Study of Ecological Water Requirements on the Gnangara and Jandakot Mounds under Section 46 of the Environmental Protection Act

Task 1: Identification and Re-evaluation of Ecological Values

Prepared for:

The Water and Rivers Commission

Prepared by:

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BACKGROUND

(Excerpts of the WRC Project Brief (RFT No. 0001/2003) are included below as background for this first stage of the project)

The Water and Rivers Commission manages groundwater resources of the Gnangara and Jandakot Mounds primarily though control of abstraction that might affect environmental values associated with groundwater dependent ecosystems over critical areas of the Mounds. As a condition of environmental approvals for abstraction, the Water and Rivers Commission is required to report annually to the Environmental Protection Authority on the performance if the Mounds and effects on associated environmental values. Detailed reports are required on a triennial basis. Over recent years, a number of environmental conditions for the Mounds have been transgressed, despite significant efforts to reduce public abstraction in sensitive areas. However, preliminary investigations indicate that in many cases the environmental values identified as the protection objective of these conditions may not have been materially affected.

The Water and Rivers Commission is undertaking a review of the environmental conditions of approval for the management of the groundwater resources of the under Section 46 of the *Environmental Protection Act* 1986. The Environmental Protection Authority has endorsed a two-stage approach. Stage 1 comprised an initial investigation into critical areas where breaches of environmental conditions have occurred and a proposal for a short-term management strategy for the summers of 2001/02 and 2002/03.

Stage II is to involve a rigorous investigation and review of environmental criteria, climate variability, long-term groundwater level behaviour, management of public and private abstraction and pine management plus offsetting factors such as urbanisation (including water sensitive urban design) and the Gnangara Park options. This is expected to provide the basis for a comprehensively revised management program for the relevant groundwater resources with respect to their groundwater dependent ecosystems, abstraction, pine clearing and Gnangara Park revegetation.

This ecological water requirements study is one of several specific studies being undertaken as input into the Stage II review. This study is aimed at reviewing the groundwater dependent ecosystem values in the study area to be protected through water and land planning and management decision making. Within this, there are three detailed aspects to be considered:

1. ecological water requirements and environmental water provisions;
2. environmental criteria and the form of future environmental conditions; and
3. biological monitoring techniques and programs.

1: IDENTIFICATION AND RE-EVALUATION OF ECOLOGICAL VALUES

1a. Identification of ecological values

Desktop review of ecological values identified in the 1995 Section 46 Review (Gnangara), 1997 East Gnangara Environmental Water Provisions Plan, and 1991 Public Environmental Review and 1992 Environmental Management Programme (Jandakot).

1a.1. Restatement of the 1995, 1997, 1991 and 1992 values and where applicable, re-assessment and redefinition of these values where they have changed.

In this section of the report the relevant documents and associated literature are considered in a review of ecological values. All Previous GDE values are restated as published and presented in tabular form along with previous values of wetlands, mound springs, caves and terrestrial vegetation identified by other sources. River base-flow and near-shore marine systems were not considered in previous reports and will therefore be discussed in the following section (1a.2). Due to the extent of remnant terrestrial vegetation in north Gnangara and large number of wetlands within both the Jandakot and Gnangara study areas, wetlands and terrestrial vegetation are divided into sub-groups based on vegetation complexes described by Heddle *et al*. (1980), for ease of description. Changes in ecological condition, as noted during monitoring, are also presented in tabular form. This information is used to justify restatement, reassessment and/or redefinition of ecological values by Core Technical Group members.

The majority of the work associated with this task is desk-based and draws from the field experience of the project team and their extensive quantitative databases on GDE parameters within the study area.

Wetland Ecosystems (including Mound Springs)

The following are recognized as generic wetland values;

- Aesthetics and recreation
- Filter surface water run-off
- Flood mediation
- Provide complex habitat
- Biota adapted to and rely on water above or near surface
  - Support vegetation types less tolerant to water level declines
  - Littoral zone and associated habitats important for invertebrates which form basis of food-chain for other fauna
  - Amphibians require clear water in lakes
  - Waterbirds, tortoise and mammals depend on wetland vegetation and water itself

A substantial volume of work has been undertaken on wetlands of the Swan Coastal Plain. This work represents a valuable source of information on ecological values of dependent ecosystems in the study areas.

A two-tiered approach to assessing wetland values was applied to all wetlands of the Swan Coastal Plain by Hill *et al.* (1996). First-tier evaluations recognised values at the international, national and regional level based on expert detailed information (Table 1). Second-tier evaluations (Table 2) were based on rapid, preliminary evaluations using one of two methods; direct assessment of vegetation status or consideration of natural attributes and human-use criteria. To avoid confusion between wetlands and allow for easy identification of unnamed wetlands, unique identification numbers (WINs) were also assigned based on the AMG co-ordinates of the center point of the wetland (Hill *et al*., 1996).

Under the RAMSAR Convention (ANON, 1990), a wetland is identified as being of international importance if it meets at least one of the criteria which include representativeness or uniqueness of the wetland, maintenance of biodiversity and support of significant waterbird populations (Hill *et. al*, 1996). National recognition of wetland values through 'The Directory of Important Wetlands in Australia' (ANCA, 1993) is based on representativeness, rarity, biodiversity, wetland functions and historic and cultural significance. National recognition is also afforded through The Register of the National Estate (AHC, 1990), a national list of Australia's natural, historic and cultural heritage which it is believed should be preserved (Hill *et. al*, 1996).

Wetland values are recognized on a regional scale though the System 6 Study which identified wetlands as representative bushland worthy of conservation. Although System 6 has evolved into Bush Forever (Government of Western Australia, 2000), the northern sector of the study area has not been assessed. Regional recognition in the Perth to Bunbury Study (WAWRC, 1991) is based on the outcome of five projects which identified wetlands significant for environmental, recreational or cultural purposes (Hill *et. al*, 1996). Other regional wetland studies considered in first-tier evaluations included 'The State of the Rivers Report' (Olsen and Skitmore, 1991), CAMBA and JAMBA Migratory Bird Agreements and CALM managed protection devices targeting rare or priority listed species (Hill *et. al*, 1996).

Table 1: First-tier evaluation of Perth to Bunbury wetlands.

Level of recognition	Recognition mechanisms
International	R – RAMSAR (UNESCO, 1971)
National	N - included in ' Directory of Important Wetlands in Australia' (ANCA, 1993)
	A - area listed or interim listed on Register of National Estate (AHC, 1990)
Regional	S - System 6 (Department of Conservation and Environment, 1981, 1983)
	W - regionally significant wetland as identified in Perth to Bunbury Study (WAWRC, 1991)
	O - outstanding wetland recognised in other regional wetland studies

Source: Hill *et. al*, 1996a.

Table 2: Second-tier evaluation

Management Category
C - conservation wetlands; wetlands which support high levels of attributes and functions
R - resource enhancement; wetlands which have been partly modified but still support substantial functions and attributes
M - sustainable use/multiple use wetland; wetlands with few attributes which still provide important wetland functions

Source: Hill *et. al*, 1996a, p. 9.

Monitoring programs were established for criteria wetlands on the Gnangara and Jandakot Mounds following the Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER.

Mound springs or tumulus springs are recognised as a Threatened Ecological Community (TEC). They occur where permanently moist peat mounds accumulate above areas of continuous groundwater discharge. These microclimates support discrete assemblages of vegetation and macroinvertebrates. Three occurrences of this TEC are known in the Gnangara study area.

Terrestrial Vegetation

The following generic values are recognised for areas of phreatophtyic (groundwater dependent) terrestrial vegetation;

- Aesthetics
- Soil stabilisation
- Mediate groundwater levels
- Provide habitat and food for terrestrial fauna
- Mediates microclimate

The Bush Forever project (Western Australian Government, 2000) is concerned with the protection of regionally significant bushland and associated wetlands across the Swan Coastal Plain portion of the Perth Metropolitan Region, with addition of the Wilbingia-Caraban area to the immediate north. Criteria considered in the selection of Bush Forever sites included representativeness of ecological communities, diversity, rarity and maintenance of ecological processes or natural systems. 'Bush Forever Volume 2 – Directory of Bush Forever Sites' (Government of Western Australia, 2000) describes each site in terms of location, boundaries and natural attributes of each site. Natural attributes described include vegetation condition, vegetation complexes and significant species of flora and fauna.

Vegetation condition ratings under Bush Forever were based on assessments of disturbance in relation to vegetation structure, that is, the impact of disturbance on each vegetation layer and the ability to regenerate (Government of Western Australia, 2000). The condition scales followed those developed by Keighery (1994) and are generally an estimate of the percentage of the bushland area in a range of conditions.

The vegetation complexes were defined by Heddle *et al*. (1980) in relation to the land-form soil units determined by Churchward and McArthur (1980). Complexes were based on vegetation and flora data, ground surveys, road traverses, aerial photographs and other vegetation information. A total of 38 complexes are described on the Swan Coastal Plain (Government of Western Australia, 2000). Due to the extent of remnant terrestrial vegetation in north Gnangara and large number of wetlands within both the Jandakot and Gnangara study areas, wetlands and terrestrial vegetation are divided into sub-groups for ease of description. The complexes represented in the study areas are listed in Table 3 (see Appendix 1 for vegetation complex descriptions).

Table 3: Vegetation complexes in the Gnangara and Jandakot study areas.

Gnangara	**Jandakot**
Bassendean Central and South	Bassendean Central and South
Bassendean North	Bermullah
Bassendean North Transition Vegetation	Cottesloe Central and South
Cottesloe Central and South	Herdsman
Cottesloe North	Karrakatta Central and South
Herdsman	Southern River
Karrakatta North	
Pinjar	
Quindalup	
Southern River	
Yanga	

Species of flora are defined as rare or given a priority conservation status when existing populations are geographically restricted or threatened by ecological processes. Rare Flora species are gazetted under the Wildlife Conservation Act (1950) and it is therefore an offence to take or damage rare flora without Ministerial approval. It is not however, a legal offence to take flora classified as Priority Taxa, although caution should be exercised as Priority Flora are under consideration fro declaration as 'rare flora, but are in urgent need of further survey (Priority 1-4) or require monitoring every 5-10 years (Priority 4). Following listing in WA, taxa are forwarded to ANZECC for consideration for inclusion on the ANZECC register of nationally-threatened flora and fauna. Once listed by ANZECC, they are automatically considered for listing in the Commonwealth 'Endangered Species Protection Act, 1992'.

Monitoring programs were established for vegetation of criteria wetlands and areas of phreatophytic vegetation on the Gnangara and Jandakot Mounds following the 1995 Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER.

Terrestrial fauna

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999 and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994). The *WA Wildlife Conservation Act* 1950 uses a set of Schedules but also classifies species using some of the IUCN categories. In Western Australia, the Department of Conservation and Land Management has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the WA Act but for which the Department feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN Conservation Dependent category.

With the exception of primarily aquatic species that occur in wetlands dependent upon groundwater, the dependence of fauna upon groundwater is largely indirect, with the fauna dependent upon vegetation that itself may or may not be groundwater dependent. Stand alone reports by Bamfod and Metcalf (2003) describing generic values of fauna of the Gnangara and Jandakot Mounds are presented in the Appendices.

Cave and Aquifer Ecosystems

Extensive karst (limestone) systems occur within Yanchep National Park in the Gnangara study area. Over 400 karst features have been documented with approximately 50 known to have (or have had) permanent streams and pools (Froend *et al.*, 2002). A number of these are known to contain submerged root mats from

overlying, living Tuart trees (*Eucalyptus gomphocephala*). These root mats are a primary food source for invertebrate faunal assemblages which are known to be Gondwanan relicts (Jasinka, 1995).

Those caves containing root mat communities are listed as Threatened Ecological Communities (TECs) 'Aquatic Root Mat Community no. 1 of caves of the SCP' (WATER01, CARPK01, GILGIE01, CABAR01, YN99, TWILIGHT01).

Threatened Ecological Communities

Threatened Ecological Communities (TECs) or threatened species of flora and fauna are listed under the Federal 'Environmental and Biodiversity Act, 1999'. A TEC is identified through consideration of geographic extent of an ecological community and any processes that may threaten it. There is currently no formal state (WA) policy covering TECs, however an informal non-statutory process is in place, through which a TEC database is established and steps for assigning ecological communities to categories of threat taken (Government of Western Australia, 2000). Once assessed, a TEC is assigned to one of four categories related to the status of the threat; 'Presumed Totally Destroyed', 'Critically Endangered', 'Endangered' or 'Vulnerable'. Three categories are also identified; 'Data Deficient', 'Lower Risk' and 'Not Assessed'.

A number of TEC types occur within the Study Areas. One TEC, '*Melaleuca huegelli – M. acerosa* shrublands on limestone ridges' (SCP26a), has no potential for groundwater dependence and will not be discussed, while 'Aquatic Root Mat Community No. 1 of Caves of the SCP' and 'Communities of Tumulus Springs' have been discussed previously.

- Deeper seasonal wetlands on sandy soils (SCP14)

This community is recognised as high priority for survey and/ or research as there is inadequate data to assign it to one of the above categories. Community 14 is described as woodland to open low woodland, with typical species including *Melaleuca preissiana*, *Eucalyptus rudis*, *Kunzea ericifolia* and *Baumea vaginalis* (Gibson, *et al*., 1994). The wetlands associated with this TEC generally experience long periods of inundation. Two occurrences are known within the Gnangara study area. The first within the Yeal Nature Reserve (MILT05), the second (YAN21) is within the Ridges Conservation reserve.

- Sedgelands in Halocene dune swales of the southern Swan Coastal Plain (SCP 19)

This Critically Endangered wetland community type occurs within the Wanneroo Linear Wetlands west of Lake Wilgarup and north of Pipindinny Swamp (XYAN 10). A species poor community, this TEC is dominated by *Lepidosperma longitudinale, Isolepis nodosa* and *Muehlenbeckia teretifolia.*

- Herb rich saline shrublands in claypans (SCP 07)

Community type 7 is described as mosaic of structural types ranging from open herbs, through dense heath to low woodland (Gibson, *et al*., 1994). It a species rich community occurring on heavy clay soils that are generally inundated from winter to mid summer. Typical species include *Melaleuca viminea* and *Centrolepis ariststa.* This community occurs in a number of locations near the north-eastern eastern boundary of the Gnangara study area including sites around Lake Bambun (GINGIN 01, 02, 03; BAMBUN 01, 03) and Bullsbrook (BULL 06, BULL 08) and to the north of the study area at Lake Muckenburra (MUCK 02) and is listed as Vulnerable.

- Forest and woodlands of deep seasonal wetlands of the Swan Coastal Plain (SCP 15)

One occurrence of this TEC is located near the eastern boundary of the Gnangara study area at Lake Bambun (BAMBUN 02) north of the Yeal Nature Reserve. Two others are located near the south-east boundary north-east of Lexia (TWIN05, TWIN10). Community type 15 occurs on alluvial sediments that are inundated for long periods (Gibson, *et al*., 1994). *Melaleuca rhaphiophylla* and *Casuarina obesa* dominate this species poor community that has been listed as Vulnerable.

- Perth to Gingin Ironstone Community (NTIRON)

This Critically Endangered TEC occurs on seasonally inundated ironstone and heavy clay soils in a low area adjacent to a peak in the groundwater mound (English and Blyth, 2000). The only known occurrences of this community are in the east of the Gnangara study area on land adjacent to the Gingin airfield (NIRONSE, NIRONSE2, NIRONSW, NIRONNW, NIRON02, NIRON03). Typical and common species include *Melaleuca viminea, Grevillea curviloba* subsp. *Incurva* and *Kunzea* aff. *recurve* (English and Blyth, 2000).

- Herb rich shrublands in claypans (SCP 08)

This Vulnerable TEC occurs in seasonal wetlands of the heavy soil of the eastern side of the Swan Coastal Plain (English and Blyth, 2000). The communities can be dominated by *Viminaria juncea, Melaleuca viminea, M. lateritia* or *M. uncinata* and occasionally *Eucalyptus wandoo*. Five occurrences are known within the Gnangara study area east of Bullsbrook (ELLEN 01, ELLEN 02, ELLEN 03, ELLEN 04, ELLEN 05).

- *Eucalyptus (Corymbia) calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (SCP 3c)

This endangered community occurs on the heavy soils from Waterloo to Pearce on the eastern side of the SCP (English and Blyth, 2000). Two occurrences are known in the Gnangara study area, one east of Bullsbrook (PEARCE 02) and the second in Ellenbrook (ELLEN 06).

- Shrublands on calcareous silts of the Swan Coastal Plain (SCP 18)

Previously described as restricted to calcareous silt flats in Yalgorup National Park (English and Blyth, 2000), this vulnerable community type was recorded in the Ellenbrook area east of Lexia (VINESSE). Common taxa are *Acacia saligna, Xanthorrhoea preissii, Gahnia trifida,* and *Melaleuca teretifolia*.

- *Banskia attenuata* woodland over species rich dense shrubland (SCP 20a)

Sites in this Endangered community occur on sandy soils in the Gnangara Rd Bushland (Telstra01-08), Decourcey Road Bushland (GOLF01-03), Landsdale Rd. Bushland (LAND01), Errina Road Bushland (ERRINA01-05).

- Shrublands on dry clay flats (SCP 10a)

Three occurrences of this endangered TEC are also known in the study area; Forrestdate Lake and adjacent bushland, Anstey/Keane dampland and adjacent bushland and Nicholson Road bushland.

Groundwater Dependent Ecosystems Identified in the 'Review of Proposed Changes to Environmental Conditions – Gnangara Mound Groundwater Resources (Section 46)' (WAWA, 1995).

The Review of Proposed Changes to Environmental Conditions for the Gnangara Mound Groundwater Resource was undertaken to review conditions set prior to the development of the first stage of the Pinjar Groundwater Scheme. The document outlined proposed changes to groundwater allocation, as well as identifying Environmental Water Provisions and establishing a new management and monitoring programme for the Gnangara Mound. Environmental Water Requirements were developed for selected wetlands and mound springs, areas of native phreatophtyic vegetation and cave streams and pools.

<u>Wetlands</u>

In selecting wetlands for which environmental water requirements were to be set under the Section 46 Review, the Water Authority considered the following;

- Wetlands which currently had water level criteria set by the EPA.
- The natural and human use attributes of the wetland as determined through the application of EPA Bulletin 374 - A Guide to Wetland Management (EPA, 1990). All H and C category wetlands were identified.
- Wetlands specified in the Environmental Protection (Swan Coastal Plains Lakes) Policy, 1992.
- Wetlands falling within System 6 Recommendation areas.
- The predicted impact of groundwater abstraction, with priority given to wetlands likely to be affected.
- Wetland ownership, with preference given to wetlands in public ownership.
- Representativeness to reflect the range of wetlands which exist over the given study area.

Individual wetland water levels were developed using a process by which wetland characteristics and values were identified and management objectives determined. The water regimes required to maintain these were then determined. Although wetlands can have numerous values including social, economic and environmental, this review focussed on social and environmental as all bar one wetland were partly or fully in public ownership. To identify environmental values input from scientific researchers and management agencies on issues including the degree of disturbance, abundance and diversity of flora and fauna and the uniqueness of wetland characteristics were considered. Social values were identified through discussions with the local community.

Ecological values, management objectives, water regime management objectives and Environmental Water Requirements were established for eleven individual wetlands and two wetland complexes.

– Loch McNess

Loch McNess is located in the Yanchep National Park (Bush Forever site no. 288) managed by the Department of Conservation and Land Management (CALM) to maintain its high environmental and human use attributes (WAWA, 1995). As a large permanent lake (292 ha) within a national park this wetland is relatively undisturbed with large areas of intact Herdsman Complex vegetation and relatively good water quality, providing habitat for water birds and other aquatic fauna. It is one of the few SCP wetlands that contains Nightfish (*Bostokia porosa*) and is rich in Odonata and Coleoptera species (Davies *et al,* 1991). Yanchep National Park also supports significant mammal and reptile species. Due to these values Loch McNess has been included in the '*Directory of Important Wetlands in Australia*' (N), is listed on the Register of the National Estate (A), is recognised as a System 6 wetland (S) and is identified as regionally significant (W) and as an EPP and Conservation Category (C) wetland (Hill *et al.*, 1996).

– Lake Yonderup

Yonderup Lake is also located in an area of relatively undisturbed remnant Herdsman Complex vegetation within Yanchep National Park (Bush Forever site no. 288) in an interdunal depression of the coastal limestone (WAWA, 1995). The lake has an undisturbed hydrologic regime with little seasonal variation in water levels, is rich in invertebrate fauna and has excellent water quality. Due to these values Lake Yonderup is listed on the Register of the National Estate (A), is recognised as a System 6 wetland (S) and is identified as regionally significant (W) and as an EPP and Conservation Category (C) wetland (Hill *et al.*, 1996).

– Lake Wilgarup

Lake Wilgarup is located in remnant native vegetation of the Herdsman Complex within the southern boundary of the Yanchep National Park (Bush Forever site no. 288) within an interdunal depression of the coastal limestone. The bathymetry of the wetland indicates that it is shallow broad basin suggesting that

small changes in water level would have a large impact on the area of surface water (WAWA, 1995). Lake Wilgarup is managed to maintain the environmental qualities related to wetland vegetation including macroinvertebrate habitat (WAWA, 1995). The wetland was also described as supporting rich and dense vegetation of monospecific stands (WAWA, 1995). Due to these values, this wetland has been listed on the Register of the National Estate (A), recognised as a System 6 wetland (S) and identified as regionally significant (W) and as an EPP and Conservation Category (C) wetland (Hill *et al.,* 1996).

– Pipidinny Swamp

Pipidinny Swamp is located in Yanchep National Park (Bush Forever site no. 288) within the Herdsman Vegetation Complex. The wetland supports a Threatened Ecological Community (see section on TECs). This wetland is highly modified and has been used previously for market gardening (WAWA, 1995). Although much of the natural vegetation was cleared from this site, some areas remain and sumps and channels constructed across the wetland basin to drain surface water now support a diverse range of macroinvertebrates and birds (Loomes and Froend, 2001b). Pipidinny Swamp is recognised as a System 6 (S) and Conservation Category (C) wetland (Hill *et al.,* 1996).

– Coogee Springs

Coogee Springs is located to the south of Yanchep National Park within the Herdsman Vegetation Complex (WAWA, 1995). The vegetation of this small, resource enhancement category (R) wetland is severely degraded due to its usage as summer pasture and surrounding farming activities. Despite this degradation Coogee Springs was described as supporting diverse invertebrate fauna and a range of breeding bird species (WAWA, 1995). Due to declining groundwater levels this wetland has been artificially maintained since 1998 years to protect these values.

– Lake Nowergup

Lake Nowergup is a permanent wetland managed by CALM for wildlife and landscape conservation, scientific study and historic purposes (WAWA, 1995). As one of the deepest wetlands on the Swan Coastal Plain, it is important as a habitat for birds, aquatic macroinvertebrates (one species of Cladocera, *Leydigia ciliatea*,unique to lake) and fish (Swan River Goby – *Pseudogobius;* Mosquitofish – *Gambusia holbrooki*) and as a drought refuge for water birds (WAWA, 1995). The surrounding bushland supports significant mammal and reptile species.

Although the majority of native vegetation on eastern side of the wetland has been cleared for agriculture, ecological values have lead to listing of Lake Nowergup on the Register of the National Estate (A), recognition as a System 6 wetland (S), identification as regionally significant (W) and as an EPP and Conservation Category wetland (C). (Hill *et al.,* 1996). Lake Nowergup occurs in Bush Forever site no. 383 within the Herdsman Vegetation Complex. Habitat values have also resulted in the artificial maintenance of water levels in recent years following the impacts of low rainfall and groundwater abstraction.

– Lake Joondalup

The largest of the study wetlands (611.5ha), Lake Joondalup is located in the Yellagonga Regional Park (Bush Forever Site 28) within in the Herdsman Vegetation Complex. The wetland is managed by CALM for conservation and public enjoyment and was recognized as an important waterbird habitat and for its diverse range of macrophytes (WAWA, 1995). Lake Joondalup also supports significant fish species (Mosquitofish - *Gambusia holbrooki*, Swan River Goby - *Pseudogobius olorum*), with the surrounding bushland known to provide habitat for significant mammal species. This wetland has been listed on the Register of the National Estate (A), recognised as a System 6 wetland (S), described as an outstanding wetland recognised in other regional wetland studies (O) and identified as regionally significant (W) and as an EPP and Conservation Category (C) wetland (Hill *et al.*, 1996).

– Lake Goollelal

Lake Goollelal is also situated within the Yellagonga Regional Park in the Herdsman vegetation Complex. Managed by CALM for conservation and public enjoyment the wetland was recognized as an important waterbird habitat and drought refuge, provides diverse macroinvertebrate habitats and supports good populations of native fish (Mosquitofish -*Gambusia holbrooki,* Swan River Goby -*Pseudogobius olorum*, Western Pygmy Perch -*Edelia vittata*) (WAWA, 1995). Lake Goollelal is recognized as a System 6 wetland (S), identified as regionally significant (W) and as an EPP and Conservation category (C) wetland (Hill et al., 1996).

– Lake Jandabup

Lake Jandabup is a large flat, oval-shaped wetland where large changes in surface water area can result from small changes in water level. The lake occurs in Bush Forever Site 324 within the Pinjar Vegetation Complex. It has been described as supporting the most diverse sedge and macrophyte vegetation of all Bassendean Dune wetlands. It also provides habitat for a wide range of waterbirds and aquatic macroinvertebrates. WAWA (1995) described water quality as extremely good with low nutrients. These ecological values have lead to listing of Lake Jandabup on the Register of the National Estate (A), recognition as a System 6 wetland (S), identification as regionally significant (W) and as an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996). High ecological values have also resulted in the artificial maintenance of water levels in recent years following the impacts of low rainfall and groundwater abstraction.

– Lake Mariginiup

Lake Mariginiup is situated in Bush Forever site no. 324 within the Pinjar Vegetation Complex. Much of the vegetation around the lake has been cleared by landowners. WAWA (1995) described the wetland as supporting rich aquatic fauna (Mosquitofish -*Gambusia holbrooki*, Swan River Goby - *Pseudogobius olorum*), providing wading bird habitat and having good water quality. Lake Mariginiup is recognised as a

System 6 wetland (S), identified as regionally significant (W) and as an EPP and Conservation Category wetland (C). (Hill *et al.*, 1996).

– Lake Gnangara

Situated in Bush Forever Site no. 193 within the Pinjar Vegetation Complex, Lake Gnangara was described as having low ecological value due to poor water quality, especially low pH (WAWA, 1995), the result of which is an abundance of acid tolerant macroinvertebrates. Land surrounding the lake is zoned special rural, sand quarries operate nearby and mining of the lake bed for diatomite has occurred since the early 1900s (WAWA, 1995). Despite low ecological values Lake Gnangara is a System 6 wetland (S), has been identified as regionally significant (W) and as an EPP and Conservation Category wetland (C). (Hill *et al.*, 1996).

– Bombing Range wetlands

This group of Conservation Category (C) wetlands occur in the Bassendean Central and South Transition Vegetation Complex north-east of Lake Pinjar within land vested in the Commonwealth of Australia for defence purposes (Bush Forever Site no. 380) and in State Forest directly to the south. Ecological values related to the remnant vegetation supported by the damplands WAWA (1995).

– Melaleuca Park wetlands

The wetlands of Melaleuca Park occur in the Bassendean North Complex, covering approximately 10% of the 3000ha of the park (Bush Forever Site no. 399) (WAWA, 1995). Prior to 1995 the vegetation of the park was described as the most important example of the Bassendean Dune coastal vegetation remaining in State Forest. However, since that time some areas have been degraded (WAWA, 1995). Wetland vegetation assemblages were also identified as important. Hill *et al*. (1996) described more than 60 wetlands within the area, two of which contained permanent water (see WRC, 1997). Thirty four Conservation Category (C) damplands and 11 sumplands were classified as System 6 (S) and regionally significant (W) wetlands (Hill et al., 1996).

Terrestrial Phreatophytic Vegetation

In selecting terrestrial phreatophytic vegetation for which groundwater level requirements were to be set, the Water Authority considered all areas of *Banksia* trees which occurred in areas of less than 8m depth to groundwater. The value of the woodland was described based on the degree of canopy disturbance, as determined by aerial ortho-photography. The development of groundwater level requirements targeted minimisation of the potential for deaths of *Banksia* trees in undisturbed areas to occur as a result of groundwater abstraction. Whiteman Park and Melaleuca Park bores are monitored to protect native vegetation from any further groundwater abstraction impacts.

Groundwater level requirements were set in the following areas for monitoring at the listed bores, selected to represent water levels over areas of phreatophtyic vegetation;

- Whiteman Park: MM16, MM18, MM49B, MM 53, MM55B, MM59B
- Melaleuca Park: WM2, WM6, WM8, NR6C
- Pinjar: PM6, PM7, PM9, PM24, PM25, WM1
- Jandabup: JB5
- Mariginiup: MT3S

– PM24 and PM25

These Pinjar phreatophtyic vegetation criteria bores occur in the basin of Lake Pinjar in Bush Forever Site no. 382. The central section of the basin is cleared with only small areas of *Leptocarpus scariosus* and wetter areas of low *Melaleuca teretifolia* with emergent *M. preissiana* and *Eucalyptus rudis* remaining on private property. The vegetation within some uncleared parts in the southern area of Lake Pinjar has been identified as one of the remaining examples of the Pinjar Vegetation Complex in the area and is considered to have significant conservation value (Bowman Bishop Gorham, 1994).

– MT3S

Located north-west of Lake Jandabup, this criteria bore is located in an isolated patch of remnant Pinjar Complex Vegetation that makes up part of Bush Forever Site no. 324.

– JB5

Criteria bore JB5 is located on a mostly cleared lower slope within a semi-cleared rural area in the vicinity of Bush Forever Site no. 324. There has been some clearing of the remnant *Banksia attenuata* and *B. menziesii* woodland in the past for housing and semi-rural activities.

– MM18, MM53, MM59B, MM55B and MM49B

These criteria bores are located in Whiteman Park (Bush Forever Site no. 304) a 4300ha Conservation Reserve within the Bassendean Central and South Vegetation Complex. Whiteman Park is considered regionally significant (CALM, 1994) and supports significant flora, bird, mammal and reptile species. The vegetation ranges from woodland of *Eucalyptus marginata – Allocasuarina fraseriana – Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites. This includes the transition of *Eucalyptus marginata* to *E. todtiana.* A vegetation monitoring transect was established in the park in 1991 (Mattiske, 2003).

– MM16

Criteria bore MM16 is situated west of Whiteman Park in Bush Forever Site no. 196 within the Bassendean Central and South Vegetation Complex. The site supports significant flora and mammal species.

– PM6, PM7, PM9

These bores are located east of Lake Pinjar in the Rosella Road Bushland (Bush Forever Site no. 380) within the Bassendean North Vegetation Complex. This area contains the northern most occurrence of *Eucalyptus marginata* (jarrah) and forms part of a regionally significant contiguous bushland linkage recommended for protection (Trudgen, 1996). PM6 is located on the lower slopes of a sandy dune system dominated by *Banksia attenuata* and *B. menziesii* woodland, north-east of operational bores P50, P60 and P70. PM7 and PM9 are situated in areas of *Banksia* woodland.

– WM1

WM1 is situated in the Chitty Road Bushland (Bush Forever Site no. 398) east of the southern region of Lake Pinjar within the Bassendean North Vegetation Complex. Vegetation is predominately *E. todtiana*, *B. attenuata* and *B. menziesii* low woodland (WA Government, 2000).

– WM2, WM6, WM8, NR6C

Bores WM2, WM6, WM8 and NR6C were established as criteria bores for Melaleuca Park (Bush Forever Site no. 389) within the Bassendean North Vegetation Complex. The Park is entered on the Register of the National Estate, recognised as regionally significant and recommended for protection (Trudgen, 1996). It supports significant flora and reptile species. Vegetation is dominated by low open forests to low open woodlands of *B. attenuata*, *B. menziesii* or *B. ilicifolia* with *E. todtiana*, *Nutysia floribunda*, *E. marginata* or *M. presiiana* (WA Government, 2000).

Cave Streams and Pools

A total of 273 caves were recorded in the Gnangara study area at the time of the Section 46 Review. WAWA (1995) acknowledged that the Yanchep area contains a number of caves which contain shallow pools and streams of groundwater, and these are important in that they support a diverse range of aquatic fauna, some of which are undescribed. The fauna was considered to have very high conservation significance, and all fauna was thought to depend on permanent water and therefore “it is important that water levels within the streams be maintained”.

WAWA (1995) did not consider it possible to set EWRs for cave fauna, and developed the management objective to conserve aquatic fauna of cave pools and streams in Yanchep National Park, with the water regime management objective being to maintain the existing hydrological regime, particularly to maintain permanent water in those caves containing aquatic fauna. To meet this objective, routine monitoring of water levels in three caves, Crystal Cave (YN1), Census cave located near Lake Wilgarup (YN26) and Onycophera Cave (YN102) located near Lake Yonderup. Because of a roof collapse in Census Cave, an

additional cave was selected as a replacement; unnamed in WAWA (1995). WAWA (1995) recommended that aquatic invertebrate fauna be monitored on a yearly basis, in spring, although caves to be monitored were not listed. Two transects of additional ground water piezometers were also to be established.

– Crystal Cave

This site is known to have had a permanent stream since discovery in 1942 (Bastian, 2003). It supports an undescribed amphipod listed as threatened under Section 14 (2) of the WA Wildlife Conservation Act 1950 (English and Blyth, 1996).

– Water Cave

This site contains a permanent deep stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (WATER01) (Bastian, 2003; English and Blyth, 1996).

– Carpark Cave

This site contains a permanent stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (CARPK01) (English and Blyth, 1996). Jasinka (1997) identified 23 invertebrate species including 3 cavernicoles (stygofauna).

– Gilgie Cave

This site contains a permanent stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (GILGIE01) (English and Blyth, 1996). Jasinka (1997) identified 28 invertebrate species including 1 cavernicole (stygofauna).

– Cabaret Cave

This site contains a permanent stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (CABAR01) (English and Blyth, 1996). Jasinka (1997) identified 33 invertebrate species including 3 cavernicoles (stygofauna).

– Boomerang Cave

This site contains a permanent stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (YN99) (English and Blyth, 1996). Jasinka (1997) identified 34 invertebrate species including 1 cavernicole (stygofauna).

– Twilight Cave

This site contains a permanent stream and root mats supporting cave root mat fauna, which lead to listing as a Threatened Ecological Community (TWILIGHT01) (English and Blyth, 1996). Jasinka (1997) identified 29 invertebrate species including 5 cavernicoles (stygofauna).

East Gnangara Environmental Water Provisions Plan (WRC, 1997)

The East Gnangara Environmental Provisions Plan was undertaken to establish and control groundwater allocations on the eastern side of the Gnangara Mound and set EWRs for wetlands, mound springs and phreatophtyic terrestrial vegetation prior to the development of the Lexia Groundwater Scheme.

Wetlands and Mound Springs

The selection of wetlands for which environmental water requirements were set and the identification of ecological and social values followed the same process as that described for the Section 46 Review of Proposed changes.

Ecological values, management objectives, water regime management objectives and Environmental Water Requirements were described for five wetlands;

– Lexia 94

Lexia 94 is a 18.9 ha dampland located in the Maralla Rd Bushland (Bush Forever Site no. 300) within the Bassendean North Vegetation Complex. It is a Conservation category (C) wetland and has been listed on the Interim Register of the National Estate (A). This wetland has a broad basin dominated by *Leptocarpus tenax* and *Pericalymma ellipticum* with other myrtaceous shrubs on the fringes. The undisturbed nature of the wetland and the vegetation assemblages supported were identified as ecological values by WRC (1997).

– Lexia 186

Lexia 186 also occurs in the Maralla Rd Bushland. This 0.7 ha sumpland is a Conservation category (C) wetland, is listed on the Interim Register of the National Estate (A) and is an outstanding regional wetland (O) (Hill et al., 1996). Lexia 186 is undisturbed by typical impacts and is managed to conserve vegetation assemblages and aquatic invertebrate fauna (WRC, 1997).

– Lexia 86

Lexia 86 is located in close proximity to wetlands 186 and 94 in the Maralla Rd Bushland. A 0.5 ha sumpland, this wetland is ranked as a regionally significant (W), an outstanding wetland (O), is listed on the Interim Register of the National Estate (A) and is a Conservation category (C) wetland (Hill et al., 1996). Lexia 86 is undisturbed by typical impacts and is managed to conserve vegetation assemblages and aquatic invertebrate fauna (WRC, 1997).

– EPP Wetland 173

EPP Wetland 173 is located in Melaleuca Park (Bush Forever Site no. 399) within the Bassendean North Vegetation Complex. Several springs seep from the western side of this highly coloured wetland while a

creek runs from the north-east corner (WRC, 1997). High macroinvertebrate species richness has been linked to the coloured waters. The wetland also supports a significant outlier population of the endemic Black-striped minnow (*Galaxiella nigrostriata*), a crayfish and frog species. EPP 173 is a System 6 wetland (S), is ranked as a regionally significant (W) and is an EPP and Conservation category (C) wetland (Hill et al., 1996).

– Dampland 78

Dampland 78 is located north-west of the Lexia wetlands in the southern area of Melaleuca Park in Bush Forever site 399. This 6.7 ha dampland is a Conservation category (C) wetland, was included in System 6 (S) and is ranked regionally significant (W) (Hill et al., 1996). The wetland is managed to conserve wildlife and landscape values associated with wetland vegetation (WRC, 1997).

Jasinska & Knott (1994) surveyed springs of the Ellen Brook & Muchea Area in autumn 1994, at the request of WAWA. They sampled 13 spring sites and recorded 147 invertebrate species, 91 of which had not been found before from SW WA. Each site contained at least three endemic taxa, a new genus of Amphipoda was taken from Egerton Spring and a new Syncarida, Bathynellacaea Sp. 1 was taken from Edgecombe Spring. Based on these findings, WRC (1997) acknowledged that there were multiple springs in the east Gnangara area, but selected those with the highest conservation values to protect and to set EWRs for and to monitor. In considering the mound springs for which environmental water requirements would be set, the Water and Rivers Commission considered the following;

- The conservation significance in terms of the vegetation and invertebrate fauna present at the site.
- The likelihood of the spring/seepage being impacted by groundwater abstraction for the Lexia groundwater scheme.

Two seepages were selected for EWR determination, Egerton and Edgecombe. EWRs were set following the identification of the characteristics and values of springs/seepages and the determination of management objectives. As with wetlands the values which were considered important were social and ecological values. Factors considered in identifying environmental values included the degree of disturbance, the abundance and diversity of flora and the uniqueness of characteristics.

– Egerton

Located directly to the north of the Ellen Brook development, Egerton Srping sampled in autumn 1994 by Jasinska & Knott (1994). Twenty three species of aquatic invertebrate were recorded, of which 14 were endemic, including the new genera of Amphipod. In addition, Egerton spring contained pristine vegetation, and supported bog club moss, liverworts and other species at their northern limit of distribution.

– Edgecombe

Located at the junction of Gnangara Road and West Swan Road on Edgecombes Grape Bin Winery was sampled in Autumn 1994 by Jasinska & Knott (1994). This spring flows into the Lake Yakine wetland. Sampling of the spring and lake recorded 19 and 30 taxa of invertebrate respectively, of which 7 and 17 were endemic respectively, including a single record of a unique Syncarid from Edgecombe spring.

Terrestrial Phreatophytic Vegetation

Five main areas of native vegetation were identified in the East Gnangara study area including two areas, Melaleuca Park and Whiteman Park, previously considered in the Section 46 Review. In selecting the new areas for which groundwater level requirements were to be set, the Water and Rivers Commission again considered all areas of *Banksia* trees which occurred in areas of less than 8m depth to groundwater. The Ellenbrook bushland and a vegetation corridor running between Melaleuca Park and Whiteman Park were identified as areas requiring protection.

In addition to groundwater level requirements set and monitored under the Section 46 review, the following bores were required to protect other areas of terrestrial vegetation within the East Gnangara study boundary;

- Melaleuca Park: NR11C

Criteria bore NR11C is located in Melaleuca Park discussed in a previous section (p.16) .

– MM12

MM12 is located in the Wetherall Road Bushland (Bush Forever Site no. 192) in Lexia within the Bassendean North Vegetation Complex. It was established to monitor groundwater levels in the Vegetation Corridor linking Melaleuca Park and Lexia. The dominant vegetation is *B. attenuata, B. menziesii, B. ilicifolia, E. todtiana* low open forest with emergent *Corymbia calophylla* (WA Government, 2000). The area supports significant mammal species.

– Vegetation corridor: L30C, L110C and L220C (replaced by GNM1, GNM2 and GNM3).

These bores were also installed in Melaleuca Park to monitor groundwater in the Vegetation Corridor, with GNM2 also occurring on the boundary of Maralla Road Bushland (Bush Forever Site no. 300). Maralla Road Bushland supports significant flora, bird, reptile and mammal species (WA Government, 2000) and is recommended for protection (Trudgen, 1996). The dominant vegetation is low woodlands of *B. attenuata, B. menziesi* or *B. ilicifolia* with *E. todtiana, C. calophylla* or *E. marginata.*

Jandakot Groundwater Scheme Stage 2 PER (WAWA, 1991) & Environmental Management Programme – Jandakot Groundwater Scheme Stage 2 (WAWA, 1992)

Approval to develop both Stages 1 and 2 of the Jandakot Groundwater Scheme was given by the EPA in 1976. Stage 1 of the Scheme became operational in 1979 however, due to the delay in implementing Stage

2, the Water Authority chose to refer the development to the EPA for reassessment in 1991. The document considered the combined effect of public and private abstraction on both the water resource and the environment. The approach adopted to protect the environment involved the identification of components and functions supported by the shallow groundwater regime and the setting of water level criteria required to maintain social and environmental values. Environmental criteria (water requirements) were developed for selected wetlands and areas of terrestrial vegetation.

The Environmental Management Programme was prepared in accordance with the Minister for the Environment's conditions of approval for the Stage 2 Scheme. It reiterated the environmental commitments, conditions and criteria that applied to the operation of the scheme, and included, amongst other things, a specific environmental monitoring plan and a wetland monitoring plan.

Wetlands

Ecological values, management objectives, water regime management objectives and environmental criteria (water requirements) were established for ten individual wetlands.

– Thomsons Lake

Thomsons Lake is located in Thomsons Lake Nature Reserve (Bush Forever Site no. 391) within the Herdsman Vegetation Complex. The lake is fenced to restrict vehicle access to dieback infected areas and is managed for passive recreation related to conservation. It was described as having a high degree of naturalness and human use interest and as an important habitat for waterbirds, terrestrial birds and other vertebrate species (WAWA, 1991). Due to these values Thomsons Lake is listed as a RAMSAR wetland (R), included in the 'Directory of Important Wetlands in Australia' (N), listed on the Register of the National Estate (A), recognised as System 6 wetland (S), is regionally significant (W), a wetland of outstanding value (O) and is an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996). The surrounding bushland supports significant flora.

– Forrestdale Lake

Forrestdale Lake is located in Bush Forever Site 345 (Forrestdale Lake and Adjacent Bushland) within the Karrakatta Central and South Vegetation Complex. The lake was described as an important habitat for waterbirds, with the lake fringes supporting rare flora, terrestrial birds and other vertebrate species (WAWA, 1991). It is managed to maintain and enhance natural attributes and functions. Forrestdale Lake is listed as a RAMSAR wetland (R), included in the 'Directory of Important Wetlands in Australia' (N), listed on the Register of the National Estate (A), recognised as System 6 wetland (S), is regionally significant (W), a wetland of outstanding value (O) and is an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996).

– North Lake

North Lake is located in Bush Forever Site 244 (North Lake and Adjacent Bushland) within the Herdsman Vegetation Complex. It is managed to provide for human uses whilst maintaining and enhancing natural attributes. Despite urban development of the surrounding area following a history of rural use, North Lake was described as providing a summer refuge for waterbirds and as supporting extensive stands of *M. rhaphiophylla* and *B. articulata* (WAWA, 1991). The lake is recognised as System 6 wetland (S), is regionally significant (W), a wetland of outstanding value (O) and is an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996). North Lake is the only known urban wetland supporting freshwater sponges. The surrounding bushland also supports significant flora, bird and mammal species.

– Bibra Lake

Bibra Lake is also located in Bush Forever Site 244 (North Lake and Adjacent Bushland) within the Herdsman Vegetation Complex. Despite its history as a sanitary landfill site, the lake is now managed for conservation and recreation. Bibra Lake was described as supporting a diverse range of waterbird habitats with the modified western shore of high values for waterbird breeding (WAWA, 1991). The lake is recognised as System 6 wetland (S), is regionally significant (W) and is an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996).

– Twin Bartram Swamp

Twin Bartram Swamp is located in a small area of remnant vegetation in close proximity to housing and urban parkland within the Bassendean Central and South Vegetation Complex. The wetland was described as supporting vegetation representative of the former *Melaleuca* forest of the region and as having potential for waterbird breeding (WAWA, 1992). Twin Bartram Swamp is a Conservation Category (C) and EPP wetland (Hill *et al.,* 1996).

– Banganup Swamp

Banganup Swamp is located in the Harry Warring Marsupial Reserve (Bush Forever Site 392) within the Herdsman Vegetation Complex. It is managed to maintain and enhance natural attributes and functions. This wetland was described as having high conservation values due to the diversity and condition of littoral and surrounding vegetation. The wetland fringe also supports rare and endangered flora and provides non-avian fauna habitat (WAWA, 1991). Banganup Swamp is recognised as System 6 wetland (S), is regionally significant (W), a wetland of outstanding value (O) and is an EPP and Conservation Category wetland (C) (Hill *et al.,* 1996).

