sites, public water supply production bores and drawpoints of private licences with larger entitlements

1.2 The Gngangara groundwater system

The Gngangara 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 2,200 km² (Figure 2). The system comprises four main aquifers:

- the shallow, unconfined Superficial (watertable) aquifer sometimes referred to as the Gngangara Mound
- the shallow, semi-confined Mirrabooka Aquifer
- the deep, partially-confined Leederville Aquifer
- the deep, mostly-confined Yarragadee Aquifer.

The Gngangara groundwater system is now over-allocated and overused. This has contributed to water level declines over the last 40 years, which have impacted on important wetlands and other groundwater-dependent ecosystems. Water level declines are the result of:

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

Environmental impacts to ecosystems from groundwater level decline can occur where those ecosystems are directly supported by the regional watertable. In the Gngangara 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 Gngangara plan area (Figure 2).

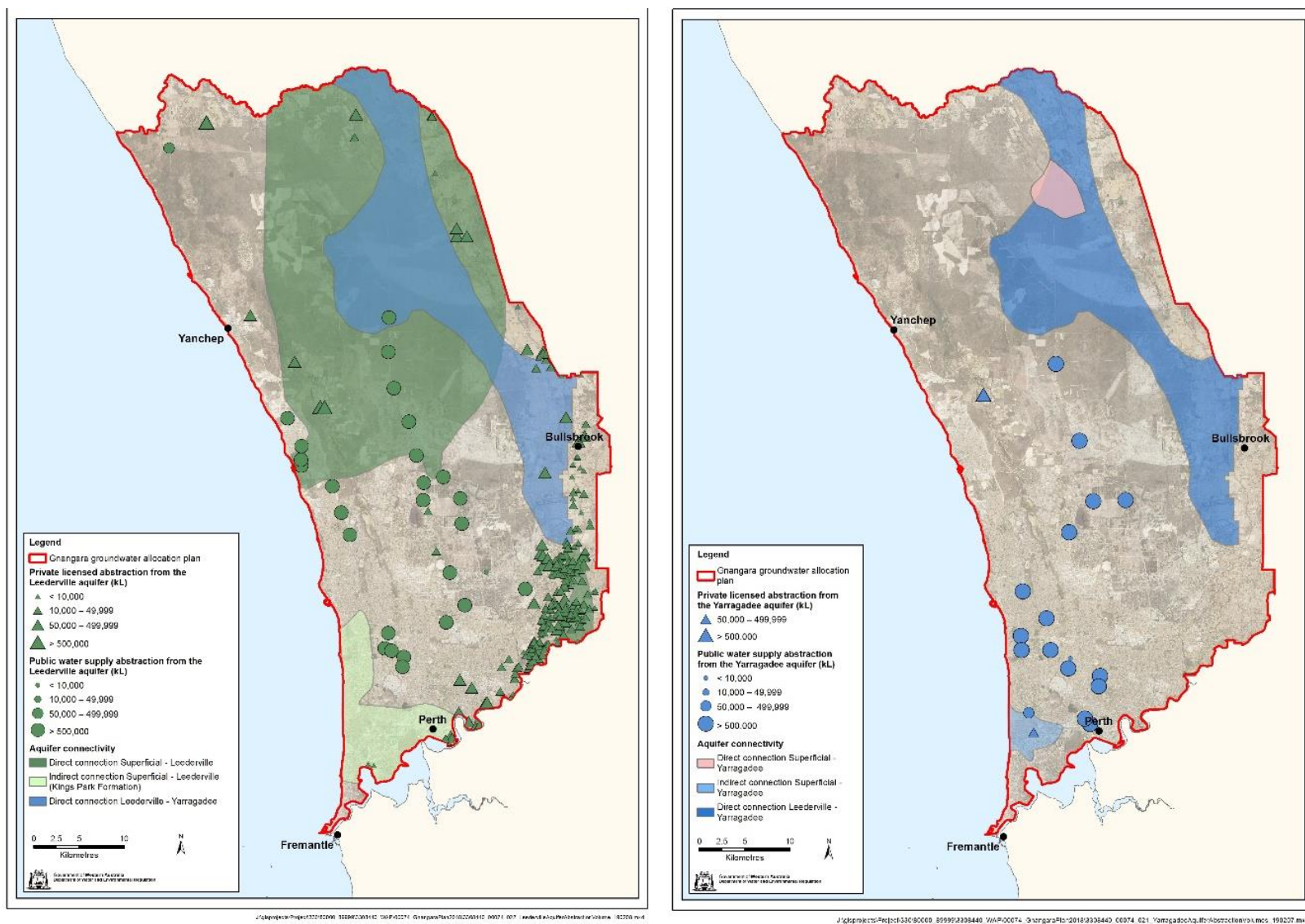


Figure 2 Groundwater connectivity of the Leederville (left) and Yarragadee (right) aquifers, with abstraction locations and volumes

1.3 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.

Groundwater abstracted as part of a managed aquifer recharge scheme (including Water Corporation's Groundwater Replenishment Scheme – see section 3.1) is licensed but accounted for outside the allocation limit as there is no net deficit from the groundwater resource.

Water for the environment is not included as part of the allocation limit, as it is left in the groundwater system to support non-consumptive benefits. The water level criteria set at high value wetland and bushland sites on the Gnamptara groundwater system serve to restrict the amount of water that can be allocated from the system. This ensures there is sufficient water left in the system to meet environmental needs.

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. Groundwater licences are issued within the allocation limits and must be consistent with the allocation plan and licensing policies as well as meet individual licence conditions.

Allocation limits for the Gnamptara groundwater resources were reviewed as part of the development of the *Gnamptara groundwater allocation plan: draft for public comment* (DWER 2021).

2 Rainfall

Groundwater is recharged by rainfall. How much groundwater levels rise and fall each year is affected by the amount of rainfall 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 climate change research (Bates et al. 2010), as well as relevant global climate change models, project continued rainfall reduction in the region.

Rainfall at Perth Airport BoM station over the reporting period was 662 mm in 2018–19, 562 mm in 2019–20 and 658 mm in 2020–21. Rainfall was well below the long-term (75 year) average of 760 mm and was similar to the short term (10 year) average of 652 mm (Figure 3).

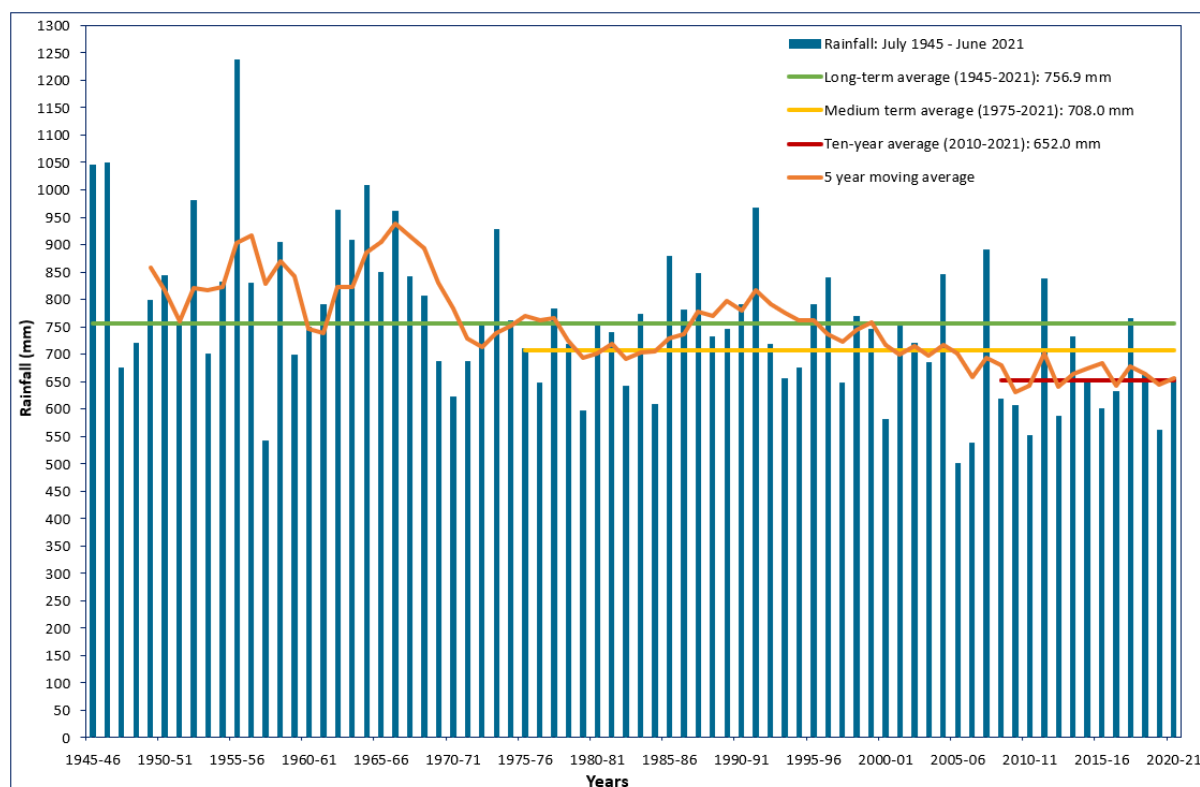


Figure 3 Annual and average water-year (July–June) rainfall at Perth Airport (BoM site no. 9021)

3 Groundwater use

The Gngangara groundwater system is the Perth region's largest source of easily accessible, low cost, good quality 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 estimates of use that are exempt from licensing within the Gngangara allocation plan area for the reporting period.

3.1 Public water supply entitlements

The department licenses Water Corporation to take groundwater from the Gngangara 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 Gngangara system, there is also a small volume of groundwater licensed from the Leederville Aquifer for the Woodridge town water supply and for the Moore River South development. These volumes do not form part of the IWSS and are licensed separately.

The volume of groundwater licensed for public and town water supply from all aquifers remained similar over the triennial reporting period. 111.47 GL was licensed in 2018–19, 111.59 GL in 2019–20 and 112.52 GL in 2020–21. See Table 2 for the distribution of licences by all aquifers and Table 3 for the superficial aquifer.

We continue to work with Water Corporation to distribute public water supply abstraction in response to groundwater level trends, and to move abstraction away from sites where levels are non-compliant with water level criteria in *Ministerial Statement no. 819*.

Groundwater replenishment scheme

The licensing of groundwater associated with Water Corporation's groundwater replenishment and recovery scheme (GWR) is managed outside the allocation limits set for the Gngangara system because water abstracted is balanced by water reinjected. Licensed volumes are reported separately from other volumes licensed for public water supply.

Groundwater replenishment is a form of managed aquifer recharge. At Beenyp Wastewater Treatment Plant in Craigie, water is treated to drinking water quality standard and recharged (or injected) into the Leederville and Yarragadee aquifers onsite. In 2018–19 3.45 GL was injected, in 2019–20 12.74 GL was injected, and in 2020–21 15.24 GL was injected.

An equivalent amount of water is then abstracted from aquifers across the Gngangara or Jandakot groundwater systems, and this is subject to a groundwater licence.

The groundwater abstracted or 'recovered' from the aquifer as part of Stage 1 of the Beenyp GWR scheme, is pumped from bores that are part of the existing IWSS

network. Abstraction locations are distributed to limit overall impacts to groundwater-dependent ecosystems supported by the Gnamptara groundwater system.

