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Management Area Review of Shallow Groundwater Systems on Gnangara and Jandakot Mounds

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1 Summary

This Management Area Review (MAR) of the sustainability of shallow groundwater systems on Gnangara and Jandakot mounds summarises the current management issues facing selected lakes and wetlands in the Perth region, and identifies the information and data required to address these issues. The review presents the results of a comprehensive audit of the existing groundwater, surface water and ecological monitoring networks at 40 shallow groundwater system sites on Gnangara and Jandakot mounds. The review provides an assessment of the current monitoring infrastructure and its suitability for an investigation to fill any knowledge gaps.

Current management challenges facing shallow groundwater systems are the decline in regional groundwater levels, breaching Ministerial water level criteria and a general deterioration of the environmental, social and cultural values of lakes and wetlands. To ensure the sustainability of these systems, detailed, site-specific understanding of surface water-groundwater interactions, long-term lake level trends and the potential of wetland chemistry to impact on groundwater resources is required. However, these processes are currently not well understood.

The review recommends a detailed and well-structured investigation of 39, prioritised sites on Gnangara and Jandakot mounds that will address the knowledge gaps that currently prevent the sustainable management of shallow groundwater systems. It is recommended that an investigation should aim at installing new monitoring infrastructure at ecologically significant sites and upgrading the existing network.

Such an investigation would assist in the development of a framework that could improve the understanding of the interrelationship between wetlands and the superficial aquifer, and the complex, superimposed impacts of climate change, land-use and abstraction.

2 Introduction

2.1 Need for Management Area Review

The Gnangara and Jandakot mounds are the most significant sources of groundwater in Western Australia, supporting a variety of horticultural, agricultural, industrial, domestic and recreational needs totalling 487 G/L per year. The mounds also sustain numerous groundwater dependent features (many with international recognition) that support a range of social, cultural and environmental values (Clark and Horwitz, 2005; Froend *et al.*, 2004). These groundwater dependant features are also sites of significant Indigenous cultural and social value (Beckwith Environmental Planning, 2006; Estill & Associates, 2005).

It is the responsibility of the Department of Water (DoW) to balance the water requirements of lakes and wetlands, and the social/economic benefits of the groundwater resources of the Perth region. However, due to a combination of low rainfall, reduced recharge and increasing demand meeting this balance is becoming increasingly difficult and regional groundwater levels are declining.

The DoW faces numerous management challenges associated with water level decline which include the exposure and oxidation of Acid Sulphate Soils (ASS), the irretrievable loss of biodiversity and the potential for groundwater resource degradation. The DoW currently lacks the information required to meet these management challenges and to develop appropriate and effective strategies.

The replacement cost of the groundwater reserves of the Gnangara and Jandakot mounds, is substantial when measured against the value of replacement desalination plants, horticultural downsizing, stunted industrial development and the restrictions to the Perth conurbation water supply.

This Management Area Review (MAR) will assess the current state of the shallow groundwater systems on the Gnangara and Jandakot mounds, and recommend future work to be undertaken to facilitate the sustainable management of these valuable systems.

2.2 Aims of this review

The specific aims of this review are to:

1. Highlight the major management issues currently affecting the shallow groundwater systems on the Gnangara and Jandakot Mounds;

2. Identify the data and information required to improve management strategies for shallow groundwater systems on Gnangara and Jandakot mounds that address the current issues;

3. Assess the suitability of the existing groundwater, surface water and ecological monitoring networks to provide the information required to support wetland management; and

4. Recommend an investigation program that will ensure the sustainability of shallow groundwater systems on Gnangara and Jandakot mounds.

3 Management issues affecting shallow groundwater systems on the Gnangara and Jandakot Mounds

3.1 Water level decline

Water levels in shallow groundwater systems (both lake and groundwater level) are declining across both the Gnangara and Jandakot mounds (Figure 1). The causes of this decline are a complex mix of natural and anthropogenic factors (Yesertner, 2004). Regionally, the climate is becoming drier (Figure 2), reducing recharge and leading to lower groundwater levels. This trend is predicted to continue with reductions in rainfall and increases in temperature expected across the Swan Coastal Plain (Indian Ocean Climate Initiative, 2002). Superimposed on this regional trend are the effects of localised land use, vegetation, urbanisation and abstraction (Figure 3).

Declining water levels in shallow groundwater systems have been linked with negative ecological changes and loss of biodiversity (Clark and Horwitz, 2005; Froend *et al*., 2004). Water level declines in and around wetlands substantially increase the risks associated with Acid Sulphate Soils (ASS) and are linked to environmental and groundwater degradation (Appleyard *et al.,* 2006). However, our current understanding of shallow groundwater systems is inadequate for predictions of the likely range of future impacts under current management strategies.

3.2 Ministerial water level criteria breaches

The DoW has a significant role in wetland management including the management of water levels and water quality where they have the potential to affect environmental, cultural and other wetland values. Wetland water levels are currently managed by adherence to ecological water provisions (EWPs)[1] set as Ministerial conditions. These EWPs were first set for wetlands and other groundwater dependent ecosystems (GDEs)[2] on Gnangara Mound in 1986 (EPA Statement 438), and in 1992 for Jandakot Mound wetlands (EPA Bulletin 587). For the Gnangara and Jandakot mounds, EWPs have been set typically as minimum water levels at criteria sites, which were chosen to represent the

[1] Environmental Water Provisions (EWPs) are the water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts. They may meet in part or in full the ecological water requirements (Water and Rivers Commission, 2000).

[2] Groundwater dependent ecosystems (GDEs) can be defined as a complex community of organisms where groundwater is a key element required for consumptive use, biophysical processes or as habitat (Sinclair Knight Merz, 2001).

range of GDEs across the mounds. These water level criteria were established through the determination of ecological water requirements (EWRs)[3].

Ministerial water level and environmental criteria are consistently breached at a number of wetlands on the Gnangara and Jandakot mounds (Figures 4 and 5). The number of Ministerial water level criteria breaches at numerous wetland and terrestrial vegetation sites is increasing (Figure 6) in spite of the 1995 revision of water level criteria (Water and Rivers Commission, 2004). The persistent breaching of several criteria has prompted a review of environmental conditions through a Section 46 (*Environmental Protection Act, 1986*) review and is ongoing.

The current management approach for lakes and wetlands with breaching Ministerial water level criteria is to directly alter the hydrology by supplementation. For example, the Department of Water artificially supplements wetland water levels in order to improve compliance with Ministerial water level criteria. Lake Nowergup is a Conservation Category Wetland[4] on the Gnangara Mound that provides habitat for water birds and turtles. In order to maintain lake water levels, the lake is supplemented with approximately 1.4GL of water per year, sourced from the Leederville aquifer, at a cost of around $50,000 per year (Vitale, pers, comm.). Other wetlands are hydrologically altered by drains. Table 1 lists some of the lakes and wetlands that have artificially altered hydrological regimes.

The causes and implications of Ministerial criteria breaches are varied. Groundwater modelling has shown that some criteria breaches are due mostly to climate and new management objectives need to be determined to mitigate these impacts (Vogwill *et al*., 2007). At other sites the rationale to set EWPs is now considered unrealistic and a new approach is required to better manage ecological impacts in a drying climate (Rockwater, 2003). At some GDEs, the monitoring network is unsuitable; bores and staff gauges are unsuitably positioned or inappropriately constructed leading to artificial breaches of Ministerial water level criteria. Site-specific investigations are required to differentiate between the combined effects of reduced rainfall, abstraction, land-use and an inappropriately constructed monitoring network so realistic and achievable management objectives can be determined.

[3] Ecological water requirements (EWR) describe water regimes needed to sustain the ecological values of water dependent ecosystems (such as GDEs) at a low level of risk (NHMRC/ARMCANZ , 1996).

[4] Conservation Category Wetlands have support high natural attributes (Hill *et al.,* 1996).

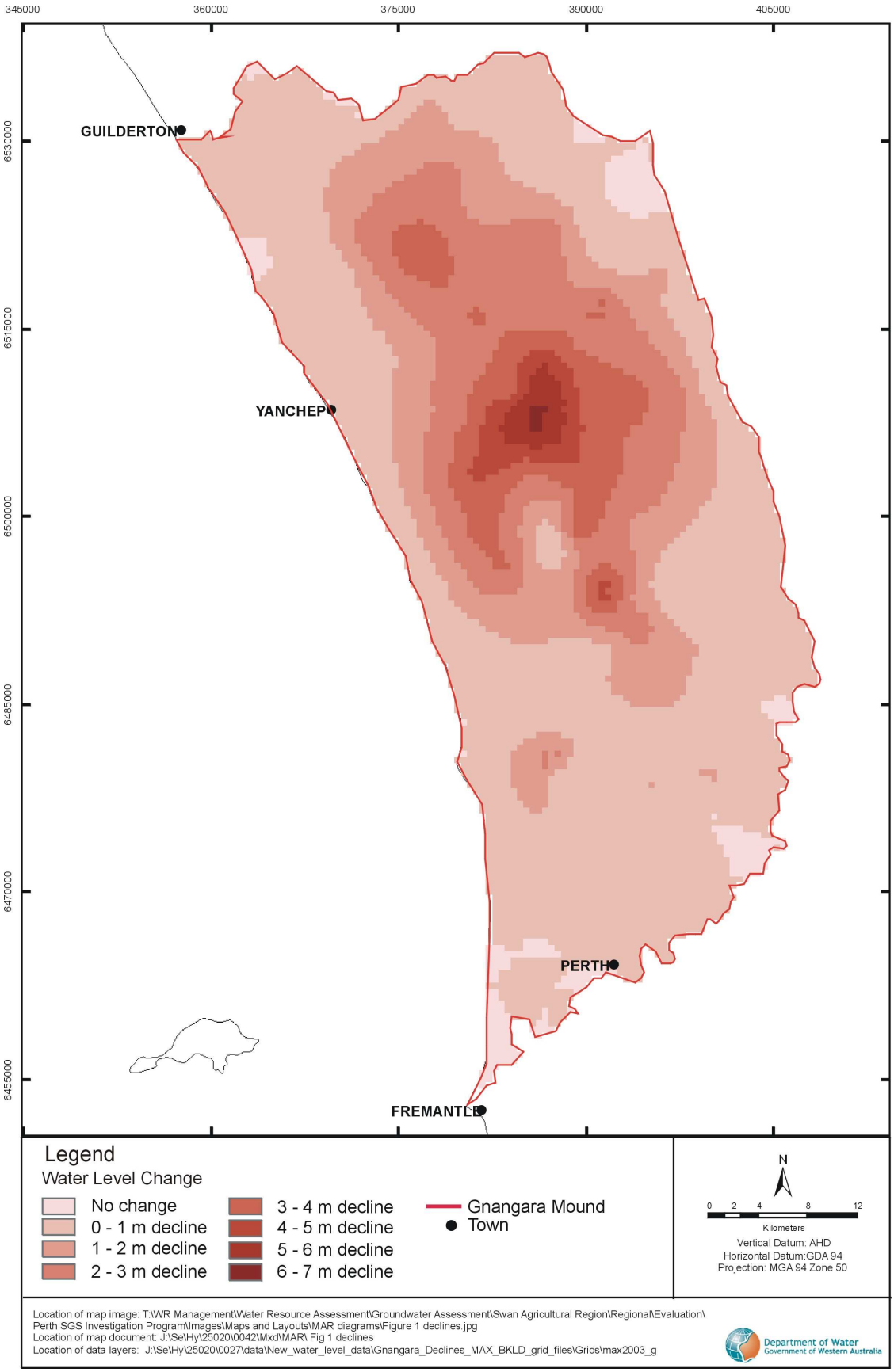

Figure 1. Water table decline on the Gnangara Mound between 1979 and 2003 (modelled using PRAMS[5]).

[5] Perth Regional Aquifer Model System (PRAMS) is a numerical groundwater flow model, developed by the Department of Water. For full details see Davidson and Yu, 2006.

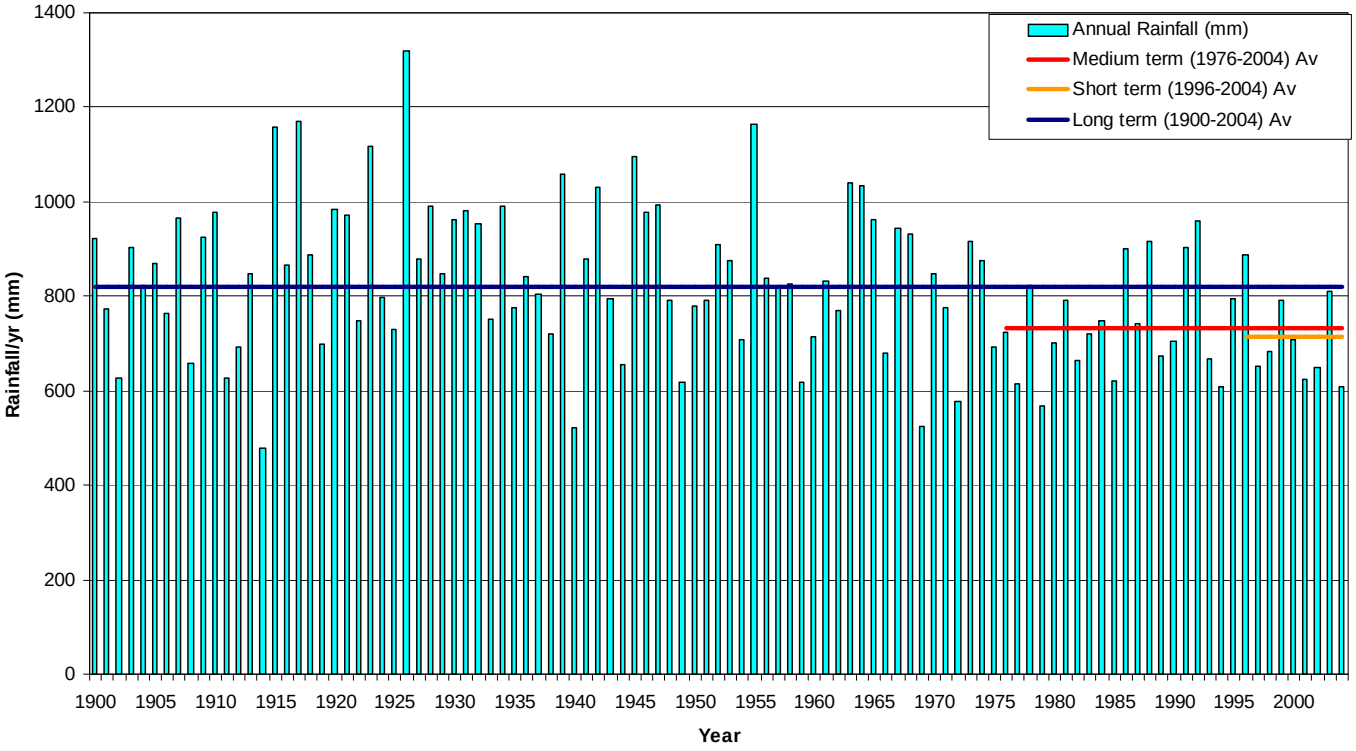

Figure 2. Annual average rainfall for Perth Airport showing long-term, medium-term and short-term averages.

Table 1. Lakes and wetlands on Gnangara and Jandakot mounds that have directly altered hydrological states

Lake/Wetland	Location	Altered hydrological state	Source
Lake Nowergup	Gnangara Mound	Supplementation	Leederville Aquifer
Lake Jandabup	Gnangara Mound	Supplementation	Superficial aquifer
Thomsons Lake	Jandakot Mound	Drainage Input	Southern Lakes Main Drainage System
Bibra Lake	Jandakot Mound	Drainage Input	Southern Lakes Main Drainage System
Kogolup Lake	Jandakot Mound	Drainage Input	Southern Lakes Main Drainage System
The Spectacles	Jandakot Mound	Drainage Input	Peel Main Drain

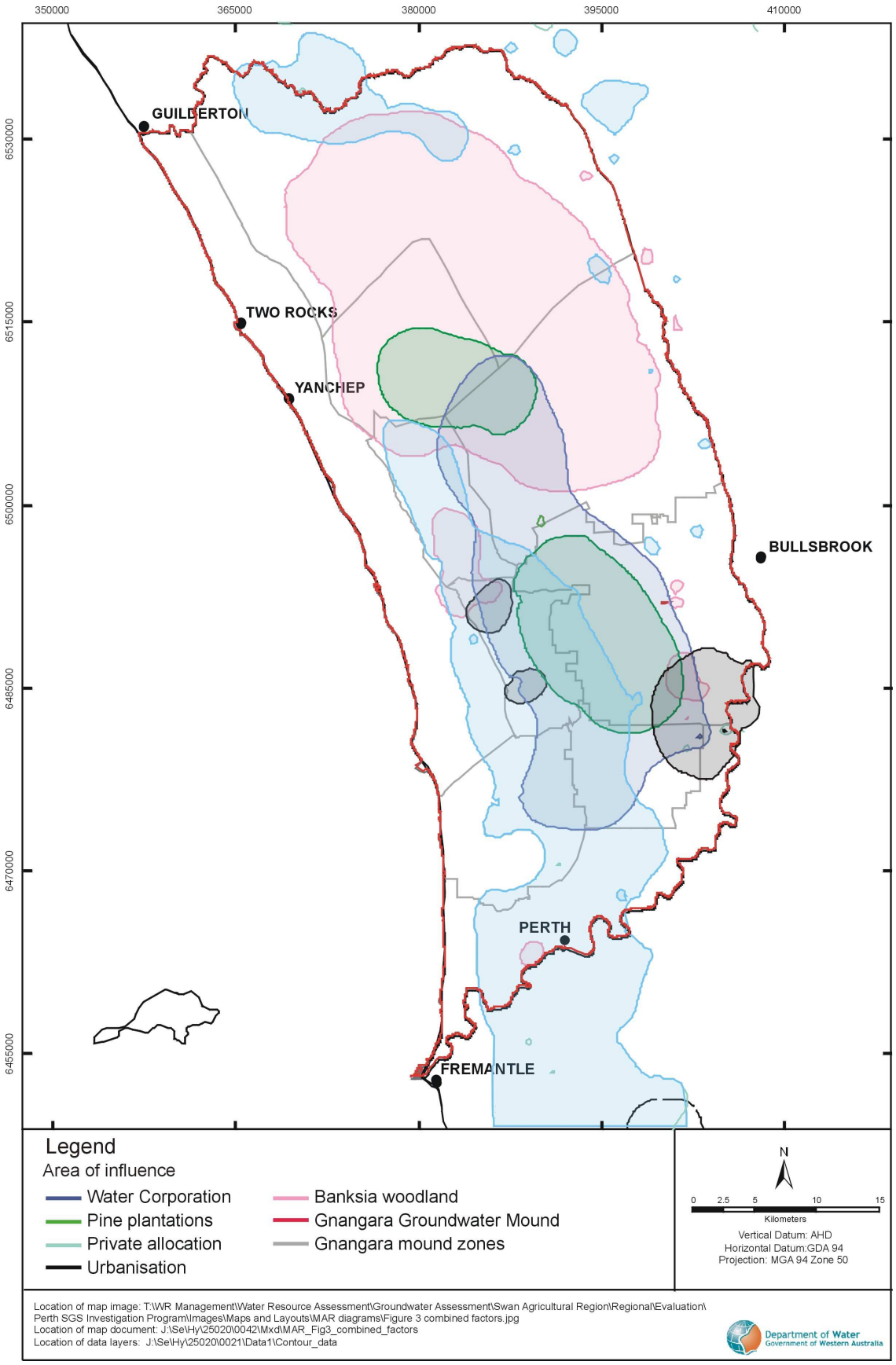

Figure 3. Land use factors that impact water levels on the Gnangara and Jandakot mounds (Vogwill, 2004).

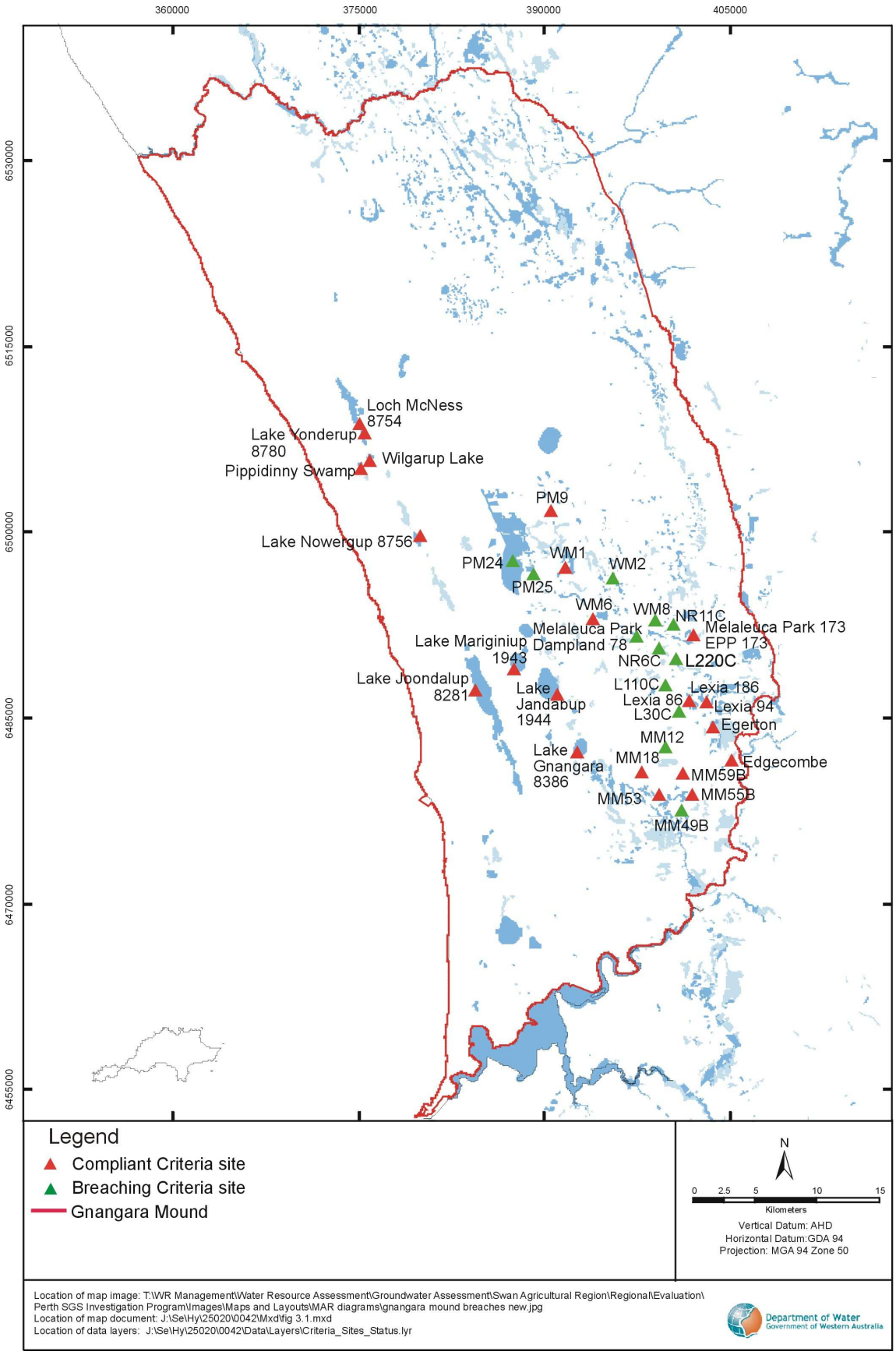

Figure 4. Gnangara Mound: Ministerial breaching and compliant criteria sites, as at May 2007.

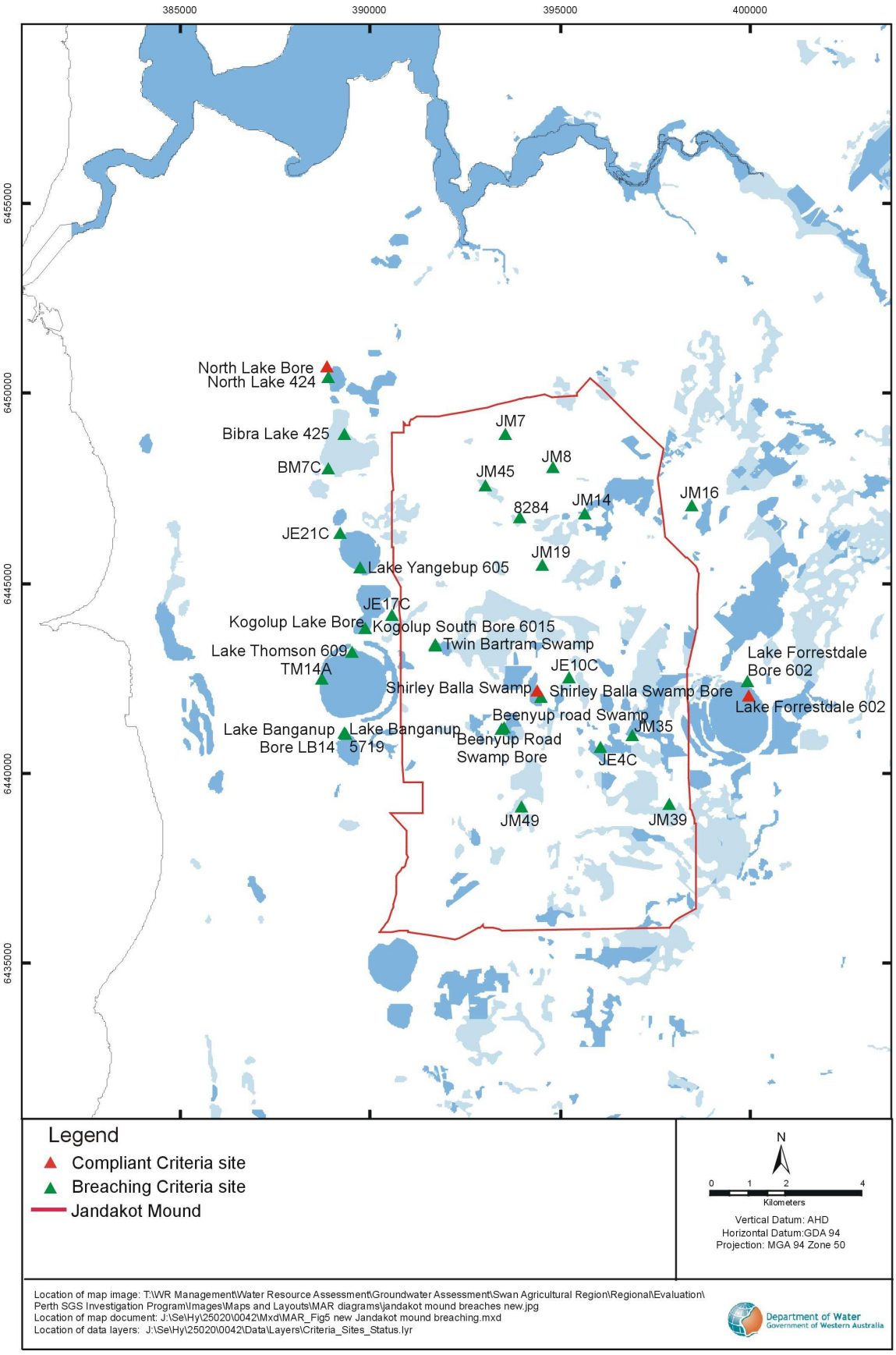

Figure 5. Jandakot Mound: Ministerial breaching and compliant criteria sites, as at May 2007.

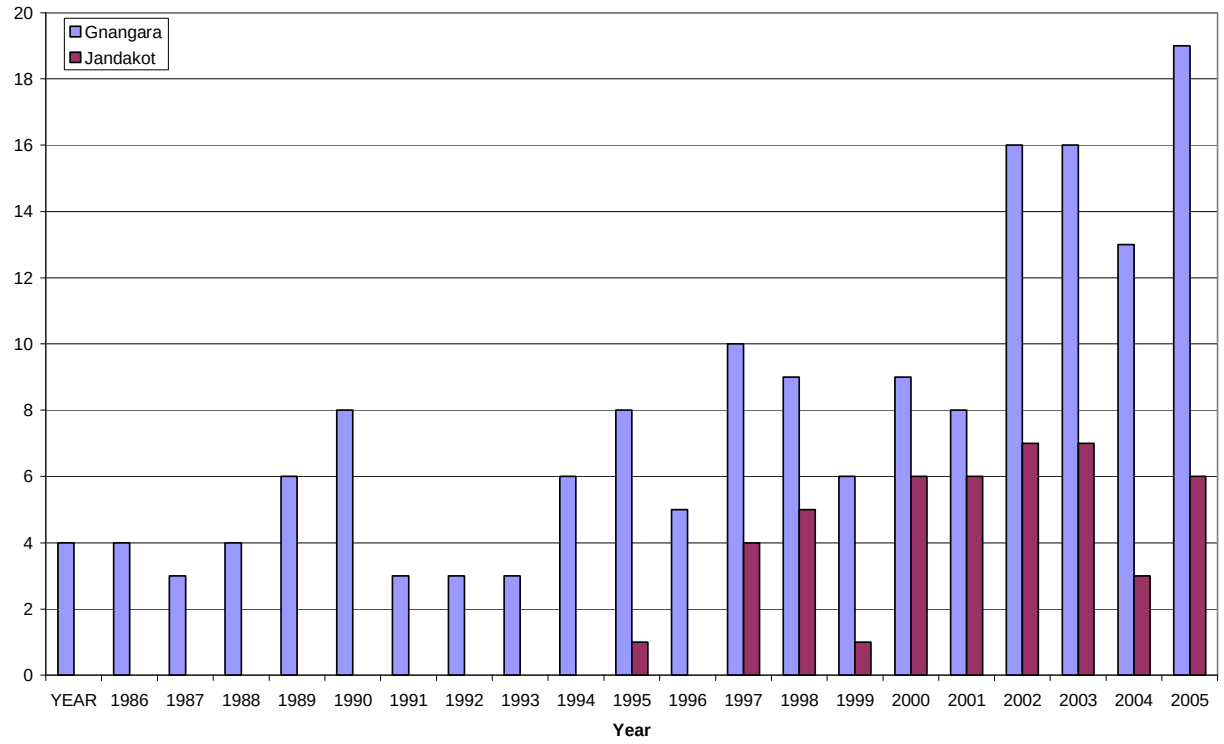

Figure 6. Number of criteria breaches in wetland and terrestrial vegetation sites across the Gnangara and Jandakot mounds.

4 Knowledge gaps that must be addressed to facilitate the management of shallow groundwater systems on the Gnangara and Jandakot Mounds

4.1 Wetland hydrogeology and surface-water interactions

Most lakes and wetlands on the Swan Coastal Plain are connected to regional groundwater systems via the superficial aquifer (Townley *et al.,* 1993; Davidson, 1995). However, the hydrological/hydrogeological interrelationship of surface water bodies on Gnangara and Jandakot mounds is site specific and no general relationship can be applied to all wetlands. Both aquifer anisotropy and lakebed sediments can affect the nature and degree of connection of each wetland with the regional groundwater flow systems (Arnold, 1990).

An investigation is required to provide base level knowledge of the hydrogeologic regime of individual lakes and wetlands, and elucidate the relationship between surface water levels and underlying hydrogeology. This understanding of the connection of wetlands to the regional groundwater system is vital to making realistic evaluations of the impact of regional watertable trends on groundwater dependent ecosystems, and to setting appropriate ministerial water level criteria. This knowledge can then be used to construct local area groundwater models, to provide more robust predictions of future groundwater levels under various management regimes.

4.2 Wetland palaeohydrology and climate change

Long-term variation in lake water levels is not currently well understood for most of the lakes and wetlands on the Gnangara and Jandakot mounds. The monitoring of lake level change spans only 60 years and it is only during the last 30 years that water levels have been monitored on a regular, seasonal basis. There has been significant advancement in understanding wetland response to changing hydrologic regimes from a biological perspective (eg. Davis *et al*., 1993; Froend *et al*., 1993; Storey *et al*., 1993; Sommer and Horwitz, 1999). However, the DoW does not fully understand the role of climate variability in changing water levels, nor is the natural range of water level natural variability experienced in the lakes fully appreciated.

Radiocarbon dating has revealed that most lakes and wetlands have been in existence for at least the past 10 000 years (Pickett, 1997; McHugh, 2004). Given this, the historical water level record is clearly not adequate to place the current changes and associated problems in a recent geological context. Research suggests that water levels in some wetlands have fluctuated throughout the last 10 000 years and with greater amplitude than the historical record of monitored water levels suggest (McHugh, 2004). However, the

timing or rates of these events are unclear because the resolution of these dates is coarse, offering only a suggestion of environmental change over the Holocene. A recent workshop on palaeoclimate data in the Australasian region[6] highlighted the paucity of high-resolution, terrestrial proxy data from southwestern Australia.

The continued breaching of water level criteria highlights our lack of understanding of long-term hydrological changes in lakes. At some sites, the breaches are mainly due to inter-annual climate variability and long-term climate change. However, the current EWPs do not adequately accommodate changes in climate. In light of the current drying climate it is increasingly important to understand the full range of natural states of wetlands on the Swan Coastal Plain.

The sediment record is the only archive available that allows the water level history of lakes and wetlands over their "life history" to be deciphered. Environmental changes in lakes are recorded in the sediments in a variety of ways. These include the formation of redox sensitive minerals, the preservation of sedimentary structures and the accumulation of biogenic remains. These sediment characteristics record the evolution of the lake and the external processes, which influence their development. Analysis of these characteristics, used in conjunction with a statistically robust age/water chemistry model, can provide a valuable record of hydrological, chemical and climatic change in and around lakes.

4.3 Wetland hydrogeochemistry

The chemical characteristics of wetland waters and their sediments play an important role in the quality of wetland water bodies and impact on the quality of groundwater systems. While the impacts of poor wetland water quality on biodiversity have been identified at many wetland sites on Gnangara and Jandakot mounds (Clark and Horwitz, 2005; Froend *et al.,* 2004) the geochemistry of wetland sediments is not well documented.

Understanding the geochemical characteristics of sediments within and around wetlands is particularly important in areas where Acid Sulphate Soils (ASS) and Potential Acid Sulphate Soils (PASS) may exist (Cook, 2006). ASS are naturally occurring soils and sediments that contain iron sulphide materials (usually pyrite) and release sulphuric acid when oxidised. PASS are soils and sediments containing stored sulphuric acid that is yet to be oxidised (Fanning and Fanning, 1989). Our current understanding of ASS/PASS risks are at a broad regional scale and most wetlands on Gnangara and Jandakot mounds are considered a high risk of ASS (Figure 7). However, for site specific management the

[6] Held under the auspices of the Australian Academy of Science's National Committees for Earth System Science and Quaternary Research, the GeoQuEST Research Centre, IGBP Past Global Changes, PAGES/CLIVAR Intersection and the International Union for Quaternary Research (INQUA), 'Discovering the Past and Present to Shape the Future' and 'Earth System Science'. Monday 27th & Tuesday 28th June 2005, Australian Academy of Sciences, Canberra, ACT Australia.

distribution of acid producing sediments, their buffering capacity and the potential to pollute the groundwater resource at high risk sites needs detailed investigation.

Determining the chemistry of groundwater and wetlands can also improve our understanding of the interaction between groundwater and surface waters. The Department is currently undertaking the Perth Hydrochemistry Survey (Yesertener, 2003, 2004) which involves quantifying the amount of groundwater in storage and calculating groundwater throughflow rates and changes in the water chemistry of groundwater within and between aquifers. A similar analysis of the hydrochemistry of shallow groundwater systems will provide a more detailed appreciation of the connectivity of the superficial aquifer and key wetland sites and allow predictions of the wetland response to environmental change to be made.

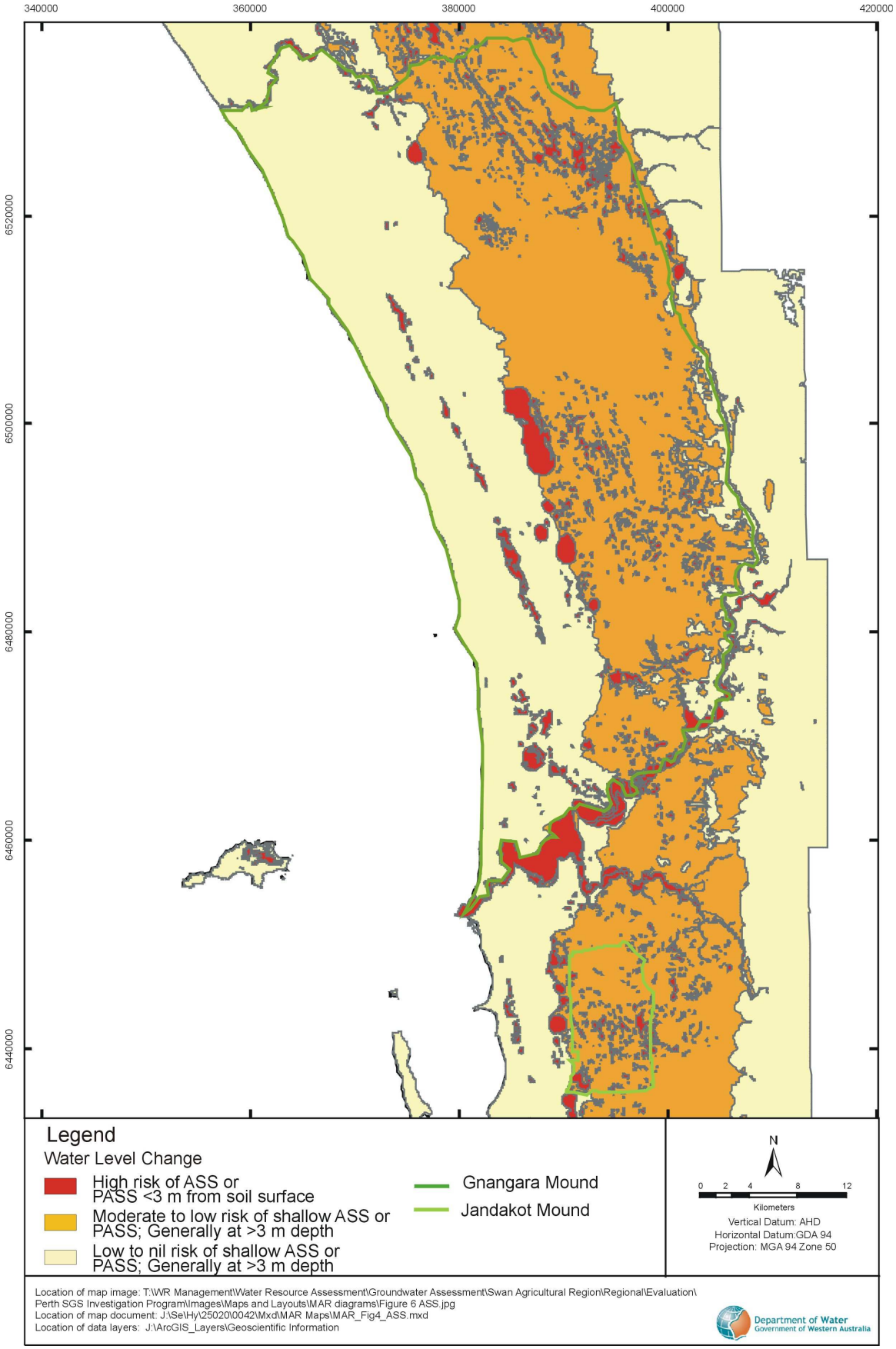

Figure 7. Acid sulphate soil risk areas on the Gnangara and Jandakot mounds (Degens, 2006).

5 Monitoring infrastructure audit

5.1 Implications of an unsuitable monitoring network

The DoW monitors surface water levels in lakes and wetlands of the Gnangara and Jandakot mounds as well as groundwater level fluctuations from many monitoring bores (Figures 4 and 5). The integrity of these time-series data is essential for meaningful evaluations of the impact of groundwater abstraction, land use and climate change on GDEs, water level criteria and the understanding of groundwater-surface water interaction. However, an audit of wetlands on Gnangara and Jandakot mounds undertaken by Rockwater (2003) and Froend *et al.*, (2004) highlighted numerous deficiencies in the current monitoring network. Rockwater (2003) showed that of the 28 wetlands investigated, 23 (82 percent) either have no criteria bores, the criteria bores are unsuitably positioned, or there are no (or insufficient) monitoring data available (Table 2).

The unsuitability of monitoring infrastructure has, in many instances, resulted in the artificial breaching of environmental water level criteria. The location of the criteria bore at North Lake provides an example of unsuitable monitoring infrastructure (Figure 8). The criteria monitoring bore (North Lake Bore) is located on the north-western side of the lake, down-gradient of both the lake, and the vegetation transect where the EWR was determined. As a result, groundwater levels measured in this bore will be lower than lake water levels, and groundwater levels at the vegetation transect on the eastern side of the lake. This water level difference can be significant, with the difference between groundwater levels at the criteria bore and the vegetation transect of the order of one metre.[7] Water levels measured in this bore have consistently breached Ministerial water level criteria, by an amount also of the order of one metre (Figure 9).

Table 2. Summary of results from the Rockwater (2003) monitoring network audit

Gnangara Mound		**Jandakot Mound**	
Unsuitable Criteria Bores		Unsuitable Criteria Bores	
Lake Joondalup Lake Nowergup	Coogee Spring Lake Yonderup	Lake Yangebup Lake Thomson Forrestdale Lake	North Lake Shirley Balla Swamp
No Criteria Bore			
Lake Goollelal Loch McNess	Melaleuca Park EPP 173 Lake Jandabup		
Insufficient Data for Assessment			
Lexia 94 Swamp Bibra Lake Lexia 186 Swamp Kogolup Lake South		Melaleuca Park Dampland 78 Pipindinny Swamp	Egerton Seepage Edgecombe Seepage

[7] One metre head difference based on groundwater contours interpolated from water levels measured in May 2003, sourced from the Groundwater contours, minimum layer in the DoW corporate geodatabase.