– Beenyup Swamp

Beenyup Swamp is located in the Lyon Road Bushland (Bush Forever Site 492) within the Bassendean Central and South Vegetation Complex. It is regarded as a semi-pristine wetland with unusual vegetation

(*Melaleuca pauciflora* community of limited occurrence elsewhere) and is significant due to its size, status and species assemblages (WAWA, 1992). The surrounding bushland also supports non-aquatic species of fauna. Beenyup Swamp is included in the 'Directory of Important Wetlands in Australia' and is a Conservation Category Wetland (C) (Hill *et al.*, 1996).

– Shirley Balla Swamp

Shirley Balla Swamp is located in the Banjup Bushland (Bush Forever Site no. 263) within the Bassendean Central and South Vegetation Complex. The wetland was recognised as supporting a diverse array of vegetation communities, floristically and in terms of habitat for fauna and as a site of high waterbird breeding potential (WAWA, 1992). Shirley Balla Swamp is managed to maintain this breeding role. It is included in the 'Directory of Important Wetlands in Australia' and is a Conservation Category (C) and EPP wetland (Hill *et al.*, 1996). The surrounding bushland supports significant flora and mammal species.

– Lake Yangebup

Lake Yangebup is located within Bush Forever Site no. 256 (Yangebup and Little Rush Lakes) in the Herdsman Vegetation Complex. As a permanent, deep wetland it was recognised as providing a drought refuge for waterbirds (WAWA, 1991) and is managed to maintain and enhance natural attributes and functions. Lake Yangebup and surrounding bushland support significant flora, bird and mammal species. The lake is recognised as System 6 wetland (S), is regionally significant (W) and is an EPP and Conservation Category wetland (C) (Hill *et al.*, 1996).

– Kogolup Lake

Located within the Herdsman Vegetation Complex in the Thomsons Lake Nature Reserve (Bush Forever Site no. 391), North and South Kogolup Lakes are managed to maintain and enhance natural attributes and functions. It was recognised as containing representatives of most vegetation types of Cockburn wetlands, as supporting high vegetation diversity and as having moderate potential for waterbird breeding (WAWA, 1991). The lakes are recognised as regionally significant (W) and are EPP and Conservation Category wetlands (C) (Hill *et al.*, 1996).

Terrestrial phreatophytic vegetation

The vast majority of terrestrial native vegetation on the Jandakot Mound has been cleared or significantly disturbed through agriculture, market gardening, drainage scheme, land filling and fire. The System 6 report (DCE, 1983) recommended that the area from North Lake to Lake Banganup, which incorporated areas of *Banksia* woodland, be designated as a regional park. A second area of *Banksia* woodland subject to System Six Conservation Recommendations occurs on Commonwealth land surrounding Jandakot airport.

Groundwater level criteria were developed to protect these areas and all other remnant *Banksia* woodland occurring in areas of less than 5m to groundwater.

Groundwater level requirements were set for monitoring at a number of bores, the following of which remain current;

- J310, JE19C, JE17C, JM45, JM7, JM8 (rare flora bores)
- JE12C, JM49, JM39, JM24, JM33, JM29, JM18, JE1B, JE10C, JE18C, JE20C, JE23C, JM19, JE4C, JM14, JM35, JM31, JM27, JM15, JM5, JM16 (terrestrial vegetation)

– JE17C and JM24

These bores are located in, or adjacent to, the Thomsons Lake and Adjacent Bushland Reserve (Bush Forever Site no. 391) within the Herdsman Vegetation Complex. The vegetation of the area is dominated by *B. attenuata* and *B. menziesii* low open forest. Rare species of orchids were identified in the vicinity of JE17C in 1989 (WAWA, 1991), which is monitored as a rare flora bore. However, it is not known whether this species persists in the area. JM24 is in unreserved bushland to the east of the Reserve. The Reserve supports significant flora and mammal species (Government of WA, 2000).

– JE10C, JM31, JM35 and JM29

The phreatophytic vegetation criteria bores (JE10C, JM31, JM35) are located in the Denis de Young Reserve and Gibbs Rd, Swamp (Bush Forever Site no. 344) to the west of Forrestdale Lake within the Bassendean Central and South Complex. The vegetation of the area is dominated by *B. attenuata* and *B. menziesii* low open forest. The Reserve supports significant bird and mammal species with the wetlands regarded as important bird breeding areas and protected under JAMBA/CAMBA (Government of WA, 2000). JM29 is to the west of the Denis de Young Reserve in an area cleared for semi-rural use (Mattiske Consulting P/L, 2001). Pockets of remnant vegetation occur nearby along drainage lines (*E. rudis* and *M. rhaphiophylla*) or in cleared *Banksia* woodland and *M. preissiana* swamps. Due to the near total absence of terrestrial vegetation in the vicinity of this bore, the value on continued monitoring should be questioned.

– JM7 and JM8

These bores are located in the Jandakot Airport Reserve (Bush Forever Site no. 388) within the Bassendean Central and South Vegetation Complex. The vegetation of the area is dominated by *E. marginata* over *B. attenuata, B. menziesii, A. fraseriana* and *E. todtiana* (Government of WA, 2000). As rare flora bores they were established to monitor rare orchid species in the vicinity. It is not known if these species persist at JM7. The Reserve supports significant flora, bird, mammal and reptile species.

– JM45 and 8284

Both bores are located in unreserved bushland in urban developments to the south and south-west of the Jandakot Airport Reserve within the Bassendean Central and South Vegetation Complex. The vegetation of the area is dominated by *E. marginata* over *B. attenuata, B. menziesii, A. fraseriana* and *E. todtiana* (Government of WA, 2000). 8284 is a phreatophytic vegetation criteria bore. JM45 is a rare flora criteria bore established to monitor rare orchid species. It is not known is these species persist in the area.

– JM49, JM39, JE12C, JM33, JE23C, JE20C, J310, JM18, JE1B and JE18C

Bore J310 is a rare flora bore, the remainder are phreatophytic vegetation criteria bores. All are located in unreserved bushland between Thomsons and Forrestdale Lakes and further south within the Bassendean Central and South Vegetation Complex. There is no available information on the ecological values of these sites.

– JM16

This phreatophytic vegetation criteria bore is located in the Harrisdale Swamp and Adjacent Bush (Bush Forever Site no. 253) within the Cottesloe Central and South Vegetation Complex. The vegetation of the area is dominated by *B. attenuata – B. menziesii* woodland. The Reserve supports significant flora and mammal species (Government of WA, 2000).

– JM14 and JM15

Phreatophytic vegetation criteria bore JM14 is located in the Acourt Rd Bushland (Bush Forever Site No. 389) within the Southern River Vegetation Complex. This vegetation of the area is dominated by *B. attenuata, B. menziesii* and *B. ilicifolia* low woodland (Government of WA, 2000). The Reserve supports significant flora species. Phreatophytic vegetation criteria bore JM15 is located beyond the boundary of the Reserve.

– JM19

Phreatophytic vegetation criteria bore JM19 is located in the vicinity of Fraser Rd Bushland (Bush Forever Site No. 390) within the Southern River Vegetation Complex. This vegetation of the area is dominated by *B. attenuata* and *B. menziesii* low woodland to low open forest (Government of WA, 2000). The Reserve supports significant flora and mammal species.

– JM27 and JM5

These phreatophytic vegetation criteria bores are located to the north-west of Forrestdale Lake within the Karrakatta Central and South Vegetation Complex. JM27 is in unreserved bushland while JM5 is in a built up area. There is no available information on the ecological values of these sites.

Table 4 (next page): Table detailing previous values of criteria wetlands, caves and terrestrial ecosystems identified in the Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER and associated literature (other sources). Due to the extent of remnant terrestrial vegetation in north Gnangara and large number of wetlands within both the Jandakot and Gnangara study areas, wetlands and terrestrial vegetation are divided into sub-groups, based on vegetation complexes, for ease of description. Although identified as separate groups of GDE by Hatton and Evans (1998), mound springs and base flow systems have been described as wetland ecosystems.

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
WETLAND ECOSYSTEMS		
Gnangara		
Herdsman Complex		
Loch McNess (37411651052)	*WAWA (1995)* • Undisturbed wetland. • Unusual hydrologic regime. • Rich aquatic fauna. • Vegetation largely intact, provides range of habitat types. • Supports good populations of water-birds and acts as drought refuge. • Excellent water quality.	*Hill et al. (1996)* • NASW C EPP. *Government of WA (2000)* • Bush Forever Site 288. • Vegetation condition; >90% very good to excellent, <10% good to very degraded, with areas of severe localized disturbance. • Significant bird species. • Significant flora • Significant mammal species. *Davis et al., (1991).* • Rich in Odonata and Coleoptera species. • Among most pristine wetlands sampled. *Usback and James (1993)* • Site No. SWA016WA • One of the few wetlands on SCP that contains Nightfish (*Bostokia porosa*) and exotics, including Goldfish (*Carrasius auratus*) and Mosquitofish (*Gambusia holbrooki*). *Benier & Horwitz, (2003)* • Very high macroinvertebrate family richness. • Wide diversity of habitat types. • Important refuge for taxa requiring permanent water. *Bamford and Bamford (2003)* • Key faunal habitat. *WA Herbarium (2003)* DRF; P3 – *Lasiopetalum membranacuem.*
Lake Yonderup (37524650756)	*WAWA (1995)* • High ecological values due to undisturbed nature. • Rich invertebrate fauna. • Excellent water quality. • Undisturbed hydrologic regime and lack of seasonal variation.	*Hill et al. (1996)* • ASW C EPP. *Government of WA (2000)* • Bush Forever Site 288. • See Loch McNess. *Sommer & Horwitz (1999).* • High macroinvertebrate species richness (previously underestimated). • Great habitat diversity. *Benier & Horwitz (2003)* • Best water quality of all wetlands on SCP. • Diverse habitat types. • Harbours several species only found in northernmost Gnangara Mound EMP wetlands. • Important refuge for taxa during periods of low water levels.
Lake Wilgarup (37577650595)	*WAWA (1995)* • One of few remaining undisturbed wetlands within the region. • Rich and unusual vegetation (dense monospecific stands of sedges). • Likely to support diverse fauna.	*Hill et al. (1996)* • ASW C EPP. *Government of WA (2000)* • Bush Forever Site 288. • See Loch McNess.
Pipidinny Swamp (37504650521)	*WAWA (1995)* • Waterbird habitat.	*Hill et al. (1996)* • S C. *WA Herbarium (2003)*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
		• P4 flora – *Lepidium pseudotasmanium.* *Benier & Horwitz (2003)* • Unique macroinvertebrate assemblage. • Significant macroinvertebrate family and species richness.
Coogee Springs (37725650450)	*WAWA (1995)* • Diverse aquatic fauna. • Supports breeding bird species and provides winter feeding habitat for a range of ducks.	*Hill et al. (1996)* • R. *Davis et al. (1991).* • Second highest species richness for Coleoptera and Odonata taxa of 16 SCP wetlands surveyed. *Davis et al. (1993).* • Highest aquatic invertebrate species richness of 40 SCP wetlands surveyed. *Froend et al. (2002)* • Supports diverse invertebrate fauna despite vegetation being severely degraded.
Lake Nowergup (37958649929)	*WAWA (1995)* • As a permanent deep-water wetland acts as a major drought refuge for waterbirds. • Supports dependent invertebrates and fish species (one native, Swan River Goby; & one exotic, Mosquitofish). • Large areas of sedges minimise impact of nutrient enrichment on aquatic fauna.	*Hill et al. (1996)* • ASW C EPP. *Government of WA (2000)* • Bush Forever Site 383 - Nowergup Nature Reserve. • Vegetation condition; >85% very good to excellent, <15% good to degraded. • Significant bird species. • Significant mammal species. • Significant reptiles. *Davis et al., (1993).* • Median macroinvertebrate species richness for 40 SCP wetlands sampled. • One species of Cladocera (*Leydigia ciliata*) unique to lake. *Bamford and Bamford (2003)* • Key faunal habitat. *Horwitz and Rogan (2003)* • Significant wetland regionally for aquatic macroinvertebrate family richness and species richness.
Lake Joondalup (3857664875)	*WAWA (1995)* • Waterbird habitat. • Diverse range of macrophytes.	*Hill et al. (1996)* • NASWO C EPP. *Kinnear and Garnett (1997).* • Abundant & rich macroinvertebrate fauna in South; main water body depauperate fauna. *Government of WA (2000)* • Bush Forever Site 299. • Vegetation condition; >75% very good to excellent, <25% good to degraded, with areas of severe localized disturbance. • Significant bird species. • Significant mammal species. • Significant native fish species *Benier & Horwitz (2003)* • Significant wetland system in terms of the richness of macroinvertebrate) families and richness of species recorded *Bamford and Bamford (2003)* • Key faunal habitat. *WA Herbarium (2003)* • DRF; P4 – *Jacksonia sericea*
Lake Goollelal (38769647968)	*WAWA (1995)* • Waterbird habitat and drought refuge. • Supports good populations of native fish species (Swan River Goby & Western Pygmy Perch).	*Hill et al. (1996)* • SW C EPP. *Kinnear & Garnett (1997).* • Representative of coloured, alkaline, permanent wetland within SCP Maintains substantial dipteran fauna. *Government of WA (2000)*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
		• Bush Forever Site 299. • See Lake Joondalup for vegetation condition and significant species. *Benier & Horwitz (2003)* • Diverse macroinvertebrate habitats. *Bamford and Bamford (2003)* • Key faunal habitat.
Pinjar Complex		
Lake Jandabup (39020648649)	*WAWA (1995)* • Most diverse sedge and macrophyte vegetation of all Bassendean dune wetlands, including unusual species. • Supports wide range of waterbirds, especially waders. • Extremely good water quality with low nutrients.	*Hill et al. (1996)* • ASW C EPP. *Government of WA (2000)* • Bush Forever Site 324. • (See p. 39 for significant species and vegetation condition). *Davis et al., (1993).* • Richest aquatic invertebrate fauna of same suite and highest of SCP wetlands studied. *Sommer & Horwitz (1999), Benier & Horwitz (2003)* • Very significant wetland: second highest recorded macroinvertebrate species richness. • Great habitat diversity. *Bamford and Bamford (2003)* • Key faunal habitat.
Lake Mariginiup (38773648936)	*WAWA (1995)* • Rich aquatic fauna (fish species - one native, Swan River Goby; & one exotic, Mosquitofish). • Wading bird habitat. • Good water quality.	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Bush Forever Site 147. • Vegetation condition; 40% very good to excellent, 60% degraded to completely degraded with areas of severe localised disturbance. *Bamford and Bamford (2003)* • Key faunal habitat. *Benier & Horwitz (2003)* • Significant wetland regionally for macroinvertebrate family richness.
Bassendean Central & South Complex		
Lake Gnangara (39278648240)	*WAWA (1995)* • Low value due to poor water quality, especially high pH.	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Bush Forever Site 193. • Significant flora. • Vegetation condition; >75% very good to excellent, <25% good to degraded, with areas of severe localized disturbance. • Significant bird species. *Sommer & Horwitz (2001)* • Acidification of lake in 1970s as a result of mining activities. • Abundance of acid-tolerant species. *WA Herbarium (2003)* • DRF ; P3 – *Cyathochaeta teretifolia*
Bassendean North Complex – Lexia		
Lexia 86 (40136648637) sumpland.	*WRC (1997)* • Undisturbed by typical impacts.	*Hill et al. (1996)* • ASWO C. *Government of WA (2000)*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
	• Supports diverse vegetation. • Significant fauna habitat.	• Bush Forever Site 300. • See p.41 for significant species and vegetation condition. *Benier & Horwitz (2003)* • Refugial aquatic habitats (Cherax burrows).
Lexia 186 (40164648730) sumpland	*WRC (1997)* • Undisturbed by typical impacts. • Supports diverse vegetation. • Significant fauna habitat.	*Hill et al. (1996)* • ASO C EPP. *Government of WA (2000)* • Bush Forever Site 300. • See p.41 for significant species and vegetation condition. *Benier & Horwitz (2003)* • Potential biogeochemical value; maintenance of anaerobia and PASS (potential acid sulphate soils).
Lexia 94 (39830648856) dampland	*WRC (1997)* • Undisturbed by typical impacts. • Dampland supporting sedge and wetland shrub and tree species.	*Hill et al. (1996)* • AS C. *Government of WA (2000)* • Bush Forever Site 300. • See p.41 for significant species and vegetation condition. *Benier & Horwitz (2003)* • Potential biogeochemical value; maintenance of anaerobia and PASS (potential acid sulphate soils).
Bassendean North Complex – Melaleuca Park		
EPP Wetland 173 (40146649172) sumpland	*WRC (1997)* • Unique hydrology. • High vertebrate and macroinvertebrate species richness. • Contains most northern population of Black-stripe minnow (*Galaxiella nigrostriata*).	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Bush Forever Site 399. • See p.41 for vegetation condition and significant species. *Benier & Horwitz (2003)* • Potential biogeochemical value; maintenance of anaerobia and PASS (potential acid sulphate soils).
Dampland 78 (38959649551)	*WRC (1997)* • Supports swamp vegetation.	*Hill et al. (1996)* • SW C. *Government of WA (2000)* • Bush Forever Site 399. • See p.41 for vegetation condition and significant species. *Mattiske Consulting (2003)* • Melaleuca terrestrial vegetation monitoring transect established 1996.
Melaleuca Park Wetlands 34 damplands (395655649347, 39541649417, 39514649463, 395246449428, 39455649394, 39527649600, 39550649619, 39547649649, 39507649695, 39478649638, 39498679636, 39881649161, 39813649148, 39685649249, 39592649232, 39493649320, 39647649353, 39580649387, 39559649393, 39616649454, 39627649484, 39712649551, 39985649160, 39961649188, 39943649226, 39956649258, 40001649291,	*WAWA (1995)* • Support original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation.	*Hill et al. (1996)* • SW C. *Government of WA (2000)* • Bush Forever Site 399. • See p.41 for vegetation condition and significant species.

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
39989649284, 39993649344, 39947649380, 39906649362, 39876649518, 40037649313) 11 sumplands (39582649556, 39554649527, 39523649527, 39477649525, 39442649618, 39496649584, 39556649708, 39610649565, 396536449561, 39576649679, 39969649158, 40010649385)		
4 damplands (39421649304, 39432649481, 39443649445, 39592649724) 1 sumpland (39920649456)	*WAWA (1995)* • Support original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation.	*Hill et al. (1996)* • W C *Government of WA (2000)* • Bush Forever Site 399. • See p.41 for vegetation condition and significant species.
6 damplands (39433649770, 394746449776, 39504649769, 395522649773, 39533649759, 39572649792)	*WAWA (1995)* • Support original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation.	*Hill et al. (1996)* • C. *Government of WA (2000)* • Bush Forever Site 399. • See p.41 for vegetation condition and significant species.
Bassendean North Complex – East Pinjar		
Bombing Range Wetlands 2 dampland (39038650735, 39528649912)	*WAWA (1995)* • Values related to remnant vegetation supported.	*Hill et al. (1996)* • SW C. *Government of WA (2000)* • Bush Forever Site 380. • See p.40 for vegetation condition and significant species.
29 damplands (38942650419, 38935650377, 39038650735, 38954650363, 38981650273, 38976650360, 38986650306, 38984650324, 38999650292, 39013650443, 39009650127, 39044650152, 39059650062, 39073650393, 39079650301, 39103650224, 39122650392, 39170650336, 39220650202, 39263650076, 39315650224, 39467650163, 39467650061, 39476650091, 39271649907, 39301649862, 39453659899, 39470650054, 39480650015, 39540649876)	*WAWA (1995)* • Values related to remnant vegetation supported.	*Hill et al. (1996)* • C.
Southern River Complex		
Edgecombe Seepage and Lake Yakine (40506648187) sumpland	*WRC (1997)* • High conservation value due to mosaic of habitats likely to support diverse fauna populations.	*Hill et al. (1996)* • C. *Government of WA (2000)* • Bush Forever Site 22.

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
		• Vegetation condition; >90% excellent to very good, <10% good to degraded, with small areas of severe localized disturbance. • Significant bird species. • Significant mammal species. • Rich and diverse aquatic invertebrate fauna. *Jasinska & Knott (1994)* • 19 species of aquatic invertebrate recorded, of which 7 were endemic, including a record of a unique syncarid.
Egerton Seepage (40361648418)	*WRC (1997)* • Supports significant club moss and liverwort species. • Supports pristine fringing vegetation. • High conservation value as invertebrate habitat.	*Hill et al. (1996)* • O C. *Jasinska & Knott (1994)* • Large area of peat mounds with many springs. • 23 species of aquatic invertebrate recorded, of which 14 were endemic, including a new genera of Amphipod. • TEC Mound Springs SCP (EGO1) listed in 1995.
Jandakot		
Herdsman Complex		
Thomsons Lake (38942644227)	*WAWA (1991)* • High degree of naturalness & human use interest. • Important habitat for waterbirds. • Lake margins support terrestrial bird and other vertebrate species.	*Hill et al. (1996)* • RNASWO C EPP. *Government of WA (2000)* • Bush Forever Site 391. • See p.42 for vegetation condition and significant species. *Horwitz and Rogan (2003)* • Significant wetland due to high species richness of aquatic macro-invertebrates.
North Lake (38891645024)	*WAWA (1991)* • Permanent wetland provides summer waterbird refuge. • Supports extensive *M. rhaphiophylla* and *B .articulata* stands.	*Hill et al. (1996)* • SWO C EPP *Government of WA (2000)* • Bush Forever Site 244. • Only known urban wetland supporting freshwater sponges. • Vegetation condition; >20% good to very good, 80% degraded with areas of severe localised disturbance. • Significant flora species. • Significant bird species. • Significant mammal species.
Banganup Swamp (38927644051) sumpland	*WAWA (1991)* • High conservation value due to diversity and condition of littoral and surrounding vegetation. • Wetland fringe supports rare and endangered flora. • Non-avian fauna habitat.	*Hill et al. (1996)* • SWO C EPP. *Government of WA (2000)* • Bush Forever Site 392. • Vegetation condition; 70% excellent to very, 30% good to degraded. • Significant flora species. • Significant mammal species. *McGuire et al., (2001)* • Supports high number of macroinvertebrate taxa. *Froend et al. (1993).* • Undisturbed extensive fringing vegetation. *WA Herbarium (2003)* • DRF; P4 – *Dodoneae hackettiana.*
Bibra Lake (38945644839)	*WAWA (1991)* • Supports a diversity of habitats used by wading birds.	*Hill et al. (1996)* • SW C EPP *Government of WA (2000)*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
	• Modified western shore of high value for waterbird breeding	• Bush Forever Site 244. • See North Lake (p.36) for significant species and vegetation condition.
Yangebup Lake (38969644509)	*WAWA (1991)* • Permanent deep wetland provides summer refuge for waterbirds.	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Bush Forever site 256. • See North Lake (p.36) for vegetation condition and significant species. *McGuire et al. (2001); Wild et al., (2003)* • In degraded state. • Poor water quality (saline, eutrophic and high pH) • Supports high number of macroinvertebrate taxa.
Kogolup Lake (38989644422) sumpland	*WAWA (1991)* • Contains representatives of most vegetation types of Cockburn wetlands. • High diversity in vegetation surrounding lake. • Moderate potential for waterbird breeding.	*Hill et al. (1996)* • W C EPP. *Government of WA (2000)* • Bush Forever Site 391. • See p.42 for vegetation condition and significant species. *McGuire et al. (2001).* • Poor water quality (saline, eutrophic and high pH). *Horwitz and Rogan (2003)* • Kogolup South significant wetland due to macroinvertebrate high family richness.
Bassendean Central & South Complex		
Shirley Balla Swamp (39419644203) sumpland	*WAWA (1992).* • Diverse array of vegetation communities, floristically & in terms of habitat for fauna. High waterbird breeding potential.	*Hill et al. (1996)* • N C EPP. *Government of WA (2000)* • Bush Forever Site 263. • Vegetation condition; >80% excellent, <20% good to completely degraded. • Significant flora species. • Significant mammal species. *Wild et al., (2003).* • Supports high number of macroinvertebrate taxa. *WA Herbarium (2003)* • DRF; P4 – *Anthotium junciforme*, R – *Drakaea micrantha.*
Twin Bartram (39174644318) sumplands	*WAWA (1992).* • Vegetation representative of former *Melaleuca* forest of the region. • Potential for waterbird breeding.	*Hill et al. (1996)* • C EPP.
Beenyup Rd Swamp (39361644097) sumpland	*WAWA (1992)* • Supports *M. pauciflora* community of limited occurrence elsewhere. • Significant due to size, assemblages and status (little weed or track invasion). • Potential use as feeding area for secretive waterbird species. • Potential use for breeding by bird species whose young leave nest shortly after hatching.	*Hill et al. (1996)* • N C. *Government of WA (2000)* • In vicinity of Bush Forever Site 492.
Karrakatta Central & South Complex		
Forrestdale Lake (39960644134)	*WAWA (1991)* • Important habitat for waterbirds.	*Hill et al. (1996)* • RNASWO C EPP.

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
	• Supports rare flora (*Diuris purdiei*). • Lake margins support terrestrial bird and other vertebrate species.	*Government of WA (2000)* • Bush Forever Site 345. • Vegetation condition; >50% excellent to very good, <50% good to degraded. • Significant flora. • Significant mammal species. • Significant bird species. • Significant reptile species. *WA Herbarium (2003)* • DRF; R – *Diuris purdiei*, *Drakaea elastica*, P4 – *Drosera occidentalis, Villarsia submerse.*
TERRESTRIAL ECOSYSTEMS **Gnangara** ***Pinjar Complex***		
PM24, PM25 - Pinjar phreatophytic vegetation criteria bores. Lake Pinjar and adjacent bushland (735.4ha inc. open water) – *B. attenuata* & *B. menzeisii* low open forest to low woodland with scattered *E. todtiana* & *E. marginata.*	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • <8m to groundwater.	*Government of WA (2000)* • Bush Forever Site 382. • Recognized as regionally significant contiguous and fragmented bushland/wetland linkage. • As part of Gnangara Park proposal may become National/Conservation/ Regional Park or Nature Reserve. • Vegetation condition: >80% excellent to very good with pristine areas, <20% good, with areas of severe localized disturbance. • Significant mammal species. *Trudgen (1996)* • Due to remnant vegetation (*Leptocarpus scariosus*), areas are recommended for protection.
MT3S- Jandabup phreatophytic vegetation criteria bore. In Jandabup Lake and adjacent bushland (107.5ha inc. open water) – *E. marginata* closed forest; B. attenuata, B. menziesii, A. fraseriana low open forest. JB5 – in vicinity of Lake Jandabup and adjacent Bushland.	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 324. • Vegetation condition: <80% excellent to very good, >20% good to degraded, with areas of severe localized disturbance. • Significant bird species. • High species richness of aquatic invertebrates. *Mattiske and Associates (1988)* • West Gironde terrestrial vegetation monitoring transect established 1966, destroyed 1987. • Lake Jandabup terrestrial vegetation monitoring transect established 1976.
Bassendean Central and South Complex		
MM18, MM 53, MM59B, MM 55B, MM49B - phreatophytic vegetation criteria bores. Whiteman Park (1547.9ha) – *C. calophylla* woodland to low open woodland, often with *E. marginata, M. preissiana, B. ilicifolia* or *B. grandis* & generally over *V. nitens* or mixed open low heath to low shrubland.	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 304. • Significant flora. • Vegetation condition: >70% very good to excellent, <30% good to degraded, with areas of sever localized disturbance. • Significant bird species. • Significant mammal species. • Significant reptiles. *CALM (1994)* • considered regionally significant *Mattiske Pty Ltd (2003)* • Whiteman terrestrial vegetation monitoring transect established 1991. *WA Herbarium (2003)* • DRF; R - *Epiblema grandiflora var. cyaneum*, P3 – *Cyathachaeta teretifolia*, P4 – *Sachystemon axillaries.*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
MM16 phreatophytic vegetation criteria bore. Gnangara Road Bushland, Cullacabardee (236.6ha) – woodland dominated by combinations of *C. calophylla, E. marginata, B. menziesii, B. attenuata, B. ilicifolia* over species-rich shrublands over herblands and sedgelands.	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 196. • Vegetation condition: >80% excellent, <15% very good with localized areas of disturbance. • Significant flora species. • Significant mammal species. *CALM (2003)* Supports TEC SCP 20a (Telstra01-08) (see p.10).
Bassendean North		
PM6, PM7, PM9- Pinjar phreatophytic vegetation criteria bores. Rosella Rd bushland (8001.6ha) – *B. attenuata, B menziesii, E. todtiana* low open forest to low woodland, with *B. ilicifolia. C. calophylla* or *N. floribunda.*	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 380. • May Support significant flora. • Contains northern most major stands of *E. marginata.* • Vegetation condition: >90% pristine to excellent, >10% very good, with areas of localized disturbance along tracks. *Trudgen (1996)* • Part of a regionally significant contiguous bushland linkage, areas recommended for protection. *CALM (1994)* • Yeal Nature Reserve - A Class reserve of high conservation value containing vegetation and soil types not represented in any other reserves. • Part of site proposed to become State Forest. *Mattiske and Associates (1988)* • P50 terrestrial vegetation monitoring transect established 1988 (near PM9).
WM1 - Pinjar phreatophytic vegetation criteria bore. Chitty Rd Bushland, Pinjar (928.5ha inc open water) – *E. todtiana, E. attenuata* & *E. menziesii* low woodland with occasional *N. floribunda*.	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 398. • May Support significant flora. • Vegetation condition: >60% pristine to excellent, >20% very good, with areas of severe localized disturbance).
WM2, WM6, WM8, NR6C, NR11C- Melaleuca Park phreatophytic vegetation criteria bores. L30C, L110C, L220C - Vegetation Corridor phreatophytic vegetation criteria bores. Melaleuca Park and adjacent bushland - (4150.9ha inc. open water) – low open forests to low open woodland of *B. attenuata, B. menziesii* or *B. ilicifolia* sometimes with *E. todtiana, N. floribunda, E. marginata* or *M. preissiana* over mixed open heaths to low shrublands.	*WAWA (1995)* • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater. *WRC (1997)* • Established to ensure comprehensive representation of native vegetation areas which are susceptible to drawdown. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 399. • Significant flora. • Vegetation condition: >5% pristine, >85% excellent to very good, <10% good to degraded, with areas of severe localized disturbance. • Significant reptile species. • Entered in register of the National Estate. *Trudgen (1996)* • Recommended for protection. *CALM (1994)* • Proposed to become State Forest. • Part of proposed Gnangara Park. *CALM (1987)* • Recommended for conservation. • Recognised as a regionally significant area of bushland. *Mattiske Pty Ltd (2003)* • Neaves terrestrial vegetation monitoring transect established 1996. *WA Herbarium (2003)* • DRF; R – *Calandenia huegelii.*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
Ellenbrook Bushland Maralla Road bushland (641.5ha inc. open water) – low closed woodlands to low open woodlands of *B. attenuata, B. menziesii* or *B. ilicifolia* sometimes with *E. todtiana, C. calophylla* or *E. marginata.; C. calophylla* woodland.	*WRC (1997)* • Established to ensure comprehensive representation of native vegetation areas which are susceptible to drawdown. • *Banksias* in areas of less than 8m depth to groundwater. • Area recognised as one of the most floristically rich remnants of native vegetation on the Swan Coastal Plain with a total of 427 different species. • Listed by The National Trust. • Entered onto the interim list of The National Estate. • Identified as regionally significant.	*Government of WA (2000)* • Bush Forever Site 300. • Significant flora (not listed in CALM, 2003) • Vegetation condition: >90% excellent to very good, >10% good to degraded, with areas of localized disturbance. • Significant bird species. • Significant reptile species • Significant mammal species *Trudgen (1996)* • Recommended for protection *CALM (1994)* • Proposed to become State Forest. • Part of proposed Gnangara Park. *Mattiske Pty Ltd (2003)* • Maralla and Bell terrestrial vegetation monitoring transects established 1996.
MM12 – Vegetation Corridor phreatophytic vegetation criteria bore. Wetherall Rd bushland, Lexia (40.7ha) – *B. menziesii, B. ilicifolia, B. attenuata, E. todtiana* low open forest with emergent *C. calophylla.*	*WRC (1997)* • Established to ensure comprehensive representation of native vegetation areas which are susceptible to drawdown. • *Banksia* woodland <8m depth to groundwater.	*Government of WA (2000)* • Bush Forever Site 192. • Vegetation condition: 5% excellent, <60% very good, >30% good, with areas of severe localized disturbance. • Significant mammal species.
Jandakot		
Herdsman Complex		
JE17C - rare flora criteria bore JM24 – phreatophytic vegetation monitoring bore (in vicinity of site 391) Thomsons Lake Nature reserve and adjacent bushland - (366.7ha inc. open water) – *E. marginata* low open forest; *B. attenuata* & *B. menziesii* low open forest & low woodland with *E. marginata* & *E. todtiana*. *E. rudis, M. rhaphiophylla, M. preissiana* open forest to low woodland.	*WAWA (1991)* • Thomsons Lake terrestrial vegetation monitoring transect established 1988. JM24 • *Banksia* woodland occurring in area of less than 5m to groundwater JE17C • Established to monitor rare orchid species in vicinity.	*Government of WA (2000)* • Bush Forever Site 391. • Significant flora. • Vegetation condition: >30% excellent, >50% very good to good, <20% degraded, with areas of severe localized disturbance. • Significant bird species. • Significant mammal species. *WA Herbarium (2003)* • DRF; P4 – *Dodoneae hackettiana*
Bassendean Central and South Complex		
JE10C, JM31, JM35 - Phreatophytic vegetation criteria bores. JE4C- aquifer evaluation bore Denis de Young Reserve and Gibbs Rd Swamp - (289.8ha inc. open water) - *B. attenuata* & *B. menziesii* low woodland; *B. attenuata* low woodland with scattered *B. menziesii, B. ilicifolia* & *E. todtiana* woodland.	*WAWA (1991)* • Liddelow transect terrestrial vegetation monitoring transect established 1988. JE10C, JM31, JM35 • *Banksia* woodland occurring in area of less than 5m to groundwater.	*Government of WA (2000)* • Bush Forever Site 344. • Significant flora. • Vegetation condition >60% excellent to very good, >40% good to degraded with areas of severe localized disturbance. • Important breeding area for 18 bird species. • Protected under JAMBA/CAMBA. • Significant mammal species. *WA Herbarium (2003)* • DRF; P4 – *Verticordia lindley subsp. lindleyi*
JM29 - Phreatophytic vegetation criteria bore.	*WAWA (1991)*	

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
Located in area largely cleared of native vegetation.	• *Banksia* woodland occurring in area of less than 5m to groundwater.	
JM7, JM8 - rare flora criteria bores. Jandakot Airport (410ha) – *E. marginata* over *B. attenuata, B. menziesii, A. fraseriana* and *E. todtiana* low woodland; *B. attenuata, B. menziesii* and *N. floribunda* low woodland.	*WAWA (1991)* • Established to monitor habitat of rare orchid species in vicinity.	*Government of WA (2000)* • Bush Forever Site 388. • Significant flora species (not recorded in CALM database). • Vegetation condition: >85% excellent to very good, <15% very good to good. • Significant bird species. • Significant mammal species. • Significant reptile species. *K Atkins pers. comm. (CALM)* • DRF; R - *Caladenia huegelii*
JM45 - rare flora criteria bore 8284 - Phreatophytic vegetation criteria bore. Unreserved bushland in urban development south of airport.	*WAWA (1991)* 8284 • *Banksia* woodland occurring in area of less than 5m to groundwater. JM45 • Established to monitor rare orchid species in vicinity.	
JM49, JM39- Phreatophytic vegetation criteria bores JE12C - aquifer evaluation bore. Unreserved bushland on Rowley Rd, Banjup.	*WAWA (1991)* JM49, JM39 • *Banksia* woodland occurring in area of less than 5m to groundwater.	
JM33 - Phreatophytic vegetation criteria bore. Unreserved bushland Lyon Rd, Banjup.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
JE23C - Phreatophytic vegetation criteria bore. Unreserved bushland Gaebler Rd, Bnajup.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
JE20C - Phreatophytic vegetation criteria bore. Unreserved bushland near corner Beenyup Rd and Sheok Crt., Banjup.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
J310 – Rare flora criteria bore. Unreserved bushland near corner Princep Rdand Cutler Rd near Jandakot industrial area.	*WAWA (1991)* • Established to monitor rare orchid species in vicinity .	
JM18 - Phreatophytic vegetation criteria bores. JE1B - aquifer evaluation bore. Unreserved bushland Solomon Rd near quarry, Banjup.	*WAWA (1991)* JM18 • *Banksia* woodland occurring in area of less than 5m to groundwater.	
JE18C - phreatophytic vegetation criteria bore. Unreserved bushland Solomon Rd near Jandakot Rd, Banjup.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
Cottesloe Central & South Complex		
JM16- Phreatophytic vegetation criteria bore.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	*Government of WA (2000)* • Bush Forever Site 253.

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
Harrisdale Swamp and adjacent bushland (98.4ha inc. open water) - *Banksia attenuata – B. menzesii* woodlands.		• Significant flora. • Significant mammal species. *Trudgen (1990)* • Vegetation condition: >60% pristine to very good, <good to completely degraded. *WA Herbarium (2003)* • DRF; R – *Caladenia huegelii*
Southern River Complex		
JM14, JM15 -Phreatophytic vegetation criteria bores. Acourt Rd bushland (295.2ha) – *B. attenuata, B. menziesii* & *B. ilicifolia* low woodland; *B. attenuata* & *B. menziesii* low woodland.	*WAWA (1991)* • Airport transect terrestrial vegetation monitoring transect established 1988. • *Banksia* woodland occurring in area of less than 5m to groundwater.	*Government of WA (2000)* • Bush Forever Site 389. • Significant flora (not recorded in CALM database) • Vegetation condition: >80% good to very good, <20% good to completely degraded. *WA Herbarium (2003)* • DRF; P1 – *Tripterococcus paniculatus*
JM19 - Phreatophytic vegetation criteria bore. In vicinity of Fraser Rd bushland (171.7ha) – *B. attenuata* & *B. menziesii* low woodland to low open forest with scattered *A. fraseriana, E. marginata, E. todtiana* & *N. floribunda*.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	*Government of WA (2000)* • Bush Forever Site 390. • Significant flora (not recorded in CALM database). • Significant mammal species. *Trudgen (1990)* • Vegetation condition: >75% excellent, <25% very good to completely degraded.
Karrakatta Central & South Complex		
JM27 - Phreatophytic vegetation criteria bore. Unreserved bushland corner Armadale and Taylor Rd., Forrestdale.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
JM5 - Phreatophytic vegetation criteria bore. Built-up area Waratah Blvd., Canningvale.	*WAWA (1991)* • *Banksia* woodland occurring in area of less than 5m to groundwater.	
AQUIFER AND CAVE SYSTEMS		
Yanchep Caves		
Crystal Cave (YN1)	• Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Contains an undescribed Crangonyctoid amphipod (WAM#642-97 – Hurleya sp) listed as threatened under Section 14(2) of the WA Wildlife Conservation Act 1950. *Bastian (2003)* • Known to have permanent stream since discovery in 1942. • Site contains a permanent stream and root mats.
Water Cave (YN11)	• Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Listed as a TEC (WATER01) due to combination of root mats and flows. *Bastian (2003*) • Has permanent deep water.
Carpark Cave (YN18)	*WAWA (1995)* • Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Supports an occurrence of the Cave Root Mat Fauna TEC (CARPK01). *Jasinska (1997)* • 23 species recorded, including 3 cavernicoles.
Gilgie Cave (YN27)	• Site contains a permanent stream and root mats.	*English and Blyth (1996)*

Sub-group / GDE	Previous stated values in WAWA (1995), WRC (1997), WAWA (1992) or WAWA (1991).	Previous values stated by other sources
		• Supports an occurrence of the Cave Root Mat Fauna TEC (GILGIE01). *Jasinska (1997)* • 28 species recorded, including 1 cavernicole.
Cabaret Cave (YN30)	*WAWA (1995)* • Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Supports an occurrence of the Cave Root Mat Fauna TEC (CABAR01). *Jasinska (1997)* • 33 species recorded, including 3 cavernicoles.
Boomerang Cave (YN99)	• Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Supports an occurrence of the Cave Root Mat Fauna TEC (YN99). *Jasinska (1997)* • 34 species recorded, including 1 cavernicole.
Twilight Cave (YN194)	• Site contains a permanent stream and root mats.	*English and Blyth (1996)* • Supports an occurrence of the Cave Root Mat Fauna TEC (TWILIGHT01). *Jasinska (1997)* • 29 species recorded, including 5 cavernicoles.

In the second stage of Task 1a.1, changes in the ecological condition of GDEs are described based on results of long-term monitoring of wetlands, terrestrial vegetation and cave systems and associated literature and/or field visits of unmonitored sites. Changes in ground and surface water levels at sites relevant to each GDE are also described.

Following a review of changes in ecological condition and consideration of previously stated values and new information, revised ecological values are presented and assigned to one of the five following categories;

- Retained – values (published in Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER) remain unchanged.
- Changed – values are retained but are now of either greater or less significance.
- Lost – values have been lost due to significant changes in ecological condition.
- Recoverable – changed or lost values that can be recovered through active management.
- New – values not previously identified.

Where insufficient information or data are available previous values are generally restated.

Wetlands and Mound Springs

Monitoring programs were established for criteria wetlands on the Gnangara and Jandakot Mounds following the Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER.

Macroinvertebrates and water quality at 14 Gnangara Mound and 11 Jandakot Mound wetlands are monitored twice per year, in spring when water levels and biological activity are at their highest in wetlands and in summer when water levels at permanent wetlands are at their lowest, or shortly before ephemeral wetlands dry out, when the major stress to fauna occurs. The main objective of this monitoring is to describe the status of aquatic macroinvertebrates in terms of family richness and community structure and their response to changes in water quality and water levels (Benier and Horwitz 2002). This monitoring is an important source of information on changes in ecological condition since the previous assessments were undertaken.

Vegetation monitoring is undertaken annually in spring across permanent transects at 13 wetlands on the Gnangara Mound and 9 on the Jandakot Mound. The main objective is to monitor changes in fringing and emergent vegetation and to determine if any changes are related to changes in groundwater levels or other factors affecting wetlands (WAWA, 1995). This monitoring is an important source of information on changes in ecological condition since the previous assessments were undertaken.

As part of the environmental commitments made in the Public Environmental Review for the East Gnangara Environmental Water Provisions Plan, monitoring of frog populations in six wetlands on the Gnangara Mound has been carried out for the Water and Rivers Commission since 2000 (Davis and Bamford, 2003). During the 2003 survey period, changes were implemented so that the project focussed more intensely on a smaller number of wetlands than was the case in the original study.

Waterbirds are monitored during spring, summer and winter at twelve wetlands on the Jandakot Mound. Surface and/or groundwater levels are monitored at least monthly at all criteria wetlands on both the Jandakot and Gnangara Mounds.

Gnangara wetlands

- Loch McNess

There has been no previous annual monitoring of wetland vegetation at Loch McNess however, wetland tree species and emergent macrophytes are healthy and some recruitment was noted during a recent assessment (Loomes *et al.*, 2002) (Table 6). Benier and Horwitz (2003) described good water quality, a diversity of habitat types and the highest cumulative macroinvertebrate family richness of monitored (Gnangara) wetlands. However, there is evidence of high chlorophyll *a* concentration and high turbidity in the northern section of the lake (Benier and Horwitz, 2003). Surface water levels (6162564) have decreased since 1995 however, the wetland still contains permanent water and seasonal fluctuations remain low (WRC, 2003).

As there has been little or no change in the ecological condition of Loch McNess, the wetland retains the values described in WAWA (1995) (see Table 5). Values are however, at high risk from eutrophication and introduced species, with some risk from water level decline, fire and species loss.

- Lake Yonderup

There has been increased invasion of the wetland basin and surrounds by exotic flora (Froend *et al.*, 2003), with the health of fringing *M. rhaphiophylla* in the south of wetland declining since 1997 (Loomes *et al.*, 2003). Lake Yonderup has shown signs of declining water levels and drying of organic rich sediments (Benier and Horwitz, 2003). Surface water levels (staff gauge 6162565) have decreased since 1995 however seasonal fluctuations remain low (WRC, 2003).

As there has been little or no change in the ecological condition of Lake Yonderup, the wetland retains the values described in WAWA (1995) (see Table 6). The nature of the wetland's largely intact vegetation and its provision of a range of habitat types should be considered as an additional, previously undescribed ecological value. There are however, concerns over water level declines, susceptibility to fire and introduced species.

– Lake Wilgarup

In response to drying at Lake Wilgarup in recent years there has been widespread loss of *M. rhaphiophylla* saplings and some mature individuals along with deaths of mature *B. littoralis* (Table 6). *Baumea articulata* and *L. longitudinale* are thinning in the understorey resulting in the encroachment of exotic species into the basin (Froend *et al.*, 2002).

Recent surveys indicate low macroinvertebrate species richness (Sommer and Horwitz, 1999; Benier and Horwitz, 2002). Declining water levels have also resulted in the drying of organic rich sediments (Benier and Horwitz, 2003). Although surface water was recorded in winters from 1993 to 1998, the lake bed has remained dry since that time (staff gauge 6162623). Groundwater levels (61618500) have also declined since records commenced in 1997 (WRC, 2003).