Construction of Stage 2 of the GWR scheme was predominantly completed in 2019, with commissioning and testing continuing through 2020. Stage 2 injection of treated wastewater into the Leederville and Yarragadee aquifers occurs further north than Stage 1, in Wanneroo and Neerabup. This location will provide broader benefits to groundwater-dependent ecosystems, including wetlands, as there is greater connection between the deep and Superficial aquifers in this area. This was one of the major reasons why this injection location was chosen for Stage 2 of the scheme.

New Leederville and Yarragadee production bores will be constructed in the Whitfords, Quinns and Gwelup borefields to ensure that abstraction of groundwater for Stage 2 of the GWR scheme does not affect wetlands or other groundwater-dependent ecosystems. With the commissioning of these additional production bores as part of Stage 2, the overall scheme capacity will then increase to 28 GL.

See Table 2 for the distribution of licences, GWR injection volumes and GWR abstraction by aquifer.

3.2 Private licensed entitlements

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

Private licensed entitlements have remained relatively steady since the department implemented the *Gnamptara groundwater areas allocation plan* (DoW 2009a), which capped private entitlements in most subareas (Tables 2 and 3).

The reduction between 2018–19 and 2019–20 is due to the expiry of short-term licences associated with development activities like dewatering and dust suppression.

3.3 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 the Gnamptara system are garden bores used in urban areas and stock and domestic bores used in rural areas where there is often no scheme water connection. In the Gnamptara area we estimate that a total of 36 GL is abstracted from about 65,000 garden bores and 4,000 stock and domestic bores each year.

We use the best-available information to estimate exempt uses. This is subject to change over time as we get better information on the rates of instalment and average water use per bore in urban and rural areas.

Good information on the rate of new bore installation in urban areas across Perth is available – data from on-the-ground surveys by the Water Corporation; surveys by the Australian Bureau of Statistics in 2003, 2006 and 2009; and independent phone

surveys conducted for us in 2012, 2016 and 2018. This data shows that the rate of garden bore installation has dropped since the bore rebate scheme ended in 2009. The number of urban garden bores is increasing by about 1 per cent a year compared with 2 per cent before 2009.

Average water use per bore has also decreased in urban areas because of the three-day sprinkler restrictions for garden bores (from about 800 to 430 kL/year). Average water use per bore was estimated for our domestic bore metering project (which operated from 2009–2012) and was updated in 2016. The phone surveys conducted in 2016 and 2018 confirmed our assumptions that more bores were being installed across Perth.

Table 2 Licensed entitlements and estimates of garden bore use from all aquifers in the Gngangara groundwater system

Aquifer			Superficial	Mirrabooka ³	Leederville	Yarragadee ⁴	Fractured Rock and Coastal Saline ³	Total	
Public water supply entitlements (GL) ¹	Baseline licences (IWSS + Town of Woodridge + Moore River South) ²	2018–19	30.95	1.60	33.82	45.10	-	111.47	
		2019–20	32.05	3.50	32.02	44.02	-	111.59	
		2020–21	31.90	3.50	32.32	44.80	-	112.52	
	Entitlements ⁵	2018–19	1.00	0.80	8.45	3.05	-	13.30	
		2019–20	1.00	0.80	8.45	3.05	-	13.30	
		2020–21	1.62	0.80	15.63	9.10	-	27.15	
	Groundwater replenishment (GWR)	Injected	2018–19	-	-	2.75	0.84	-	3.59
			2019–20	-	-	9.59	3.15	-	12.74
			2020–21	-	-	11.50	3.74	-	15.24
	Abstracted	2018–19	-	-	1.24	-	-	1.24	
		2019–20	0.69	0.55	5.84	2.34	-	9.42	
		2020–21	1.58	0.74	7.85	2.15	-	12.33	
Private licensed entitlements (GL)		2018–19	116.19	3.08	11.64	0.68	0.09	131.59	
		2019–20	112.13	2.50	11.57	1.55	0.10	127.86	
		2020–21	112.75	2.52	11.44	0.68	0.58	127.38	
Garden and stock/domestic bore use exempt from licensing (GL)		2018–19	36.00	-	-	-	-	36.00	
		2019–20	36.00	-	-	-	-	36.00	
		2020–21	36.00	-	-	-	-	36.00	

1 Public water supply volumes include groundwater licensed to Water Corporation for the IWSS, the Woodridge town water supply and the Moore River South development.

2 In 2020–21 the IWSS baseline licence from the Gngangara groundwater system (including bore MR17) was 111.70 GL. In 2019–20 it was 110.77 GL and in 2018–19 it was 110.65 GL. In 2018–19 reporting year the Woodridge town water supply entitlement was 0.16 GL (Superficial and Leederville aquifers). In 2019–20 and 2020–21 it was 0.13 GL (Leederville aquifer). In all years of the triennial reporting period the Moore River South development entitlement was 0.69 GL (Leederville aquifer).

3 Mirrabooka and fractured rock aquifer volumes, previously reported together, have been separated out in compliance reports.

4 Yarragadee public water supply entitlement volumes include: 0.85 GL in 2018–19, 0.83 GL in 2019–20 and 0.78 GL in 2020–21 from bore MR17 which is located outside of the Gngangara allocation plan boundary, but within the Perth South Groundwater Area.

5 With the completion of Stage 2, GWR licensed entitlements have increased from 13.30 GL up to 27.15 GL. 0.3 GL of the 13.30 GL (2018–19 and 2019–20) and 0.10 GL of the 27.15 GL (2020–21) licensed for GWR is licensed from bore MR17.

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

Table 3 Licensed entitlements from the Superficial aquifer in subareas of the Gnamangara groundwater system

Groundwater area	Subarea	Ministerial criteria site present?	Public water supply entitlements ¹ (GL)						Private licensed entitlements ² (GL)		
			Baseline licences (IWSS + Town of Woodridge)			Groundwater replenishment			2018–19	2019–20	2020–21
			2018–19	2019–20	2020–21	2018–19	2019–20	2020–21			
Gingin	Beermullah Plain South	No	-	-	-	-	-	-	3.13	3.13	3.11
	Deepwater Lagoon South	No	-	-	-	-	-	-	2.97	2.53	2.90
	Guilderton South	No	0.03	-	-	-	-	-	9.79	9.59	9.49
	Lake Mungala	No	-	-	-	-	-	-	2.87	2.70	2.70
Total for Gingin Groundwater Area			0.03	0.00	0.00	0.00	0.00	0.00	18.72	17.95	18.20
Gnamangara	Reserve	Yes	0.65	0.65	0.65	-	-	-	1.55	1.57	1.57
	Wanneroo Wellfield	Yes	6.10	6.10	6.05	-	-	-	2.41	2.15	2.15
Total for Gnamangara Groundwater Area			6.75	6.75	6.70	0.00	0.00	0.00	3.96	3.72	3.72
Gwelup	Gwelup	No	3.20	3.30	3.30	-	-	0.10	1.10	1.10	1.19
Total for Gwelup Groundwater Area			3.20	3.30	3.30	0.00	0.00	0.10	1.10	1.10	1.19
Mirrabooka	Ballajura	No	1.80	2.00	2.00	0.05	0.05	0.05	1.20	0.89	0.97
	Beechboro	No	-	-	-	-	-	-	0.34	0.29	0.35
	Henley Brook	No	0.50	0.50	0.50	-	-	-	0.25	0.23	0.29
	Improvement Plan 8	No	1.05	1.55	-	-	-	-	0.66	0.12	0.16
	Landsdale	Yes	-	-	-	-	-	-	0.48	0.45	0.47
	Plantation	No	-	-	-	-	-	-	0.36	0.36	0.36
	State Forest	No	-	-	-	-	-	-	1.30	1.00	0.99
	Whiteman Park	Yes	0.15	0.10	0.10	-	-	-	1.21	1.40	0.63
Total for Mirrabooka Groundwater Area			3.50	4.15	4.15	0.05	0.05	0.05	5.82	4.74	4.23
Perth	City of Bayswater	No	-	-	-	-	-	-	2.26	3.17	2.22
	City of Fremantle North	No	-	-	-	-	-	-	0.05	0.05	0.05
	City of Nedlands	No	-	-	-	-	-	-	2.33	1.58	2.38
	City of Perth	No	-	-	-	-	-	-	1.85	1.57	1.86
	City of Stirling	No	2.70	2.80	2.80	0.30	0.30	0.30	7.98	7.83	7.83
	City of Subiaco	No	-	-	-	-	-	-	0.99	0.87	1.06
	Eglinton	No	-	-	-	-	-	-	2.79	3.46	3.43
	Quinns	No	10.65	11.05	10.85	0.25	0.25	0.25	2.96	3.09	3.61
	Shire of Peppermint Grove	No	-	-	-	-	-	-	0.08	0.08	0.08
	Shire of Swan North	No	-	-	-	-	-	-	1.52	0.61	0.73
	Town of Bassendean	No	-	-	-	-	-	-	0.39	0.37	0.37
	Town of Cambridge	No	-	-	-	-	-	-	1.84	2.43	2.37
	Town of Claremont	No	-	-	-	-	-	-	0.67	0.54	0.66
	Town of Cottesloe	No	-	-	-	-	-	-	0.27	0.28	0.28
	Town of Mosman Park	No	-	-	-	-	-	-	0.48	0.48	0.48
	Town of Vincent	No	-	-	-	-	-	-	0.76	0.82	0.82
	Whitfords	Yes	2.60	2.60	2.80	0.40	0.40	0.93	8.85	8.81	8.96
Total for Perth Groundwater Area			15.95	16.45	16.45	0.95	0.95	1.48	36.07	34.60	37.21
Swan	Bandy Spring	No	-	-	-	-	-	-	0.33	0.33	0.33
	Central Swan	No	-	-	-	-	-	-	1.23	1.27	1.26
	Cockman Bluff	No	-	-	-	-	-	-	1.22	1.02	0.80
	East Swan	No	-	-	-	-	-	-	0.71	0.71	0.78
	Neaves	No	-	-	-	-	-	-	3.24	3.23	3.23
	North Swan	Yes	-	-	-	-	-	-	3.12	2.73	2.73
	Radar	No	-	-	-	-	-	-	2.88	2.13	1.79
	South Swan	No	-	-	-	-	-	-	3.77	3.86	3.81
Total for Swan Groundwater Area			0.00	0.00	0.00	0.00	0.00	0.00	16.51	15.28	14.73
Wanneroo	Adams	Yes	-	-	-	-	-	-	1.08	1.03	1.04
	Carabooda	No	-	-	-	-	-	-	8.04	7.85	7.83
	Carramar	No	-	-	-	-	-	-	1.49	1.50	1.60
	Jandabup	No	-	-	-	-	-	-	0.18	0.16	0.18
	Joondalup	No	-	-	-	-	-	-	0.80	0.77	0.73
	Lake Gnamangara	No	-	-	-	-	-	-	6.48	6.19	6.01
	Mariginiup	Yes	-	-	-	-	-	-	4.17	4.09	4.12
	Neerabup	No	-	-	-	-	-	-	2.54	2.53	2.52
	Nowergup	Yes	-	-	-	-	-	-	2.74	2.74	2.74
	Pinjar	Yes	-	-	-	-	-	-	0.56	0.56	0.58
Total for Wanneroo Groundwater Area			0.00	0.00	0.00	0.00	0.00	0.00	28.06	27.40	27.33
Yanchep	Yanchep	Yes	1.55	1.40	1.30	-	-	0.00	5.95	5.58	6.13
Total for Yanchep Groundwater Area			1.55	1.40	1.30	0.00	0.00	0.00	5.95	1.58	6.13
Total for Gnamangara groundwater allocation plan area			30.95	32.05	31.90	1.00	1.00	1.62	116.19	112.13	112.75

1 Public water supply information is from COMPASS as well as annual reports submitted to the department as a condition of Water Corporation's licences.