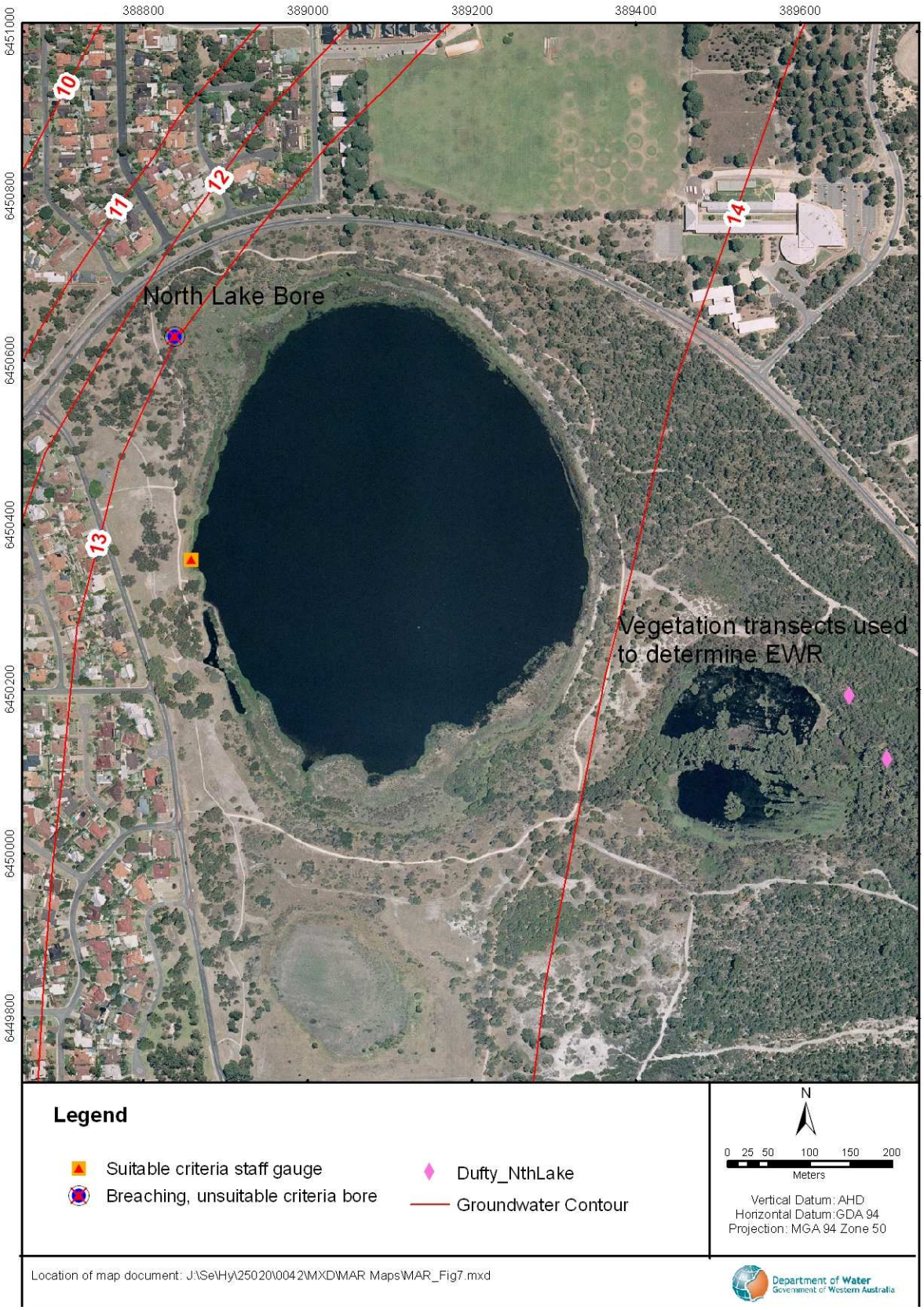

Figure 8. Location of current monitoring infrastructure and vegetation monitoring transects at North Lake. Groundwater contours are shown at 1-metre intervals, based on interpolation of groundwater levels measured in May 2003. Breaching status as at January 2007.

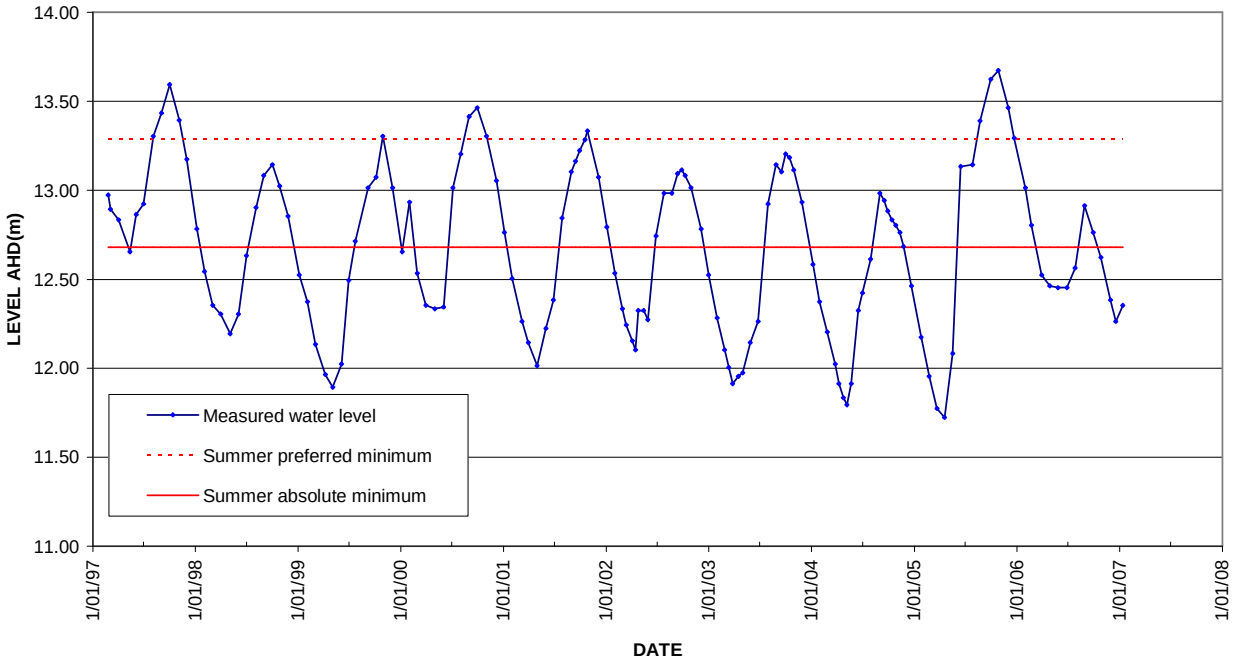

Figure 9 . Hydrograph of groundwater monitoring bore North Lake 424 (388839E 6450629N, MGA Zone 50), the monitoring bore used to measure compliance with Ministerial water level criteria at North Lake, January 1997 to January 2007.

5.2 Monitoring audit

The monitoring infrastructure audited for this review was evaluated in terms of its suitability to gather the data needed to formulate improved management strategies that address the current problems facing these systems today and into the future. Specifically, the audit assessed the existing infrastructure according to several criteria:

1) The positioning of the bore in relation to regional groundwater flow, the wetland (i.e. up-gradient and down-gradient of the wetland) and proximity to an existing ecological monitoring transect/site;

2) The depth interval of screens;

3) The positioning of staff gauges able to measure lake and wetland water levels (over the entire range likely); and

4) The existence of an ecological monitoring site that can evaluate the impacts of water level changes on biological assemblages.

The monitoring audit was conducted on 39 prioritised shallow groundwater system sites on Gnangara and Jandakot mounds (Table 3, Figures 10 and 11). The list of 39 sites was derived from multiple levels of consultation. Expertise was sought from internal staff from the Environmental Water Planning and Groundwater Assessment sections, Allocation

Branch, Land and Water Quality Branch, Salinity and Land Use Impact Branch, Swan-Goldfields Region, external consultants and Edith Cowan University. Previously delineated suites of wetlands based on geomorphic setting (Hill *et al.,* 1996; Semeniuk and Semeniuk, 2005) and ecological values (Froend *et al.,* 2004) have also been incorporated into the selection process.

Prioritisation of the wetland sites was based on the following:

1) Specific lakes and wetlands that are currently in breach of, or at risk of breaching Ministerial criteria, or at risk of impact from watertable drawdown as determined by PRAMS;

2) Wetlands that are representative of certain hydrogeological settings, the understanding of which can that can be extrapolated to similar wetlands, or wetlands with poor hydrogeological understanding;

3) Wetlands that are situated in areas where future groundwater use might be impacted (eg. Yarragadee aquifer impact area near Yeal) or heavily exploited; and

4) Wetlands that have been identified as supporting ecologically significant or threatened biological communities.

Table 2 lists the prioritised shallow groundwater system sites identified in this review and summaries the rationale for each sites inclusion in the list. The sites are a mixture of existing wetland criteria sites and non-criteria, ecologically significant sites.

The results of the monitoring network audit show that many breaching criteria sites have an unsuitably placed monitoring bore or staff gauge (e.g. Lake Joondalup, Lake Nowergup, Lake Thomson, Lake Forrestdale). At other sites, the understanding of surface water-groundwater interaction is not well understood and more monitoring bores are required (e.g. Lake Yonderup, Lake Forrestdale). Many ecologically significant or threatened sites currently have no groundwater or ecological monitoring infrastructure. Appendix 1 summarises the current management issues facing each of the 39 shallow groundwater system sites, and presents detailed maps and tables summarising the findings of the monitoring network review.

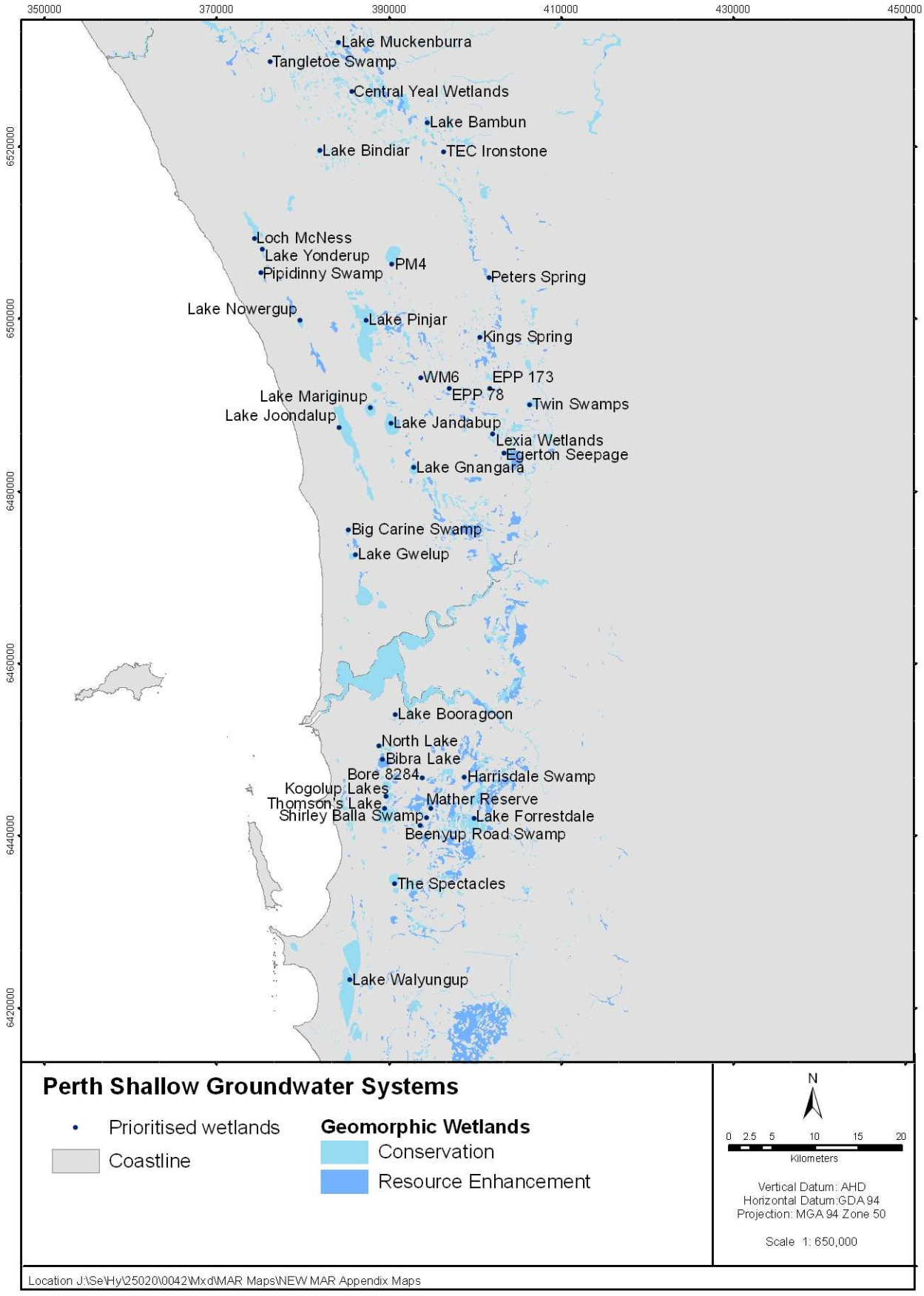

Figure 10. Prioritised shallow groundwater system sites on Gnangara and Jandakot mounds

Table 3. Prioritised list of shallow groundwater system sites on Gnangara and Jandakot mounds.

Gnangara Mound		Jandakot Mound	
Lake Joondalup	• Breaching criteria site • Unsuitable monitoring bores and staff gauge • Surface-water groundwater interactions unknown	Thomson's Lake	• At risk of breaching • Unsuitable monitoring bore • Sever risk of drawdown
Lake Nowergup	• Breaching criteria site • Unsuitable staff gauge • Hydrogeology unknown • Water levels artificially maintained	Spectacles North	• At severe risk of impact from drawdown • Hydrogeologically different to other sites on Jandakot Mound • No hydrogeological investigation have been undertaken at this site • Current ecological status of the lake is unknown
WM6 (Neaves)	• At risk of breaching • Unsuitable/insufficient bores • Significant flora and fauna	North Lake	• Breaching criteria site • Unsuitable monitoring bore • Complex hydrogeology • Server risk of drawdown
Lake Yonderup	• Breaching criteria site • Unsuitable monitoring bore • Complex hydrogeology • Severe risk of drawdown	Forrestdale Lake	• Breaching criteria site • Unsuitable monitoring bore and staff gauge • Complex hydrogeology • Severe risk of drawdown
Central Yeal Wetlands	• In confined aquifer impact area • No monitoring bores • Hydrogeology unknown • Morphologically different to other wetlands	Bibra Lake	• At risk of breaching • Unsuitable monitoring bores • Waterbird refuge habitat • Poor correlation between groundwater levels and lake levels
Lake Bambun	• Distinct hydrogeological setting • No monitoring infrastructure • Ecologically significant	Shirley Balla Swamp	• High risk of losing ecological value • Unsuitable staff gauge • Evidence of perching • Past 10 years water levels decline • Server risk of drawdown
EPP 173	• At risk of breaching • Unsuitable criteria bore • Supports significant vertebrate and macroinvertebrate species • Unique hydrology • Possibly perching	Bore 8284	• Phreatpphytic vegetation Ministerial criteria site • Criteria bore is stranded and needs replacing
EPP 78	• Not staff gauge • Groundwater-surface water relationship unclear • Supports endemic intertebrates • High risk of ecological impact due to water level declines	Harrisdale Swamp	• Severe risk of drawdown • No vegetation transect • Significant flora and faunal species
Lake Bindiar	• In confined aquifer impact area • No monitoring bores • Distinct hydrogeological setting • Has excellent palaeoclimate record • No Hydrogeological studies have been undertaken in the area	Booragoon Lake	• Northernmost site on Jandakot Mound • High concentrations of metals in sediments • Excellent palaeoclimate record • Important waterbird breeding site
Peters Spring (GN31)	• Different hydrogeological setting • No studies undertaken • Supports several threatened ecological communities • Poor monitoring network	Lake Walyungup	• Supports rare thrombolites • Unique hydrogeology • Insufficient monitoring • Excellent palaeoclimate record
PM4	• Complex hydrogeology • Has excellent palaeoclimate record • On the margin of the Yarragadee impact area	Mather Reserve	• Supports rare wetland vegetation • Insufficient monitoring network • Waterbird feeding site • Ecologically significant • Severe risk of drawdown
Egerton Seepage	• At risk of breaching • No surface water monitoring bore • Unique hydrogeological setting • Surface-water groundwater interactions unknown	Kogolup Lakes (North and South)	• Insufficient monitoring bores • Important breeding site for important bird species • Surface water –groundwater interaction unclear

Timuru (Ironstone Community)	• Possibly hydrogeologically unique and not well understood • Supports threatened ecological community	Beenyup Road Swamp	• Supports significant waterbirds • Insufficient monitoring bores • Evidence of perching • Server risk of drawdown • Decline in wetland vegetation
Loch McNess	• At risk of breaching • At severe risk of impact from drawdown • Supports rare ecological community		
Lake Jandabup	• Breaching criteria site • Falling water levels despite artificial water level maintence • Susceptible to acidification • No monitoring bores close to vegetation transect	Twin Swamps	• Supports critically endangered Western Swamp Tortoise • Supports threatened phreatophytic vegetation community • Insufficient monitoring bores, hydrgeology not well understood.
Lake Gnangara	• Permanently acidified site and need to understand potential for groundwater degradation • Ecological values lost • Severe risk of drawdown		
Lake Mariginiup	• Breaching criteria site • Susceptible to acidification • Severe risk of drawdown • Waterbird habitat • Evidence of habitat loss		
Lake Gwelup	• Southernmost site on Gnangara Mound • Supports rare wetland vegetation		
Lake Pinjar	• Supports rare wetland vegetation • Severely degraded from agriculture land use • Ecologically important site for terrestrial fauna		
Tangletoe Swamp	• Suggested reference for water level changes on Gnangara mand • Hydrogeology not well understood • Supports high macroinvertebrate species richness		
Big Carine Swamp	• Supports rare wetland vegetation • Insufficient monitoring bores • Waterbird habitat • Severe risk of drawdown		
Kings Spring	• Rare phreatophytic vegetation • Insufficient monitoring bores • No recent monitoring data • Severe risk of drawdown		
Lexia Wetlands	• Lack of staff gauges • Supports diverse vegetation • Probably PASS bearing sediments • Lack of hudrogeological knowledge		
Lake Muckenburra	• No existing monitoring network • Significant faunal habitats		
Pipidinny Swamp	• Need deeper bore installed • Good palaeoclimate record that needs radiocarbon dating • Ecologically significant vegetation but needs monitoring transect set up		

6 Recommended Investigation Program

6.1 Program scope and purpose

This management area review has highlighted deficiencies in the current monitoring network at both criteria and non-criteria shallow groundwater system sites Gnangara and Jandakot mounds. To address this deficiency, it is recommended that a dedicated, detailed and well-structured investigation of shallow groundwater systems, including a substantial upgrade of the existing monitoring network, is required to maintain sustainable development of groundwater resources. Such an investigation would assist in the formulation of a framework that could improve the understanding of the interrelationship between wetlands and the superficial aquifer, and the complex, superimposed impacts of climate change, land-use and abstraction and to optimise the production of groundwater.

The purpose of a shallow groundwater systems investigation would be to provide the essential information on the site-specific function of wetlands over a range of spatial and temporal scales. This will facilitate setting up relevant and meaningful criteria for measuring man-made impacts on wetlands on the Swan Coastal Plain and will provide a regional understanding of the hydrogeology of what is essentially a highly complex system.

The overall benefit of a shallow groundwater system investigation would be the development of management strategies, based on regionally focused, scientific data that will promote the sustainable use of the groundwater resources of the Gnangara and Jandakot mounds and ensure the protection of the environmental features dependent on that groundwater. The program design should be synergetic and complimentary to other monitoring and research projects, keeping costs low and maintaining strong beneficial outcomes.

This review has identified a list of 40 lakes, wetlands and remnant wetlands that require investigation for improved management (Table 3; Section 5.2). It is recommended that the scope of any investigation should include, but not be limited to, these shallow groundwater system sites. Specific objectives of a shallow groundwater systems investigation should be:

1. Redesign and upgrade the existing monitoring infrastructure and install new monitoring networks at ecologically important sites;

2. A hydrogeological investigation of selected lakes, wetlands and remnant wetlands to determine the interactions and connectivity of surface water bodies and groundwater;

3. A palaeoclimatological investigation of key wetlands that store climate change information over at least the past 10 000 years. This will provide an

appreciation of how lakes have functioned in the past and enable us to place the current changes within this long-term context; and

4. A geochemical and hydrochemical investigation of wetland and wetland sediments to provide a detailed understanding of the ability, (both realised and potential), of wetlands to alter lake water and groundwater quality.

The work required to address each of these four objectives is outlined in the following sections.

6.2 Upgrade of monitoring infrastructure

6.2.1 Groundwater monitoring bores and neutron probe access tubes

In most cases, it is recommended that clusters of groundwater monitoring bores be installed in clusters of three; shallow (screened at the water table), intermediate (screened approximately half way though the superficial aquifer) and deep (screened at the base of the superficial aquifer). The clusters should be positioned up-gradient and down-gradient of the main lake water body so that both horizontal and vertical groundwater flow can be measured. It is also important that the flow components of the regional groundwater system be known in the vicinity of the lakes. Neutron probe access tubes, for monitoring unsaturated zone moisture content, should be installed adjacent to monitoring bores and existing ecological monitoring transects at select sites.

6.2.2 Staff gauges

A surface water staff gauge should be positioned so that wetland water levels can be measured when they are at their lowest and highest. Some of the current infrastructure is frequently left stranded by lake level declines. It is proposed that a lakebed sediment bathymetric survey be carried out on each of the wetlands to determine the lowest lakebed level, so that surface water staff gauges can be installed in the most appropriate locations. The bathymetric data will also be used to target the areas of thickest lake sediment deposition for coring.

6.2.3 Ecological monitoring transects

In order to place the additional hydrological and hydrogeological information in an ecological context, a range of ecological monitoring techniques should be implemented. Current monitoring of criteria sites on an annual or triennial basis should continue. This should be supplemented by a combination of wetland vegetation monitoring, macroinvertebrate and water quality sampling, and phreatophytic vegetation monitoring at those sites identified by Froend *et al.,* (2004).

6.3 Wetland hydrogeology and surface water-groundwater interactions

Groundwater and surface water monitoring aims to obtain high-quality time-series data for hydrogeological analysis and local area groundwater flow modelling. The upgraded monitoring infrastructure outlined above (section 4.3) facilitates a holistic monitoring program that will improve the DoW's understanding of relationships between groundwater, lake water levels and soil moisture profiles, as required to interpret ecological changes in wetlands and their surrounds. It is proposed that at least a full year of water level data be recorded so that an understanding of the surface water-groundwater interaction under both wetting and drying phases can be gained, including the following;

- Lake water levels measured monthly using suitable existing and upgraded staff gauges.

- Groundwater levels in each bore cluster monitored monthly, providing an indication of the flow regime within the superficial aquifer.

- Soil moisture profiles monitored seasonally using neutron probes, which will be passed down access tubes installed at adjacent to groundwater monitoring bores.

- Analysis of sediment core will allow the determination of hydrogeological parameters including porosity, specific yield, specific retention, permeability and hydraulic conductivity at each site.

6.4 Wetland Palaeohydrology and Climate Change

Crucial to a sedimentological study of lakes is the successful extraction of continuous, undisturbed core. It is recommended that a shallow groundwater system investigation should target lakes that have thick, well-preserved lake sequences that are suitable for a variety of analyses. It is also important that coring will penetrate through the lake deposition sequence and to the top of the underlying Pleistocene sediments (eg. Bassendean Sands, Tamala Limestone). Recommended analyses include:

- Age determination using standard dating techniques for lakebed sediments such as ^{210}Pb, ^{137}Cs and accelerated-mass spectrometer ^{14}C dates (Williams, *et al.,* 1998). A robust chronological model, derived from the high-resolution dating of lake sediments, can provide the framework essential to understanding the rate and timing of hydrological and climatic change. This is essential for any meaningful palaeoenvironmental reconstruction and for the integration of palaeoclimate data into predictive climate and/or groundwater modelling systems.

- Palaeoenvironmental reconstruction (ie hydrological and climate change) using proxy indicators stored in lake sediments. Indicators may include macro and

microfossils, trace elements, stable isotope ratios and the physical characteristics of the sediments themselves. It is recommended that a shallow groundwater system investigation should focus on a multi-proxy approach to lake sediment analysis, as it is with multiple lines of evidence that the strongest interpretation for environmental reconstruction can be made.

6.5 Wetland chemistry and water quality

6.5.1 Wetland hydrochemisty

A lake water and groundwater sampling and analysis program will determine the hydrochemical characteristics of each site, the distribution and availability of potential pollutants if oxidation through sub aerial exposure occurs and the interaction between the superficial aquifer. The following analyses should be performed;

- Total heavy metals and metalloid content including aluminium, arsenic, iron, cadmium, zinc, nickel, cobolt, mercury and selenium of both water and sediments determined through Inductively Coupled Plasma Mass Spectrometery (ICPMS) of lake water and groundwater samples;

- Electrochemical field parameters such as Eh pH, electroconductivity and total acidity/alkalinity titrimetric determination. These parameters would also be monitored over a full annual cycle to determine the seasonal fluctuations; and

- Laboratory analysis of basic anions, basic cations and Total Organic Carbon (TOC). As above these parameters will be monitored for a full annual cycle.

6.5.2 Wetland geochemistry

It is proposed that the top part of the sedimentary profile be sampled at select wetland sites in order to determine the potential for the generation of acidic drainage and the release of metals on drying. This sediment sampling should be conducted in accordance with the Department of Environment and Conservation guidelines on the identification and investigation of acid sulphate soils (Department of Environment, 2006) and the National Advisory Committee for Acid Sulphate Soils (NatCASS).

Analyses should address not only obvious ASS and PASS (organic rich, peaty or clayey material), but also the potentially more widespread occurrence of ASS and PASS as fine framboidal sulphidic minerals adhering to the surface of quartz grains. These sediments are identical in appearance to Bassendean and Quindalup sands, which are the dominant sediments of the upper parts of the sedimentary profile of the mounds. The extent and implication of base cation depletion of these sediments/soils also warrants investigation as this increases the risk of groundwater acidification dramatically due to an almost total lack of buffering capacity (Cook, 2006).

7 Conclusions and Recommendations

The conclusions and recommendations from the Sustainability of Shallow Groundwater Systems Management Area Review are as follows:

- Water levels are declining on the Gnangara and Jandakot Mounds due to a combination of regional climate change, local land use patterns and abstraction.

- The potential negative environmental, social and economic impacts of declining water levels are significant.

- Site-specific information about wetland function is required to appropriately manage the shallow groundwater systems of the Gnangara and Jandakot mounds.

- The investigation program outlined in Section 4 of this report will provide the information required for sustainable management of shallow groundwater systems on the Gnangara and Jandakot mounds and should be implemented by the Department of Water.

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Appendix 1. Monitoring network audit: maps and tables

Contents

Explanatory Notes

The results of the monitoring network audit are presented in the following maps and tables. Location details (co-ordinates, wetland classification of Hill *et al.,* 1993, Aboriginal Heritage status, etc) and a summary of current management issues as identified by numerous sources (Froend *et al.,* 2004, Rockwater, 2003) is provided for each shallow groundwater system site. The maps show superficial aquifer DoW and non-DoW monitoring bores stored in WIN (Water Information Network) within approximately 500 m of each wetland site and any existing staff gauges. All monitoring bores and staff gauges were assessed for their suitability to be used in an investigation of the sustainability of shallow groundwater systems. The accompanying tables for each map provide bore details and reasons for unsuitability. A detailed explanation of the symbology used to depict bore status as determined from the review and rationale of suitability/unsuitability is given below.

DoW monitoring bore

DoW monitoring bores that are currently operational, appropriately positioned with the respect to regional groundwater flow, have known construction and lithology information are considered suitable for a shallow groundwater system investigation. DoW monitoring bores are labelled on each map and general bore information is given in the accompanying table.

Unsuitable DoW monitoring bore

DoW monitoring bores that are currently not operating, have insufficient construction information (i.e. no screen interval data) are deemed unsuitable. These bores require further investigation to determine their suitability for inclusion into a shallow groundwater systems monitoring network. Other bores are considered unsuitable due to screen lengths being greater than 10 m. Unsuitable DoW monitoring bores are labelled on each map and general bore information, including the reason for unsuitability is given in the accompanying tables.

DoW criteria bore

DoW monitoring bores that are suitably placed near existing ecological monitoring transects and adequately reflect wetland and/or groundwater levels are considered suitable. These bores are labelled on each map and bore data given in the accompanying tables.

Unsuitable DoW criteria bore

DoW criteria bores that are not placed near an ecological monitoring transect from which an Environmental Water Provision has been set is considered an unsuitable criteria bore. In most cases a new criteria bore is required. These bores are labelled on the map, and bore data and reasons for unsuitability are given in the accompanying tables.

DoW staff gauge

Suitable DoW staff gauges are positioned within a wetland body such that the gauge can read minimum water levels. Theoretically staff gauges should be placed at the deepest region of a wetland.


DoW Criteria staff gauge

As above, but gauges are criteria staff gauges.


Unsuitable DoW Criteria staff gauge

DoW staff gauges that are not positioned within a wetland water body, or become stranded when there remains open water within a wetland are considered unsuitable.


Unsuitable DoW staff gauge

DoW staff gauges that are not positioned within a wetland water body, or become stranded when there remains open water within a wetland are considered unsuitable.


DoW other bores

DoW other bores are those bores that are generally not part of the current DoW monitoring network. These bores are usually not-operating or abandoned, though may have been used for investigation and/or monitoring in the past. Further onsite investigation of these bores is required to determine whether they are suitable for inclusion in a shallow groundwater system investigation. DoW other bores are usually not labelled on the maps but existing bore data is given in the accompanying tables.


Non- DoW other bores

Non- DoW other bores are those bores that are not monitored by the DoW. Some are privately owned and are used to fulfil groundwater license conditions. Others have been installed for other investigation purposes. Many are not operating or abandoned. Bore construction and lithological details are often missing. These bores are Non-DoW other bores are usually not considered suitable for a shallow groundwater system investigation and if shown on a map, are not labelled, and not included in the tables.


Water Corporation Bores

Water Corporation bores can have large screen intervals which are not suitable for a shallow groundwater systems investigation.


Proposed bore

Based on the requirements for a suitable monitoring network for investigating the sustainability of shallow groundwater systems as identified in this review, sites for new monitoring bores are proposed. In most cases the proposed site consists of a watertable bore, an intermediate bore and a base of superficial aquifer monitoring bore.


Proposed neutron tube

At selected vegetation monitoring transects clusters of neutron tubes are proposed.


Ecological monitoring transect

The location of existing ecological monitoring transects.


Threatened Ecological Communities (TECs)

TECs are defined by the Department of Environment and Conservation (DEC)

Definition of abbreviations

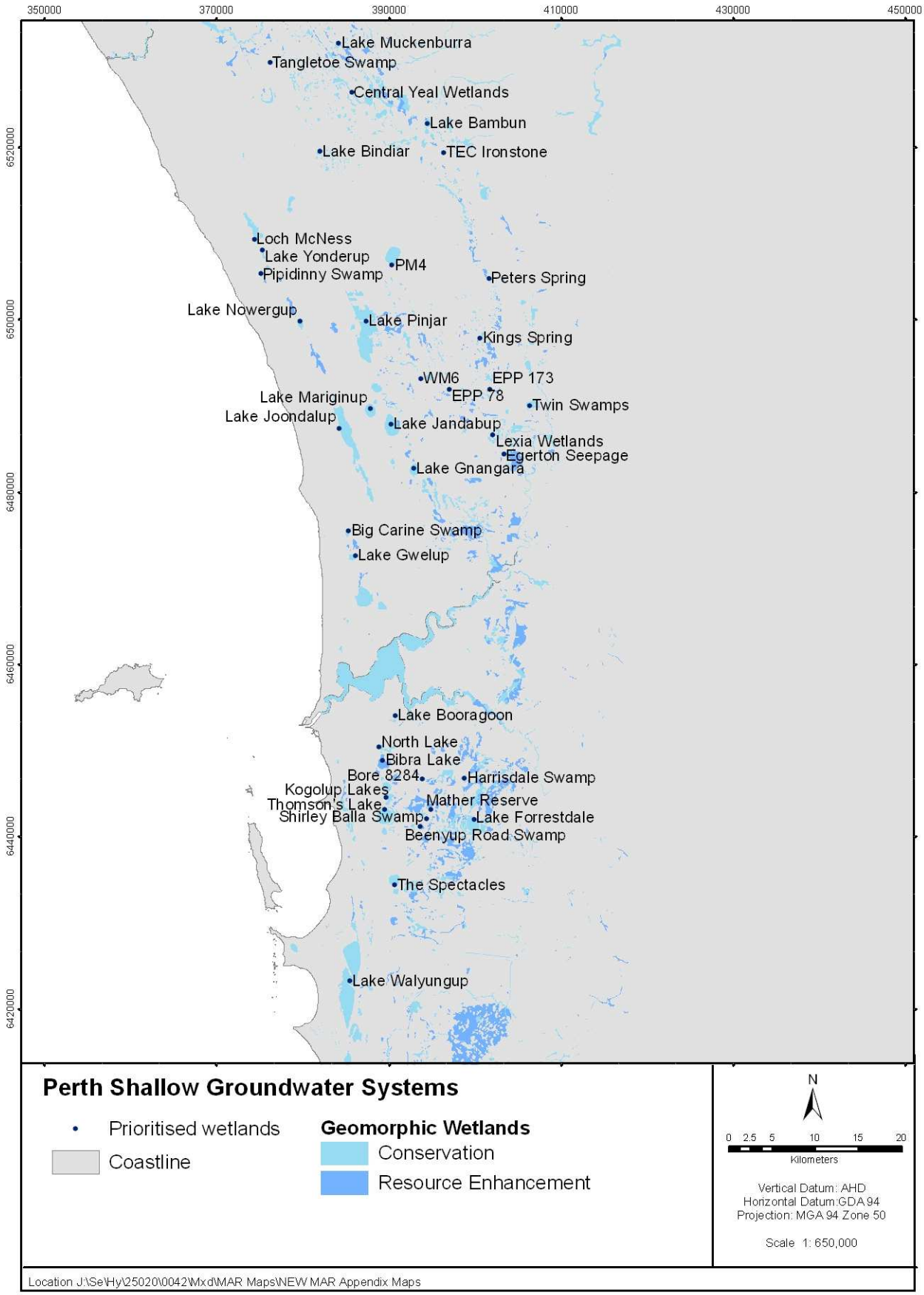
AWRC – Australian Water Resource Council
WIN – Water Information Network. This is the Department of Water database of groundwater and surface water monitoring and sampling infrastructure.
AHD – Australian Height Datum
GW – groundwater

Purpose
D - Domestic
E - Exploration
I - Investigation
M - Monitoring
MC – Ministerial Criteria
O - Observation
P - Production

Lithology
Y – Yes. Lithological logs are recorded in WIN
N – No. Lithological logs are not recorded in WIN

Geophysical Logs
Y – Yes. Geophysical logs are recorded in WIN
N – No. Geophysical logs are not recorded in WIN

Status
A - Abandoned
NO – Not operating
O – Operating



Map of prioritised shallow groundwater system sites.

Lake Bambun

Wetland/GDE name	Lake Bambun
Location (co-ords)	E: 394510, N: 6522805
Wetland/GDE type & description	Permanent lake
Ecological recognition	Conservation Category, EPP
Aboriginal Heritage	Nine Registered Sites of Significance (19138, 19183, 20008, 21615, 21616, 21617, 21618, 21619, 21620)
Wetland suite	Mungala (B/P.2)

Summary of Issues

- The site is hydrogeologically different from others in the region, in that it is a permanent lake and is probably perched.
- There is currently no monitoring infrastructure at the site.
- The site supports diverse fish species, vertebrates, macroinvertebrates and several surrounding TECs.