Due to the drying of Lake Wilgarup and associated declines in the ecological condition, the ecological values of the wetland have been altered (Table 6). Loss of vegetation density and structure has reduced the value of the vegetation, previously described as 'rich and unusual', while weed invasion and sediment shrinkage have effectively 'disturbed' the wetland. The greatest change to ecological values however, is the loss of the potential of Lake Wilgarup to 'support diverse fauna', that has resulted from the complete absence of surface water in recent years. Values are at further severe risk from further water level decline, fire and species loss and possibly acidification if the system returns to a wetter water regime.

– Pipidinny Swamp

Although there has been on-going invasion of exotic flora at Pipidinny Swamp, a mix of fauna habitats have been retained (Loomes and Froend, 2001a). There has however, been an increase in conductivity in ponds adjacent to sand dunes, possibly due to groundwater level decline and associated marine water intrusion (Benier and Horwitz, 2003). Surface water levels (staff gauge 6162624) have decline since 1995 (WRC, 2003).

As there has been little or no change in the ecological condition of Pipidinny Swamp, the wetland retains the values described in WAWA (1995) (see Table 6). Further, previously unrecognized values have also been identified, 1: Pipidinny Swamp supports unique macroinvertebrate assemblages and 2: the wetland area supports rare or priority flora. All values are however, at risk from declining water levels which may lead to a loss of fauna.

– Coogee Springs

Coogee Springs exhibits poor vegetation health and diversity due to livestock disturbance and too frequent fires (Loomes and Froend, 2001b). There was significant loss of organic/peat soils in the northern sector of the lake following a fire in spring 2002 and numerous *M. rhaphiophylla* were uprooted due to loss of substrate (Benier and Horwitz, 2003).

Surface water levels (staff gauge 6162533) have declined since 1995 (WRC, 2003), with the drying rate increasing significantly between 1998 and 2001, indicating that the wetland has become disconnected from the underlying groundwater table (Benier and Horwitz, 2002). Prolonged drought has lead to terrestrialisation and decomposition of some vegetation may in part be causing an increase in nutrient levels (Sommer and Horwitz, 1999).

In an attempt to preserve high macroinvertebrate species richness at Coogee Springs, artificial maintainance has been undertaken since 1998 (Benier and Horwitz, 2002). Despite this the frequency and severity of drying events have not been reduced and the wetland has dried each summer since 1995 (Staff gauge 6162566) (WRC, 2003). The rapid drawdown of water in summer (after the maintenance has stopped) is of concern as it may not allow the aquatic life phase of some taxa to be completed. There has been a significant decline in spring macroinvertebrate species richness since augmentation commenced and several taxa considered rare in other SCP wetlands have been lost from Coogee Springs (Benier and Horwitz, 2002). Prior to artificial maintenance the wetland was a shallow, tannin stained, brackish, dystrophic system. Following augmentation, it changed to a clear, fresh, ologotrophic wetland. This is due to the dilution effect of pumping clear, fresh water from the Leederville aquifer (Benier and Horwitz, 2002).

Due to the drying of Coogee Springs and associated declines in the ecological condition, the ecological values of the wetland have been severely altered (Table 6). The wetland no longer supports ‘diverse aquatic fauna’ nor supports breeding bird species or ducks. There is risk of further impact from water level decline, fire and introduced species.

- Lake Nowergup

Despite artificial maintenance of surface water levels at Lake Nowergup, the health of *M. rhaphiophylla* and *E. rudis* has declined significantly in recent years (Loomes *et al.*, 2003). *Baumea articulata* have been thinning and the exotic *Typha orientalis* is encroaching into the wetland (Loomes *et al.*, 2003) however, enlarged area of *T. orientalis* may provide further habitat for waterbirds and other species (Bamford, 2003).

Water quality changes include an increase in pH range, decreased conductivity, nutrient levels and chlorophyll-a values, these are mostly attributable to supplementation of water levels using fresh water from the Leederville aquifer (Benier and Horwitz, 2003). Augmentation is not leading to sustainable protection of biodiversity values. There has been a slight decline in summer invertebrate family richness

however, species of Cladocera (Leydigia ciliata) are now known from several wetlands (Benier and Horwitz, 2003). Surface water levels (staff gauge 6162567) have declined since 1995 (WRC, 2003).

Although there has been some decline in the ecological condition of Lake Nowergup, the wetland has retained values related to fauna habitat (see Table 6). However, as the density of sedges on the eastern side of the lake has declined, their role in reducing nutrient enrichment near the source has declined. The value of fringing vegetation as habitat should also be recognized. The future risks to values of Lake Nowergup are substantial. Vegetation and biodiversity values could be threatened as organic rich sediments become drier and potentially lead to the terrestrialisation of sediments, mobilization of nutrients and increased likelihood of fire. There is also concern for the impact of introduced species, loss of native vegetation, eutrophication and acidification.

- Lake Joondalup

The fringing vegetation at Lake Joondalup has been impacted by frequent fires and wind-throw due to drying sediments (Lam *et al.*, 2002). *Typha orientalis* is encroaching in the southern section of the lake and *E. rudis* in the southern sector was badly impacted by a fire in summer 2002/03 (Lam *et al.*, 2002). Poor water quality, high nutrients and chlorophyll a and low dissolved oxygen were recorded in summer (Benier and Horwitz, 2003). Surface water levels (staff gauge 6162572) and groundwater levels (61610661) have declined since 1995 (WRC, 2003).

Although there has been some change in the ecological condition of Lake Joondalup, the ecological values of this wetland identified by WAWA (1995) have been retained (see Table 6). In addition the value of the largely intact, fringing vegetation should be recognized, while the bushland surrounding the lake supports declared rare or priority flora.

- Lake Goollelal

Lake Goollelal has experienced a 'wetter' hydrological regime than other Gnangara wetlands leading to prolonged flooding of littoral and fringing vegetation (Lam *et al.*, 2002). The health of *E. rudis* and *M. rhaphiophylla* has declined and the band of *B. articulata* on the western shore has contracted. Exotics have also continued to invade (Lam *et al.*, 2002). Consistently high chlorophyll *a* levels are evidence of increasing eutrophication (Benier and Horwitz, 2003) resulting from urbanisation. There is a high abundance of *Gambusia* sp. known to predate on aquatic macroinvertebrates and a relatively low cumulative macroinvertebrate family richness (Benier and Horwitz, 2003). Surface water levels (staff gauge 6162517) have declined since 1995 following a longer term increase (WRC, 2003).

Although there has been some change in the ecological condition of Lake Goollelal, the ecological values of this wetland identified by WAWA (1995) have been retained (see Table 6). In addition the value of the

largely intact, fringing vegetation should be recognized while the bushland surrounding the lake supports declared rare or priority flora.

– Lake Jandabup

The vegetation within the lake has changed substantially, with an extension of sedge species and a decrease in health of *M. rhaphiophylla* and *E. rudis* on the fringes (Mattiske Pty Ltd, 2001; Loomes and Froend, 2001b). There has also been a decline in flora species richness in monitoring plots since 1997 (Loomes and Froend, 2001b).

Prior to 2001 a shift in the macroinvertebrate community structure was noted including local extinctions and decreases of highly sensitive taxa (Sommer and Horwitz, 2001; Horwitz and Benier, 2002). There was also an increase in the abundance of apparently acid-tolerant macroinvertebrate species and changes in the proportion of relative abundances of families (Horwitz and Benier, 2002) along with a decline in pH and subsequent water quality; increased sulphate, iron, and ammonium concentrations, decreased phosphorus and gilvin (Sommer and Horwitz, 2001). Lake Jandabup has been showing signs of declining water levels and drying of organic rich sediments (Horwitz and Benier, 2002).

In recent years there has been an increase in pH (decrease in acidification) and some return of significant macroinvertebrate species abundant prior to acidification (Benier and Horwitz, 2003). This is a result of changes to the artificial maintenance regime to prevent drying of the lake in summer. Surface water levels (staff gauge 6162578) have declined since 1995 (WRC, 2003).

Although there has been some change in the ecological condition of Lake Jandabup, the wetland has retained ecological values pertaining to an ability to ‘support a wide range of waterbirds’ and ‘diverse sedge and macrophyte vegetation’. However, it is unknown if the ‘unusual species’ recognized by WAWA (1995) persists. The values related to the water quality at Lake Jandabup, described as ‘extremely good’, were thought lost following acidification in the late 1990s. However, this value now appears to be recoverable under an appropriate water level augmentation scheme (and presumably maintained) (Benier and Horwitz, 2003). The recent apparent improvements in the aquatic macroinvertebrate community composition seem to indicate that the macroinvertebrate community of this wetland has the possibility to recover from a significant acidification stress event. In addition to previously described ecological values the bushland surrounding the lake supports declared rare or priority flora.

Despite apparent recovery from acidification the ecological values of Lake Jandabup remain at risk from water level decline, eutrophication and acidification. There is also concern over susceptibility to fire and loss of species.

– Lake Mariginiup

There has been significant decline in the condition of fringing vegetation at Lake Mariginiup due to drying, fire, physical disturbance and exotics. There has also been a decline in flora species richness in the monitoring plot since 1997 (Loomes *et al.*, 2002).

There have been signs of declining water levels and drying of organic rich sediments affecting water holding capacity and increasing acidification in recent years (Benier and Horwitz, 2003). There is now evidence to suggest Lake Mariginiup is on the brink of a serious ecological collapse due to acidification (J. Benier, pers. comm., November 2003). Surface (staff gauge 6162577) and groundwater levels (61610685) have declined since 1995 (WRC, 2003).

Despite declines in ecological condition, Lake Mariginiup retains its value as wading bird habitat and still supports rich aquatic fauna (Table 6). However, decreased pH has reduced water quality previously described as 'good'. Ecological values remain at extreme risk from acidification and water level decline along with susceptibility to fire, loss of vegetation and loss of fauna.

– Lake Gnangara

Lake Gnangara exhibits consistently low macroinvertebrate family richness in comparison to other wetlands in the area. The lake also has a low pH and there is evidence of eutrophication. Due to reduced inundation of the littoral and fringing vegetation there is a lower habitat complexity (Benier and Horwitz, 2003). Maximum surface water levels have decreased approximately 25cm since 2000 and the lake bed has dried in summer since 1995. Surface (staff gauge 6162591) and groundwater levels (61618440) have declined since 1995 (WRC, 2003).

Continued declines in ecological condition have prevented the recovery of water quality of Lake Gnangara. The low ecological value of this wetland has therefore been retained. However, bushland surrounding the lake supports declared rare or priority flora and this should be recognized as a new value. There is potential for further reduction in the ecological value of Lake Gnangara due to further acidification, water level decline and eutrophication.

– Lexia 86

There has been a decline in health and patch deaths of fringing *M. preissiana* and *B. ilicifolia* at Lexia 86 with fringing vegetation encroaching into the wetland basin as *B. articulata* contracts (Loomes *et al.*, 2002).

The Swamp-dependent skink *Acritoscincus trilineata* was recorded in Spring 2003 and the Western pygmy possum was trapped in autumn 2003 (Davis and Bamford, 2003). The Western pygmy possum was

formerly abundant on the Swan Coastal Plain but is now presumed locally extinct in the metropolitan region (apart from a known population in the Gingin area) (B. Maryan, WA Museum, Pers. Comm.). There has been no evidence of recruitment of the Moaning frog *Heleioporus eyrei* from the previous breeding season (2002) and an absence of young adults, suggesting that there had been no recruitment for several years prior to 2002, probably due to low water levels in previous years (Davis and Bamford, 2003).

The wetland is showing signs of declining water levels and drying of organic rich sediments (Benier and Horwitz, 2003). Surface (staff gauge 6162630) and groundwater (6163215) levels have declined since 1997 with the lake bed drying each summer (WRC, 2003).

Despite changes in the structure of vegetation at Lexia 86 the wetland still 'supports diverse vegetation'. However, other ecological values – 'undisturbed by typical impacts' and 'significant fauna habitat'; have been reduced as a result of declining water levels. Ecological values of the wetland are at risk from further water level decline, acidification, fire and loss of vegetation.

- Lexia 186

Lexia 186 has dried significantly leading to a loss of *B. articulata* and some encroachment of fringing tree species, which are also showing a decline in health (Loomes *et al.*, 2002). There have also been signs of drying of organic rich sediments with a low macroinvertebrate family richness (Benier and Horwitz, 2003). Groundwater levels (61613214) have declined since 1997 (WRC, 2003) with surface water now restricted to a small man-made sump.

Due to changes in vegetation assemblages, severe reduction in surface water area and other impacts of drying, the ecological value of Lexia 186 (see Table 5) has declined. The wetland faces further impacts from potential acidification, fire and loss of vegetation.

- Lexia 94

Lexia 94 exhibits drying and thinning of wetland shrubs and emergent macrophytes across the wetland basin and also shows a decline in the health of fringing *M. preissiana* (Loomes *et al.*, 2002). Vehicular traffic has also disturbed the eastern side of the wetland. There are signs of declining water levels and drying of organic rich sediments (Benier and Horwitz, 2003). Groundwater levels (61613216) have declined since 1997 (WRC, 2003).

Drying and disturbance have impacted on the ecological condition of Lexia 94, reducing the value 'undisturbed by typical impacts'. However the previously unrecognized habitat value of the extensive area of dampland vegetation should be considered. Lexia 94 is at risk from further water level declines and fire.

- EPP Wetland 173

EPP wetland 173 has shown some decline in condition of fringing *M. preissiana* (Lam et al, 2002). There is also a possible decline in Black-stripe minnow as only 1 was taken in last two sampling rounds (Storey, 2003). The Swamp dependent skink (*Acritoscincus trilineata*) was recorded in autumn and spring 2003 (Davis and Bamford, 2003). Surface water (staff gauge 6162628) levels have declined since 1997 and the wetland has dried each summer at the staff gauge (WRC, 2003). There are signs that declining water levels are reducing water quality and drying organic rich sediments (Benier and Horwitz, 2003).

Although there has been a decline in the ecological condition of EPP 173, the wetland still retains a unique, spring –fed hydrology and supports high vertebrate and macroinvertebrate species richness. However, the value of the site as habitat for the Black-stripe minnow may be at risk as evidenced by the low number of the species recorded in recent times. The habitat value of the littoral and fringing vegetation of EPP 173 should also be considered an ecological value. Values are at risk from further water level decline, acidification, fire and species loss.

– Dampland 78

Dampland 78 is showing signs of water stress with the deaths of wetland vegetation and also a drying of the wetland basin (Lam *et al.*, 2002). The number of healthy *M. preissiana, B. ilicifolia* and *B. attenuata* stems were noted to have declined on Melaleuca transect since 1996, with the density of *P. reticulata* and *B. elegans* also having declined while terrestrial species density increased (Mattiske Consulting, 2003). Groundwater levels (6163231) have declined since 1997 (WRC, 2003).

The decline in condition of wetland vegetation at Dampland 78 impacts directly on the recognized ecological value of the system – 'supports swamp vegetation'. However, the value of fringing vegetation as habitat should be recognized. Dampland 78 is at risk from further water level declines and fire.

– Melaleuca Park Wetlands

Melaleuca Park Wetlands are showing signs of declining water levels and drying of organic rich sediments (Benier and Horwitz, 2003). In the absence of information or data to the contrary, the previously described ecological values of the wetlands (Table 6) should be considered to have been retained. However, due to general decline in water levels in the area, it is expected that vegetation condition has also declined.

– Bombing Range Wetlands

There is no record of changes in ecological condition or values of the Bombing Range Wetlands. In the absence of information or data to the contrary, the previously described ecological values of the wetlands (Table 6) should be considered to have been retained.

– Edgecombe Seepage and Lake Yakine

Faunal diversity at Edgecombe seepage declined from 11 species in April 1999 to two of the original species in December 1999 and November 2000 following drying of the spring (Knott, 2001). During 2000 a firebreak was graded along a fence line and the spring was cleared and heavily disturbed. By 2002 flows were returning and the spring was recovering. Fauna were recorded during monitoring in spring 2002 however, important bathynellid speices were absent (Horwitz and Knott, 2003).Groundwater flow was also stonger and the area was showing a return to conditions of the 1990s. Groundwater levels (61618606) have declined from early 2000, before rising slightly in winter 2003 (WRC, 2003).

As Edgecombe Seepage is highly disturbed and fauna abundance and diversity has declined, the ecological values of the seepage - '…due to mosaic of habitats likely to support diverse fauna population', should be considered to have declined However, they may recover if condtions continue to improve. Values are a risk of further impact if perennial flows dry again during summer.

- Egerton Seepage

Egerton seepage site dried in 1999/2000. Altough vegetation condition is not monitored, a field visit by the authors suggests the system remains in good ecological condition. Water quality monitoring in 2002 indicated that the spring is continung to discharge good quality fresh water with limited nutrient concentration (Horwitz and Knott, 2003). Fauna sampled continued to be diverse with crustacean groups well represented. There is also no evidence of degradation of the spring resulting from clearing of vegetation to the west and north (Horwitz and Knott, 2003). Groundwater levels (61618607) have declined since early 2000, before rising slightly in winter 2003 (WRC, 2003).

The continued good condition of Egerton Seepage, indicates the ecological values of the ecosystems have been retained (See Table 6). The wetland also supports a Threatened Ecological Community, previously unidentified as a value. Values are a risk of impact if perennial flows dry during summer.

<u>Jandakot wetlands</u>

- Thomsons Lake

The density of *B. articulata* has diminished since 1996 and prolific sapling growth accompanied with declines in health of some mature *E. rudis* is possibly due to lower water levels (Hancock and Ladd, 2002). The lake also shows an increased invasion of weeds due to lack of inundation (McGuire *et al.*, (2002). The water quality is poor (saline, eutrophic and high pH) (McGuire *et al.*, 2002). Surface (staff gauge 6162557) and groundwater (61410367) levels have declined since 1992 (WRC, 2003).

Despite declines in ecological condition, Thomsons Lake retains values related to provision of habitat for waterbirds and other vertebrate fauna. However, the 'naturalness' of the wetland has declined due to altered hydrology (Table 6). The large tract of terrestrial vegetation surrounding the lake should also be regarded

as an ecological value. Values are at risk from groundwater abstraction, loss of vegetation and water quality issues associated with increasing urban development.

– North Lake

Although tree health along biological monitoring transects either increased or did not change significantly prior to 2000, there had been some encroachment of native vegetation into previously inundated areas closer to the center of the wetland basin (Ladd, 2001). The condition of mature *E. rudis* has since decreased around the lake (Loomes *et al*., 2002). There has been no regular water quality and macroinvertebrate monitoring for the WRC. Surface water levels (staff gauge 6142521) have declined since 1992 with groundwater levels (61410726) also decreasing since records commenced in 1997 (WRC, 2003).

Despite some changes in vegetation condition, North Lake still supports values related to the 'extensive *M. rhaphiophylla* and *B. articulata* stands'. However, as the numbers of waterbirds have decreased in recent years in response to drying, the value of North Lake as a summer refuge for waterbirds has declined. Ecological values are at further risk from groundwater decline and fire.

– Banganup Swamp

Prior to 2001 the drying of the wetland lead to the encroachment of *Typha orientalis* and severe cultural eutrophication occurred (McGuire *et al*., 2001). However, subsequent monitoring indicated chlorophyll-*a*, turbidity and nutrient levels were very low compared to other wetlands in the area, with the nitrogen the lowest of those sampled. (McGuire *et al.*, 2002). Surface water levels (staff gauge 6142516) have declined since 1992 with groundwater levels (6141914) also decreasing since records commenced in 1993 (WRC, 2003).

Although conditions at Lake Banganup have changed in response to lower water levels, the value of the wetland as non-avian fauna habitat and the high conservation values of the littoral and fringing vegetation remain. However, it is not known if the wetland fringe still supports rare and endangered flora. The ecological values of Lake Banganup are at risk from groundwater decline, too frequent fires and loss of vegetation.

– Bibra Lake

Prior to 1996, prolonged inundation of the vegetation on the west side of the lake, caused severe deterioration of tree health, particularly *M. rhaphiophylla* and *E. rudis* (WRC, 1996). Water level decline and insect attack have had some impact of wetland trees since that time (Ladd, 1999) and exotics are threatening to become dominant in some areas of the wetland. There has been no regular monitoring of water quality and macroinvertebrates for the WRC. Surface water levels (staff gauge 3142520) have declined since 1992 (WRC, 2003).

The decline in condition of fringing vegetation at Bibra Lake has had no impact on the value of the wetland as wading bird habitat or for waterbird breeding. However, these values are at risk from water level decline, fire and potentially water quality issues.

– Yangebup Lake

Severe cultural eutrophication occurred at Yangebup Lake and there was an overall reduction in macroinvertebrate species richness between 1996 and 2001 (McGuire *et al.*, 2001). Yangebup Lake has poor water quality with frequently elevated nutrients, brackish water and marked differences with water level fluctuations (McGuire *et al.*, 2001). Surface (staff gauge 6142523) and groundwater levels (61419707) have declined since 1992 (WRC, 2003).

As Lake Yangebup is a permanent wetland it still provides summer refuge for waterbirds, thereby retaining its previously identified ecological value. However, the wetland is at severe risk from water level decline and continued poor water quality.

– Kogolup Lake

At North Kogolup water-logging prior to 2000 resulted in loss of fringing vegetation, while at South Kogolup weed invasion increased although weediness is still considered low (WRC, 2000). The health of some *E. rudis* has been gradually declining since 1998 (Hancock and Ladd, 2002). There was little variation in the macroinvertebrate community between July 1999 and June 2002, indicating that no significant impacts occurred (WRC, 2003a), despite the severe cultural eutrophication noted during that time (McGuire *et al.*, 2001). Surface water levels (staff gauge 6142522) have declined at South Kogolup since 1992 (WRC, 2003).

Despite some decline in ecological condition, Kogolup Lake still maintains moderate potential for waterbird breeding and supports diverse vegetation. In the absence of data to the contrary, it is assumed the wetlands still contain representativeness of most vegetation types of the Cockburn wetlands. Ecological values are at risk from groundwater abstraction and water quality issues associated with increasing urban development (McGuire *et al.*, 2001).

– Shirley Balla Swamp

Shirley Balla Swamp has been impacted by fire and physical disturbance in recent years, leading to declines in vegetation condition (Hancock and Ladd, 2002). The wetland has been described as the least used by water birds in the Jandakot area (Bamford, 2001), and macroinvertebrate sampling has shown decreased family richness (McGuire *et al.*, 2001). Shirley Balla Swamp has been contaminated with hydrocarbons, however there has some recovery in water quality (Wild *et al.*, 2003). Surface (staff gauge

6142576) and groundwater levels (61410713) have declined since records commenced in 1993 and 1996 respectively (WRC, 2003), with the wetland drying completely in most summers.

Despite the high level of disturbance at this wetland in recent years, Shirley Balla Swamp retains a diverse array of vegetation. However, declining surface water levels have reduced the potential value of the wetland for waterbird breeding. The ecological values of Shirley Balla are at risk from further water level declines, physical disturbance, fire and water quality issues.

– Twin Bartram Swamp

Fire, weed invasion and increased water levels have all impacted the area (WRC, 2003a), with Twin Bartram Swamp recording the highest percentage of exotic species of all studied (Jandakot) wetlands (Loomes, 2000). The health of trees remains moderate to good and shows signs of recovery since fire in 1999 (WRC, 2003a). Surface water levels (staff gauge 6142544) have increased since 1992 with groundwater levels (61410715) also rising since records commenced in 1996 (WRC, 2003).

Fire, disturbance and weed invasion have impacted on the condition of the vegetation at Twin Bartram thereby reducing its value as representative of former *Melaleuca* forest of the area. However the wetland retains its potential for waterbird breeding. Ecological values are at risk from further disturbance, fire, altered water levels, exotic species and eutrophication as urbanization of the surrounding area continues.

– Beenyup Rd Swamp

Although tree health showed no deterioration prior to 2001 (Ladd, 2001), the condition of *M. rhaphiophylla* on the permanent monitoring transect declined markedly in 2002/03 (Loomes *et al.,* 2003). The density of *B. articulata* has decreased since 1997 (Ladd, 2001), with the lack of inundation preventing growth and permitting weeds to thrive in wetter plots. There has also been some decline in the density and health of wetland shrubs (Loomes, *et al*, 2003). The exotics *E. longiflora* and *B. maxima* have become dominant in the understorey (Hancock and Ladd, 2002). There is currently no invertebrate or waterbird monitoring. Maximum surface water levels decreased approximately 40cm since 1992 and the lake bed has dried in summer since 1993. Surface water levels (staff gauge 6142547) have declined since 1992 with groundwater levels (61410711) also decreasing since records commenced in 1993 (WRC, 2003).

Despite declines in the condition of some wetland vegetation and water levels at Beenyup Road Swamp, the wetland remains significant due to its size and the assemblages and status of the vegetation. As wetlands with fringing Typha are used for feeding by ‘secretive waterbird species’, this value is also retained. In the absence of information to the contrary, Beenyup Swamp still should be regarded to support *M. pauciflora* (See Table 6). The value of the wetland for waterbird breeding has most likely declined due

to lower water levels. The ecological values of the wetland are at further risk from water level decline, fire, exotics, loss of species and water quality issues.

– Forrestdale Lake

Forrestdale Lake has increased weed invasion due to lack of inundation and during 2000 there were indications that declining watertable affected the vegetation including *M. rhaphiophylla* and *E. rudis* which were generally in poorer health than at other wetlands assessed in the Jandakot area (Ladd, 2001). Drying, fire and physical disturbance has impacted negatively on *Melaleuca* sp. (WRC, 2002) with exotics becoming dominant in the understorey in some area (Loomes *at al*, 2003). The nutrient levels were low compared to other wetlands for the first water quality sampling undertaken in 2001 (McGuire, 2002). Surface water levels (staff gauge 6162557) have declined since 1992, with the wetland drying completely in ecent years. Groundwater levels (61410714) have also decreased since records commenced in 1996 (WRC, 2003).

Despite some decline in ecological condition, the fringes of Forrestdale Lake should be considered to still support terrestrial bird and other vertebrate species. However, declining water levels have resulted in the loss of muddy shorelines and shallows reducing the waterbird habitat value of the lake. There is also no record on the CALM database of the rare flora species previously identified at Lake Forrestdale. Wetland ecological values are at further risk form water level decline, fire, exotics, loss of species and water quality issues.

Terrestrial vegetation

Monitoring programs were established for vegetation of criteria wetlands and areas of phreatophytic vegetation on the Gnangara and Jandakot Mounds following the Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan and the Jandakot Groundwater Scheme Stage 2 PER.

Triennial terrestrial/phreatophytic vegetation monitoring is undertaken at 16 selected sites across the Gnangara Mound and 5 across the Jandakot Mound. Transects are monitored for vegetation health, species composition and abundance and soil moisture. The objective is to relate vegetation condition to soil moisture and climate and pumping operations. The location of transects ranges from areas currently impacted by groundwater abstraction to areas remote from abstraction and development (WAWA, 1995).

Changes in vegetation condition also consider results of the Land Monitor Project – Vegetation Extent and Change, conducted by CSIRO's Mathematical and Information Sciences. In this project changes in vegetation density over time are determined through interpretation of satellite imagery. All sites were visited during 2003/04 and visual assessments of current vegetation condition undertaken. It was recommended that 14 Jandakot and two Gnangara sites be 'decommissioned' due to land use changes.

Groundwater levels are monitored monthly at a number of phreatophytic vegetation criteria bores across the Gnangara and Jandakot mounds and a smaller group rare flora bores in Jandakot.

Gnangara Terrestrial Vegetation

- Lake Pinjar and surrounding bushland

Lake Pinjar and surrounding bushland is now recognized as a Bush Forever Site (no. 382) and supports significant mammal species.

  - PM24 & PM25

Vegetation in much of Lake Pinjar, where these bores are located, is heavily modified through agriculture, with little undisturbed vegetation remaining (Froend *et al*., 2002). Between 1988-2000 vegetation density was stable in the center of the lake and to the east however, density showed decreasing trends in the north and south-west (CSIRO, 2001). Areas of *E. rudis* along the western border of the lake are exhibiting substantial crown dieback (Froend *et al*., 2002). There is no notable decline in condition of open *Banksia* woodland to north of the lake (Froend *et al*., 2002). At PM24 (61610697) and PM25 (61610750) groundwater levels decreased since 1995 (WRC, 2003).

The level of disturbance to vegetation in the vicinity of PM24 and PM25 has reduced the value of these sites as representatives of undisturbed phreatophtyic vegetation. However, as depth to groundwater remains less than 8m, this value has been retained. Ecological values are at risk from further groundwater decline and loss of wetland vegetation.

- Lake Jandabup and surrounding bushland

Lake Jandabup and surrounding the bushland is also now recognized as a Bush Forever Site and supports declared rare or priority flora and significant bird species.

  - MT3S

Although there has been some decline in the condition of *Banksia* woodland in the vicinity of MT3 (CSIRO, 2001), the value of this site as representative of undisturbed phreatophtyic vegetation is retained. Althoguh groundwater (61610743) levels have decreased since 1995 (WRC, 2003) depth to groundwater remains less than 8m, this value has also been retained. Ecological values are at risk from further groundwater decline.

  - JB5

Banksias in the woodland adjacent to JB5 have shown signs of stress in recent years (CSIRO, 2001; Loomes, *et al*, 2003). In addition the understorey is weed infested and a market garden is in operation within 50m of the bore (Loomes *et al*., 2003). Long-term monitoring of phreatophytic vegetation in the

area, suggests wetland trees and shrubs have declined in density while terrestrial species have increased in cover.

Although depth to groundwater (61610732) has increased since 1995 (WRC, 2003) it remains less than 8m and this value is therefore retained, the degree of disturbance to vegetation at JB5 has reduced the value of this site as representative of undisturbed phreatophtyic vegetation.

- Whiteman Park

There has been some decline in density of wetland trees and shrubs on the terrestrial monitoring transect in Whiteman Park since 1999. However the area remains representative of terrestrial vegetation with respect to structure, composition and habitat value. The Park is also now recognized as a Bush Forever Site and supports declared rare or priority flora and significant bird, mammal and reptile species.

– MM18

In the absence of information on the conditions at this site, it is assumed the vegetation remains representative of undisturbed phreatophtyic vegetation. Although groundwater levels (61610918) have declined since 1993 (WRC, 2003), depth to groundwater remains above 8m, and this value is therefore retained.

– MM53

Vegetation density has decreased in the vicinity of this bore (CSIRO, 2001) with a small number of dead *Banksias* noted in the area (Loomes *et al*., 2003). These declines have had no impact on the value of the site as an area of undisturbed phreatophtyic vegetation. Groundwater levels (61610493) have decreased since 1995 (WRC, 2003) however, depth to groundwater remains less than 8m.

– MM59B

Despite an increase in vegetation density (CSIRO, 2001), a number of dead and stressed *Banksias* were noted in the vicinity of this bore (Loomes et al., 2003). These declines have slightly reduced the value of the site as an area of undisturbed phreatophtyic vegetation. Groundwater levels (61611025) have decreased since 1995 (WRC, 2003) however, depth to groundwater remains less than 8m.

– MM55B

The vegetation in the vicinity of MM55B has been heavily modified by grazing however, an area of vegetation dominated by *M. preissiana* has been fenced (Loomes *et al*., 2003) and is growing more dense (CSIRO, 2001). Despite the recent recovery grazing has reduced the value of the site as an area of undisturbed phreatophtyic vegetation. Although groundwater levels (61610559) have decreased since 1995 (WRC, 2003), depth to groundwater remains less than 8m.

– MM49B

The *Banksia* woodland at this site has been largely cleared in recent times and, as a result, it has been suggested it be replaced as a criteria site (N. Hyde, pers., comm., March 2004). Although groundwater levels (61610525) have declined since 1995 (WRC, 2003), depth to groundwater remains above 8m, and this value is therefore retained.

- Gnangara Road Bushland

This Bush Forever Site (no. 193) supports a Threatened Ecological Community and declared rare or priority flora.

– MM16

Vegetation density in the vicinity of MM16 has generally increased in recent times (CSIRO, 2001), retaining its value as undisturbed phreatophytic vegetation. Although groundwater levels (61610835) have generally declined since 1995 (WRC, 2003), depth to groundwater remains above 8m and this value is therefore also retained.

- Rosella Road Bushland

This Reserve has been listed as a Bush Forever Site (no. 380) and supports declared rare or priority flora.

– PM6

Recent deaths of some *Banksias* and epicormic growth in a small number of surviving trees have been noted at this site (Loomes *et al*., 2003). Despite this there has been little change in ecological condition, and the value of the site as undisturbed bushland is retained. However, significant declines in groundwater levels (61610756) since 1995 (WRC, 2003), has increased the depth to groundwater to approximately 12m, the value of the site as being representative of phreatophytic vegetation <8m to groundwater has changed.

– PM7

There has been a decline in the density of vegetation near PM7 in recent times (CSIRO, 2001). This represents little change in ecological condition, and the value of the site as undisturbed bushland is retained. However, significant declines in groundwater levels (61610834) since 1995 (WRC, 2003), has increased the depth to groundwater to >8m, the value of the site as being representative of phreatophytic vegetation <8m to groundwater has changed.

– PM9

Although an increase in vegetation density has been noted (CSIRO, 2001), there is evidence of a decline in the condition of *Banksia* woodland in the vicinity of PM9 over recent years. This decline is of sufficient magnitude to change the value of the site as representative of undisturbed phreatophtyic vegetation. Despite a significant decline in groundwater levels (61610804) since 1995 (WRC, 2003), depth to groundwater remains <8m.

- Chitty Road Bushland

Chitty Road Bushland has been listed as a Bush Forever Site (no. 398).

– WM1

There has been a significant decline in vegetation density at this site (CSIRO, 2001), with deaths in both the overstorey and understorey (Loomes *et al*., 2003). This decline in vegetation condition had decreased the value of the site as undisturbed vegetation. However, despite a significant decline in groundwater levels (61610833) since 1995 (WRC, 2003), depth to groundwater remains <8m.

- Melaleuca Park

Melaleuca Park is recognised as a Bush Forever Site (no. 399) and supports declared rare or priority flora and significant reptile species.

– WM2, WM8, NR6C, NR11C, L30C, L110C, L220C

Although vegetation density has increased near WM8 and NR11C all other sites show signs of decreasing density (CSIRO, 2001). However, these sites still retain their value as representative of undisturbed phreatophtyic vegetation. Despite significant declines in groundwater levels (WRC, 2003), depth to groundwater at all sites remains <8m.

– WM6

This bore is within 50m of a rural property in the vicinity of the Neaves vegetation monitoring transect. There has been some decline in condition of wetland trees and shrubs along this transect since 1999 (Mattiske Consulting, 2003). *M. preissiana* in paddocks to the south of the bore have also shown serious declines in condition, with *Banksia* woodland to north also showing signs of stress (Loomes et al., 2003). These declines in condition have decreased the value of the site as undisturbed phreatophytic vegetation. However, despite groundwater level (61610860) declines (WRC, 2003), depth to groundwater remains <8m. The area also retains it value as representative of terrestrial vegetation with respect to structure, composition and habitat values.

- Maralla Road Bushland

– Ellenbrook Bushland

Ellenbrook Bushland occurs within the Maralla Road Bush Forever site (no. 300) known to support declared rare or priority flora and significant bird, mammal and reptile species. Vegetation density in the west has significantly increased grading to significant decrease in the east. On the Bell permanent monitoring transect there has been a slight increase in the number of healthy *M. preissiana* and *A. fascicularis* and a decreased in *B. ilicifolia* since 1996. On the Maralla transect *A fascicularis* has increased in density while other shrub and tree species have declines.

Although there have been some declines in the condition of vegetation in the area, these are insufficient to alter ecological values. The Ellenbrook Bushland remains representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

- Wetherall Road Bushland

Wetherall Road Bushland is a Bush Forever site (no. 192) and supports significant mammal species.

– MM12

There is evidence that vegetation density has increased in this area in recent times (CSIRO, 2001). Despite declines in groundwater levels (61610898) since 1997 (WRC, 2003), the depth to groundwater remains <8m. This site therefore retains its value as an area of undisturbed phreatophytic vegetation <8m to groundwater.

Jandakot Terrestrial Vegetation

- Thomsons Lake Nature Reserve and adjacent bushland

Thomsons Lake Nature Reserve is a Bush Forever site (no. 391) and supports declared rare or priority flora and significant bird and mammal species.

– JE17C

The *E. rudis* in the vicinity of JE17C have been impacted by insect attack in recent years and exotics have become dominant in the understorey however, *M. preissiana* remain in relatively good condition (Loomes and Bertuch, 2004). There has been an increase in groundwater levels (61419703) since 1992 (WRC, 2003). Although this bore is monitored to protect the habitat of a rare orchid species, the CALM database has no current record of this species in the vicinity. However, this site has value as mixed, phreatophytic woodland at 0-3m to groundwater.

Vegetation condition decline has also been noted in the Thomsons Lake monitoring transect to the south (Mattiske Consulting, 2001). However, the surrounding *Banksia* woodland still retains its value with respect to vegetation structure, composition and fauna habitat.

– JM24

Groundwater levels (61410193) have increased in recent years (WRC, 2003), however, as a result of recent clearing for urban development, only a small area of *Banksia* woodland persists in the vicinity of JM24 (Loomes and Bertuch, 2004). The remaining area is to be totally cleared for furture development (WA Planning Commission, 2003). Therefore this site retains has lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

- Denis de Young Reserve and Gibbs Road Swamp

This Reserve is recognised as a Bush Forever Site (no. 344) protected under JAMBA/CAMBA. It supports a significant species of mammal.

– JE10C

JE10C occurs adjacent to *Banksia* woodland on private semi-rural property that has been impacted by land use practices (Loomes and Bertuch, 2004). There has been an increasing trend in groundwater levels (61410250) since 1992 (WRC, 2003). This site therefore retains its value as *Banksia* woodland occurring in an area of 3-6m to groundwater. Values are however at further risk from land use practices.

– JM31

Although the *Banksia* woodland in the vicinity of JM31 has been impacted by proximity to semi-rural properties (Loomes and Bertuch, 2003) and groundwater levels (61610334) have declined since 1992 (WRC, 2003), this site retains its value as *Banksia* woodland occurring in an area of 3-6m to groundwater.

– JM35

The *Banksia* woodland in the vicinity of JM35 shows evidence of recent declines in condition (Loomes and Bertuch, 2004) and there has been a decline in the number of healthy wetland trees on the nearby Liddelow vegetation transect (Mattiske Consulting, 2001). Groundwater levels (61610333) have increased since 1992 (WRC, 2003). Despite declines in condition, this site retains its value as *Banksia* woodland occurring in an area of 3-6m to groundwater and with respect to vegetation structure, composition and fauna habitat.

– JE4C

Melaleuca woodland near JE4C is in good condition (Loomes and Bertuch, 2004), despite a significant decline in groundwater levels (61610234) since 1992 (WRC, 2003). Although JE4C is an aquifer evaluation bore, the site has value as *Melaleuca* woodland occurring in an area of 3-6m to groundwater.

- Jandakot Airport

The bushland of the Jandakot Airport is listed as a Bush Forever site (no. 388) and supports significant bird, mammal and reptile species.

– JM7

There have been recent *Banksia* deaths and stress in wetland species in the vicinity of JM7 (WRC, 2003; Loomes and Bertuch, 2004) and groundwater levels (61610180) have declined since 1992 (WRC, 2003). Although the decline in condition is likely to have no impact on the ecological value of the surrounding bushland, this bore is monitored to protect the habitat of a rare orchid species. The CALM database has no current record of this species in the vicinity of JM7. However, this site has value as mixed, phreatophytic woodland at 3-6m to groundwater.

– JM8

There has been an increase in vegetation density in the vicinity of JM8 (CSIRO, 2001). However, stress has been recently noted in the overstorey of wetland trees. Groundwater levels (61610248) have declined since 1992 (WRC, 2003). Although the decline in condition is likely to have no impact on the ecological value of the surrounding bushland, this bore is monitored to protect the habitat of a rare orchid species. The CALM database has a current record of this species in the vicinity of JM8. The site also has value as mixed, phreatophytic woodland at 3-6m to groundwater.

- Unreserved Bushland

– JM29

JM29 is located on private property adjacent to an area that has been largely cleared for urban development (Loomes and Bertuch, 2004). Although a small area of *M. preissiana/E. rudis* woodland persists approximately 50m southwest of the bore this is marked for future urban development (WA Planning Commission, 2003). Groundwater levels (61410237) have also declined since 1992 (WRC, 2003). The retention of the value of this bore as representative of woodland occurring in an area of less than 5m to groundwater, should therefore be considered to have been lost.

– JM45

B. ilicifolia, B. attenuata, M. preissiana and *E. rudis* in the vicinity of JM45 have shown recent signs of drought stress WRC, 2003; Loomes and Bertuch, 2004). There have been declines in groundwater levels (61610179) since 1992 (WRC, 2003), with depth to groundwater now greater than 5m. Although the decline in condition is likely to have no impact on the ecological value of the surrounding bushland, this bore is monitored to protect the habitat of a rare orchid species. The CALM database has no current record of this species in the vicinity of JM45. However, this site has value as mixed, phreatophytic woodland at 3-6m to groundwater.

– 8284

This mixed *M. preissinan/ E. rudis*/ *Banksia* woodland on private property in the vicinity of bore 8284 remains in good condition (Loomes and Bertuch, 2004) despite groundwater level (61610178) declines since 1992 (WRC, 2003). This site retains its value as mixed phreatophytic woodland occurring in an area of 3-6m to groundwater.

– JM49

The *M. preissiana/ B. littoralis* woodland on private property is in relatively good condition despite land-use changes, weed invasion and groundwater level (61410111) decreases since 1992 (WRC, 2003). This site therefore retains its value as mixed phreatophytic woodland occurring in an area of less than 3-6m to groundwater.

– JM39

Banksia/ M. preissiana woodland on private property in the vicinity of JM39 is relatively intact despite land-use changes (Loomes and Bertuch, 2004) and a significant decline in groundwater levels (61410142) since 1992 (WRC, 2003). Therefore JM39 retains its value as mixed phreatopyhtic woodland occurring in an area of 3-6m to groundwater.

– JE12C

Mixed *Banksia/ Eucalyptus* woodland in the vicinity of JE12C is in good condition (Loomes and Bertuch, 2004). However, groundwater levels (61410103) have declined significantly since 1992 (WRC, 2003) and depth to groundwater is currently greater than 15m. The value of this site for phreatophtyic vegetation monitoring has declined due to the depth to groundwater.

– JM33

A significant area of woodland adjacent to JM33 has been cleared for urban development (Loomes and Bertuch, 2004) with the remaining woodland marked for future development (WA Planning Commission, 2003). There has also been a significant decline in groundwater levels (61410211) since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

– JE23C

A significant area of woodland adjacent to JE23C has been cleared for urban development (Loomes and Bertuch, 2004) with the surrounding area also marked for future urban development (WA Planning Commission, 2003). There has also been a significant decline in groundwater levels (61419712) since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

– JE20C

A significant area of woodland adjacent to JE20C has been cleared for semi-rural development (Loomes and Bertuch, 2004) with the surrounding area also marked for future urban development (WA Planning Commission, 2003). Groundwater levels (61419706) have also declined since 1992 (WRC, 2003). This site has therefore lost its value as woodland occurring in an area of less than 5m to groundwater.

– J310

The woodland surrounding J310 has been completely cleared for industrial development (Loomes and Bertuch, 2004) and groundwater levels (61410232) have declined since 1992 (WRC, 2003). This bore was established to monitor the habitat of a rare orchid species however, the CALM database has no current

record of this species in the vicinity of J310. This site has therefore lost all values as phreatophytic woodland supporting rare flora.

– JM18

The woodland surrounding JM18 has been completely cleared for industrial development (Loomes and Bertuch, 2004) and groundwater levels (61410239) have declined since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

– JE1B

Woodland in the vicnity of JE1B has been impacted by clearing for a sand-mine and semi-rural land use practices (Loomes and Bertuch, 2004). Groundwater levels (61410243) have also declined significantly since 1992 (WRC, 2003) with depth to groundwater now greater than 10m. The value of this site for phreatophtyic vegetation monitoring has been lost.

– JE18C

This area has been largely cleared for semi-rural and recreational land-use. Groundwater levels (61419704) have also declined since 1992 (WRC, 2003). JE18C has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

- Harrisdale Swamp and Adjacent Bushland

Harrisdale Swamp and adjacent bushland is recognised as a Bush Forever site (no. 253) and supports significant mammal species.

– JM16

The *B. attenuata/ B. menziesii* woodland in the vicinity of JM16 is healthy and intact (Loomes and Bertuch, 2004) despite a decline in groundwater levels (61610445) since 1992 (WRC, 2003). Although there have been changes in the condition of the vegetation (CSIRO, 2001), this site retains its value as *Banksia* woodland occurring in an area of 3-6m to groundwater.

- Acourt Road Bushland

Acourt Road Bushland is recognised as a Bush Forever Site (no. 389).

– JM14

There has been a decrease in the number of healthy stems in *Banksia* species and *M. preissiana* on the Airport monitoring transect in the vicinity of JM14 since 1988 (Mattiske Consulting, 2001) and there is current evidence of declining health in understorey species (Loomes and Bertuch, 2004). These changes correspond to groundwater level (61610247) declines since 1992 (WRC, 2003). Although there have been changes in the condition of the vegetation, this site retains its value as *Banksia* woodland occurring in an area of 3-6m to groundwater and with respect to vegetation structure, composition and fauna habitat.