2 The 2018–19 report was run on 1 July 2019. The 2019–20 report was run on 1 July 2020. The 2020–21 report was run on 1 July 2021. All reports were run 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.

4 Compliance

The conditions and commitments that the department is required to comply with from *Ministerial Statement no. 819: Gnamptara groundwater resources* under Part IV of the *Environmental Protection Act 1986* (Government of Western Australia 2009) are shown in Appendices A and B (the ‘audit tables’).

4.1 Compliance with water level criteria

Ministerial Statement no. 819 sets water level criteria at 30 sites across the Gnamptara Mound. 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 – set at some wetlands to 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.

The number of sites that were non-compliant with absolute minimum or peak water level criteria increased from 12 in 2018–19 to 14 in 2019–20 and to 16 in 2020–21 (Table 4).

In 2020–21 absolute summer minimum water levels at WM2 fell and the site was non-compliant for the first time since 2017–18. Lake Jandabup was also non-compliant for the first time since 2017–18.

In 2019–20 water levels at WM8 declined and were non-compliant with absolute minimum water level criteria for the first time since 2016–17. The peak levels at Lake Mariginiup fell and the site was non-compliant after being compliant in 2018–19.

Levels at Melaleuca Park Dampland 78 were incorrectly reported as non-compliant in 2018–19 due to a water level recording error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

Management and mitigation actions implemented by the department in response to non-compliance are described in Section 5. Details for individual sites can be found in the ‘audit tables’ in Appendix A.

Table 4 Summary of non-compliance with water level criteria for Gnangara groundwater resources for the reporting period

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
2018–19				
Loch McNess				
Lake Yonderup			Lake Joondalup	
Lake Nowergup	MM53		Lake Mariginiup	
Lake Wilgarup	MM55B		Lake Nowergup	
Pipidinny Swamp	MM59B	43 ¹² out of 30	Lexia 86	6 out of 8
Lexia 186	PM9		Lexia 186	
Melaleuca Park	WM1		Melaleuca Park	
EPP173			Dampland 78	
Melaleuca Park				
Dampland 78²				
2019–20				
Loch McNess				
Lake Yonderup	MM53		Lake Mariginiup	
Lake Mariginiup	MM55B		Lake Nowergup	
Lake Nowergup	MM59B		Lexia 86	5 out of 8
Lake Wilgarup	PM9	14 out of 30	Lexia 186	
Pipidinny Swamp	WM1		Melaleuca Park	
Lexia 186	WM8		Dampland 78	
Melaleuca Park				
EPP173				
2020–21				
Loch McNess				
Lake Yonderup	MM53		Lake Joondalup	
Lake Mariginiup	MM55B		Lake Mariginiup	
Lake Jandabup	MM59B		Lake Nowergup	
Lake Nowergup	PM9	16 out of 30	Lexia 86	6 out of 8
Lake Wilgarup	WM1		Lexia 186	
Pipidinny Swamp	WM2		Melaleuca Park	
Lexia 186	WM8		Dampland 78	
Melaleuca Park				
EPP173				

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.

2 Melaleuca Park Dampland 78 was incorrectly reported as being non-compliant with absolute summer minimum water levels in 2018–19 due to a water level reporting error. The correct number of sites non-compliant with absolute minimum water level criteria in 2018–19 was 12 out of 30.

5 Environmental monitoring, management, research and consultation

5.1 Environmental monitoring

Expert environmental consultants undertake environmental monitoring of groundwater-dependent ecosystems for the department in line with the commitments in *Ministerial Statement no. 819: Gnangara Mound groundwater resources* (Government of Western Australia 2009). This long-term monitoring program provides a representative indication of changes in the overall health of the Gnangara system over time 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, carried out each spring in the reporting period, to continually improve our understanding of the relationship between water levels and ecological condition. The information is also used to manage public supply abstraction at priority locations, by reducing abstraction where monitoring indicates ecological condition.

The department is required to update the monitoring program every six years and submit it to the EPA. This is in line with commitment 6.3 in *Ministerial Statement no. 819: Gnangara Mound groundwater resources* (Government of Western Australia 2009). See Appendix D for the revised monitoring program.

Wetland vegetation

Over the triennial reporting period the condition of wetland vegetation was monitored in spring by Edith Cowan University at the sites listed in Table 5.

Table 5 Sites where wetland vegetation monitoring occurred over the 2018–21 triennial reporting period

	2018–19	2019–20	2020–21
Ministerial criteria sites	Loch McNess	Loch McNess	Loch McNess
	Lake Yonderup	Lake Yonderup	Lake Yonderup
	Lake Jandabup	Lake Wilgarup	Lake Nowergup
	Lake Nowergup	Lake Nowergup	Lake Jandabup
	Lake Mariginiup	Lake Goollelal	Lake Mariginiup
	Lexia 86	Lexia 86	Lexia 86
	Lexia 186	Lexia 186	Lexia 186
	Melaleuca Park EPP173	Melaleuca Park EPP173	Melaleuca Park EPP173
	Melaleuca Park	Melaleuca Park	Melaleuca Park
	Dampland 78	Dampland 78	Dampland 78
Other sites	Quin Brook	Quin Brook	Quin Brook Lake Gwelup
Reference	Buller et al. 2019	Buller et al. 2020	Buller et al. 2021

The increases in groundwater levels seen over the 2018–19 reporting period continued at some sites in 2019–20, including at Melaleuca Park Dampland 78, Lexia 86, Lexia 186 and Lake Nowergup. Only minor changes in tree health were recorded.

Below average rainfall in 2020–21 contributed to declines in water levels and minor declines in vegetation condition were recorded at most sites.

An intense fire in the Yanchep area in December 2019 resulted in a significant decline in canopy condition being recorded at Lake Yonderup and Loch McNess during the 2020–21 monitoring program. The fire also resulted in an increase in cover and abundance of exotic species, including potentially dominant/invasive terrestrial native species (Blake et al. 2021).

There are several wetlands at which long-term declines in groundwater levels have contributed to declines in health of overstorey species, and/or the disappearance or decline in condition and abundance of some key wetland species. Some of these sites have been identified as being at potential risk of, or have experienced a, threshold change in ecohydrological state. These wetlands include:

- Loch McNess – declines in groundwater levels since 2004 have contributed to the loss of the key wetland sedge, *Baumea articulata*, a decline in health of *Melaleuca raphiophylla* and, since 2017, a decline in abundance of *Lepidosperma longitudinale*, also a sedge species. The 2019 fire resulted in a large decline in tree health. *M. raphiophylla* individuals were severely affected with only a few trees still alive and all in poor health. *Eucalyptus rudis* was less severely impacted and some post-fire recruitment was evident at the time of monitoring in spring 2020. Exotic species richness and cover

abundance both increased, including species not previously recorded on the transect.

- Lake Yonderup – a fire in December 2019 resulted in the deaths of most *M. raphiophylla*, with only two mature trees remaining alive on the transect at the time of monitoring in spring 2020. *Eucalyptus gomocephala*, which had become the dominant understorey species, had a higher post-fire survival rate. There was evidence of post-fire recruitment of both *E. gomocephala* and *M. raphiophylla*. *Banksia littoralis* saplings that had previously recruited were absent from the transect in 2020.
- Lake Wilgarup – steady declines in water levels over many years, coupled with a severe fire in 2005–06, have resulted in a change to terrestrial species, although some mature *M. raphiophylla* are persisting.
- Lake Mariginiup – water level declines since 1997 have contributed to the poor health of wetland vegetation. The health of *E. rudis* has been in decline for much of the long-term monitoring period. The vegetation monitoring transect will be repositioned to capture where native wetland vegetation is still present. Groundwater modelling indicates that groundwater levels are likely to rise in the vicinity of Lake Mariginiup over the next decade as East Wanneroo is urbanised, which should offset some of the declines that have occurred in the past and lead to a positive impact on the health of wetland species.
- Lake Nowergup – water level declines have led to deaths of mature trees, including widespread mortality of *M. raphiophylla*. There has been a drastic loss of native species including the sedge *B. articulata* which is now absent from the transect. Lake Nowergup is artificially maintained year-round to prevent excessive drying of the wetland.
- Melaleuca Park EPP173 – groundwater declines since the mid-2000s have contributed to the wetland species *B. articulata* and *Pericalymma ellipticum* almost disappearing from the transect. Despite lower water levels in 2019–20 *B. articulata* was still present in very low abundances. Other tree species remain in good health.

Over the longer term, most monitored wetlands show declines in tree health and species similarity, and a general increase in the cover and abundance of exotic species.

Wetland macroinvertebrates and water quality

Over the reporting period macroinvertebrates and water quality were monitored in spring at the sites listed in Table 6.

Table 6 Sites where wetland macroinvertebrate and water quality monitoring occurred over the 2018–21 triennial reporting period

	2018–19	2019–20	2020–21
Ministerial criteria sites	Lake Goollelal	Lake Goollelal	Lake Goollelal
	Loch McNess	Loch McNess	Loch McNess
	Lake Yonderup	Lake Yonderup	Lake Yonderup
	Lake Joondalup	Lake Joondalup	Lake Joondalup
	Lake Mariginiup	Lake Mariginiup	Lake Mariginiup
	Lake Jandabup	Lake Jandabup	Lake Jandabup
	Lake Nowergup	Lake Nowergup	Lake Nowergup
	Melaleuca Park EPP173	Pipidinny Swamp	Pipidinny Swamp
		Lexia 86	Melaleuca Park EPP173
		Melaleuca Park EPP173	
	Lake Gngangara	Lake Gwelup	Lake Gwelup
		Lake Gngangara	Lake Gngangara
Reference	Judd and Horwitz 2019	Lette et al. 2020	Lette and Horwitz 2021

The surveys showed that low surface water levels continue to contribute to:

- risk of acidification at lakes Jandabup, Mariginiup and Gngangara (though acidity results improved at Lake Jandabup over the reporting period)
- high nutrient levels at Lake Jandabup, Lake Nowergup (despite supplementation of water levels), Lake Mariginiup, Lake Gngangara and Loch McNess
- 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 at lakes Yonderup, Nowergup, Jandabup and Gngangara
- localised extinction of the native fish *Galaxiella nigrostriata* from Melaleuca Park EPP173. Macroinvertebrate richness has also declined due to habitat loss resulting from lower water levels.

At Lake Goollelal and Lake Joondalup, where surface water levels have been higher (possibly as a result of continued urbanisation in the East Wanneroo catchment), pH levels increased in 2020–21. Combined with high Chlorophyll-a levels, this puts Lake Goollelal at risk of eutrophication.