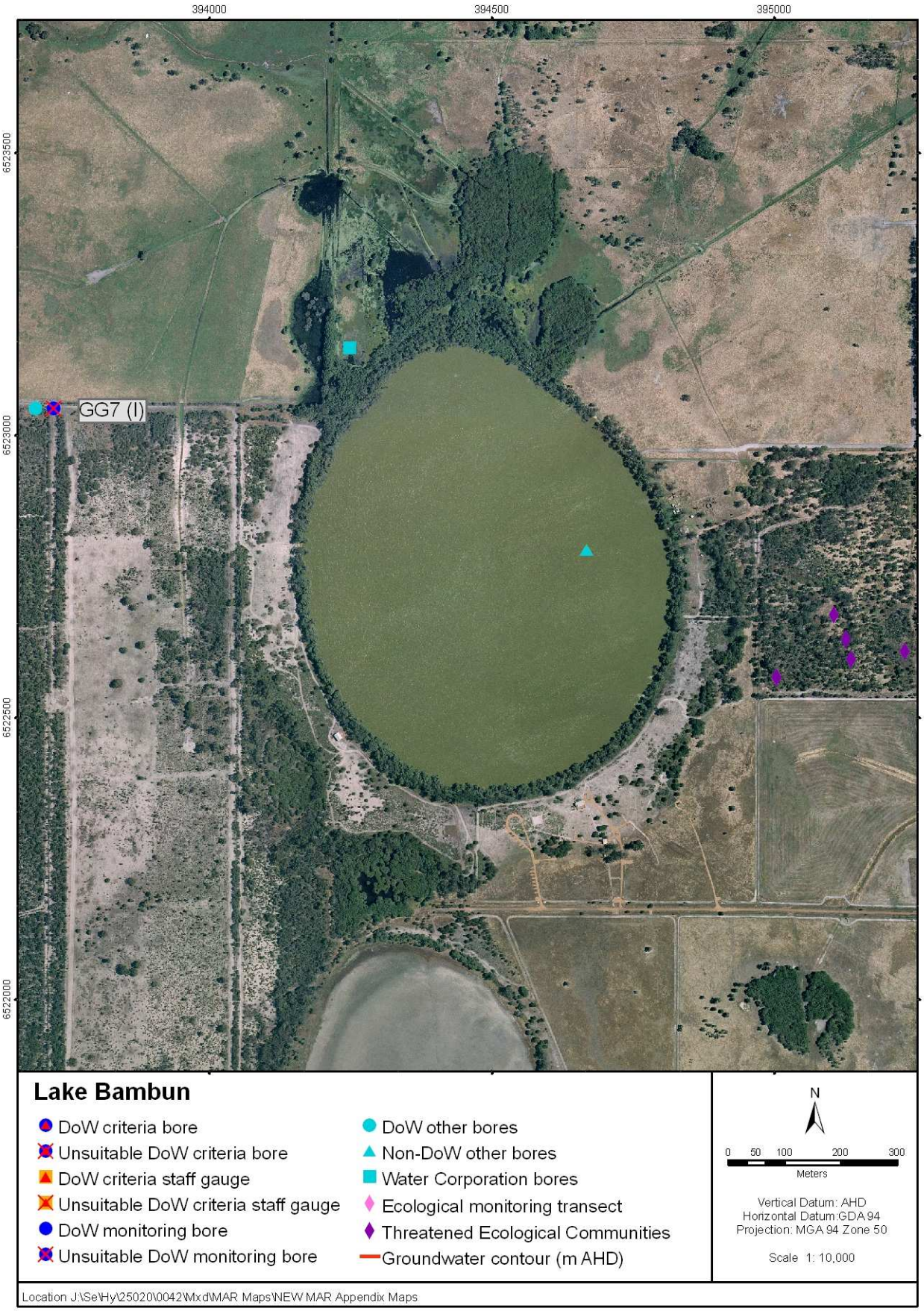
Suitable Monitoring Infrastructure

No current suitable infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable current monitoring bores and bores requiring further investigation

	DoW monitoring bore	**DoW Other Bore**	**Water Corp Bore**
AWRC Name	GG7 (I)	GG7 (O)	GINGIN OB7
AWRC Ref	61710107	61710108	61711686
Easting	393724	393692	394248
Northing	6523048	6523048	6523155
Purpose	I / M	O	
Depth drilled (m)	42		70
Screens (m)	26.9 - 39		
Lithology	N	N	Y
Status	O	NO	
Geophysical Logs	N	N	Y
Topography (mAHD)	70	70	70
Base superficial aquifer (mAHD)	24	24	25
GW* minimum (mAHD)	67	67	67
Depth to base superficial aquifer (m)	46	46	45
Depth to GW* (m)	3	3	3
Seasonal Variation (m)	1.1		
Reason for Unsuitability	Screens	Screens	Screens


394000
394500
395000
6523500
6523000
6522500
6522000
GG7 (I)
Lake Bambun
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Beenyup Road Swamp

Wetland/GDE name	Beenyup Road Swamp
Location (co-ords)	E: 393675, N: 6441183
Wetland/GDE type & description	Sumpland, seasonally inundated, through-flow lake
Ecological recognition	Conservation status, (none), or EPP, not sure which bit
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- The magnitude and time of inundation of Beenyup Road Swamp is progressively decreasing, resulting in a decline in wetland vegetation
- Classified as being at severe risk from drawdown
- Evidence of perching
- Waterbird habitat

Suitable Monitoring Infrastructure

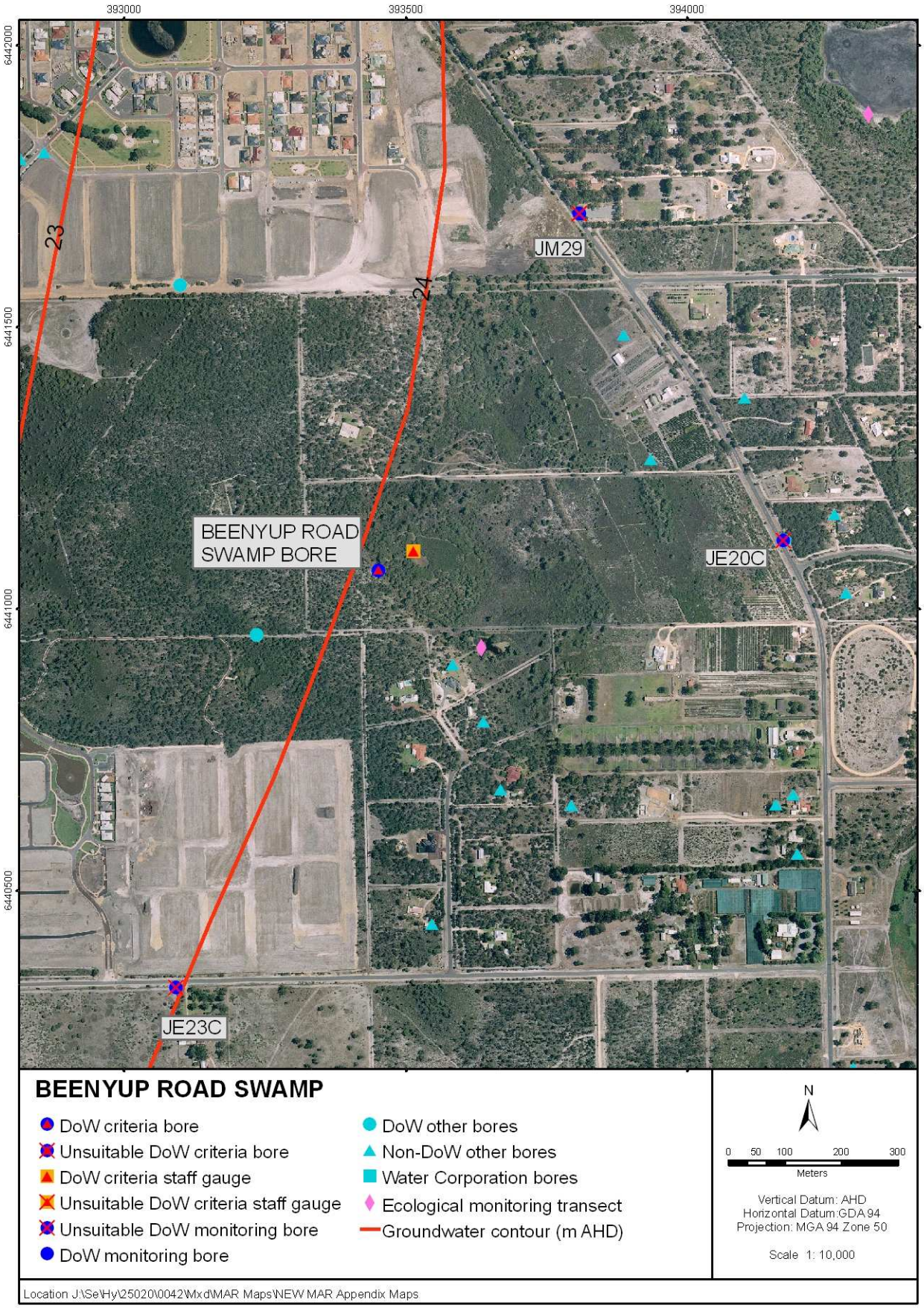
	Criteria Staff Gauge	**DoW monitoring bore**
AWRC Name	BEENYUP ROAD SWAMP	JE20C
AWRC Ref	6142547	61419706
Easting	393514	394171
Northing	6441102	6441122
Purpose	M / MC	O / M
Depth drilled (m)		6
Screens (m)		0 - 6
Lithology		N
Status	O	O
Topography (mAHD)		30
Base superficial aquifer (mAHD)		-18
GW* minimum (mAHD)		24
Depth to base superficial aquifer (m)		48
Depth to GW* (m)		6
Seasonal Variation (m)		1.5

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and infrastructure requiring further investigation

	Criteria Bore	**DoW monitoring bore**		
AWRC Name	BEENYUP ROAD SWAMP BORE	JM29	JE20C	JE23C
AWRC Ref	61410711	61410237	61419706	61419712
Easting	393452	393809	394171	393093
Northing	6441068	6441702	6441122	6440328
Purpose	M / MC	M	O / M	O / M
Depth drilled (m)	4.78		6	7.5
Screens (m)	1.5 - 4.78		0 - 6	4.5 - 7.5
Lithology	N	N	N	Y
Status	O	O	O	O
Topography (mAHD)	30	30	30	30
Base superficial aquifer (mAHD)	-18	-20	-18	-17
GW* minimum (mAHD)	24	24	24.5	24
Depth to base superficial aquifer (m)	48	50	48	47
Depth to GW* (m)	6	6	5.5	6
Seasonal Variation (m)	1.5	2.2	1.2	1.3
Reason for Unsuitability	Location	Screens	Location	Location

	DoW Other Bore	
AWRC Name	TD15A	TD13A
AWRC Ref	61410409	61410408
Easting	393236	393100
Northing	6440954	6441575
Purpose		
Depth drilled (m)		
Screens (m)		
Lithology	N	N
Status	A / NO	A / NO
Topography (mAHD)	30	30
Base superficial aquifer (mAHD)	-18	-21
GW* minimum (mAHD)	24	23.5
Depth to base superficial aquifer (m)	48	51
Depth to GW* (m)	6	6.5
Seasonal Variation (m)		
Reason for Unsuitability	Screens	Screens


393000
393500
394000
6442000
6441500
6441000
6440500
23
24
JM29
BEENYUP ROAD
SWAMP BORE
JE20C
JE23C
BEENYUP ROAD SWAMP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Bibra Lake

Wetland/GDE name	Bibra Lake
Location (co-ords)	E: 389289, N: 6448839
Wetland/GDE type & description	Permanently inundated
Ecological recognition	Conservation status
Aboriginal Heritage	Four Registered Sites of Significance (3196, 3293, 3709, 4107)
Wetland suite	Bibra (S/B.1)

Summary of Issues

- Water levels have fallen below preferred summer levels since 1998, and were below the absolute minimum level 2005 and 2007.
- Criteria bore has not been operating since 1999
- Poor correlation between groundwater levels and lake levels
- Waterbird refuge habitat

Suitable Monitoring Infrastructure

	DoW monitoring bore				**Criteria Staff Gauge**
AWRC Name	BM2A	BM2C	BM5A	BM5C	BIBRA LAKE 425
AWRC Ref	61410189	61410186	61410203	61419623	6142520
Easting	388492	388502	390173	390165	389289
Northing	6448887	6448887	6448261	6448261	6448839
Purpose	M	M	M	O / M	M / MC
Depth drilled (m)	52	19	41	6	
Screens (m)	40 - 45	14 - 17	33 - 36	0 - 6	
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	30	30	20	20	
Base superficial aquifer (mAHD)	-22	-22	-20	-20	
GW* minimum (mAHD)	12	12	15.5	15.5	
Depth to base superficial aquifer (m)	52	52	40	40	
Depth to GW* (m)	18	18	4.5	4.5	
Seasonal Variation (m)	1.2	0.5 - 1	1.2	0.4	

Unsuitable Monitoring Infrastructure

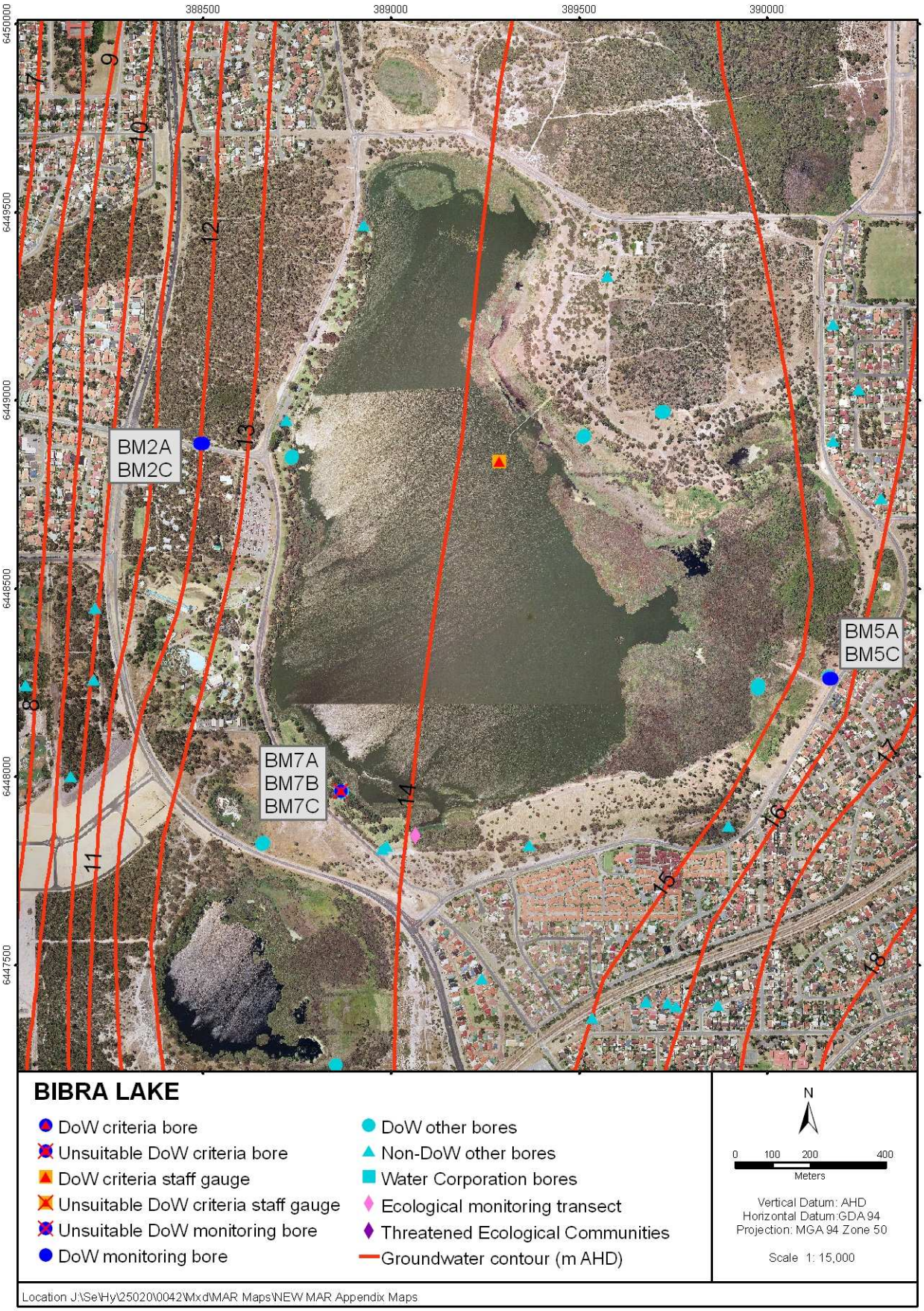
Unsuitable monitoring bores and bores requiring further investigation

	Criteria Bore	**DoW monitoring bore**
AWRC Name	BM7C	JM47
AWRC Ref	61410177	61410202
Easting	388867	390562
Northing	6447963	6448772
Purpose	MC	M
Depth drilled (m)	10	
Screens (m)	8 - 10	
Lithology	N	N
Status	NO	O
Topography (mAHD)	20	22
Base superficial aquifer (mAHD)	-21	-20
GW* minimum (mAHD)	14	17
Depth to base superficial aquifer (m)	41	42
Depth to GW* (m)	6	5
Seasonal Variation (m)		1
Reason for Unsuitability	Status	Screens

	DoW Other Bore				
AWRC Name	BM1A	BM1C	BM3A	BM3B	BM3C
AWRC Ref	61410187	61410188	61410182	61410183	61410184
Easting	388739	388737	389511	389513	389516
Northing	6448852	6448849	6448903	6448905	6448908
Purpose	M	M	M	M	M
Depth drilled (m)	31	6	35	16	6
Screens (m)	28 - 31	1 - 6	32 - 35	13 - 16	0 - 6
Lithology	N	N	N	N	N
Status	NO	NO	NO	NO	NO
Topography (mAHD)	20	20	20	20	20
Base superficial aquifer (mAHD)	-21	-21	-20	-20	-20
GW* minimum (mAHD)	13	13	14	14	14
Depth to base superficial aquifer (m)	41	41	40	40	40
Depth to GW* (m)	7	7	6	6	6
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	DoW Other Bore				
AWRC Name	BM4A	BM4B	BM4C	BM5C	BM6A
AWRC Ref	61410190	61410191	61410185	61410204	61410206
Easting	389727	389721	389724	390165	389978
Northing	6448970	6448970	6448971	6448267	6448244
Purpose	M	M	M		M
Depth drilled (m)	46	28	17.5	6	40
Screens (m)	41 - 44	25 - 28	12 - 17.5	0 - 6	33 - 36
Lithology	N	N	N	N	N
Status	NO	NO	NO	A / NO	NO
Topography (mAHD)	25	25	25	20	20
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-20
GW* minimum (mAHD)	14.5	14.5	14.5	15.5	15
Depth to base superficial aquifer (m)	45	45	45	40	40
Depth to GW* (m)	10.5	10.5	10.5	4.5	5
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	DoW Other Bore			
AWRC Name	BM6B	BM6C	BM7A	BM7B
AWRC Ref	61410207	61410205	61410179	61410178
Easting	389976	389976	388872	388870
Northing	6448241	6448235	6447960	6447961
Purpose	M	M	M	M
Depth drilled (m)	20	6	42	25
Screens (m)	18 - 20	3 - 6	34 - 37	23 - 25
Lithology	N	N	N	N
Status	NO	NO	NO	NO
Topography (mAHD)	20	20	20	20
Base superficial aquifer (mAHD)	-20	-20	-21	-21
GW* minimum (mAHD)	15	15	14	14
Depth to base superficial aquifer (m)	40	40	41	41
Depth to GW* (m)	5	5	6	6
Seasonal Variation (m)				
Reason for Unsuitability	Status	Status	Status	Status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389000
389500
390000
6450000
6449500
6449000
6448500
6448000
6447500
7
8
9
10
11
12
13
14
15
16
17
18
BM2A
BM2C
BM5A
BM5C
BM7A
BM7B
BM7C
BIBRA LAKE
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 100 200 400
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Big Carine Swamp

Wetland/GDE name	Big Carine Swamp
Location (co-ords)	E: 385336, N: 6475527
Wetland/GDE type & description	Sumpland
Ecological recognition	Bush Forever site, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Balcatta (S.2)

Summary of Issues

- Condition of the wetland has declined as water levels have decreased
- Classified as being at severe risk from drawdown
- No vegetation monitoring transect
- Waterbird habitat

Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and infrastructure requiring further investigation

	DoW monitoring bore		**Staff Gauge**
AWRC Name	GM1	GM4	BIG CARINE SWAMP 464
AWRC Ref	61610039	61610038	6162509
Easting	385605	385811	385014
Northing	6476010	6474995	6475104
Purpose	M	M	M
Depth drilled (m)	16.21	20.9	
Screens (m)	4.21 - 16.21	8.9 - 20.9	
Lithology	N	N	
Status	O	O	O
Topography (mAHD)	10	15	
Base superficial aquifer (mAHD)	-25	-25	
GW* minimum (mAHD)	4	5	
Depth to base superficial aquifer (m)	35	40	
Depth to GW* (m)	6	10	
Seasonal Variation (m)	1 - 1.5	1.4	
Reason for Unsuitability	Screens	Screens	Stranded


385000
385500
386000
6476000
6475500
6475000
GM1
GM4
BIG CARINE SWAMP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW staff gauge
Unsuitable DOW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Bindiar

Wetland/GDE name	Lake Bindiar
Location (co-ords)	E: 381987, N: 6519544
Wetland/GDE type & description	Dampland (remnant wetland)
Ecological recognition	Conservation Category, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- The site is in the Yarragadee impact area.
- Field evidence suggests lake levels have been much higher in the past and that the wetland may be detaching from the regional water table.
- The site contrasts to the other sites in this complex area.
- No hydrogeological studies have been undertaken in the area.
- Site has an excellent palaeoclimate record stored in the wetland sediments.
- The site is close to the pine plantations.

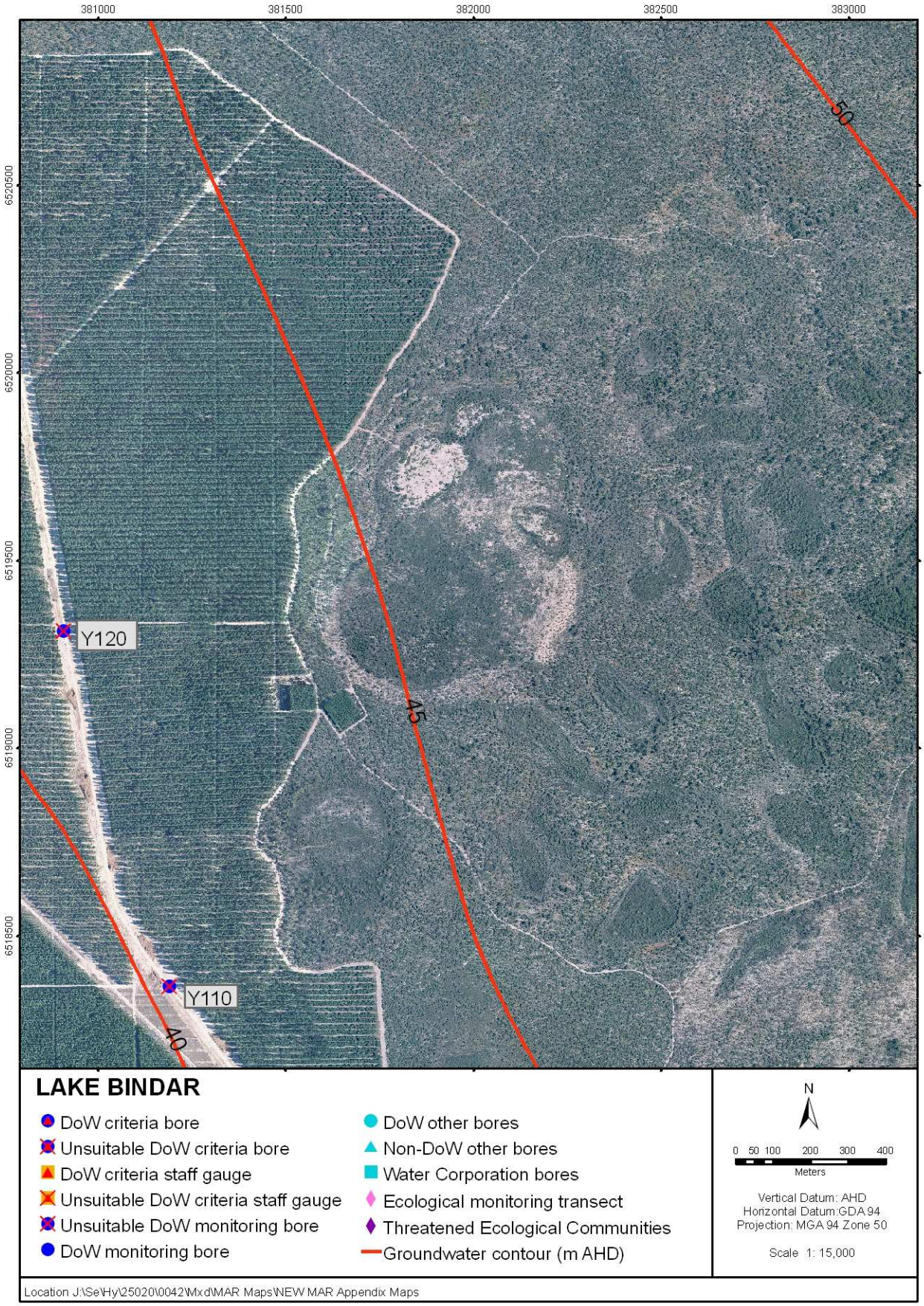
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable infrastructure; no infrastructure requiring further investigation

	DoW monitoring bore	
AWRC Name	Y110	Y120
AWRC Ref	61710049	61710050
Easting	381190	380908
Northing	6518365	6519312
Purpose	M	O / M
Depth drilled (m)	58	59
Screens (m)	15 - 54	15 - 52
Lithology	N	N
Status	O	O
Topography (mAHD)	59	55
Base superficial aquifer (mAHD)	1	1
GW* minimum (mAHD)	40	41
Depth to base superficial aquifer (m)	58	54
Depth to GW* (m)	18	13
Seasonal Variation (m)	Negligible	Negligible
Reason for Unsuitability	Screens	Screens


381000
381500
382000
382500
383000
6520500
6520000
6519500
6519000
6518500
Y120
Y110
50
50
40
LAKE BINDAR
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300 400
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Bore 8284

Wetland/GDE name	Bore 8284
Location (co-ords)	E: 393919, N: 61610178
Wetland/GDE type & description	Sumpland
Ecological recognition	-
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	

Summary of Issues

- Phreatophytic vegetation Ministerial criteria site
- Ministerial criteria bore is not deep enough to measure water levels and needs to be replaced.

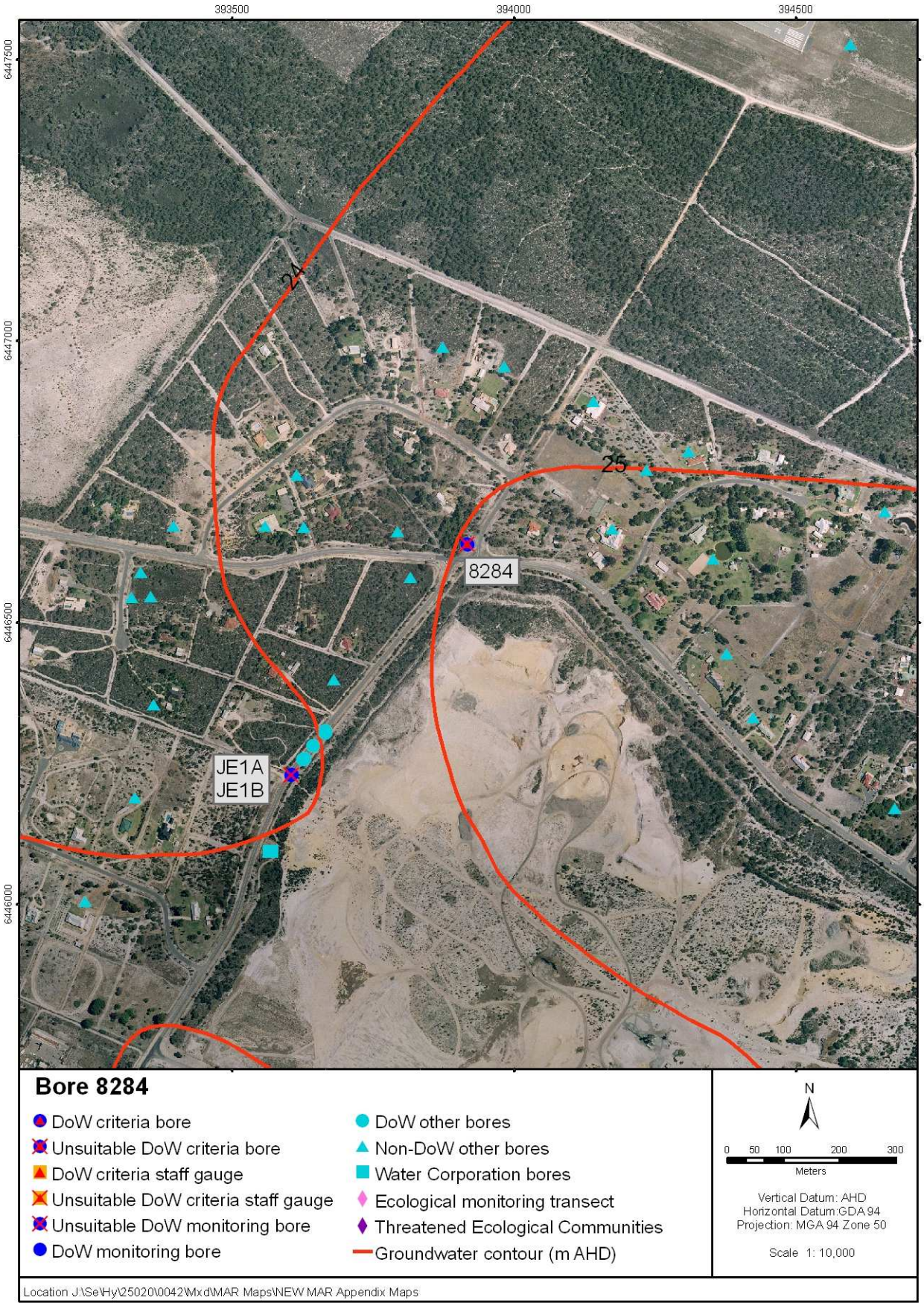
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure.

Unsuitable Monitoring Infrastructure

	DoW monitoring bore			Water Corp. bore
AWRC Name	8284	JE1A	JE1B	J380
AWRC Ref	61610178	61410242	61410243	61410611
Easting	393919	393605	393606	393566
Northing	6446639	6446230	6446231	6446094
Purpose	M/MC	O/M	O/M	P
Depth drilled (m)	3.6	58.5	20	57
Screens (m)	-	41.5 – 58.5	13 - 18	39 - 57
Lithology	N	N	N	N
Status	O	O	O	NO
Topography (mAHD)	30	40	40	40
Base superficial aquifer (mAHD)	-18	-18	-18	-18
GW* minimum (mAHD)	25	24	24	24
Depth to base superficial aquifer (m)	48	58	58	58
Depth to GW* (m)	5	16	16	16
Seasonal Variation (m)	0.8	1.5	1.0	
Reason for Unsuitability	Screens	Screens	Location	Screens

	DoW other bores				
AWRC Name	JE2A	JE2B	JE3	T50(I)	T50(O)
AWRC Ref	61410244	61410245	61410246	61410241	61410240
Easting	393627	393629	393666	393645	393666
Northing	6446257	6446259	6446308	6446281	6446304
Purpose	I	O	O	P	O
Depth drilled (m)	57	-	-	53	51.5
Screens (m)	40 – 57	-	-	33 – 50	8.14 – 51
Lithology	N	N	N	Y	Y
Status	NO	NO	NO		NO
Topography (mAHD)	35	35	35	35	35
Base superficial aquifer (mAHD)	-18	-18	-18	-18	-18
GW* minimum (mAHD)	24	24	24	24	24
Depth to base superficial aquifer (m)	53	53	53	53	53
Depth to GW* (m)	11	11	11	11	11
Seasonal Variation (m)	-	-	-	-	-
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens


393500
394000
394500
6447500
6447000
6446500
6446000
24
25
8284
JE1A
JE1B
Bore 8284
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Booragoon Lake

Wetland/GDE name	Booragoon Lake
Location (co-ords)	E: 390768, N: 6454043
Wetland/GDE type & description	Permanently inundated
Ecological recognition	EPP, National importance
Aboriginal Heritage	Three Registered Sites of Significance (3297, 3298, 21469)
Wetland suite	Jandakot (B.3)

Summary of Issues

- Current water levels are the lowest in recent history
- Booragoon lake is a wetland with low-closed forest and closed scrub, and is one of only a few such lakes in the metropolitan region that remains in good condition
- Important waterbird breeding and roosting site

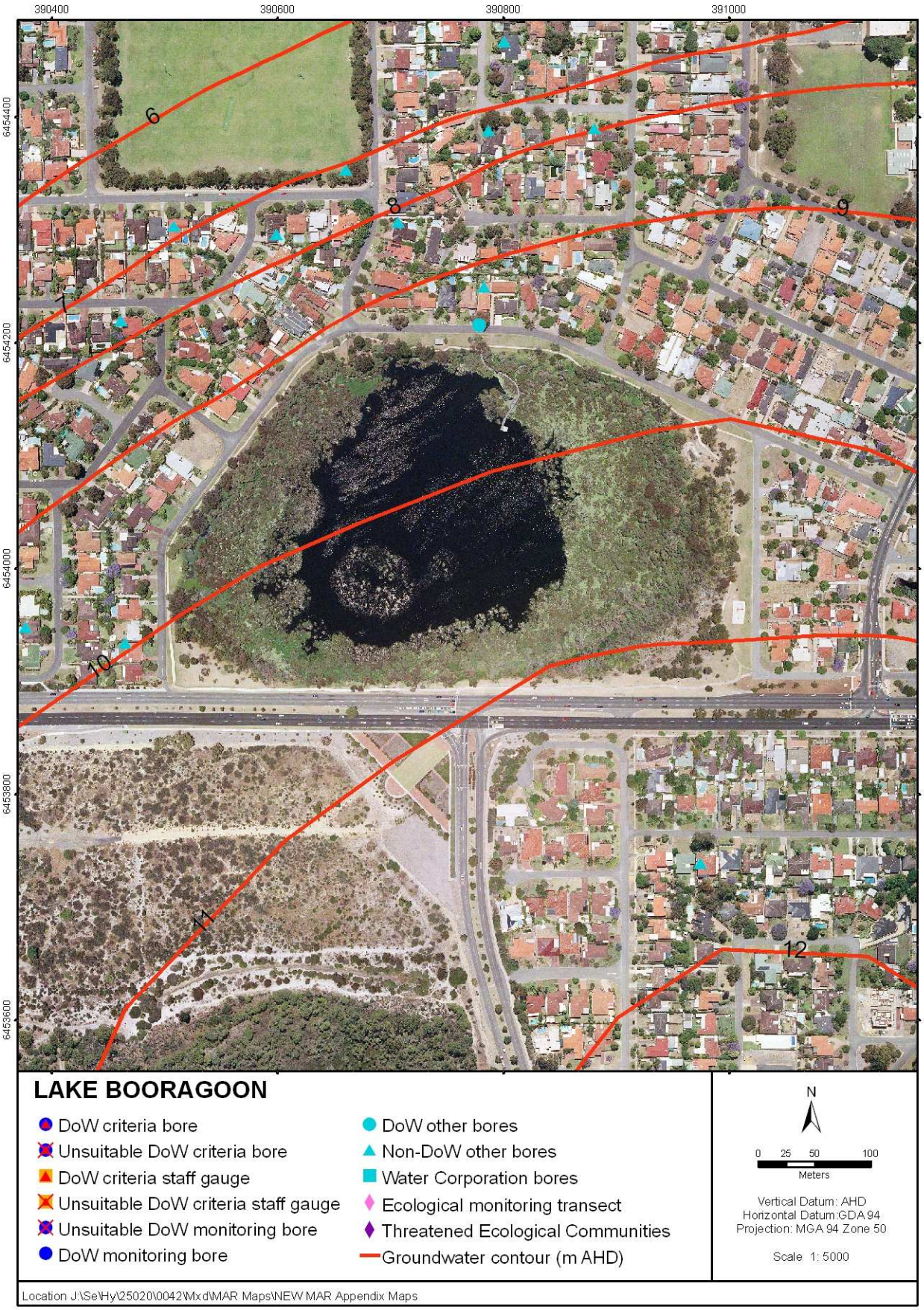
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and infrastructure requiring further investigation

	DoW Other Bore
AWRC Name	264
AWRC Ref	61610146
Easting	390779
Northing	6454216
Purpose	
Depth drilled (m)	
Screens (m)	
Lithology	N
Status	NO
Topography (mAHD)	15
Base superficial aquifer (mAHD)	-20
GW* minimum (mAHD)	9
Depth to base superficial aquifer (m)	35
Depth to GW* (m)	6
Seasonal Variation (m)	
Reason for Unsuitability	Screens


390400
390600
390800
391000
6454400
6454200
6454000
6453800
6453600
6
7
8
9
10
11
12
LAKE BOORAGOON
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 25 50 100
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 5000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Central Yeal Wetlands

Wetland/GDE name	Central Yeal (88)
Location (co-ords)	E: 385718, N: 6526406
Wetland/GDE type & description	Floodplain/Fluvial feature
Ecological recognition	Conservation Category
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Mungala (B/P.2)

Summary of Issues

- The site is in an area that is hydrogeologically complex but to date no hydrogeological studies have been undertaken in the area.
- The site is in close proximity to Yarragadee impact area, and links in with the North Gnangara deep drilling investigation
- The site is morphologically different to other wetland sites (it is a palaeodrainage feature) and as such probably functions hydrogeologically different to other sites on Gnangara Mound.
- Due to location on the Mound, the site is probably influenced by Guildford Clay, hence investigation results can be extrapolated to wetlands in similar settings (ie Lexia wetlands).
- Because of association with Guildford Clay this site can be compared to sites that are hydrogeologically controlled by diatomaceous sediments.

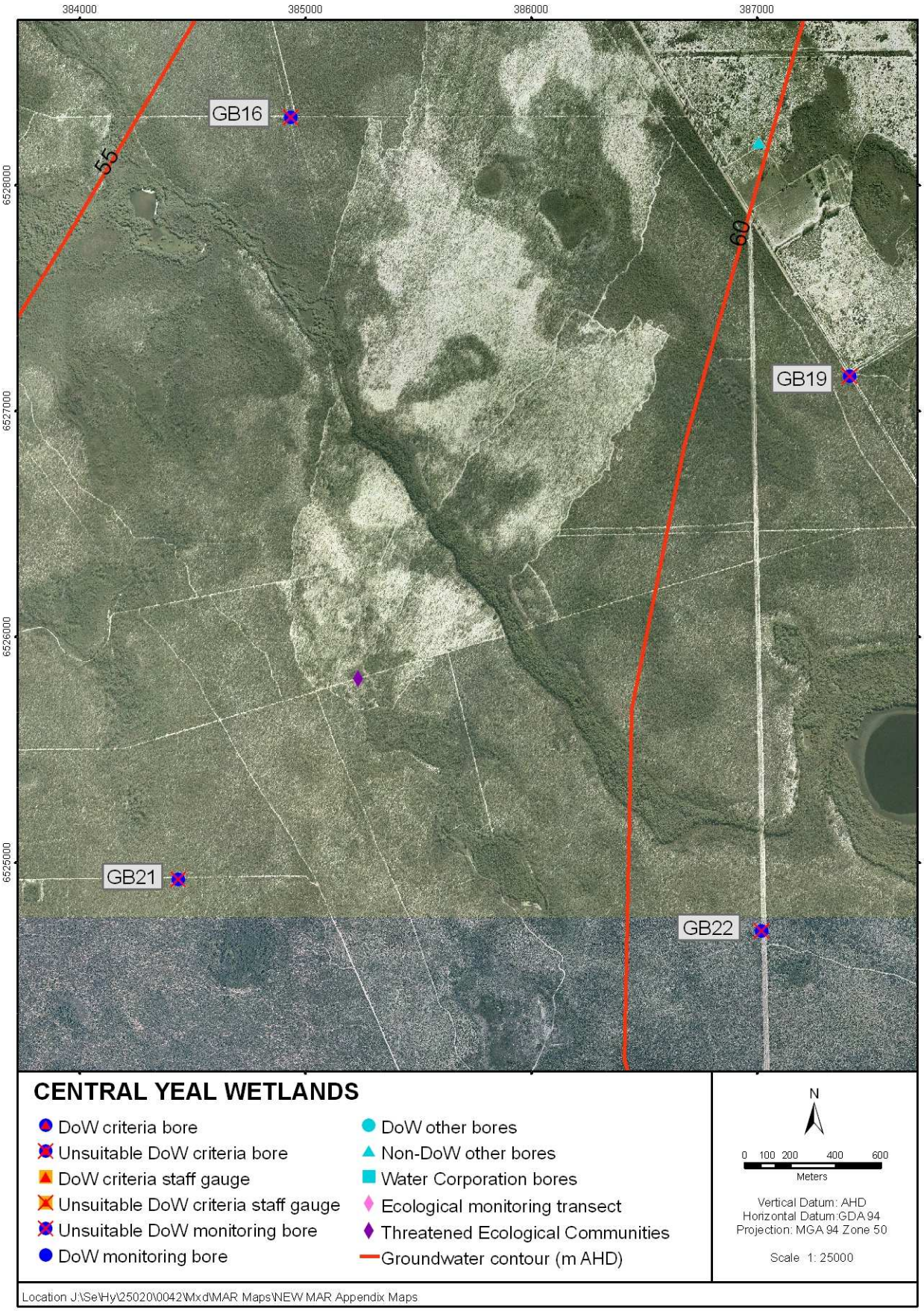
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores; no bores requiring further investigation

	DoW monitoring bore			
AWRC Name	GB19	GB21	GB22	GB16
AWRC Ref	61710098	61710089	61710097	61710092
Easting	387414	384439	387022	384936
Northing	6527158	6524929	6524698	6528303
Purpose	M	M	M	M
Depth drilled (m)	12.2	18.18	19.3	3.88
Screens (m)	2 – 12	3 – 17.5	4 - 18.5	2 - 3.88
Lithology	N	N	N	N
Status	O	O	O	O
Topography (mAHD)	65	65	65	60
Base superficial aquifer (mAHD)	30	15	23	24
GW* minimum (mAHD)	61	57	61	56
Depth to base superficial aquifer (m)	35	50	42	36
Depth to GW* (m)	4	8	5	4
Seasonal Variation (m)	0.8	1.0	0.8	0.8
Reason for Unsuitability	Location	Screens	Screens	Location


384000
385000
386000
387000
6528000
6527000
6526000
6525000
GB16
GB19
GB21
GB22
55
60
CENTRAL YEAL WETLANDS
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 100 200 400 600
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 25000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Egerton Seepage

Wetland/GDE name	Egerton Seepage
Location (co-ords)	E: 403389, N: 6484444
Wetland/GDE type & description	Groundwater seepage
Ecological Recognition	Conservation Category
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Muchea (B/P.3)

Summary of Issues

- The site is in compliance of Ministerial Criteria (April 2005) but is at risk of breaching due to declining water levels.
- There is no surface water-monitoring site.
- Our understanding of groundwater seepages on Gnangara Mound is poor and information gained from investigating this site could be extrapolated to other seepages across the Gnangara and Jandakot Mounds.
- Site is in close proximity to the Vines development and high density of superficial licenses.