– JM15

Vegetation in the vicnity of JM15 has been largely cleared for semi-rural land use (Loomes and Bertuch, 2004). This has been accompanied by a groundwater level (61610345) decline since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

- Fraser Road Bushland

This reserve is a Bush Forever site (no. 390) and supports declared rare flora and significant mammal species.

– JM19

Woodland in the vicinity of JM19 was largely cleared for the operation of a sand-mine (Loomes and Bertuch, 2004) and although there is no current evidence of water stress in the remaining area of wetland tree species, groundwater pumping for the mine may have an influence (WRC, 2003). There also been a significant decline in groundwater levels (61610177) since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

- Unreserved Bushland

– JM27

Woodland in the vicninity of JM27 has been largely cleared for rural land –use (Loomes and Bertuch, 2004) and there has been a groundwater level (61610335) decline since 1992 (WRC, 2003). This site has therefore lost its value as *Banksia* woodland occurring in an area of less than 5m to groundwater.

– JM5

The area surrounding JM5 has been totally cleared for urban development with the bore now located within the groundwas of primary school (Loomes and Bertuch, 2004). Groundwater levels (61610354) have also declined since 1992 (WRC, 2003). Due to the degree of urban development, the value of this site as *Banksia* woodland occurring in an area of less than 5m to groundwater has been lost.

Cave and Aquifer Ecosystems

WAWA (1995) recommended that aquatic invertebrate fauna be monitored on a yearly basis, in spring, although caves to be monitored were not listed. Two transects of additional ground water piezometers were also to be established.

Caves selected for yearly sampling were:

- Boomerang cave (YN99)
- Cabaret Cave (YN30)

- Carpark Cave (YN18)
- Gilgie Cave (YN27)
- Water Cave (YN99)

Table 5: Ecological values documented by Jasinska (1997) used to list sites as a TEC and as a basis for ongoing monitoring:

SITE	Cabaret	Carpark	Gilgie	Twilight	Boomerang
Total number of taxa recorded	**33**	**23**	**28**	**29**	**34**
No. of taxa in each group recorded					
Ancient cavernicoles (stygofauna)	3	3	1	5	1
Widespead marine & freshwater interstitial fauna	7	7	8	11	8
Surface waters of Loch McNess	6	2	3	2	4
Insects with terrestrial adult and aquatic larval stages	3	0	1	2	4
Unclassified	14	11	15	9	17

Terrestrial Fauna

Although there are no formal terrestrial fauna monitoring programmes associated with the Jandakot or Gnangara Mounds, terrestrial species are sampled incidentally during frog monitoring at wetlands on the Gnangara Mound. The findings of recent surveys have been described in a previous section under specific wetlands.

Table 6 (next page): Table detailing changes in ecological condition and revised ecological values of previously identified GDEs. Changes in condition are based on those described in annual monitoring of wetlands, terrestrial vegetation and cave systems and associated literature and/or field visits of unmonitored sites. Revised values consider previous values, changes in ecological condition and new information and approaches to valuing GDEs. Previous values are often restated.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
WETLANDS			
Gnangara			
Herdsman Complex			
Loch McNess (37411651052)	*Loomes et al. (2002)* • No annual monitoring of wetland vegetation. • Wetland tree species and emergent macrophytes are healthy and some recruitment noted during assessment. *Benier & Horwitz (2003)* • Loch McNess south has highest cumulative macroinvertebrate family richness of monitored Gnangara Mound wetlands. • Good water quality however, evidence of high chlorophyll *a* concentration and high turbidity in the northern section of the lake. • Diversity of habitat types. *WRC-WIN (2003)* • Trend of declining surface water (staff gauge 6162564) levels since 1995.	Retained • Vegetation largely intact, provides range of habitat types. • Undisturbed wetland. • Unusual hydrologic regime. • Supports good populations of water-birds and acts as drought refuge. • Excellent water quality. • Rich aquatic fauna. New • Bushland surrounding wetland supports priority flora. • Supports diverse fish species. • Large area of permanent open water.	• Loch McNess (North): Extreme concern for eutrophication & introduced species. • Probable concern for water levels, susceptibility to fire, loss of vegetation & loss of fauna.
Lake Yonderup (37524650756)	*Froend et al. (2003).* • Increased invasion of wetland basin and surrounds by exotic flora. *Loomes et al. (2003a)* • Health decline in fringing *M. rhaphiophylla* since 1997. *Benier & Horwitz (2003)* • Showing signs of declining water levels and drying of organic rich sediments. *WRC-WIN (2003)* • Trend of declining surface water levels (staff gauge 6162565) since 1995.	Retained • Undisturbed hydrologic regime and lack of seasonal variation - declining water levels. • High ecological values due to undisturbed nature. • Rich invertebrate fauna. • Excellent water quality. New • Vegetation largely intact, provides range of habitat types.	• Probable concern for water levels, exotics and susceptibility to fire.
Lake Wilgarup (37577650595)	*Froend et al. (2002).* • Surface water levels declining since records began in 1993; groundwater levels decreasing since 1997; periods of drying increasing each year. • Widespread loss of *M. rhaphiophylla* saplings and some mature individuals. • *B. articulata* and *L. longitudinale* thinning • Exotic species encroaching into the basin. *Sommer & Horwitz, (1999); Benier & Horwitz (2002).* • Recent surveys indicate low macroinvertebrate species richness. *Benier & Horwitz (2003).* • Drying of organic rich sediments. *WRC-WIN (2003)* • Surface water was recorded in winters from 1993- 98 the lake bed has remained dry since that time (staff gauge 6162623). • Trend of declining groundwater levels (bore 61618500) since 1995.	Changed • One of few remaining undisturbed wetlands within the region - weed invasion due to drying, sediment shrinkage, serious fire risk. • Rich and unusual vegetation (dense monospecific stands of sedges) - density and structure changed. Lost • Likely to support diverse fauna - complete absence of surface water.	• Extreme concern for water levels, susceptibility to fire, loss of vegetation and loss of fauna. • Probable concern for acidification.
Pipidinny Swamp (37504650521)	*Loomes and Froend (2001a)* • On-going invasion of wetland by exotic flora. • Mix of habitats for fauna. *Benier & Horwitz (2003)* • Conductivity increasing in ponds near dunes possibly due to intrusion of marine water. *WRC-WIN (2003)* • Trend of declining surface water levels (staff gauge 6162624) since 1995.	Retained • Waterbird habitat. New • Supports unique macroinvertebrates. • Vegetation provides range of habitat types.	• Extreme concern for water levels and quality. • Probable concern for loss of fauna.
Coogee Springs (37725650450)	*Loomes and Froend (2001b)* • Poor diversity and health of vegetation due to livestock disturbance. *Sommer & Horwitz (1999).* • Prolonged drought leading to terrestrialisation of wetland. • Decomposition of emergent veg part cause of increased nutrient levels. *Benier & Horwitz (2002).* • Drying rate increased significantly between 1998 and 2001, indicating wetland has become	Lost • Diverse aquatic fauna. • Supports breeding bird species and provides winter feeding habitat for a range of ducks.	• Extreme concern for water levels, susceptibility to fire, loss of fauna & introduced species. • Probable concern for eutrophication & loss of vegetation.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	disconnected from underlying groundwater table. • Changes in macroinvertebrate community structure due to altered hydrological regime and subsequent changes to physico-chemical status. • Decline in species richness between 1990 and 2001 abundance and diversity of Gastropoda, Arachnida, Odonata, Diptera (excluding Chirminae and Tanypodinae) declined significantly. *Benier & Horwitz (2003)* • Tree deaths evident on western margin of lake. • Significant loss of organic/peat soils in northern sector of lake following fire in spring 2002. • Numerous *M. rhaphiophylla* uprooted due to loss of substrate in fire. *WRC-WIN (2003)* • Artificial maintainance 1998-2001 failed to achieve criteria peak levels. Wetland now dry most/all of year.		
Lake Nowergup (37958649929)	*Loomes et al. (2003a)* • Despite artificial maintenance of surface water levels, health of *M. rhaphiophylla* and *E. rudis* has declined. • Thinning of *B. articulata*. • Encroachment of *Typha orientalis* into wetland. *Benier & Horwitz (2003).* • Water quality changes include increase in pH range, decreased conductivity, nutrient levels and chlorophyll-a values, mostly attributable to supplementation of water levels using fresh water from Leederville aquifer. • Augmentation not leading to sustainable protection of biodiversity values. • Slight decline in summer invertebrate family richness. • Species of Cladocera (*Leydigia ciliata*) now known from several wetlands. *Bamford (2003)* • Enlarged area of Typha may provide further habitat for waterbirds and other species. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 6162567) and groundwater levels (bore LN2/89) since 1995, despite artificial maintainance.	Retained • As a permanent deep-water wetland acts as a major drought refuge for waterbirds • Supports fish species and other dependent vertebrate species. • Significant for aquatic macroinvertebrates.. Changed • Large areas of sedges minimise impact of nutrient enrichment on aquatic fauna – areas of sedges have thinned on eastern shore near nutrient source. New • Fringing vegetation provides range of habitat types.	• Vegetation, biodiversity and landscape values could be threatened as organic rich sediments become drier and potentially lead to the terrestrialisation of sediments, mobilisation of nutrients and increase the likelihood of fire. • Extreme concern for introduced species. • Probable concern for water levels, eutrophication, acidification & loss of vegetation.
Lake Joondalup (3857664875)	*Lam et al., (2002)* • Fringing vegetation impacted by frequent fires and wind throw due to drying sediments. • *Typha orientalis* encroaching in southern section of lake. • *E. rudis* in southern sector of lake badly impacted by fire in summer 2002/03. *Benier & Horwitz (2003)* • Poor water quality (high nutrients, chlorophyll a, low dissolved O_2 recorded in summer. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 61610661) and groundwater (bore 8281) levels since 1995.	Retained • Waterbird habitat. • Diverse range of macrophytes. • Supports aquatic macroinvertebrates and vertebrates. New • Vegetation largely intact, provides range of habitat types. • Bushland surrounding wetland supports priority flora.	• Joondalup North & South: Extreme concern for eutrophication. • Probable concern for water levels.
Lake Goollelal (38769647968)	*Lam et al., (2002)* • 'Wetter' hydrological regime than other Gnangara wetlands has lead to prolonged flooding. • Health declines in *E. rudis* and *M. rhaphiophylla.* • Contraction of *B. articulata* bands • Further invasion by exotics. *Benier & Horwitz (2003)* • Consistently high chlorophyll a levels as evidence of increasing eutrophication. • High abundance of *Gambusia* sp. known to predate on aquatic macroinvertebrates. • Relatively low cumulative macroinvertebrate family richness. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 6162517) water levels since 1995.	Retained • Permanent water provides waterbird habitat and drought refuge. • Supports good populations of native fish species. New • Fringing vegetation provides range of habitat types. • Bushland surrounding wetland supports priority flora.	• Extreme concern for eutrophication. • Probable concern for introduced species.
Pinjar Complex			

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
Lake Jandabup (39020648649)	*Mattiske Pty Ltd (2001)* • Vegetation within lake changed substantially, with extension of sedge species and decrease in condition of tree species on fringes. *Loomes & Froend (2001b)* • Decline in health of fringing *M. rhaphiophylla* and *E. rudis.* • Some encroachment of emergent macrophytes. • Decline in flora species richness in monitoring plot since 1997. *Sommer & Horwitz (2001)* • Shifts in macroinvertebrate community structure. • Decline in pH & subsequent water quality; increased SO4, Fe and NH4 conc., decreased P and gilvin . *Horwitz & Benier (2002).* • Local extinctions and decreases of highly sensitive macroinvertebrate taxa. • Increasing abundance of apparently acid-tolerant species. • Change in proportion of relative abundances of families. • Showing signs of declining water levels and drying of organic rich sediments. *Benier &Horwitz (2003)* • Decrease in acidification. • Some return of significant macroinvertebrate species abundant prior to acidification. *WRC-WIN (2003)* • Trend of increasing surface water levels (staff gauge 6162578) since 1995 following artificial maintainance.	Retained • Most diverse sedge and macrophyte vegetation of all Bassendean dune wetlands – not known if 'unusual species' persist. • Supports wide range of waterbirds, especially waders. • Supports significant macroinvertebrate species. Recoverable • Extremely good water quality with low nutrients – apparent capacity to recover from acidification and associated water quality decline if appropriate water level augmentation is applied.	• Extreme concern for water levels, eutrophication & acidification. • Probable concern for susceptibility to fire & loss of fauna.
Lake Mariginiup (38773648936)	*Sommer & Horwitz (1999).* • Becoming increasingly acidic; critical macroinvertebrate species not yet showing signs of stress. *Loomes et al. (2002)* • Significant decline in condition of fringing vegetation due to drying, fire, physical disturbance and exotics. • Decline in flora species richness in monitoring plot since 1997. *Benier & Horwitz (2003)* • Showing signs of declining water levels and drying of organic rich sediments affecting water holding capacity. • Increasing acidification in recent years, now approaching critical levels. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 6162577) and groundwater (bore 61610685) levels since 1995. Wetland dries during most summers.	Retained • Wading bird habitat. • Rich aquatic fauna (under threat from acidification). Changed • Good water quality – decreasing pH in recent years.	• Extreme concern for water levels and acidification. • Extreme concern susceptibility to fire, loss of vegetation, loss of fauna. • Probable concern for eutrophication.
Bassendean Central & South Complex			
Lake Gnangara (39278648240)	*Benier & Horwitz (2003)* • Macroinvertebrate family richness consistently low in comparison to other study wetlands. • Low pH. • Evidence of eutrophication. • Reduced inundation of littoral and fringing vegetation and therefore lower habitat complexity. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 6162517) and groundwater (bore 61618440) levels since 1995.	Retained • Low value due to poor water quality, especially high pH. New • Bushland surrounding wetland supports priority flora.	• Extreme concern for acidification.. • Probable concern for water levels & eutrophication.
Bassendean North Complex – Lexia			
Lexia 86 (40136648637) sumpland.	*Loomes et al. (2002)*	Retained	• Extreme concern for water levels, acidification,

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	• Decline in health and patch deaths of fringing *M. preissiana* and *B. ilicifolia* • Encroachment of fringing vegetation into wetland basin as *B. articulata* contracts. *Benier & Horwitz (2003)* • Showing signs of declining water levels and drying of organic rich sediments. *Davis and Bamford (2003)* • No evidence of recruitment of moaning frog from previous breeding season and absence of young adults, suggesting that there had been no recruitment for several years prior to 2002. • Swamp-dependent skink *Acritoscincus trilineata* recorded in spring 2003. • Western pygmy possum trapped in autumn 2003. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 61613215) and groundwater (bore 61612630) levels since 1997. Wetland dries during most summers.	• Supports diverse vegetation. Changed • Undisturbed by typical impacts –drying is negatively impacting wetland. • Significant fauna habitat – declining water levels may be reducing habitat area.	susceptibility to fire, loss of vegetation, loss of fauna.
Lexia 186 (40164648730) sumpland	*Loomes et al. (2002)* • Drying leading to loss of *B. articulata* and some encroachment of fringing tree species. • Decline in health of fringing tree species. *Benier & Horwitz (2003)* • Showing signs of declining water levels and drying of organic rich sediments. • Low macroinvertebrate family richness. *WRC-WIN (2003)* • Trend of declining groundwater (bore 61613214) levels since 1997.	Changed • Undisturbed by typical impacts –drying is negatively impacting wetland. • Supports diverse vegetation – altered vegetation assemblage now common. • Significant fauna habitat – surface water restricted to small excavated sump severely reducing habitat availability and diversity.	• Extreme concern for water levels, acidification, susceptibility to fire, loss of vegetation, loss of fauna.
Lexia 94 (39830648856) dampland	*Loomes et al. (2002)* • Drying and thinning of wetland shrubs and emergent macrophytes across wetland basin. • Decline in health of fringing *M. preissiana* *Benier & Horwitz (2003)* • Showing signs of declining water levels and drying of organic rich sediments *WRC-WIN (2003)* • Trend of declining groundwater (bore 61613216) levels since 1997.	Changed • Undisturbed by typical impacts –drying is negatively impacting wetland. New • Fringing vegetation provides range of habitat types.	• Concern for water levels and fire.
Bassendean North Complex – Melaleuca Park			
EPP Wetland 173 (40146649172) sumpland	*Lam et al, (2002).* • Some decline in condition of fringing *M. preissiana*. *Benier & Horwitz (2003)* • Showing signs of declining water levels and quality and drying of organic rich sediments. *Storey (2003)* • Possible decline in Black-stripe minnow as only 1 taken in last two sampling rounds. *Davis and Bamford (2003)* • Swamp dependent skink (*Acritoscincus trilineata*) recorded in autumn and spring 2003. *WRC-WIN (2003)* • Trend of declining surface (staff gauge 6162628) water levels since 1997.	Retained • Unique hydrology. • High vertebrate and macroinvertebrate species richness. Changed • Contains northern most population of Black-stripped minnow – numbers may be declining. New • Fringing and littoral vegetation provides range of habitat types.	• Extreme concern for water levels, acidification, susceptibility to fire & loss of fauna. • Probable concern for loss of vegetation.
Dampland 78 (38959649551)	Lam *et al.* (2002) • Drying of wetland basin. • Water stress deaths of wetland vegetation. *Mattiske Consulting (2003)* • No. of healthy *M. preissiana, B. ilicifolia* and *B. attenuata* stems declined on Melaleuca transect since 1996. • Density of *P. reticulata* and *B. elegans* declined from 1996 while terrestrial species increased. *WRC-WIN (2003)* • Trend of declining groundwater (bores 61613231 and GNM13) levels since 1997.	Changed • Supports swamp vegetation – decline in density and health of some wetland species.	• Concern for water levels and fire.
Melaleuca Park Wetlands	*Benier & Horwitz (2003)*	Retained (in absence of information or data to the contrary)	• Concern for water levels and fire.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
SWC category - 34 damplands (395655649347, 39541649417, 39514649463, 395246449428, 39455649394, 39527649600, 39550649619, 39547649649, 39507649695, 39478649638, 39498679636, 39881649161, 39813649148, 39685649249, 39592649232, 39493649320, 39647649353, 39580649387, 39559649393, 39616649454, 39627649484, 39712649551, 39985649160, 39961649188, 39943649226, 39956649258, 40001649291, 39989649284, 39993649344, 39947649380, 39906649362, 39876649518, 40037649313) 11 sumplands (39582649556, 39554649527, 39523649527, 39477649525, 39442649618, 39496649584, 39556649708, 39610649565, 396536449561, 39576649679, 39969649158, 40010649385)	• Signs of declining water levels and drying of organic rich sediments evident in some wetlands.	• Supports original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation. New • Bush Forever Site. • Bushland supports declared rare flora. • Vegetation provides range of habitat types. No additional information to allow further assessments of values.	
WC category 4 damplands (39421649304, 39432649481, 39443649445, 39592649724) 1 sumpland (39920649456)	*Benier & Horwitz (2003)* • Signs of declining water levels and drying of organic rich sediments evident in some wetlands.	Retained (in absence of information or data to the contrary) • Supports original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation. New • Bush Forever Sit.e No additional information to allow further assessments of values.	• Concern for water levels and fire.
C Category 6 damplands (39433649770, 394746449776, 39504649769, 395522649773, 39533649759, 39572649792)	*Benier & Horwitz (2003)* • Signs of declining water levels and drying of organic rich sediments evident in some wetlands.	Retained (in absence of information or data to the contrary) • Supports original vegetation of Bassendean Dunes. • Wetlands support species of swamp vegetation. No additional information to allow further assessments of values.	
Bassendean North Complex – East Pinjar			
Bombing Range Wetlands SWC category 2 damplands (39528649912, 39038650735)	No record of changes in ecological values.	Retained (in absence of information or data to the contrary) • Values related to remnant vegetation supported. • Unique hydrology (WRC, 1997). New • Bush Forever site.	• Concern for water levels and fire.
C category - 29 damplands - (38942650419, 38935650377, 39038650735, 38954650363, 38981650273, 38976650360, 38986650306, 38984650324, 38999650292, 39013650443, 39009650127, 39044650152,	No record of changes in ecological values.	Retained (in absence of information or data to the contrary) • Values related to remnant vegetation supported. • Unique hydrology (WRC, 1997). New • Bush Forever site.	• Concern for water levels and fire.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
39059650062, 39073650393, 39079650301, 39103650224, 39122650392, 39170650336, 39220650202, 39263650076, 39315650224, 39467650163, 39467650061, 39476650091, 39271649907, 39301649862, 39453659899, 39470650054, 39480650015, 39540649876)			
Edgecombe Seepage and Lake Yakine (40506648187) sumpland	*Horwitz and Knott (2002)* • Faunal diversity declined from 11 species in April 1999 to two of the original species in December 1999 and November 2000 following drying of the spring. • Farmer had graded a firebreak along fence line and spring was cleared and heavily disturbed. By 2002 flows were returning and the spring was recovering however fauna essentially absent. *Horwitz and Knott (2003)* • Groundwater flow stronger than on previous occasions. • Fauna returning. • Water quality results indicate good water quality. • Area immediately around spring continues to repair original semblance however, habitat not improving to original conditions. *WRC-WIN (2003)* • Groundwater levels declined since 2000, before rising in winter 2003.	Retained • High conservation values due to mosaic of habitats likely to support diverse fauna populations.	• Drying of perennial flows during summer may result in loss of aquatic invertebrate habitat.
Egerton Seepage (40361648418)	*Horwitz and Knott (2002)* • Site dried in 1999/2000. *Horwitz and Knott (2003)* • Spring continuing to discharge good quality, fresh water with limited nutrient content. • Fauna sampled continues to be diverse with crustacean groups well represented and in good abundance. • No evidence of degradation following clearing of vegetation to west and north of spring. *Loomes et al. (2003b)* • Spring vegetation remains dense and intact other than season senescence in sedge species. *WRC-WIN (2003)* • Groundwater levels declined since 2000, before rising slightly in winter 2003.	Retained • Supports significant club moss and liverwort species. • Supports pristine fringing vegetation. • High conservation value as invertebrate habitat. Previously unrecognized • Supports Threatened Ecological Community EGO1.	• Drying of perennial flows in summer may result in loss of aquatic invertebrate habitat.
Jandakot			
Herdsman Complex			
Thomsons Lake (38942644227)	*Hancock and Ladd, (2002).* • The density of *Baumea articulata* has diminished since 1996 and prolific sapling growth is occurring near the lake possibly due to lower water levels. • Declines in health of some mature *E. rudis.* *McGuire et al. (2002).* • Increased weed invasion due lack of inundation. • Values influenced by GW abstraction and water quality issues associated with increasing urban development. • Poor water quality (saline, eutrophic and high pH). *WRC-WIN (2003)* • Declining trend in ground (61410367) and surface water (6162557) levels since 1992. • Wetland dry at staff gauge each year since 1996.	Retained • Important habitat for waterbirds. • RAMSAR wetland. • Lake margins support terrestrial bird and other vertebrate species. Changed • High degree of naturalness and human use interest – altered hydrology and other storm water drainage disturbances have reduced ‘naturalness’ of wetland. New • Large area of remnant vegetation associated with wetland. • Bushland surrounding wetland supports priority flora.	• Altered hydrology, fire, weed invasion, water quality issues and loss of vegetation.
North Lake (38891645024)	*Ladd (2001).*	Retained	• Declining water levels, fire, water quality issues and loss of

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	• Encroachment of native vegetation into previously inundated areas closer to the center of the wetland basin. • Tree health along biological monitoring transects has either increased or not changed significantly since monitoring began in 1997. *Loomes et al. (2002).* • Decrease in condition of mature *E. rudis* around wetland basin. *(Loomes et al., 2003).* • General decline in health of wetland trees since 1997 in response to water level decline and insect attack. • Exotics are threatening to become dominant in some areas of the wetland. (*Water Quality and Macroinvertebrates:* no regular monitoring for the WRC). *WRC-WIN (2003)* • Declining trend in surface water (6142521) levels since 1992 and in groundwater (61410726) levels since records commenced in 1997.	• Supports extensive *M. rhaphiophylla* and *B. articulata* stands. Changed • Permanent wetland provides summer waterbird refuge – numbers of waterbirds have declined with drying in recent years. New • Supports freshwater sponges.	vegetation.
Banganup Swamp (38927644051) sumpland	*Froend et al. (1993)* • Showing signs of becoming drier. *McGuire et al. (2001).* • Drying of wetland has lead to encroachment of Typha. • Severe cultural eutrophication has occurred. *McGuire et al. (2002)* • During spring 1999 mean invertebrate richness was the highest recorded during this monitoring program. • The chlorophyll-*a*, turbidity and nutrient levels very low compared to other wetlands, with the nitrogen the lowest of all the wetlands sampled. *WRC-WIN (2003)* • Lake bed has dried in summer since 1989. • Declining trend in ground (61419614) and surface water (6142516) levels since 1992.	Retained • Non-avian fauna habitat. • High conservation value due to diversity and condition of littoral and fringing vegetation. • Bushland surrounding wetland supports priority flora.	• Declining water levels and fire.
Bibra Lake (38945644839)	*WRC (1996)* • Prolonged inundation of the vegetation, on west side of the lake, has caused severe deterioration of tree health. *Ladd (1999)* • Water level decline and insect attack have had some impact of wetland trees since 1997 and exotics are threatening to become dominant in some areas. (*Water Quality and Macroinvertebrate:* no regular monitoring for the WRC) *WRC-WIN (2003)* • Declining trend in surface water (6142520) levels since 1992.	Retained • Supports a diversity of habitats used by wading birds. • Modified western shore of high values for waterbird breeding. • Summer refuge for waterbirds.	• Altered hydrology, fire and water quality issues associated with increasing urban development.
Yangebup Lake (38969644509)	*McGuire et al. (2001)* • Severe cultural eutrophication has occurred. • Increased water levels. • Overall reduction in macroinvertebrate species richness since monitoring began in 1996. • Poorest water quality with frequently elevated nutrients and brackish water and marked differences with water level fluctuations. *WRC-WIN (2003)* • Declining trend in ground (61419707) and surface water (6142523) levels since 1992.	Retained • Permanent wetland provides summer refuge for waterbirds. New • Supports high number of macroinvertebrate taxa.	• Altered hydrology and water quality issues.
Kogolup Lake (38989644422) sumpland	*WRC (2000)* • Water-logging has resulted in loss of fringing vegetation • Increased weed invasion, however weediness is still considered low. *McGuire et al. (2001).* • Severe cultural eutrophication has occurred *Hancock and Ladd (2002)* • The health of some *E. rudis* has been gradually declining since 1998	Retained • Moderate potential for waterbird breeding. • Contains representatives of most vegetation types of Cockburn wetlands • High diversity in vegetation surrounding lake. New • South Kogolup supports high macroinvertebrate species richness.	• Water level decline and water quality issues associated with increasing urban development.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	WRC-WIN (2003) • Declining trend in surface water (6142522) levels at South Kogolup since 1992.		
Bassendean Central & South Complex			
Shirley Balla Swamp (39419644203) sumpland	*Bamford (2001)* • Used least by water birds than all other wetlands studied in Jandakot area. *McGuire et al., (2001).* • Spring macroinvertebrate sampling showed decrease in family richness from 1996 to 2000. *Hancock and Ladd (2002).* • Vegetation negatively impacted by fire and physical disturbance. *Wild et al. (2003).* • Contamination of lake with hydrocarbons. • Total phosphorus and total nitrogen declined progressively. *WRC-WIN (2003)* • Lake bed dried in summer since 1994 . • Declining trend in ground (61410713) and surface water (6142576) since records commenced in 1996 and 1993 respectively.	Changed • Diverse array of vegetation, floristically and in terms of habitat for terrestrial fauna – declining naturalness through increased physical disturbance and fire. Lost • High waterbird breeding potential – water level is not high enough. New • Bushland surrounding wetland supports rare and priority flora.	• Water level decline, fire and other disturbances.
Twin Bartram (39174644318) sumplands	*Loomes (2000)* • Highest percentage of exotic species of all study (Jandakot) wetlands. *WRC (2003).* • Fire, weed invasion and increased water levels. • The health of trees remains moderate to good and shows signs of recovery since fire in 1999. *WRC-WIN (2003)* • Declining trend in ground (61410715) levels since records commeneced in 1996 and in surface water (6142544) levels since 1992.	Retained • Potential for waterbird breeding. Changed • Vegetation representative of former *Melaleuca* forest of the region.	• Water level decline and water quality issues associated with increasing urban development.
Beenyup Rd Swamp (39361644097) sumpland	*Ladd (2001).* • Tree health generally good and not shown any deterioration since 1997. • *B. articulata* density decreased 1997-2002. *Hancock and Ladd (2002)* • Lack of inundation over the last 4 years prevented growth of *B. articulata* permitting weeds to thrive in wetter plots. • *E. longiflora* is now established and co-dominant with *B. maxima.* *Loomes, et al, (2003)* • Decline in the density and health of wetland shrubs. • Decline in health of *M. rhaphiophylla.* (No invertebrate or waterbird monitoring) *WRC-WIN (2003)* • Declining trend in ground (61410711) levels since records commeneced in 1996 and in surface water (6142547) levels since 1992.	Retained • Supports *Melaleuca pauciflora (*formerly *M. leptoclada*) community of limited occurrence elsewhere – in absence of information to the contrary. • Significant due to size, assemblages and status. • Potential use as feeding area for secretive waterbird species. • Supports non-aquatic fauna. Changed • Potential use for breeding by bird species whose young leave the nest shortly after hatching.	• Water level decline, fire and other disturbances.
Karrakatta Central & South Complex			
Forrestdale Lake (39960644134)	*Ladd (2001)* • Increased weed invasion due lack of inundation. • Declining watertable affected vegetation including *M. rhaphiophylla* and *E. rudis* which were generally in poorer health than at other wetlands assessed in the Jandakot area. *WRC (2002)* • Drying, fire and physical disturbance has impacted negatively on *Melaleuca* sp. *McGuire (2002)* • Nutrient levels were low compared to other wetlands for the first water quality sampling undertaken in 2001. *WRC-WIN (2003)*	Retained • Lake margins support terrestrial bird and other vertebrate species. • RAMSAR wetland Changed • Important habitat for waterbirds – value declining due to loss of muddy shorelines and shallows. • Bushland surrounding wetland supports declared rare and priority flora.	• Water level decline, fire and other disturbances.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	• Lake bed has dried at staff gauge since 1994 (except in 1997). • Declining trend in ground (61410714) levels since records commeneced in 1996 and in surface water (6142557) levels since 1992.		
TERRESTRIAL ECOSYSTEMS			
Gnangara			
Herdsman Complex			
PM24 - Pinjar phreatophytic vegetation criteria bores. Lake Pinjar and adjacent bushland	*CSIRO (2001)* • 1988-2000 vegetation density stable in centre of wetland and to the east. • Density showed decreasing trend in north and South-west. *Froend et al. (2002).* • Areas of *E. rudis* along western border of lake exhibiting substantial crown dieback. • Vegetation in much of the lake heavily modified through agriculture, with little undisturbed vegetation remaining. *WRC-WIN (2003)* • Declining trend in groundwater levels (61610697) since 1995.	Retained • Depth to groundwater <8.0m (0-3m) Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation – vegetation highly disturbed. New • Bush Forever Site. • Regionally significant bush/wetland linkage. • Supports one of remaining examples of Pinjar veg. complex in area.	• Groundwater level decline and rural land-use practices.
PM25 - Pinjar phreatophytic vegetation criteria bores. Lake Pinjar and adjacent bushland	*CSIRO (2001)* • 1988-2000 vegetation density stable in centre of wetland and to the east. • Density showed decreasing trend in north and South-west. *Froend et al. (2002).* • Areas of *E. rudis* along western border of lake exhibiting substantial crown dieback. • Vegetation in much of the lake heavily modified through agriculture, with little undisturbed vegetation remaining. *WRC-WIN (2003)* • Declining trend in groundwater levels (61610750) since 1995.	Retained • Depth to groundwater <8.0m (3-6m) Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation – vegetation highly disturbed. New • Bush Forever Site. • Regionally significant bush/wetland linkage. Supports one of remaining examples of Pinjar veg. complex in area.	• Groundwater level decline and rural land-use practices.
Pinjar Complex			
MT3S - phreatophytic vegetation criteria bore. Jandabup Lake and adjacent bushland	*Mattiske Consulting Pty Ltd (2000)* • Decrease in abundance of healthy *E. rudis*, *M. preissiana* and *B. ilicifolia* stems and increase in stressed stems on Jandabup transect since 1993. • Increase in abundance of healthy *B. attenuata* and *B. menziesii* stems on Jandabup transect since 1993. • Decrease in abundance of *A. fascicularis*, *P. ellipticum* and *H. angustifolium* on Jandabup transect since 1993. *WRC-WIN (2003)* • (61610754) – declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (6-10m). • Selected to represent groundwater levels over area of undisturbed phreatophtyic vegetation. Jandabup transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. New • Reserve supports declared rare or priority flora. • Bush Forever Site.	• Groundwater level decline and weed invasion.
JB5 - phreatophytic vegetation criteria bore In vicinity of Jandabup Bushland	*Mattiske Consulting Pty Ltd (2001)* • Large *B. ilicifolia* near bore showing signs of stress. • *B. attenuata* and *B. menziesii* woodland ranges in condition form very healthy to slightly stressed. *Loomes et al. (2003b)* • Previous stress in *M. preissiana* and *B. attenuata.* • Understorey weed infested. • Market garden within 50m of bore.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m) Changed • Selected to represent groundwater levels over area of undisturbed phreatophtyic vegetation – vegetation severely modified.	• Groundwater level decline, rural land-use practices and weed invasion.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	WRC-WIN (2003) • (61610762) – declining trend in groundwater levels since 1995.		
Bassendean Central and South Complex			
MM18 - phreatophytic vegetation criteria bores Whiteman Park	*CSIRO (2001)* • Trends in vegetation density varied throughout park. *Mattiske Consulting Pty Ltd (2003)* • Decrease in number of healthy stems of *M. preissiana* and *B. ilicifolia* stems on Whiteman transect since 1999. • Significant decline in abundance of *P. ellipticum* since 1999. *WRC-WIN (2003)* • (61610918) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. Whiteman Transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. New • Reserve supports declared rare and priority flora. • Bush Forever Site.	• Groundwater level decline, dieback and rural land-use practices in some areas.
MM53 phreatophytic vegetation criteria bores Whiteman Park	*CSIRO (2001)* • Vegetation density decreased in vicinity. *Loomes et al (2003b)* • Number of small dead *Banksias* in area. *WRC-WIN (2003)* • (61610918) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). • Selected to represent water levels over area of undisturbed phreatophtyic vegetation.	• Groundwater level decline and dieback.
MM59B phreatophytic vegetation criteria bores Whiteman Park	*CSIRO (2001)* • 1988-2000 vegetation density increased in vicinity *Loomes et al (2003b)* • Number of dead and stressed *Banksias* in area. *WRC-WIN (2003)* • (61611025) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation - number of dead and stressed trees in area.	• Groundwater level decline and dieback.
MM55B phreatophytic vegetation criteria bores Whiteman Park	*CSIRO (2001)* • 1988-2000 vegetation density increased. *Loomes et al (2003b)* • General area modified by grazing, fenced area recovering. *WRC-WIN (2003)* • (61610559) - declining trend in groundwater levels since 1995.	Retained • *Melaleuca* woodland <8m depth to groundwater (0-3m). Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation – area modified by grazing.	• Groundwater level decline, dieback and rural land-use practices in some areas.
MM49B phreatophytic vegetation criteria bores Whiteman Park	*WRC-WIN (2003)* • (61610525) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation – area largely cleared.	• Groundwater level decline and change in land-use.
MM16 phreatophytic vegetation criteria bores Gnangara Road Bushland	*CSIRO (2001)* • 1988-2000 vegetation density ranged stable to increased. *WRC-WIN (2003)* • (61610835) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. New • Supports threatened ecological communities 20a (Telstra01-08). • Bush Forever Site.	• Groundwater level decline and weed invasion.
Bassendean North Complex			

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
PM6 - Pinjar phreatophytic vegetation criteria bore Rosella Rd bushland	*Mattiske Consulting Pty Ltd (2003)* • Recruitment of *Banksia* in woodland (P50) impacted significantly by water stress in summer 1991/92. • Increase in number of healthy *B. ilicifolia* stems on P50 transect since 1996. • No change in number of stressed *B. ilicifola* stems since 1996. • Abundance of *H. angustifolium* halved since 1999. *CSIRO (2001)* • Vegetation density decreased in vicinity 1988-2000. • In general density increased north of PM4 and decreased to south. *Loomes et al (2003b)* • Some recent *B. attenutata* deaths and epicormic growth in surviving trees. *WRC-WIN (2003)* • (61610756) - declining trend in groundwater levels since 1995.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation – some decline in vegetation condition. P50 transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. Lost • *Banksia* woodland <8m depth to groundwater (12m+). New • Bush Forever Site.	• Groundwater level decline.
PM7 - Pinjar phreatophytic vegetation criteria bore Rosella Rd bushland	*CSIRO (2001)* • Vegetation density decreased in vicinity 1988-2000. *WRC-WIN (2003)* • (61610834) - declining trend in groundwater levels since 1995.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. Lost • *Banksia* woodland <8m depth to groundwater (10m+). New • Bush Forever Site.	• Groundwater level decline.
PM9 - Pinjar phreatophytic vegetation criteria bore Rosella Rd bushland	*CSIRO (2001)* • Vegetation density increased 1988-2000. *WRC-WIN (2003)* • (61610804) - declining trend in groundwater levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (6-10m). Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation - decline in condition of vegetation. New • Bush Forever Site.	• Groundwater level decline.
WM1 - Pinjar phreatophytic vegetation criteria bore Chitty Rd Bushland, Pinjar	*CSIRO (2001)* • Significant decrease in vegetation density 1988-2000. *Loomes et al. (2003)* • Recent *B. attenuata* deaths. • Thinning in understorey. *WRC-WIN (2003)* • Declining trend in groundwater (61610833) levels since 1995.	Retained • *Banksia* woodland <8m depth to groundwater (3-6m). Changed • Selected to represent water levels over area of undisturbed phreatophtyic vegetation - decline in condition of vegetation. New • Bush Forever Site.	• Groundwater level decline.
WM2 Melaleuca Park phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • Decreased vegetation density 1988-2000. *WRC- WIN (2003)* • (61610908) - declining trend in groundwater levels since 1995.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora. • Bush Forever Site.	• Groundwater level decline.
WM6 Melaleuca Park phreatophytic vegetation criteria bore. Melaleuca Park and adjacent	*CSIRO (2001)* • No change to increased vegetation density 1988-2000. *Mattiske Consulting Pty Ltd (2003)* • Increase in number of healthy *M. pressiana* and *M. rhaphiophylla* stems on Neaves transect	Retained • *Banksia* woodland <8m depth to groundwater (6-10m). Changed	• Groundwater level decline and semi-rural landuse practices.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
bushland.	since 1999. • Decrease in number of health *B. ilicifolia* stems on Neaves transect since 1999. • Decrease in abundance of *A. fascicularis* since 1999. • Significant decline in abundance of *P. ellipticum* since 1999. *Loomes et al, (2003)* • Signs of stress in *Banksia* sp. north of bore and *M. preissiana* to south. • Bore <50m from rural property. *WRC-WIN (2003)* • (61610860) - declining trend in groundwater levels since 1995.	• Selected to represent water levels over area of undisturbed phreatophtyic vegetation - decline in condition of vegetation and clearing to south. Neaves transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat.	
WM8 Melaleuca Park phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • No change to increased vegetation density 1988-2000. *WRC-WIN (2003)* • (61610983) - declining trend in groundwater levels since 1995.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora. Bush Forever Site.	• Groundwater level decline.
NR6C Melaleuca Park phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • Decreased vegetation density 1988-2000. *WRC-WIN (2003)* • (61610982) – declining trend in groundwater levles since 1995.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora. • Bush Forever Site.	• Groundwater level decline.
NR11C - Melaleuca Park phreatophytic vegetation criteria bores. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • No change to increased vegetation density 1988-2000. *WRC-WIN (2003)* • (61611042)-. Declining trend in groundwater levles since 1997.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora. Bush Forever Site.	• Groundwater level decline.
L30C Vegetation Corridor phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • Decreased to significantly decreased vegetation density 1988-2000. *WRC-WIN (2003)* • (61611010) – Declining trend in groundwater levles since 1997	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora. Bush Forever Site.	• Groundwater level decline.
L110C Vegetation Corridor phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • Decreased to significantly decreased vegetation density 1988-2000. *WRC-WIN (2003)* • (61611011) – Declining trend in groundwater levles since 1997.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to (6-10m). New • Reserve supports declared rare flora. Bush Forever Site.	• Groundwater level decline.
L220C - Vegetation Corridor phreatophytic vegetation criteria bore. Melaleuca Park and adjacent bushland.	*CSIRO (2001)* • Decrease in vegetation density north and west of bore, increase to south and east 1988-2000. *WRC-WIN (2003)* • (61611018) - Declining trend in groundwater levles since 1997.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation. • *Banksia* woodland <8m depth to groundwater (3-6m). New • Reserve supports declared rare flora.	•