The impacts of the 2019 Yanchep fire on wetland water chemistry during 2020–21 at Loch McNess and Lake Yonderup were also investigated as part of a specific study (see section 5.3) (Blake et al. 2021). The fire had significant impacts on wetland vegetation and resulted in carbon loss as well as structural changes to sediment

stratigraphy. Despite this the results of the study indicated there was no immediate concern of the fire causing longer-term acidification as the post-fire flush of generated acidity did not exceed the buffering capacity of the wetlands.

Mound spring macroinvertebrates and water quality

Five springs along the eastern edge of the Gngangara groundwater allocation plan area were monitored for aquatic macroinvertebrates and water quality during the reporting period: Egerton Spring, Edgecombe Spring, Gaston Road Spring, Sue's Spring and Barnard Spring (WRM 2019; WRM 2020; WRM 2021).

Increased peak groundwater levels contributed to surface water flow improving at all sites over the first two years of the reporting period. In 2020–21, discharge and surface water expression remained similar, despite rainfall being lower.

Water quality remained relatively stable across the reporting period. 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 during the reporting period using trapping and aural surveys of calling males (Bamford & Everard 2019; Bamford & Everard 2020; Bamford & Everard 2021). At some sites several species have stopped calling for an extended period, suggesting that these populations have died out. Disappearances from wetlands relate mostly to declining hydroperiods – periods of surface water presence, which can be related to declining groundwater levels. The disappearances are most marked at sites where falling groundwater has resulted in a significant reduction in surface water area and duration of wetting (e.g. Lexia 86 and Lexia 186). Annual variation in rainfall and surface water levels also impact on breeding success.

The monitoring suggests that current groundwater regimes at the monitored wetlands 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 Gngangara plan 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.

Terrestrial vegetation

In 2020–21 the health of phreatophytic vegetation was monitored at seven sites on the Gngangara Mound.

At all sites there has been a general long-term declining trend in groundwater levels, vegetation condition and abundance of both overstorey and understorey species since monitoring commenced (Mattiske 2021).

5.2 Management actions

In response to the changes described in section 5.1 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 were outlined in the 2009 *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.

New draft Gnangara groundwater allocation plan

In November 2021, the department released the *Gnangara groundwater allocation plan: draft for public comment* (DWER 2021). The draft plan proposes to reduce groundwater abstraction from the Gnangara groundwater system over the next decade. The reductions are needed to ensure that Perth's unique groundwater-dependent wetlands and bushlands are healthier and more resilient to climate change, and that the city's most important water source is secure and sustainable in the long term.

The draft plan proposes adjustments to most licensed water users' entitlements that will better align the amount of groundwater abstracted with rainfall recharge under climate change. The proposed reductions to abstraction will help protect our groundwater-dependent ecosystems, including important wetlands and bushland, from declining water levels.

The public comment period on the draft plan closes on 28 February 2022 and the final plan is due to be released in the months following.

Managing public water supply use

Every year the department reviews the distribution of Water Corporation's entitlements and wherever possible moves abstraction away from bores in the environmentally sensitive areas of the Superficial aquifer and from bores in the deeper Leederville and Yarragadee aquifers where they are connected to the Superficial aquifer. This is done to reduce the impact of Water Corporation's abstraction as much as possible on Ministerial sites where water levels are non-compliant or are at risk of becoming non-compliant with water level criteria.

Groundwater Replenishment Scheme

Recycling of Perth's wastewater will become a bigger part of the total water supply mix to meet increasing water demands without negative impacts to groundwater levels. Stages 1 and 2 of the Groundwater Replenishment Scheme at Beenyup, with a combined capacity of 28 GL have been commissioned, with Stage 2 due to reach full operation in 2022.

Water injected through Stage 2 of the groundwater replenishment scheme will provide broader benefits to the groundwater system including to connected wetlands in the northern half of the Gngangara plan area. The locations of the injection bores constructed as part of Stage 2 were informed by a study completed by the department into the sustainable use of Perth's deep aquifers.

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.

The departments conducts compliance monitoring events across licences taking water from the Gngangara groundwater system. They assess for incidents of suspected non-compliance, particularly those relating to alleged exceedance of annual water entitlements. The department's response to any alleged non-compliances ranges 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*.

The department also manages groundwater used by private licensees in other ways, by continuing to work with:

- Local governments, urban developers, schools, golf clubs and other licensees that use large volumes, to improve water use efficiency, reduce demand for groundwater and assess water needs and alternative water 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. During this reporting period 14 of the 16 urban local councils across Gngangara are endorsed as 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

The use of domestic garden bores is managed under the provisions of the *Water Agencies (Water Use) By-Laws 2010*. These specify permanent sprinkler restrictions that apply to Area 3 Perth/Mandurah, covering most of the Gngangara groundwater allocation plan area.

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

- A total winter sprinkler switch off between 1 June and 31 August each year (unless delayed by the Minister due to low rainfall).

- Sprinkler use is limited to once a day on three rostered days a week between 1 September and 31 May each year.
- Daytime sprinkler ban between the hours of 9am and 6pm.

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

As part of new measures to rebalance Perth's groundwater systems, changes have been proposed to align the domestic garden bore sprinkler roster with the two-day-a-week scheme water roster, commencing 1 September 2022. This proposal is open for public comment until 28 February 2022.

Although garden bores were once promoted as a good way to reduce the need for new scheme water supplies, the effects of climate change mean that it is now necessary to use garden bores more carefully than before and that the overall amount of groundwater used to water gardens should be reduced. Reducing this use of groundwater will help slow and reverse declining groundwater levels, reducing the risk of bores going dry, the death of street trees and the salinisation or acidification of groundwater in vulnerable locations.

Various estimates of residential water use over the last decade, when comparing similar-sized properties, have consistently found that on average households with a garden bore use 3 to 4 times more water on lawns and gardens than households using scheme water. In part, this is a consequence of the extra watering day that garden bore users have under the current sprinkler restrictions.

Be Groundwater Wise website

Since 2019 we have collaborated with the Water Corporation to educate the community about the importance of groundwater, and that it is a limited and shared resource that needs to be used wisely. In 2019, the department and the Water Corporation developed the Be Groundwater Wise website. The website hosted information about garden bore management and maintenance, links to waterwise information, and education videos featuring ambassador, Josh Byrne. In December 2020, the department expanded the Be Groundwater Wise website to consolidate garden bore information across multiple sites into one. The expanded Be Groundwater Wise website provides one location for garden bore and waterwise advice, making it more accessible and easier to find: begroundwaterwise.wa.gov.au

Under the Be Groundwater Wise initiative, in spring 2019 and autumn 2021, the department ran digital campaigns to educate garden bore owners on the importance of groundwater and how to use it wisely – knowing how to have a water-efficient bore and irrigation system and a waterwise garden. Groundwater messages were included in Water Corporation's *Water for Life* media campaign in 2019 and *Think Climate Change Be Waterwise* campaign in 2020.

Waterwise Perth Action Plan

The *Waterwise Perth Action Plan* was released in October 2019 to help transition Perth to a leading waterwise city (Government of Western Australia 2019). The 2019 Action Plan is a two-year plan in a ten-year program that aims to achieve responsible and sustainable use of water from all sources, including groundwater, and well-designed private and public green spaces to make the most of Perth's limited water resources. To deliver the plan the department has worked, and continues to work, with local government, industry and the broader community to fulfil (amongst others) the following Action Plan commitments:

- reduce Perth groundwater use by 10 per cent by 2030
- manage groundwater levels to sustain wetlands and urban trees, and reducing irrigation of green spaces
- extend and enhance the Waterwise Council and Waterwise Golf Course programs
- assist schools, universities and other institutions to reduce groundwater use through the Waterwise Grounds program.

5.3 Research initiatives

The department, together with research partners, has completed several major projects that assist with planning for a drier future and focus management effort on the areas that will deliver the most benefit from changes to abstraction. Recent research initiatives have been outlined in previous reports and the department has used the results of this work to support the development of the *Gnangara groundwater allocation plan: draft for public comment* (DWER 2021).

Impacts of fire on wetland acidity

An opportunistic study was undertaken in 2020 at Loch McNess and Lake Yonderup (Blake et al. 2021). It assessed the post-fire effects of burnt wetland sediments on water quality, particularly fire-induced acidification, following a bushfire in December 2019. The study monitored water quality in and around the lakes using shallow piezometers that were placed into burnt sediments. The study found that the most severe post-fire water quality response was observed with the first hydration of wetland sediments in winter and would subside in spring as sediments were inundated. Importantly, the study found that the generated acidity did not exceed the buffering capacity of the wetlands. The study recommended that maintaining the long-term natural groundwater regime of the wetlands was the best strategy for preventing wetland sediment fires and their associated impacts.

5.4 Consultation

There has been extensive stakeholder consultation over the reporting period in the continuing development of the *Gnangara groundwater allocation plan: draft for public*

comment (DWER 2021). The department 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, prepare for a future with less groundwater availability and help build climate resilient organisations and businesses. From 2016, the department held well over 100 stakeholder meetings and workshops across all water use sectors to inform the development of the draft plan.

Appendices

Appendix A – Water level monitoring results for Ministerial sites for the Gnangara Mound Groundwater Resources for 2012-2021