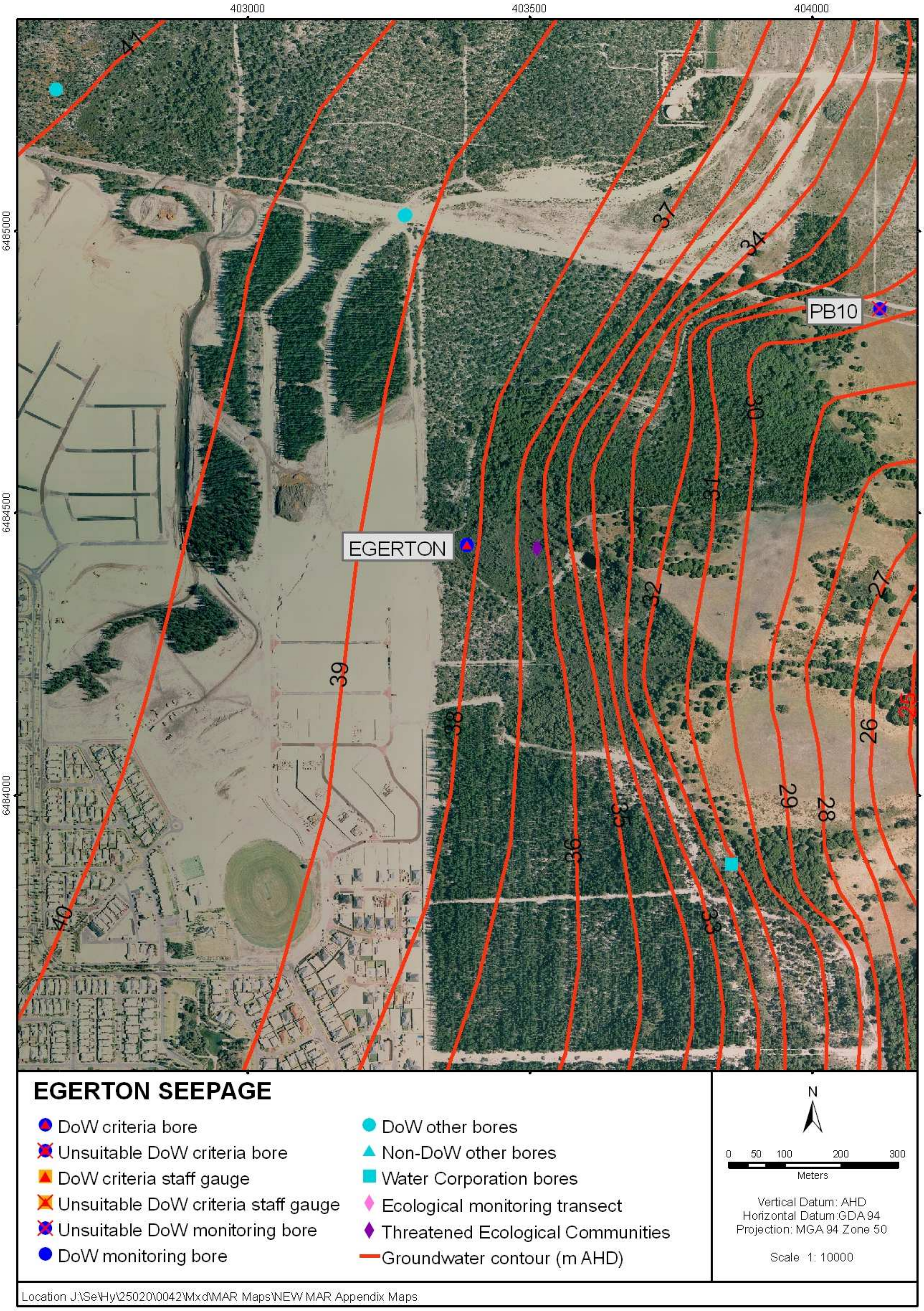
Suitable Monitoring infrastructure

	Criteria Bore
AWRC Name	EGERTON
AWRC Ref	61618607
Easting	403389
Northing	6484444
Purpose	M / MC
Depth drilled (m)	
Screens (m)	
Lithology	N
Status	O
Topography (mAHD)	40
Base superficial aquifer (mAHD)	-1
GW* minimum (mAHD)	38
Depth to base superficial aquifer (m)	41
Depth to GW* (m)	2
Seasonal Variation (m)	0.6

Unsuitable Monitoring infrastructure

Unsuitable current monitoring bores; no bores requiring further investigation

	DoW monitoring bore
AWRC Name	PB10
AWRC Ref	61611052
Easting	404121
Northing	6484862
Purpose	O / M
Depth drilled (m)	55
Screens (m)	41.2 - 44.2
Lithology	Y
Status	O
Geophysical Logs	Y
Topography (mAHD)	32
Base superficial aquifer (mAHD)	-1
GW* minimum (mAHD)	30.5
Depth to base superficial aquifer (m)	33
Depth to GW* (m)	1.5
Seasonal Variation (m)	3
Reason for Unsuitability	Location


403000
403500
404000
6485000
6484500
6484000
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
PB10
EGERTON
EGERTON SEEPAGE
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

EPP 78

Wetland/GDE name	EPP 78
Location (co-ords)	E: 397093, N: 6491888
Wetland/GDE type & description	Dampland
Ecological recognition	Conservation Category wetland, EPP lake
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot B.3

Summary of Issues

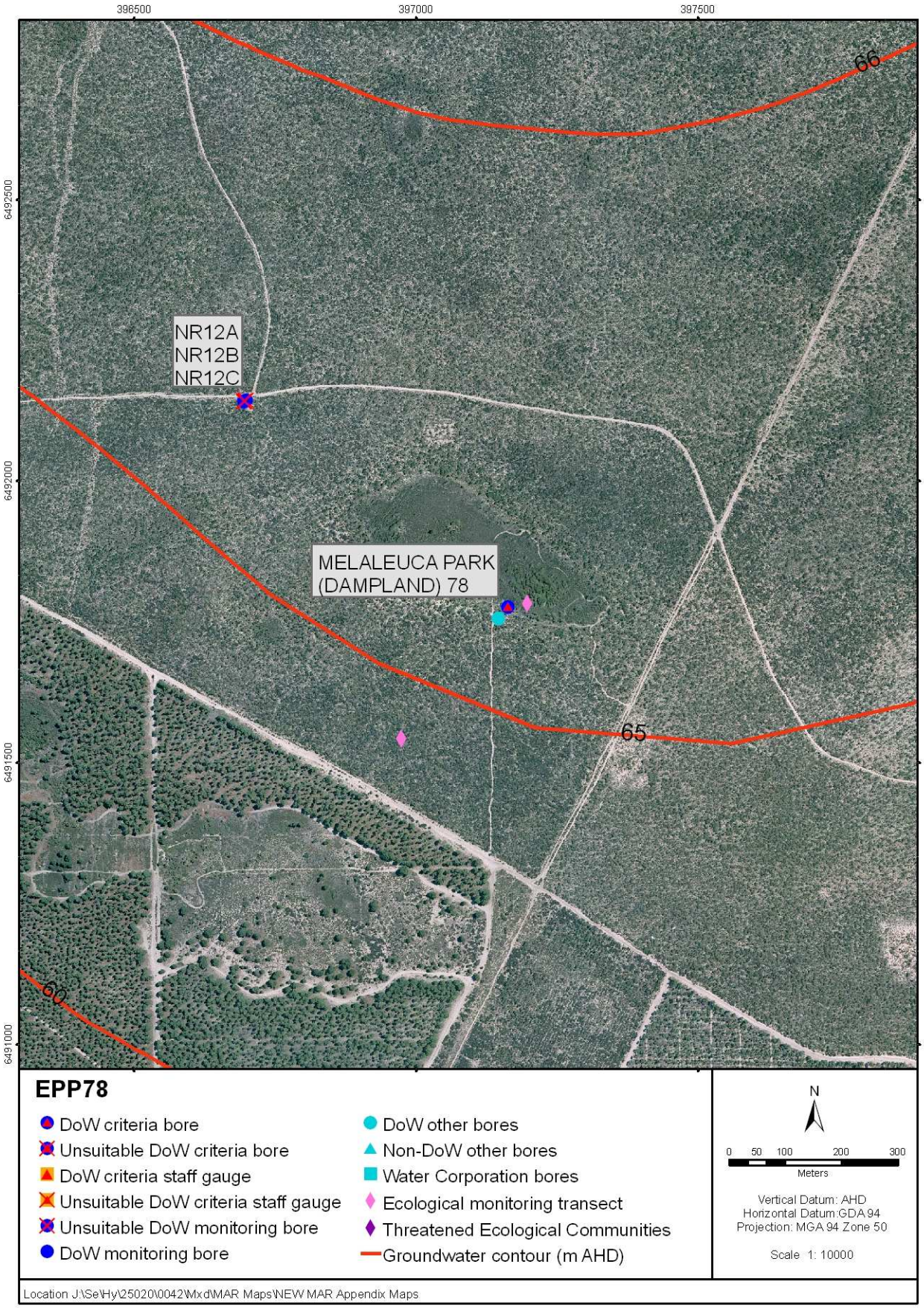
- No staff gauge to measure surface water
- Relationship between groundwater and lake levels is unclear
- Supports regionally important , endemic invertebrates
- High risk of ecological impact due to water level decline

Suitable Monitoring Infrastructure

	Criteria Bore
AWRC Name	MELALEUCA PARK (DAMPLAND) 78
AWRC Ref	61613231
Easting	397164
Northing	6491777
Purpose	M / MC
Depth drilled (m)	10.07
Screens (m)	5.07 - 10.07
Lithology	N
Status	O
Topography (mAHD)	70
Base superficial aquifer (mAHD)	-1
GW* minimum (mAHD)	65
Depth to base superficial aquifer (m)	71
Depth to GW* (m)	5
Seasonal Variation (m)	0.6 - 0.7

Unsuitable Monitoring Infrastructure

	DoW Monitoring Bore			DoW Other Bore
AWRC Name	NR12A	NR12B	NR12C	GNM13
AWRC Ref	61610937	61610938	61610936	61613212
Easting	396696	396697	396699	397147
Northing	6492142	6492143	6492144	6491757
Purpose	M	M	M	M
Depth drilled (m)	61	32	17.5	9.65
Screens (m)	57 - 60	28 - 31	11.5 - 17.5	3.65 - 9.65
Lithology	N	N	N	N
Status	O	O	O	NO
Topography (mAHD)	75	75	75	70
Base superficial aquifer (mAHD)	-1	-1	-1	-1
GW* minimum (mAHD)	65	65	65	65
Depth to base superficial aquifer (m)	76	76	76	71
Depth to GW* (m)	10	10	10	5
Seasonal Variation (m)	0.6	0.6	0.6	
Reason for Unsuitability	Location	Location	Location	Status


396500
397000
397500
6492500
6492000
6491500
6491000
66
65
60
NR12A
NR12B
NR12C
MELALEUCA PARK
(DAMPLAND) 78
EPP78
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

EPP 173

Wetland/GDE name	EPP 173 Melaleuca Park
Location (co-ords)	E: 401754, N: 6491898
Wetland/GDE type & description	Sumpland
Ecological recognition	Bushforever Site 399, System 6, EPP, Conservation Category
Aboriginal Heritage	Registered Site of Significance (3525)
Wetland suite	Riverdale (B.4)

Summary of Issues

- The site is in compliance with Ministerial Criteria but is at risk of breaching.
- The current criteria bore does not represent water levels at the vegetation monitoring transect
- The site has high vertebrate and macroinvertebrate species richness.
- Froend *et al.,* (2004) report that the site has unique hydrology, and is possibly perching

Suitable Monitoring Infrastructure

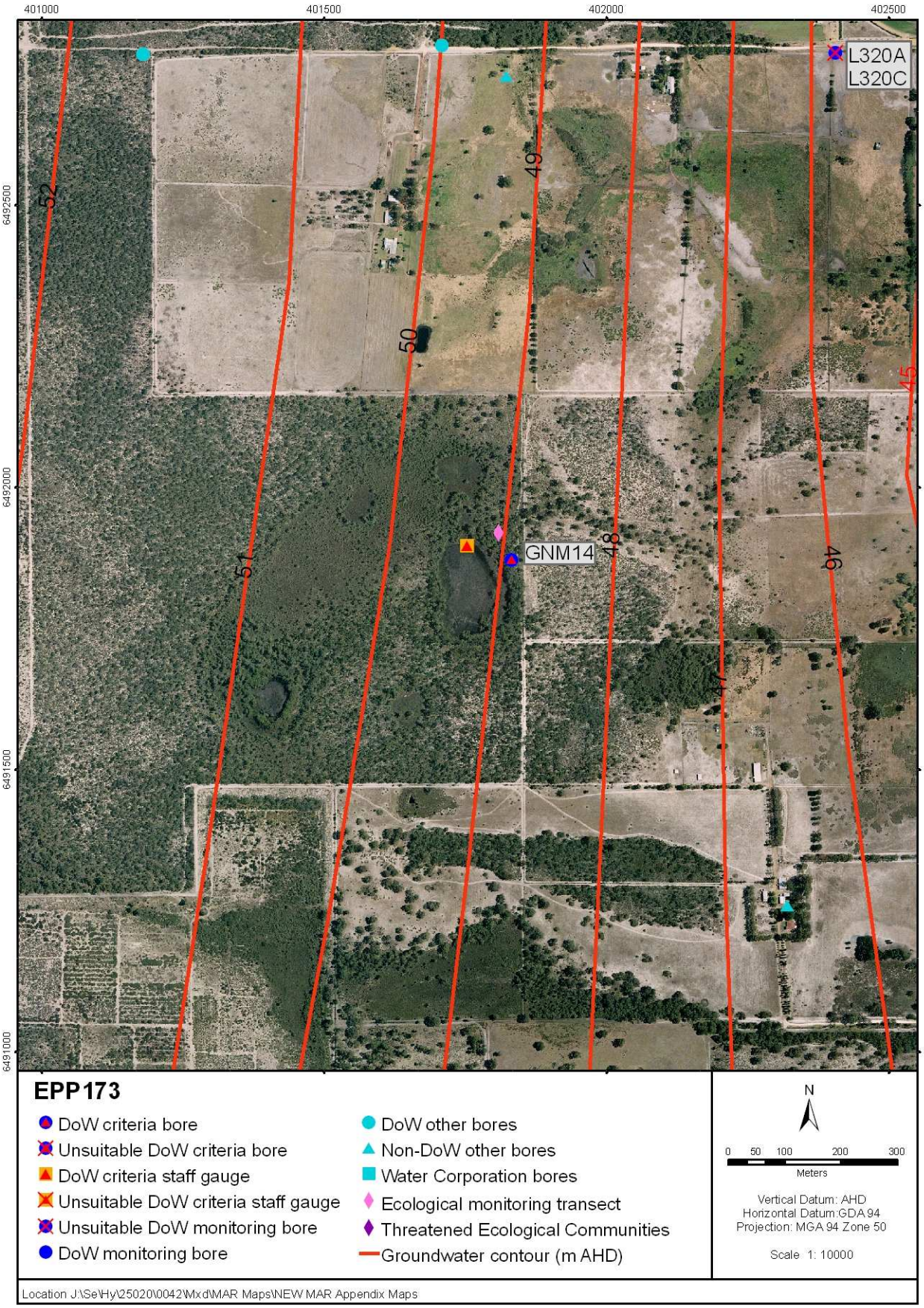
	Criteria Bore	**Criteria Staff Gauge**
AWRC Name	GNM14	MALELEUCA PARK 173 - EPP 173
AWRC Ref	61613213	6162628
Easting	401832	401754
Northing	6491872	6491898
Purpose	M	M / MC
Depth drilled (m)	8.1	
Screens (m)	2.1 - 8.1	
Lithology	N	
Status	O	O
Topography (mAHD)	53	
Base superficial aquifer (mAHD)	-4	
GW* minimum (mAHD)	49	
Depth to base superficial aquifer (m)	57	
Depth to GW* (m)	4	
Seasonal Variation (m)	2	

Unsuitable Monitoring Infrastructure

Unsuitable current monitoring bores and bores requiring further investigation.

	DoW monitoring bore	
AWRC Name	L320A	L320C
AWRC Ref	61611174	61611175
Easting	402406	402406
Northing	6492772	6492772
Purpose	O / M	O / M
Depth drilled (m)	64	8
Screens (m)	59.8 - 62.8	0 - 8
Lithology	Y	N
Status	O	O
Geophysical Logs	Y	Y
Topography (mAHD)	50	50
Base superficial aquifer (mAHD)	-2	-2
GW* minimum (mAHD)	46	46
Depth to base superficial aquifer (m)	52	52
Depth to GW* (m)	4	4
Seasonal Variation (m)	2	2
Reason for Unsuitability	Location	Location

	DoW Other Bores	
AWRC Name	NE 6-4	L310A
AWRC Ref	61612432	61611173
Easting	401709	401179
Northing	6492784	6492769
Purpose	M	O
Depth drilled (m)	4.15	67
Screens (m)	-	-
Lithology	N	Y
Status	NO	NO
Geophysical Logs	N	Y
Topography (mAHD)	55	60
Base superficial aquifer (mAHD)	-5	-5
GW* minimum (mAHD)	50	52
Depth to base superficial aquifer (m)	60	65
Depth to GW* (m)	5	8
Seasonal Variation (m)		
Reason for Unsuitability	Screens	Screens


401000
401500
402000
402500
6492500
6492000
6491500
6491000
L320A
L320C
GNM14
52
51
50
49
48
47
46
45
EPP173
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Forrestdale

Wetland/GDE name	Forrestdale Lake
Location (co-ords)	E: 399938, N: 6441937
Wetland/GDE type & description	Permanent lake
Ecological Recognition	Ramsar Wetland, Conservation Category, EPP, Register of the Estate
Aboriginal Heritage	Two Registered Sites of Significance (3713, 4149)
Wetland suite	Bennett Brook (B/P.4)

Summary of Issues

- The site is breaching Ministerial Criteria (April 2005).
- The current criteria bore does not reflect water levels at the site of the monitored vegetation transect.
- Classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- The current staff gauge at the northern end of the lake is unsuitable.
- Desktop assessment indicates that there could be a degree of perching in the lake.
- The lake hydrogeology is complex, however our understanding of groundwater/wetland interaction is poor.

Suitable Monitoring Infrastructure

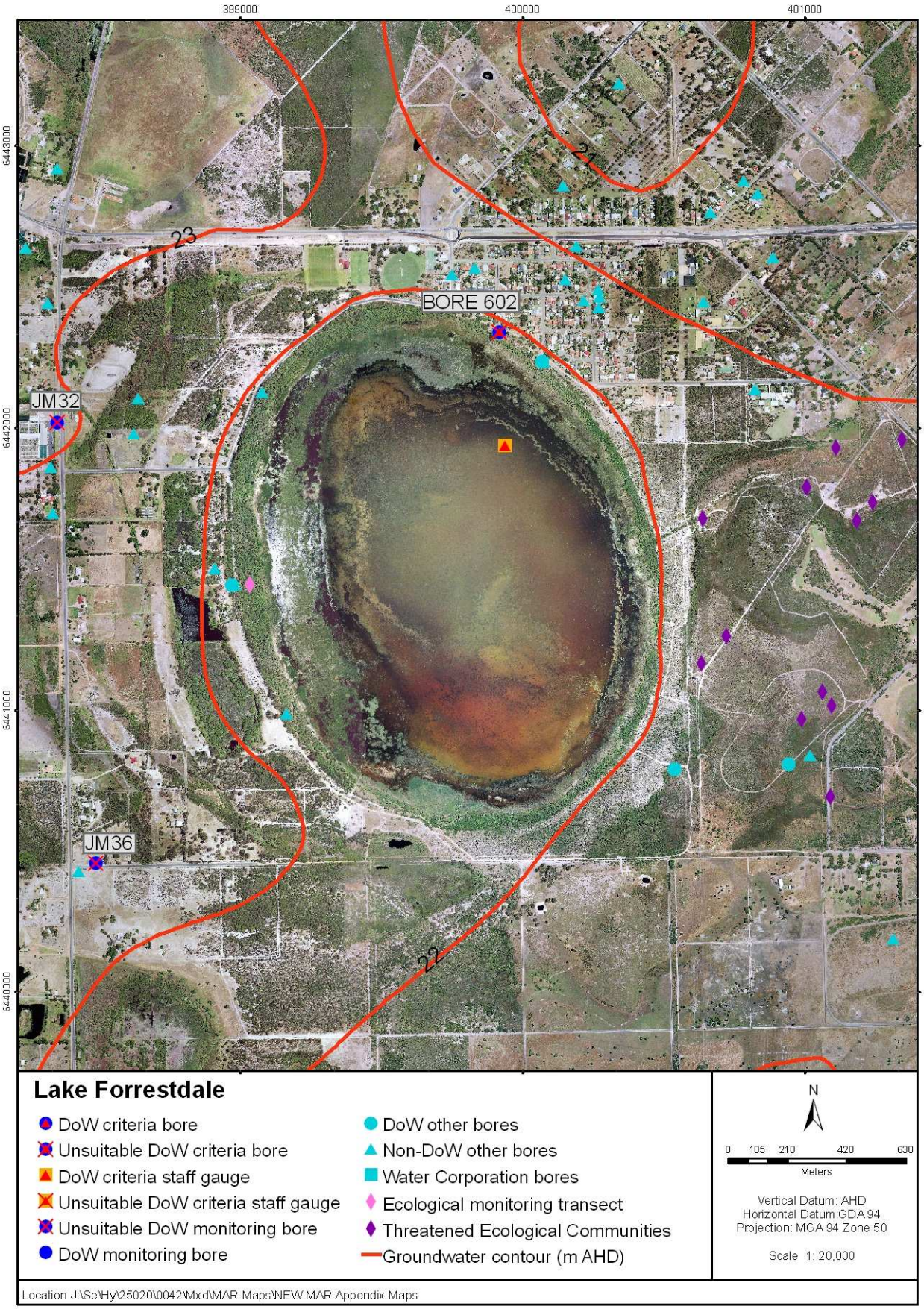
Criteria Bore (Bore 602) is unsuitable as a criteria bore, though may be suitable as a monitoring bore.

	Criteria Staff Gauge
AWRC Name	LAKE FORRESTDALE 602
AWRC Ref	6162557
Easting	399938
Northing	6441937
Purpose	M / MC
Depth drilled (m)	
Screens (m)	
Lithology	
Status	O

Unsuitable Monitoring Infrastructure

Unsuitable infrastructure and infrastructure requiring further investigation

	Criteria Bore	**DoW Monitoring Bore**	
AWRC Name	BORE 602	JM32	JM36
AWRC Ref	61410714	61610441	61610440
Easting	399919	398352	398489
Northing	6442341	6442020	6440458
Purpose	M / MC	M	M
Depth drilled (m)	6.36	15	20.2
Screens (m)	1.36 - 6.36	3 – 15	8.2 – 20.2
Lithology	N	N	N
Status	O	O	O
Topography (mAHD)	25	25	25
Base superficial aquifer (mAHD)	-10	-18	-11
GW* minimum (mAHD)	22	22	23
Depth to base superficial aquifer (m)	35	43	36
Depth to GW* (m)	3	3	2
Seasonal Variation (m)	2.5	0.7	1.0
Reason for Unsuitability	Location	Screens	Screens


399000
400000
401000
6443000
6442000
6441000
6440000
23
21
22
BORE 602
JM32
JM36
Lake Forrestdale
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 105 210 420 630
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Gnangara

Wetland/GDE name	Lake Gnangara
Location (co-ords)	E: 393063 N: 6482624
Wetland/GDE type & description	Lake
Ecological recognition	EPP Wetland
Aboriginal Heritage	Four registered sites of significance (Site ID 3772, 3319, 3169, 682)
Wetland suite	Gnangara B.2

Summary of Issues

- Severe risk of water level decline
- Management of sediment anoxia/oxia required
- Permanent acidification since 1980's
- Need to understand potential for groundwater degradation
- Little water quality monitoring data
- Staff gauge subject to damage from vandalism

Suitable Monitoring Infrastructure

	DoW Monitoring Bore
AWRC Name	8386
AWRC Ref	61618440
Easting	393395
Northing	6482300
Purpose	M
Depth drilled (m)	5.67
Screens (m)	2.75 – 5.67
Lithology	N
Status	O
Geophysical Logs	N
Topography (mAHD)	45
Base superficial aquifer (mAHD)	-5
GW* minimum (mAHD)	42
Depth to base superficial aquifer (m)	50
Depth to GW* (m)	3
Seasonal Variation (m)	0.7

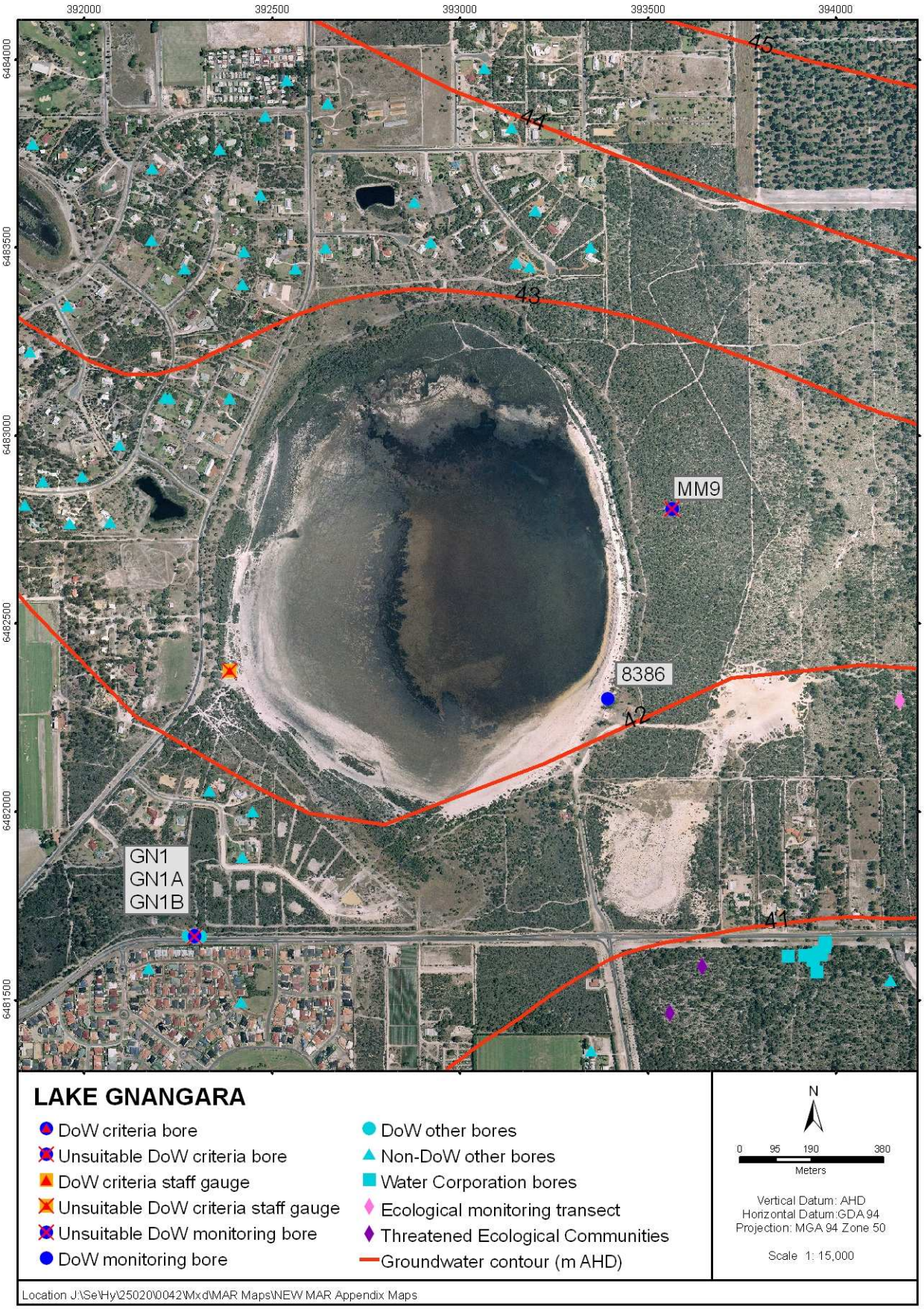
Unsuitable Monitoring Infrastructure

Staff gauge location in WIN incorrect. Actual staff gauge located on SE edge of lake.

	Criteria Staff gauge	**DoW Monitoring Bore**		**DoW Other Bore**	
AWRC Name	Lake Gnangara 8386	GN1A	MM9	GN1	GN1B
AWRC Ref	6162591	61610815	61610843	61610812	61610813
Easting	392389	392295	393565	392279	392310
Northing	6482374	6481669	6482805	6481670	6481667
Purpose	M/MC	O/M	M	I	O
Depth drilled (m)		21.11	25.6	65.53	9.75
Screens (m)		-	12.46 – 25.6	32.92 – 45.11	-
Lithology		N	N	Y	N
Status	O	O	O	NO	NO
Geophysical Logs		N	N	Y	N
Topography (mAHD)		50	55	50	50
Base superficial aquifer (mAHD)		-5	-5	-5	-5
GW* minimum (mAHD)		41.5	42.5	41.5	41.5
Depth to base superficial aquifer (m)		55	60	55	55
Depth to GW* (m)		8.5	12.5	8.5	8.5
Seasonal Variation (m)	0.7	0.7	0.7		
Reason for Unsuitability	Location	Screens	Screens	Status	Screens

	Water Corporation Bores				
AWRC Name	M300	M300B	M300A	M300C	M300D
AWRC Ref	61610836	61610837	61610838	61610839	61610840
Easting	393961	393918	393973	393875	393941
Northing	6481618	6481617	6481650	6481615	6481603
Purpose	P	O	O	O	O
Depth Drilled (m)	50	45	61	45	45
Screens (m)	32.31 - 48.46		24.38 - 46.02		
Lithology	N	N	Y	N	N
Status	NO	NO	NO	NO	NO
Geophysical Logs	N	N	Y	N	N
Topography (mAHD)	45	45	45	45	45
Base superficial aquifer (mAHD)	-5	-5	-5	-5	-5
GW* Minimum (mAHD)	41	41	41	41	41
Depth to base superficial aquifer (m)	50	50	50	50	50
Depth to GW* (m)	4	4	4	4	4
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	Water Corporation Bores				**Other - Non DoW**
AWRC Name	M300E	M300F	M305	M305-92	NO. 1
AWRC Ref	61610841	61610842	61615082	61615116	61603412
Easting	393950	393942	393971	393954	392362
Northing	6481573	6481619	6481639	6481624	6483761
Purpose	O	O	P	P	D
Depth Drilled (m)	45	47	496	381	59
Screens (m)		36.3 - 42.55	253 - 398	228.41 - 380.93	53.95 - 56.39
Lithology	N	Y	Y	N	N
Status	NO	NO	NO	NO	O
Geophysical Logs	N	N	Y	N	N
Topography (mAHD)	45	45	45	45	50
Base superficial aquifer (mAHD)	-5	-5	-5	-5	-5
GW* Minimum (mAHD)	41	41	41	41	43.5
Depth to base superficial aquifer (m)	50	50	50	50	55
Depth to GW* (m)	4	4	4	4	6.5
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Purpose


392000
392500
393000
393500
394000
6484000
6483500
6483000
6482500
6482000
6481500
45
44
43
42
41
MM9
8386
GN1
GN1A
GN1B
LAKE GNANGARA
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 95 190 380
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Gwelup

Wetland/GDE name	Lake Gwelup
Location (co-ords)	E: 386118, N: 6472626
Wetland/GDE type & description	Permanently inundated
Ecological recognition	Bush Forever site, EPP
Aboriginal Heritage	Five Registered Sites of Significance (3206, 3393, 3442, 3500, 3501)
Wetland suite	Balcatta (S.2)

Summary of Issues

- Classified as being at severe risk from drawdown
- No vegetation monitoring transect
- Significant faunal habitats

Suitable Monitoring Infrastructure

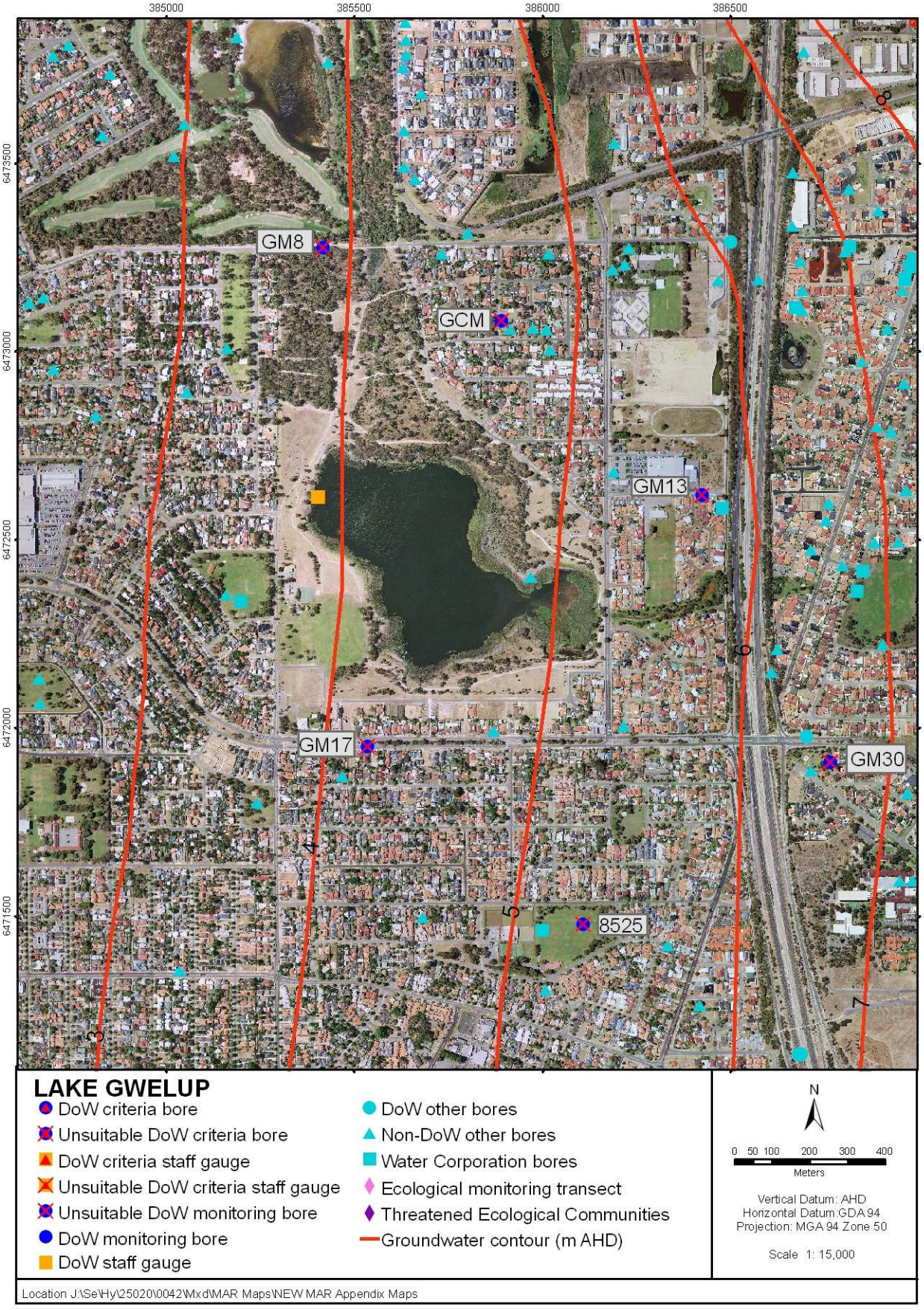
	Staff Gauge
AWRC Name	LAKE GWELUP 465
AWRC Ref	6162504
Easting	385404
Northing	6472614
Purpose	M
Status	O

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore					
AWRC Name	GM13	8525	GM17	GCM	GM8	GM30
AWRC Ref	61610035	61610032	61610033	61610034	61610036	61610080
Easting	386425	386109	385535	385892	385417	386767
Northing	6472620	6471479	6471951	6473082	6473276	6471909
Purpose	M	M	M	M	M	M
Depth drilled (m)	15.28		23.86	36	21.37	
Screens (m)	3.28 - 15.28		11.86 - 23.86		9.37 - 21.37	
Lithology	N	N	N	N	N	N
Status	O	O	O	O	O	O
Topography (mAHD)	10	15	15	23	10	15
Base superficial aquifer (mAHD)	-25	-25	-25	-25	-25	-25
GW* minimum (mAHD)	9	5	4	5	4	6.5
Depth to base superficial aquifer (m)	35	40	40	48	35	40
Depth to GW* (m)	1	10	11	18	6	8.5
Seasonal Variation (m)	2.5	1.5	1.5	2	2	2.5
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens	Screens

	Water Corp Bore
AWRC Name	GWELUP NO. 100.
AWRC Ref	61616154
Easting	385198
Northing	6472336
Purpose	
Depth drilled (m)	54.8
Screens (m)	
Lithology	Y
Status	
Topography (mAHD)	11
Base superficial aquifer (mAHD)	-25
GW* minimum (mAHD)	3.5
Depth to base superficial aquifer (m)	36
Depth to GW* (m)	7.5
Seasonal Variation (m)	
Reason for Unsuitability	Screens


385000
385500
386000
386500
6473500
6473000
6472500
6472000
6471500
GM8
GCM
GM13
GM17
GM30
8525
LAKE GWELUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300 400
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Harrisdale Swamp

Wetland/GDE name	Harrisdale Swamp
Location (co-ords)	E: 398828, N: 6446755
Wetland/GDE type & description	Sumpland
Ecological recognition	Bush Forever site, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- Classified as being at significant risk from drawdown
- No vegetation monitoring transect
- Significant floral and faunal species

Suitable Monitoring Infrastructure

JM16 is has a ministerial criteria level assigned, but is this is a phreatophytic vegetation criteria not associated with the wetland.

	DoW monitoring bore	
AWRC Name	JM16	HARRISDALE SWAMP SAND
AWRC Ref	61610445	61618562
Easting	398446	398839
Northing	6446981	6446939
Purpose	M / MC	M
Depth drilled (m)	15.3	3.8
Screens (m)	12 – 15.3	0 - 3.8
Lithology	N	N
Status	O	O
Topography (mAHD)	30	28
Base superficial aquifer (mAHD)	-10	-8
GW* minimum (mAHD)	24	23
Depth to base superficial aquifer (m)	40	36
Depth to GW* (m)	6	5
Seasonal Variation (m)	1.2	2

Unsuitable Monitoring Infrastructure

	WIN Other Bore DoW
AWRC Name	HARRISDALE SWAMP CLAY
AWRC Ref	61618563
Easting	398839
Northing	6447034
Purpose	
Depth drilled (m)	
Screens (m)	
Lithology	N
Status	NO
Topography (mAHD)	28
Base superficial aquifer (mAHD)	-8
GW* minimum (mAHD)	23
Depth to base superficial aquifer (m)	36
Depth to GW* (m)	5
Seasonal Variation (m)	
Reason for Unsuitability	Screens


398500
399000
399500
6447500
6447000
6446500
6446000
JM16
HARRISDALE SWAMP SAND
23
24
22
HARRISDALE SWAMP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Jandabup

Wetland/GDE name	Lake Jandabup
Location (co-ords)	E: 390280, N: 6487912
Wetland/GDE type & description	Permanently inundated
Ecological recognition	Conservation status
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Gnangara (B.2)

Summary of Issues

- Water levels have fallen below interim absolute minimum summer water levels several times since 1978, and acidification occurs with low water levels.
- No monitoring bores within close proximity of the vegetation monitoring transects.
- Despite a moderate correlation between groundwater and lake levels, groundwater levels are declining faster that wetland levels, and there is evidence of perching.
- Significant faunal habitats.