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
		Bush Forever Site.	
Ellenbrook Bushland Maralla Road bushland.	*CSIRO (2001)* • 1988-2000 vegetation density significantly increased in west grading to significant decrease in east. *Mattiske Consulting Pty Ltd (2003)* • Slight increase in number of healthy *M. preissiana* stems on Bell transect since 1999. • Decrease in number of healthy *B. ilicifolia* stems since 1999. • Significant increase in abundance of *A. fascicularis* since 1999. *Mattiske Consulting Pty Ltd (2000)* • Decrease in number of healthy *M. preissiana*, *B. attenuata*, *B. menziessi* and *B. ilicifolia* stems on Maralla transect 1996-2000. • Decrease in abundance of *P. ellipticum* 1996-2000. • Increase in abundance of *A. fascicularis* 1996-2000.	Retained Bell and Maralla transects • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. New • Bush Forever Site.	• Groundwater level decline and impacts of near-by urban development.
MM12 Vegetation Corridor phreatophytic vegetation criteria bore. Wetherall Rd bushland, Lexia.	*CSIRO (2001)* • Vegetation density increased or increased significantly 1988-2000.	Retained • Selected to represent water levels over area of undisturbed phreatophtyic vegetation • *Banksia* woodland <8m depth to groundwater (3-6m). New • Bush Forever Site	• Groundwater level decline
Jandakot			
Herdsman Complex			
JE17C Rare flora criteria bore. Thomsons Lake Nature reserve and adjacent bushland.	*Mattiske Consulting Pty Ltd (2001)* • Decline in number of healthy *B. littoralis* and *B. ilicifolia* stems on terrestrial Thomsons Lake vegetation monitoring transect since 1988. • Significant decline in number of healthy *E. rudis* stems since 1994. • Significant decline in number of healthy *M. preissiana* and *M. rhaphiophylla* stems since 1988. • Increase in number of stressed *B. attenuata* and *B. menziesii* stems since 1988. • Decline in abundance of wetland shrub species since 1988. • Decline in soil moisture since 1988. *WA Herbarium (2004)* • No current record of DRF in vicinity. *Loomes and Bertuch (2004)* • *E. rudis* in vicnity impacted by insects, *M. preissiana* dense. Exotics dominant in understorey. *WRC-WIN (2003)* • (61410705) increasing trend in groundwater levels since 1992.	Retained Thomsons Lake transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. Changed • Established to monitor rare orchid species in vicinity – no current record of species in area. New • Reserve supports priority flora. • Bush Forever Site. • *E. rudis/M. preissiana* woodland occurring in area of <5m to groundwater (0-3m).	• Altered hydrology, weed invasion and clearing for urban development.
JM24 phreatophytic vegetation monitoring bore. Private property.	*Loomes and Bertuch (2004)* • Only small area of intact *Banksia* woodland remains due to clearing. *Western Australian Planning Commission (2003)* • Area to be developed for urban land use. *WRC-WIN (2003)* • (61410193) Increasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of < 5m to groundwater (3-6m) – area significantly reduced through clearing and marked for urban development.	• Clearing for urban development.
Bassendean Central and South Complex			
JE10C Phreatophytic vegetation criteria	*Loomes and Bertuch (2004)* • Recent decline in health of *Banksia* woodland on private property bore.	Changed • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – impacted by	• Altered hydrology, land-use and weed invasion.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
bore. Private property.	*WRC-WIN (2003)* • (61410250) increasing trend in groundwater levels since 1992.	proximity to semi-rural properties and/or vegetation decline.	
JM31 Phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • Vegetation on private property near bore heavily modified, adjacent bushland impacted. *WRC-WIN (2003)* • (61610334) decreasing trend in groundwater levels since 1992.	Changed • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – impacted by proximity to semi-rural properties and/or vegetation decline.	• Altered hydrology, land-use and weed invasion.
JM35 Phreatophytic vegetation criteria bore. Denis de Young Reserve and Gibbs Rd Swamp.	*Loomes and Bertuch (2004)* • Recent decline in health of remnant *Banskia* woodland. *WRC-WIN (2003)* • (61610333) increasing trend in groundwater since 1992.	Changed • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – vegetation condition impacted.	• Altered hydrology, land-use and weed invasion.
JE4C Aquifer evaluation bore. Denis de Young Reserve and Gibbs Rd Swamp.	*Mattiske Consulting Pty Ltd (2001)* • Loss of *B. littoralis* from Liddelow terrestrial vegetation transect since 1981. • Decline in number of healthy *M. preissiana* and *B. ilicifolia* stems since 1988. • Decline in number of healthy *B. attenuata* and *B. menziesii* stems since 1994. • Decline in number of healthy *M. rhaphiophylla* stems since 1997. • Soil moisture levels decreased since 1988. *Loomes and Bertuch (2004)* • *Melaleuca* woodland in good condition. *WRC – WIN (2003)* • (61610234)- declining trend in groundwater levels since 1992.	Retained • Aquifer evaluation bore (3-6m to groundwater). Liddelow transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. New • Bush Forever Site. • Bushland supports priority flora. • *Meleuca* woodland occurring in area of less than 5m to groundwater (3-6m).	• Altered hydrology, land-use and weed invasion.
JM29 Phreatophytic vegetation criteria bore.	*Mattiske Consulting P/L (2001)* • No evidence of decline in vegetation condition. • Located in area largely cleared for semi-rural activities. *WRC (2003)* • No recent signs of stress in *E. rudis*, *M. rhaphiophylla* and *M. preissiana* near bore. *Western Australian Planning Commission (2003)* • Area to be developed for urban land use. *Loomes and Bertuch (2004)* • Bore on private property opposite area of cleared urban land adjacent to *M. preissiana/E. rudis* woodland. *WRC – WIN (2003)* • (61410237) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – woodland largely cleared and marked for future urban development.	• Clearing, land-use, altered hydrology and weed invasion.
JM7 Rare flora criteria bore. Jandakot Airport.	*WRC (2003)* • Physiological stress noted in overstorey of large *E. rudis* and *M. preissiana* in vicinity. • Recent deaths and varied condition of *B. ilicifolia* and *B. attenuata*. *WA Herbarium (2004)* • No current record of DRF in vicinity. *Loomes and Bertuch (2004)* • *E. rudis* and *M. preissiana* impacted by groundwater level decline and insect attack. *WRC – WIN (2003)* • (61610180) decreasing trend in groundwater levels since 1992.	Lost • Established to monitor rare orchid habitat – no current record of species in vicinity. New • Bush Forever Site. • Area supports non-aquatic fauna. • *M. preissiana/E. rudis* woodland occurring in area of leass than 5m to groundwater (3-6m).	• Altered hydrology and weed invasion.
JM8 Rare flora criteria bore. Jandakot Airport.	*WRC (2003)* • Physiological stress noted in overstorey of large *E. rudis* and *M. preissiana* in vicinity. *WA Herbarium (2004)* • DRF recorded in vicinity. *WRC-WIN (2003)*	Retained • Established to monitor rare orchid habitat. • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m). New	• Altered hydrology, land-use and weed invasion.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	(61610248) decreasing trend in groundwater levels since 1992.	• Bush Forever Site. • Area supports non-aquatic fauna.	
JM45 Rare flora criteria bore. Jandakot Airport.	*WRC (2003)* • *B. ilicifolia, M. preissiana* and *E. rudis* near bore showing symptoms of drought stress. *Loomes and Bertuch (2004)* Evidence of drying in *M. preissiana, E. rudis* and *B. attenuata*. *WA Herbarium (2004)* • No current record of DRF in vicinity of bore. *WRC-WIN (2003)* (61610179) decreasing trend in groundwater levels since 1992.	Lost • Established to monitor rare orchid habitat – no current record of species in vicinity. New • Mixed *Banksia/ E. rudis/ M. preissiana* woodland (impacted) at 3-6m to groundwater.	• Altered hydrology, land-use and weed invasion.
8284 Phreatophytic vegetation criteria bore.	*Loomes and Bertuch (2004)* • On private property however *Banksia* woodland to north in good condition. *WRC – WIN (2003)* • (61610178) - decreasing trend in groundwater levels since 1992.	Retained • Mixed *Banksia/ E. rudis/ M. preissiana* woodland occurring in area of less than 5m to groundwater (3-6m).	• Altered hydrology, land-use and weed invasion.
JM49 Phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • *B. littoralis/ M. preissiana* woodland, weedy understorey on private property opposite private land 100m west of intact *Banksia* woodland. *WRC – WIN (2003)* • (61410111) decreasing trend in groundwater levels since 1992.	Changed • *Banksia/Melaleuca* woodland occurring in area of less than 5m to groundwater (3-6m) – impacted by semi-rural land-use.	• Altered hydrology, land-use and weed invasion.
JM39 Phreatophytic vegetation criteria bore. Private property	*Loomes and Bertuch (2004)* • On private property in vicinity of intact *Melaleuca* woodland. *WRC – WIN (2003)* • (61410142) decreasing trend in groundwater levels since 1992.	Retained • *Banksia/Melaleuca* woodland occurring in area of less than 5m to groundwater (3-6m).	•
JE12C Aquifer evaluation bore. Private property	*Loomes and Bertuch (2004)* • Intact healthy *Banksia / Eucalyptus* on private property opposite developed semi-rural land 500m west of intact *Banksia* woodland. *WRC – WIN (2003)* • (61410103) decreasing trend in groundwater levels since 1992.	Lost • Aquifer evaluation bore (water level 10m+) – marked for future urban development.	• Altered hydrology, land-use, future urban development and weed invasion.
JM33 - Phreatophytic vegetation criteria bore. Unreserved bushland Lyon Rd, Banjup	*Loomes and Bertuch (2004)* • Large area of intact *Banksia / Casuarina* woodland opposite newly cleared urban land. *Western Australian Planning Commission (2003)* • Area to be developed for urban land use. *WRC – WIN (2003)* • (61410211) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater – decreased to greater than 5m (6-10m). Area to be developed for future urban land use.	• Altered hydrology, urban development and weed invasion.
JE23C - Phreatophytic vegetation criteria bore. Unreserved bushland Gaebler Rd, Banjup.	*Loomes and Bertuch (2004)* • Area largely cleared for urban development. *Western Australian Planning Commission (2003)* • Area to be developed for urban land use. *WRC – WIN (2003)* • (61419712) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – area to be developed for future urban land use.	• Land-use change.
JE20C Phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • Intact *Melaleuca/Banksia* woodland on private property opoosite cut-flower farm. *Western Australian Planning Commission (2003)* • Area to be developed for urban land use. *WRC – WIN (2003)* • (61419706) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – impacted by semi-rural land-use and to be developed for future urban land-use.	• Altered hydrology, land-use and weed invasion.
J310 Rare flora bore.	*WA Herbarium (2004)* • No current record of DRF in vicinity of bore. *Loomes and Bertuch (2004)*	Lost • Established to monitor rare orchid habitat – no current record of species in area. Bushland totally cleared for industrial development.	• Land-use change.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
Jandakot industrial area.	• Area has been cleared and developed as industrial land. *WRC – WIN (2003)* • (61410232) decreasing trend in groundwater levels since 1992.		
JM18 Phreatophytic vegetation criteria bore. Industrial area.	*Loomes and Bertuch (2004)* • Area cleared for industrial development. *WRC – WIN (2003)* • (61410239) decreasing trend in groundwater levels since 1992.	Lost *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) – area cleared for industrial development.	• Land-use change.
JE1B Aquifer evaluation bore. Private property	*Loomes and Bertuch (2004)* • Area impacted by clearing for sand mine and semi-rural land use. *WRC – WIN (2003)* • (61410243) decreasing trend in groundwater levels since 1992.	Lost • Aquifer evaluation bore (water level 10m+) – area impacted by clearing for sand mine and semi-rural land use.	• Land-use change.
JE18C phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • Located on semi-rural property opposite reticulated parkland. *WRC – WIN (2003)* • (61419704) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m) - area now cleared for semi-rural use opposite reticulated parkland.	• Land-use change.
Cottesloe Central & South Complex			
JM16- Phreatophytic vegetation criteria bore. Harrisdale Swamp and adjacent Bushland.	*Loomes and Bertuch (2004)* • Intact *B. attenauta / B. menziesii* woodland. *WRC – WIN (2003)* • (61610445) decreasing trend in groundwater levels since 1992.	Retained • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m). New • Bush Forever Site. • Area supports non-aquatic fauna. • Bushland supports declared rare flora.	• Altered hydrology and weed invasion.
Southern River Complex			
JM14 Phreatophytic vegetation criteria bore. Acourt Rd Bushland.	*Mattiske Consulting Pty Ltd (2001)* • Decline in number healthy *M. preissiana* and *B. menziesii* stems at Airport terrestrial monitoring transect since 1988. • Significant decline in number of healthy *B. ilicifolia* stems since 1988. • Decline in number of healthy *B. attenuata* stems since 1994. • Gradual decline in soil moisture since 1988. *Loomes and Bertuch (2004)* • Evidence of impact, recent deaths of *B. attenuata*, older deaths of *B. ilicifolia*, *B. attenuata* and *B. menziesii*, drying of *B. elegans* in understorey. *WRC – WIN (2003)* • (616102247) decreasing trend in groundwater levels since 1992.	Retained • *Banksia* woodland occurring in area of less than 5m to groundwater (3-6m). Airport transect • Representative of terrestrial vegetation in the area with respect to; – Vegetation structure – Vegetation composition – Fauna habitat. New • Bush Forever Site. • Bushland supports priority flora.	• Altered hydrology and weed invasion.
JM15 Phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • Area has been cleared for semi-rural land use. *WRC – WIN (2003)* • (61610345) decreasing trend in groundwater levels since 1992.	Lost • Area has been cleared for semi-rural land use.	• Land-use change.
JM19 Phreatophytic vegetation criteria bore. Fraser Rd bushland.	*Loomes and Bertuch (2004)* • Area largely cleared for sand-mine. *WRC (2003)* • Water levels strongly influenced by groundwater pumping at nearby mine, but no evidence of water stress in *B. ilicifolia* or *M. preissiana.*	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater – area largely cleared for sand mine and groundwater level now 6-10m.	• Altered hydrology and land-use change.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	WRC – WIN (2003) • (61610177) decreasing trend in groundwater levels since 1992.		
Karrakatta Central and South Complex			
JM27 Phreatophytic vegetation criteria bore. Private property.	*Loomes and Bertuch (2004)* • Area largely cleared for rural use. Only 20m strip of vegetation on one side of road. *WRC – WIN (2003)* • (61610335) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater – area largely cleared and groundwater level now 6-10m.	• Land-use change and altered hydrology.
JM5 Phreatophytic vegetation criteria bore.	*Loomes and Bertuch (2004)* • Bore located in school yard in urban area. *WRC – WIN (2003)* • (61610354) decreasing trend in groundwater levels since 1992.	Lost • *Banksia* woodland occurring in area of less than 5m to groundwater (0-3m) – area has been cleared for urban development.	• Land-use change.
AQUIFER AND CAVE ECOSYSTEMS			
Yanchep Caves			
Crystal Cave (YN1)	*Bastian (2003)* • Known to have permanent stream since discovery in 1942, now dry. • Current hydrological condition - dry	Changed • Site contains a permanent stream and root mats – stream has dried.	• Groundwater level decline.
Water Cave (YN11)	*Bastian (2003)* • Has permanent deep water, but has been steadily shallowing since mid 1990s. • Current hydrological condition – diminished. *Knott and Storey (2003)* • No species recorded Sept 2001, 4 in Sept. 2002.	Changed • Site contains a permanent stream and root mats – stream flow has decreased. New • Threatened Ecological Community – CAVES SCP01 (WATER01).	• Groundwater level decline.
Carpark Cave (YN18)	*Bastian (2003)* • Permanent stream as recently as January 1991, now dry most of year. • Current hydrological condition – seasonal. *Knott and Storey (2003)* • 1 invertebrate species recorded Sept 2001, 10 in spring 2002.	Changed • Site contains a permanent stream and root mats – stream is no longer permanent. New • Threatened Ecological Community - CAVES SCP01 (CARPK01).	• Groundwater level decline.
Gilgie Cave (YN27)	*WRC (1999)* • Unique fauna of cave lost due to drying of cave streams in 1996. • Monitoring no longer undertaken. *Bastian (2003)* • Strong permanent stream until 1990's, dried out and never came back. • Current hydrological condition – dry. *Knott and Storey (2003)* • Not monitored in spring 2002 (dry).	Changed • Site contains a permanent stream and root mats – stream has dried. • Threatened Ecological Community - CAVES SCP01 (GILGIE01) – may have been lost.	• Groundwater level decline.
Cabaret Cave (YN30)	*Bastian (2003)* • Strong permanent stream until mid 1990's, now dry. • Current hydrological condition – dry. *Knott and Storey (2003)* • 4 species of invertebrate recorded in Sept 2001, 0 in spring 2002. • Water table 5-10cm below surface in Jan. 2002.	Changed • Site contains a permanent stream and root mats – stream has dried. • Threatened Ecological Community - CAVES SCP01 (CABAR01) – may have been lost.	• Groundwater level decline.
Boomerang Cave (YN99)	*Bastian (2003)* • Was permanent now dry most of year. • Current hydrological condition – dry. *Knott and Storey (2003)* • No invertebrate species recorded in Sept. 2001, 4 species recorded in Sept. 2002.	Changed • Site contains a permanent stream and root mats – stream has dried. • Threatened Ecological Community - CAVES SCP01 (YN99) – may have been lost	• Groundwater level decline.
Twilight Cave (YN194)	*Bastian (2003)*	Changed	• Groundwater level decline.

Sub-group / GDE	Changes in ecological condition	Revised ecological values	Risks to ecological values
	• Stream ran strongly all-year-round until 1990's. • Current hydrological condition – diminished. *Knott and Storey (2003)* • No invertebrate species recorded in Sept. 2001. • Not monitored in spring 2002 as unsafe to enter.	• Site contains a permanent stream and root mats – stream flow has decreased. New • Threatened Ecological Community - CAVES SCP01 (TWILHT01).	

1a.2. Identification of the ecological values of GDEs in the wider study area that were not considered in 1995, 1997 and 1991/92 but are now appropriate to define.

The assessment by members of the core technical group covers all parts of the study areas not covered by the previous reviews. Specifically the Gnangara Mound north and north-east of Yanchep including Tick Flat, Ridges and the Yeal Nature Reserve, areas now known to support extensive areas of phreatophtyic vegetation, wetlands, base-flow systems and cave systems. Near-shore marine systems were also not considered in earlier reports however, it is now known that these systems are potentially groundwater dependent (Sinclair Knight Mertz, 2001). The assessment also considers previously unrecognised or poorly described wetlands and areas of phreatophytic vegetation across both the Gnangara and Jandakot Mounds.

The approach taken here is similar to that adopted by Froend, Loomes and Zencich (2002) for the identification of GDE values in the "Drought Response Strategy". In this approach wetland and vegetation maps are overlaid with depth to groundwater contours to identify potential GDEs. As mapping provided for the Gnangara Mound at the time of the assessment was of insufficient scale, contours provided by the Water Corporation for the 2002 Drought Response Strategy were used for this area. Ecological values of identified GDEs are assessed through comparison of a GDE's current status with existing conservation values. As there is a paucity of information on the status and values of the vast majority of previously unrecognised GDEs, many are described only in generic terms.

Wetlands and Mound Springs

More than 600 wetlands occur across the Gnangara Mound, the majority of which have only been previously described by Hill *et al*. (1996). A far smaller number of wetlands occur across the Jandakot, due to the smaller area and degree of urban and rural development. These too are largely undescribed.

Due to the paucity of information on the majority of these wetlands, only those of high ecological value or for which there is some available data will be described in this section. However, the values of all Conservation Category (Hill *et. al.,* 1996) 'previously unidentified' wetlands are presented in Table 6.

Gnangara Mound Wetlands

– Carabooda Lake

Carabooda Lake is actually a sumpland, located in the Neerabup Lake and Adjacent Bushland (Bush Forever Site no. 384) within the Herdsman Vegetation Complex. Although the vegetation of this large resource enhancement category wetland (R) has been highly modified by rural land-use practices, it is still regarded as a key faunal habitat area (Bamford and Bamford, 2003) and supports rich macroinvertebrate fauna. Carabooda Lake is also an EPP wetland (Hill *et al.,* 1996).

– Lake Neerabup

Lake Neerabup is located on private property to the east of Neerabup National Park, within the Herdsman Vegetation Complex. It is classified as a Resource Category wetland (R) and is also listed as an EPP wetland (Hill *et al*, 1996). *Typha orientalis* dominates the lake bed with *M. rhaphiophylla* occurring on the fringes (Froend *et al*., 2002). Despite drying of the wetland in recent years and the impacts of surrounding rural land-use practices, Lake Neerabup is still regarded as a key faunal habitat (Bamford and Bamford, 2003).

– Lake Gwelup

Located in the Lake Gwelup Reserve (Bush Forever Site no. 212) within the Herdsman Vegetation Complex, Lake Gwelup is recognised as System 6 wetland (S), identified as regionally significant (W) and listed as a Conservation Category (C) and EPP wetland (Hill *et al.,* 1996). Despite long-term impacts from rural land-use practices and more recent urban development, the lake supports significant bird species and is regarded as key faunal habitat (Bamford and Bamford, 2003).

– Big Carine Swamp

This wetland is located in remnant vegetation and parkland within the Herdsman Vegetation Complex. Big Carine Swamp is recognised as System 6 wetland (S), identified as regionally significant (W), described as an outstanding wetland recognised in other regional studies (O) and is listed as a Conservation Category (C) and EPP wetland (Hill *et al.,* 1996). Despite the impacts of urban development, Big Carine Swamp is regarded as key faunal habitat (Bamford and Bamford, 2003).

– Lake Pinjar

This wetland is located in the Lake Pinjar and Adjacent Bushland (Bush Forever Site no. 382) within the Pinjar Vegetation Complex. The vegetation in some uncleared parts of the wetland has been identified as one of the remaining examples of this vegetation complex and is considered to have a significant conservation value. Lake Pinjar is a large highly modified sumpland, the majority of which has been sub-divided into narrow east-west orientated lots for use in agriculture and horticulture (Froend, *et al*., 2002). This has resulted in some areas of the being wetland classified as Conservation Category (C) and others as Management Category (M). Lake Pinjar is recognised as System 6 wetland (S), identified as regionally significant (W), described as an outstanding wetland recognised in other regional studies (O) and is listed as an EPP wetland (Hill *et al.,* 1996).

– Little Emu Swamp

This Conservation Category (C) wetland is located in the Koondoola Regional Bushland (Bush Forever Site no, 202) within the Karrakatta Central and South Complex. The wetland basin has been severely disturbed

by BMX tracks, walk trials and fire (Zencich and Froend, 2002). Run-off from storm-water drains has also lead to extensive weed invasion of the basin. The surrounding area supports significant flora and fauna species.

– Ridges

This is a Conservation Category (C) wetland located in Ridges and Adjacent Bushland (Bush Forever Site no. 381) within the Cottesloe Central and South Vegetation Complex. The area supports a Threatened Ecological Community – 'deeper seasonal wetlands on sandy soils' (YAN21). Ridges was selected as representative of terrestrial vegetation with respect to structure, composition and faunal habitat and a permanent monitoring transect was established there in 1996 (Froend *et al.,* 2002). The bushland supports significant flora, birds and mammals.

– Yeal Swamp

This dampland is located in the Yeal Nature Reserve within the Bassendean North Vegetation Complex. Yeal Swamp was selected as representative of terrestrial vegetation with respect to structure, composition and faunal habitat and a permanent monitoring transect was established there in 1987 (Froend *et al.,* 2002). Despite recent declines in overstorey condition and mining of diatomaceous soils, Yeal Swamp is regarded as a key faunal habitat area. The wetland is recognised as System 6 wetland (S), identified as regionally significant (W) and is listed as Conservation Category (C) wetland (Hill *et al.,* 1996).

– Bindiar Lake

Bindiar Lake is also located in the Yeal Nature Reserve within the Bassendean North Vegetation Complex. The wetland is recognised as System 6 wetland (S), identified as regionally significant (W) and is listed as Conservation Category (C) wetland (Hill *et al.,* 1996). There is evidence of declining vegetation health at this site (Froend *et al*., 2002).

– Dampland 38488651846

This wetland is located in the south-east corner of the Yeal Nature Reserve east of pine plantations. The area is relatively undisturbed and supports intact healthy vegetation (Froend *et al.,* 2002). The wetland is listed on the Register of the National Estate (A), recognised as System 6 wetland (S), identified as regionally significant (W) and is listed as Conservation Category (C) wetland (Hill *et al.,* 1996).

– Sumpland 38551652525

This Conservation Category wetland (C) is located to the immediate east of Quin Brook in the Bassendean North Vegetation Complex. Although there is no current record of the ecological condition of this site, it supports rare or priority flora and a Threatened Ecological Community – deeper seasonal wetlands on

sandy soils (MILT05). It is also listed as a System 6 wetland (S) and identified as regionally significant (W).

– Tangletoe Swamp

This dampland is located south of Gingin Brook within the Bassendean North Vegetation Complex. Tangeltoe Swamp was selected as representative of terrestrial vegetation with respect to structure, composition and faunal habitat and a permanent monitoring transect was established there in 1987 (Froend *et al.,* 2002). Davis *et al.* (1991) described the wetland as relatively pristine with high Odonata and Coleoptera species richness. Although there is no current record of the ecological condition of this site, it should be regarded as representative of vegetation of the area and to support high macroinvertebrate species richness.

– Deepwater Lagoon

Deepwater Lagoon is a permanent wetland located to the west of the Wanneroo Branch of Gingin Brook within the Bassendean North Vegetation Complex. Although this lake is managed as a Resource Category wetland (R) it is also an EPP wetland (Hill *et al*., 1996) and has been described as key faunal habitat (Bamford and Bamford, 2003).

– Tick Flat

Tick Flat is located north-east of Yanchep National Park within the Bassendean North Vegetation Complex. This Conservation Category (C) dampland is also recognized as regionally significant (W) (Hill *et al*., 1996). A vegetation monitoring transect was established at Tick Flat in 1966 to asses the use of native species as indicators of areas suitable for pine plantations (Groom *et al*., 2000). Following the commencement of groundwater abstraction, the transect was resurveyed in 1976 and has subsequently been monitored on a tri-annual basis.

It is believed that Tick Flat formerly experienced much wetter conditions, but has filled with sand from adjacent Spearwood Dunes and is undergoing terrestrialisation (Mattiske and Associates, 1988). This drying is evidenced by the declining health and condition of overstorey and understorey species (Froend *et al.,* 2002). Despite declining ecological condition, Tick Flat retains its value as representative of terrestrial vegetation with respect to structure, composition and faunal habitat. Tick Flat also supports rare or priority flora.

– Lake Muckenburra

This Conservation Category wetland (C) is located to the north-east of the Wanneroo Branch of the Gingin Brook in the Bassendean North Vegetation Complex. Lake Muckenburra is a System 6 wetland (S) and supports a Threatened Ecological Community – herb rich saline shrublands in claypans (MUCK02).

– Lexia Wetlands 104, 156, 158 and 164 (39865648704, 40027648820, 40017648872, 40061648909)

These dampland and sumplands, in and adjacent to the Gnangara Pine Plantation, are recognized as Conservation Category wetlands (Hill *et al*., 1996). However, all are intensively monitored to detect any loss of vegetation values under a wetland mitigation strategy (Froend and Loomes, 2002). There has been notable decline in vegetation condition at Lexia 104 and 164 and little impact at 156 and 158.

– Other wetlands in the Bassendean North Vegetation North Complex (Neaves and Lexia)

These areas support a great number of un-named, largely undescribed wetlands some of which have been recognized as being of high conservation value (see Table 6).

– Spring at the Maze

The Maze spring north west of Bullsbrook, also refereed to as Kings Spring after the owner who sold the property to CALM, is now in the Neaves Road Nature Reserve. It was listed as a Threatened Ecological Community (KING01) in 1995 based on vegetation which is dependent on permanent freshwater water from the spring. The community was listed as Critically Endangered. CALM established a Recovery Team in 1996, and a Recovery Plan was declared by Commonwealth Govt under the EPBC act in 2001. Current status of community is unknown as there are no recent monitoring data.

– Bambun Lake

Bambun Lake is situated south-west of Gingin in the Yanga Vegetation Complex. It forms part of Reserves C24257 and 22831 managed for conservation of flora and fauna. Bambun Lake is listed as a System 6 wetland (S), identified as regionally significant (W), described as an outstanding wetland recognised in other regional studies (O) and is a Conservation Category (C) and EPP wetland (Hill *et al.*, 1996).

The wetland supports populations of Western Minnow (*Galaxias occidentalis*), Nightfish (*Bostockia porosa*), Swan River Goby (*Pseudogobius olorum*) and Mosquitofish (*Gambsia holbrooki*) and is also important for waterbird use (Bamford and Bamford, 2003). Bambun Lake also supports rare or priority flora and two types of Threatened Ecological Community – herb rich saline shrublands in claypans (BAMBUN 01 and 03) and forests and woodlands of deep seasonal wetlands of the SCP (BAMBUN 02). There is no record of the current condition of Lake Bambun however, it should be considered to retain high ecological values.

– Lake Nambung and Lake Mungala

These Conservation Category (C) wetlands are situated south of Bambun Lake in the Yanga Vegetation Complex. They form part of Reserve C24257, managed for conservation of flora and fauna. Both lakes are listed as System 6 wetlands (S), identified as regionally significant (W), described as outstanding wetlands

recognised in other regional studies (O) and are EPP wetlands (Hill *et al.*, 1996). The lakes are recognized as key faunal habitat (Bamford and Bamford, 2003) with Lake Mungala also important for waterbird use.

– Mound Spring sites 3s, 3b, 3r, 4, 5ps, 5s, 5pd, 5d, 6 and 7

Spring 5s on Lot 11 Archibald St supports a Threatened Ecological Community – organic mound springs (PETERS01) based on vegetation and invertebrate fauna, and is now in a CALM Nature Reserve. The spring went dry in summer 1999/2000. Current status of fauna is unknown as the spring is not monitored.

Of the other springs sampled by Jasinska and Knott (1994) none were selected for monitoring, conservation or setting of EWRs, even though they contained restricted invertebrate fauna including 53 taxa endemic to these sites. These sites have not been sampled/monitored since Jasinska & Knott (1994). Therefore, current status is unknown.

Jandakot Mound Wetlands

– Mather Reserve

Mather Reserve (Bush Forever Site no. 263) is located within the Bassendean Central and South Vegetation Complex. The Reserve has a fringing vegetation of large *Melaleuca* and supports a *Melaleuca* thicket and small areas of native sedges (WAWA, 1992). Although the immediate boundary is highly modified and the area has supported agricultural activities in the past, the wetland has been used as a feeding area for waterbirds. The wetland was included in the 'Directory of Important Wetlands in Australia' (N), recognised as an outstanding wetland in other regional studies (O) and is a Conservation Category (C) and EPP wetland (Hill et al., 1996). As there is no record of the current condition of the wetland, it is assumed these ecological values persist.

– Copolup Lake

This wetland is located to the immediate east of the Thomsons Lake Reserve within the Bassendean Central and South Vegetation Complex. Copolup Lake is a Resource Category (R) and EPP wetland (Hill et al., 1996). Little other information is available for this wetland other than its importance for waterbird breeding (WAWA, 1992). As there is no record of the current condition of the wetland, it is assumed this ecological value persists.

– Branch St Swamp

Branch St. Swamp is located in a semi-cleared area also to the immediate east of the Thomsons Lake Reserve within the Bassendean Central and South Vegetation Complex. This wetland has low potential for waterbird use due to its shallow nature and short period of inundation (WAWA, 1992). It may be used as a feeding area for secretive species of waterbird for short periods during winter. There may also be some breeding potential for species whose young leave the nest soon after hatching. Branch St Swamp is a

Conservation Category (C) and EPP wetland (Hill et al., 1996). As there is no record of the current condition of the wetland, it is assumed these ecological values persist.

– Forest-Trapper Swamp

This wetland is located to the north-east Thomsons Lake in the Bassendean Central and South Vegetation Complex. Forest-Trapper Swamp is a Resource Enhancement Category (R) and EPP wetland (Hill et al., 1996). Although the immediate area is highly modified, the wetland was described as of high importance for waterbird breeding (WAWA, 1992). As there is no record of the current condition of the wetland, it is assumed this ecological value persists.

– Solomon Rd Swamp

Solomon Rd Swamp is located to the immediate west of Forest-Trapper Swamp in an urban development. It is a Resource Enhancement Category (R) and EPP wetland (Hill et al., 1996). Although the wetland was previously described as completely vegetated with a mosaic of community types (WAWA, 1992), the degree of clearing in the area has probably reduced this value along with the value of the site as a refuge and breeding area for non-aquatic vertebrates.

– Mandogalup (Wattelup) Lake

Mandogalup Lake is located in a largely cleared area to the south of Lake Banganup within the Bassendean Central and South Vegetation Complex. It is a System 6 (S), Conservation Category (C) and EPP wetland (Hill *et al*., 1996). Mandogalup Lake was described as a waterbird breeding and summer loafing area (WAWA, 1992) and of high conservation value due to its uniqueness (Davis *et al.*, 1993). As there is no record of the current condition of the wetland, it is assumed these ecological values persist.

– Little Rush Lake

Little Rush Lake is located to the immediate north of Yangebup Lake within the Herdsman Vegetation Complex. The wetland is listed as a System 6 wetland (S), identified as regionally significant (W), and is a Conservation Category (C) and EPP wetland (Hill *et al.*, 1996). There is no further record of ecological values or condition of Little Rush Lake.

– Spectacles North

The Spectacles is a Bush Forever Site (no. 269) south of Lake Banganup within the Herdsman Vegetation Complex. The wetland was included in the 'Directory of Important Wetlands in Australia' (N), recognised as an outstanding wetland in other regional studies (O), identified as regionally significant (W), and is a Conservation Category (C) and EPP wetland (Hill *et al*., 1996). The vegetation of the wetland was described as representative of closed *Melaleuca* woodland, while the wetland itself provided a range of habitat types and is a waterbird breeding site (WAWA, 1992). Although the destruction of fringing

vegetation was recorded a decade ago (Davis *et al.*, 1993), the current condition of the wetland is unknown. Therefore, in the absence of data to the contrary, the Spectacles should be considered to retain these ecological values.

– East Swamp

East Swamp is located in the North Lake and Bibra Lake Reserve (Bush Forever Site no. 244) within the Herdsman Vegetation Complex. East Swamp is recognised as an outstanding wetland in other regional studies (O), identified as regionally significant (W), and is a Conservation Category (C) and EPP wetland (Hill et al., 1996). WAWA (1992) described the wetland as habitat for non-avian fauna. In the absence of data to the contrary, East Swamp should be considered to retain this ecological value.

– Hope Road Wetland

Hope Road Wetland is also located in the North Lake and Bibra Lake Reserve (Bush Forever Site no. 244) within the Herdsman Vegetation Complex. It is a System 6 (S), Conservation Category (C) and EPP wetland (Hill *et al.*, 1996). The wetland was described as supporting vegetation not represented in nearby wetlands with a relatively undisturbed buffer zone of native vegetation (WAWA, 1992). In the absence of data to the contrary, Hope Road Wetland should be considered to retain this ecological value.

– Harrisdale Swamp

This wetland is located in the Harrisdale Swamp and Adjacent Bushland (Bush Forever Site no. 253) within the Southern River Vegetation Complex. Harrisdale Swamp is recognised as an outstanding wetland in regional studies (O), identified as regionally significant (W), and is a Conservation Category (C) and EPP wetland (Hill *et al.*, 1996). There is no further record of ecological values or the current condition of the wetland.

– Lake Balanup

This wetland is located in the Lake Balanup and Adjacent Bushland (Bush Forever Site no. 413) within the Southern River Vegetation Complex. Lake Balanup is a Resource Enhancement (R) and EPP wetland (Hill *et al.*, 1996). McGuire *et al.* (1993) described the wetland as significant due to high aquatic macroinvertebrate species richness. However, water quality was described as low (saline, eutrophic and high pH) and fringing vegetation had been destroyed. In the absence of data to the contrary, Lake Balanup should be considered to retain high aquatic macroinvertebrate species richness.

Terrestrial Vegetation

During this stage of the project, a large number of areas of phreatophtyic vegetation, not described in early work (Section 46, East Gnangara EWP Plan, etc) were identified. The vast majority of these areas occur within Bush Forever Sites. Due to the large number of sites areas of phreatophytic vegetation will not be

discussed separately. The following is a summary of the values of the most important sites (Refer to Table 6 for further details).

Gnangara Mound

- Wilbinga-Caraban Bushland;
    - Supports threatened ecological communities.
    - Supports declared rare or priority flora.
    - Bush forever site.

- Yanchep National Park and adjacent bushland;
    - Supports threatened ecological communities.
    - Supports declared rare or priority flora.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
    - Bush forever site.

- Ridges and adjacent bushland;
    - Supports threatened ecological communities.
    - Supports declared rare or priority flora.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
    - Bush forever site.

- Neerabup National Park, Lake Nowergup Nature Reserve and adjacent bushland;
    - Supports threatened ecological communities.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
    - Bush forever site.

- Errina Road Bushland, Alexander Heights;
    - Supports threatened ecological communities.
    - Bush forever site.

- Decourcey Way Bushland, Marangaroo
    - Supports threatened ecological communities.
    - Bush forever site.

- Landsdale Road Bushland, Landsdale
    - Supports threatened ecological communities.
    - Bush forever site.

- Koondoola Regional Bushland
    - Supports threatened ecological communities.
    - Bush forever site.

- Wabling Management Priority Area
    - Supports declared rare or priority flora.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

- Yeal Nature Reserve
    - Supports declared rare or priority flora.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

- Kirby Road Bushland, Bullsbrook
    - Supports threatened ecological communities.
    - Bush forever site.

- Muchea Air Weapons Range Bushland
    - Supports declared rare or priority flora.
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
    - Bush Forever Site

- Gnangara Lake and adjacent bushland
    - Supports declared rare or priority flora.
    - Bush Forever Site.

- Yellagonga Regional Park, Wanneroo/Woodvale
    - Supports declared rare or priority flora.
    - Key fauna habitat.
    - Bush Forever Site.

- Cardinal Drive Bushland, Bullsbrook
    - Supports threatened ecological communities.
    - Bush forever site.

- Bullsbrook Nature Reserve and adjacent bushland
    - Supports threatened ecological communities.
    - Bush forever site.

- Twin Swamps Nature Reserve and adjacent bushland, Bullsbrook
    - Supports threatened ecological communities.
    - Supports threatened fauna.
    - Bush forever site.

- Ellenbrook Nature Reserve and adjacent bushland, Upper Swan
    - Supports threatened ecological communities.
    - Supports threatened fauna.
    - Bush forever site.

<u>Jandakot Mound</u>

- North Lake
    - Supports significant flora and fauna species.
    - Supports freshwater sponges.
    - Bush Forever Site.

- Bibra Lake
    - Supports rare or priority flora.
    - Supports significant fauna species.
    - Bush Forever Site.

- The Spectacles
    - Supports significant flora and fauna species.
    - Bush Forever Site.

- Banjup Bushland
    - Supports significant flora and fauna species.
    - Bush Forever Site.

- Modong Nature Reserve and adjacent bushland, Oakford
    - Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
    - Bush Forever Site.

- Harry Waring Marsupial Reserve, Wattleup
    - Supports significant flora and fauna species.
    - Bush Forever Site.

- Yangebup and Little Rush Lakes, Yangebup
    - Supports significant flora and fauna species.
    - Bush Forever Site.

- Forrestdale Lake and adjacent bushland, Forrestdale
    - Supports significant flora and fauna species.
    - Bush Forever Site.

Base-flow Systems

- Gingin Brook

Gingin Brook is located on the northern boundary of the study area largely within the Bassendean North Vegetation Complex. *Nannatherina balstoni* Balston's pygmy perch has been recorded in Gingin Brook in the region of the confluence with Mungala Brook, which joins from the north. Although Morgan *et al*. (2000) searched for this species, it has not been recorded in recent times. It is therefore not known if this northern population is extant. Gingin Brook also supports a high diversity of other native freshwater fish species and is regionally significant for this composition. Species include Freshwater Cobbler (*Tandanus bostocki*), Western Minnow (*Galaxias occidentalis*), Nightfish (*Bostockia porosa*), Western Pygmy perch (*Edelia vittata*), Western hardyhead (*Leptatherina wallacei*), Swan River goby (*Pseudogobius olorum*) and Big-headed goby (*Afurcagobius suppositus*) (Morgan *et al*, 2000).

Gingin Brook has also been described as a coloured wetland of extremely high conservation value given its uniqueness (Davis *et al.,* 1993). Ecological interest stems from high TP and low chlorophyll *a* concentrations and the fact that Odonata or Coleoptera species have not been collected indicating the uniqueness of ecological processes within the wetland (Davis *et al.,* 1993).

A series of four high conservation value wetlands form part of Quin Brook (the Wanneroo Branch of Gingin Brook). A floodplain wetland (38231652928) in the north of the system is listed as System 6 (S), described as an outstanding wetland recognised in other regional studies (O) and is listed a Conservation

Category (C) and EPP wetland (Hill *et al.*, 1996). Mattiske Consulting (2001) described a nearby area of vegetation as "Low forest of *Melaleuca preissiana* over *Hypocalymma angustifolium* and *Baeckea* on a seasonally inundated area". This floodplain wetland flows into a Conservation Category (C) dampland (38385652763) described as System 6 wetland (S), identified as regionally significant (W) and described as an outstanding wetland recognised in other regional studies (O) (Hill *et al.*, 1996). The dampland then empties into a second floodplain wetland (3845652772) also a SWO C and EPP wetland. This floodplain wetland in turn flows into a large lake (38749652539) which, as well as being a SWO C and EPP wetland, is also listed on the Register of the National Estate.

Gingin Brook should therefore be considered to support a high diversity of native freshwater fish species and to have high conservation value to its uniqueness (Table 6).

– Lennards Brook

Lennards Brook occurs beyond the boundary of the study area in the Yanga Vegetation Complex flowing into Bambun Lake from the north. There is little information available on the wetland other than it supports the northern most occurrence of the Mud Minnow (*Galaxiella munda),* a rare fish species with restricted distribution (Morgan *et al*., 2000).

– Ellen Brook

The Ellenbrook creek system also occurs beyond the study area largely within the Yanga Vegetation Complex. The system supports native species of fish which have disappeared from other water bodies in the area (Morgan *et al.*, 2000).

– Bennett Brook

The Bennett Brook system consists of a number of pools and creek linkages including a recently constructed fish ladder. The system flows from Whiteman Park to the Swan River and supports an array of vertebrates, invertebrates and vegetation. Fish species identified include Western Minnow (*Galaxias occidenalis*), Nightfish (*Bostockia porosa*), Western Pgymy Perch (*Edelia vittata*) along with a further 3 native species, 3 introdued and an estuarine species in the lower reaches (Bamford, Morgan and Gill, 1998).

Cave and Aquifer Systems

The following information on caves in the Yanchep area, including those within and adjacent to the Yanchep National Park was supplied by Lex Bastian, a local speleologist of immense experience. Seventy one caves known to contain water at some stage in the past were identified from oral records, journals of the earliest explorers, or from personal records of the condition of the caves when Mr Bastian first visited them. For each cave, the current hydrological condition was documented. This information is detailed in

Appendix 1. For each cave the hydrological condition was summarised as 'unknown' if a cave had not been entered in the last ~ 10 years, 'dry' if it no longer contained water at any time, 'seasonal' if it contained water in winter only, and 'diminished' if it still contained water, but less than previous.

Of the 71 caves, 33 (46.5 %) were now dry, 9 (13%) were seasonal, 13 (18%) were diminished and 16 (23%) had an unknown status. These 'unknown' status caves should be revisited as soon as possible to document their current hydrological regime.

In support of the observed changes to the hydrological regime of the caves, supplementary evidence of the progressive drying-out is regarded as unprecedented in the previous history of these caves: (L. Bastian, pers. comm.).

- Congealing of loose peat sludge. This occurs in deep water situations such as in Jackhammer Cave (YN438) when the sludge, which normally lies below the permanent water surface with a layer of clear water above it, becomes sloughed down by lowering of the water. As the water continues to subside the sludge subsides with it, becoming as a result progressively more congealed until finally it packs firmly. If there is a winter rise the congealed sludge does not re-expand to its former loose state, but can be seen as a congealed peat mass beneath the water. (Formerly the sludge in these lakes was not distinctly visible, e.g. in YN61 in the early 1990's, the sludge could not be seen beneath the water - which merely looked dark and impalpable.)

- New cracking in peat beds. This occurs in shallower ponds, which have begun to dry out altogether with lowering of the water table. New cracking starts off with very large polygonal blocks; with continued drying these large blocks crack progressively into smaller pieces; then the blocks shrink from the sides, edges curl and the cracks broaden into open spaces. A final stage is reached when blocks have become small dried-out chunks, the cracks have now become broad spaces, and the sandy substrate exposed beneath the isolated chunks of dry peat. New cracking, resulting in the creation of very large polygonal blocks, has been observed in YN61, also in the eastern most lake in Mambibby Cave (YN12), and in one shallow lake chamber in YN438. If there is a winter rise in water levels, the congealed and cracked peat does not re-expand, but can be seen submerged with its cracking intact beneath the water.

- A subsidence hole in the spongy floor of YN193 shows that the floor is shrinking. With seasonal water table rises occurring below the floor - but unable to reach (and hence saturate) the surface layer as in former years – this has had an undermining effect on the dried-out surface layer, causing a subsidence.

- A new trickle channel was seen to have formed in the abovementioned shallow lake chamber in YN438. When first discovered (1996) the peat in this pond was loose sludge, but has now congealed and developed the first stage of large polygonal cracking.

The formerly impalpable nature of the sludge in deep lakes and ponds suggests that in former dry periods, e.g. in the early 1900's, they did not suffer drying out. All the evidence points to the caves having been in a stable hydrological condition for thousands of years.

Near Shore Ecosystems

It is known that mixing at the interface of freshwater and seawater produces a large number of food sources and habitat for a diverse range of species. Hatton and Evans (1998) described the majority of near-shore marine habitats as using groundwater opportunistically or to a very limited extent. The potential of seagrass systems and near shore fishereis to be groundwater dependent has become an area of focus for marine ecologists in recent years (J. Griffith, ECU, pers. Comm., 2001). Studies have shown that seagrass composition can be altered following groundwater abstraction and the resulting reduction in freshwater input (Hemminga and Durate, 2000). Groundwater may also provide seagrss in some coastal areas with nutrients (Hatton and Evans, 1998).

The following near-shore marine ecosystems occur along the coastal boundary of the Gnangara Mound study area. Although EWRs will not be identified for these systems, they should be considered in the water allocation process.

Limestone Reefs

Limestone reefs are found throughout the region. The tend to form a fringing, offshore reef system which intercepts swells and wind waves and therefore produces a lower-energy environment within the reef line (often referred to as a lagoon). The reefs are a highly stable substrate and provide a habitat for a wide range of flora and fauna. Consequently, they are valued for their habitat provision, both directly and indirectly, through the creation of lagoons in the lee of the reefs. Some specific values that have been identified are the diverse algal and macroinvertebrate assemblages that occur on the reefs, some specific species know to have all or part of their life-cycle on the reef and the geomorpholoical significance they represent.

1. The provision of food that is facilitated by limestone reefs, come from the macroalgae assemblages that dominate them. Fish and urchins have been found to directly graze on macroalgae as do other invertebrates, such as abalone (Wells and Keesing 1989). The algae that is consumed may either be attached or drift macrophytes.
2. A number of commercially important species inhabit limestone reefs at different phases of their life history. The Western Australian Jewfish (*Glaucosoma. hebraicum*) is found throughout its life history either on the reef or on hard substrate adjacent to these limestone reefs (Hesp et al 2002). Western

Rock lobster (*Panulirus cygnus*) and abalone (*Haliotis roei*) are also valuable species that inhabit limestone reefs off the western coast of Australia (Kendrick 1999).

3. The offshore islands and sub tidal reef system off the W.A. coast are a series of exposed or submerged ancient sand dune. These dunes have undergone metamorphosis to limestone (Tamala limestone) which provides a stable base for the reef ecosystem (Kendrick 1999).
4. McQuillan (unpublished data) exemplifies the diversity of fauna assemblages that can be found on reefs. The examination of sponge assemblages on limestone reefs of Marmion Marine Park (within the geographic context of this report) found a total of 243 sponge species with a mean of 6 species / m2 over the 49.5 m2 of reef sampled. Other studies have noted the extensive macroinvertebrate diversity on the reefs.
5. Studies undertaken as part of the Perth Coastal Waters Study (Lavery, 1993) estimated the nutrient uptake capacity of macroalgal assemblages on the reefs systems and estimated they could remove 2400 t. of dissolved nitrogen per annum for the northern metropolitan waters. In addition, they are the major source of detritus and macroalgal wrack to many part of the study area. Reefs may also influence water clarity in the region through their production of detached macrophyte material that contributes to higher light attenuation of light in the water column, and the removal of particulate material through filter-feeder activity (Lavery, 1993).

Seagrass Meadows

Seagrass meadows occur throughout the region. However, they are poorly studied in comparison with meadows just south of the study area. The dominant meadow-forming species are *Posidonia sinuosa, P.australis,* and *P. coriacea* and the two Amphibolis species *A. Antarctica* and *A. grifithii*. A major research programme was conducted over 1996-2001 on the ecological significance of many of these species on Success and Parmelia Banks, just south of Fremantle. That work attempted to define ecological significance in terms of the main ecological processes seagrasses contribute to, as summarised below:

1. Seagrass possess an intrinsic value as marine angiosperms. They are a unique type of plant able to tolerate saline environment, grow while wholly submerged, anchor against wave action and tidal currents and have the capacity for hydrophilous pollination (King et al 1990).
2. The meadows of seagrass are a major concentration of primary and secondary production. However, there is a considerable degree of variability in the magnitude of these functions among the different species of seagrass. *Amphibolis* and *Posidonia* meadows tend to have relatively high rates of both primary and secondary production whereas meadows of other species, such as *Heterozostera*, may have relatively low values of primary production and secondary production rates similar to organically rich deep but unvegetated sediments. Seagrasses are presumed to be important contributors to the local foodweb, through the input of seagrass detritus rather than direct grazing of the plants. Epiphytic algal material is also know to be a favoured target of grazers within seagrass systems and unpublished work

(Hyndes & Lavery) suggests that exported epiphytic algae may be important in supporting fish production in adjacent unvegetated sandy beaches (Walker et al 1999).