Bold text refers to compliance with water level 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)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
Lake Goollelal	6162517			26.2*	26.0	Max	27.2	27.3	27.2	27.1	27.3	27.3	27.2	27.5	27.3	<u>Compliance:</u> Compliant with absolute summer minimum and other criteria. Water levels at lake Goollelal have never been non-compliant with absolute summer minimum water level criterion and groundwater modelling projects that the ongoing urbanisation of East Wanneroo is likely to lead to further increases in the surface water levels of Lake Goollelal.
						Min	26.5	26.5	26.6	26.4	26.8	26.9	26.9	26.7	26.7	
Loch McNess	6162564				6.95	Max	6.40	6.39	6.25	6.25	6.25	6.25	6.25	6.02	6.03	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. The lake has been non-compliant since 2002–03 and lake levels have fallen rapidly since 2006 with some stabilisation evident in recent years. The original staff gauge at the lake is no longer inundated and a new staff gauge was installed in a deeper part of the wetland in 2019. Water levels are now measured from the new staff gauge. Water levels increased by around 10cm in the month following the December 2019 fires but quickly returned to the normal summer pattern and fell again in February 2020. <u>Ecological condition:</u> Long-term monitoring has shown declines in the health of <i>Melaleuca raphiophylla</i> ; 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 <i>Baumea articulata</i> at the monitoring transect and the degradation and loss of aquatic habitat for macroinvertebrates. <u>Management and mitigation:</u> 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 peak levels declined over the 2018-2020 period but the 2021 peak level was similar to 2018. Detailed findings and recommendations from the shallow groundwater systems investigation of Loch McNess can be found in the published report (DoW 2011a). The department completed a further 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: <ul style="list-style-type: none">reduced Superficial aquifer abstraction in the Yanchep National Parkceased the Yanchep caves supplementation trialreduced public supply abstraction from the Leederville Aquifer in the Pinjar borefield. The impacts of a fire over the reporting period on water quality was investigated (see Section 5.3 (Blake et al. 2021) and it was found that: <ul style="list-style-type: none">the most severe post-fire water quality response was observed with the first hydration of wetland sediments in winter and subsided in spring as sediments were inundatedthe generated acidity did not exceed the buffering capacity of the wetland.
						Min	6.10	6.25	6.25	6.07	6.25	6.25	6.25	5.89	5.94	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
Lake Yonderup	6162565				5.9	Max	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. The lake has been non-compliant since 2007–08. Levels declined since the start of monitoring in 2002 to 2014 but peak levels have been relatively stable in recent years. Peak levels were the lowest on record in 2019 but recovered in 2020 and 2021. Water levels increased by approximately 10cm in January 2020 in response to the fire in December 2019 but then fell again in February. <u>Ecological condition:</u> Water level declines have contributed to reduced condition of <i>Melaleuca rhaphiophylla</i> and recent deaths of mature trees. They are also contributing to the degradation and loss of aquatic habitat for macroinvertebrates. <u>Management and mitigation:</u> 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. The impacts of a fire over the in the 2019–20 reporting period on water quality was investigated (see Section 5.3) (Blake et al. 2021) and found that: <ul style="list-style-type: none">the most severe post-fire water quality response was observed with the first hydration of wetland sediments in winter and would subside in spring as sediments were inundatedthe generated acidity did not exceed the buffering capacity of the wetland
						Min	5.6	5.6	5.6	5.5	5.6	5.5	5.5	5.6	5.5	
Lake Joondalup	6162572 (Staff 8281)			16.2*	15.8	Max	16.8	17.1	17.0	16.9	17.1	17.3	17.6	17.5	17.4	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Compliant with other criterion. Levels have been above the preferred minimum since 2016–17 and have risen in recent years. Groundwater modelling projects that water levels at Lake Joondalup are likely to rise further as result of the ongoing urbanisation of East Wanneroo. High water levels may be having an impact on the health of fringing <i>Melaleuca rhaphiophylla</i> adjacent to the lake. This will be assessed during the next round of ecological monitoring and reported on in the 2021–22 compliance report.
	Min					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	16.8 4/6 yr	16.7	16.7		
	Max					18.6	19.0	18.9	18.7	19.0	19.2	19.4	19.4	19.2		
	Min					18.0	18.2	18.3	18.1	18.5	18.6	18.7	18.6	18.6		

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
Lake Mariginiup	6162577 (Staff 1943)	42.1*	41.5			Max	41.1	41.3	41.3	41.1	41.4	41.5	41.6	41.4	41.3	<p><u>Compliance and trends:</u> Non-compliant with absolute minimum spring peak criterion. Peak levels decreased over the reporting period and were non-compliant with the absolute spring peak criterion. Non-compliant with other criterion. Water levels have not reached the preferred spring peak since 1994.</p> <p><u>Ecological condition:</u> Groundwater declines have contributed to the lake being one of the poorest sites in terms of vegetation health.</p> <p><u>Management and mitigation:</u> Work completed as part of the Perth shallow groundwater systems investigation found that:</p> <ul style="list-style-type: none">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 mAHDthe newly installed bore MGP_C (AWRC ref. 61611440) should be used to relate changes in the watertable to wetland vegetation condition. <p>Detailed findings and recommendations from the investigation can be found in Searle et al. (2010a).</p> <p>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 declined marginally over the reporting period.</p> <p>Groundwater modelling projects that water levels at Lake Mariginiup are likely to rise in the future due to increasing urbanisation of the East Wanneroo area and a corresponding decrease in groundwater abstraction from agricultural land uses.</p>
	Min					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	41.0 4/6 yr	41.0 4/6 yr	41.0 4/6 yr	
	61610685 (Bore MS10)					Max	40.8	41.0	41.2	40.8	41.1	41.1	41.2	41.1	40.9	
	Min					40.1	40.1	40.2	40.0	40.4	40.4	40.3	40.2	40.2		
Lake Jandabup	6162578 (Staff 1944)	44.7*	44.2		44.3	Max	44.6	44.7	44.7	44.6	44.7	44.8	45.0	44.8	44.6	<p><u>Compliance and trends:</u> Compliant with absolute spring peak criterion. Compliant with absolute summer minimum criterion. In 2020–21 water levels recorded were below the absolute minimum criterion before being rounded to one decimal place. In 2018–19 and 2019–20 minimum water levels recorded were above the absolute minimum criterion before being rounded to one decimal place.</p> <p>Water Corporation supplements lake levels to meet the absolute spring peak water level criterion and to prevent the lakebed from drying and oxidising, causing acidification upon rewetting. Recently, levels have been relatively stable, and the supplementation has been successful in preventing the lake from acidifying.</p> <p><u>Ecological condition:</u> 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 due to excessive drying of the lakebed is high if water levels decline. However, groundwater modelling projects that water levels at Lake Jandabup are likely to rise in the future due to increasing urbanisation of the East Wanneroo area and a corresponding decrease in groundwater abstraction from agricultural land uses. This should reduce the need for artificial supplementation of the lake.</p> <p><u>Management and mitigation:</u> Work completed as part of the Perth shallow groundwater systems investigation found that bore JB12B (AWRC ref. 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.</p>
						Min	44.1	44.2	44.2	44.1	44.3	44.2	44.3 .0+20	44.3	# 44.3	

[illegible]

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
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	<p><u>Compliance and trends:</u> 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. <u>Ecological condition</u> Vegetation composition at Lake Wilgarup has shifted from one dominated by wetland species such as <i>Baumea articulata</i> to a terrestrial community dominated by <i>Eucalyptus gomocephala</i>. Bushfire events have also led to the significant loss of peat from the wetland. <u>Management and mitigation:</u> Given the location of Lake Wilgarup just to the east of Loch McNess, the department's management actions to improve water levels at Loch McNess also aim to benefit groundwater levels at Lake Wilgarup. However, groundwater modelling results indicate that any improvement in groundwater levels will not be sufficient to produce surface water at Lake Wilgarup and therefore the vegetation is likely to remain dominated by terrestrial species. A lowering of the summer minimum criterion to 3.2 mAHD measured at the bore at Lake Wilgarup is proposed in the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i>.</p>
	Min															
	61618500 (Bore)					Max	4.31	4.41	4.29	4.21	4.34	4.29	3.64	3.43	3.32	
						Min	3.83	3.82	3.79	3.66	3.88	3.75	2.99	2.86	2.83	
Pipidinny Swamp	6162624 (Staff)	2.70	2.40		1.6	Max	1.8	2.2	1.9	1.6	2.0	2.0	2.2	1.4	0.9	<p><u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Levels at the swamp have been non-compliant since 2009–10. Non-compliant with absolute spring peak criterion. Spring peak levels have been non-compliant since 2005–06. <u>Management and mitigation:</u> A new bore – PIP_C (AWRC ref. 61611872) – 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. A lowering of the summer minimum criterion to 1.1 mAHD to be measured at the bore PIP_C is proposed in the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i>.</p>
						Min	1.0	1.0	1.0	1.0	1.0	1.0	1.0	<0.7	<0.7	
Lexia 86 (GNM16)	61613215			47.3*	47.0	Max	47.6	47.8	47.7	47.3	47.7	47.9	48.2	48.2	47.8	<p><u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. 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. <u>Ecological condition:</u> 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. <u>Management and mitigation:</u> 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.</p>
						Min	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	47.3 4/6 yr	47.2 4/6 yr	47.1 4/6 yr	

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
Lexia 186 (GNM15)	61613214			47.5*	47.2	Max	46.9	47.2	47.1	46.7	47.0	47.3	47.5	47.6	47.3	<u>Compliance and trends:</u> 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. Water levels have shown a general rising trend since 2015–16. Non-compliant with other criterion. Minimum water levels have not been above the preferred summer minimum criteria since 1995. <u>Ecological condition:</u> 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. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. A lowering of the summer minimum criterion to 46.5 mAHD measured at the bore at Lexia 186 is proposed in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
		Min	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	46.8 4/6 yr	46.8 4/6 yr	46.7 4/6 yr			
Melaleuca Park EPP173	6162628 (Staff)				50.2	Max	50.6	50.9	50.7	50.4	50.8	51.0	51.1	50.8	50.6	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Water levels have been non-compliant with absolute summer minimum criterion since 1995. The spring peak in 2020–21 was the lowest recorded since 2015–16, which was the lowest peak on record. <u>Ecological condition:</u> Groundwater declines since the mid-2000s have contributed to the wetland species <i>Baumea articulata</i> and <i>Pericalymma ellipticum</i> almost disappearing from the transect. Despite lower water levels in 2019–20 <i>B. articulata</i> was still present in very low abundances. Other tree species remain in good health. Declines have also contributed to the degradation and loss of aquatic habitat for macroinvertebrates and a decline in macroinvertebrate richness. The native fish <i>Galaxiella nigrostriata</i> has also become locally extinct. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. A lowering of the summer minimum criterion to 48.5 mAHD measured at the bore GNM14 is proposed in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
	Min	50.4	50.4			50.4	50.4	50.4	50.4	50.4	50.7	50.4				
	61613213 (Bore GNM14)	Max	49.7			50.3	50.1	49.3	50.2	50.3	50.8	50.1	49.8			
		Min	48.7			48.8	48.7	48.5	49.0	48.8	48.7	48.7	48.6			

Wetland	AWRC reference number	Water level criteria (mAHD)				Water level (mAHD)										Status and comments on compliance during the triennial reporting period
		Spring peak		End of summer minimum												
		Pref	Abs	Pref	Abs		2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
Melaleuca Park Dampland 78 (GNM31)	61613231			65.4*	65.1	Max	65.2	65.3	65.2	64.9	65.1	65.2	65.4	65.5	65.4	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Non-compliant with other criterion. Minimum water levels have not been above the preferred summer minimum criteria since 2013–14. This site was incorrectly reported as non-compliant in 2018–19 (64.8mAHD) due to a reporting measurement error. <u>Ecological condition:</u> Long-term monitoring has shown reduced frog numbers, declines in tree health, changes in species composition to more terrestrial species and increases in abundance of exotic species. <u>Management and mitigation:</u> A cluster of bores were installed adjacent to GNM31 as part of the Perth shallow groundwater systems investigation (Searle 2009). A lowering of the summer minimum criterion to 64.7 mAHD measured at the bore GNM31 is proposed in the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i>
		Min	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	65.2 4/6 yr	65.2 4/6 yr	65.1 4/6 yr			
Egerton Spring (B25)/ Egerton Spring (B25A)	61618607/ 61672233				39.29	Max	40.04	40.17	40.12	39.97	40.10	40.20	40.26	40.15	40.07	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels have been compliant since 2003 and since then there has been a rising trend in response to increased localised recharge associated with the surrounding urban development. <u>Additional information:</u> The department was unable to continue monitoring at bore B25 due to access and OSH issues. The department now uses B25A (AWRC ref. 61672233), located nearby, to measure water level criteria.
		Min	39.69	39.73		39.79	39.58	39.84	39.84	39.76	39.71	39.77				