Suitable Monitoring Infrastructure

	DoW monitoring bore				
AWRC Name	JB10A	JB10B	JB9A	JB9C	JB10C
AWRC Ref	61610768	61610769	61610820	61610822	61610770
Easting	391232	391233	391370	391372	391230
Northing	6489078	6489078	6488073	6488076	6489078
Purpose	M	M	M	M	M
Depth drilled (m)	55	32	54	22	7
Screens (m)	51 - 53	28 - 30	50 - 52	18 - 20	0 - 7
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	54	54	55	55	54
Base superficial aquifer (mAHD)	-5	-5	-5	-5	-5
GW* minimum (mAHD)	46.5	46.5	45.5	45.5	46.5
Depth to base superficial aquifer (m)	59	59	60	60	59
Depth to GW* (m)	7.5	7.5	9.5	9.5	7.5
Seasonal Variation (m)	0.8 - 1	1	0.8	0.8 - 1	1

	DoW monitoring bore				Criteria Staff Gauge
AWRC Name	JB9B	JB12A	JB12B	JB12C	JANDABUP LAKE 1944
AWRC Ref	61610821	61610763	61610764	61610765	6162578
Easting	391370	391158	391158	391157	390818
Northing	6488078	6486828	6486828	6486828	6487087
Purpose	M	M	M	M	M / MC
Depth drilled (m)	7	7	28	53	
Screens (m)	0 - 7	0 - 7	25 - 27	50 - 52	
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	55	52	52	52	
Base superficial aquifer (mAHD)	-5	-8	-8	-8	
GW* minimum (mAHD)	45.5	44	44	44	
Depth to base superficial aquifer (m)	60	60	60	60	
Depth to GW* (m)	9.5	8	8	8	
Seasonal Variation (m)	0.6 - 0.8	1	1	1	

Unsuitable Monitoring Infrastructure

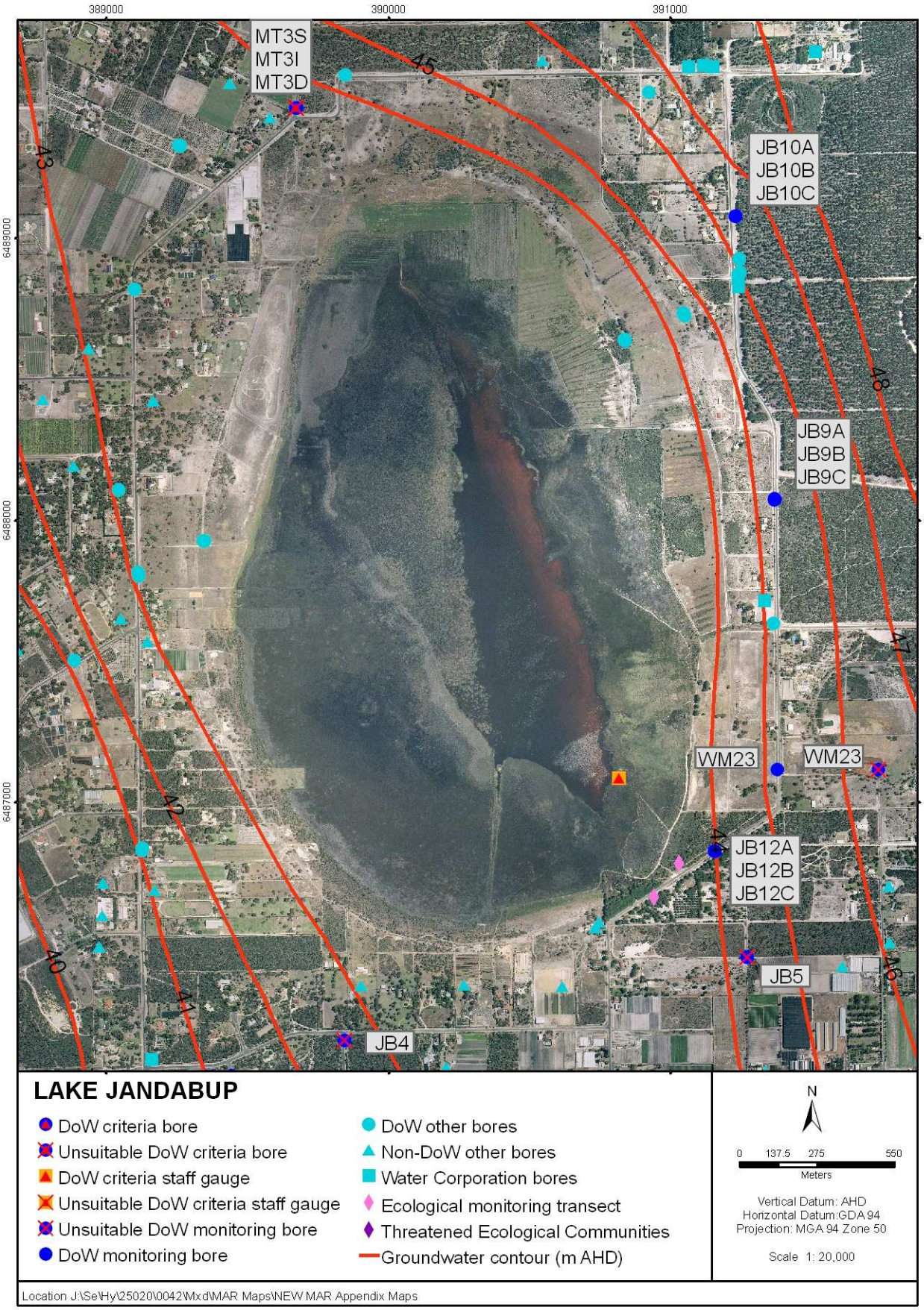
Unsuitable monitoring bores and bores requiring further investigation

	Criteria Bore	DoW Other Bore			
AWRC Name	MT3S	JB11A	JB11B	JB8A	JB8B
AWRC Ref	61610745	61610721	61610722	61610726	61610727
Easting	389674	389130	389130	389115	389115
Northing	6489464	6486839	6486836	6487817	6487813
Purpose	M / O / M C	M	M	M	M
Depth drilled (m)	13	66	31	30	66
Screens (m)	6.0 - 13	62 - 64	27 - 29	26 - 28	62 - 64
Lithology	N	N	N	N	N
Status	O	NO	NO	NO	NO
Topography (mAHD)	50	65	65	57	57
Base superficial aquifer (mAHD)	-6	-14	-14	-10	-10
GW* minimum (mAHD)	44	41	41	43	43
Depth to base superficial aquifer (m)	56	79	79	67	67
Depth to GW* (m)	6	24	24	14	14
Seasonal Variation (m)	1.5				
Reason for Unsuitability	Location	Status	Status	Status	Status

	DoW Other Bore				
AWRC Name	JB15B	JB15C	MS15	JB13A	JB13B
AWRC Ref	61610729	61610730	61610731	61610771	61610772
Easting	389347	389349	389046	391048	391050
Northing	6487929	6487929	6488109	6488735	6488732
Purpose	M	M	M	M	M
Depth drilled (m)	60.6	26	26.5	62	31
Screens (m)	45 - 47	21 - 23	19.2 - 26.5	50 - 52	26 - 28
Lithology	N	N	N	N	N
Status	NO	NO	NO	NO	NO
Topography (mAHD)	50	50	65	50	50
Base superficial aquifer (mAHD)	-10	-10	-10	-5	-5
GW* minimum (mAHD)	43	43	43	44	44
Depth to base superficial aquifer (m)	60	60	75	55	55
Depth to GW* (m)	7	7	22	6	6
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	DoW Other Bore				
AWRC Name	JB14A	JB11C	JB15A	JB13C	JB14C
AWRC Ref	61610774	61610723	61610728	61610773	61610776
Easting	390842	389130	389344	391052	390840
Northing	6488637	6486830	6487929	6488727	6488643
Purpose	M	M	M	M	M
Depth drilled (m)	30	20.6	10	8.2	9
Screens (m)	24 - 26	18 - 20	0 - 10	0 - 8.2	0 - 8
Lithology	N	N	N	N	N
Status	N O	N O	N O	N O	N O
Topography (mAHD)	50	65	50	50	50
Base superficial aquifer (mAHD)	-5	-14	-10	-5	-5
GW* minimum (mAHD)	44	41	43	44	44
Depth to base superficial aquifer (m)	55	79	60	55	55
Depth to GW* (m)	6	24	7	6	6
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	DoW Monitoring Bore					
AWRC Name	MS14	MT3I	MT3D	JB4	JB5	WM23
AWRC Ref	61610734	61610743	61610744	61610761	61610762	61610817
Easting	388538	389676	389676	389845	391272	391379
Northing	6488504	6489463	6489463	6486158	6486453	6487117
Purpose	M / O	M / O	M / O	M	M	M
Depth drilled (m)	16	36	61	30	10.75	18
Screens (m)	8.0 - 16	30 - 33	54 - 56	18 - 30	6 - 10.7	5.7 - 17.7
Lithology	N	N	N	N	N	N
Status	O	O	O	O	O	O
Topography (mAHD)	52	50	50	65	50	54
Base superficial aquifer (mAHD)	-10	-6	-6	-14	-8	-6
GW* minimum (mAHD)	42	44	44	43	44	45
Depth to base superficial aquifer (m)	62	56	56	79	58	60
Depth to GW* (m)	10	6	6	22	6	9
Seasonal Variation (m)	1.2	1.5	1.5	0.8	1 - 1.5	1.5
Reason for Unsuitability	Location	Location	Location	Screens	Location	Screens


389000
390000
391000
6489000
6488000
6487000
MT3S
MT3I
MT3D
JB10A
JB10B
JB10C
JB9A
JB9B
JB9C
WM23
WM23
JB12A
JB12B
JB12C
JB5
JB4
45
43
48
47
42
44
40
41
46
LAKE JANDABUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 137.5 275 550
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Joondalup

Wetland/GDE name	Lake Joondalup
Location (co-ords)	E: 384239, N: 6487399
Wetland/GDE type & description	Permanent lake
Ecological Recognition	Conservation Category, EPP, Register of National Estate, System 6
Aboriginal Heritage	Four Registered Sites of Significance (3316, 3640, 3740, 4102)
Wetland suite	Yanchep (S.1)

Summary of Issues

- The site is breaching Ministerial Criteria (as of 2007). Water levels have fallen below the preferred summer minimum level each summer since 1998, but not the absolute minimum summer level.
- The lake is classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- The current criteria bore does not reflect water levels at the site of the monitored vegetation transect.
- The current staff gauge located about 150 m west of the lake is unsuitable to measure lake levels.
- Detailed hydrogeological characteristics and surface water-groundwater interactions are unknown.

Suitable Monitoring Infrastructure

See the tables for Lake Mariginiup for bores in the north-east corner of the map.

	DoW monitoring bore	
AWRC Name	WM42	JP26
AWRC Ref	61618432	61618499
Easting	386838	382807
Northing	6485293	6489796
Purpose	O / M	M
Depth drilled (m)	19	70
Screens (m)	11.0 - 19	67 - 70
Lithology	N	N
Status	O	O
Topography (mAHD)	42	50
Base superficial aquifer (mAHD)	-23	-27
GW* minimum (mAHD)	28	5
Depth to base superficial aquifer (m)	65	77
Depth to GW* (m)	14	45
Seasonal Variation (m)	0.7	0.3

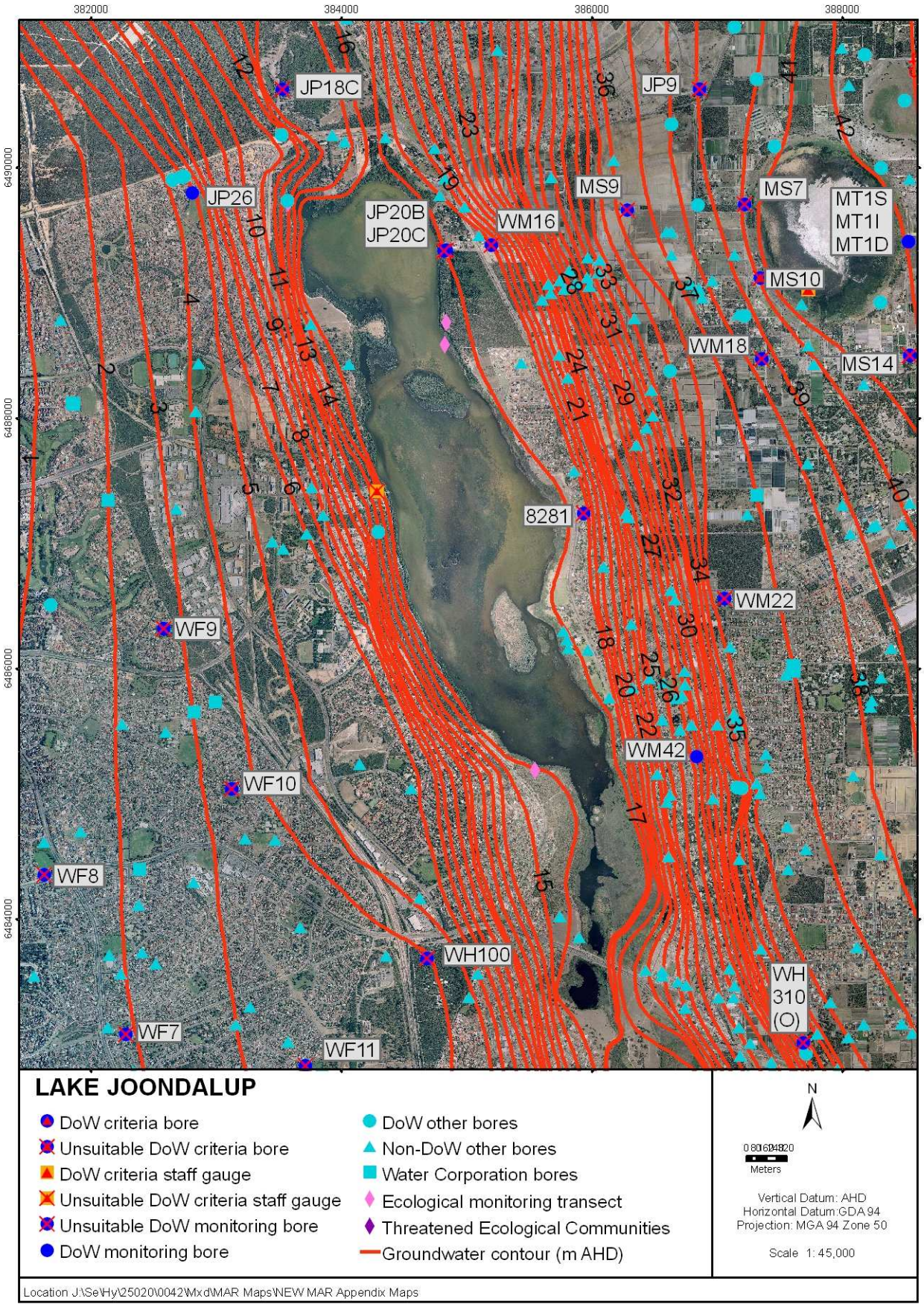
Unsuitable Monitoring Infrastructure

Unsuitable current monitoring infrastructure and bores requiring further investigation. Staff gauge location shown in WIN is incorrect.

	Criteria Staff Gauge
AWRC Name	LAKE JOONDALUP 8281
AWRC Ref	6162572
Easting	384239
Northing	6487399
Purpose	M / MC
Depth drilled (m)	4.6
Screens (m)	-
Lithology	N
Status	O
Topography (mAHD)	20
Base superficial aquifer (mAHD)	-22.5
GW* minimum (mAHD)	18
Depth to base superficial aquifer (m)	42.5
Depth to GW* (m)	2
Seasonal Variation (m)	0.8
Reason for Unsuitability	Location

	DoW monitoring bore					
AWRC Name	WM16	JP18C	JP20B	JP20C	WF7	WF8 (multiport)
AWRC Ref	61610662	61610630	61610628	61610629	61620106	61609997
Easting	385199	383530	384835	384819	382275	381623
Northing	6489383	6490265	6489341	6489337	6483076	3484349
Purpose	M	I / M	I / M	I / M	M	
Depth drilled (m)	20.7		34.65 (*)	5.18 (*)	58.5	77.7
Screens (m)	8.7 - 20.7				29.33 - 50	48.7 – 77.7
Lithology	N	N	N	N	Y	N
Status	O	O	O	O	O	-
Topography (mAHD)	26	20	20	20	30	45
Base superficial aquifer (mAHD)	-20	-25	-22	-22	-30	-30
GW* minimum (mAHD)	18	12	17	17	2	2
Depth to base superficial aquifer (m)	46	45	42	42	60	75
Depth to GW* (m)	8	8	3	3	29	43
Seasonal Variation (m)	1	0.8 - 1	0.8	0.8	0.4	
Reason for Unsuitability	Screens	Location	Screens	Screens	Screens	Screens

	DoW monitoring bore						
AWRC Name	WF9	WF10	WF11 (multiport)	WH100	WM22	8281	WH310 (O)
AWRC Ref	61620108	6120109	61620110	61610627	61610683	61610661	61610678
Easting	382581	383121	383713	384683	387060	385935	387691
Northing	6486318	6485040	6482824	6483681	6486556	6487238	6483007
Purpose	M/O	M/O	M/O	O/M	M	O/M	O/M
Depth drilled (m)	65.75	61.5	58	64	41.4	4.6	68.58
Screens (m)	35.8 – 63.8	30.42 – 60.42	23.83 – 50.83		29.4 – 41.4		33.53 - 68.58
Lithology	Y	Y	Y	Y	N	N	Y
Status	O	O	O	O	O	O	O
Topography (mAHD)	35	30	25	35	65	21	55
Base superficial aquifer (mAHD)	-30	-30	-30	-30	-22	-23	-22
GW* minimum (mAHD)	3	3.5	3	4	36	18	33
Depth to base superficial aquifer (m)	65	60	55	65	87	44	77
Depth to GW* (m)	32	26.5	22	31	29	3	22
Seasonal Variation (m)	0.5	0.5	0.5	0.5	0.5	1	0.5
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens	Screens	Screens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388000
6490000
6488000
6486000
6484000
JP18C
JP9
JP26
JP20B
JP20C
WM16
MS9
MS7
MT1S
MT1I
MT1D
MS10
WM18
MS14
8281
WM22
WF9
WM42
WF10
WF8
WH100
WH 310 (O)
WF7
WF11
LAKE JOONDALUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 45,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Kings Spring

Wetland/GDE name	Kings Spring
Location (co-ords)	E: 400635, N: 6497859
Wetland/GDE type & description	Mound spring
Ecological recognition	Bush Forever site
Aboriginal Heritage	Registered Site of Significance (3525)
Wetland suite	Riverdale

Summary of Issues

- Classified as being at significant risk from drawdown
- No recent monitoring data
- Significant faunal communities
- DEC registered Threatened Ecological Communities

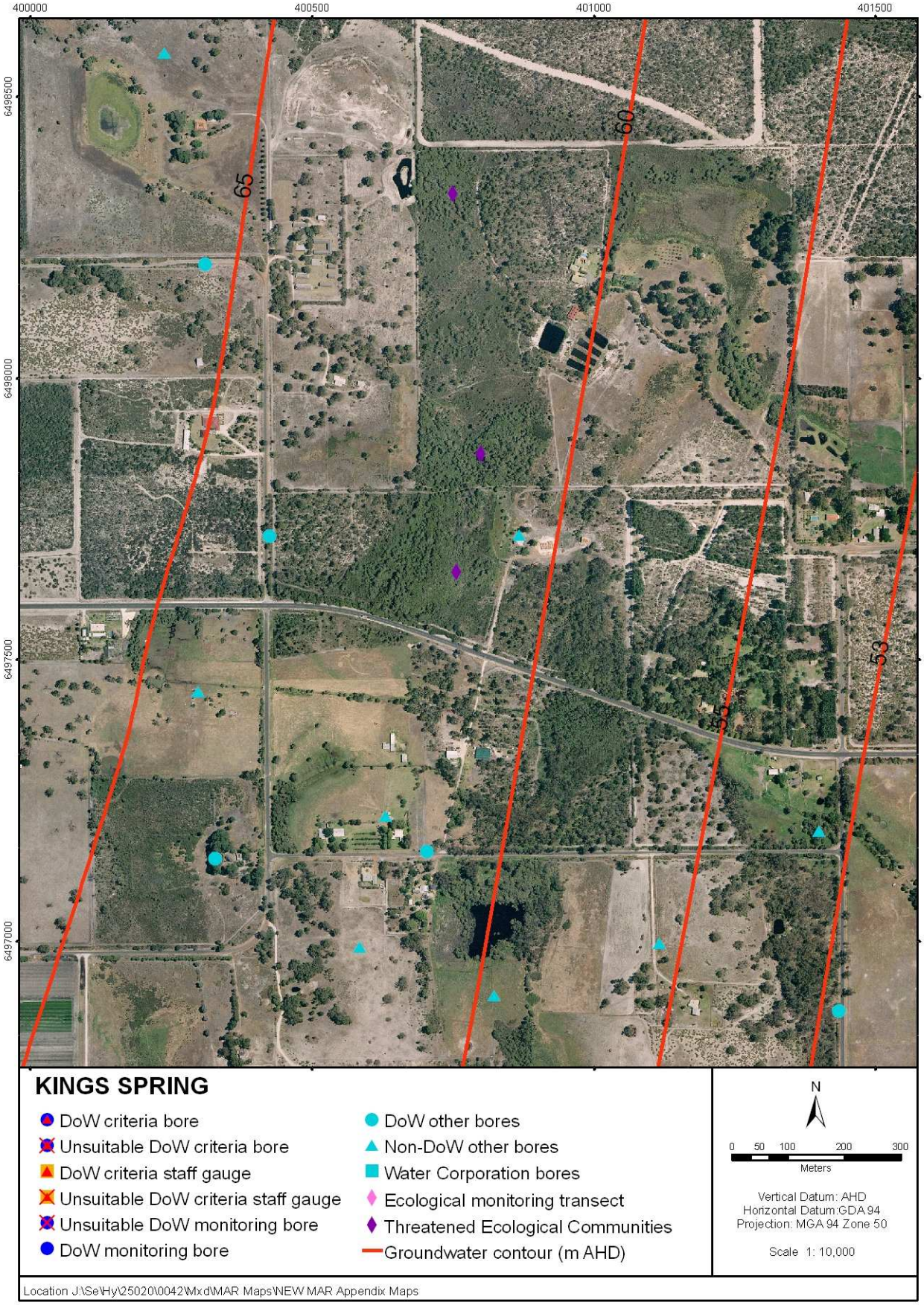
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore	**DoW Other Bore**
AWRC Name	NR2C	NE7-9
AWRC Ref	61611021	61612445
Easting	399619	400425
Northing	6498229	6497720
Purpose	M	M
Depth drilled (m)	16.04	2.72
Screens (m)	9.0 - 15	0.26 - 2.72
Lithology	N	N
Status	O	NO
Topography (mAHD)	70	67
Base superficial aquifer (mAHD)	8	4
GW* minimum (mAHD)	66.5	64
Depth to base superficial aquifer (m)	62	63
Depth to GW* (m)	3.5	3
Seasonal Variation (m)	1 - 1.5	
Reason for Unsuitability	Location	Status


400000
400500
401000
401500
6498500
6498000
6497500
6497000
65
60
55
53
KINGS SPRING
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Kogolup Lakes

Wetland/GDE name	Kogolup Lakes (North and South)
Location (co-ords)	E: 389676, N: 6444504
Wetland/GDE type & description	Sumpland, seasonally inundated
Ecological recognition	EPP
Aboriginal Heritage	Two Registered Sites of Significance (120, 18937)
Wetland suite	Bibra (S/B.1)

Summary of Issues

- Water levels have breached, or been close to breaching, preferred and absolute summer levels in the late 70s/early 80s, and in 1998. Water levels not been monitored since 1999.
- Relationship between groundwater and surface water is unknown, as the surface-water monitoring bore was installed in 2001
- Possible perching
- Bores located too far from vegetation monitoring transect
- No criteria bore
- Waterbird site

Suitable Monitoring Infrastructure

One additional staff gauge exists at Kogolup South, not shown in WIN, which is suitable for reading lake levels.

	DoW monitoring bore			**Criteria Staff Gauge**	**Staff Gauge**
AWRC Name	JE17C	TD4	TM2C	KOGOLUP LAKE STH 6015	KOGOLUP LAKE NORTH
AWRC Ref	61419703	61410385	61611112	6142522	6142575
Easting	390557	390445	389271	389838	389679
Northing	6444079	6444570	6443694	6443716	6444649
Purpose	O / M	O / M	O / M	MC	O
Depth drilled (m)	6	4	22.5		
Screens (m)	-	0 - 4	16.5 - 21.5		
Lithology	N	N	N		
Status	O	O	O	O	O
Topography (mAHD)	22	20	30		
Base superficial aquifer (mAHD)	-22	-22	-22		
GW* minimum (mAHD)	17	16.5	12.5		
Depth to base superficial aquifer (m)	44	42	52		
Depth to GW* (m)	5	3.5	17.5		
Seasonal Variation (m)	0.7 – 1	1	0.6 - 1		

Unsuitable Monitoring Infrastructure

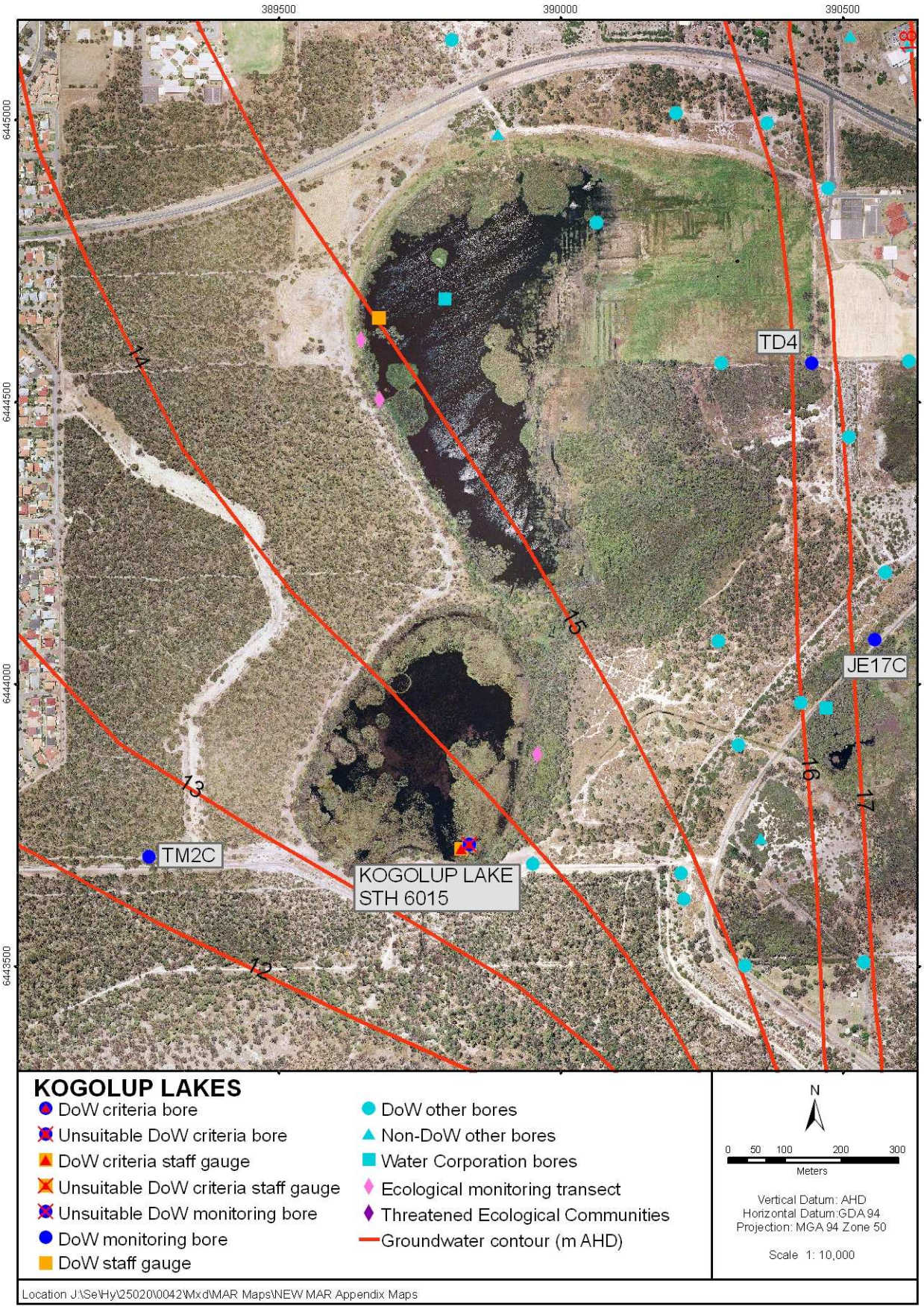
Unsuitable monitoring bores and bores requiring further investigation

	DoW Criteria Monitoring Bore	**DoW monitoring bore**		
AWRC Name	KOGOLUP LAKE BORE	JM24	JM17	TM6C
AWRC Ref	61410727	61410193	61410195	61611122
Easting	389839	391115	391305	390616
Northing	6443716	6443954	6445328	6443296
Purpose	M / MC	M	M	O / M
Depth drilled (m)	1.5	16.35	24.3	9.5
Screens (m)	0.5 - 1.5	4.5 - 16.35	12.3 - 24.3	3.5 - 8.5
Lithology	N	N	N	N
Status	O	O	O	O
Topography (mAHD)	20	25	35	25
Base superficial aquifer (mAHD)	-22	-22	-20	-23
GW* minimum (mAHD)	14	19.5	21.5	11.5
Depth to base superficial aquifer (m)	42	47	55	48
Depth to GW* (m)	6	5.5	13.5	13.5
Seasonal Variation (m)	1.5	1.2	1.2	1 - 1.2
Reason for Unsuitability	Location	Location	Location	Location

	DoW monitoring bore		**DoW Other Bore**	
AWRC Name	T40 (I)	TD29	TD1	TD3
AWRC Ref	61410196	61410411	61410382	61410384
Easting	390176	389806	390205	390618
Northing	6445263	6445189	6445013	6444573
Purpose	I / P / M	M		
Depth drilled (m)	43.27	5.2	4	4
Screens (m)		0 - 5.2	0 - 4	0 - 4
Lithology	Y	N	N	N
Status	O	O	A / NO	A / NO
Topography (mAHD)	20	20	20	22
Base superficial aquifer (mAHD)	-21	-21	-22	-22
GW* minimum (mAHD)	16	15.5	16	17.5
Depth to base superficial aquifer (m)	41	41	42	44
Depth to GW* (m)	4	4.5	4	4.5
Seasonal Variation (m)	1	1 - 1.2		
Reason for Unsuitability	Location	Location	Status	Status

	DoW Other Bore			
AWRC Name	TD5	TD6	TD7	TD8
AWRC Ref	61410386	61410387	61410388	61410389
Easting	390286	390576	390426	390280
Northing	6444569	6444199	6443968	6444076
Purpose				
Depth drilled (m)	4	4	4	4
Screens (m)	0 - 4	0 - 4	0 - 4	0 - 4
Lithology	N	N	N	N
Status	A / NO	A / NO	A / NO	A / NO
Topography (mAHD)	20	22	21	20
Base superficial aquifer (mAHD)	-22	-22	-22	-22
GW* minimum (mAHD)	16	16	17	15.5
Depth to base superficial aquifer (m)	42	44	43	42
Depth to GW* (m)	4	6	4	4.5
Seasonal Variation (m)				
Reason for Unsuitability	Status	Status	Status	Status

	DoW Other Bore			**Water Corp Bore**
AWRC Name	TD2	TD9	TD10	LB 14
AWRC Ref	61410383	61410390	61410391	61403892
Easting	390475	390214	389952	389795
Northing	6444879	6443665	6443682	6444682
Purpose			O	
Depth drilled (m)	4	4	4	4.05
Screens (m)	0 - 4	0 - 4	0 - 4	0 - 4
Lithology	N	N	N	Y
Status	A / NO	A / NO	NO	
Topography (mAHD)	20	20	20	20
Base superficial aquifer (mAHD)	-22	-22	-22	-22
GW* minimum (mAHD)	17	15	14	15
Depth to base superficial aquifer (m)	42	42	42	42
Depth to GW* (m)	3	5	6	5
Seasonal Variation (m)				
Reason for Unsuitability	Status	Status	Status	Status


389500
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6445000
6444500
6444000
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TD4
JE17C
TM2C
KOGOLUP LAKE
STH 6015
Z1
Z2
Z3
Z4
Z5
Z6
Z7
KOGOLUP LAKES
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lexia Wetlands

Wetland/GDE name	Lexia Wetlands (94 Swamp, 186 Swamp, 86 Swamp)
Location (co-ords)	E: 401801 N: 6487538
Wetland/GDE type & description	Sumpland
Ecological recognition	Conservation Category, Interim Register of the National Estate, Bushforever Site 300
Aboriginal Heritage	-
Wetland suite	Muchea

Summary of Issues

- Lack of detailed hydrogeological knowledge
- No staff gauge (Lexia Swamp 186)
- Supports diverse vegetation
- Important breeding site for aquatic invertebrate fauna
- Ecological health and biodiversity has been impacted by water level decline
- Probable PASS bearing sediments

Suitable Monitoring Infrastructure

	DoW Criteria bores		**DoW Monitoring bores**		
AWRC Name	LEXIA 186	LEXIA 86	GNM2	L130C	L140C
AWRC Ref	61613214	61613215	61613201	61611037	61611056
Easting	401801	401429	401218	401629	402636
Northing	6487538	6486537	6486829	6487714	6487728
Purpose	M	M	M	M	M
Depth drilled (m)	2.91	2.4	10.2	9	10
Screens (m)	0.91 – 2.91	0.4 – 2.4	4.2 – 10.02	1 - 9	3 - 10
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	49	50	52	52	52
Base superficial aquifer (mAHD)	-5	-5	-5	-5	-5
GW* minimum (mAHD)	47	47.5	48.3	47.9	45.9
Depth to base superficial aquifer (m)	54	55	57	57	57
Depth to GW* (m)	2	1.5	3.7	4.1	6.1
Seasonal Variation (m)	1	1 – 1.2	1 – 1.2	1	1

Unsuitable Monitoring Infrastructure

	DoW Criteria Bore	DoW Monitoring bores		
AWRC Name	LEXIA 94	L50C	PB2	PB3
AWRC Ref	61613216	61611033	61611034	61611031
Easting	402824	402276	401247	401239
Northing	6486433	6485230	6486369	6485499
Purpose	M	M	O/P/M	O/P/M
Depth drilled (m)	1.2	14	42	48
Screens (m)				34.8 -47
Lithology	N	N	N	N
Status	O	O	O	O
Topography (mAHD)	48	52	52	51
Base superficial aquifer (mAHD)	-5	-5	-5	-5
GW* minimum (mAHD)	45.7	41.6	48	45.9
Depth to base superficial aquifer (m)	53	57	57	56
Depth to GW* (m)	2.3	10	4	5.1
Seasonal Variation (m)	1.2	1.5 – 2	1	<1
Reason for Unsuitability	Screens/Stranded	Screens	Screens	Screens

	DoW Other bore			
AWRC Name	BBG1(S)	BBG1(D)	BBG1(N)	BBG2
AWRC Ref	61640028	61640029	61640030	61640031
Easting	402521	402521	402521	403363
Northing	6487593	6487593	6487593	6487376
Purpose				
Depth drilled (m)				
Screens (m)				
Lithology	N	N	N	N
Status	O*	O*	O*	O*
Topography (mAHD)	49	49	49	49
Base superficial aquifer (mAHD)	-5	-5	-5	-5
GW* minimum (mAHD)	46	46	46	44
Depth to base superficial aquifer (m)	54	54	54	54
Depth to GW* (m)	3	3	3	4
Seasonal Variation (m)				
Reason for Unsuitability	Screens/Status	Screens/Status	Screens/Status	Screens/Status

* no data for these bores after 1996

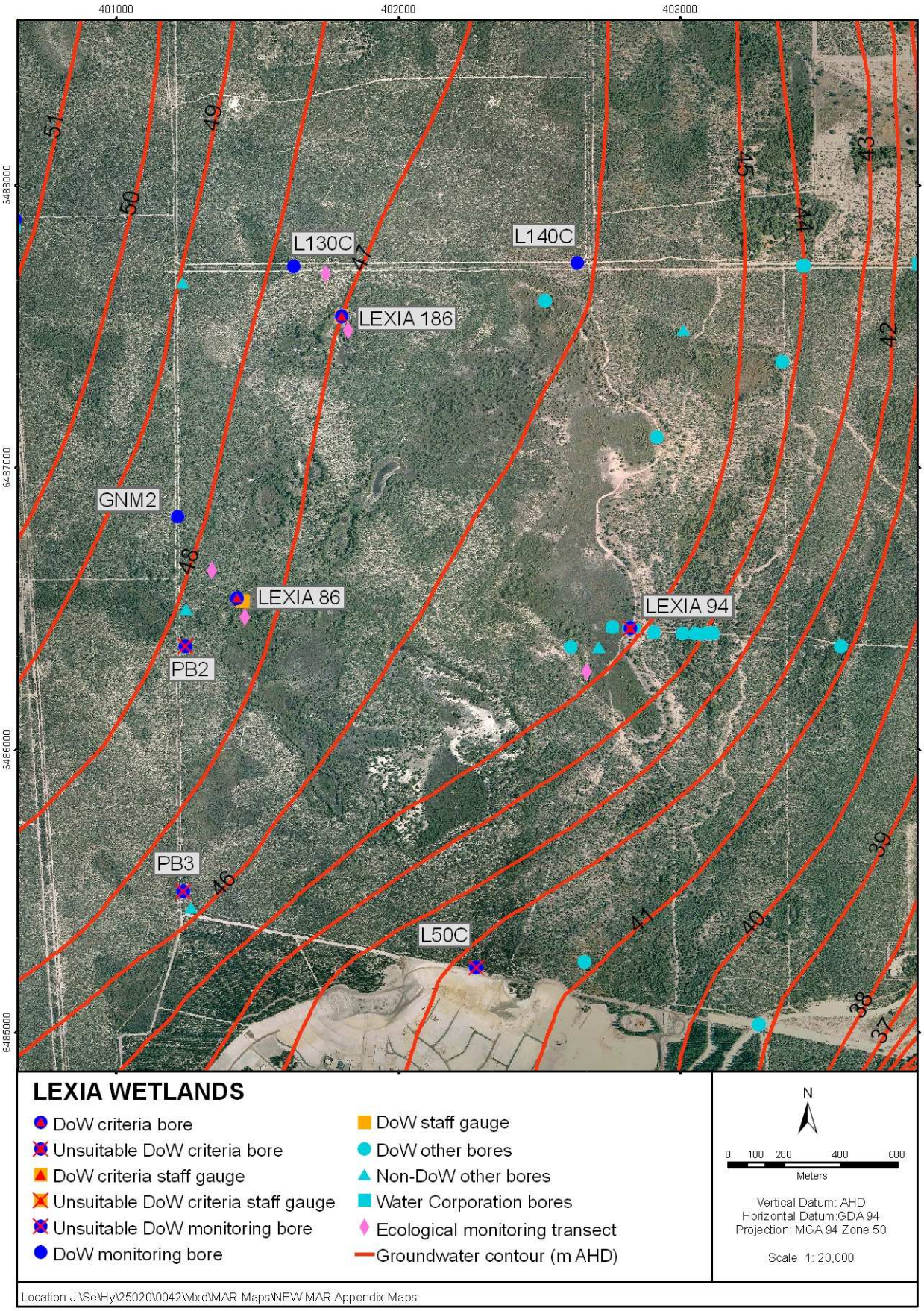
	DoW Other bore				
AWRC Name	BBG2 (N)	BBG5	L150C	NE D10	NE D9
AWRC Ref	61640031	61640035	61611058	61612508	61612507
Easting	403363	402918	403437	402613	402671
Northing	6487376	6487109	6487718	6486365	6486436
Purpose			M	M	M
Depth drilled (m)			10		
Screens (m)			1 - 10		
Lithology	N	N	N	N	
Status	O*	O*	NO	NO	NO
Topography (mAHD)	49	48	48.5	49	47
Base superficial aquifer (mAHD)	-5	-5	-5	-4	-4
GW* minimum (mAHD)	44	45.5	44	45	45
Depth to base superficial aquifer (m)	54	53.5	53.5	53	51
Depth to GW* (m)	4	2.5	3.5	4	2
Seasonal Variation (m)			1 – 1.5		
Reason for Unsuitability	Screens/Status	Screens/Status	Status	Screens/Status	Screens/Status

* no data for these bores after 1996

	DoW Other bore				
AWRC Name	NE D8D	NE D6	NE D5	NE D4	NE D3
AWRC Ref	61612506	61612503	61612502	61612501	61612500
Easting	402819	402908	403009	403055	403075
Northing	6486433	6486420	6486414	6486414	6486412
Purpose	M	M	M	M	M
Depth drilled (m)					
Screens (m)					
Lithology	N	N	N	N	N
Status	NO	NO	NO	NO	NO
Topography (mAHD)	48	51	48	47	47
Base superficial aquifer (mAHD)	-4	-4	-3	-3	-3
GW* minimum (mAHD)	45	45	44.5	44	44
Depth to base superficial aquifer (m)	52	55	51	50	50
Depth to GW* (m)	3	6	3.5	3	3
Seasonal Variation (m)					
Reason for Unsuitability	Screens/Status	Screens/Status	Screens/Status	Screens/Status	Screens/Status

	DoW Other bore			
AWRC Name	NE D2	NE D1S	NE D1D	BBG8
AWRC Ref	61612499	61612497	61612498	61640038
Easting	403100	403116	403117	403571
Northing	6486417	6486415	6486414	6486369
Purpose	M	M	M	
Depth drilled (m)				
Screens (m)				
Lithology	N	N	N	N
Status	NO	NO	NO	O
Topography (mAHD)	46	46	46	44
Base superficial aquifer (mAHD)	-3	-3	-3	-2
GW* minimum (mAHD)	44	44	44	41
Depth to base superficial aquifer (m)	49	49	49	46
Depth to GW* (m)	2	2	2	3
Seasonal Variation (m)				
Reason for Unsuitability	Screens/Status	Screens/Status	Screens/Status	Screens

	DoW Other bore		
AWRC Name	BBG6(S)	L60A	L60C
AWRC Ref	61640036	61611054	61611053
Easting	402661	403281	403278
Northing	6485251	6485029	6485027
Purpose		M	M
Depth drilled (m)		70	23
Screens (m)		61 - 74	14 – 23
Lithology	N	Y	N
Status	O	A / NO	A / NO
Topography (mAHD)	45	54	54
Base superficial aquifer (mAHD)	-4	-3	-3
GW* minimum (mAHD)	41	39	39
Depth to base superficial aquifer (m)	49	57	57
Depth to GW* (m)	4	15	15
Seasonal Variation (m)			
Reason for Unsuitability	Screens	Status	Status


401000
402000
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6486000
6485000
L130C
L140C
LEXIA 186
GNM2
LEXIA 86
LEXIA 94
PB2
PB3
L50C
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37
LEXIA WETLANDS
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Groundwater contour (m AHD)
N
0 100 200 400 600
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Loch McNess

Wetland/GDE name	Loch McNess
Location (co-ords)	E: 374395, N: 6509358
Wetland/GDE type & description	Permanently inundated
Ecological recognition	Conservation status, National importance
Aboriginal Heritage	2 Registered Sites of Significance (3186, 3742)
Wetland suite	Yanchep (S.1)

Summary of Issues

- Not complying with Ministerial Criteria (breached summer water levels in April 2005)
- Is a good example of a relatively undisturbed lake that is undergoing succession to marsh and wooded swamp
- Is the only major wetland of the Swan Coastal Plain that naturally exhibits relatively small annual depth fluctuations.
- Classified as being at severe risk from possible drawdown
- No criteria bore
- Significant floral and faunal species

Suitable Monitoring Infrastructure

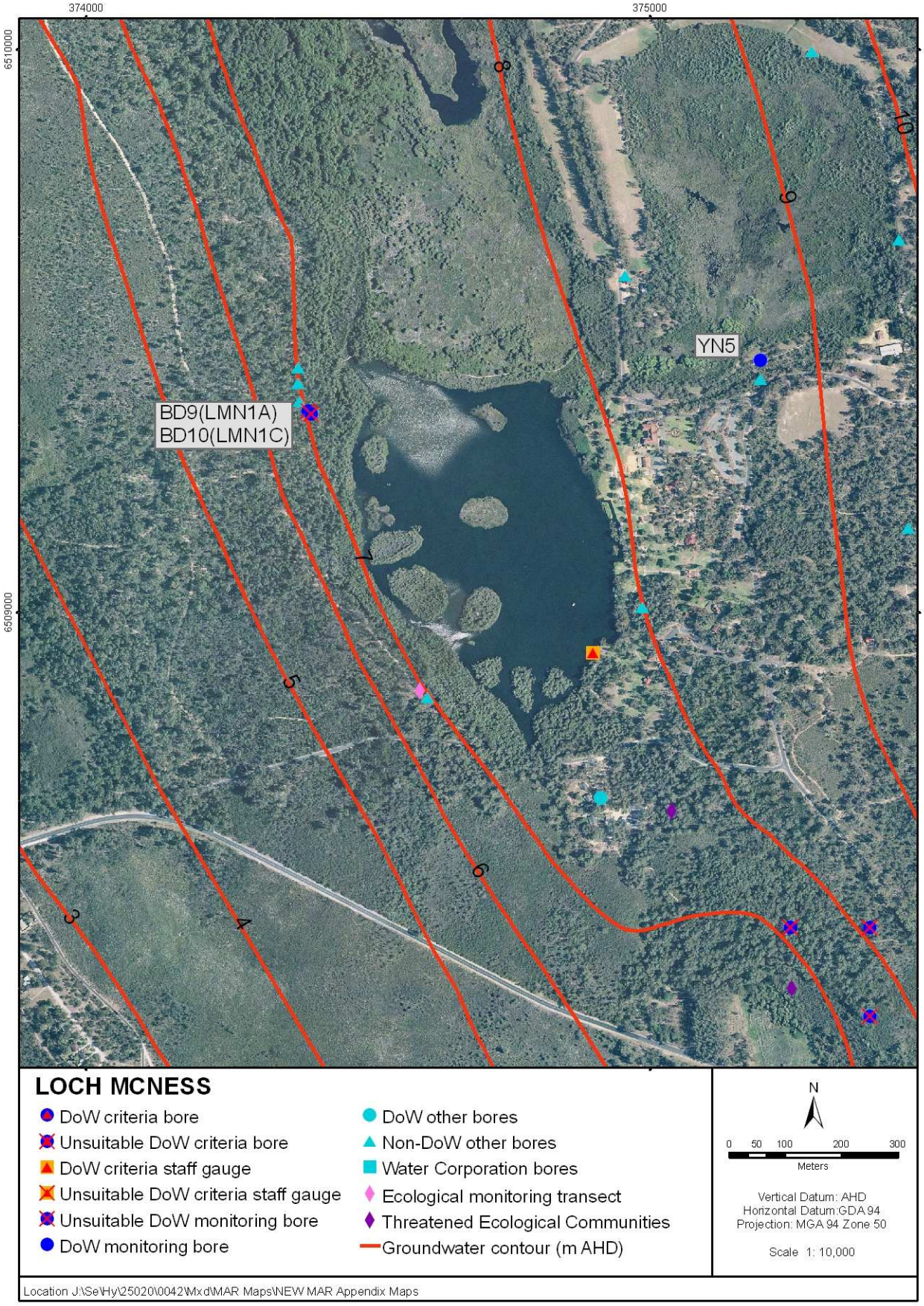
	DoW monitoring bore	**Criteria Staff Gauge**
AWRC Name	YN5	LOCH MCNESS 8574
AWRC Ref	61612104	6162564
Easting	375197	387900
Northing	6509449	6508930
Purpose	O / M	M / MC
Depth drilled (m)	8.96	
Screens (m)	2.94 - 8.96	
Lithology	N	
Status	O	O
Topography (mAHD)	10	
Base superficial aquifer (mAHD)	-26	
GW* minimum (mAHD)	9	
Depth to base superficial aquifer (m)	36	
Depth to GW* (m)	1	
Seasonal Variation (m)	0.2	