3. Seagrasses differ in their structural attributes. This variation in structure provides diversity in habitats, which are utlised by a variety of fish and invertebrate species. MacArthur and Hyndes (2001) found that certain Odacid fish species, likely influenced by the seagrass and or meadow structure, were restricted to different seagrass assemblages. Seagrasses provide an important habitat for different species at different parts of the life cycle. Western Rock lobster is known to use meadows during it juvenile stages (ref) and different species are known to support distinct fish assemblages.
4. Seagrasses may act as baffles to water movement in the nearshore environment. Depending on the density of seagrasses, it is either the meadow (high density) or the individual plant (low density) that may baffle water movement. The deposition of suspended particles be it sand or invertebrate larvae occur in the lee of either the meadow or the plant depending on the seagrass density (see Butler and Jernakoff 1999). The ability to influence water flow and cause deposition of suspended particles leads a more stable substrate. The rhizome and roots of seagrass plants, which serve to bind the substrate, further enhance substrate stability. (Butler and Jernakoff 1999). Despite these generalized presumed roles for seagrasses, local research has produced no empirical evidence to suggest that seagrasses play a major role in shoreline or seabed stability in the higher energy marine zones typical of the study area.

<u>Wrack (Detached Macrophytes)</u>

1. The study area is typified by large masses of detached macrophytes, referred to as wrack, either submerged or on the beaches. This occurs most dramatically during winter, as storms remove macrophytes from adjacent reefs and transport them to the nearshore, creating a seasonal habitat. This wrack accumulations are highly mobile and can appear and disappear in the space of hours to days.
2. A number of invertebrate species utilise the detached macrophytes for habitat, in particular the amphipod *Allorchestes compressa*, which is restricted to these detached plants. Allochestes is thought to be a significant food source for many species of fish, which will congregate offshore from wrack accumulations. Juveniles from a number of fish species as well as some adults inhabit the wrack as it probably confers protection from larger predatory fish and diving birds (Lenanton et al 1982). Herbivorous invertebrates will directly consume algae contained within the wrack (Robertson and Lucus 1983). In turn, invertebrates such as *Allorchestes compressa* form the major portion of the diet for a number of commercially important species (Lenanton et al 1982).
3. Research in W.A. and in South Africa suggests that much of the wrack material is rapidly broken down and remineralised through bacterial action. It may therefore be an important source of recycling inorganic nitrogen to the nearshore marine waters.
4. There is a common, anecdotal suggestion that large accumulations of wrack may provide a temporary shore stabilising role. These accumulations can, at times, be metres deep and extend into the surf zone, helping to absorb incoming wave energy. There is no empirical quantification of the significance of this role.

Un-vegetated Sand

This is a poorly studied marine ecosystem, but a very common one. A number of recent studies have begun to highlight the potential values of the habitat. These fall into two main categories of value – those which the habitat holds and those derived from the potential of the unvegetated habitat to become vegetated.

- Whilst not vegetated by macro algae or seagrass, primary production does occur on sandy habitats through benthic micro algae (Macini, 1990).
- Nearshore bare sand habitats are important nursery habitats for juveniles of species belonging to euryhaline families (Hyndes et al 1996).
- Work conducted by Hyndes et al (1996) demonstrated that certain whiting species utilise both sallow and deep un-vegetated sand habitats at different stages of their life cycle. Commercially significant species such as the Yellow-finned Whiting utilise the shallow sand habitat throughout its life history. There are markedly different assemblages of fish species occurring over sandy habitats depending on water depth and distance from shore (Hyndes et al 1999).
- Sand patches, often adjacent to reef or seagrass meadows are utilised by a number of macro invertebrates. Burying molluscs are found in such patches and in turn are consumed by other predatory invertebrates such as baler shells (CALM 1992) and whiting species (Hyndes et al 1997).
- Un-vegetated sand habitats were identified in Cockburn Cement's ERMP studies (Cockburn Cement 2001) and were ascribed many of the same values that vegetated ecosystems possess. Both deep and shallow sand habitats were assessed for ecological value over a range of biological parameters, including habitat complexity, primary production, biogeochemical cycling and secondary production. Deep sands habitats were seen to have a higher probability of many of these ecological values than that of some seagrass (*Heterozostra tasmanica*) habitats due to their higher secondary production (CCL, 2001). A major value that was recognised was its role as 'potential' seagrass habitat. In highly dynamic environments (such as those in the study area), seagrass ecosystems are often patches of vegetated and unvegetated areas. On a decadal timescale, seagrass can be lost through storm removal and other process, but the overall 'landscape' function is retained by virtue of new seagrass colonising into the bare sand areas.

Intertidal Reef Platforms

There is no published work describing ecological values of this habitat in the study region. However, it is possible to summise that the major value will be as habitat for a set of inter-tidal organisms. Most algae on this habitat will be present on submerged reefs but there will be a set of macroinvertebrates that are restricted to inter-tidal reef platforms.

Water Column

The water column itself is an important habitat in the study region. The area has an oligotrophic water column with a relatively high degree of flushing compared to many of the areas immediately south of the Swan River. Specific identified values of the water column are gleaned from specific works, plus those

implied in the recently produced Environmental Protection Policy for Cockburn Sound (EPA, 2003), which included defined Environmental Values for Perth's coastal waters. The main values ascribed to the water column:

1. Production in the water column accounts for most of the biological production in the sea. While not as productive on a per unit area basis as a number of benthic systems such as seagrass beds and coral reefs, it does still form the basis of the food web of important fisheries (Levinton 1995)
2. The water column provides a habitat for planktonic and mobile pelagic species.
3. Fundamental to the maintenance of ecosystem integrity. This is a generalized value inferred in the EPP (Cockburn Sound) (EPA, 2003) and is based on the role of the water column in several major areas, including its role:
    - as a medium for the dispersal of reproductive propagules, planktonic life stages, nutrients and productivity;
    - in providing connectivity between habitats; and
    - in light attenuation, thereby determining benthic primary production.

<u>Marmion Marine Park</u>

The Marmion Marine Park (MMP) is the only marine park in the study area. Its values have been described in the Management Plan for the Park (CALM 1992) and form the basis for its declaration as a Marine Park. These are:

1. The Marmion Marine Park encompasses a number of marine habitats within it bounds eg.
    - Lagoon and Sub tidal Sandy sea floor.
    - Lagoon and Sub Limestone Pavement
    - Lagoon Intertidal Reefs and Little Island
    - Nearshore Reefs and Intertidal Offshore platforms.
    - Offshore Shallow Limestone Reefs
2. Exceptional biodiversity of algae and macroinvertebrates exist on the high-relief limestone reef contained within the park;
3. The park also includes a number of small islands serve as a habitat for small numbers of Australian Sea lion (declared "in need of special protection"). There are also remnants of the heavily exploited humpback whale population, which migrate through the park in August and October each year. Other cetaceans such as Bottlenose dolphins and Striped dolphins visit the area with a pod of Bottlenose dolphins appearing to have park of their home range within the park (CALM 1992);
4. The park incorporates a number of seagrass meadows. As identified and explained above, these meadows contribute to ecosystem energy flow dynamics, as well as providing a stabilising effect on the substrate.

5. The representative nature of the habitats and species that they support, contribute to the overall conservation values of the marine park. It provides a reserve characteristic of a number of similar environments from Western Australia's mid west coast.

Table 7: Previous values, changes in ecological condition and revised values of GDEs not assessed in the Section 46 Review of Environmental Conditions, the East Gnangara Water Provisions Plan, the Jandakot Groundwater Scheme Stage 2 PER or the Jandakot Environmental Management Programme.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
WETLANDS			
Gnangara			
Herdsman Complex			
Carrabooda Lake (37849650146)	*Hill et al. (1996)* • R EPP. *Davis et al., (1991)* • Supports rich macroinvertebrate fauna. *Bamford and Bamford (2003)* • Key faunal habitat area.	*Horwitz and Rogan (2003)* • Macroinvertebrate richness not considered significant in a regional context due to greater understanding of comparative regional species richness of wetland. *DoE (2004)* • Wetland surrounded by market gardens and pasture. All terrestrial vegetation cleared to edge of lake with some localized infilling at the southern end. • Some annual & perennial weeds encroaching margins of lake.	• Key faunal habitat area.
Lake Neerabup (38205649442)	*Hill et al. (1996)* • R EPP. *Bamford and Bamford (2003)* • Key faunal habitat area. *Government of WA (2000)* • Bush Forever Site 384.	*Froend et al., (2002).* • Groundwater levels decreasing since records began in 1978 leading to encroaching of *Typha*. • Possible eutrophication due to surrounding land-uses. *DoE (2004)* • Lake adjoins extensive bushland remnant to east with evidence of grazing. Market gardens / semi-rural development on the west side with market gardens intruding into the wetland in the NW. A road intersects the wetland at the north end. • Some areas of severe weed infestation.	• Key faunal habitat area. • Bush Forever Site 384.
Lake Gwelup (38561647226)	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Bush Forever Site 212. *Bamford and Bamford (2003)* • Key faunal habitat area.	*DoE (2004)* • Lake surrounded by parkland and urban development with a wide buffer of remnant bushland to the north. The main area of the lake is fed by several drains and supports a herbland of annual weeds, suggesting surface water is present annually. Wetland dry in 2004. • *Typha* encroaching further into wetland. • Both terrestrial & wetland trees effected by fire.	• Key faunal habitat area. • Bush Forever Site 212.
Beenyup Swamp (38625648247)	*Hill et al. (1996)* • SO C. *Government of WA (2000)* • Bush Forever Site 299.	*DoE (2004)* • Wetland contains one large area of open water which may provide useful refuge for water birds. Surrounded by cleared parkland on all sides. Connected to Wallubuenup Swamp by a narrow creek in south-east corner which was flowing slowly in April 2004. • Annual & perennial weed invasion at perimeter of swamp.	• Bush Forever Site 299.
Big Carine Swamp (38506647515)	*Hill et al. (1996)* • SWO C EPP. Government of WA (2000) • Bush Forever Site 203. *Bamford and Bamford (2003)* • Key faunal habitat area.	*DoE (2004)* • Wetland situated in a large grassed, recreation reserve with a small area of remnant vegetation in the NE corner. Narrow band of wetland trees remain around much of the perimeter with extensive areas of trees towards the centre of the lake. • Fringing *M. rhaphiophylla* on west & southern side showing some signs of drought stress – generally restricted to higher sections of littoral zone.	• Key faunal habitat area. • Bush Forever Site 203.
Careniup Swamp (38595647369) - sumpland	*Hill et al. (1996)* • R EPP.	*DoE (2004)* • Highly modified wetland with infilling and urban development on all sides. Area to the east are being filled currently. Some deep water occurs at the northern end and eastern side however the northern end receives road runoff and is highly eutrophic.	
Wallubuenup Swamp (38696648190)	*Hill et al. (1996)* • C EPP.	*DoE (2004)* • Mainly cleared for urban and semi-rural development. Agricultural land on eastern shore to basin. Narrow, patch band of littoral veg to west surrounded by parkland. Fire and weed invasion has impacted on remnant vegetation.	
Badgerup Lake (39028648351)	*Hill et al. (1996)* • S C EPP. *Government of WA (2000)* • Bush Forever Site 327.	*DoE (2004)* • Large (>100m) vegetation buffer to the north, west and south. Eastern margin predominantly cleared for semi-rural development. Majority of woody littoral species cleared from the perimeter. Wetland dry April 2004. • Recent fire scorched wetland trees.	• Bush Forever Site 327.
Little Badgerup Lake (39037648274)	*Hill et al. (1996)* • S C EPP.	*DoE (2004)* • Wide buffer of vegetation surrounds wetland. Semi-rural development encroaching at the northern side led to loss of large area of wetland tree community that connects wetland to Badgerup Lake. Some littoral vegetation has been lost on the west side due to	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
		clearing. Wetland dry April 2004. • Disturbed areas of littoral zone are heavily weed infested.	
sumpland (38348649057)	*Hill et al. (1996)* • SO C EPP.	*DoE (2004)* • Wetland adjoins Neerabup National Park to the west so has substantial vegetation buffer on this side. Much of the east and SW is private property. Horses have access to much of the wetland perimeter leaving the zone highly degraded by grazing. Soil under the tree canopy is moist suggesting surface water may be present further into the wetland.	
Pinjar Complex			
Lake Pinjar (38766649788)	*Hill et al. (1996)* • SWO C EPP. *Government of WA (2000)* • Bush Forever Site 382.	*Froend et al., (2002)* • Vegetation in much of the lake heavily modified through agriculture, with little undisturbed vegetation remaining. *DoE (2004)* • Majority of lake cleared or otherwise disturbed by agriculture. No surface water was apparent in April 2004. • *E. rudis* shows signs of stress with many dead trees.	• Bush Forever Site 382.
Little Mariginiup (38830649035) Sumpland.	*Hill et al. (1996)* • SW C EPP.	*DoE (2004)* • Wetland on private property and predominantly cleared. Entire wetland appears to be grazed. Some scattered *Eucalypts* remain around the fringe of the seasonally wet area.	
Hawkins Rd Swamp (39120648926) Sumpland.	*Hill et al. (1996)* • SW C.	*DoE (2004)* • Swamp lies within pine plantation adjacent to cleared land on the west side. Tracks intersect the swamp forming a cleared circle near the centre. Some dumping of rubbish and regular fires is apparent. • Some invasion of exotics grasses. • Some terrestrialising occurring.	
Lake Adams (38844649190)	*Hill et al. (1996)* • S C EPP.	*DoE (2004)* • More than half wetland is privately owned and currently used as paddock. Some scattered wetland trees remain in this area with a weedy understorey. The section under Crown Reserve has not been cleared although a walkway has been constructed by mounding earth and planted with non-local tree species. Dry in April 2004.	
Little Adams Swamp (38955649226) – dampland	*Hill et al. (1996)* S C EPP.	*DoE (2004)* • Wetland sits on extensively cleared private property with grazing access to the lake bed.	
Unnamed (39012649008) dampland	*Hill et al. (1996)* • C EPP	*DoE (2004)* • Wetland is surrounded by cleared farmland with scattered remnant *Eucalyptus* and *Banksia* sp. Remnant littoral trees have an understorey of dense annual and perennial grasses. • Pines invading from east • Some die-back of E. rudis on west side.	
Karrakatta Central and South Complex			
Little Emu Swamp (39360647560) sumpland	*Hill et al. (1996)* • C *Government of WA (2000)* • Bush Forever Site 201.	*Zencich and Froend (2002)* • Wetland basin severely disturbed by BMX tracks, walk trails and fire. • Run-off from storm water drains has lead to massive weed invasion. *DoE (2004)* • Buffer of remnant vegetation surrounds the lake although reduced to a very narrow strip to the east. Vehicle tracks surround the wetland basin and fire occurs regularly. Wetland was dry April 2004. • Substantial annual weed cover.	• Bush Forever Site 201.
Cottesloe Central and South Complex			
Ridges - sumpland	*Hill et al. (1996)* • C *Government of WA (2000*) • Bush Forever Site 381. • Supports TEC SCP14 (YAN21) *Mattiske and Associates (1988)*	*Mattiske Consulting Pty Ltd (2000)* • Transect not monitored since 1996 due to fire. *Froend et al. (2002)* • Mortalities of *B. ilicifolia* since 2001. *DoE (2004)* • Some clearing apparent in the north section (limestone mining). Track extends onto wetland fringe leading to dumping of car	• Supports threatened ecological community. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	• Ridges vegetation monitoring transect established 1987.	bodies / rubbish. Dry in April 2004. • Weeds generally restricted to NW area • Mature *E. rudis* show high degree of stress • *K. ericifolia* appear drought stressed	• Bush Forever Site 381.
Bassendean North Transition Complex – North			
11 damplands (38613651757, 38368651780, 38636651749, 38669651758, 38731651919, 38798652311, 38825652147, 38875652172, 38861652407, 38919652275, 38933652030)	*Hill et al. (1996)* • SW C.	*DoE (2004)* • 38613651757: System of generally connected damplands situated within a large area of high quality bushland. This dampland occurs on the eastern slope above the large central dampland. Dominated by terrestrial species in the understorey. • 38638651780: Northern section of dampland area. Comprises a low central section consisting of wetland species and broad areas of transition vegetation on the eastern slope. Some evidence of stress in *E. rudis* occupying the lowest areas. • 38636651749: One small area within a large dampland is identified by Hill *et al*.. No clear boundaries exist although the vegetation is variable across the dampland. Some chlorosis in *E. rudis* appears to be recent. • 38669651758: Dampland occurs in a swale between two low dunes running north-south. Possibly connected to the other damplands in this area at the southern end. Number of very stressed *M. preissiana* & occasional dead *B. ilicifolia*. • 38731651919: A very small dampland. Road through middle does not appear to have impacted condition. Wetland generally in good condition. Approximately 50% of *mature M. preissiana* are dead. Patches of *Kunzea sp*. are severely drought affected. • 38798652311: A narrow dampland with a mixed terrestrial understorey. Located in a large nature reserve, which is essentially undisturbed. However, dieback does occur in adjacent blocks of the nature reserve. • 38825652147: 2 damplands possibly connected located in a large undisturbed nature reserve. Generally in a very good condition. • 38875652172: One dampland of a pair that are possibly hydrologically connected. Both are located in a large nature reserve. *M. preissiana* are dead. Majority of *B. ilicifolia* are resprouting. Various dead *Banksia* trees & some shrub death. • 38861652407: A small distinct dampland surrounded by larger damplands. Roads upland of the dampland do not appear to negatively impact the dampland. Generally in very good condition, with only small patches of dead vegetation, some death of mature *M. preissiana*. Terrestrial vegetation generally excellent, however some shrub death & some *B. attenuata* deaths. • 38919652275: A small dampland in a dieback affected area. A road through middle of the wetland has had detrimental impact (the wetland is small and the road has been widened). Many trees dead or dying possibly from *Phytophthora cinnamomi.* • 38933652030: A medium sized dampland in a line of wetlands, in valley that runs east-west. The land adjacent to the dampland, particularly to the east, appears to be severely dieback affected. Approximately 60% *of M. preissiana* very stressed or dead. Scattered dead *B. ilicifolia* & other *Banksias.* Most of tall *Kunzea* scrubland dead.	
Bassendean North Complex - Yeal Swamp			
Yeal Swamp (38267651751)	*Hill et al. (1996)* • SW C. *Government of WA (2000)* • Beyond Bush Forever Study boundary. *Mattiske and Associates (1988)* • Yeal Swamp vegetation monitoring transect established 1987. *Bamford and Bamford (2003)* • Key faunal habitat area.	*Froend et al. (2002)* • Declining health of overstorey species. • Mining of diatomaceous earth in recent years. *DoE (2004)* Large wetland within nature reserve. Dry April 2004. Disturbance from vehicle tracks & invasion of annual weeds. Some *E. rudis* death in southern section. *Kunzea sp*. show signs of drought stress.	• Key faunal habitat area. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Bindiar Lake (38181651941)	*Hill et al. (1996)* • SW C EPP. *Government of WA (2000)* • Beyond Bush Forever study boundary.	*Froend et al. (2002)* • Declining health of *E. rudis* species. *DoE (2004)* • In nature reserve with excellent vegetation buffer. Pines occur within 100m of western side. Vehicles access the claypan area in the n/w leading to some localised areas of damage to the vegetation. Dry in April 2004. Mature *E. rudis* on west side showing signs of stress.	
Dampland (38488651846)	*Hill et al. (1996)* • ASW C *Government of WA (2000)*	*Froend et al (2002)* • Undisturbed with intact vegetation. *DoE (2004)*	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	• Beyond Bush Forever study boundary.	• Occurs in large bush block and forms part of a series of damplands with similar vegetation associations. Extends well beyond the boundaries defined in Hill *et al.* Large buffer of vegetation separates the damplands from vehicle tracks. Virtually undisturbed system. Some *E. rudis* show signs of stress.	
Dampland 38340651762	*Hill et al. (1996)* • SW C EPP.	*DoE (2004)* • Wetland in excellent condition. Dry in April 2004. Evidence of fire approximately 2 years ago in terrestrial vegetation.	
Dampland 38337651800	*Hill et al. (1996)* • SW C EPP.	*DoE (2004)* • Small steep sided dampland in nature reserve. Shows sharp transition from terrestrial to wetland vegetation. • Closed low forest of *Melaleuca* suggests this site is wetter than surrounding damplands. Dry April 2004.	
Bassendean North Complex – Yeal West			
Dampland (38821652464)	*Hill et al. (1996)* • ASW C	*DoE (2004)* • Wetland generally in very good condition with some dead *Banksia spp*.	
2 damplands (38144652776, 38174652305)	*Hill et al. (1996)* • SW C EPP	*DoE (2004)* • 38144652776: Dampland with mixture of terrestrial and wetland species. Some dead *M. preissiana* in south-east & occasional patches of dead scrub. Other vegetation in excellent condition. • 38174652305: Dampland with some areas near a track at the south-west end severely dieback affected & extending downslope into the wetland basin. The majority of the *E. rudis* show signs of stress. Most other vegetation is in excellent health.	
Sumpland (38551652525)	*Hill et al. (1996)* • SWC. Supports TEC SCP14 (MILT05) *WA Herbarium (2003)* • DRF; P3 - *Dillwynia dillwynioides.*	*DoE (2004)* • Peaty soil present in basin of dampland. Vegetation generally in excellent condition. Some dead *Banksia sp*. and *Corymbia sp*. & indications of previous fire in northern area.	• Supports threatened ecological community - SCP14 (MILT05) (see p. 8). • Bushland supports priority flora.
Tangletoe Swamp (37607652972)	*Hill et al. (1996)* • C *Davis et al., (1991).* • Among most pristine wetlands sampled. • High species richness for Odonata and Coleoptera.	*DoE (2004)* • Pristine wetland in extensive reserve of undisturbed vegetation, with some isolated dead *Banksias* on the wetland fringe.	• Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Supports high macroinvertebrate species richness .
63 damplands (37917652461, 37948652434, 37987652796, 37981652582, 37987652446, 38030652677, 38009652550, 38024652295, 38026652641, 38039652524, 38033652611, 38036652738, 38046652635, 38058652554, 38083652724, 38078652433, 38090652633, 38082652192, 38088652250, 38097652471, 38139652681, 38122652574, 38147652733, 38151652708, 38168652666, 38162652573, 38167652757, 38182652512, 38225652757, 38220652466, 38230652721, 38231652411, 38245652664, 38252652683, 38266652435, 38280652700, 38285652373, 38289652487, 38287652725, 38310652767, 38309652440,	*Hill et al. (1996)* • SW C	*DoE (2004)* • 37917652461, 37948652434 &37987652446: Three damplands with no distinct boundaries between them. Condition varies across these damplands with a general decline to the east. Myrtaceous shrubs show signs of drought stress across the entire area, significant areas of tall open scrub dead or very stressed in the eastern section. Much of the *M. preissiana* dead or dying in the centre & eastern sections. Dead *Banksia* can be seen in the lower section. • 37987652796: small steep sided wetland with dense stands of wetland trees with locally unique species (*M. teretifolia*). Appears to be wetter than surrounding wetlands, with moist organic sediments. Wetland in pristine condition. • 37981652582: Located in a large nature reserve the dampland has a distinct basin & is in excellent to pristine condition. However, some of the upslope *M. preissiana* are in poor condition. • 38030652677: Large wetland dominated by terrestrial vegetation, wetland species only dominate in the lowest area to the north-east. Some dead & stressed *B. ilicifolia* to the south. Roughly 50% of *E. rudis* very stressed in the western section. *Melaleuca sp.* stags amongst healthy individuals in the north-west. Some stressed *E. rudis* & recently dead *Banksia sp.* & large patches of dead Myrtaceous scrub. Obvious signs of drought stress along west side. • 38009652550: Dampland in excellent condition. Has a road through the southern tip however, this does not appear to have a direct impact. The *M. preissiana* & *E. rudis* on higher ground are in excellent condition however, those on lower ground are very stressed. • 38024652295: Steep-sided dampland with a rapid & distinct transition between terrestrial & wetland vegetation. Vegetation condition is generally excellent. However, the majority of the *E. rudis* appear stressed with numerous dead stems in the basin. *M. preissiana* in excellent condition. Some saplings of both species around the edge of the basin.	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
38317652442, 38336652318, 38342652392, 38394652578, 38386652685, 38361652523, 38381652418, 38416652349, 38455652718, 38415652188, 38456652444, 38480652351, 38532652185, 38533652305, 38560652228, 38580652413, 38587652096, 38585652194, 38589652128, 38642652041, 38651652093, 38732652377, 38420652687, 38389652800, 38334652752, 38764652463, 38997652088)		• 38026652641: Vegetation in excellent condition, with some *M. preissiana* saplings present. • 38039652524: Dampland generally in excellent condition with only the occasional *Banksia* & *M. Preissiana* stag & stressed individuals. • 38033652611: Some terrestrial plant species appear to be invading the dampland. Vegetation condition in generally excellent. *M. preissiana* population is senescent but living. • 38036652738: Small dampland in a shallow swale. Vegetation is generally in excellent condition, however, there is the occasional dead *Banksia sp*. • 38046652635: Vegetation is in excellent condition. • 38058652554: Dampland generally in excellent condition. Some scattered dead *B. attenuata* & senescent *M. preissiana*. • 38083652724: large dampland joined to northern end of dampland 20. Large flat basin with mixed terrestrial & wetland species. Vegetation generally in excellent condition with some localized patches of dead scrub & occasional dead or stressed *M. preissiana* & *Banksia sp*. • 38078652433: Large area of transition vegetation, which consists of terrestrial vegetation & stands of *M. preissiana*. Vegetation generally in excellent condition, some *M. preissiana* seedlings & saplings in basin, some dead *Banksia sp*. & *M. preissiana* & localized areas of dead Myrtaceous scrub. • 38090652633: dampland appears to be becoming invaded with terrestrial species. Vegetation generally in very good condition, however, significant deaths of Myrtaceous shrubs and a general decrease in both over & understorey species. • 38082652192: Peaty dampland supporting an open forest of *B. littoralis* & *M. preissiana*. Previous fire had a large impact on vegetation however as regeneration progress vegetation in generally in excellent condition. • 38088652250: Dampland located in a large nature reserve close to a road, shows virtually no signs of disturbance from surrounding landuse, vegetation in excellent condition. • 38097652471: Dampland generally in good condition however, has road through middle of it. Minor localised drought stress in the *Kunzea* & *M. preissiana*. • 38139652681: Large variable dampland with a wide transition zone and large areas of dead *M. preissiana* & *B. littoralis*, understorey in excellent condition. Evidence of a recent fire. • 38122652574: Large wetland with indistinct boundary. Overstorey of *Melaleuca* is all but gone although a tall scrub of Myrtaceous species still dominates much of the wetland although there are large dead patches. Some dead *Banksia spp*. are present in & around the wetland. Wetland appears to be terrestrialising. • 38147652733: Large variable dampland with obvious decline in overstorey health. Approximately 30% of *M. preissiana* dead or stressed, some recently dead *B. attenuata* & *B. ilicifolia* as well dead patches of Myrtaceous scrub. • 38151652708: Small dampland with severely stressed vegetation. Most Myratceous species showing signs of drought stress. Terrestrial species colonizing dampland basin. 90% of *M. preissiana* dead or very stressed. Occasional dead or stressed *Banksia sp*. • 38168652666: Large variable dampland with a wide transition zone. Vegetation generally in excellent condition. Some senescent *M. preissiana* & scattered dead *Banksia sp*. • 38162652573: Small dampland with gradual slope towards a central basin dominated by Myrtaceous shrubs. Approximately 70% of *M. preissiana* is stressed to very stressed. Some dead *Banksia* occurs around the wetland perimeter. • 38167652757: Small dampland showing signs of drought stress. Most *M. preissiana* are dead & being replaced by *Banksia sp*. Large patches of dead Myrtaceous heath across the dampland. *Banksia sp*. in excellent condition. • 38182652512: Small dampland dominated by *Banksias* with a Myrtaceous shrub understorey. Occasional dead *Banksia* & scattered patches of dead Myrtaceous scrub. Otherwise vegetation in excellent condition. • 38225652757: Large dampland supporting *Melaleuca sp*. trees across much of the wetland basin. Majority of *Melaleuca sp*.in excellent condition with a few isolated stressed individuals. Some localized areas of dead Myrtaceous scrub. Otherwise vegetation in excellent condition. • 38220652466: Dampland has lost the majority of its overstorey & is essentially an open heath to tall open scrub of mixed wetland & terrestrial species. Occasional dead *Banksia spp*.. The wetland trees are predominantly very stressed *B. ilicilfolia* & regenerating *M. preissiana*. • 38230652721: Small dampland with gradual slope down to a low central basin dominated by Myrtaceous shrubs. Evidence of *M. preissiana* in center of wetland although these individuals are long dead. Scattered dead *Banksia sp*. around perimeter, otherwise vegetation is in excellent condition. • 38245652664: All *M. preissiana* in lower basin are dead. Approximately half the remaining *Melaleuca* around the perimeter are	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
		stressed. Considerable *Banksia sp*. death in surrounding terrestrial vegetation. Understorey generally in excellent condition with some areas of localized drought stress. • 38252652683: No live *M. preissiana* left but stags suggest the wetland was once a *Melaleuca* woodland. Remaining trees & understorey in generally excellent condition with some evidence of drought stress in localized areas of scrub. • 38266652435: *M. preissiana* generally stressed or very stressed with several large stags. Roughly 30% of the *B. ilicifolia* appear stressed. Other trees generally excellent. Some localized dead patches of *Kunzea sp*. & *Beaufortia sp*. • 38280652700: Majority of *M. preissiana* dead or stressed (may be old deaths). *B. ilicifolia* & tall scrub all in excellent condition. • 38285652373: Dampland shows a gradual transition of terrestrial vegetation into a basin supporting dense Myrtaceous shrubs & *M. preissiana*. Overstorey condition is variable throughout the area with regular patches of dead trees in both the wetland & terrestrial vegetation. Many dead *Banksia spp.* in the wetland centre. • 38289652487: open dampland located in nature reserve close to a road. Some localised plant deaths. Most *M. preissiana* are stressed or dead & extensive shrub & *Kunzea spp*. death. • 38287652725: Majority of *M. preissiana* dead or very stressed. Otherwise vegetation in excellent condition. • 38310652767: Dampland located in a nature reserve & generally in excellent condition. However, there are signs of dieback in the terrestrial vegetation. There are also signs of dieback & stress in the dampland with 25% of *Banksias* & 30% of *M. preissiana* effected. • 38309652440: Dampland is generally very good condition, some of the larger trees are dead. • 38317652442: Dampland located in nature reserve, vegetation generally on excellent condition however, 60% of the shrubland in the basin is dead. • 38336652318: Dampland located in nature reserve, virtually undisturbed, although some possible *Phytophthora cinnamomi* & drought stress particularly of *Banksia spp*., some *Beaufortia sp.* & myrtaceous heath. • 38342652392: Dampland located in nature reserve. Vegetation generally in excellent condition. However, some localised areas of dead *Kunzea sp*., stressed & dead *B. ilicifolia* & *B. attenuata* & scattered dead *M. preissiana*. • 38394652578: Dampland in excellent condition with the occasional mature *M. preissiana* stag. • 38386652685: Large dampland with variable vegetation communities. Steeply sloping on the south-west side. Occasional stressed *M. preissiana* & *Banksia spp*.. Substantial death of *E. rudis* on south-west side with most trees appearing stressed. • 38361652523: Small dampland in average condition. Vegetation condition generally very good however, *M. preissiana* virtually all gone & the shrublands appear drought stressed with some localised dead patches. • 38381652418: Vegetation generally in excellent condition, with the exception of some *M. preissiana* stags. • 38416652349: Dampland in very good condition however, *M. preissiana* recently stressed to very stressed. Scattered dead *Banksia spp*. & localised areas of dead myrtaceous shrub. • 38455652718: Terrestrial & wetland vegetation in pristine condition. • 38415652188: Small dampland with moist, organic soils in centre. Evidence of recent, intense fire which has caused considerable damage to this 'wet' dampland. Many *M. preissiana* occurring in dense stands have been killed by fire. Some individuals resprouting & some new saplings in localised areas. Some terrestrial species are establishing. • 38456652444: Dampland in excellent condition, however, there are no longer any live *M. preissiana* in the basin. • 38480652351: The majority of the *M. preissiana* population is stressed & contains some recently dead individuals. • 38532652185: Vegetation generally in excellent condition. *M. preissiana* generally in very good condition however, there are numerous stags. *E. rudis* is generally in excellent condition, as is the *Banksia sp*., with the exception of some *Banksia sp*. deaths upslope. • 38533652305: Large dampland supporting healthy stands of *E. rudis.* Scattered dead *B. ilicifolia* occur in the centre of the dampland. Occasional senescent *Melaleuca* & dead patches of *Kunzea* within the wetland. • 38560652228: Dampland in two distinct zones based on elevation gradient. Higher zone supports mixed terrestrial/wetland communities & surrounds a lower area dominated by a tall scrub of myrtaceous species. *M. preissiana* population consists of numerous senescent individuals & many, very stressed trees. • 38580652413: Large flat basin covered with a tall open scrub & a closed sedgeland, fringed with *M. preissiana.* The dampland is somewhat unique for the area in which it is located. Generally in excellent condition, with some localised disturbance. • 38587652096: *M. preissiana* generally in excellent condition. A few stags & stressed individuals are apparent on the edge of the wetland. Tall scrub in excellent condition except for a few localised dead patches. • 38585652194: Wetland generally in excellent condition with some senescent *M. preissiana.*	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
		• 38589652128: Indistinct dampland with terrestrial species throughout. Wetland trees restricted to a band on the east side. • 38642652041: Dampland in generally excellent condition with a few senescent *M. preissiana*. • 38651652093: Dampland in excellent condition. • 38732652377: Dampland has road through middle of it. Some stress is evident however, is generally in excellent condition. Some dying off in numerous *E. rudis* & *M. preissiana*. Recently dead *M. preissiana* & dead or stressed *B. ilicifolia* in the western part of the dampland & some shrub death and chlorosis. • 38420652687: Signs of previous fire. *Adenanthos sp*. & *Banksia ilicifolia* appear to be colonizing the wetland. Vegetation is generally in excellent condition. Occasional *Banksia sp*. & *M. preissiana* deaths & scattered stressed *M. preissiana*. • 38389652800: Linear feature of dense terrestrial vegetation slightly upslope of large dampland/floodplain. Vegetation surrounding wetland is die-back affected. • 38334652752: Small basin dominated by Myrtaceous shrubs within the Quin Brook floodplain. *M. preissiana* stags in centre of wetland with scattered dead *Banksia spp*. Otherwise in excellent condition. • 38764652463: Terrestrial & wetland species in excellent condition, with the minor exception of some senescent *M. preissiana*. • 38997652088: Dampland with track through middle. All Melaleuca tree have been dead for some time, terrestrial plants species are encroaching. Remaining wetland vegetation is in very good condition. Terrestrial vegetation is in excellent condition.	
Deepwater Lagoon (38881652828) - lake	*Hill et al. (1996)* • R EPP *Bamford and Bamford (2003)* • Key faunal habitat.	*DoE (2004)* • .Extremely degraded, being paddock with some remnant stands of *Melaleuca sp*. on the perimeter of lake. Surface water is present.	• Key faunal habitat.
1 dampland (37797652988) & 2 sumplands (37852653007, 37879652973)	*Hill et al. (1996)* • C EPP	*DoE (2004)* • 37797652988: Vegetation generally in excellent condition. Evidence of previous fire. Some *M. preissiana* trees stressed, otherwise excellent condition. • 37852653007: *E. rudis* saplings & *M. preissiana* seedlings & saplings are present on the edge of the basin. Vegetation is generally in excellent condition, overstorey in excellent condition, however, *B. articulata* has recently died. • 37879652973: Wetland in excellent condition; trees in pristine condition however, *Baumea sp.* appears to be very drought stressed.	
Bassendean North Complex – Tick Flat			
Tick Flat (37632652620)	*Hill et al. (1996)* • W C *WA Herbarium (2003)* • DRF; P3 – *Eucalyptus argutifolia.*	*Froend et al. (2002)* • Wetland is becoming terrestrialised. • Declining condition and health of understorey and overstorey vegetation. *DoE (2004)* • Large dampland extending across remnant bushland through to cleared pasture. Recent fires affected area although large unburnt patches remain, particularly in the northern section. Dry in May 2004. • Vehicle track have lead to localised weed invasion • Some pines trees invading near wetland.	• Supports rare or priority flora. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
4 damplands (37668652593, 37577652591, 37588652556, 37593652546)	*Hill et al. (1996)* • SW C	DoE (2004) • (37668652593); Large dampland approximately 100m east of the main Tick Flat wetland. Recent fire evident in the southern half. Dry in May 2004. Majority of *M. preissiana* dead or very stressed. Localised dead areas in understorey. • (37577652591); Small wetland in the central section of the Tick Flat complex. Unburnt in the recent fires. Dry in May 2004. Occasional dead *Banksia*. • (37593652546; 37588652556); Lie to west of the main Tick Flat wetland in a *Banksia* and *Melaleuca* woodland. Boundaries defined in Hill *et al*., cannot be distinguished in the field. Dry in May 2004. Unburnt areas in good condition. Fires have killed some areas of shrubland.	
Bassendean North Complex – Yeal East			
Lake Mukenburra (38405653196) -lake	*Hill et al. (1996)* • S C EPP • Supports TEC SCP 07 (MUCK02).	No record of current condition of wetland.	• Supports threatened ecological community – SCP 07 (MUCK02) (see p. 9).

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
17 damplands (38829652308, 38831651988, 38898652368, 38861652005, 38913652246, 38913652012, 38919652275, 38933652030, 38951652330, 38973652008, 39008652386, 39008652298 39026652224, 39045652254, 39058652235, 38685652685) & 2 sumplands (38570652790 38606652771)	*Hill et al. (1996)* • SW C	*DoE (2004)* • 38829652308: Wetland dominated by open heath of wetland & terrestrial species with wetland trees restricted to the north-west edge suggesting terrestrialisation of wetalnd. *Melaleuca* generally stressed. Scattered dead *B. ilicifolia*. • 38831651988: Some terrestrial plants invading wetland, otherwise vegetation in very good to excellent condition. Almost no live *M. preissiana* left on the basin however healthy individuals on the fringe. There are some large areas of dead scrub. *Kunzea sp*. seedlings on the basin. *B. ilicifolia* establishing on the basin & *Banksia sp*. establishing in the fringing vegetation. • 38898652368: A very large wetland with several tracks & beehives in the eastern section. Vegetation generally in excellent condition. However, 50% of *M. preissiana* appear stressed or dead. Numerous immature *B. ilicifolia* in the basin with range extending into wetland. *E. rudis* in good condition. • 38861652005: A broad transition zone of mixed terrestrial & wetland vegetation surrounding the dampland. Vegetation in generally very good to excellent condition, with some drought stress in *Kunzea sp*. • 38913652246: Large linear dampland, wide transition zone of mixed species. Evidence of dieback. Occasional stressed *Melaleuca* & localised areas of dead scrub, otherwise vegetation in excellent condition. *Banksia sp*. colonising basin. • 38913652012: *M. preissiana* generally in very good to excellent condition. Occasional dead *B. ilicifolia*. Large areas of dead scrub on basin, some regeneration of *Kunzea sp*. • 38919652275: No record of current condition of wetland. • 38933652030: No record of current condition of wetland. • 38951652330: Healthy, intact dampland, with a mix of wetland & terrestrial vegetation in excellent condition. • 38973652008: Small dampland dominated by Myrtaceous shrubs. Surrounding vegetation dieback affected. Numerous *Melaleuca* stags on & around basin with remaining stems showing signs of stress. Scrub very drought stressed, although *Kunzea sp*. regenerating. *B. ilicifolia* saplings establishing in basin. • 39008652386: Track runs through wetland which is mix of wetland & terrestrial vegetation. Vegetation generally in excellent condition, some senescent *M. preissiana* on the wetland & some *Banksia sp*. seedlings on the wetland, indicating terrestrial species invading. • 39008652298: A distinct transition between terrestrial & wetland vegetation is observed at this site & the vegetation is generally excellent to pristine. • 39026652224: Vegetation in very good condition. *Banksia sp*. appear to be replacing the *M. preissiana* as the dominant overstorey species, shrub condition is excellent. • 39045652254: Vegetation is generally in excellent condition. Some *M. preissiana* stags & stressed individuals. • 39058652235: Sharp transition between terrestrial & wetland vegetation. Wetland significantly altered in structure, with most *M. preissiana* dead, possibly due to drought stress. *B. ilicifolia* seedlings in the lower part of the wetland indicating that terrestrial species are invading. Vegetation is generally in very good condition. • 38685652685: Linear wetland with sharp transition between terrestrial & wetland vegetation. Clearing through the middle of wetland for a high-tension powerline has taken place. Vegetation condition is excellent. 50% of the mature *M. preissiana* are stressed or very stressed. Terrestrial vegetation is in excellent condition. • 38570652790: Visual evidence of a recent fire. Vegetation severely fire affected, however regeneration appears healthy. • 38606652771: Area recently burnt & this has severely affected vegetation however, regeneration appears to be healthy.	
1 sumpland (38773652686)	*Hill et al. (1996)* • O C EPP	No record of current condition of wetland.	
1 floodplain (39108652522) & 1 sumpland (38828652623)	*Hill et al. (1996)* • O C	*DoE (2004)* • 39108652522: No record of current condition of wetland. • 38828652623: Sumpland in cleared paddock with narrow, patchy fringe of trees. Entire area is private property, surface water present July 2004. A block of more intact vegetation to the north-west, although generally area is degraded by clearing & grazing.	
Bassendean North Complex – Melaleuca Park			
1 dampland (39496649584)	*Hill et al. (1996)* • SW C EPP	*DoE (2004)* • Large variable dampland with central “wet” area with surface water present in July 2004. Disturbance included mining for diatomaceous earth, cleared track aournd central section, dumping of rubbish & car bodies. Approximately 50-70% of M. preissiana dead or stressed, many recently dead. Saplings occur throughout much of the tall scrub which along with the remnant	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
25 damplands (39455649394, 39464649585, 39478648638, 39498649636, 39507649695, 39513649527, 39514649463, 39527649600, 39547649649, 39541649417, 39565649347, 39550649619, 39559649393, 39572649792, 39616649454, 39627649484, 39647649353, 39712649551, 39876649518, 39906649362, 39592649232, 39685649249, 39660649160, 39813649148, 39881649161)	*Hill et al. (1996)* • SW C	sedgeland is in excellent condition. *DoE (2004)* • 39455649394: Dominant M. preissiana overstorey has been replaced by B. ilicifolia, which is increasing in abundance on the dampland. Transition toward terrestrial species is also apparent in the understorey. Vegetation condition generally excellent. • 39464649585: Some of the *M. preissiana* appear to have died recently leaving few living and numerous stags across the basin. There are also scattered *Banksia spp*. stags in the fringing vegetation. The remiaing vegetation is in excellent condition. • 39478648638: Tall scrub in excellent condition. Approximately 80% of *Melaleuca* dead or very stressed. *Most E. rudis* in good condition although drought stress is evident in a small proportion. Evidence of hot fire (>4yrs) which killed many *B. ilicifolia* in surrounding littoral vegetation. Scattered *Banksia sp*. & *X. preissii* establishing in the dampland. • 39498649636: Small dampland connected to Dampland 24 by broad area of *Melaleuca* woodland & tall scrub. Healthy *M. preissiana* are generally restricted to the west side of the dampland. Numerous stags & very stressed individuals occur across rest of basin. *B. ilicifolia* & *B. attenuata* are establishing within the dampland basin. Tall scrub in excellent condition. • 39507649695: There are numerous *B. ilicifolia* stags on the perimeter of the dampland which appear to have been killed by fire. The scrub is in excellent condition. The dampland appears to becoming terrestrialised, there are *B. ilicifolia* seedlings across the basin, also *Adenanthos sp*. & *Verticordia nitens*. • 39513649527: All *M. preissiana* very stressed or dead. *B. ilicifolia* colonising much of wetland (although many have been killed by fire). Tall scrub geneally in excellent condition. • 39514649463: Small dampland with some localised weed invasion & rubbish dumping in the north. All *M. preissiana* dead or stressed. Some drought stress in heath vegetation. *B. attenuata* & *B. ilicifolia* colonising into lower area of dampland. • 39527649600: Small dampland dominated by tall scrub in excellent condition. *Banksia spp*. encroaching onto the dampland. All *Melaleuca* dead. • 39547649649: Linear dampland with a *Banksia* overstorey & mixed terrestrial/wetland understorey. Approximately 50% of *Banksia sp*. dead. Myrtaceous species appear drought stressed in places although a central strip of tall scrub remains healthy. The edges & southern section are dominated by terrestrial species. • 39541649417: Small dampland close to Neaves Rd. Track runs through east side & has been used for rubbish dumping, also evidence of frequent fire. 50% of *Melaleuca* dead or very stressed. Young saplings in wetland centre in excellent health. Myrtaceous scrub shows localised signs of stress. • 39565649347: Large dampland dominated by tall closed scrub of *Kunzea* with scattered emergent trees. Some tracks intersect dampland causing disturbance & weed invasion. 50-60% of *Melaleuca* dead (some recently) or vey stressed. Scattered *M. preissiana* saplings can be found in tall scrub. Majority of *E. rudis* in excellent condition. Tall scrub in excellent condition. • 39550649619: Vegetation is in very good condition. However, there are scattered *M. preissiana* stags across the basin; some recent *Banksia spp*. stags; and large areas of drought-stressed scrub. • 39559649393: • 39572649792: Vegetation condition is very good to excllent However, ther are dead *Banksia sp*. on the wetland fringe which may be due to fire and drought. Also the tall scrub appears to be retreating, consequentially there is now a wide buffer of mixed wetland & terrestrial vegetation surrounding the basin. • 39616649454: Large dampland which has lost majority of overstorey & is being colonised by terrestrial species. Some rubbish dumping around perimeter. Only one living individual of *M. preissiana* remains. *E. rudis* is restricted to south-west corner & is very stressed. *Banksia sp*. establishing over much of the dampland. Some stressed & recently dead *B. ilicifolia* & *B. attenuata* occur on the south & west sides. Heath in generally very good condition. • 39627649484: Small dampland with indistinct, gradual transition from terrestrial to wetland vegetation type. Vegetation generally in excellent condition. Occasional stressed *E. rudis* & localised dead patches of scrub. Numerous *E. rudis* saplings occur on the western side. No evidence of *M. preissiana* within the wetland. • 39647649353: Large dampland with virtually all *Melaleuca* dead. *B. ilicifolia* colonsing much of the wetland. *B. ilicifolia* & *B. littoralis* in excellent condition. Tall scrub generally excellent condition with some localised dead patches. • 39712649551: Very few live *M. preissiana* remain although some regeneration is apparent on the southern side. *Eucalypts* are in very good condition. Evidence of fire in some sections of the heath although this is regenerating vigtourously. Terrestrial species form the dominant overstorey of the dampland. • 39876649518: The dampland is adjacent to private property used for market gardens. The dampland appears dry and drought stressed with very few *live M. preissiana* present. There are also very few *M. preissiana* stags indicating that these trees have been dead for quiet some time. There are also *B. ilicifolia* stags & patches of dead shrubland, the terrestrial vegetation appears to have	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
		dieback (*Phytophthora cinnamomi*). *B. attenuata* & *Dasypogon sp*. are establishing in the basin indicating terrestrialisation. • 39906649362: Wetland appears to be becoming terrestrialised. Condition of the terrestrial vegetation is generally excellent with only scattered dead patches of scrub. However, the absin appears to be drying & the *M. preissiana* population is very stressed, with many stags across the absin & *Banksia spp*. invading the basin. • 39592649232: Vegetation generally in very good to excellent condition. Terrestrial vegetation is in excellent condition and there are large areas of dense *E. rudis* saplings in the absin. However, the *M. preissiana* & *E. rudis* populations are very stressed, with stags across the basin. • 39685649249: Wetland is generally in poor condition. There are patches of drought stressed scrub in the basin and fringing vegetation. *B. attenuata* and *B. menziesii* are encroaching into the wetland. *M. preissiana* stags are present across the wetland which previously appeared to be a *M. preissiana* woodland, currently there appear to be no live *M. preissiana* left. • 39660649160: Small dampland dominated by tall Myrtaceous scrub & Banksia sp. Evidence of long dead *M. preissiana* stags in wetland. Overstorey is now dominated by *Banksia* species. Understorey generally in excellent condition. • 39813649148: Large areas of terrestrial vegetation appear to have been burnt approximately 3-5 years ago but are healthy. Vegetation in generally in excellent condition. However, approximately 50% of *M. preissiana* in the wetland are stags and *Banksia spp*. appear to be moving into the wetland. 39881649161: Wetland is generally in excellent condition. However, there are some disturbances; weeds are present in some areas, there are several tracks running through the eastern part and much of the terrestrial and a small section of the western part of the wetland are damaged by fire.	
1 dampland (39183649754)	*Hill et al. (1996)* • O C	*DoE (2004)* • Large dampland surrounded by cleared pine plantation. Vegetation varies with elevation & hence creates a mosaic structure. Disturbance includes numerous tracks around dampland and vegetation clearing. However, the dampland vegetation appears to be in excellent condition, with the M. preissiana population in near pristine condition making this a unique dampland. Understorey is in excellent condition, as is the overstorey. There are E. rudis saplings on parts of the basin.	
6 damplands (39421649304, 39442649618, 39443649445, 39433649770, 39510659739, 39575649169)	*Hill et al. (1996)* • W C	*DoE (2004)* • 39421649304: Large dampland with variable vegetation complexes ranging from wet areas dominated by Astartea sp. through to terrestrial communities. Western area has been cleared for housing & farming and high tension power lines divide the remaining intact area. Remaining vegetation is in generally excellent condition. Wetland trees are healthy which is unusual in the regional context. One area of trees (south-east) has been affected by recent fire. Understorey is excellent where not disturbed by clearing. • 39442649618: Surrounding vegetation has been cleared to the wetland edge except on east side (appeared to have been pine plantation). Other disturbances include; road circling wetland; mining for diatomaceous earth; numerous weed species and fire. Very dense *M. preissiana* on the north-western side. Vegetation is generally in excellent condition, with only several *M. preissiana* stags in the far eastern part of the wetland. • 39443649445: Large wetland divided by logging road. North-west section lies within pine plantation & south-east section within remnant vegetation. Approximately 90% of *Melaleuca* dead, some recently. Banksia sp. colonsing central section of dampland. Heath in excellent condition. All *Melaleuca* dead in northern section & large patches of heath have died recently. • 39433649770: Terrestrial species appear to be invading wetland, large mixed terrestrial & wetland vegetation buffer surrounding a small retreated basin. Vegetation condition generally excellent. Very few M. preissiana at this site (several re-sprout individuals in basin & no stags). Scrub in excellent condition. • 39510659739: Dampland disturbed by several roads & hot fire 5-6 years ago. Vegetation very good to excellent condition. M. preissiana restricted to small area in north-west corner but in excellent condition. Numerous B. ilicifolia stags in the dampland appear to have been killed bu fire. Numerous B. ilicifolia seedlings across basin. Tall scrub in excellent condition. • 39575649169: Small remnant wetland within cleared pine plantation. Wetland was probably cleared initially & has been recolonised by wetland shrubs, no wetland trees present. Tall scrub in very good condition. Some invasion of annual weeds & pine seedlings.	
Sumpland (39969949158)	*Hill et al. (1996)* • SW C	*DoE (2004)* • Most of the wetland overstorey is on the edge of the basin, as opposed to across the basin. Banksia attenuata seedlings are present on the basin, indicating that the wetland may be becoming drier. Vegetation is generally in excellent condition.	
6 sumplands (39556649708, 39554649527, 39582649556, 39576649679, 39610649565, 39653649561)	*Hill et al. (1996)* • SW C	*DoE (2004)* • 39556649708: Wetland generally in excellent condition. Disturbance includes, fire in the north & mining for diatomaceous earth in the basin. Some establishment of terrestrial plants in the wetland. However, *M. preissiana* appears to be regenerating well however, mature trees to the norh are very stressed or dead. *Bossiaea articulata* population appears to have been very stressed, but appears to be regenerating.	