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

Table A 2 Terrestrial phreatophytic vegetation sites

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)										Status and comments on compliance during the reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
MM16	61610835	38.8	Max	39.6	40.1	40.2	40.1	40.3	40.7	41.1	41.0	40.7	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels have shown a general rising trend since 2011.
			Min	39.0	39.2	39.5	39.3	39.5	39.8	40.0	40.0	40.0	
MM18	61610918	38.6	Max	39.6	39.9	40.0	39.6	40.0	40.2	40.6	40.6	40.2	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels have shown a general rising trend since 2011.
			Min	39.0	38.6	39.2	39.1	39.2	39.4	39.6	39.6	39.5	
MM53	61610493	33.3	Max	33.6	34.0	34.0	33.5	33.7	34.0	34.3	34.1	33.7	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. In 2018–19 minimum water levels recorded were below the absolute minimum criterion before being rounded to one decimal place. Minimum water levels have been stable in recent years. <u>Management and mitigation:</u> 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	33.0	32.8	33.1	32.9	33.1	33.1	33.3	33.2	33.1	
MM55B	61610559	29.5	Max	30.3	30.5	30.5	30.3	30.4	30.6	30.8	30.7	30.2	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Water levels showed a general rising trend between 2011 and 2018 but fell slightly over the reporting period. The site has been non-compliant with absolute summer minimum water level criteria in all years, except 2014–15. In 2017–18 and 2018–19 minimum water levels recorded were below the absolute minimum criterion before being rounded to one decimal place.
			Min	29.2	29.2	29.7	29.2	29.4	29.5	29.5	29.3	29.3	
MM59B	61611025	36.3	Max	36.2	36.3	36.3	36.0	36.1	36.4	36.7	36.5	36.0	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Minimum water levels have been stable in recent years. <u>Management and mitigation:</u> 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. A lowering of the summer minimum criterion to 36.2 m AHD is proposed in the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i>
			Min	35.5	35.5	35.6	35.4	35.5	35.6	35.8	35.6	35.5	
MT3S	61610745	43.0	Max	44.2	44.6	44.5	44.3	44.6	44.9	45.0	44.8	44.5	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. After a long declining trend between 1980 and 2010, groundwater levels increased between 2011 and 2018, but fell again slightly over the reporting period.
			Min	43.5	43.7	43.7	43.6	44.0	44.1	44.0	44.0	43.9	
NR6C	61610982	58.5	Max	59.3	59.7	59.5	59.1	59.5	60.0	59.9	59.7	59.5	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels declined over the 1990s to 2015 and in 2015–16 were the lowest on record. Minimum water levels have since increased slightly since then and were stable over the reporting period, until a slight drop in 2021.
			Min	58.7	58.9	59.0	58.7	58.8	59.0	59.0	59.0	58.8	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)										Status and comments on compliance during the reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
PM9	61610804	56.3	Max	54.8	55.0	54.7							<u>Compliance and trends:</u> 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. Water levels at the site are now greater than 10.5 m depth to groundwater, and it is unlikely vegetation in the vicinity is accessing groundwater. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. The department is proposing a removal of the water level criteria at PM9 in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
			Min	54.4	54.3	54.1	51.8						
PM24	61610697	40.5	Max	42.0	42.1	42.3	42.1	42.2	41.6	42.5	42.2	42.0	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels have been stable since 2011.
			Min	41.1	41.1	41.3	41.0	41.4	41.0	41.1	41.0	40.9	
WM1	61610833	55.7	Max	54.4	54.7	54.4	54.5	55.1	55.6	55.9	55.6	55.2	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Water levels have been showing a rising trend in recent years and in 2018–19 and 2019–20 the site recorded its highest minimum water level since 2008–09. Water levels declined again in 2020–21 in response to the reduced rainfall and lower groundwater levels. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. A lowering of the summer minimum criterion to 53.7 mAHD is proposed in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
			Min	54.1	54.2	54.1	54.1	54.3	54.7	54.9	54.9	54.6	
WM2	61610908	66.5	Max	66.4	66.7	66.5	66.6	67.2	67.3	67.5	67.0	66.6	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. Minimum water levels recorded were above the absolute minimum criterion before being rounded to one decimal place. In 2017–18 this site was compliant for the first time since 2010–11. Until 2020–21 water levels were showing a general rising trend. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. A lowering of the summer minimum criterion to 64.7 mAHD is proposed in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
			Min	66.1	66.2	66.1	66.3	66.4	66.7	66.7	66.5	66.2	
WM8	61610983	64.8	Max	64.7	65.0	64.8	64.3	64.7	65.2	65.6	65.5	64.7	<u>Compliance and trends:</u> Non-compliant with absolute summer minimum criterion. In 2019–20 the site was non-compliant for the first time since 2016–17. In 2017–18 this site was compliant for the first time since 2009–10. Until 2020–21 water levels have shown a general rising trend. <u>Management and mitigation:</u> The department has worked with Water Corporation to reduce groundwater abstraction from the Superficial aquifer in borefields located close to the crest of the Gngangara 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. A lowering of the summer minimum criterion to 63.7 mAHD is proposed in the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021), and this will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
			Min	64.4	64.7	64.3	64.1	64.1	64.9	65.0	64.7	64.4	

Groundwater monitoring bore	AWRC reference number	End of summer absolute minimum (mAHD)	Water levels (mAHD)										Status and comments on compliance during the reporting period
				2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	
MM12	61610989	42	Max	43	43	43	43	43	43	44	44	43	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels have shown a general rising trend since 2007.
			Min	43	43	43	43	43	43	43	43	43	
L30C	61611010	47.2	Max	47.8	47.9	48.0	47.7	47.9	48.1	48.6	48.9	48.2	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Water levels generally fell from 2005 to 2016 and were showing a general rising trend until 2020–21.
			Min	47.5	47.5	47.7	47.3	47.3	47.6	48.0	48.0	47.8	
L110C	61611011	55.7	Max		57.4	57.6	57.4	57.6	57.8	57.9	57.7	57.3	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Minimum levels could not be measured at the Ministerial criteria bore between March 2010 and July 2013 because of a blockage.
			Min		57.1	57.3	57.1	57.1	57.3	57.3	57.2	57.0	
L220C	61611018	52.2	Max	52.8	53.1	53.9	53.4	53.8	54.1	54.4	54.3	54.1	<u>Compliance and trends:</u> Compliant with absolute summer minimum criterion. Levels have generally fallen since 1991 and the 2015–16 levels were the lowest on record. Water levels rose again in 2017 and have been stable since then.
			Min	52.1	52.3	53.1	52.8	53.1	53.2	53.3	53.3	53.2	

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 Gnambarra groundwater resources

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

Period: 1 July 2018 to 30 June 2021

Table B 1 Ministerial conditions and procedures

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
819: M 1-1	Implementation	The proponent shall implement the proposals as documented in "Section 46 Review of Environmental Conditions on Management of the Gnambarra 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 <i>Ministerial Statement no. 819</i> .	Compliance report	Minister for the Environment		Overall		Non-compliant Strategies have been implemented to reduce impacts on environmentally important sites. These are outlined in the <i>Gnambarra groundwater allocation plan</i> (2009) and include: <ul style="list-style-type: none">significantly reducing abstraction for public water supplyincreasing licence compliance and enforcement activitiescapping abstraction for private licensed water supply Further amendments have been proposed in the <i>Gnambarra groundwater allocation plan: draft for public comment</i> (DWER 2021) and will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> . Compliance monitoring and reporting results have been used to support the development of the draft plan. The plan includes new strategies to return the system to balance and reduce groundwater use in line with climate change. The draft plan supports one of the targets of the government's 2019 <i>Waterwise Perth Action Plan</i> (Government of Western Australia 2019), which is a 10 per cent reduction in groundwater use across Perth and Peel by 2030.
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 <i>Ministerial Statement no. 819</i> , 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 <i>Ministerial Statement no. 819</i> .	Compliance report	Minister for the Environment	EPA	Overall		Non-compliant Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnambarra Mound. A number of sites were non-compliant with the absolute minimum and/or peak water level criteria identified in Schedule 1 of <i>Ministerial Statement no. 819</i> . 12 sites were non-compliant in 2018–19, 14 sites in 2019–20 and 16 sites in 2020–21.
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 <i>Environmental Protection Act 1986</i> 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 <i>Ministerial Statement no. 819</i> . 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		Not required at this time No change to proponent was made over the 2018–21 triennial reporting period.
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		Not required at this time No change to proponent was made over the 2018–21 triennial reporting period.

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
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	Not required at this time No change to proponent was made over the 2018–21 triennial reporting period.
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: <ul style="list-style-type: none"> evidence of compliance with the conditions and commitments. 	Detail in annual/triennial reports. Compliance report will include: <ul style="list-style-type: none"> evidence of compliance with the conditions and commitments. 	Audit program	CEO		Overall	Annually	Compliant. Performance and compliance with water level criteria, management activities and research initiatives are 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: <ul style="list-style-type: none"> the performance of the environmental management plans and programs. 	Detail in annual/triennial reports. Compliance report will include: <ul style="list-style-type: none"> the performance of the environmental management plans and programs. 	Compliance report	CEO			Annually	Compliant. Environmental management plans and programs are ongoing and include the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021). It includes strategies to work towards meeting the following objectives: <ul style="list-style-type: none"> reducing the total volume of water abstracted from the Gnangara groundwater system towards a level that better reflects the recharge from rainfall due to climate change. protecting groundwater-dependent ecosystems from impacts associated with abstraction. It also proposes some changes to Ministerial conditions in Statement No. 819, which will be assessed by the Environmental Protection Authority under section 46 of the <i>Environmental Protection Act 1986</i> .
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: <ul style="list-style-type: none"> compliance with the conditions. 	The performance review will address: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> the achievement of environmental objectives set for the proposal. 	The performance review will address: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER, 2021) was released for public comment in November 2021. A summary of consultation that has occurred to date as part of its development is contained within this report. The previous <i>Gnangara groundwater areas allocation plan</i> was released in November 2009. The accompanying <i>Gnangara groundwater areas allocation plan: statement of response</i> (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 2013a; DoW 2015). 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.

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
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: <ul style="list-style-type: none"> proposed environmental management over the next three years to comply with conditions and environmental objectives set for the proposal. 	The performance review will address: <ul style="list-style-type: none"> 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. The department submits annual and triennial compliance reports that are performance review reports on compliance with water level criteria, management activities and research initiatives. The department has implemented a number of management actions and research initiatives such as upgrading the PRAMS model and completing the Perth Regional Confined Aquifer Capacity (PRCAC) project to help understand and 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 website.	Reports made available on the Department of Water's website.	CEO		Overall	After EPA acknowledgment letter being received. Department of Water and Environmental Regulation website.	Compliant. Gnangara annual and triennial compliance reports are available on the department's website.
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 water level 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 help calculate allocation limits for the new <i>Gnangara groundwater allocation plan</i> (DWER 2021). The department recognises that sustainable yield has diminished because recharge has decreased since the 2009 plan was released and has reassessed future allocation of Gnangara resources as part of the development of the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021).
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 EPA 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 <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021) was released or public comment in November 2021. Until the new plan is finalised, the 2009 <i>Gnangara groundwater areas allocation plan</i> (DoW 2009) provides the foundation for water allocation decisions on the Gnangara Mound. We have issued two evaluation statements for the 2009 plan (DoW 2013a; DoW 2015). 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. Gnangara annual and triennial compliance reports are also available on the department's website.