Unsuitable monitoring infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore				
AWRC Name	BD9(LMN1A)	BD10(LMN1C)	YN3	YN4	BOOMERANG GORGE-YN99
AWRC Ref	61710028	61710029	61612102	61612103	61612111
Easting	374394	374399	375804	375558	375739
Northing	6509359	6509354	6509679	6509599	6509499
Purpose	O / M	O / M	O / M	O / M	M
Depth drilled (m)					
Screens (m)					
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	15	15	35	15	20
Base superficial aquifer (mAHD)	-28	-28	-26	-26	-26
GW* minimum (mAHD)	7	7	12	10.5	11
Depth to base superficial aquifer (m)	43	43	61	41	46
Depth to GW* (m)	8	8	23	4.5	9
Seasonal Variation (m)	unclear	0.5	0.1	0.3	
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens

	DoW monitoring bore	
AWRC Name	CARPARK CAVE - YN14	ONYCHOPORA - YN102
AWRC Ref	61612112	61612109
Easting	375250	375391
Northing	6508442	6508285
Purpose	M	M
Depth drilled (m)		
Screens (m)		
Lithology	N	N
Status	O	O
Topography (mAHD)	12	17
Base superficial aquifer (mAHD)	-28	-27
GW* minimum (mAHD)	7	7.5
Depth to base superficial aquifer (m)	40	44
Depth to GW* (m)	5	9.5
Seasonal Variation (m)		
Reason for Unsuitability	Screens	Screens


374000
375000
6910000
6909000
BD9(LMN1A)
BD10(LMN1C)
YN5
LOCH MCNESS
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Mariginiup

Wetland/GDE name	Lake Mariginiup
Location (co-ords)	E: 387851, N: 6489665
Wetland/GDE type & description	Permanently inundated
Ecological recognition	Conservation status
Aboriginal Heritage	Registered Site of Significance (3741)
Wetland suite	Gnangara (B.2)

Summary of Issues

- Water levels have failed to reach preferred minimum spring levels since 1997
- Surrounding the wetland there is evident habitat loss
- Classified as being at significant impact from drawdown
- Episodic acidification events; management of sediment anoxia required
- Waterbird habitat

Suitable Monitoring Infrastructure

	DoW monitoring bore		
AWRC Name	MT1S	MT1I	MT1D
AWRC Ref	61610736	61610737	61610738
Easting	388528	388528	388528
Northing	6489410	6489410	6489410
Purpose	M / O	M / O	M / O
Depth drilled (m)	9	27	52
Screens (m)	2.0 - 9	22 - 24	45 - 47
Lithology	N	N	N
Status	O	O	O
Topography (mAHD)	45	45	45
Base superficial aquifer (mAHD)	-7	-7	-7
GW* minimum (mAHD)	42	42	42
Depth to base superficial aquifer (m)	52	52	52
Depth to GW* (m)	3	3	3
Seasonal Variation (m)	0.8	1 - 1.2	1 - 1.2

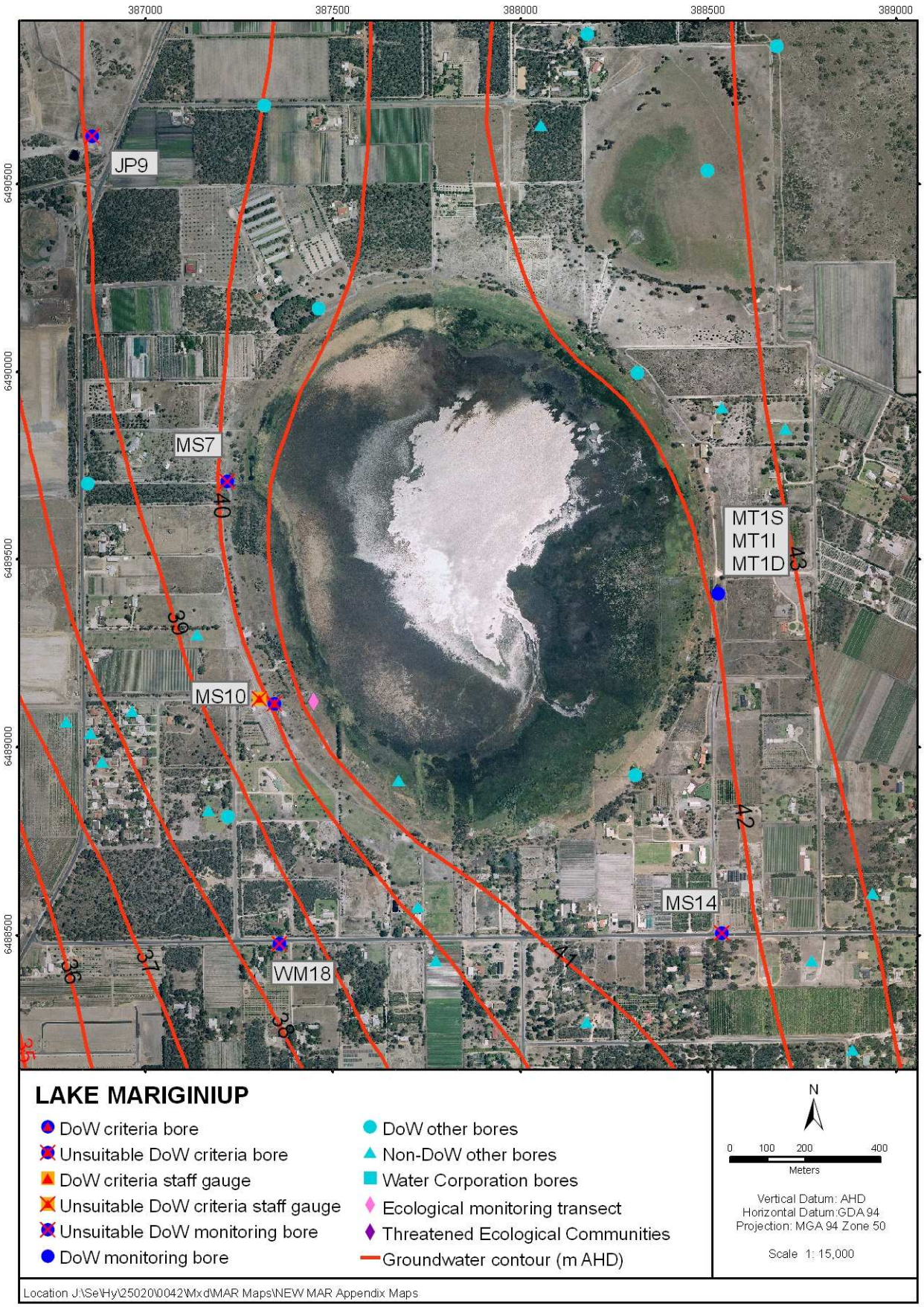
Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and infrastructure requiring further investigation. Criteria bore MS10 is unsuitable as a criteria bore, though may be suitable as a monitoring bore. The co-ordinates of the staff gauge in WIN are incorrect. The actual staff gauge is not located in the deepest part of the lake and is stranded when lake water levels are low.

AWRC Name	**Criteria Staff Guage**
AWRC Ref	LAKE MARIGINIUP 1943
Easting	387304
Northing	6489134
Purpose	6489134
Depth drilled (m)	M / M C
Topography (mAHD)	O

	Criteria Bore	**DoW monitoring bore**			
AWRC Name	MS10	MS7	WM18	JP9	MS14
AWRC Ref	61610685	61610688	61610684	61610690	61610734
Easting	387344	387220	387359	386859	388538
Northing	6489116	6489709	6488475	6490629	6488504
Purpose	M / O	M / O	M / O	I / O / P / M	M / O
Depth drilled (m)	9	9	27.4	58.52	16
Screens (m)	2.0 - 9				8.0 - 16
Lithology	N	N	N	Y	N
Status	O	O	O	O	O
Geophysical Logs	N	N	N	Y	N
Topography (mAHD)	45	45	55	45	52
Base superficial aquifer (mAHD)	-12	-12	-15	-11	-10
GW* minimum (mAHD)	40	40	39	39	42
Depth to base superficial aquifer (m)	57	57	70	56	62
Depth to GW* (m)	5	5	16	6	10
Seasonal Variation (m)	1	1	0.8	1	1
Reason for Unsuitability	Location	Screens	Screens	Location	Location

AWRC Name	**DoW Other Bore**				
AWRC Ref	MS8	MS13	MS1	MS11	MS4
Easting	61610689	61610733	61610742	61610687	61610694
Northing	386847	388307	388312	387221	387463
Purpose	6489703	6488925	6489997	6488814	6490170
Depth drilled (m)	O	O	O	O	M
Screens (m)	28.5	9	9	19.5	9
Lithology	21 - 28.5	1.0 - 9	2.0 - 9	11 - 19.5	2.0 - 9
Status	N	N	N	N	N
Geophysical Logs	NO	NO	NO	NO	NO
Topography (mAHD)	N	N	N	N	N
Base superficial aquifer (mAHD)	60	45	45	50	45
GW* minimum (mAHD)	-13	-9	-5	-15	-10
Depth to base superficial aquifer (m)	38.5	41.5	42	39	41
Depth to GW* (m)	73	54	50	65	55
Seasonal Variation (m)	21.5	3.5	3	11	4
Reason for Unsuitability	Status	Status	Status	Status	Status


387000
387500
388000
388500
389000
6490500
6490000
6489500
6489000
6488500
JP9
MS7
MS10
WM18
MS14
MT1S
MT1I
MT1D
40
39
43
42
47
36
37
38
35
LAKE MARIGINIUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 100 200 400
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Mather Reserve

Wetland/GDE name	Mather Reserve
Location (co-ords)	E: 394876, N: 6443090
Wetland/GDE type & description	Dampland
Ecological recognition	Bush Forever site, EPP
Aboriginal Heritage	Registered Site of Significance (3447)
Wetland suite	Jandakot (B.3)

Summary of Issues

- Classified as being at significant to severe risk from drawdown
- Ecologically significant, yet no vegetation monitoring transect
- Waterbird feeding site

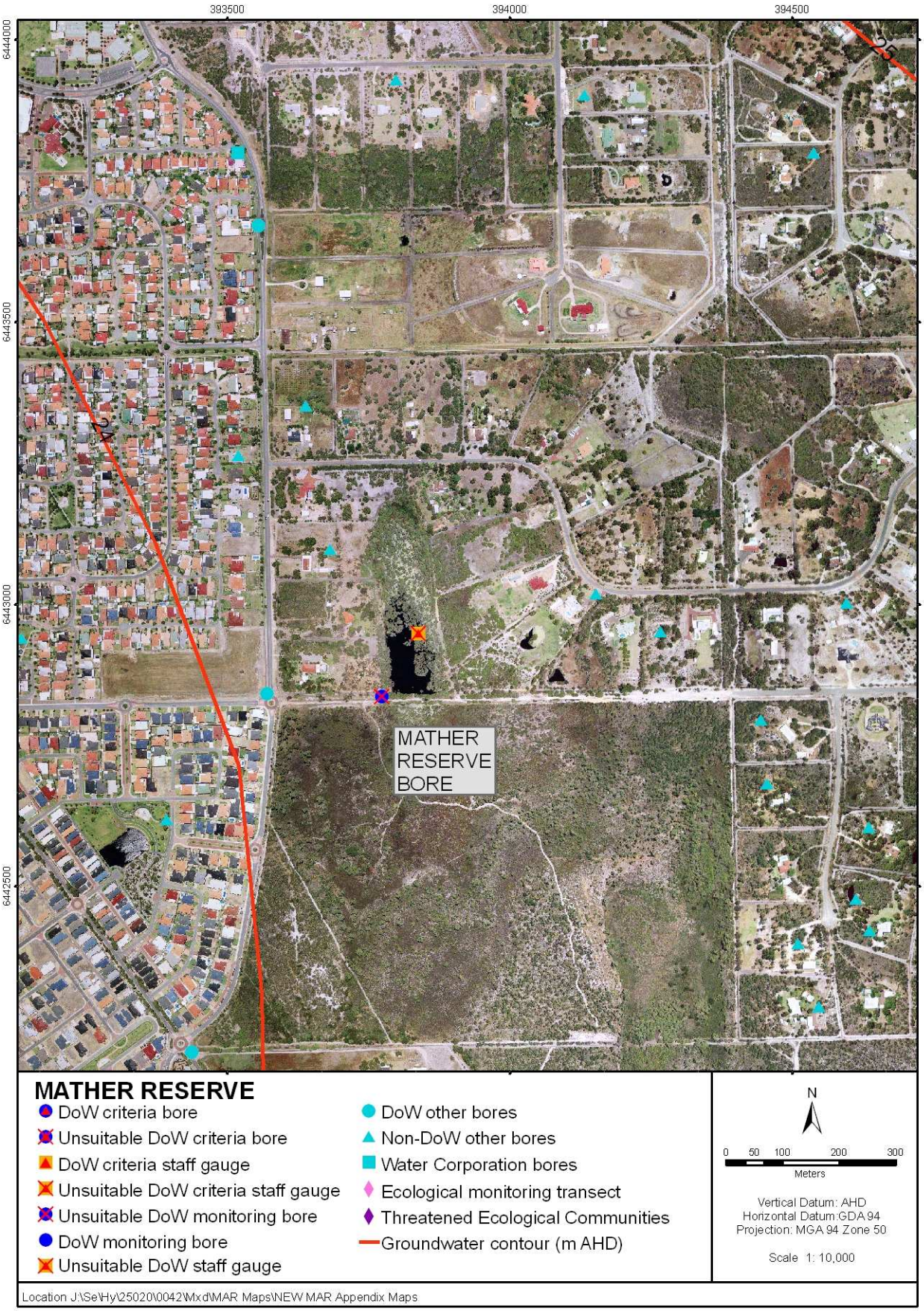
Suitable Monitoring Infrastructure

	DoW monitoring bore
AWRC Name	MATHER RESERVE BORE
AWRC Ref	61410712
Easting	393774
Northing	6442837
Purpose	M
Depth drilled (m)	4.9
Screens (m)	
Lithology	N
Status	O
Topography (mAHD)	30
Base superficial aquifer (mAHD)	-20
GW* minimum (mAHD)	24
Depth to base superficial aquifer (m)	50
Depth to GW* (m)	6
Seasonal Variation (m)	1.5

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation. Staff gauge location in WIN is incorrect, a suitable staff gauge is installed at the southern end on the lake.

	Staff Gauge
AWRC Name	MATHER RESERVE
AWRC Ref	6142545
Easting	393839
Northing	6442949
Purpose	M


393500
394000
394500
6444000
6443500
6443000
6442500
MATHER
RESERVE
BORE
MATHER RESERVE
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
Unsuitable DoW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Muckenburra

Wetland/GDE name	Lake Muckenburra
Location (co-ords)	E: 384175, N: 6532151
Wetland/GDE type & description	Permanently inundated
Ecological recognition	EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Mungala (B/P.2)

Summary of Issues

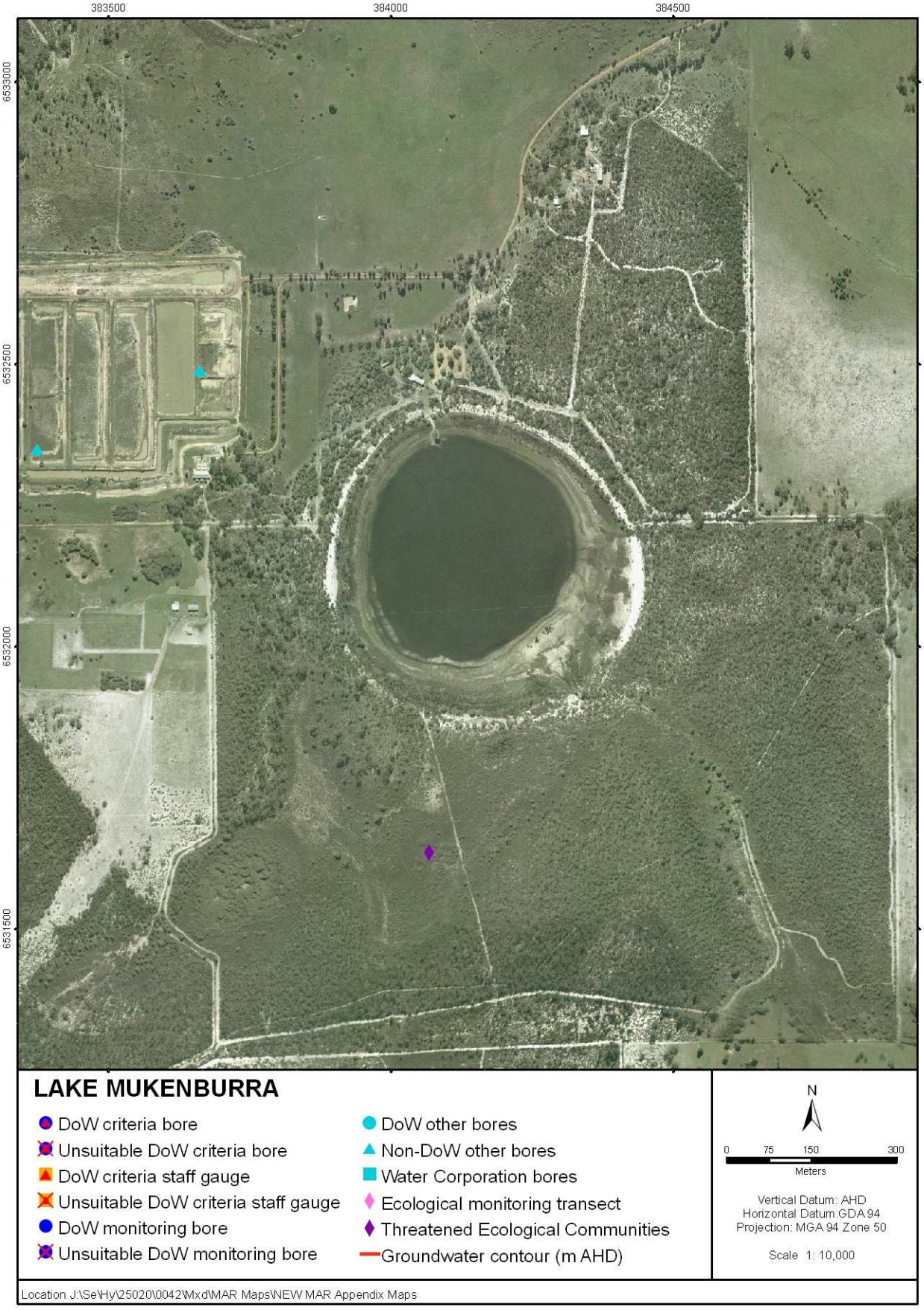
- No vegetation monitoring transect
- The TEC is not currently monitored
- Significant faunal habitats

Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable monitoring infrastructure

No unsuitable monitoring infrastructure


383500
384000
384500
6533000
6532500
6532000
6531500
LAKE MUKENBURRA
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 75 150 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

North Lake

Wetland/GDE name	North Lake
Location (co-ords)	E: 388 859, N: 6 450 358
Wetland/GDE type & description	Permanent lake
Ecological recognition	Conservation Category, EPP, System 6
Aboriginal Heritage	Four Registered Sites of Significance (3294, 3295, 3709, 4106)
Wetland suite	Bibra (S/B.1)

Summary of Issues

- The site is breaching Ministerial Criteria (as of 2007) and hydrographs show a declining trend.
- The current criteria bore does not reflect water levels at the site of the monitored vegetation transect.
- Classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- Desktop assessment indicates that there could be a degree of perching in the lake.
- There is no detailed hydrogeological study of the lake and our understanding of groundwater/wetland interaction is poor.

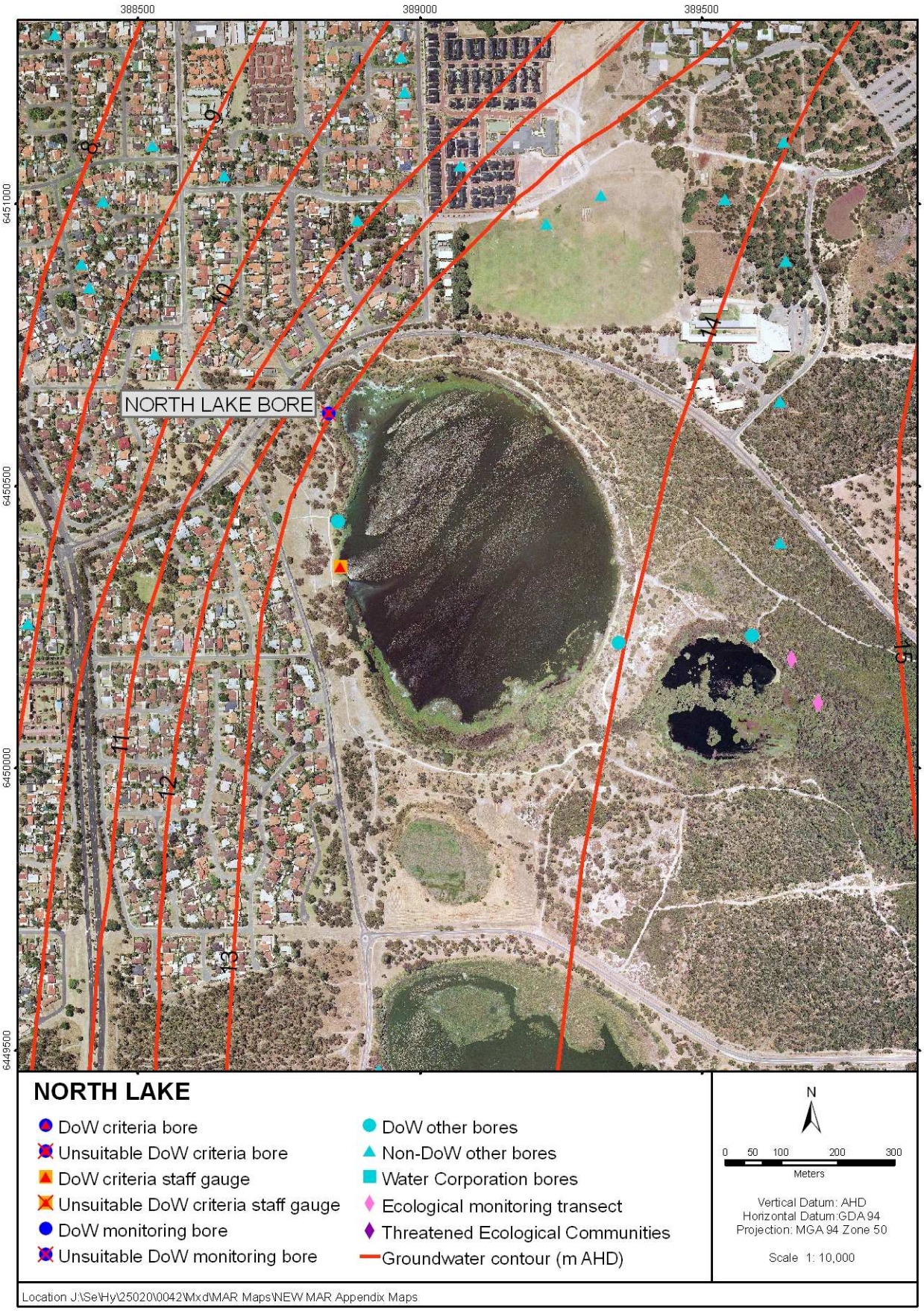
Suitable Monitoring Infrastructure

	Criteria Staff Gauge
AWRC Name	NORTH LAKE 424
AWRC Ref	6142521
Easting	388859
Northing	6450358
Purpose	M / MC
Status	O

Unsuitable Monitoring Infrastructure

Unsuitable current monitoring bores and bores requiring further investigation. The Criteria Bore unsuitable due to its location relative to vegetation transect; it may be suitable as a monitoring bore.

	Criteria Bore
AWRC Name	NORTH LAKE BORE
AWRC Ref	61410726
Easting	388839
Northing	6450629
Purpose	M / MC
Depth drilled (m)	3.26
Screens (m)	0 - 3.26
Lithology	N
Status	O
Topography (mAHD)	20
Base superficial aquifer (mAHD)	-20
GW* minimum (mAHD)	13
Depth to base superficial aquifer (m)	40
Depth to GW* (m)	7
Seasonal Variation (m)	2
Reason for Unsuitability	Location


388500
389000
389500
6451000
6450500
6450000
6449500
NORTH LAKE BORE
9
10
11
12
13
14
15
NORTH LAKE
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Nowergup

Wetland/GDE name	Lake Nowergup
Location (co-ords)	E: 379746, N: 6499839
Wetland/GDE type & description	Permanent lake
Ecological recognition	Conservation Category, EPP, Register of the National Estate, System 6
Aboriginal Heritage	Registered Site of Significance (17450)
Wetland suite	Yanchep (S.1)

Summary of Issues

- The site is breaching Ministerial Criteria (April 2005).
- Classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- The current staff gauge located on the northern side of the lake is unsuitable to measure lake levels*.
- Water levels in the lake are currently being supplemented by groundwater from the Leederville aquifer at great cost.
- There is no detailed hydrogeological study of the lake.

Suitable Monitoring Infrastructure

While the staff gauge site recorded in WIN is not suitable, there are staff gauges that are recorded in WIN that are suitable for measuring lake levels.

	Criteria Staff Gauge	**DoW monitoring bore**	
AWRC Name	LAKE NOWERGUP 8756	LN19-89	LN2-89
AWRC Ref	6162567	61611220	61611247
Easting	379746	379947	379431
Northing	6499839	6499724	6499522
Purpose	M / MC	O / M	O / M
Depth drilled (m)		5.3	8.2
Screens (m)		2.3 - 4.3	5.2 - 7.2
Lithology		N	N
Status	O	O	O
Geophysical Logs			
Topography (mAHD)		25	25
Base superficial aquifer (mAHD)		-20	-23
GW* minimum (mAHD)		16	15
Depth to base superficial aquifer (m)		45	48
Depth to GW* (m)		9	10
Seasonal Variation (m)		1.2	3

	DoW monitoring bore					
AWRC Name	LN8-89	LN5-89	LN3-89	LN24-89	LN14-89	LN22-89
AWRC Ref	61611228	61611234	61611235	61611236	61611240	61611241
Easting	380098	379672	379157	379005	380199	380199
Northing	6499295	6499078	6499430	6499384	6499879	6499879
Purpose	O / M	O / M	O / M	O / M	O / M	O / M
Depth drilled (m)	8.4	13.4	29.8	29.4	11.4	47.4
Screens (m)	6.4 - 8.4	11.4 - 13.4	27.8 - 29.8	27.4 - 29.4	8.4 - 10.4	42.4 - 45.4
Lithology	N	N	N	N	N	N
Status	O	O	O	O	O	O
Topography (mAHD)	25	25	32	35	25	25
Base superficial aquifer (mAHD)	-20	-22	-24	-25	-20	-20
GW* minimum (mAHD)	17	13	7	6	16.5	16.5
Depth to base superficial aquifer (m)	45	47	56	60	45	45
Depth to GW* (m)	8	12	25	29	8.5	8.5
Seasonal Variation (m)	1.2	1	0.5	0.5	0.5	0.5

	DoW monitoring bore					
AWRC Name	LN23-89	LN16-89	LN17-89	LN18-89	LN32-89	LN37-89
AWRC Ref	61611242	61611243	61611244	61611246	61611248	61611253
Easting	380199	380053	380049	379947	380104	379158
Northing	6499879	6499798	6499801	6499719	6499295	6499431
Purpose	O / M	O / M	O / M	O / M	O / M	O / M
Depth drilled (m)	31.4	40.9	26	46.3	29.5	53
Screens (m)	26.4 - 30.4	38.9 - 40.9	23 - 26	44.3 - 46.3	26.5 - 29.5	50 - 53
Lithology	N	N	N	N	N	N
Status	O	O	O	O	O	O
Topography (mAHD)	25	25	25	25	25	32
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-20	-24
GW* minimum (mAHD)	16.5	16	16	16	17	7
Depth to base superficial aquifer (m)	45	45	45	45	45	56
Depth to GW* (m)	8.5	9	9	9	8	25
Seasonal Variation (m)	0.6	0.8	1	1.5	1	1.5

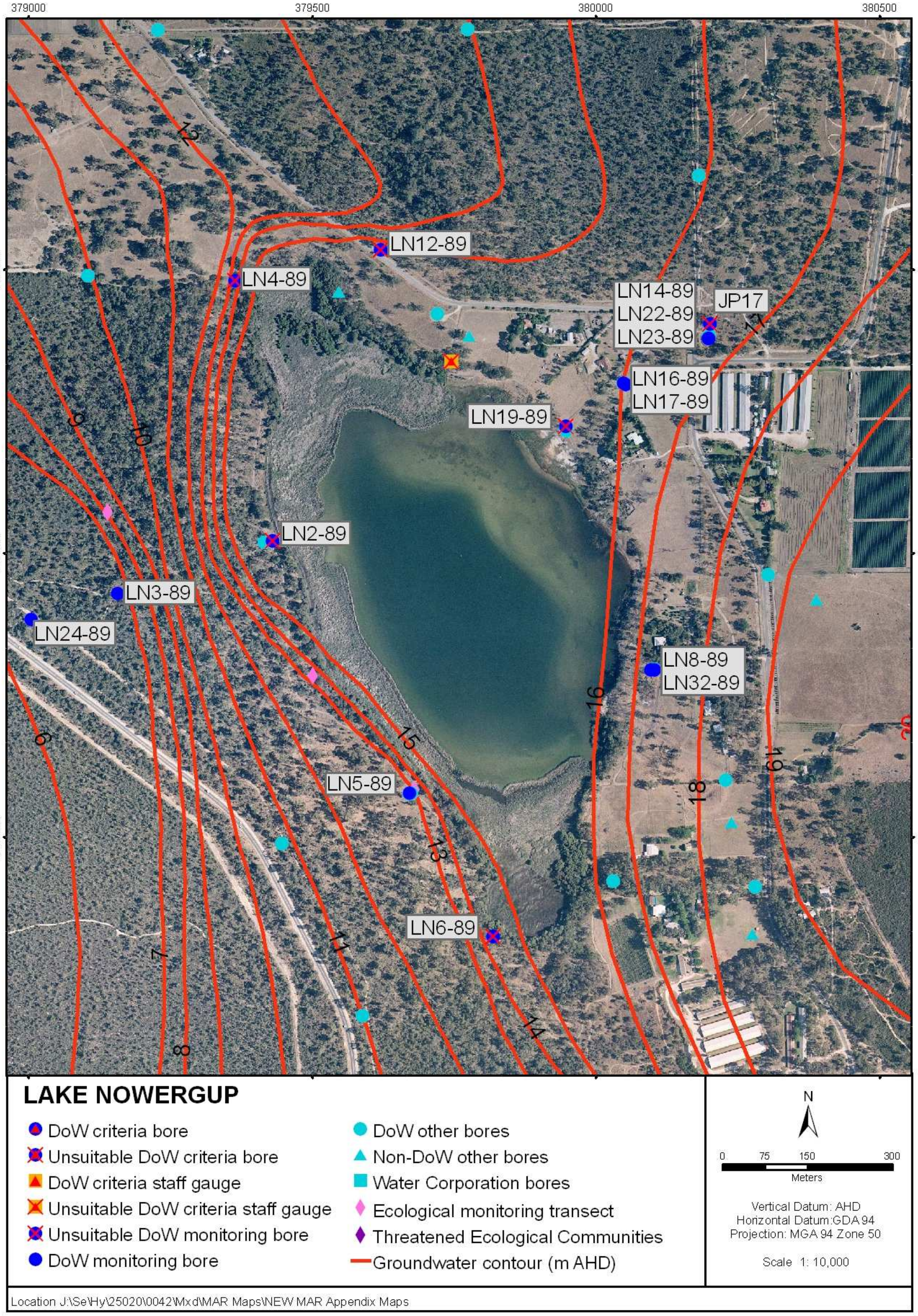
Unsuitable Monitoring Infrastructure

Unsuitable current monitoring bores and bores requiring further investigation. Extra staff gauges have been added at locations within the lake that are suitable for monitoring the water level of the lake.

	DoW monitoring bore			
AWRC Name	JP17	LN12-89	LN4-89	LN6-89
AWRC Ref	61610602	61611223	61611225	61611233
Easting	380201	379621	379365	379819
Northing	6499905	6500035	6499981	6498825
Purpose	O / O / M	O / M	O / M	O / M
Depth drilled (m)	49.08	13.4	8.2	8.4
Screens (m)	21 - 39	11.4 - 13.4	6.2 - 8.2	6.4 - 8.4
Lithology	Y	N	N	N
Status	O	O	O	O
Geophysical Logs	Y			
Topography (mAHD)	25	25	25	25
Base superficial aquifer (mAHD)	-20	-22	-23	-21
GW* minimum (mAHD)	16.5	15	13.5	14
Depth to base superficial aquifer (m)	45	47	48	46
Depth to GW* (m)	8.5	10	11.5	11
Seasonal Variation (m)	0.8	1.2	1.2	
Reason for Unsuitability	Screens	Location	Location	Location

	DoW other Bore					
AWRC Name	LN20-89	LN21-89	LN7-89	LN9-89	LN25-89	LN13-89
AWRC Ref	61611221	61611222	61611227	61611229	61611237	61611239
Easting	379948	379949	380305	380229	379447	380199
Northing	6499719	6499717	6499462	6499100	6498988	6499881
Purpose	O	O	O		O	O
Depth drilled (m)	18.3	27.8	10.4	5.5	38.4	51.4
Screens (m)	16.3 - 18.3	25.8 - 27.8	8.4 - 10.4	3.5 - 5.5	36.4 - 38.4	48.4 - 51.4
Lithology	N	N	N	N	N	N
Status	NO	NO	NO	A / NO	NO	NO
Geophysical Logs						
Topography (mAHD)	25	25	25	25	42	26
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-23	-20
GW* minimum (mAHD)	16	16	17	18.5	11	17
Depth to base superficial aquifer (m)	45	45	45	45	65	46
Depth to GW* (m)	9	9	8	6.5	31	9
Seasonal Variation (m)						
Reason for Unsuitability	Status	Status	Status	Status	Status	Status

	DoW Other Bore				
AWRC Name	LN15-89	LN33-89	LN38-89	LN39-89	LN40-89 (multiport)
AWRC Ref	61611245	61611249	61611254	61611255	61611256
Easting	380049	380104	379672	379676	379417
Northing	6499800	6499296	6499076	6499078	6499520
Purpose	O	O	O	O	O
Depth drilled (m)	8.4	17.5	54.8	31.5	
Screens (m)	6.4 - 8.4	14.5 - 17.5	51.8 - 54.8	29.5 - 31.5	
Lithology	N	N	N	N	N
Status	NO	NO	NO	NO	NO
Topography (mAHD)	25	25	25	25	25
Base superficial aquifer (mAHD)	-20	-20	-22	-22	-23
GW* minimum (mAHD)	16	17	13	13	15
Depth to base superficial aquifer (m)	45	45	47	47	48
Depth to GW* (m)	9	8	12	12	10
Seasonal Variation (m)					3
Reason for Unsuitability	Status	Status	Status	Status	Status


379000
379500
380000
380500
6500000
6499500
6499000
LN12-89
LN4-89
LN14-89
LN22-89
LN23-89
JP17
LN16-89
LN17-89
LN19-89
LN2-89
LN3-89
LN24-89
LN8-89
LN32-89
LN5-89
LN6-89
LAKE NOWERGUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 75 150 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Peters Spring

Wetland/GDE name	Peters Spring (PETERS01)
Location (co-ords)	E: 401639, N: 6504799
Wetland/GDE type & description	Seepage, mound spring
Ecological recognition	Resource Enhancement
Aboriginal Heritage	Two Registered Sites of Significance (3525, 3930)
Wetland suite	Ellen Brook (R.3)

Summary of Issues

- No hydrogeological studies have been undertaken on any mound spring site on the Swan Coastal Plain
- The site represents a different hydrogeological regime to other sites in the investigation program.
- Information from the investigation can be applied to other mound spring sites on both Gnangara and Jandakot mounds.
- This site maintains several threatened communities that are currently not currently monitored.
- Froend *et al.,* (2004) recommend that ecological monitoring should be reinstated at this site.

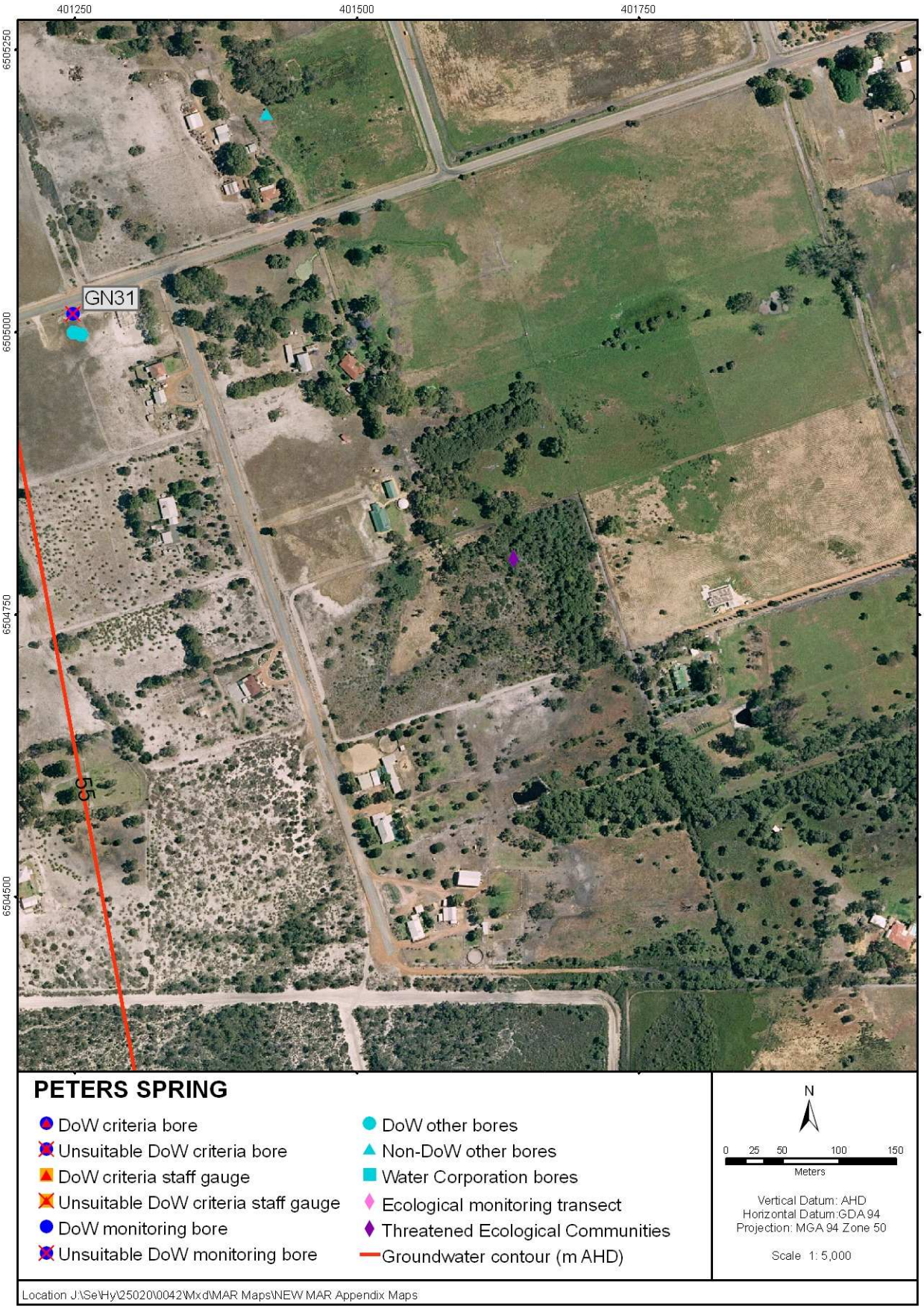
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable monitoring infrastructure

Unsuitable monitoring bore; no infrastructure requiring further investigation

	DoW monitoring bore
AWRC Name	GN31
AWRC Ref	61611044
Easting	401249
Northing	6505017
Purpose	Inv / Inv / M
Depth drilled (m)	91.44
Screens (m)	78.77 - 85.34
Lithology	Y
Status	O
Geophysical Logs	Y
Topography (mAHD)	67
Base superficial aquifer (mAHD)	12
GW* minimum (mAHD)	55
Depth to base superficial aquifer (m)	55
Depth to GW* (m)	12
Seasonal Variation (m)	0.8
Reason for Unsuitability	Screens


401250
401500
401750
6505250
6505000
6504750
6504500
GN31
55
PETERS SPRING
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 25 50 100 150
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 5,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Pinjar

Wetland/GDE name	Lake Pinjar
Location (co-ords)	E: 384591, N:6499998
Wetland/GDE type & description	Sumpland
Ecological recognition	Bush Forever site, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Pinjar (B.1)

Summary of Issues

- Site is severely degraded from agricultural land use.
- High conservation value of remnant wetland vegetation.
- Ecologically important site for terrestrial fauna.