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
		• 39554649527: Small dampland with generally intact heath. No evidence *of M. preissiana*. Numerous dead *B. ilicifolia* and some dead *B. attenuata*. Evidence of recent hot fire. Some localised dead patches of scrub otherwise vegetation in good condition. • 39582649556: Dense areas of annual & perennial weeds along tracks which pass through southern end. Vegetation is generally in good to very good condition. Approximately 50% *E. rudis* & *M. preissiana* are stressed or very stressed with some recent deaths of E. rudis. Scattered Banksia sp. stags & patches of dead scrub which appear to be drought affected. • 39576649679: Vegetation generally in very good condition. Numerous *M. preissiana* stags across basin no live specimens left. Areas of dead scrub, possibly due to drought stress & some dead *Banksia sp*. • 39610649565: Evidence of terrestrialisation. Vegetation generally in excellent condition. Large areas of dead scrub & shrubland. 50% of *M. preissiana* showing signs of chlorosis. • 39653649561: This wetland is degraded by adjacent road and rubbish dumping. Vegetation condition is generally very good to excellent. However, there are numerous *M. preissiana* stags across the basin; the living *M. preissiana* are very stressed; *E. rudis* is also slightly stressed. *B. ilicifolia* & *B. attenuata* appear to be extending their range into the wetland.	
1 sumpland (39920649456)	*Hill et al. (1996)* • W C EPP	*DoE (2004)* • Part of wetland in private property & consequentially that part is invaded with weeds & possibly grazed by livestock. Remaining wetland & terrestrial vegetation is generally in excellent condition	
Bassendean North Complex – Lexia			
4 sumplands (40141648670, 40132648626, 40149648594, 40163648635) & 1 dampland (40135648601)	*Hill et al. (1996)* • ASWO C	No record of current condition of wetlands.	
Sumpland (40148648729)	*Hill et al. (1996)* • ASO C EPP	No record of current condition of wetland.	
Sumpland (40156648685, 40238648707)	*Hill et al. (1996)* • ASO C	No record of current condition of wetland.	
Dampland (40203648567) & 1 sumpland (40256648635)	*Hill et al. (1996)* • WO C EPP	No record of current condition of wetland.	
Sumpland (40292643721)	*Hill et al. (1996)* • O C EPP	No record of current condition of wetland.	
2 damplands (40297648639, 40346648631) & 1 sumpland (40140648683)	*Hill et al. (1996)* • O C	No record of current condition of wetland.	
Dampland (40272648506)	*Hill et al. (1996)* • W C	No record of current condition of wetland.	
Spring near The Maze, NW of Bullsbrook	Site listed as a Mound Springs TEC (KING01) in 1995 based on vegetation composition.	*Personal observation of authors (March 2004)* • Apparent decline in water levels. • Drying of understorey. • Invasion by exotics – bracken fern and blackberry. *DoE (2004)* • Spring fed wetland in area of mixed rural uses & remnant vegetation (dry in April 2004). Remnant terrestrial & wetland vegetation to west in excellent condition. To the east vegetation in good condition however, blackberry rapidly invading & dominating understorey.	• Supports threatened ecological communities (Communities of Tumulus Springs – see p. 5).
Yanga Complex			
Bambun Lake (39435652283)	*EPA (1983)* • Contains Western Minnow, Swan River goby, Nightfish & Mosquitofish. *Hill et al. (1996)* • SWO C EPP	*DoE (2004)* • Permanent wetland. Narrow fringe of littoral vegetation surrounds the lake. Some buffer remains although the majority of the surrounding land is cleared farmland. Very weedy understorey around lake.	• Supports threatened ecological communities – TEC SCP15 and SCP07 (see p.9) • Key faunal habitat area.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	Government of WA (2000) • Supports TEC SCP15 (BAMBUN02), SCP07 (BAMBUN01, BABUM03). *Mattiske and Associates (2002)* • Reserve C24257 & 22831. • Managed for conservation of flora and fauna. *WA Herbarium (2003)* • DRF; R – *Eleocharis keigheryi*, P2 – *Isotropis cunefolia subsp. glabra*.. *Bamford and Bamford (2003)* • Key faunal habitat area. • Important for waterbird use.		• Supports rare and priority flora.
Lake Nambung (39421652168)	*Hill et al. (1996)* • SWO C EPP. *Mattiske and Associates (2002)* • Reserve C24257. • Managed for conservation of flora and fauna. *Bamford and Bamford (2003)* • Key faunal habitat area.	*DoE (2004)* • Ephemeral lake with narrow strip of littoral vegetation to the south and east separating the wetland from farmland. Some remnant vegetation occurs to the north-west.	• Key faunal habitat area. • Important for waterbird use.
Lake Mungala (39482652119)	*Hill et al. (1996)* • SWO C EPP. *Mattiske and Associates (2002)* • Reserve C24257. • Managed for conservation of flora and fauna. *Bamford and Bamford (2003)* • Key faunal habitat area. • Lake Mungala important for waterbird use.	*DoE (2004)* • Wetland completely surrounded by private property. Owners refused access. Following comments are made from distant inspection. Wetland appears to be dry. Trees appear to be in good health.	• Key faunal habitat area.
Springs on Lot 11 Archibald St., Muchea (site 5s of Jasinska & Knott, 1994)	*Jasinska & Knott (1994)* • Sampled in Autumn 1994. • 23 species of invertebrate, including 5 endemic taxa. *CALM* • Mound Spring TEC (PETERS01) listed in 1995 for vegetation and invertebrate fauna.	Site is now in a Nature Reserve. Site dried in 1999/2000.	• Supports threatened ecological community - Mound Spring (PETERS01) (see p. 5)
Spring sites 3s, 3b, 3r, 4, 5ps, 5pd, 5d, 6, and 7	*Jasinska & Knott (1994)* • Contain restricted and endemic invertebrate fauna. • Contain 53 taxa which were endemic to these sites.	Current status is unknown as sites have not been monitored since 1994.	• Supports restricted and endemic invertebrate fauna.
Jandakot			
Bassendean Central & South Complex			
Mather Reserve (39361644253) sumpland	*WAWA (1992)* Supports large *Melaleuca* and *Melaleuca* thicket. Water bird feeding. *Hill et al. (1996)* NO C EPP. *Government of WA (2000)* Bush Forever Site 263. (See terrestrial vegetation GDEs for significant species)	*WAWA (1992)* • Boundary extensively modified. • Area has supported agricultural activity.	In absence of information to the contrary; • Supports large *Melaleuca* and *Melaleuca* thicket. • Water bird feeding. • Bush Forever Site 263.
Copolup Lake (39075644156) sumpland	*WAWA (1992)* Waterbird breeding. *Hill et al. (1996)* R EPP.	No record of current condition of wetland.	In absence of information to the contrary; • Water bird breeding.
Branch St Swamp	*WAWA (1992)*	No record of current condition of wetland.	In absence of information to the

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
(39094644246) sumpland	Potential use as feeding area for secretive waterbird species. Potential use for breeding by bird species whose young leave nest shortly after hatching. *Hill et al. (1996)* C EPP.		contrary; • Potential use as feeding area for secretive waterbird species. • Potential use for breeding by bird species whose young leave nest shortly after hatching.
Forest-Tapper Swamp (39297644396) sumpland	*WAWA (1992)* • Waterbird breeding. *Hill et al. (1996)* • R EPP	No record of current condition of wetland.	In absence of information to the contrary; • Water bird breeding.
Solomon Rd Swamp (39232644307) sumpland	*WAWA (1992)* • Support non-aquatic species of vertebrate. • Vegetation communities not widely represented elsewhere in the region. *Hill et al. (1996)* • R EPP	No record of current condition of wetlands.	In absence of information to the contrary; • Supports non-aquatic species of vertebrate. • Vegetation communities not widely represented elsewhere in the region.
Mandogalup (Wattelup) Lake (38930643850) sumpland	*WAWA (1992)* • Waterbird breeding and summer loafing area. *Davis et al., (1993).* • Coloured wetland of extremely high conservation value given uniqueness. *Hill et al. (1996)* • S C EPP	No record of current condition of wetland.	In absence of information to the contrary; • Water bird breeding and summer loafing area.
Herdsman Complex			
Little Rush Lake (sumpland)	Hill et al. (1996) • SW C EPP	No record of current condition of wetland	
Spectacles North (39041643485) sumpland	*WAWA (1992)* • Representative closed *Melaleuca* woodland. • Range of habitat types. • Waterbird breeding site. • Waterbird monitoring. *Davis et al., (1993).* • Coloured wetland of extremely high conservation value given uniqueness *Hill et al. (1996)* • NWO C EPP *Government of WA (2000)* • Bush Forever Site 269. (See terrestrial vegetation GDEs for significant species)	*Davis et al., (1993)* • Destruction of fringing vegetation.	In absence of information to the contrary; • Representative closed *Melaleuca* woodland. • Range of habitat types. • Waterbird breeding site. • Waterbird monitoring. • Bush Forever Site 269.
East Swamp (38996644985) sumpland	*WAWA (1992).* • Habitat for non-avian fauna. (Bandicoot) *Hill et al. (1996)* • WO C EPP. *Government of WA (2000)* • Bush Forever Site 244. (See terrestrial vegetation GDEs for significant species)	No record of current condition of wetland.	In absence of information to the contrary; • Habitat for non-avian fauna. • Bush Forever Site 244.
Hope Rd (38892644967) lake	*WAWA (1992)* • Supports vegetation not represented in nearby wetlands.	No record of current condition of wetland.	In absence of information to the contrary;

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	Hill et al. (1996) • S C EPP.		• Supports vegetation not represented in nearby wetlands.
Southern River Complex			
Harrisdale Swamp (sumpland)	*Hill et al. (1996)* • WO C EPP. *Government of WA (2000)* • Bush Forever Site 253.	No record of current condition of wetland.	• Bush Forever Site 253.
Lake Balanup (sumpland)	*Hill et al. (1996)* • R EPP *Government of WA (2000)* • Bush Forever Site 413 *McGuire et al. (2001)* • Significant wetland – high aquatic macroinvertebrate species richness.	*McGuire et al. (2001)* • Poor water quality • Destruction of fringing vegetation	In absence of information to the contrary; • Supports high aquatic macroinvertebrate species richness. • Bush Forever Site 413.
TERRESTRIAL ECOSYSTEMS			
Gnangara			
Cottesloe Central and south Complex			
Wilbinga-Caraban Bushland (9158.3ha) – Spearwood dunes: *E. gomphocephala* open forest to woodland; *E. todtiana, B. attenuata, B. menziesii* low open forest. Quindalup Dunes: open low heaths.	*Government of WA (2000)* • Bush Forever Site 406. • Supports TEC 26a (MYWAN01-04, MYWABL01-19, WABL01, SHE04-05, MYSHEA-09. *WA Herbarium (2003)* • DRF; R - *Eucalyptus argutifolia*, P1 - *E. x mundijongensis.*	*CSIRO (2001)* • 1988-2000 change in vegetation density range from no change to significant increase.	• Supports threatened ecological communities (see p.5). • Supports declared rare and priority flora. • Bush Forever Site 406.
Yanchep National Park and adjacent Bushland (2706.7ha inc open water) – *E. gomphocephala* or *E. marginata* open forest generally over or mixed with *Banksia* low open forest and low woodland & often with *C. calophylla* or *A. fraseriana; B. attenuata* and *B. menziesii* low open forest often with *A. fraseriana, E. marginata, E. todtiana, B. grandis* or *N. floribunda.*	*Government of WA (2000)* • Bush Forever Site 288. • Supports TECs SCP19 (XYAN10), Limestone ridges SCP26a (MYYAN02, MYYAN03, MYYAN07, YAN02). *Mattiske and Associates (1988*) • Yanchep terrestrial vegetation monitoring transect established 1987. *WA Herbarium (2003)* • DRF; P3 - *Lasiopetalum membranacuem.*	*Mattiske and Associates (2003)* • Slight decline in number of healthy *B. littoralis* and *M. rhaphiophylla* stems on Yanchep monitoring transect since 1999. • Increase in number of healthy *E. rudis* stems since 1999. *CSIRO (2001)* • 1988-2000 change in vegetation density range from no change to increase.	• Supports threatened ecological communities (see p. 8). • Supports priority flora. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Bush Forever Site 288.
Cottesloe North/Cottesloe Central & South Complex			
Ridges and adjacent Bushland – Yanchep (3004.9ha) - *E. gomphocephala* woodland; *E. marginata* open forest to open woodland; low woodland of *B. attenuata, B. menziesii, B. grandis, A. fraseriana* and *N. floribunda.*	*Government of WA (2000*) • Bush Forever Site 381. • Supports TEC Limestone Ridges (SCP26a) (YAN12, YAN13, YAN15, YAN24, YAN25, MYPARROT01, MYPARROT02, MYYAN01, MYYAN04-06, MYYEAL01-05, MYHADR01-02). *Mattiske and Associates (1988)* • Ridges terrestrial vegetation monitoring transect established 1987. *WA Herbarium (2003)*	*CSIRO (2001)* • 1988-2000 vegetation density decreased in the east, remaining stable to increasing in the west and central areas of the site.	• Supports threatened ecological communities (see p. 5). • Supports declared rare and priority flora. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	• DRF; R – *Eucalyptus argutifolia*, P2 - *Haloragis aculeolata.*		• Bush Forever Site 381.
State Forest 65 – Pinjar Plantation South Bushland, Nowergup/Yanchep/Neerabup (61.5ha – 15 remnants) – not described	*Government of WA (2000)* • Bush Forever Site nos. 95, 134-137, 139, 140, 417, 425, 428, 444, 446, 451, 455, 457.		• Bush Forever Sites.
Neerabup National Park, Lake Nowergup Nature Reserve and adjacent Bushland, Neerabup (1736.1ha inc. open water) – *E. gomphocephala* woodland to open forest; *E. marginata* woodland to forest over *Banksia* woodland; woodlands dominated by *B. attenuata, B. menziesii, A. fraseriana* and *N. floribunda*.	*Government of WA (2000)* • Bush Forever Site 383. • Supports TEC 26a (NEERABUP01-08). *Mattiske and Associates (1988)* • Lake Nowergup terrestrial vegetation monitoring transect established 1987.	*Mattiske and Associates (1996)* • Nowergup transect not monitored since 1990. *CSIRO (2001)* • 1988-2000 vegetation density stable to increasing in Neerabup NP, stable to decreasing in remainder.	• Supports threatened ecological community (see p. 5). • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Bush Forever Site 383.
Garden Park Bushland, Wanneroo (5.1ha) - *B. attenuata, B. menziesii* and *B. ilicifolia* low open forest to low woodland with emergent *E. marginata; E. marginata, B. attenuata, B. menziesii* low open forest to woodland; C. calophylla open forest to woodland.	*Government of WA (2000)* • Bush Forever Site 470.		• Bush Forever Site 470.
High Road Bushland, Wanneroo (41.8ha) – *B. ilicifolia, B. attenuata* low open forest; *B. attenuata, B. menziesii, A. fraseriana* low woodland to open forest.	*Government of WA (2000)* • Bush Forever Site 471.	*CSIRO (2001)* • 1988-2000 vegetation density change patchy across site.	• Bush Forever Site 471.
Errina Road Bushland, Alexander Heights (8.5ha) - *B. attenuata, B. menziesii* low woodland with scattered emergent *E. marginata* and *B. ilicifolia*.	*Government of WA (2000)* • Bush Forever Site 493. • Supports TEC SCP 20a. (ERRINA01-05) • A Class Nature Reserve.	*CSIRO (2001)* • 1988-2000 vegetation density decreased significantly.	• Supports threatened ecological communities (see p. 10). • Bush Forever Site 493.
Lake Gwelup Reserve, Gwelup (19.9ha) – *E. gomphocephala* low woodland to open forest; *C. calophylla* and *E. gomphocephala* open woodland.	*Government of WA (2000)* • Bush Forever Site 212.	*CSIRO (2001)* • 1988-2000 vegetation density increased.	• Bush Forever Site 212.
Decourcey Way Bushland, Marangaroo (32.8ha) - *B. attenuata* low woodland with scattered emergent *E. marginata.*	*Government of WA (2000)* • Bush Forever Site 328. • Supports TEC SCP 20a (GOLF01-03).	*CSIRO (2001)* • 1988-2000 vegetation density increased to significantly increased.	• Supports threatened ecological communities (see p. 10). • Bush Forever Site 328.
Landsdale Road Bushland, Landsdale (15.78ha) – *B. attenuata* and *B. menziesii* low	*Government of WA (2000)* • Bush Forever Site 199. • Supports TEC SCP 20a (LAND01).	*CSIRO (2001)* • 1988-2000 vegetation density increased to significantly increased.	• Supports threatened ecological communities (see p. 10). • Bush Forever Site 199.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
woodland with scattered emergent *E. marginata.*			
Koondoola Regional Bushland (123.5ha) – *B. attenuata, B. menziesii, A. fraseriana* low woodland to low open woodland with scattered emergent *E. marginata.*	*Government of WA (2000)* • Bush Forever Site 201. • Supports TEC SCP 20a. • A Class Nature Reserve.	*CSIRO (2001)* • 1988-2000 vegetation density stable.	• Supports threatened ecological communities (see p. 10). • Bush Forever Site 201.
Bassendean North Complex			
State Forest 65 – Gnangara Plantation Bushland (31.5ha – 21 remnants)– boundary has been drawn to include any unmapped Bushland remnants & wetlands in the pine plantation	*Government of WA (2000)* • Bush Forever Site nos. 96, 99, 101-108, 126, 427, 432, 433, 441, 448, 450, 452, 459, 461.	*CSIRO (2001)* • 1988-2000 change in vegetation density patchy across area.	• Bush Forever Sites.
Della Road South Bushland, Bullsbrook (10.1ha) – *M. rhaphiophylla, E. wandoo* low open woodland.	*Government of WA (2000)* • Bush Forever Site 298.	*CSIRO (2001)* • 1988-2000 vegetation density increased to significantly increased.	• Bush Forever Site 298.
Wabling Management Priority Area	*Mattiske and Associates (1988)* • Tick Flat vegetation monitoring transect established 1966. *Mattiske and Associates (2002)* • Reserve A24436 – Tick Flat. • Managed for conservation of flora, fauna and landscape. *WA Herbarium (2003)* • DRF; R – *Eucalyptus argutifolia.*	*Mattiske and Associates (2001)* • Decline in number of healthy *B. littoralis, B. ilicifolia, E. rudis* and *M. preissiana* stems across Tick Flat transect since 1996. *CSIRO (2001)* • 1988-2000 vegetation density increased in east of site and decreased in west.	• Supports declared rare flora. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Yeal Nature Reserve Mosaic of low open *B. attenuata* and *B. menziesii* woodlands with *B. ilicifolia* and shrublands	*Mattiske Consulting Pty Ltd (2002)* • Entered in register of National Estate Includes reserves C31241 and C33784. • Not included in Bush Forever Study area. • Rare flora recorded in area. *Mattiske and Associates (1988)* • Yeal Swamp terrestrial vegetation monitoring transect established 1987. *WA Herbarium (2003)* • DRF; P1 – *Grevillea evanescens.* P3 – *Dillwynia dillwynioides.*	*CSIRO (2001)* • 1988-2000 vegetation density increased in east of site, increased significantly in center of Park and decreased in west. *Mattiske and Associates (2003)* • Increase in number of healthy *M. preissiana* and *B. ilicifolia* on Yeal Swamp transect since 1996. • Decline in number of healthy E. rudis stems since 1996. • Decline in abundance *of H. angustifolium* since 1996.	• Supports priority flora. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Tangletoe- Mosaic of low open *B. attenuata* and *B. menziesii* woodlands with *B. ilicifolia* and shrublands	*Mattiske and Associates (1988)* • Tangletoe terrestrial vegetation monitoring transect established 1987. Not included in Bush Forever Study area.	*CSIRO (2001)* • 1988-2000 vegetation remained stable or increased in vicinity of transect. *Mattiske and Associates (2003)* • Increase in number of healthy *B. ilicifolia* and *M. preissiana* stems since 1999 on Tangletoe transect.	• Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Kirby Rd Bushland , Bullsbrook (440.7ha) – *B. attenuata* low woodland with occasional *N. floiribunda, A. fraseriana, C. calophylla* & *B. ilicifolia.*	Supports TEC Communities of Tumulus Springs (KINGS 01). *Government of WA (2000)* • Bush Forever Site 97. *Connell (1995).* • Vegetation condition: very good to good.	*CSIRO (2001)* • 1988-2000 vegetation density ranged from decreasing to increasing across site.	• Supports threatened ecological community (see p. 3) • Bush Forever Site 97.
Department of Defence – Muchea Air Weapons Range Bushland	*Government of WA (2000)* • Bush Forever Site 462.	*CSIRO (2001)* • 1988-2000 vegetation density decreased in south of site and decreased in north. *Mattiske Consulting Pty Ltd (2003)*	• Representative of terrestrial vegetation with respect to structure, composition and fauna

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
(1759.3) – low lying *Banksia attenuata* woodlands or shrublands*; Banksia ilicifolia* woodlands.	• Vegetation condition: >40% excellent, <40% very good, <15% good, with areas of severe localized disturbance. *Mattiske Pty Ltd (2003)* • Neaves terrestrial vegetation monitoring transect established 1966. • Bombing Range terrestrial vegetation monitoring transect established 2002.	• Bombing Range transect initial monitoring 2002.	habitat. • Bush Forever Site 462.
Bassendean North Transition Complex			
Hawkins Rd Bushland, Jandabup (313.9ha) - *B. attenuata, B. menziesii, E. todtiana* & A. fraseriana low woodland; *B. attenuata, B. menziesii* low open forest; *B. attenuata, B. ilicifolia* low woodland.	*Government of WA (2000)* • Bush Forever Site 326.	*CSIRO (2001)* • 1988-2000 vegetation density decreased significantly in areas sub-divided for rural blocks and remained stable across remainder of site.	• Bush Forever Site 326.
Bassendean Central and South Complex			
Gnangara Lake and adjacent Bushland, Gnangara (162.3ha inc open water) - *B. attenuata, B. menziesii, E. todtiana* low open woodland; E. marginata open forest; B. attenuata, B. menziesii low open forest; *B. menziesii, B. ilicifolia, B. attenuata, E. todtiana, N. floribunda* low open woodland.	*Government of WA (2000)* • Bush Forever Site 193. *Mattiske and Associates (1988)* • South Kendall terrestrial vegetation monitoring transect established 1987. *WA Herbarium (2003)* • DRF; P3 – *Cyathachaeta teretifolia.*	*Mattiske and Associates (1996)* • South Kendall transecst not monitored since 1996. *CSIRO (2001)* • 1988-2000 vegetation density remained stable east of lake.	• Supports priority flora. • Bush Forever Site 193.
Herdsman Complex			
Badgerup Lake and Adjacent Bushland, Wanneroo (92.6ha inc. open water) – *E. marginata* open forest to closed forest; *B. attenuata, B. menziesii* low open forest.	*Government of WA (2000)* • Bush Forever Site 327.	*CSIRO (2001)* • 1988-2000 vegetation density increased in north-east and Decreased in south-east.	• Bush Forever Site 327.
Yellagonga Regional Park, Wanneroo/Woodvale (380.9 ha inc. open water) - *E. gomphocephala* tall open forest over *B. grandis; B. attenuata* and *C. marginata* woodland. Wetlands – *E. rudis* scattered open forest to woodland.	*Government of WA (2000)* • Bush Forever Site 299. *WA Herbarium (2003)* • DRF; P4 – *Jancksonia sericea.*	*CSIRO (2001)* • 1988-2000 vegetation density decreased west of Lake Joondalup and decreased to west. Density increased around Lake Goollelal.	• Supports priority flora. • Key faunal habitat. • Bush Forever Site 299.
Pinjar Complex			
Numbat Rd Bushland, Mariginiup (64.4ha) – *B. attenuata, B. ilicifolia, B. menzeisii* low woodland.	*Government of WA (2000)* • Bush Forever Site nos. 141, 146.	*CSIRO (2001)* • 1988-2000 vegetation density increased significantly.	• Bush Forever Sites 141, 146.
Little Coogee Flat, Pinjar (5.6ha) – vegetated wetlands. Not	*Government of WA (2000)* • Bush Forever Site 443.	*CSIRO (2001)* • 1988-2000 vegetation density increased.	• Bush Forever Site 443.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
described.			
Southern River Complex			
Cardinal Drive Bushland, Ellenbrook (26.8ha) – Low closed woodland to low open woodland of *B. attentuata, B. menziesii* or *B. ilicifolia* and combinations of these sometimes with *C. calophylla; C. calophylla* woodland.	*Government of WA (2000)* • Bush Forever Site 23. • Northern most occurrence of Southern River Complex. • Supports TEC Shrublands and woodlands on Muchea Limestone and SCP 18.	*CSIRO (2001)* • 1988-2000 vegetation density decreased significantly.	• Supports threatened ecological communities. • Bush Forever Site 23.
Caversham Airbase Bushland, West Swan (97ha) – *E. marginata* woodland to open woodland over *B. attenuata* and *B. menziesii* low woodland; *C. calophylla* low woodland.	*Government of WA (2000)* • Bush Forever Site 200.	*CSIRO (2001*) • 1988-2000 vegetation remained stable.	• Bush Forever Site 200.
Yanga Complex			
Ellenbrook, Upper Swan (44.1ha) – *E. rudis* open forest to woodland over/or *M. rhaphiophylla* low open forest to woodland.	*Government of WA (2000)* • Bush Forever Site 296.	*CSIRO (2001)* • 1988-2000 vegetation density increased.	• Bush Forever Site 296.
Bullsbrook Nature Reserve and Adjacent Bushland (191.8ha) – *E. marginata* woodland to forest; *C. calophylla* woodland*; B. attenuata* and *B. menziesii* woodland with scattered *E. todtiana*.	*Government of WA (2000)* • Bush Forever Site 292. • Supports TEC SCP07 (BULL06, BULL08).		• Supports threatened ecological communities. • Bush Forever Site 292.
Sawpit Road Bushland, Bullsbrook (14.8ha) – not described.	*Government of WA (2000)* • Bush Forever Site 13.	*CSIRO (2001)* • 1988-2000 vegetation density stable to decreasing.	• Bush Forever Site 13.
Twin Swamps Nature Reserve and Adjacent Bushland, Bullsbrook (170.7ha inc. open water) – woodland to open forest dominated by *B. menziesii* or *B. attenuata*. Wetlands: *M. rhaphiophylla* low closed to open forest.	*Government of WA (2000)* • Bush Forever Site 400. • Supports TEC SCP 15 (TWIN05, TWIN10). *ANCA (1996)* • Ellen Brook & Twin Swamps wetlands contain wild and stocked populations of the Western Swamp Tortoise (*Pseudemydura umbrina*) the most endangered vertebrate animal in Australia.	*Morgan (2002)* • Perched wetlands, with inundation in Twin Swamps supplemented by a bore.	• Supports threatened ecological communities. • Supports threatened fauna. • Bush Forever Site 400.
Ellenbrook Nature Reserve and Adjacent Bushland, Upper Swan (63.6ha) – *C. calophylla* open forest to woodland. Wetlands: *E. rudis* open forest.	*Government of WA (2000)* • Bush Forever Site 301. • Supports significant reptile species – Western Swamp Tortoise. • Supports TEC SCP 3c (ELLEN06), SCP 08 (ELLEN01-05).		• Supports threatened ecological communities. • Supports threatened fauna. • Bush Forever Site 301.
Jandakot			
Bassendean Central & South Complex			

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
North Lake, North Lake – *E. marginata* open forest, *B. attenuata, B. menziesii, Allocasuarina fraseriana* low open forest.	*Government of WA (2000)* • Bush Forever Site 244. • Significant flora. • Vegetation condition: >20% good to very good, <80% degraded, with areas of severe localized disturbance. • Significant bird species. • Significant mammal species. • Supports freshwater sponges.	*CSIRO (2001)* • 1988-2000 vegetation density stable to increasing.	• Supports freshwater sponges. • Bush Forever Site 244.
Bibra Lake, Bibra Lake - *B. attenuata, B. menziesii, Allocasuarina fraseriana* low open forest, with *E. marginata.*	*Government of WA (2000)* • Bush Forever Site 244. • Significant flora. • Vegetation condition: >20% good to very good, <80% degraded, with areas of severe localized disturbance. • Significant bird species. • Significant mammal species.	*CSIRO (2001)* • 1988-2000 vegetation density stable to increasing.	• Supports significant fauna species. • Bush Forever Site 244.
South Lake - *E. marginata* & *C. calophylla* open forest, *B. attenuata, B. menziesii* low open forest.	*Government of WA (2000)* • Bush Forever Site 254. *Weston (1993)* • Vegetation condition: >50% good to very good, with areas of severe localized disturbance. WA Herbarium (2003) • DRF; P4 – *Dodoneae hackettiana.*	*CSIRO (2001)* • 1988-2000 vegetation density stable to increasing.	• Supports priority flora. • Bush Forever Site 254.
Mandogalup Rd Bushland, Mandogalup - *E. gomphocephala* low open woodland over scattered *E. marginata, B. attenuata* & *B. grandis*; Mixed *E. marginata, B. attenuata, B. menziesii, B. grandis* open forest.	*Government of WA (2000)* • Bush Forever Site 268.	*CSIRO (2001)* • 1988-2000 vegetation density stable to increasing.	• Bush Forever Site 268.
The Spectacles - *C. calophylla* & *B. attenuata* low woodland.	*Government of WA (2000)* • Bush Forever Site 269. • Significant flora. • Significant mammal species. • Significant reptile species. *Weston (1993).* • Vegetation condition: >60% excellent to very good, <40% good to degraded. WA Herbarium (2003) • DRF; P4 – *Dodoneae hackettiana.*	*CSIRO (2001)* • 1988-2000 vegetation density increased in eastern half of wetland, increased significantly east of wetland and showed no change to the west.	• Supports priority flora. • Bush Forever Site 269.
Sandy Lake & adjacent Bushland, Anketell - *B. attenuata* & *B. menziesii* low woodland to low open forest with *scattered E. gomphocephala* & *Allocasuarina fraseriana, Nutysia floribunda* & *E. todtiana.*	*Government of WA (2000)* • Bush Forever Site 270.	*CSIRO (2001)* • 1988-2000 vegetation density patchy across site.	• Bush Forever Site 270.
Sicklemore Rd Bushland, Parmelia/Casuarina - mixed *B. attenuata, B.*	*Government of WA (2000)* • Bush Forever Site 272.	*CSIRO (2001)* • 1988-2000 vegetation density increased.	• Bush Forever Site 272..

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
menziesii and *Allocasuarina fraseriana* low woodland with emergent *C. calophylla.*			
Casuarina Prison Bushland - *B. attenuata, B. ilicifolia* & *E. marginata* low woodland: *B. attenuata, B. ilicifolia* low open forest.	*Government of WA (2000)* • Bush Forever Site 273.	*CSIRO (2001)* • 1988-2000 vegetation density increased.	• Bush Forever Site 273.
Wandi Nature Reserve & adjacent Bushland, Wandi/Oakford – *B. attenuata, B. menziesii, B. ilicifolia, A fraseriana* & *E. todtiana* low woodland; *B. attenuata, B. menziesii* & *B. ilicifolia* low woodland.	*Government of WA (2000)* • Bush Forever Site 347. • A Class Reserve.	*CSIRO (2001)* • 1988-2000 vegetation density increased in east of site and showed little change in the west.	• Bush Forever Site 347.
Banjup Bushland, Banjup - *B. attenuata* & *B. menziesii* low woodland; *B. attenuata* low woodland with scattered *B. menziesii, B. ilicifolia* & *E. todtiana*.	*Government of WA (2000)* • Bush Forever Site 263. • Significant flora. • Significant mammal species. *Trudgen (1990)* • Vegetation condition: >80% excellent, >20% good to completely degraded. WA Herbarium (2003) • DRF; P4 – *Verticordia lindleyi subsp. lindleyi.*	*CSIRO (2001)* • 1988-2000 vegetation showed no change.	• Supports priority flora. • Bush Forever Site 263.
Modong Nature Reserve & adjacent Bushland, Oakford – *C. calophylla* woodland; *B. attenuata* low woodland; *B. attenuata* & *B. ilicifolia* low open forest.	*Government of WA (2000)* • Bush Forever Site 348. *Mattiske (2001)* • Modong East and West vegetation monitoring transects established 1988.	*Mattiske and Associates (2001)* • Modong East - Increase in number of healthy *M. preissiana, B. ilicifolia, B. menziesii* and *B. attenuata* stems since 1991. • Decrease in number of *A. fascicularis, H. angustifolium* and *P. ellipticum* since 1991. • Modong West - Increase in number of healthy *M. preissiana* stems since 1991. • Increase in number of healthy *B. ilicifolia* stems since 1997 Decrease in number of healthy *B. attenuata* and *B. menziesii* stems since 1997. • Decrease in number of *A. fascicularis, H. angustifolium* and *P. ellipticum* since 1991. *CSIRO (2001)* • 1988-2000 vegetation density decreased in center of reserve showing little change elsewhere.	• Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Bush Forever Site 348.
Herdsman Complex			
Harry Waring Marsupial Reserve, Wattleup – *E. marginata* open woodland; *B. attenuata* & *B. menziesii* low open woodland to low closed forest.	*Government of WA (2000)* • Bush Forever Site 392. • Significant flora. • Significant mammal species. *Weston (1993).* • Vegetation condition: >70% excellent to very good, 30% good to degraded. WA Herbarium (2003) • DRF; P4 – *Dodoneae hackettiana.*	*CSIRO (2001)* • 1988-2000 vegetation density decreased in east of reserve showing little change elsewhere.	• Supports priority flora. • Bush Forever Site 392.
Southern River Complex			
Piarra Nature Reserve, Forrestdale - B. menzesii, B. ilicifolia & E.	*Government of WA (2000)* • Bush Forever Site 262.	*CSIRO (2001)* • 1988-2000 vegetation density decreased in east of reserve showing little change elsewhere.	• Bush Forever Site 262.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
marginata low open forest. Anstey/Keane dampland & adjacent Bushland, Forrestdale - *B. attenuata, B. menziesii* & *Allocasuarina fraseriana* low woodland to low open forest with *scattered E. marginata, Nutysia floribunda* & *E. todtiana.*	*Government of WA (2000)* • Bush Forever Site 342. • Supports TEC SCP 10a and SCP 08. WA Herbarium (2003) • DRF; P4 – *Jacksonia sericea, Drosera occidentalis subsp. occidentalis, Villarsia submersa.*	*CSIRO (2001)* • 1988-2000 vegetation density increased or increased significantly across site.	• Supports threatened ecological community (no record of TEC on CALM data base). • Bush Forever Site 342. • Supports priority flora.
Balannup and adjacent Bushland, Southern River/Forrestdale – E. todtiana open woodland; *B. attenuata, B. menziesii* & *N. floribunda* low woodland; *B. menziesii* & *B. ilicifolia* low woodland to low open forest.	*Government of WA (2000)* • Bush Forever Site 413.	*CSIRO (2001)* • 1988-2000 vegetation density patchy across site.	• Bush Forever Site 413.
Karrakatta Central & South Complex			
Yangebup & Little Rush Lakes, Yangebup - *B. attenuata* & B. *menzesii* low woodland & *E. marginata*. Uplands *E. gomphocephala, E. marginata*, & *C. calophylla* woodlands.	*Government of WA (2000)* • Bush Forever Site 256. • Significant flora. • Significant bird species. • Significant mammal species. *Weston (1993).* • Vegetation condition: <20% excellent to very good, >80% good to completely degraded, with areas of severe localized disturbance. *WA Herbarium (2003)* • No current record of declared rare or priority flora.	*CSIRO (2001)* • 1988-2000 vegetation density decreased on edges of wetland and increased to the west.	• Bush Forever Site 256.
Forrestdale Lake & adjacent Bushland, Forrestdale – *C. calophylla* open woodland; *B. attenuata, B. menziesii* open forest to woodland with *N. floribubda; B. littoralis* & *B. menziesii* open forest to woodland with *N. floribunda.*	*Government of WA (2000)* • Bush Forever Site 345 • Supports TEC SCP 10a and SCP 08. • Significant flora. • Vegetation condition; >50% excellent to very good, <50% good to degraded, with areas of severe localized disturbance. • Significant bird species. • JAMBA and CAMBA species. • Significant reptile species. • Significant mammal species. *WA Herbarium (2003)* • DRF; R – *Diuris purdiei, Drakaea elastica,* P4 – *Drosera occidentalis, Villarsia submersa.*	*CSIRO (2001)* • 1988-2000 vegetation density showed little change.	• Supports threatened ecological community (no record of TEC on Calm data base). • Supports JAMBA and CAMBA bird species. • Supports declared rare and priority flora. • Bush Forever Site 345.
BASE-FLOW SYSTEMS			
Gnangara			
Gingin Brook	*Morgan et al. (2000)* • Supports a high diversity of native freshwater fish species. • Regionally significant for fish species composition. • Likely groundwater dependent in summer. *Davis et al., (1993)* • Coloured wetland of extremely high conservation value given uniqueness		• Supports a high diversity of native freshwater fish species. • High conservation value due to uniqueness.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	• Of ecological interest due to high TP and low chlorophyll a concentrations; No Odonata and Coleoptera species collected indicative of uniqueness of ecological processes within wetland • Poor species richness		
Lake (38749652539) - part of Quin Brook (Wanneroo Branch of Gingin Brook)	*Hill et al. (1996)* • ASWO C EPP *Froend et al. (2002)* • Large area of open water.	*DoE (2004)* • Large semi-permanent lake. Intact vegetation buffer although heavy weed infestation of predominantly annual grasses in inflow. Vegetation otherwise excellent to pristine. Some surface water still present in May 2004.	
Sumpland (38385652763)- part of Quin Brook	*Hill et al. (1996)* • SWO C	*DoE (2004)* • Large sumpland joined to, & forming part of the floodplains 188 & 48. Vegetation in excellent condition. E rudis in the north west section show signs of stress. Some dieback apparent in the terrestrial vegetation. Surface water present in June 2004.	
Floodplain (38454652772) - part of Quin Brook	*Hill et al. (1996)* • SWO C EPP	*DoE (2004)* • Numerous tracks cross the floodplain leading to weed invasion in localised areas. Recent fire is apparent in central region and has caused some death of Myrtaceous shrublands. Paperbarks appear to be regenerating well. Some aggressive weeds around vehicle tracks eg. *Mentha sp*. Dieback apparent in some sections of terrestrial vegetation.	
Floodplain (38231652928) - part of Quin Brook	*Hill et al. (1996)* • SO C EPP	*DoE (2004)* • Large floodplain with localised areas of disturbance in the privately owned northern section (roughly half the floodplain). The following description applies predominantly to the southern section within the Yeal Reserve. Vegetation excellent to pristine. Weed invasion and dieback is apparent around the vehicle tracks. Some patches of terrestrial vegetation contain numerous dead *Banksia spp.*	
Lennards Brook (on boundary of study area)	*Morgan et al (2000)* • *Galaxiella munda* Mud Minnow rare species with restricted distribution – this population is northern limit of range.	No record of current condition of wetland.	• Supports near threatened taxa.
Ellen Brook creek system (on boundary of study area)	*Morgan et al (2000)* • System supports native species of fish which have disappeared from other water bodies in the area. • 4 native and 2 introduced species recorded along Ellen Brook.	No monitoring data – so not possible to determine level of change – if any.	• System supports native species of fish which have disappeared from other water bodies in the area.
Bennett Brook	*Bamford, Morgan and Gill (1998)* • System supports 6 native and 3 introduced fish species. • System supports tortoises, Gilgies, freshwater mussels.		• System supports native species of fish and other vertebrates and invertebrate species.
AQUIFER AND CAVE ECOSYSTEMS			
Yanchep caves			
Un-named cave (YN61) - within Yanchep National Park	*Bastian (2003)* • First sampled in Sept 2002. • Contained shallow water, cracked mud on floor suggesting earlier drying, and a small amount of root mat. • 5 taxa recovered, including ancient cavernicole - Genera of Amphipoda, new to science, and different from that taken from YN256.	*Bastian (2003)* • In 1990 had water up to 1m deep with thick sludge, now drying in summer. • Current hydrological condition - seasonal	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.
Cave on Lot 51 (YN555) – outside Yanchep National Park	*Bastian (2003)* • First sampled in Sept 2002. • Contained a reasonably deep pool (~ 1 m), although no visible root mat. • 8 taxa recovered, including a Phreatoicid Isopod taxonomically close to Paramphisopus pauustris, but sufficienty different as to suggest active insipient speciation.	*Bastian (2003)* • Solution carving shows cave had been completely water-filled, now shallow. • Current hydrological condition - diminished	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.
Orpheus Cave (YN256) – within Yanchep National Park	*Bastian (2003)* • First sampled in Dec 2002. • Contained relatively deep, small pool (~1 m deep), but no visible root mat. • Only 2 taxa recovered, an ancient cavernicole, being a Genera of Amphipoda, new to science and different from that taken from YN61	*Bastian (2003)* • Laket in bottom now much shallower at winter peak. • Current hydrological condition -diminished.	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
Jackhammer Cave (YN438)	*Bastian (2003)* • First sampled in Dec 2002. • 4 specimens of 1 taxa recorded.		• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.
ESTUARINE AND NEAR-SHORE MARINE ECOSYSTEMS			
Marmion Marine Park	*CALM (1992)* • Rich and diverse marine communities that represent a variety of marine habitats • Invertebrate species of special interest e.g. Cowry Shells • Habitat for marine mammals e.g. Sea lions, dolphins and whales • Seagrass beds in shallow lagoons that contribute to energy flow in coastal ecosystems and stabilise sandbanks • Natural marine features supplement coastal panoramas • A suite of marine species and habitats characteristic of WA's mid west coast, that contribute to the biodiversity and overall conservation value of the marine reserve estate.		• Rich and diverse marine communities that represent a variety of marine habitats
Limestone reefs	*CALM (1992), Lavery (1993), McQuillan (unpubl.)* • Highly productive areas supporting diverse faunal and floral assemblages *Hesp et al (2002), Kendrick (1999)* • Habitat for some specific species: Western Australian Jewfish (*Glaucosoma. Hebraicum*) abalone (*Heliotis roei*) and the Western Rock Lobster (*Panulirus cygn)* provision of food • Physical stability of the seafloor and coastline • Nutrient recycling and formation of detritus and wrack		• Highly productive areas supporting diverse faunal and floral assemblages
Seagrass Meadows	*Cockburn Cement (2000), EPA (1997), King et al. (1990), MacArthur an Hyndes (2001), Butler & Jernakoff (1999)* • High degree of endemism to SW Australia • Intrinsic value as marine angiosperms • Primary and secondary production roles • Food provision for diverse marine fauna and fish • Habitat provision for diverse marine fauna and fish • Baffling effects of waves and currents • Sediment stabilization • Biogeochemical cycling		• Highly productive areas supporting diverse faunal and floral assemblages
Wrack (Detached Macrophytes)	*Lavery, (1993), Lenanton et al. (1982), Robertson and Lucas (1983)* • Habitat provision for diverse marine fauna and fish • Food provision for diverse marine fauna and fish • Nutrient recycling role • Transient role in shore stabilizing shores		• Habitat provision for diverse marine fauna and fish
Un-vegetated Sand	*Cockburn Cement (2001), Macini (1990), Hyndes et al. (1996), Hyndes et al. (1999), CALM (1992), Hyndes et al. (1997)* • Primary production through benthic microalgae • Fish nursery area in shallow sand ecosystems • Unique fish assemblages associated with un-vegetated sand • Important macroinvertebrate habitat • Role as potential vegetated habitat (.i.e. it has been valued as an essential part of patchy vegetated ecosystems)		• Important as fish nursery • Supports unique fish assemblages • Important macroinvertebrate habitat
Water Column	*Levinton (1995), Cockburn Cement (2000)* • Phytoplankton major primary producer • Habitat to a number of pelagic species both fish and mammal		• Fauna habitat values • Important for ecosystem processes

Group/sub-group GDE	Previous values	Changes in ecological condition	Current ecological values
	• Fundamental to ecosystem integrity through its role in the dispersal of material, connectivity of habitats and its light attenuation characteristics.		