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
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		<p>Non-compliant.</p> <p>The addition of the Perth and Southern desalination plants, and the Groundwater Replenishment scheme to the Integrated Water Supply Scheme has reduced the pressure on the Gnamptarra groundwater system for public water supply. From 2012–13 Water Corporation’s baseline groundwater allocation from Gnamptarra and Jandakot for the Integrated Water Supply Scheme has been reduced from 145 GL to 120 GL per year (from existing infrastructure).</p> <p>The department recognises that it remains non-compliant with approximately half of the environmental water provision criteria for the Gnamptarra 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.</p> <p>The <i>Gnamptarra groundwater allocation plan: draft for public comment</i> (DWER 2021) outlines proposals for further reductions in licensed groundwater entitlements along with other strategies to help bring Gnamptarra groundwater resources back into balance.</p>
819: M 7-1	Groundwater-dependent ecosystems	The proponent shall ensure that the integrity of all groundwater-dependent ecosystems (GDE) located on the Gnamptarra 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 <i>Ministerial Statement no. 819</i> . Undertake a monitoring program to measure integrity of GDEs.	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		<p>Non-compliant.</p> <p>Section 6.1 and Appendix C describe the department’s environmental monitoring program (in line with the commitments in <i>Ministerial Statement no. 819</i>). The department undertakes management and research initiatives to limit impacts of abstraction on groundwater-dependent ecosystems.</p>
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 Gnamptarra Mound.	Detail limits on availability on the (now Department of Water and Environmental Regulation) website.	Allocation limits made available on the (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	<p>Compliant.</p> <p>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></p>
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 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	<p>Compliant.</p> <p>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></p>

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
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		<p>Compliant.</p> <p>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.</p> <p>A cross-agency <i>Waterwise Perth Action Plan</i> (Government of Western Australia 2019) has been initiated to help transition Perth to become a leading water wise city. The plan advocates responsible and sustainable use of water from all sources, including groundwater, and sets a target of a 10 per cent reduction in groundwater use across Perth and Peel by 2030.</p> <p>The Waterwise Council Program, a partnership between the Department of Water and Environmental Regulation 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.</p> <p>Under the Be Groundwater Wise initiative, in spring 2019 and autumn 2021, the department ran digital campaigns to educate garden bore owners on the importance of groundwater and how to use it wisely – knowing how to have a water-efficient bore and irrigation system and a waterwise garden.</p>
819: M 10-1 1	Research and monitoring	<p>The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:</p> <ul style="list-style-type: none"> 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). 	<p>Engage in research projects to address this issue, which includes:</p> <ul style="list-style-type: none"> 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		<p>Compliant.</p> <p>The department used Perth Regional Aquifer Modelling System (PRAMS) modelling to examine the relationship between rainfall and groundwater levels as climate changes as part of our review of future allocation for the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021). The PRAMS model is currently undergoing another version update.</p>
819: M 10-1 2	Research and monitoring	<p>The proponent shall participate in and undertake research and monitoring on the Gnangara Mound which includes:</p> <ul style="list-style-type: none"> 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). 	<p>Engage in research projects to address this issue, which includes:</p> <ul style="list-style-type: none"> improvement in the understanding of the relationship between groundwater levels and vegetation, including plantations. 	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		<p>Compliant</p> <p>As part of the development of the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), the department used PRAMS modelling to simulate groundwater levels under various pines, land use and climate scenarios.</p> <p>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.</p> <p>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 the 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 draft plan.</p>

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/ Where	Status and further information for the 2018–21 triennial reporting period
819: M 10-1 3	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnamara Mound which includes: <ul style="list-style-type: none"> improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnamara 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: <ul style="list-style-type: none"> improvement in the understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnamara Mound. 	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		<p>Compliant</p> <p>The department is using PRAMS modelling to improve understanding of the relationship between groundwater level and abstraction from unconfined and confined aquifers of the Gnamara system.</p> <p>The Perth Regional Confined Aquifer Capacity (PRCAC) 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.</p> <p>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.</p>
819: M 10-1 4	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnamara Mound which includes: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> clarification of the relationship between groundwater level and wetland water levels and wetland water quality. 	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		<p>Compliant</p> <p>The department has studied hydrogeology at a number of sites across the Gnamara 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.</p>
819: M 10-1 5	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnamara Mound which includes: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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		<p>Compliant</p> <p>Water quality and macroinvertebrate monitoring in the Yanchep caves ceased in 2013–14 because of low water levels and cave safety issues. Water loggers have been installed in some caves to monitor water levels. As water levels in caves reflect the surrounding groundwater levels the department uses nearby monitoring bores to monitor caves water levels. The department has a good understanding of the relationship between groundwater levels and cave water levels.</p> <p>Building on the work of the shallow groundwater system investigation, the department recently completed a study on the cause of rapidly declining levels at 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.</p>
819: M 10-1 6	Research and monitoring	The proponent shall participate in and undertake research and monitoring on the Gnamara Mound which includes: <ul style="list-style-type: none"> improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnamara 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: <ul style="list-style-type: none"> improvement in understanding of the conservation value of wetland and other groundwater-dependent ecosystems on the Gnamara Mound. 	Compliance report	Minister for the Environment	EPA/ DBCA	Overall		<p>Compliant</p> <p>The conservation value of wetlands is a prime responsibility of the Department of Biodiversity, Conservation and Attractions (DBCA, 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.</p>

Audit code	Subject	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
819: M Procedure 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		Non-compliant Not the responsibility of the Proponent (Department of Water and Environmental Regulation).
819: M Procedure 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		Non-compliant Not the responsibility of the Proponent (Department of Water and Environmental Regulation).
819: M Procedure 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: <ul style="list-style-type: none"> 2,4,6,8,21 = DBCA (formerly DEC) 21 = FPC. Both the FPC and the then DEC made public submissions to the <i>Gnangara groundwater areas water management plan: draft for public comment</i> (DoW 2008a), which dealt with similar issues as the conditions. The Department is working directly with these two advisory bodies on future management of the Gnangara, Pinjar and Yanchep pine plantations given the multiple objectives of the area – pine harvesting, Carnaby’s Cockatoo conservation and groundwater recharge.

Table B 2 The proponent's (Department of Water, now Department of Water and Environmental Regulation) environmental management conditions

Audit code	Subject	Objective	Action	How	Evidence	Requirement of	On advice from	Phase	When/ Where	Status and further information for the 2018–21 triennial reporting period
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 (<i>Ministerial Statement no. 819</i>).	Meet objectives and EWPs criteria presented in tables 1 and 2 (<i>Ministerial Statement no. 819</i>).	Compliance report	Minister for the Environment		Overall		Non-compliant Refer to the results given in Appendix A – water level monitoring results for Ministerial sites on the Gnangara Mound. A number of sites were non-compliant with the absolute minimum and/or peak water level criteria identified in Schedule 1 of <i>Ministerial Statement no. 819</i> . 12 sites were non-compliant in 2018–19, 14 sites in 2019–20 and 16 sites in 2020–21.
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 2013a; DoW 2015). These statements evaluated the department's management of Gnangara groundwater resources against the objectives in the 2009 <i>Gnangara groundwater areas allocation plan</i> (DoW 2009). 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 <i>Review of Ministerial Conditions on the groundwater resources of the Gnangara Mound</i> (DoW 2008c) and confirmed in <i>Ministerial Statement no. 819</i> . The department reviewed the management objectives and allocation limits of Gnangara resources as part of the development of the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021). The draft plan proposes some changes to environmental conditions and water level criteria, which will be assessed by the Environmental Protection Authority in 2022.
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		Non-compliant Water levels in Yanchep Caves have been declining for many years and accessible caves are now dry. We can no longer gain access to a number of caves 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. We have also installed loggers in some of the bores in the caves to monitor cave water levels. Building on the work of the shallow groundwater system investigation, the department completed a 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. It has also made changes to public water supply abstraction to limit impacts on the caves and adjoining Loch McNess. There have been reductions to some northern Superficial and Leederville licence entitlements in line with the recommendations in Kretschmer and Kelsey (2016). Further reductions in licensed groundwater entitlements are proposed in the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021), which also aim to improve groundwater levels in the vicinity of Yanchep National Park and the Yanchep Caves.
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: <ul style="list-style-type: none"> 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 worked with the Department of Planning, Lands and Heritage (DPLH), City of Wanneroo and Urbaqua to complete the District Water Management Strategy for East Wanneroo. The existing environmental conditions set on lakes Mariginiup and Jandabup were significant considerations for the establishment of Controlled Groundwater Levels and overall drainage designs for future urban development in the East Wanneroo area.

Audit code	Subject	Objective	Action	How	Evidence	Requirement of	On advice from	Phase	When/ Where	Status and further information for the 2018–21 triennial reporting period
819: P 5 1	Research and investigation program	Improving understanding of: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 <i>Ministerial statement nos. 438 and 496</i>. 	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	<p>Compliant</p> <p>A previous research and investigation program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of Gngangara 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 (now DBCA).</p> <p>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 has informed the <i>Gngangara groundwater allocation plan: draft for public comment</i> (DWER 2021) and includes:</p> <ul style="list-style-type: none"> Updates to the Perth Regional Aquifer Modelling System (PRAMS). The completion of the Perth Regional Confined Aquifer Capacity (PRCAC) studies that investigated the best locations and depth for sustainable abstraction from the Leederville and Yarragadee aquifers and for groundwater replenishment (or managed aquifer recharge). Completion of the Perth shallow groundwater system investigations (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. A conceptual model of vegetation water requirements developed by Edith Cowan University was used in the draft plan, to assess the risk of impacts to groundwater-dependent vegetation under different water, land use and climate scenarios.
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		<p>Compliant</p> <p>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 Gngangara system.</p>
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)	<p>Compliant</p> <p>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 (PRAMS).</p>
819: P 6 1	Environmental monitoring program	To enable evaluation of the environmental impact of groundwater abstraction from the Gngangara 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: <ul style="list-style-type: none"> 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	<p>Compliant</p> <p>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 (EMP). The previous environmental monitoring program was produced and submitted to the EPA on 21 December 2005. It was detailed in Appendix 7 of the Gngangara triennial report 2003–06 (DoW 2007). The audit of 2006–07 compliance report agreed commitment could be 'cleared' upon confirmation from the then DEC.</p> <p>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.</p>
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		<p>Compliant</p> <p>(See 819: P 6 1)</p>

Audit code	Subject	Objective	Action	How	Evidence	Requirement of	On advice from	Phase	When/ Where	Status and further information for the 2018–21 triennial reporting period
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 Although the action states that a review must be compiled in triennial reports every 6 years, the EMP undergoes regular revisions as required. Recent revisions were made in 2010 and 2013 and have been previously reported. We assess the monitoring program each year to ensure that the right sites are being monitored based on water level and ecological condition trends. The department has also reviewed environmental objectives and monitoring as part of developing the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021). See Appendix D for the most recent revised EMP.
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		Not required at this time (See M19: 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		Not required at this time The Gnangara GCC at the time of the Gnangara Sustainability Study provided a cross-government approach to the sustainable management Gnangara groundwater resources. Whilst it hasn't been reinstated, the department continues to consult with a range of stakeholders on sustainable use of Gnangara groundwater. To develop the <i>Gnangara groundwater allocation plan: draft for public comment</i> (DWER 2021) we consulted extensively with water users on how to adjust to climate change.
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 the Water Corporation operating strategy.	Compliance report	Minister for the Environment		Overall		Compliant The department has classified the sensitivity of each public water supply bore based on its proximity to environmentally sensitive areas and uses 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.