Suitable Monitoring Infrastructure

	DoW monitoring bore	
AWRC Name	GN23	GNM6
AWRC Ref	61610753	61613205
Easting	389030	387956
Northing	6499466	6502085
Purpose	O / M	
Depth drilled (m)	76.81	11.57
Screens (m)	37.49 - 38.1	5.57 - 11.57
Lithology	Y	N
Status	O	O
Geophisical Logs	Y	
Topography (mAHD)	55	57
Base superficial aquifer (mAHD)	-5	-5
GW* minimum (mAHD)	45	43.5
Depth to base superficial aquifer (m)	60	62
Depth to GW* (m)	10	13.5
Seasonal Variation (m)	2.5	0.8

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	Criteria Bores	
AWRC Name	PM24	PM25
AWRC Ref	61610697	61610750
Easting	387197	388939
Northing	6497829	6496827
Purpose	M / MC	M / MC
Depth drilled (m)	14	13.5
Screens (m)	1.0 - 14	1 - 13.5
Lithology	N	N
Status	O	O
Geophysical Logs	N	N
Topography (mAHD)	45	48
Base superficial aquifer (mAHD)	-12	-8
GW* minimum (mAHD)	41.5	43.5
Depth to base superficial aquifer (m)	57	56
Depth to GW* (m)	3.5	4.5
Seasonal Variation (m)	2	1.8
Reason for Unsuitability	Screens	Screens

	DoW monitoring bore					
AWRC Name	PM37	PM23	PVEG1	PVEG2	PVEG3	GNM5
AWRC Ref	61610670	61610698	61611150	61611151	61611152	61613204
Easting	385406	387970	388256	388312	388412	390013
Northing	6502138	6500163	6500955	6500935	6500894	6497415
Purpose	M	M	O / M	O / M	O / M	M
Depth drilled (m)	-	13.2	-	-	-	12.04
Screens (m)	-	1 - 13.2	-	-	-	5.49 - 11.49
Lithology	N	N	N	N	N	N
Status	O	O	O	O	O	O
Geophysical Logs	N	N	N	N	N	N
Topography (mAHD)	45	47	55	55	55	59
Base superficial aquifer (mAHD)	-14	-10	-10	-10	-10	-5
GW* minimum (mAHD)	38	43	44	44	46.5	47.5
Depth to base superficial aquifer (m)	59	57	65	65	65	64
Depth to GW* (m)	7	4	11	11	8.5	11.5
Seasonal Variation (m)	1.5	1.5	1	0.8 - 1	1	1
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens	Location

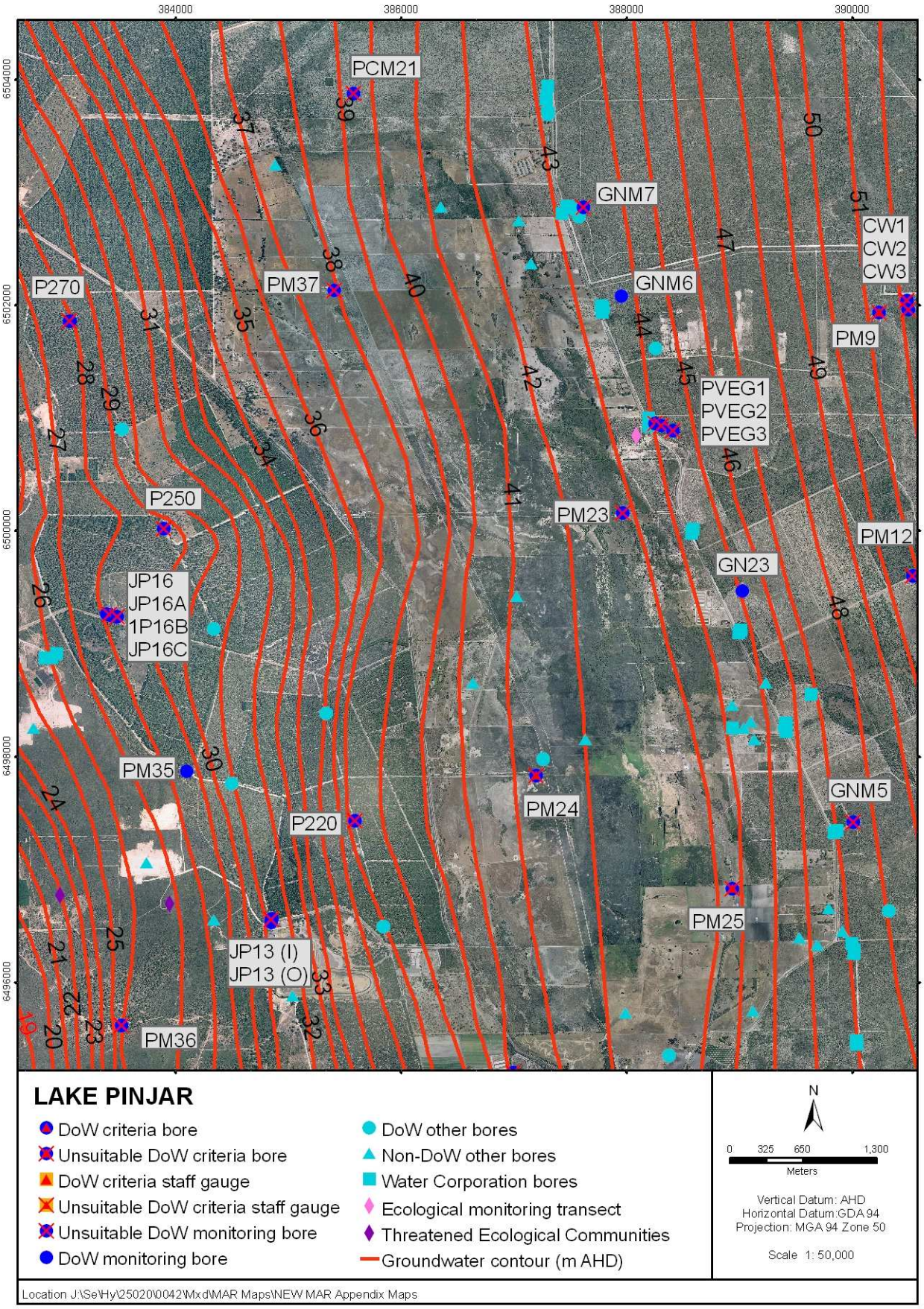
	DoW monitoring bore					
AWRC Name	PCM21	P270	CW1	CW2	CW3	P250
AWRC Ref	61610671	61610614	61611941	61611942	61611943	61610639
Easting	385583	383062	390497	390496	390490	383899
Northing	6503879	6501862	6501968	6501972	6502040	6500020
Purpose	M	O / M	M	M	M	O / M
Depth drilled (m)	25.9	73	8.72	2.31	9.53	72
Screens (m)	5 – 25.9	16 - 73	5.72 – 8.72	0 - 2.31	3.53 – 9.53	0 – 72
Lithology	N	N	N	N	N	N
Status	O	O	O	NO	O	O
Geophysical Logs	N	N	N	N	N	N
Topography (mAHD)	49	48	65	65	65	50
Base superficial aquifer (mAHD)	-12	-16	-5	-5	-5	-18
GW* minimum (mAHD)	39	28	52	52	52	29
Depth to base superficial aquifer (m)	61	64	70	70	70	68
Depth to GW* (m)	10	20	13	13	13	21
Seasonal Variation (m)	1.3	0.1	1- 0.5		0.5	0.25
Reason for Unsuitability	Screens	Screens	Depth	Status	Depth	Screens

	DoW monitoring bore					
AWRC Name	PM35	JP16	JP16A	JP16B	JP16C	P220
AWRC Ref	61610636	61610638	6161064	61610641	61610642	61610677
Easting	384101	383390	383399	383421	383480	385591
Northing	6497871	6499264	6499261	6499255	6499238	6497428
Purpose	M	I / E / O	O	O	O	O / M
Depth drilled (m)	36.4	71	74.5	73	-	74
Screens (m)	19 – 36.4	34 - 70	10 - 70	11 - 71	32 – 68	0 - 74
Lithology	N	Y	N	N	N	N
Status	O	O	O	O	O	O
Geophysical Logs	N	Y	N	N	N	N
Topography (mAHD)	52	45	45	45	45	50
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-20	-20
GW* minimum (mAHD)	29	28	28	28	28	37
Depth to base superficial aquifer (m)	72	65	65	65	65	70
Depth to GW* (m)	23	17	17	17	17	13
Seasonal Variation (m)	0.2	0.4	0.4	0.3	0.3	
Reason for Unsuitability	Screens	Screens	Screens	Screens	Screens	Screens

	DoW monitoring bore			
AWRC Name	JP13 (I)	JP13 (O)	PM36	PM12
AWRC Ref	61610634	61610635	61610633	61610803
Easting	384852	384854	383525	390545
Northing	6496529	6496559	6495612	6499600
Purpose	I / O	O / M	M	M
Depth drilled (m)	91	81	44.9	13.4
Screens (m)	49.5 – 79.5	-	30 – 44.9	1 – 13.4
Lithology	Y	N	N	N
Status	O	O	O	O
Geophysical Logs	Y	Y	N	N
Topography (mAHD)	70	70	60	60
Base superficial aquifer (mAHD)	-17	-17	-15	-4
GW* minimum (mAHD)	31	31	26	51
Depth to base superficial aquifer (m)	87	87	45	64
Depth to GW* (m)	39	39	34	
Seasonal Variation (m)		0.2	0.25	0.5 – 1.0
Reason for Unsuitability	Screens	Screens	Screens	Screens

	DoW Other Bore					
AWRC Name	MONITOR BORE PM24	P25A	P65 3-92	P65 5-92	CW8	CW9
AWRC Ref	61620027	61618400	61618404	61618406	61611948	61611949
Easting	387264	389403	387792	387791	387527	387577
Northing	6497974	6498258	6501966	6501965	6502859	6502789
Purpose		O	O	O		
Depth drilled (m)		10.1	9	56.52	10.13	11.13
Screens (m)		7.1 - 10.1	0 - 9	55.52 - 56.52	.13 - 9.13	2.13 - 11.13
Lithology	N	N	N	N	N	N
Status	NO	NO	O	O	NO	NO
Geophysical Logs	N	N	N	N	N	N
Topography (mAHD)	45	55	55	55	59	60
Base superficial aquifer (mAHD)	-13	-5	-5	-5	-5	-5
GW* minimum (mAHD)	42.5	44.5	43	43	43.5	43.5
Depth to base superficial aquifer (m)	58	60	60	60	64	65
Depth to GW* (m)	2.5	10.5	12	12	15.5	16.5
Seasonal Variation (m)						
Reason for Unsuitability	Status	Status	Access	Access	Status	Status

	DoW Other Bore				
AWRC Name	P210	GN33 (I)	GN33 (O)	WRR1	P65 6-92
AWRC Ref	61610666	61610701	61610703	61618560	61618407
Easting	385846	387307	387309	388259	387789
Northing	6496487	6503697	6503729	6501624	6501965
Purpose	O	I	O		O
Depth drilled (m)	74	91.59	64.62	8.4	81.27
Screens (m)	60 - 71	55.1 - 63.2		5.4 - 8.4	80.07 - 81.27
Lithology	N	Y	N	N	N
Status	NO	A / NO	A / NO	NO	O
Geophysical Logs	N	Y	N	N	N
Topography (mAHD)	53	60	60	55	55
Base superficial aquifer (mAHD)	-16	-5	-5	-6	-5
GW* minimum (mAHD)	37	43	43	44.5	43
Depth to base superficial aquifer (m)	69	65	65	61	60
Depth to GW* (m)	16	17	17	10.5	12
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Access


384000
386000
388000
390000
6504000
6502000
6500000
6498000
6496000
PCM21
GNM7
CW1
CW2
CW3
P270
PM37
GNM6
PM9
PVEG1
PVEG2
PVEG3
P250
PM23
PM12
GN23
JP16
JP16A
1P16B
JP16C
PM35
PM24
GNM5
P220
PM25
JP13 (I)
JP13 (O)
PM36
37
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43
50
51
38
40
47
31
35
44
45
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29
42
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23
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19
33
32
LAKE PINJAR
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 325 650 1,300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 50,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Pipidinny Swamp

Wetland/GDE name	Pipidinny Swamp
Location (co-ords)	E: 375155, N: 6505342
Wetland/GDE type & description	Sumpland
Ecological recognition	Conservation status
Aboriginal Heritage	Registered Site of Significance (17451)
Wetland suite	Yanchep (S.1)

Summary of Issues

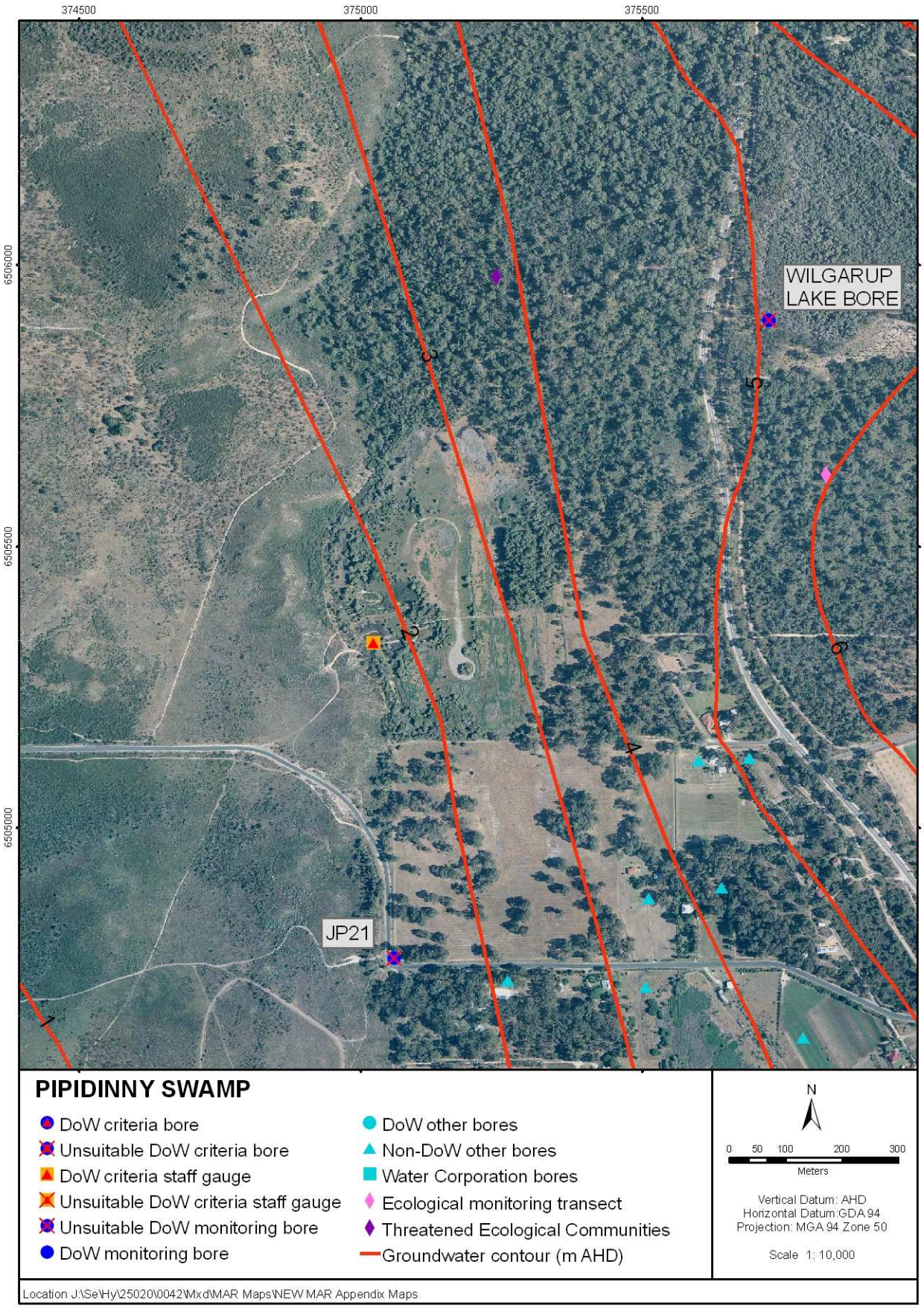
- Breaching preferred summer minimum levels every year since 1994, and breached absolute summer minimum levels in 1998 and 2001.
- No shallow monitoring bores within 500 m of the swamp, which dries out 4-5 months per year.

Suitable Monitoring Infrastructure

	Criteria Staff Gauge
AWRC Name	PIPPIDINNY SWAMP
AWRC Ref	6162624
Easting	375023
Northing	6505329
Purpose	M / M C
Status	O

Unsuitable Monitoring Infrastructure

	DoW monitoring bore	
AWRC Name	WILGARUP LAKE BORE	JP21
AWRC Ref	61618500	61610581
Easting	375726	375060
Northing	6505902	6504769
Purpose	M	O / M
Depth drilled (m)	6.54	58
Screens (m)	3.54 – 6.54	36.4 - 54.4
Lithology	N	Y
Status	O	O
Geophysical Logs	N	Y
Topography (mAHD)	10	13
Base superficial aquifer (mAHD)	-30	-30
GW* minimum (mAHD)	5	2
Depth to base superficial aquifer (m)	40	43
Depth to GW* (m)	5	11
Seasonal Variation (m)	0.8	0.6
Reason for Unsuitability	Location	Location


374500
375000
375500
6506000
6505500
6505000
WILGARUP
LAKE BORE
JP21
PIPIDINNY SWAMP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

PM4

Wetland/GDE name	PM4
Location (co-ords)	E: 390 409, N: 6 506 351
Wetland/GDE type & description	Dampland (remnant wetland)
Ecological recognition	Conservation Category
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- The site is in a similar setting to Lake Bindiar but represents a more advanced “wetland evolutionary stage".
- Site has an excellent palaeoclimate record stored in the wetland sediments.
- Is on the margin of the Yarragadee impact area.

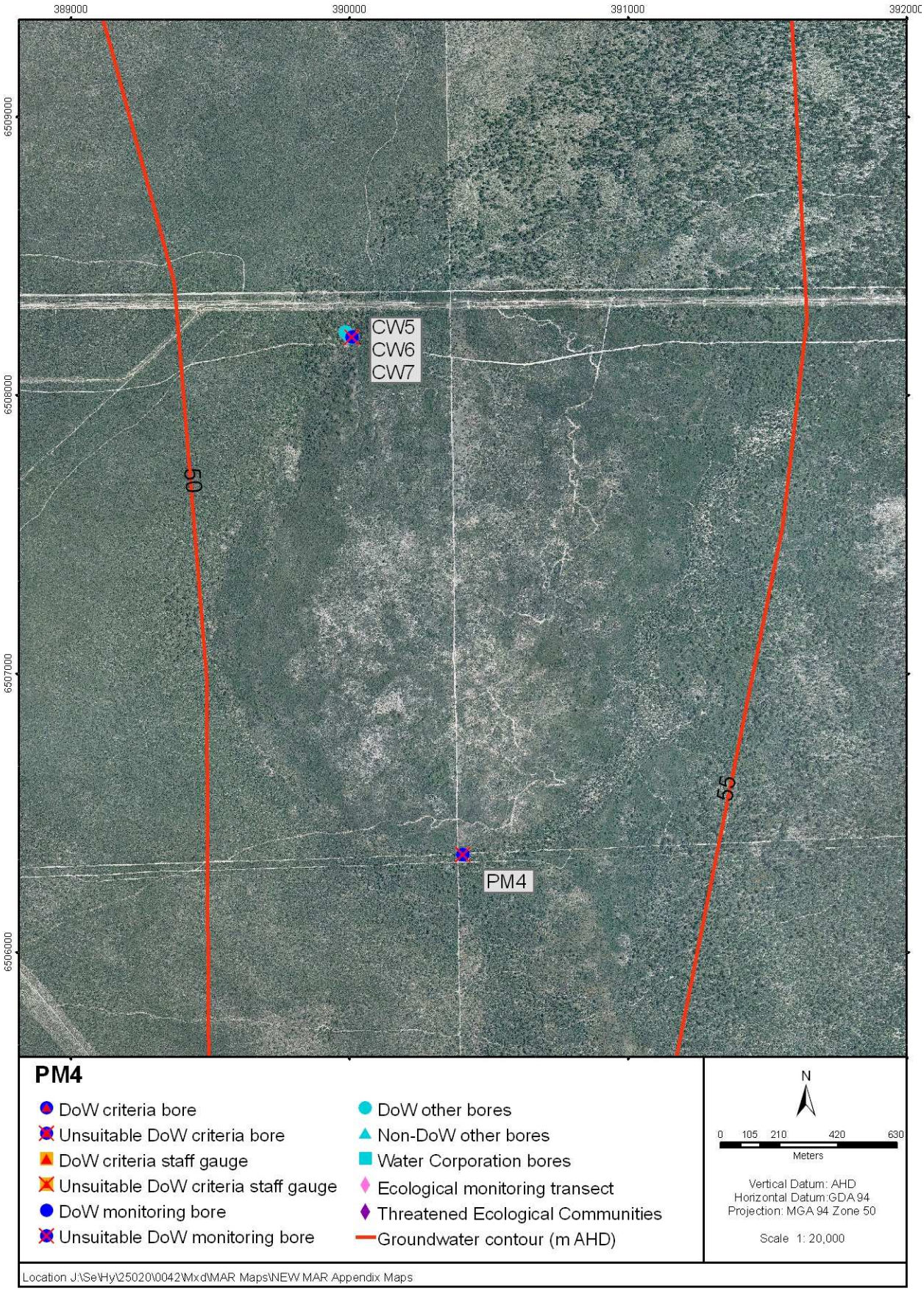
Suitable Monitoring Infrastructure

No current suitable bores

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore		**DoW Other Bore**	
AWRC Name	PM4	CW5	CW6	CW7
AWRC Ref	61610805	61611945	61611946	61611947
Easting	390409	390009	390005	389986
Northing	6506351	6508210	6508208	6508227
Purpose	M	M	M	M
Depth drilled (m)	19.5	9.51	2.58	9.9
Screens (m)	7 - 19.5	6.62 - 9.51	0.6 - 2.58	3.9 - 9.9
Lithology	N	N	N	N
Status	O	O	NO	NO
Topography (mAHD)	70	70	70	70
Base superficial aquifer (mAHD)	0	7	7	7
GW* minimum (mAHD)	53	52	52	52
Depth to base superficial aquifer (m)	70	63	63	63
Depth to GW* (m)	17	18	18	18
Seasonal Variation (m)				
Reason for Unsuitability	Screens	Stranded	Stranded	Stranded


389000
390000
391000
392000
6509000
6508000
6507000
6506000
CW5
CW6
CW7
PM4
50
52
PM4
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 105 210 420 630
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Shirley Balla Swamp

Wetland/GDE name	Shirley Balla Swamp
Location (co-ords)	E: 394438, N: 6442037
Wetland/GDE type & description	Sumpland, seasonally inundated (seasonal groundwater through-flow wetland)
Ecological recognition	Conservation status, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- Breaching absolute summer minimum water levels every year since 1997, which has resulted in a decline in the condition of fringing vegetation and a decrease in macroinvertebrate richness
- Over the last ten years, water levels have been gradually declining
- Classified as being at severe risk from drawdown
- Evidence of perching

Suitable Monitoring Infrastructure

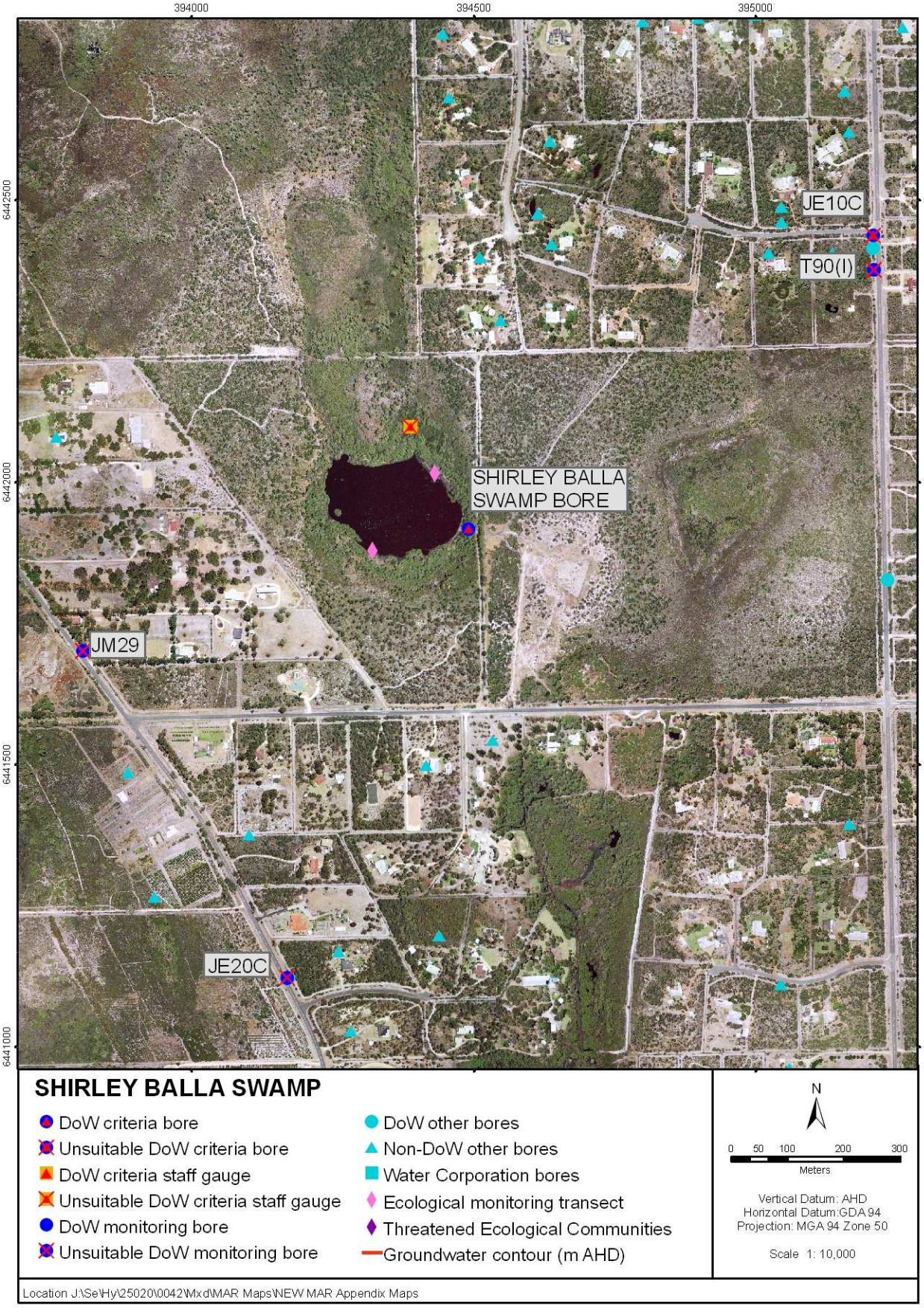
	Criteria Bore
AWRC Name	SHIRLEY BALLA SWAMP BORE
AWRC Ref	61410713
Easting	394492
Northing	6441918
Purpose	M / MC
Depth drilled (m)	4.53
Screens (m)	0.28 - 4.53
Lithology	N
Status	O
Topography (mAHD)	30
Base superficial aquifer (mAHD)	-20
GW* minimum (mAHD)	24.5
Depth to base superficial aquifer (m)	50
Depth to GW* (m)	5.5
Seasonal Variation (m)	1.5

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and infrastructure requiring further investigation.

	Criteria Staff Gauges
AWRC Name	SHIRLEY BALLA SWAMP
AWRC Ref	6142576
Easting	394389
Northing	6442089
Purpose	O / M / MC
Depth drilled (m)	
Screens (m)	
Lithology	
Status	O

	Criteria Bore	**DoW monitoring bore**			
AWRC Name	JE10C	JM29	T90 (I)	JE19C	JE20C
AWRC Ref	61410250	61410237	61410249	61419705	61419706
Easting	395209	393809	395210	393528	394171
Northing	6442439	6441702	6442378	6442080	6441122
Purpose	I / M / MC	M	M / P	O / M	O / M
Depth drilled (m)	10		45	6	6
Screens (m)	0.75 - 10			0 - 6	0 - 6
Lithology	N	N	Y	N	N
Status	O	O	O	O	O
Topography (mAHD)	30	30	30	30	30
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-18
GW* minimum (mAHD)	25	24	25	24	24
Depth to base superficial aquifer (m)	50	50	50	50	48
Depth to GW* (m)	5	6	5	6	6
Seasonal Variation (m)	2.5	2.2	2.2	1.8	1.6
Reason for Unsuitability	Location	Screens	Screens	Location	Location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394500
395000
6442500
6442000
6441500
6441000
JE10C
T90(I)
SHIRLEY BALLA
SWAMP BORE
JM29
JE20C
SHIRLEY BALLA SWAMP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

The Spectacles

Wetland/GDE name	The Spectacles
Location (co-ords)	E: 390739, N: 6435338
Wetland/GDE type & description	Dampland
Ecological recognition	Conservation Category, EPP, National importance
Aboriginal Heritage	Registered Site of Significance (3247)
Wetland suite	Bibra (S/B.1)

Summary of Issues

- The lake is classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- The site functions differently to Thomsons Lake (located directly north) and we need to understand the differences between the two sites
- No hydrogeological investigations have been undertaken at the site.
- There is no vegetation monitoring and the current ecological status of the lake is unknown.

Suitable Monitoring Infrastructure

	DoW monitoring bore					**Staff Gauge**
AWRC Name	T140 (I)	SP1-1A	SP1-1B	SP1-1C	SP1-1D	SPECTACLES SWAMP
AWRC Ref	61410418	61419851	61419852	61419853	61419854	6142528
Easting	390983	389952	389952	389952	389952	390739
Northing	6435951	6434940	6434938	6434937	6434935	6435338
Purpose	O / M	M	M	M	M	M
Depth drilled (m)	29	34	25	19.5	7	
Screens (m)	22 - 28	27 - 30	22.5 - 24	17 - 18.5	3.0 - 7	
Lithology	N	Y	N	N	N	N
Status	O	O	O	O	O	O
Topography (mAHD)	15	15	15	15	15	
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-20	
GW* minimum (mAHD)	11	8	8	8	8	
Depth to base superficial aquifer (m)	35	35	35	35	35	
Depth to GW* (m)	4	7	7	7	7	
Seasonal Variation (m)	1	0.7	0.6 - 0.8	0.8	0.8	

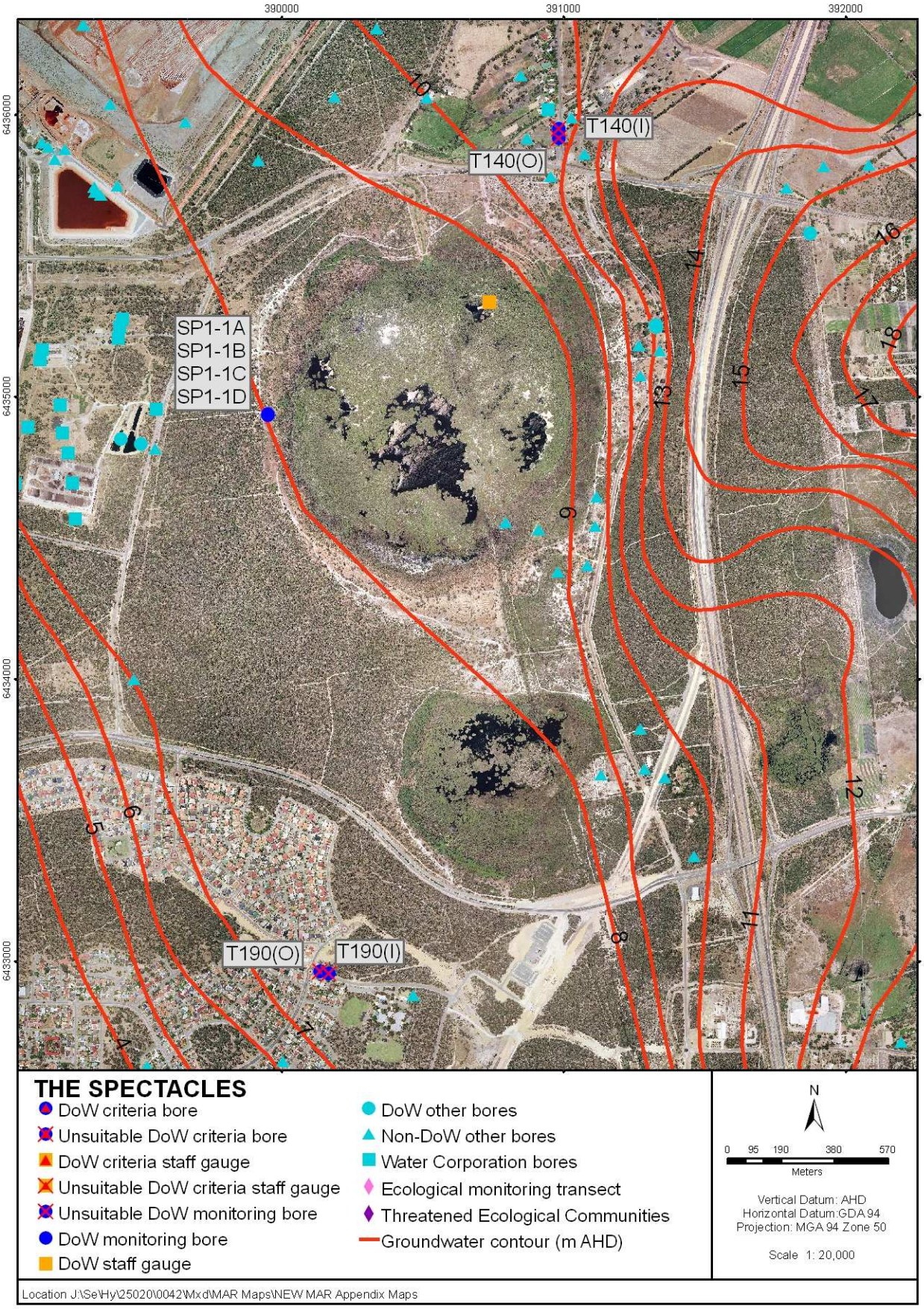
Unsuitable monitoring infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore		
AWRC Name	T190 (O)	T190 (I)	T140 (O)
AWRC Ref	61410082	61410083	61410084
Easting	390138	390169	390984
Northing	6432965	6432956	6435919
Purpose	O / M	I / M	O / M
Depth drilled (m)	62.449	56.5	45
Screens (m)		44.5 - 45.1	
Lithology	Y	N	Y
Status	O	O	O
Geophysical Logs	Y	N	Y
Topography (mAHD)	34	33	15
Base superficial aquifer (mAHD)	-20	-20	-20
GW* minimum (mAHD)	7	7	11
Depth to base superficial aquifer (m)	54	53	35
Depth to GW* (m)	27	26	4
Seasonal Variation (m)	0.5	0.5	0.8
Reason for Unsuitability	Screens	Location	Screens

	DoW Other Bore				
AWRC Name	SP1-2A	SP1-2B	SP1-2C	SP-KW1	SP-KW2
AWRC Ref	61419855	61419856	61419857	61419870	61419871
Easting	391328	391329	391329	389504	389433
Northing	6435255	6435252	6435249	6434834	6434852
Purpose	M	M	M	M	M
Depth drilled (m)	32	17.5	5	7.5	9.56
Screens (m)	27 - 31	14.5 - 17.5	3.0 - 5	1.5 - 7.5	6.56 - 9.56
Lithology	Y	N	N	N	N
Status	NO	NO	NO	NO	NO
Geophysical Logs	N	N	N	N	N
Topography (mAHD)	15	15	15	20	21
Base superficial aquifer (mAHD)	-20	-20	-20	-20	-20
GW* minimum (mAHD)	12	12	12	7.5	7.5
Depth to base superficial aquifer (m)	35	35	35	40	41
Depth to GW* (m)	3	3	3	12.5	13.5
Seasonal Variation (m)					
Reason for Unsuitability	Status	Status	Status	Status	Status

	Water Corp Bore			
AWRC Name	KW7	KW6	KW8	KW14
AWRC Ref	61410271	61410272	61410279	61425000
Easting	389427	389436	389421	389557
Northing	6435249	6435276	6435207	6434955
Purpose	O	O	O	
Depth drilled (m)	21.8	20.8	21.5	16.26
Screens (m)	15.8 - 20.8	14.8 - 19.8	15.5 - 20.5	10.26 - 16.26
Lithology	N	N	N	N
Status	O	O	O	O
Geophysical Logs	N	N	N	N
Topography (mAHD)	25	26	25	22
Base superficial aquifer (mAHD)	-20	-20	-20	-20
GW* minimum (mAHD)	7.5	7.5	7.5	7.5
Depth to base superficial aquifer (m)	45	46	45	42
Depth to GW* (m)	17.5	18.5	17.5	14.5
Seasonal Variation (m)				
Reason for Unsuitability	Access	Access	Access	Access


390000
391000
392000
6436000
6435000
6434000
6433000
T140(I)
T140(O)
SP1-1A
SP1-1B
SP1-1C
SP1-1D
T190(O)
T190(I)
10
14
16
18
15
13
17
9
12
11
8
5
6
7
THE SPECTACLES
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 95 190 380 570
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Tangletoe Swamp

Wetland/GDE name	Tangletoe Swamp
Location (co-ords)	E: 378632, N: 6530259
Wetland/GDE type & description	Dampland
Ecological recognition	Conservation Category Wetland
Aboriginal Heritage	No registered sites of significance
Wetland suite	Jandakot

Summary of Issues

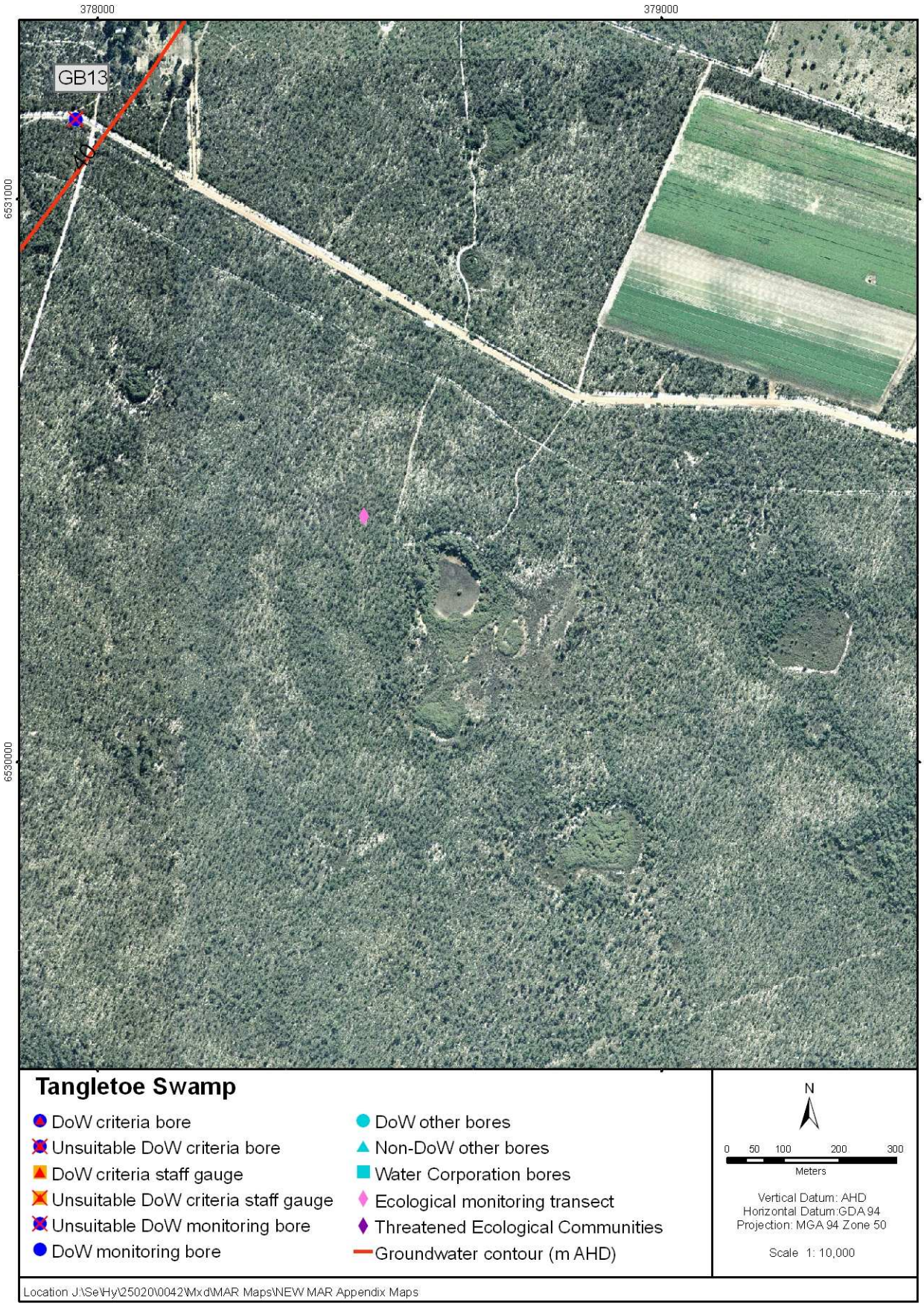
- Suggested reference site for water level changes on Gnangara Mound
- Little detailed understanding of hydrogeology
- Supports high macroinvertebrate species richness
- Site is relatively pristine

Suitable Monitoring Infrastructure

There is no suitable monitoring infrastructure at this site.