Audit code	Subject	Objective	Action	How	Evidence	Requirement of	On advice from	Phase	When/Where	Status and further information for the 2018–21 triennial reporting period
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.
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		Compliant A similar commitment from previous <i>Ministerial Statement no. 438</i> : P 2 was stated as 'cleared' by the then 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 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 then DoW (now Department of Water and Environmental Regulation) on implementation.	Require information in the 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	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 <i>Gnangara sustainability strategy</i>) and other investigations outlined in the status against commitment 819: P 5 1. To date no further actions have been taken.

Appendix C – History of Ministerial statements for the Gngangara Mound

The importance of managing abstraction from the Gngangara Mound to protect groundwater-dependent ecosystems was formally recognised in the late 1980s. The Environmental Protection Authority (EPA) proposed conditions on Gngangara groundwater abstraction in 1986 when the Gngangara 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 then 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.

After further research on wetland water requirements, in 1995 WAWA reviewed the Ministerial water level criteria (WAWA 1995). The review highlighted that climate was an important factor affecting groundwater levels, and it was difficult to predict future groundwater levels given the uncertainty of future climatic conditions. Following the release of this report in 1996 the water service provision and water management arms of WAWA were separated to form Water Corporation and Water and Rivers Commission. A new Ministerial statement (Statement no. 438) with revised conditions was issued to the Water and Rivers Commission in 1997. With the addition of Water Corporation's new Lexia Borefield in the late 1990s another set of Ministerial conditions were established on the Water and Rivers Commission for the East Gngangara area in 1999 (Statement no. 496).

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 Gngangara, East Gngangara and Jandakot mounds under section 46 of the *Environmental Protection Act 1986*. The first stage of the review led to *Ministerial Statement no. 687* for Gngangara/East Gngangara (Government of Western Australia 2005a) and *Ministerial Statement no. 688* for Jandakot (Government of Western Australia 2005b).

In 2007, the Department of Water conducted a further review of Ministerial conditions and commitments on Gngangara (DoW 2008b). Its purpose was to remove Ministerial criteria from sites where ecological values had been lost due to reasons other than groundwater level change, and from sites where analysis showed that abstraction was not the main factor influencing groundwater levels. This review eventually led to a revised *Ministerial Statement no. 819* being released in 2009, which as of December 2021 is the current set of environmental conditions under which the Gngangara groundwater resources is managed (Government of Western Australia 2009).

The second stage of the Section 46 review proposed in 2001 was meant to be 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. The results of these and other investigations has been used to develop the new draft Gngangara groundwater allocation plan. The draft plan also proposes changes to water level criteria at some sites that will require assessment by the EPA under the *Environmental Protection Act 1986*. The department has written to the Minister for Environment to initiate the section 46 review process. The public comment period for the draft allocation plan closes on 28 February 2022 and the plan will be finalised and released once the Minister for Environment has made his determination on the EPA's proposed changes to conditions.

References

- Bamford M & Everard C 2019, *Frog Monitoring on the Gngangara Mound: 2003 – 2018*, Prepared for the Department of Water and Environmental Regulation, MJ & AR Bamford, Consulting Ecologists, Kingsley, Western Australia.
- 2020, *Frog monitoring on the Gngangara Mound: 2003 – 2019*, Prepared for the Department of Water and Environmental Regulation, MJ & AR Bamford, Consulting Ecologists, Kingsley, Western Australia.
- 2021, *Frog Monitoring on the Gngangara Mound: 2003 – 2020*, Prepared for the Department of Water and Environmental Regulation, MJ & AR Bamford, Consulting Ecologists, Kingsley, Western Australia.
- Bates BC, Chandler RE, Charles SP & Campbell EP 2010, *Assessment of apparent nonstationarity in time series of annual inflow, daily precipitation, and atmospheric circulation indices: A case study from southwest Western Australia*, Water Resources Research, vol. 46, W00H02, doi:10.1029/2010WR009509.
- Blake D, Horwitz P & Zwickl K 2021, *Wildfire in Yanchep National Park wetlands: post-fire effects, water chemistry and macroinvertebrate response*, prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- Buller G, Kavazos C & Froend R 2019, *Wetland Vegetation Monitoring 2018 Survey of Gngangara Wetlands*, Report No. CEM 2019 - 01, Prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- 2020, *Wetland vegetation monitoring 2019 survey of Gngangara Wetlands*, Report No. CEM 2020 - 01, Prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- 2021, *Wetland vegetation monitoring 2020 survey of Gngangara Wetlands*, Report No. CEM 2021 - 01, Prepared for the Department of Water and Environmental Regulation, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- Department of Environment 2005, *Section 46 review of environmental conditions on management of the Gngangara and Jandakot Mounds: Section 46 progress report – State of the Gngangara Mound*, Department of Environment, Government of Western Australia, Perth.
- DoE – see Department of Environment
- Department of Water 2007, *Environmental management of groundwater allocation from Gngangara groundwater mound – triennial compliance report to the Environmental Protection Authority, July 2003–June 2006*, Department of Water, Government of Western Australia, Perth.

- 2008a, *Gnangara groundwater areas allocation plan: for public comment*, Department of Water, Government of Western Australia, Perth.
- 2008b, *Review of Ministerial conditions on the groundwater resources of the Gnangara Mound*, Department of Water, Government of Western Australia, Perth.
- 2009a, *Gnangara groundwater areas allocation plan*, Department of Water, Government of Western Australia, Perth.
- 2009b, *Gnangara groundwater areas allocation plan: Statement of response*, Department of Water, Government of Western Australia, Perth.
- 2011a, *Perth Shallow Groundwater Systems Investigation: Loch McNess*, Hydrogeological Record no. HG 43, Department of Water, Government of Western Australia, Perth.
- 2011b, *Perth Shallow Groundwater Systems Investigation: Lake Yonderup*, Hydrogeological Record no. HG 51, Department of Water, Government of Western Australia, Perth.
- 2013b, *Gnangara groundwater areas allocation plan: Evaluation statement 2009–2011*, Department of Water, Government of Western Australia, Perth.
- 2015, *Gnangara groundwater areas allocation plan: Evaluation statement 2011–2014*, Department of Water, Government of Western Australia, Perth.

DoW – see Department of Water

Department of Water and Environmental Regulation 2021 *Gnangara groundwater allocation plan: draft for public comment*, Department of Water and Environmental Regulation, Government of Western Australia, Perth.

DWER – see Department of Water and Environmental Regulation

Global Groundwater 2015, *Lake Nowergup: Factors in declining lake and groundwater levels*, prepared for the Department of Water, Government of Western Australia, Perth.

Government of Western Australia 2005a, *Statement to amend conditions applying to proposals – Gnangara Mound groundwater resources, Ministerial Statement 687*, Minister for Environment, Government of Western Australia, Perth.

—2005b, *Ministerial statement no. 688: Jandakot Mound groundwater resources*, Government of Western Australia, Perth.

—2009, *Statement to amend conditions applying to proposals – Gnangara Mound groundwater resources, Ministerial statement 819*, Minister for Environment, Government of Western Australia, Perth.

—2019, *Waterwise Perth Action Plan*, Government of Western Australia, Perth.

- Judd S & Horwitz P, 2019 *Annual Report for the Gngangara Mound Environmental Monitoring Programme - Macroinvertebrate and Water Quality Wetland Monitoring for Spring 2018*. Report No. CEM2019, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- Kretschmer P & Kelsey P 2016, *Loch McNess hydrogeology and causes of water level decline*, Hydrogeological record series, HG60, Department of Water, Western Australia.
- Lette E, Judd S & Horwitz P 2020, *Annual report for the Gngangara Mound environmental monitoring programme - macroinvertebrate and water quality wetland monitoring for spring 2019*, Report No. CEM2020 - 1, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- Lette E & Horwitz P 2021, *Annual report for the Gngangara Mound environmental monitoring programme - macroinvertebrate and water quality wetland monitoring for spring 2020*, Centre for Ecosystem Management, Edith Cowan University, Joondalup.
- Mattiske Consulting Pty Ltd 2021. Monitoring the effects of groundwater abstraction on native vegetation on the norther Swan Coastal Plain. Unpublished report by Mattiske Consulting Pty Ltd to Department of Water & Environmental Regulation.
- MacTiernan A (Minister for Agriculture and Food) 2019, *Minister for Agriculture and Food Response to North Wanneroo Agriculture and Water Taskforce Recommendations 30 January 2019*, available at <https://www.agric.wa.gov.au/sites/gateway/files/Response-to-taskforce-report.pdf> (accessed 22/12/2021)
- McHugh SL & Bourke SA 2007, *Management area review: shallow groundwater systems on Gngangara and Jandakot mounds*, HG25, Department of Water, Government of Western Australia.
- North Wanneroo Agriculture and Water Taskforce (NNAWT) 2018, *Recommendations to the Hon. Alannah MacTiernan, MLC Minister for Agriculture and Food – Thursday 16 August 2018*, available at https://www.agric.wa.gov.au/sites/gateway/files/Taskforce-report_1.pdf (accessed 22/12/2021)
- Searle JA 2009, *Bore completion report for Perth shallow groundwater systems: investigation – stage 2*, Hydrogeology Report no. HR 276, Department of Water, Government of Western Australia, Perth.
- Searle JA, McHugh SL, Paton AC & Bathols GR 2010a, *Perth shallow groundwater systems investigation: Lake Mariginiup*, Hydrogeological Record no. HG 36, Department of Water, Government of Western Australia, Perth.
- Searle JA, Hammond MJ & Bathols G 2010b, *Perth Shallow Groundwater Systems Investigation: Lake Nowergup*, Hydrogeological Record no. HG 40, Department of Water, Government of Western Australia, Perth.

Water Authority of Western Australia 1986, *Gnamptogara Mound groundwater resources – environmental review and management*, Water Authority of Western Australia, Government of Western Australia, Perth.

—1995, *Review of proposed changes to environmental conditions, Gnamptogara Mound groundwater resources (Section 46)*, Water Authority of Western Australia, Government of Western Australia, Perth.

WAWA – see Water Authority of Western Australia

WRM 2019, *East Gnamptogara Mound Springs: Invertebrate monitoring, spring 2018 survey*. Unpublished Draft report by Wetland Research & Management to Department of Water & Environmental Regulation.

—2020, *East Gnamptogara Mound Springs: Invertebrate monitoring, spring 2019 survey*, Unpublished report by Wetland Research & Management to Department of Water & Environmental Regulation.

—2021, *East Gnamptogara Mound Springs: Invertebrate monitoring, spring 2020 survey*. Unpublished report by Wetland Research & Management to Department of Water & Environmental Regulation.

Department of Water and Environmental Regulation
Prime House 8 Davidson Terrace
Joondalup WA 6027

Phone: 08 6364 7000
Fax: 08 6364 7001
National Relay Service 13 36 77
dwer.wa.gov.au

9489 00 0519