Unsuitable monitoring infrastructure

	DoW Monitoring Bore
AWRC Name	GB13
AWRC Ref	61710078
Easting	377961
Northing	6531142
Purpose	M
Depth drilled (m)	18.4
Screens (m)	4 – 18.4
Lithology	N
Status	O
Topography (mAHD)	45
Base superficial aquifer (mAHD)	2
GW* minimum (mAHD)	40
Depth to base superficial aquifer (m)	43
Depth to GW* (m)	5
Seasonal Variation (m)	0.5
Reason for Unsuitability	Location


378000
379000
GB13
A0
6531000
6530000
Tangletoe Swamp
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Timuru

Wetland/GDE name	Timuru (Ironstone Community)
Location (co-ords)	E: 396359, N: 6519429
Wetland/GDE type & description	Dampland/Palusplain
Ecological recognition	CALM registered Threatened Ecological Community
Aboriginal Heritage	Nine Registered Sites of Significance (19183, 19138, 20008, 21615, 21616, 21617, 21618, 21619, 21620)
Wetland suite	Ellen Brook (R.3)

Summary of Issues

- The site is possibly hydrogeologically unique and needs to be understood to preserve a rare ecological community
- Detailed hydrogeological characteristics and surface water-groundwater interactions are unknown.
- DEC registered Threatened Ecological Communities

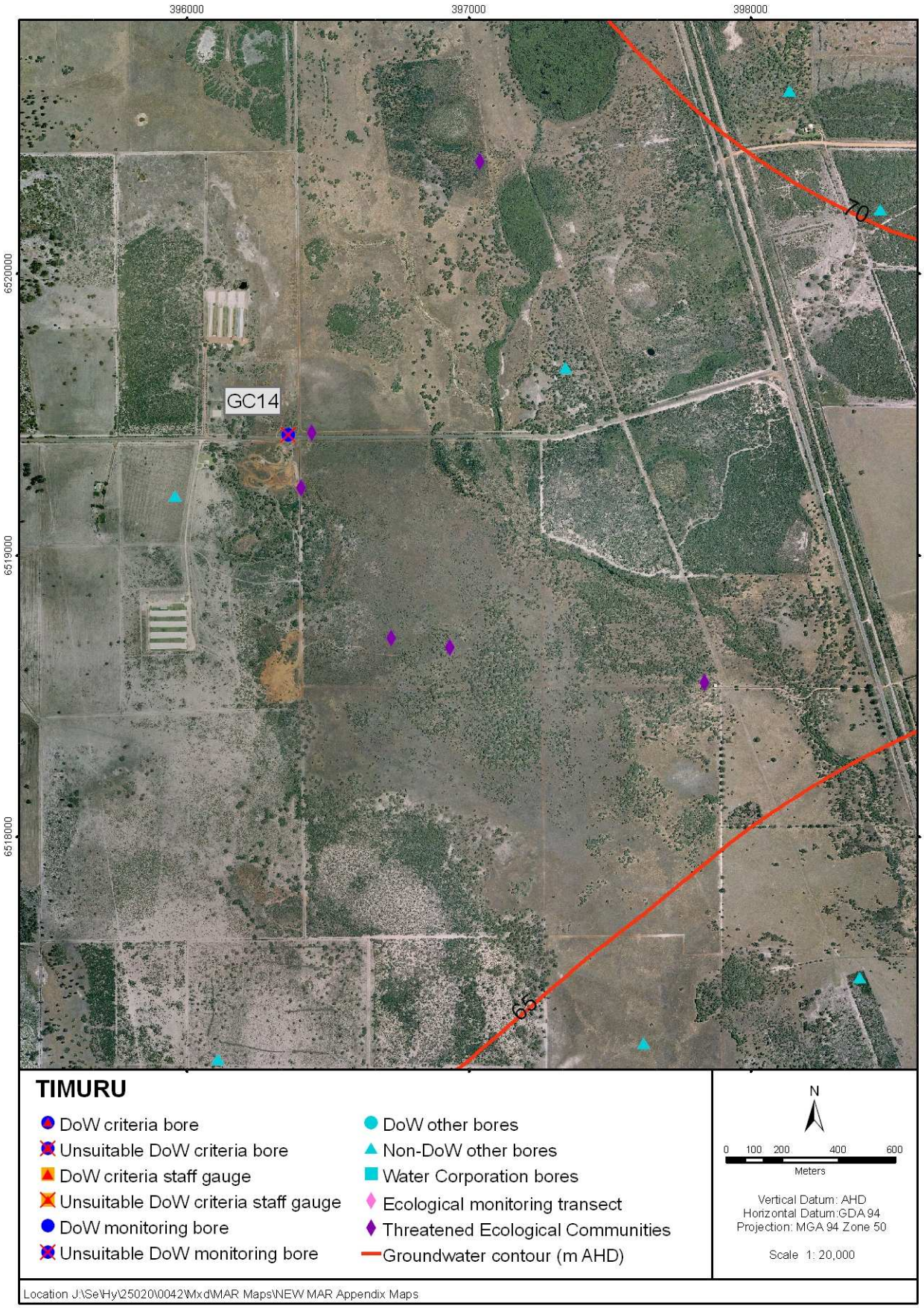
Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable monitoring infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	DoW monitoring bore
AWRC Name	GC14
AWRC Ref	61610953
Easting	396359
Northing	6519429
Purpose	M / O
Depth drilled (m)	14
Screens (m)	
Lithology	Y
Status	O
Topography (mAHD)	70
Base superficial aquifer (mAHD)	25
GW* minimum (mAHD)	67
Depth to base superficial aquifer (m)	45
Depth to GW* (m)	3
Seasonal Variation (m)	2
Reason for Unsuitability	Screens


396000
397000
398000
6520000
6519000
6518000
GC14
70
65
TIMURU
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
Unsuitable DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 100 200 400 600
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Thomson's Lake

Wetland/GDE name	Thomson's Lake
Location (co-ords)	E: 389513, N: 6443112
Wetland/GDE type & description	Permanent lake
Ecological recognition	Conservation Category, EPP, System 6, Register of the National Estate, Ramsar Wetland
Aboriginal Heritage	Three Registered Sites of Significance (3290, 3292, 18938)
Wetland suite	Bibra (S/B.1)

Summary of Issues

- The site is in compliance with Ministerial Criteria but is at risk of breaching.
- Classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- Froend *et al.,* 2004 recommend that the Environmental Water Requirement be increased for this site.
- Current criteria bore does not reflect wetland water levels

Suitable Monitoring Infrastructure

	DoW monitoring bore				
AWRC Name	TM7A	TM16A	TM7C	TM14C	TM4C
AWRC Ref	61410365	61410369	61611109	61611110	61611111
Easting	388198	390720	388185	388683	388874
Northing	6442303	6442883	6442303	6442403	6442978
Purpose	O / M	O / M	O / M	O / M	O / M
Depth drilled (m)	49.39	38.6	19.2	6	6
Screens (m)	47 - 49	35 - 37.6	13.2 - 18.2	0 - 6	0 - 6
Lithology	N	N	N	N	N
Status	O	O	O	O	O
Topography (mAHD)	25	22	25	15	15
Base superficial aquifer (mAHD)	-25	-25	-25	-25	-25
GW* minimum (mAHD)	9	17	9	11	11
Depth to base superficial aquifer (m)	50	47	50	40	40
Depth to GW* (m)	16	5	16	4	4
Seasonal Variation (m)	0.4	1.2	0.4	1.5	1.5

Unsuitable Monitoring Bores

Unsuitable current monitoring infrastructure and infrastructure requiring further investigation. Infrastructure in the LB series is not suitable for investigating Thomsons Lake, but may be suitable for Lake Banganup.

	Criteria Bore	**Criteria Staff Gauge**
AWRC Name	TM14A	LAKE THOMSON 609
AWRC Ref	61410367	6142517
Easting	388683	389513
Northing	6442392	6443112
Purpose	M / MC	MC
Depth drilled (m)	35	
Screens (m)	32 - 34	
Lithology	N	
Status	O	O
Topography (mAHD)	15	
Base superficial aquifer (mAHD)	-25	
GW* minimum (mAHD)	11	
Depth to base superficial aquifer (m)	40	
Depth to GW* (m)	4	
Seasonal Variation (m)	1	
Reason for Unsuitability	Location	Location

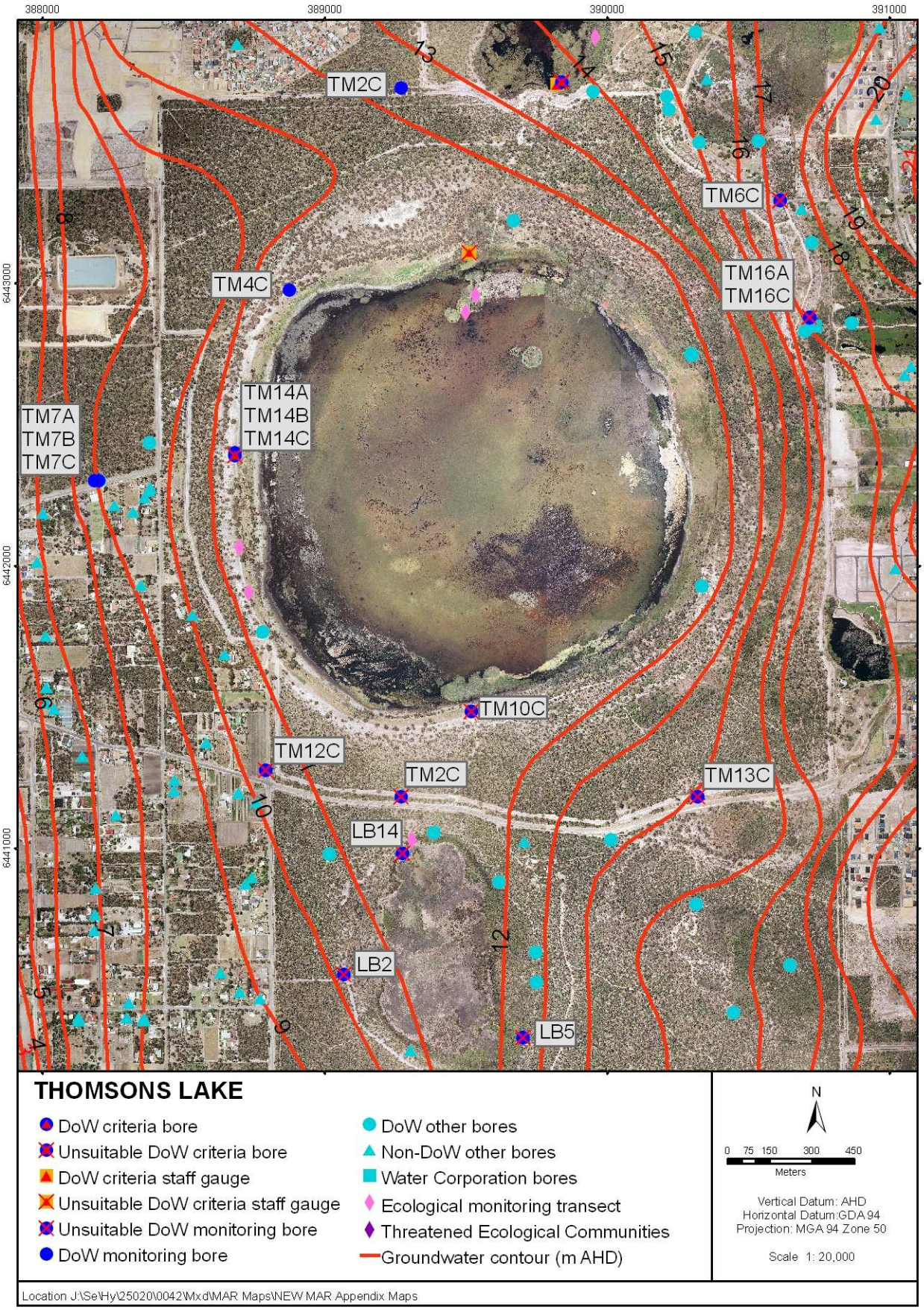
	DoW monitoring bore			
AWRC Name	LB14**	TM16C	TM12C	TM10C
AWRC Ref	61419614	61410371	61611106	61611108
Easting	389276	390719	388790	389521
Northing	6440981	6442881	6441276	6441484
Purpose	O / M / MC	O / M	O / M	O / M
Depth drilled (m)	4.05		21.1	5
Screens (m)	0 - 4.05		15.1 - 20.1	0 - 5
Lithology	N	N	N	N
Status	O	O	O	O
Topography (mAHD)	15	22	25	15
Base superficial aquifer (mAHD)	-25	-25	-25	-25
GW* minimum (mAHD)	11	17	10.5	11
Depth to base superficial aquifer (m)	40	47	50	40
Depth to GW* (m)	4	5	14.5	4
Seasonal Variation (m)	1.2	1	0.5	1
Reason for Unsuitability	Location	Screens	Location	Location

** LB14 is the Ministerial criteria bore for Lake Banganup and is considered suitable for this purpose.

	DoW monitoring bore			
AWRC Name	TM2C	TM13C	TM6C	LB2**
AWRC Ref	61611112	61611117	61611122	61419602
Easting	389271	390322	390616	389067
Northing	6443694	6441183	6443296	6440552
Purpose	O / M	O / M	O / M	O / M
Depth drilled (m)	22.5	6.9	9.5	5.49
Screens (m)	16.5 - 21.5	0 - 6.9	3.5 - 8.5	0 - 5.49
Lithology	N	N	N	N
Status	O	O	O	O
Topography (mAHD)	30	20	25	15
Base superficial aquifer (mAHD)	-25	-25	-25	-24
GW* minimum (mAHD)	12.5	14	17	10
Depth to base superficial aquifer (m)	55	45	50	39
Depth to GW* (m)	17.5	6	8	5
Seasonal Variation (m)	1	1	1.2	1
Reason for Unsuitability	Location	Location	Location	Location

	DoW Other Bore					
AWRC Name	TM9C	TOMPKIN	TM1C	TM11C	TM8B	TM15C
AWRC Ref	61611107	61403623	61611113	61611116	61611118	61611119
Easting	388780	388531	388379	390338	390301	390703
Northing	6441768	6441826	6442439	6441929	6442749	6442835
Purpose	O		O	O	O	O
Depth drilled (m)	6	40	61	6	22	6
Screens (m)	0 - 6	31 - 40	50 - 56	0 - 6	18 - 21	0 - 6
Lithology	N	Y	N	N	N	N
Status	NO		NO	NO	NO	NO
Topography (mAHD)	15	39	29	15	15	21
Base superficial aquifer (mAHD)	-25	-25	-25	-25	-25	-25
GW* minimum (mAHD)	11	10	9.5	12	12	17
Depth to base superficial aquifer (m)	40	64	54	40	40	46
Depth to GW* (m)	4	29	19.5	3	3	4
Seasonal Variation (m)						
Reason for Unsuitability	Status	Status	Status	Status	Status	Status

	DoW Other Bore					
AWRC Name	TM8C	TM5C	TM7B	TM14B	TM16B	TD14
AWRC Ref	61611121	61611114	61410366	61410368	61410370	61410395
Easting	390303	389671	388201	388683	390719	390869
Northing	6442747	6443225	6442304	6442395	6442878	6442861
Purpose	O	O	O	O	O	
Depth drilled (m)	6	5	34	21	18	4
Screens (m)	0 - 6	0 - 5	31 - 33	18 - 20	15 - 17	0 - 4
Lithology	N	N	N	N	N	N
Status	NO	NO	NO	NO	NO	A / NO
Topography (mAHD)	15	15	25	15	21	22
Base superficial aquifer (mAHD)	-25	-25	-25	-25	-25	-25
GW* minimum (mAHD)	11	12	9	11	17	18
Depth to base superficial aquifer (m)	40	40	50	40	46	47
Depth to GW* (m)	4	3	16	4	4	4
Seasonal Variation (m)						
Reason for Unsuitability	Status	Status	Status	Status	Status	Status


388000
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TM2C
TM6C
TM4C
TM16A
TM16C
TM14A
TM14B
TM14C
TM7A
TM7B
TM7C
TM10C
TM12C
TM2C
TM13C
LB14
LB2
LB5
THOMSONS LAKE
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 75 150 300 450
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 20,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Twin Swamps

Wetland/GDE name	Twin Swamps
Location (co-ords)	E: 406810, N: 6490000
Wetland/GDE type & description	Palusplain
Ecological recognition	Registered Threatened Ecological Community
Aboriginal Heritage	One registered Site of Significance (Site ID 3525)
Wetland suite	Muchea B/P3

Summary of Issues

- Supports one of the two remaining wild populations of critically endangered Western Swamp Tortoise
- Water level decline has impacted on tortoise breeding habitat
- Unsuccessful soil moisture supplementation indicates hydrogeologically complex site however no geological completed and no monitoring network exists

Suitable Monitoring Infrastructure

	DoW Monitoring Bore	
AWRC Name	L280A	L280C
AWRC Ref	61611081	61611082
Easting	406700	406700
Northing	6490627	6490627
Purpose	M	M
Depth drilled (m)	28	8
Screens (m)	19 – 28	0 – 8
Lithology	Y	N
Status	O	O
Topography (mAHD)	30	30
Base superficial aquifer (mAHD)	5	5
GW* minimum (mAHD)	26	26
Depth to base superficial aquifer (m)	25	25
Depth to GW* (m)	4	4
Seasonal Variation (m)	1.5	1.5

Unsuitable Monitoring Infrastructure

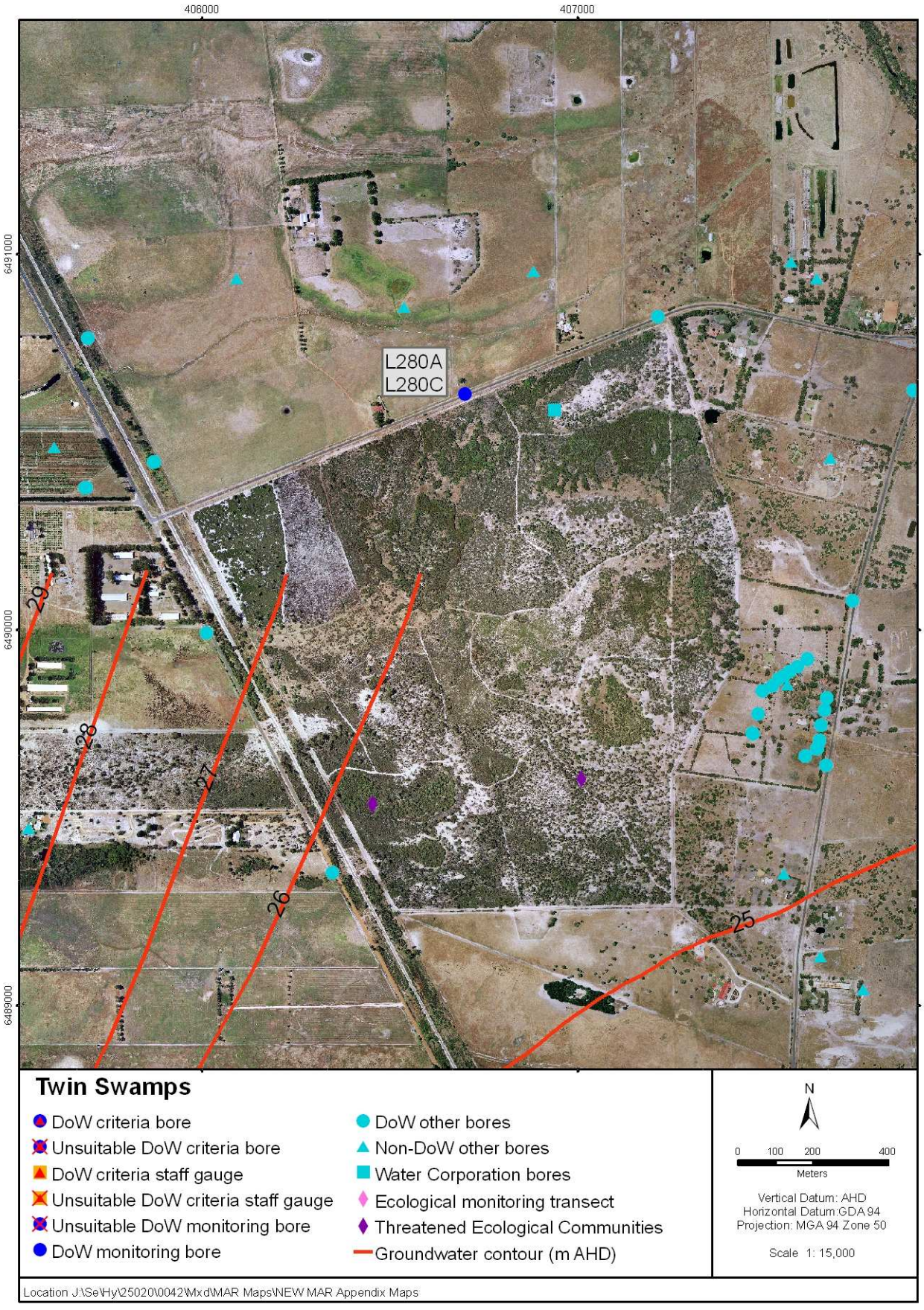
	DoW Other Bore						
AWRC Name	NE B2S	NE B2D	NE B1S	NE B1D	NE4-21	NE5-16	NE4-25
AWRC Ref	61612484	61612485	61612482	61612483	61612417	61612429	61612419
Easting	405696	405696	405872	405873	406347	407215	407895
Northing	6490776	6490777	6490447	6490447	6489354	6490834	6490637
Purpose	M	M	M	M	M	M	M
Depth drilled (m)					2.51	5.03	5.19
Screens (m)					0.49 - 2.51	0.29 – 5.03	0.41 – 5.19
Lithology	N	N	N	N	N	N	N
Status	NO	NO	NO	NO	NO	NO	NO
Topography (mAHD)	30	30	30	30	30	27	27
Base superficial aquifer (mAHD)	0	0	0	0	5	10	12
GW* minimum (mAHD)	29	29	28	28	26	25.5	25.5
Depth to base superficial aquifer (m)	30	30	30	30	25	17	15
Depth to GW* (m)	1	1	2	2	4	1.5	1.5
Seasonal Variation (m)							
Reason for Unsuitability	Status	Status	Status	Status	Status	Status	Status

	DoW Other Bore						
AWRC Name	NE4-27	NE A1S	NE A1D	NE A2	NE A3	NE A4	NE A5
AWRC Ref	61612420	61612462	61612463	61612464	61612456	61612466	61612467
Easting	407733	407612	407162	407587	407565	407550	407536
Northing	6490077	6489922	6489921	6489902	6489888	6489878	6489869
Purpose	M	M	M	M	M	M	M
Depth drilled (m)	4.22						
Screens (m)	0.38 – 4.22						
Lithology	N	N	N	N	N	N	N
Status	NO	NO	NO	NO	NO	NO	NO
Topography (mAHD)	27	27	27	27	27	27	27
Base superficial aquifer (mAHD)	10	8	8	8	8	8	8
GW* minimum (mAHD)	17	25.5	25.5	25.5	25.5	25.5	25.5
Depth to base superficial aquifer (m)	19	19	19	19	19	19	19
Depth to GW* (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Seasonal Variation (m)							
Reason for Unsuitability	Status	Status	Status	Status	Status	Status	Status

	DoW Other Bore						
AWRC Name	NE A6	NE A7S	NE A7D	NE A8	NE A9S	NE A9D	NE4-28
AWRC Ref	61612468	61612469	61612470	61612471	61612472	61612473	61612421
Easting	407519	407492	407493	407482	407467	407468	407662
Northing	6489851	6489838	6489838	6489776	6489724	6489723	6489639
Purpose	M	M	M	M	M	M	M
Depth drilled (m)							5.26
Screens (m)							0.44 – 5.26
Lithology	N	N	N	N	N	N	N
Status	NO	NO	NO	NO	NO	NO	NO
Topography (mAHD)	27	27	27	27	27	27	27
Base superficial aquifer (mAHD)	8	8	8	8	8	8	8
GW* minimum (mAHD)	25.5	25.5	25.5	25.5	25.5	25.5	25.5
Depth to base superficial aquifer (m)	19	19	19	19	19	19	19
Depth to GW* (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Seasonal Variation (m)							
Reason for Unsuitability	Status	Status	Status	Status	Status	Status	Status

	DoW Other Bore						
AWRC Name	NE A10S	NE A10D	NE A11	NE A12	NE A13	NE A14S	NE A14D
AWRC Ref	61612474	61612475	61612476	61612477	61612478	61612479	61612480
Easting	407664	407664	407658	407649	407646	407638	407639
Northing	6489819	6489818	6489785	6489746	6489705	6489683	6489684
Purpose	M	M	M	M	M	M	M
Depth drilled (m)							
Screens (m)							
Lithology	N	N	N	N	N	N	N
Status	NO	NO	NO	NO	NO	NO	NO
Topography (mAHD)	27	27	27	27	27	27	27
Base superficial aquifer (mAHD)	8	8	8	8	8	8	8
GW* minimum (mAHD)	25.5	25.5	25.5	25.5	25.5	25.5	25.5
Depth to base superficial aquifer (m)	19	19	19	19	19	19	19
Depth to GW* (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Seasonal Variation (m)							
Reason for Unsuitability	Status	Status	Status	Status	Status	Status	Status

	DoW Other Bore	Water Corporation Bore
AWRC Name	NE A15	BORE
AWRC Ref	61612481	61609337
Easting	407608	406938
Northing	6489664	6490584
Purpose	M	
Depth drilled (m)		29.5
Screens (m)		26.5 – 29.5
Lithology	N	N
Status	NO	
Topography (mAHD)	27	28
Base superficial aquifer (mAHD)	8	7
GW* minimum (mAHD)	25.5	26
Depth to base superficial aquifer (m)	19	19
Depth to GW* (m)	1.5	2
Seasonal Variation (m)		
Reason for Unsuitability	Status	Status


406000
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L280A
L280C
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27
26
25
Twin Swamps
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 100 200 400
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 15,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Walyungup

Wetland/GDE name	Lake Walyungup
Location (co-ords)	E: 385507, N: 6423194
Wetland/GDE type & description	Permanently inundated
Ecological recognition	EPP, TEC's
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Cooloongup (Qu.1)

Summary of Issues

- Rare stromatalite/thrombolite community
- Long palaeoclimatic record
- Threatened ecological communities
- No existing monitoring network

Suitable Monitoring Infrastructure

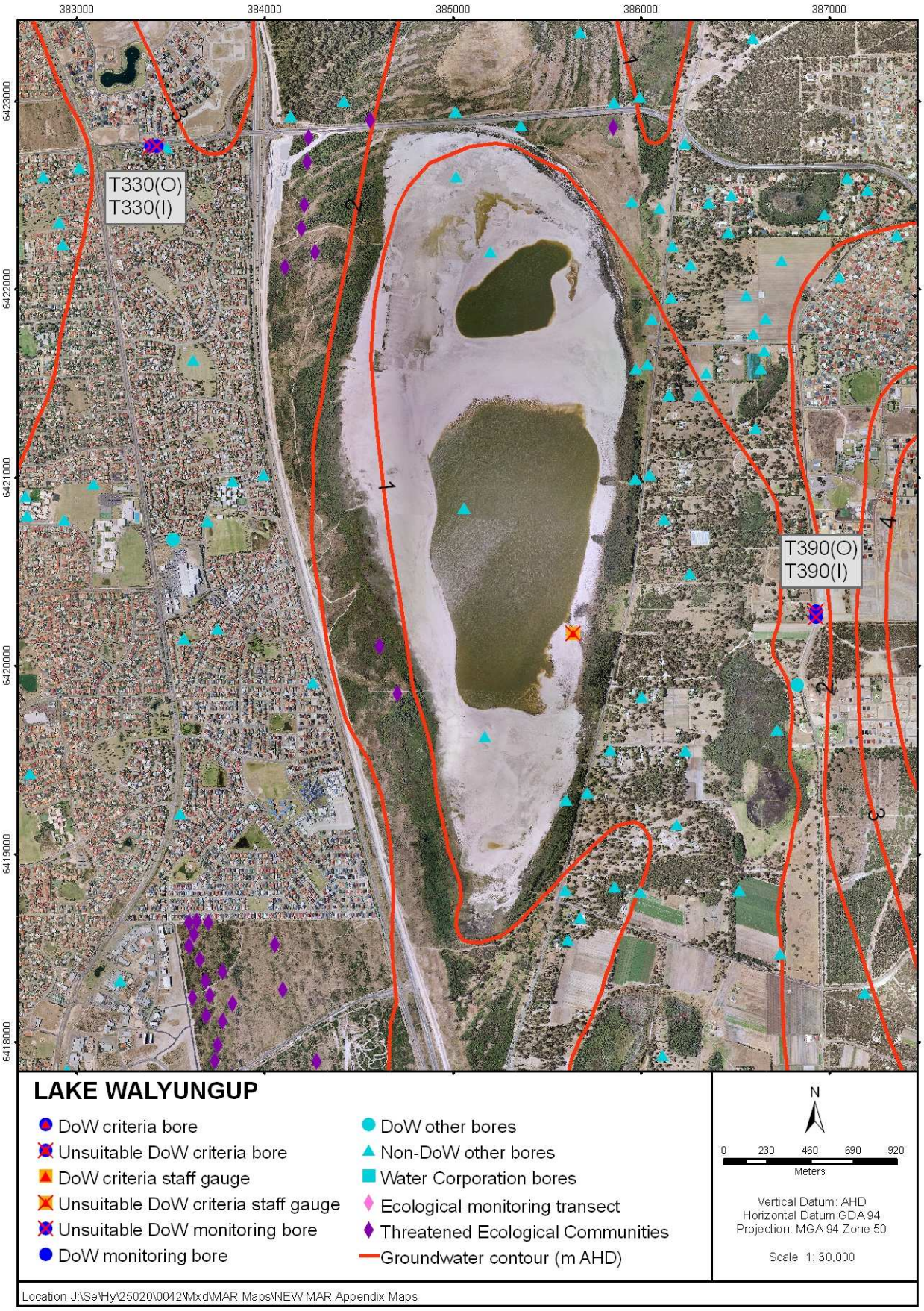
There is currently no suitable monitoring infrastructure at Lake Walyungup

Unsuitable Monitoring Infrastructure

Unsuitable monitoring bores and bores requiring further investigation

	Staff Gauge
AWRC Name	LAKE WALYUNGUP 1470
AWRC Ref	6142504
Easting	385642
Northing	6142504
Purpose	O / M
Status	O
Reason for Unsuitability	Location

	DoW monitoring bore			
AWRC Name	T330 (O)	T330 (I)	T390 (O)	T390 (I)
AWRC Ref	61410031	61410032	61410061	61410062
Easting	383397	383429	386934	385704
Northing	6422764	6422766	6420261	6420293
Purpose	O / M	I / M	O / M	I / M
Depth drilled (m)	34.26	34.09	45.04	25.17
Screens (m)				
Lithology	Y	Y	Y	Y
Status	O	O	O	O
Geophysical Logs	Y	N	Y	N
Topography (mAHD)	10	10	10	10
Base superficial aquifer (mAHD)	-22	-22	-15	-15
GW* minimum (mAHD)	3	3	2	2
Depth to base superficial aquifer (m)	32	32	25	25
Depth to GW* (m)	7	7	8	8
Seasonal Variation (m)	1	2	0.7	0.5
Reason for Unsuitability	Screens	Screens	Screens	Screens


383000
384000
385000
386000
387000
6423000
6422000
6421000
6420000
6419000
6418000
T330(O)
T330(I)
T390(O)
T390(I)
LAKE WALYUNGUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 230 460 690 920
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 30,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

WM6

Wetland/GDE name	WM6 (Neaves)
Location (co-ords)	E: 393713, N: 6493181
Wetland/GDE type & description	Phreatophytic vegetation site
Ecological recognition	Bushforever Site 399, Register of the National Estate, EPP
Aboriginal Heritage	No Registered Sites of Significance
Wetland suite	Jandakot (B.3)

Summary of Issues

- Site is in compliance with Ministerial Criteria but is at risk of breaching.
- Current criteria bore is unsuitable (located 2 m upslope of vegetation transect).
- The site has significant flora and fauna species.

Suitable Monitoring Infrastructure

No suitable monitoring infrastructure

Unsuitable monitoring infrastructure

Unsuitable monitoring bores infrastructure requiring further investigation.

	Criteria Bore	**DoW other bore**		
AWRC Name	WM6	GNM24	GNM25	GNM26
AWRC Ref	61610860	61613224	61613225	61613226
Easting	393713	393880	393793	393439
Northing	6493181	6492679	6493298	6492487
Purpose	M / MC	M	M	M
Depth drilled (m)	13.45	8	8	6
Screens (m)	3.2 - 13.45	5.5-7	5.5-7	3.5-5
Lithology	N	N	N	N
Status	O	NO	NO	NO
Topography (mAHD)	67	67	67	67
Base superficial aquifer (mAHD)	-2	-2	-2	-2
GW* minimum (mAHD)	55	54	55	51
Depth to base superficial aquifer (m)	69	69	69	69
Depth to GW* (m)	12	13	12	16
Seasonal Variation (m)	1.2			
Reason for Unsuitability	Screens	Status	Status	Status


393000
394000
6494000
6493000
60
55
55
55
WM6
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
DoW monitoring bore
DoW Staff gauge
DoW other bores
Non-DoW other bores
Water Corporation bores
Ecological monitoring transect
Threatened Ecological Communities
Groundwater contour (m AHD)
N
0 50 100 200 300
Meters
Vertical Datum: AHD
Horizontal Datum:GDA 94
Projection: MGA 94 Zone 50
Scale 1: 10,000
Location J:\Se\Hy\25020\0042\Mxd\MAR Maps\NEW MAR Appendix Maps

Lake Yonderup

Wetland/GDE name	LAKE YONDERUP
Location (co-ords)	E: 375300, N: 6508100
Wetland/GDE type & description	Permanent lake
Ecological Recognition	Conservation category, EPP, Register of National Estate, System 6
Aboriginal Heritage	Registered Site of Significance (3186)
Wetland suite	Yanchep (S.1)

Summary of Issues

- Water levels in the lake have gradually declined since 1987 and the site has breaching Ministerial Criteria water levels each summer from 2004 to 2007.
- Classified as being at severe risk of possible impact from groundwater drawdown (Froend *et al.,* 2004).
- Compliance may be achieved if the monitoring bore is moved to reflect water levels at ecosystem.
- The wetland is located near Monte's property, an extremely high groundwater user.
- Monitoring data show that groundwater levels and lake levels are poorly correlated, suggesting karst control of the lake by inflow of water from Loch McNess and outflow via caves.
- Site has a CALM registered TEC.

Suitable Monitoring Infrastructure

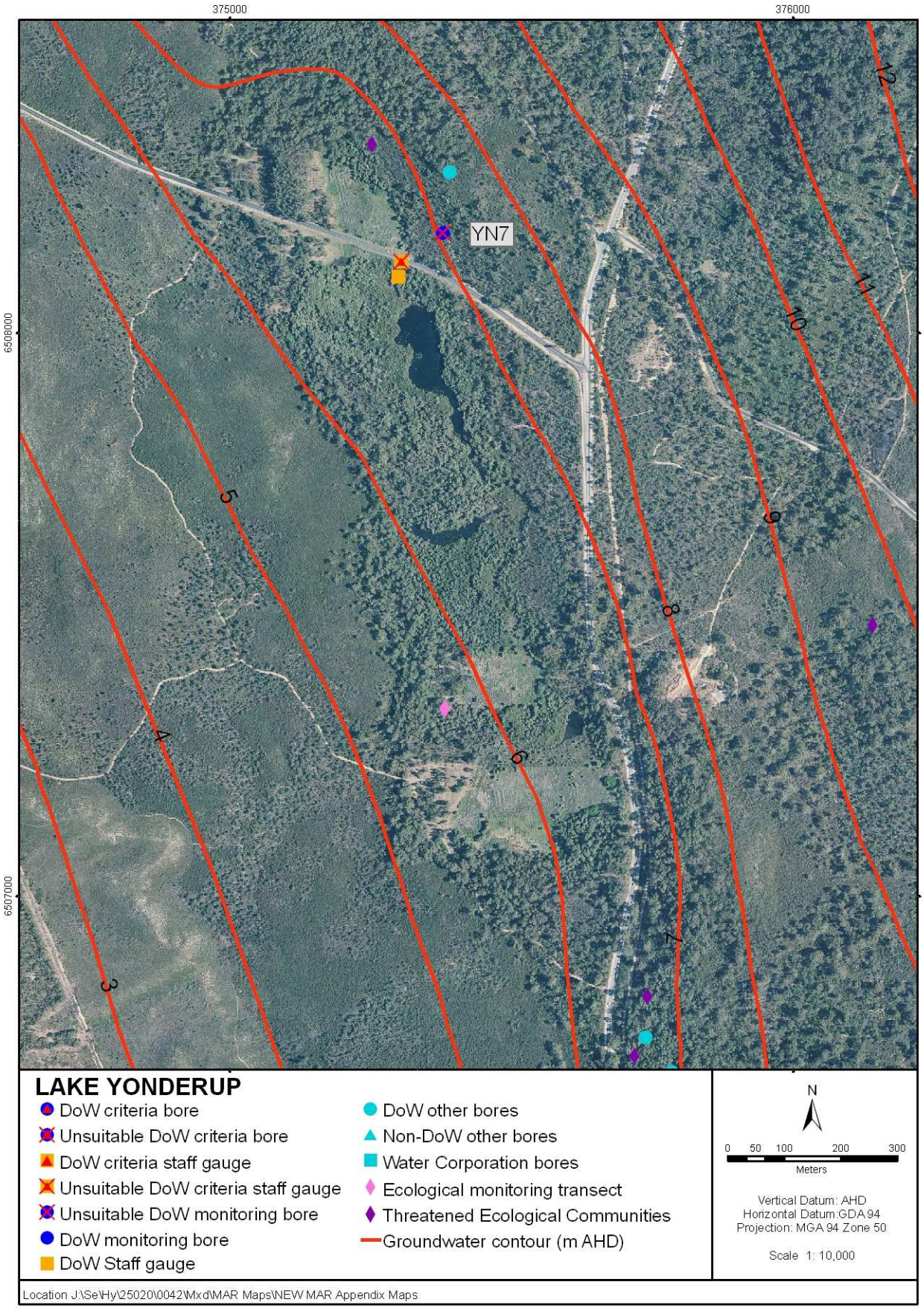
No current suitable bores. There is a staff gauge installed at the northern end of the lake that is suitable for reading lake levels, but this is not shown in WIN.

Unsuitable Monitoring Infrastructure

Unsuitable current monitoring bores and bores requiring further investigation.

	Criteria Staff Gauge	**Staff Gauge**
AWRC Name	LAKE YONDERUP 8780	LAKE YONDERUP STH
AWRC Ref	6162565	6162990
Easting	375305	375300
Northing	6508126	6508100
Purpose	M / MC	
Depth drilled (m)		
Screens (m)		
Lithology		
Status	O	O

	DoW monitoring bore	DoW other bore	
AWRC Name	YN7	ONYCHOPORA - YN102	YN194
AWRC Ref	61612106	61612109	61612110
Easting	375379	375391	375739
Northing	6508177	6508285	6506749
Purpose	O / M	M	M
Depth drilled (m)			
Screens (m)			
Lithology	N	N	N
Status	O	O	O
Topography (mAHD)	13	12	20
Base superficial aquifer (mAHD)	-27	-27	-27
GW* minimum (mAHD)	7	7	6.5
Depth to base superficial aquifer (m)	40	39	47
Depth to GW* (m)	6	5	13.5
Seasonal Variation (m)	0.5		
Reason for Unsuitability	Screens	Screens	Screens


375000
376000
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YN7
3
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12
LAKE YONDERUP
DoW criteria bore
Unsuitable DoW criteria bore
DoW criteria staff gauge
Unsuitable DoW criteria staff gauge
Unsuitable DoW monitoring bore
DoW monitoring bore
DoW Staff gauge
DoW other bores
Non-DoW other bores
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