Table 8: GDEs not assessed in previous EWR studies for which it may now be appropriate to describe EWRs, based on values described in Hill *et al*., (1996) (see page 5), the presence of TECs and/or DRF, other values as described in Table 7 and whether the GDE is representative of those in previously unassessed areas. (D: Dampland, L: Lake, F: Floodplain, S: Sumpland). Cave and near-shore marine ecosystems have not been listed pending further investigation.

Region/GDE	Values - Hill et al (1996)	TEC and/or DRF	Other values	Representative of unassessed area
Gnangara Wetlands				
Lake Gwelup	SW C EPP	No	• Bush Forever site. • Key faunal habitat. • Significant bird species.	No
Little Emu Swamp	C	No	• Bush Forever Site. • Significant flora. • Significant bird species. • Significant mammal species.	No
Big Carine Swamp	SWO C EPP	No	• Bush Forever Site. • Key faunal habitat. • Significant bird species.	No
Neaves				
S 39496649584	SW C EPP			No
Spring near the Maze		TEC	• High conservation value as invertebrate habitat.	No
Pinjar				
Lake Pinjar	SWO C EPP	No	• Bush Forever Site. • Key faunal habitat. • Significant flora. • Significant mammal species.	No
Ridges				
Ridges	C	TEC	• Bush Forever Site. • Representative of terrestrial vegetation with respect to composition and fauna habitat.	Yes
Yeal Nature Reserve				
Yeal Swamp	SW C	DRF	• Key faunal habitat.	Yes

			• Representative of terrestrial vegetation with respect to composition and fauna habitat.	
Bindiar Lake	SW C EPP	No		Yes
D 38340651762	SW C EPP	No		Yes
D 38337651800	SWC EPP	No		Yes
D 38488651846	ASW C	No		Yes
Tangeltoe				
Tangletoe Swamp	C	No	• Supports high macroinvertebrate species richness. • Representative of terrestrial vegetation with respect to composition and fauna habitat.	Yes
Lake Mukenburra	S C EPP	TEC		Yes
Wallingup Plain				
Quin Brook (Wanneroo branch of Gingin Brook)				
F 38454652772	SWO C EPP			Yes
F 38231652928	SO C EPP			Yes
S 38385652763	SWO C			Yes
D 38821652464	ASW C			Yes
L 3874965239	ASWO C EPP			Yes
S 38551652525	SW C	TEC, DRF		Yes
D 388216552464	ASW C	No		Yes
Bambanup				
Bambun Lake	SWO C EPP	TEC, DRF	• Key faunal habitat area. • Supports Nightfish, Western Minnow and Swan River Goby.	Yes
Lake Nambung	SWO C EPP	No	• Managed for conservation of flora and fauna. • Key faunal habitat.	Yes
Lake Mungala	SWO C EPP	No	• Waterbird habitat. • Key faunal habitat.	Yes
Jandakot Wetlands				

Mather Reserve	NO C EPP	No	• Bush Forever Site. • Water bird feeding. • Significant flora species. • Significant mammal species.	No
Little Rush Lake	SW C EPP	No		No
Spectacles North	NOW C EPP	?	• Bush Forever Site. • Significant flora species. • Significant mammal species. • Significant reptile species. • Waterbird breeding site.	No
East Swamp	WO C EPP	?	• Bush Forever Site. • Habitat for non-avian fauna.	No
Harrisdale Swamp	WO C EPP	?	• Bush Forever Site. • Significant flora species. • Significant mammal species.	No
Gnangara Terrestrial Ecosystems				
Wilbinga-Caraban Bushland		TEC, DRF	• Bush Forever Site 406. • Significant bird species. • Significant mammal species. • Significant reptile species. • Large area intact vegetation.	Yes
Ridges and adjacent bushland		TEC, DRF	• Bush Forever Site 381. • Significant bird species. • Significant mammal species. • Representative of terrestrial vegetation with respect to composition and fauna habitat.	Yes
Rosella Rd Bushland (north)		No	• Large area of intact *Banksia* woodland.	No
Yeal Nature Reserve		DRF	• Entered in Register of National Estate. • Representative of terrestrial vegetation with respect to composition and fauna habitat. • Large area of intact native vegetation.	Yes

Muchea Air Weapons Range	DRF	• Bush Forever Site 462. • Representative of terrestrial vegetation with respect to composition and fauna habitat. • Large area of intact native vegetation.	No
Yanchep Cave Ecosystems			
Un-named cave (YN61) in Yanchep National Park	No	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.	
Cave on Lot 51 (YN555)	No	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.	
Orpheus Cave (YN256)	No	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.	
Jackhammer Cave (YN438)	No	• Supports unique fauna but does not constitute a new occurrence of Cave Root Mat TEC.	

1b. Consideration of how ecological values may change under a dry climate scenario or other land-use changes.

During this stage of the project, predictions based on probable continuation of current water level trends are considered to propose how the values defined in Task 1a. may alter under a declining water level scenario. In the absence of modelled climate scenarios water level trends for the next five years are based trends over the past five years (since 1998) as this time frame most accurately reflects currents drying (or wetting) patterns. Hydrographs depicting the future trend in water levels at each criteria wetland and phreatophtyic vegetation site are presented in Appendix 2.

Wetland ecosystems

There are several key vegetation attributes that may undergo change in response to drying;

1. Vigour
2. Distribution
3. Composition

Measured changes in the vigour of vegetation, associated with reduced water availability, are the precursor to changes in distribution and composition. As water requirements are not being met, the vigour of individuals within a population will decline (water stress, branch die-back, reduced growth, leaf shed, chlorosis), leading to loss of individuals at drier areas of the water availability gradient (altered distribution), or total loss of the local (within ecosystem) population (altered composition). Due to gradients in water availability, there is the potential for extreme variability in vegetation vigour. Vegetation at the driest extreme of its distribution will always reflect the poorest (relative) vigour. As water levels gradually decline, a greater proportion of the vegetation will have poor vigour and die, with progressively less habitat for colonisation.

A gradual reduction in the water available to plants usually sees a change in distribution along the water-availability gradient across the littoral zone of wetlands. This is also associated with changes in plant distribution in surrounding upland areas typical of shallow depths to groundwater as well as areas of permanent water that may occur. The characteristics of change in distribution of vegetation are influenced by many factors including the water requirements of resident plant species, sources of propagules for colonisation, the magnitude and rate of water level change and the geomorphology of the wetland and surrounds.

Changes in vegetation composition is perhaps more controversial with respect to loss of native species and gain of exotic species. The factors that influence the character and rate of composition changes are the same as for distribution. Added factors include the potential for terrestrialisation as more xeric species colonise and the increase in habitat for exotics that may result from canopy decline.

Gnangara

– Loch McNess

This wetland is characterised by low variations in seasonal and long term water levels, there has however, been a decline in surface water levels since the early 1990s. Over the past five years the spring peak has declined approximately 0.08m and the autumn minimum 0.08m. A continuation of this trend over the next five years should have little impact of the ecological values of the wetland however, there is an increased chance of poor water quality and decline in available fauna habitat.

– Lake Yonderup

Lake Yonderup is also characterised by low variations in seasonal and long term water levels. However, since 1998 spring peak surface water levels have declined by 0.05m and autumn minimums by 0.03m. A continuation of this trend over the next five years should have little impact of the ecological values of the wetland however, there is an increased chance of poor water quality and decline in available fauna habitat.

– Lake Wilgarup

No surface water has been recorded at Lake Wilgarup since 1998. Peak groundwater levels have declined by 0.73m since 1998 and minimums levels by 0.41m. The ecological values of this wetland have already been severely impacted by previous water level declines, a continuation of this trend may result in total loss of the wetland as mesic vegetation is lost and replaced by terrestrial species.

– Pipidinny Swamp

Peak surface water levels at this wetland have declined 0.52m since 1998 however, minimum levels appeared to increase until 2001 since which time the wetland has dried in autumn. As there are a number of ponds at this site and the staff gauge can only represents one, it is not known if these water levels are representative. A continuation in the trend of water level decline may lead to further increases in salinity (due to salt water intrusion) thereby reducing water quality. This may in turn impact on the wetland's values as waterbird and macroinvertebrate habitat.

– Coogee Springs

Although surface water levels at Coogee Springs were artificially maintained until 2002, the wetland has dried each autumn since 1993 and has held no surface water since 2001. As the ecological values of this wetland have already been lost due to previous water level declines and land-use patterns, a continuation of the water level trend can have no further impact other than complete loss of wetland vegetation.

– Lake Nowergup

Despite continued and prolonged artificial maintenance of surface water levels at Lake Nowergup, peak levels have generally declined since 1998, while minimums have increased slightly. A continuation of this trend should have little impact other than an increased chance of poor water quality and decline in available habitat for waterbirds and macroinvertebrates.

Groundwater levels have shown a different response to artificial maintenance, with higher than average spring/summer peak levels falling rapidly to lower minimums when maintenance bores are turned off. As fringing vegetation is ground rather than surface water dependent, these rapid declines have had a serious impact on the condition of fringing trees. A continuation of this pattern or a return to an unaugmented water regime may result in the loss of fringing vegetation at Lake Nowergup and changes in the wetland ecological values.

– Lake Joondalup

Despite significant declines in surface water levels from 1992 to 1998, peak levels have risen 0.08m since that time with minimums up by 0.02m. Although there has been some decline in the ecological condition of this wetland in recent times, a continuation of the current water level trend should have little impact on ecological values over the next five years. There is however, an increased chance of poor water quality and decline in available fauna habitat.

– Lake Goollelal

There has been a long-term increase in surface water levels at Lake Goollelal. Peak levels are continuing to rise, with an increase of 0.15cm over the past years, while minimums have remained stable. A continuation of this water level trend over the next five years will have no impact on the ecological values of the wetland related to waterbird habitat and drought refuge and fish habitat. However, the condition of fringing tree species may decline further with increased duration and depth of inundation.

– Lake Jandabup

Despite long-term declines in surface water levels, artificial maintenance has lead to an increase of 0.21m in peak levels and an increase of 0.08m in minimums since 1998. Continuation of artificial maintenance and the trend in increasing water levels over the next five years should support the ecological values of Lake Jandabup related to diverse sedge and macrophytes and waterbirds and see further improvements in water quality.

– Lake Mariginiup

Peak surface water levels at Lake Mariginiup have declined since the late 1960s. Although there has only been a decrease of 0.085m since 1998, a decrease of 0.23m occurred the previous year. The lake has also dried every autumn since 1995. A continuation of this declining water level trend over the next five years

could have serious impacts on the ecological values of Lake Mariginiup as water quality declines further. There is evidence to suggest that this wetland is on the brink of a serious ecological collapse due to acidification as experienced at Lake Jandabup in 1997 (J. Benier, pers. comm., November 2003). Lakes Mariginiup and Jandabup share similar characteristics including soil types, bathymetry, hydrology and surrounding land-use patterns. Prior to the 1997 collapse, the lakes also shared similar macroinvertebrate family composition. pH levels at Lake Mariginiup have declined since 2000 and are now approaching those recorded at Lake Jandabup immediately before the collapse in 1997. It is envisaged that another drying event over summer 2003/04 may cause the acidification of Lake Mariginiup and the loss of existing macroinvertebrate composition. This in turn may impact on the value of the lake as waterbird habitat thereby seriously affecting the ecological values of Lake Mariginiup.

– Lake Gnangara

Despite an increase of 0.04m in peak surface water levels at Lake Gnangara over the past five years, there has been a long-term decline in water levels, with the wetland drying in all but one year since 1995, and fairly frequently prior to that. Due to the low water quality and habitat value of the wetland, continuation of the trend for increasing water levels over the next five years should do little to improve the ecological values of Lake Gnangara.

– Lexia 86

Surface and groundwater levels have declined at Lexia 86 since records commenced in 1995/96, with the wetland drying completely in 2002. Although average winter rainfall in 2003 resulted in the highest peak levels since 1996, the trend of declining levels should be expected to continue for the next five years. This decline should be expected to further impact on the ecological values of the wetland as fauna habitat and breeding opportunities for frogs is reduced.

– Lexia 186

Groundwater levels have generally declined at Lexia 186 since records commenced in 1995/96 however, average winter rains in 2003 resulted in the highest levels since 1996. Autumn minimums have declined 0.14m over the past five years, with peak levels dropping 0.26m between 1998 and 2002. No surface water has been recorded at the staff gauge since 1996, now only occurring during winter in a small excavated sump. A continuation of the current trend in water level declines over the next five years may further reduce the ecological values of Lexia 186 as vegetation assemblages continue to change in response to drying and the remaining fauna habitat (excavated sump) dries.

– Lexia 94

Spring peak groundwater levels have generally declined since 1995 before increasing in 2003 in response to average winter rainfall. There is no clear trend in minimum water levels. A continuation of current water

level trends over the next five years may reduce the ecological value of Lexia 94 if drying results in further thinning of wetland vegetation.

– EPP Wetland 173

Spring peak surface water levels declined approximately 0.11m between 1998 and 2002, before rising to the highest level since 1999 following average winter rains in 2003. The wetland has dried at the stafff gauge each spring since records commenced in 1996. A continuation in this trend for lower water levels over the next five years may further reduce the numbers of the Black-striped minnow and possibly reduce richness of macroinvertebrate and vertebrate species, thereby impacting on the ecological values of EPP Wetland 173. Impacts of water level decline on the Black-striped minnow are described in detail in Appendix 3.

– Dampland 78

Groundwater levels have been recorded at bore GNM31 since 1999. In that time autumn minimum levels have declined 0.51m, while spring peaks dropped 0.56m between 1999 and 2002 before increasing briefly following average winter rains in 2003. A continuation of this declining trend over the next five years may lead to further loss of wetland vegetation at Dampland 78 thereby impacting on the ecological values of the wetland.

– Melaleuca Park Wetlands

It is not possible to comment on the likely impact of further groundwater declines on these wetlands due to the absence of monitoring data (other than EPP 173 and Dampland 78 discussed above). However, as the majority of the wetlands are likely to be damplands the following general comments can be made. The vegetation communities of these wetlands reflect the drier water regime, supporting species more tolerant of drying and often including terrestrial species. A continuation of the drying trend experienced in this area may result in the death of some less tolerant plants and changes in floristic composition as terrestrial species become more dominant. This in turn may lead to changes in fauna such as decline/disappearance of species dependent upon dampland vegetation and/or increase in species associated with invading upland vegetation.

– Bombing Range Wetlands

As with the Melaleuca Park Wetlands there is little information specific to the values and condition of the Bombing Range Wetlands. As the majority of wetlands in the area are also damplands the comments made above apply here also.

– Edgecombe and Egerton Seepages

Groundwater levels have been monitored at Bore B10, 144m upstream of Edgecombe Seepage, since 1994. Water levels remained reasonably constant from April 1994 to February 1996 declining some 0.4m from 2000-2003 before increasing in winter 2003. Bore B25, 130m upstream of Egerton Seepage has been monitored since early 1995 and also shows a relatively constant water level between 1995 and 1996, before declining some 0.25m between 2000 and 2002 and rising in winter 2003. Water level trends for both seepages between 1996 and 2000 are not known as spring was not monitored during this time.

The ecological values of the seepages are dependent upon perennial flow from the springs. It is likely that if the springs stops flowing, it will be in summer time, when minimum groundwater levels fall below a threshold level at which water no longer exudes form the springs.

Predicting the effects of groundwater drawdown on flows from springs is problematic, as it is not known if the discharge from a spring merely reflects groundwater level in the adjacent/upstream part of the aquifer, or is a function of hydrostatic head which may require higher groundwater levels, and in areas further afield and not immediately adjacent to the spring. This problem aside, an attempt was made to extrapolate current trends in water levels from Bores B10 and B25, to predict effects on Edgecombe and Egerton Seepages. The direct relevance of data from these bores to the respective springs is unknown, but given their relative close proximity to the respective, it is assumed for this exercise that water levels in these bores relate directly to flows from the springs.

Unfortunately, the AHD for these springs is unknown, and so the relationship between bore water levels and the surface level of the springs is unknown. However, it is known that Edgecombe Spring ceased flowing in spring/summer 1999. Therefore, by inference, it may be assumed that at this time the minimum groundwater level in Bore B10 fell below the AHD of Edgecombe Spring.

Although it is not possible to definitively say what the effects of the continuing trends for the next five years will be on Edgecombe and Egerton Springs, based on past drying of Edgecombe Spring, and trends of declining minimum summer groundwater levels, it may be assumed that both springs are likely to dry in summer within the next five years if these trends continue, resulting in loss of aquatic invertebrates and therefore the ecological values for which they have been listed for conservation.

<u>Jandakot</u>

– Thomsons Lake

Spring peak surface water levels have declined by 1.4m since 1992 however, levels have fluctuated and increased 0.29m since 1998. It is not possible to comment on minimum surface water levels as the lake has dried at the staff gauge since 1996. Maximum groundwater levels have increased 0.03m and minimums decreased 0.08m since 1998. The increase in the peak level occurred in response to average rainfall in

winter 2003. There has been some decline in the ecological condition of this wetland in recent times. A continuation of the current water level trend over the next five years may impact negatively on the condition of littoral and fringing vegetation possibly reducing the habitat values of Thomsons Lake.

– North Lake

Minimum surface water levels at North Lake have increased 0.01m since 1998, following significant declines since the late 1980s. The increase in the peak level occurred in response to average rainfall in winter 2003. However, minimum levels have declined 0.25m since 1998. As the lake has become progressively drier in recent years its value as a drought refuge for waterbirds is already threatened. Therefore a continuation of the current drying trend may further reduce the ecological values of North Lake.

– Banganup Swamp

Banganup Swamp has dried each year since 1989 with no surface water recorded at the staff gauge between winter 2001 and August 2003 at which time it was 0.87m higher than during 1998. Minimum and maximum groundwater levels have declined 0.2m and 0.6m respectively since 1998. A continuation of the drying trend over the next five years may have a negative impact on the littoral and fringing vegetation of the wetland and reduce the period of flooding available for aquatic fauna thereby reducing ecological values.

– Bibra Lake

Maximum and minimum surface water levels have declined by 0.14m and 0.38m respectively at Bibra Lake since 1998. These declines follow a significant decrease in water levels since the late 1980s. A continuation of this drying trend over the next five years may have a cumulative impact on wetland vegetation. Lower maximum surface water levels may also reduce breeding by some waterbirds impacting on the ecological values of Bibra Lake.

– Lake Yangebup

Maximum and minimum surface water levels have increased 0.36m and 0.07m respectively at Lake Yangebup since 1998 following decreases from 1992. A continuation of the current ‘wetting’ trend over the next five years may alleviate water quality issues and should have little impact on the value of the wetland as a summer refuge for waterbirds.

– Kogolup Lake

Peak surface water levels have increased 0.54m at Lake Kogolup South since 1998 following declines since 1994. The lake has dried at the staff gauge each summer since 1998. A continuation of the current ‘wetting’ trend over the next five years should have little impact on the ecological values of the wetland.

– Shirley Balla Swamp

Maximum surface water levels have declined by approximately 0.25m since 1998 with the wetland drying each summer since records commenced in 1994 and not re-wetting in winter since August 2000. Maximum groundwater levels have increased 0.15m and minima declined 0.12m respectively since 1998. Drying has already reduced the value of the wetland as a potential waterbird breeding site with disturbances and drying negatively impacting on the faunal habitat value of littoral and fringing vegetation. Continuation of the drying trend over the next five years may further reduce the value of the vegetation of Shirley Balla Swamp.

– Twin Bartram Swamp

Peak surface water levels have increased approximately 0.75m since 1998 however, the wetland has still dried each summer since 1994. Maximum and minimum groundwater levels have increased by 0.13m and 0.17m respectively over the same time period. A continuation of the current 'wetting' trend over the next five years should have little impact on the ecological values of the wetland however, Twin Bartram Swamp remains at threat from urban development in the area.

– Beenyup Road Swamp

Maximum surface water levels have declined by approximately 0.09m since 1998 with the wetland drying each summer since 1993 for progressively longer periods each year. Maximum groundwater levels have increased 0.24m during the same period and minimum declined 0.19m. The increase in the peak level was largely due to average rainfall in winter 2003. A continuation of this drying trend over the next five years may have a negative impact on the littoral and fringing vegetation of the wetland thereby reducing ecological values.

– Forrestdale Lake

Peak surface water levels have increased 0.28m since 1998 (largely due to average rainfall in winter 2003) following a significant decline from 1992. The wetland has dried each summer since 1994. Maximum and minimum groundwater levels have declined 0.29 and 0.09m respectively since 1998. Although there have already been some changes in waterbird habitat values, a continuation of relatively stable surface water levels over the next five years should have little further impact on the ecological values of the wetland.

Terrestrial Ecosystems

Little specific research has been carried out on characteristics, current status and changes in condition of phreatophytic vegetation in the vicinity of criteria bores on the Gnangara and Jandakot Mounds. In areas of high groundwater (<3m), much of the remnant vegetation is likely to be dominated by species tolerant of

high soil moisture (*M. rhaphiophylla, M. preissiana, E. rudis, B. littoralis* and *B. ilicifolia*), while at greater depths (3-10m) less tolerant species may become more dominant (*B. attenuata* and *B. menziesii*). Generally species tolerant of high soil moisture should be expected to respond most severely to groundwater declines yet endure increases. Species less tolerant of high soil moisture may respond less severely to groundwater declines yet be impacted by increased levels (waterlogged). The degree of response is dependent on the following factors;

- Magnitude, rate and duration of water level increase/decrease.
- Historic changes in water levels.
- Specific site conditions (stratigraphy etc).
- Habitat type and species in question.
- Influence of disturbance impacts (fire etc).
- Vegetation condition.

The following generic ecological responses may occur in response to future changes in groundwater levels;

- Changes in diversity.
- Changes in species richness.
- Increase in xerophtyic/mesic species.
- Temporary loss of overstorey.
- Potential for invasion by exotics.

There is less data available on the impact of changes in groundwater levels on vertebrate fauna however, the following general comments can be made on responses under a drying regime;

- Fauna may respond to alterations in floristic composition by moving to lower areas of the landscape that still support less xeric vegetation species.
- Short-term declines in species reliant on mature trees but increases in species that utilize dead trees.
- Species that visit seasonally to exploit nectar sources may be adversely affected.

Due to the paucity of information available on the vegetation at the criteria bores, the following predictions of possible changes in ecological condition are based largely on remote sensing of changes in vegetation density between 1988 and 2000 (CSIRO, 2001), rapid field assessments of a limited number of sites and long-term monitoring of terrestrial transects. The terrestrial transects are often well removed from the bores but provide an impression of vegetation status in the general area.

<u>Gnangara</u>

– PM24 and PM25

Following a long-term decrease in groundwater levels, the spring maximum levels at PM24 and PM25 have declined 0.35 and 0.15m respectively since 1998. Minimums have also declined 0.06 and 0.09 respectively in that time. The condition of vegetation in the vicinity of these bores at the southern end of Lake Pinjar has declined over time (Froend *et al*. 2002) in response to disturbance and possibly water level decline. However, a continuation of the current drying trend over the next five years should have little further impact on the ecological values of this site.

– MT3S

Spring maximum groundwater levels have declined 0.04m since 1998 with minimums falling 0.03m, following a long-term decline. There has been a general decline in the density of *Banksia* woodland in the area in recent years (CSIRO, 2001) however, a continuation of the current water level trend should have little further impact on the ecological values of this site.

– JB5

Although groundwater levels have fluctuated since 1998, following a long-term decline, there has been an overall increase of 0.1m in the maximum and 0.12m decline in the minimum. The condition of *Banksia* woodland in the vicinity has declined over time in response to disturbance and possibly water level decline (Loomes *et al.*, 2003). However, a continuation of the current trend over the next five years should have little further impact on the ecological values of this site.

– MM18

Although groundwater levels have fluctuated since 1998 there has been an overall decrease of 0.21m and 0.19m in maximum and minimum levels respectively. The density of vegetation in the vicinity has remained relatively stable in recent years (CSIRO, 2001) and a continuation of the current trend over the next five years should have little impact on the ecological values of the site.

– MM53

Groundwater levels have also fluctuated at this bore since 1998 with a nett increase of 0.13m and 0.05 in maximum and minimum levels respectively. There has been some decline in the condition of *Banksia* woodland at this site however (Loomes *et al*, 2003), a continuation of the current 'wetting' trend over the next five years should have no further impact on ecological values.

– MM59B

Despite fluctuations in groundwater levels since 1998 there has been an overall decrease of 0.14m and 0.15m in maximum and minimum water levels respectively. There has been some decline in the condition of *Banksia* woodland at this site in recent years (Loomes *et al*., 2003). A continuation of the current drying trend over the next five years should have little impact on the ecological values of the site.

– MM55B

Although there have been fluctuations in groundwater levels since 1998 there has been a nett increase in maximum and minimum levels of 0.33m and 0.2m respectively. The *Melaleuca* woodland in the area has been modified by grazing (Loomes *et al*., 2003) however, it is unlikely that a continuation in the current 'wetting' trend over the next five years will have a further impact on ecological values.

– MM49B

There has been an overall increase in maximum and minimum groundwater levels of 0.25m and 0.15m respectively since 1998 despite fluctuations. There has been no record of decline in the condition of phreatophytic vegetation in this are in recent times (CSIRO, 2001) and it is unlikely that a continuation of the current 'wetting' trend will have an impact on ecological values in the next five years.

– MM16

Although there have been fluctuations in groundwater levels since 1998 there has been a nett increase in maximum and minimum levels of 0.37m and 0.31m respectively. There has been no decline in the condition of phreatophytic vegetation in this area in recent years. A continuation of the current 'wetting' trend over the next five years should have no impact on the ecological values.

– PM6

There has been a significant decline in groundwater levels at this bore since the mid 1990s with declines of 1.81m and 1.76m in maximum and minimum levels respectively since 1998. These declines have lowered the water table to 12.0m, 4.0m below the level on which the selection of criteria bores were based. There has been some decline in the condition of *Banksia* woodland in the area in recent years (Loomes *et al*., 2003) however, it is suspected that perched groundwater lenses have prevented the full impact of the water level decline. A continuation of the current drying trend over the next five years should not result in further changes in ecological condition. However, hot dry summers may reduce the soil moisture available from the perched lenses and lead to further vegetation decline.

– PM7

There has also been a significant decline in groundwater levels at this bore with maximum and minimum levels declining by 1.59m and 1.47m respectively since 1998. These declines have lowered the water table below the level on which the selection of criteria bores were based. Although there has been some decline in the condition of vegetation at this site (personal observation) it does not reflect the magnitude of the groundwater decline. A continuation of this declining trend in water levels over the next five years should severely alter the ecological values of the site, unless perched groundwater lenses are supporting the vegetation here also.

– PM9

Maximum and minimum groundwater levels have decreased 1.06m and 1.05m respectively since 1998. This has coincided with a decline in the condition of *Banksia* woodland in the vicinity (personal observation). A continuation of the current declining trend in groundwater levels should be expected to have further significant impacts on the ecological value of the site.

– WM1

There has been a decrease of 0.99m and 0.92m in maximum and minimum groundwater levels respectively since 1998. This has coincided with a decline in the condition of *Banksia* woodland in the vicinity (Loomes *et al*., 2003). A continuation of the current declining trend in groundwater levels should be expected to have further impacts on the ecological value of the site.

– WM2

Maximum and minimum groundwater levels have decreased 0.79m and 0.65m respectively since 1998. This has coincided with a decline in the condition of phreatophytic vegetation in the vicinity (personal observation). A continuation of the current declining trend in groundwater levels should be expected to have further impacts on the ecological value of the site.

– WM6

There has been a decrease of 0.54m and 0.37m in maximum and minimum groundwater levels respectively since 1998. This has coincided with a decline in the condition of phreatophtyic vegetation in the vicinity (Loomes *et al*., 2003). A continuation of the current declining trend in water levels will see the groundwater table drop to >8m, less than depth on which criteria bores were selected. This decline should also be expected to have further impacts on the ecological value of the site.

– WM8

Although there have been fluctuations in groundwater levels since 1998 there has been an overall decrease in maximum and minimum levels of 0.09m and 0.17m respectively. There has been no decline in the condition of phreatophytic vegetation in this area in recent years (CSIRO, 2001). A continuation of the current drying trend over the next five years should have little impact on the ecological values.

– NR6C

Although there have been fluctuations in groundwater levels since 1998 there has been an overall decrease in maximum and minimum levels of 0.4m. There has also been a decline in the condition of phreatophtyic vegetation at this site in recent years (CSIRO, 2001). A continuation of the current trend in groundwater levels over the next five years should have little further impact on the ecological values of the site.

– NR11C

Despite fluctuations in groundwater levels since 1998 there has been a nett increase in maximum and minimum levels of 0.15m and 0.03m respectively. There has been no change in the condition of phreatophtyic vegetation in the vicinity in recent years (CSIRO, 2001). A continuation of the current 'wetting' trend should have no impact on the ecological values of the site.

– L30C

Despite fluctuations in groundwater levels since 1998 there has been a nett increase of 0.14m in maximum levels and a decrease of 0.1m in minimums. There has been a decrease in vegetation condition in the vicinity in recent years (CSIRO, 2001). A continuation in the current groundwater level trends over the next five years should have little impact on the ecological values of this site.

– L110C

Although there have been fluctuations in groundwater levels at this bore there has been an overall decrease of 0.29m in maximum and minimum levels. There has been some decline in the condition of phreatophtyic vegetation in the area in recent times (CSIRO, 2001). A continuation in the current groundwater level trends over the next five years should have little further impact on the ecological values of this site.

– L220C

There has been a decrease of 0.2m in both maximum and minimum groundwater levels since 1998. Phreatophytic vegetation to the north and west of the bore has shown sings declining condition, while vegetation to the south and east has become denser (CSIRO, 2001). A continuation of the current trend in groundwater levels over the next five years should have little impact on the ecological condition of the site.

<u>Jandakot</u>

– JE17C

There has been an increase in minimum groundwater levels at this bore since 1998, while maximums have risen 0.17m. There has been some decline in the condition of vegetation in the surrounding *Banksia* woodland (CSIRO, 2001) however, it is unlikely that a continuation in the current groundwater level trends over the next five years will have further impact on phreatophytic vegetation unless the area becomes waterlogged. Therefore there should be little impact on the ecological values of the site.

– JM24

Maximum and minimum groundwater levels have increased by 0.49m and 0.16m respectively since 1998 following a long-term increasing water level trend (since 1975). There appears to have been no change in

vegetation condition near this bore (CSIRO, 2001) however, a continuation of this rising water level trend over the next five years may result in waterlogging and impact on ecological values of the site.

– JE10C

Despite a long-term decline in groundwater levels at this bore maximum and minimum levels have increased by 0.87m and 1.02m respectively since 1998. There is evidence of long-term declines in phreatophytic vegetation condition in the area (Mattiske Consulting, 2001) however, a continuation of the current wetting trend should have no further impact on ecological values as water levels may return to an earlier regime.

– JM31

Maximum groundwater levels have increased by 0.18m since 1998 (largely due to average winter rainfall in 2003) while minimum having declined by 0.13m, following a longer term decline. There is evidence of long-term declines in phreatophytic vegetation condition in the area (Mattiske Consulting, 2001). A continuation of the current general declining trend in water levels may impact on the condition of the site, but should have little impact on ecological values.

– JM35

Following a long-term trend of declining groundwater levels, maximum and minimum levels have increased by 1.91m (largely due to average winter rainfall in 2003) and 0.09m respectively since 1998. There is evidence of long-term declines in phreatophytic vegetation condition in the area (Mattiske Consulting, 2001). A continuation of the general increasing trend in water levels should have little impact on ecological values.

– JE4C

Following a long-term trend of declining water levels, minimum levels have decreased by 0.18m while maximums have increased 0.5m (largely due to average winter rainfall in 2003) since 1998. There is evidence of long-term declines in phreatophytic vegetation condition in the area (Mattiske Consulting, 2001). A continuation of the current general declining trend in water levels may impact further on the condition of the site, but should have little impact on ecological values.

– JM29

Maximum groundwater levels have increased by 0.23m (largely due to average winter rainfall in 2003) with minimums declining by 0.08m since 1998, following a long-term trend of declining water levels. Although there is little remnant vegetation remaining in the area there is little evidence of declining vegetation condition (Mattiske Consuting P/L, 2001). A continuation of the drying trend over the next five

years may impact further (already largely cleared) on the condition of the site but should have little impact on the already altered ecological values.

– JM7

Maximum groundwater levels have increased 0.17m since 1998 (largely due to average winter rainfall in 2003) while minimum levels declined 0.17m, following a long-term trend of declining water levels. There is evidence of declining vegetation condition in the vicinity of the bore (WRC, 2003). A continuation of the general declining trend in water levels may impact further on the condition of the site, but should have little impact on ecological values.

– JM8

Maximum groundwater levels have increased by 0.28m (largely due to average winter rainfall in 2003) with minimums declining by 0.12m since 1998, following a long-term trend of declining water levels. There is evidence of declining vegetation condition in the vicinity of the bore (WRC, 2003). A continuation of the general declining trend in water levels may impact further on the condition of the site, but should have little impact on ecological values.

– JM45

Following a long-term trend of declining water levels, maximum and minimum levels have increased by 0.15m (largely due to average winter rainfall in 2003) and 0.01m respectively since 1998. There is evidence of drought stress in phreatophytic vegetation near the bore (WRC, 2003). A continuation of the general declining trend in water levels may impact further on the condition of the site, but should have little impact on ecological values.

– 8284

Following a long-term trend of declining water levels, maximum levels have increased by ?? and minimums decreased by 0.16m since 1998. Changes in the condition of vegetation are unknown however, the area has been developed for rural/urban use. A continuation of the general declining trend in water levels may impact further on the condition of the site, but should have little impact on ecological values.

– JM49

Maximum and minimum groundwater levels have declined 0.01m and 0.14m respectively since 1998, following a long-term trend of declining water levels. Although there is evidence of increased vegetation density in the vicinity of the bore (CSIRO, 2001), continuation of the drying trend over the next five years may impact on the condition of the site, yet have little impact on ecological values.

– JM39

Following a long-term decrease in groundwater levels, maximum levels have increased 0.29m since 1998 (largely due to average winter rainfall in 2003) while minimums have declined 0.19m. Although there is evidence of increased vegetation density in the vicinity of the bore (CSIRO, 2001), continuation of the drying trend over the next five years may impact on the condition of the site, yet have little impact on ecological values.

– JE12C

Maximum and minimum groundwater levels have decreased 0.04m and 0.48m respectively since 1998, following a long-term trend of declining water levels. Although there is evidence of increased vegetation density in the vicinity of the bore (CSIRO, 2001), the depth to groundwater at this bore is now >15m, and native vegetation in the vicinity is unlikely to be groundwater dependent. Continuation of the drying trend over the next five years should therefore have little impact on the ecological values of the site.

– JM33

Following a long-term decrease in groundwater levels, maximum levels have increased 0.28m (largely due to average winter rainfall in 2003) since 1998 while minimums have declined 0.17m. Depth to groundwater is now >5m, lower than that used to select criteria bores. There is evidence of an increase in vegetation density in the vicinity (CSIRO, 2001) however, continuation of the drying trend over the next five years should have little impact on the ecological values of the site.

– JE23C

There has been a general decrease in groundwater levels at this bore since records commenced in the early 1990s, with minimum levels declining 0.31m since 1998. Maximum levels however, have increased 0.06m largely due to average winter rainfall in 2003. Although there has been no evidence of decline in vegetation condition a continuation of the drying trend over the next five years may impact on the condition of the site. There should however, be little change in ecological values.

– JE20C

Although there has been a general decrease in groundwater levels at this bore since records commenced in the early 1990s, since 1998 maximum levels have increased 0.23m (largely due to average winter rainfall in 2003) while minimums declined 0.17m. Although there has been no evidence of decline in vegetation condition a continuation of the general drying trend over the next five years may impact on the ecological condition of the site. There should however, be little change in ecological values.

– J310

Despite a long-term decline in groundwater levels, maximum and minimum levels had increased by 0.47m (largely due to average winter rainfall in 2003) and 0.15m respectively since 1998. There has been no

change recorded in vegetation condition (CSIRO, 2001) however, should the general drying trend continue over the next five years, the condition of the site may be impacted. There should however, be little change in ecological values.

– JM18

Following a long-term decline in groundwater levels there has been an increase of 0.02m in maximum levels (largely due to average winter rainfall in 2003) and no change in minimums since 1998. There is evidence of decreased vegetation density in the area (CSIRO, 2001). Should the drying trend continue over the next five years, the condition of the site may be impacted however, there should be little change in ecological values.

– JE1B

Although there has been a general decrease in long-term groundwater levels at this bore, since 1998 maximum levels have increased 0.09m (largely due to average winter rainfall in 2003) while minimums have declined 0.3m. There is evidence of a significant decline in vegetation density in the area (CSIRO, 2001). Should the general drying trend continue over the next five years, the condition of the site may be further impacted however, there should be little change in ecological values.

– JE18C

Although there has been a general decrease in groundwater levels at this bore since records commenced in the early 1990s, since 1998 maximum levels have increased 0.03m (largely due to average winter rainfall in 2003) while minimums have declined 0.35m. There has been a significant decline in vegetation density which may be furthered over the next five years under a continuation of the drying trend. There should however, be little change in the ecological values of the site.

– JM16

Although there has been a general decrease in long-term groundwater levels at this bore, since 1998 maximum levels have increased 0.32m (largely due to average winter rainfall in 2003) while minimums have declined 0.26m. Although there is no evidence of a decline in vegetation density in the area (CSIRO, 2001), a continuation of the general drying trend over the next five years may impact on the condition of the site. There should however, be little change in ecological value.

– JM14

Despite a long-term decrease in groundwater levels, there has been an increase of 1.2m (largely due to average winter rainfall in 2003) and a decrease of only 0.03m in minimum levels since 1998. There has been a decline in the condition of phreatophtyic vegetation in the area in recent years (Mattiske Consulting

P/L, 2001), an impact which may be exacerbated under a continuation of the long-term drying trend. There should however, be little change in ecological value.

– JM15

Following a long-term decrease in groundwater levels there has been an increase of 0.38m in maximum levels and a decrease of 0.20m in minimums since 1998. There has been a decline in the condition of phreatophtyic vegetation in the area in recent years (Mattiske Consulting P/L, 2001), an impact which may be exacerbated under a continuation of the long-term drying trend. However, there should be little change in ecological values.

– JM19

Despite a long-term decrease in groundwater levels there has been an increase of 0.07m and 0.18m in maximum and minimum levels since 1998. Although the area is under the influence of groundwater abstraction from a nearby mine there is no evidence of stress in phreatophytic vegetation (WRC, 2003). A continuation of the current water level trend over the next five years should have little impact on the condition and ecological value of the site.

– JM27

Following a long-term decrease in groundwater levels there has been an increase of 0.62m (largely due to average winter rainfall in 2003) in maximum levels and a decrease of 0.19m in minimums since 1998. There is evidence of some decline in vegetation density (CSIRO, 2001), which may be exacerbated under a continuation of the drying trend over the next five years. However, there should be little change in ecological value of the site.

– JM5

There has been an increase in the maximum groundwater level of 0.12m and a decline in 0.26m in the minimum since 1998, following a long-term decrease. There has been a decrease in vegetation density which me be further exacerbated under a continuation of drying water level trend over the next five years. However, as the site has already been altered through urbanization, there should be no further change in ecological values.

Aquifer and Cave Ecosystems

The AHD of the floor of some of the caves holding TECs have recently been surveyed and these data were provided by W&RC to relate changes in groundwater levels to cave stream water levels (Table 8)

Table 8: AHD of the floor of caves containing root mat communities listed as TECs.

Cave	mAHD
Carpark Cave	7.660
Water Cave	6.186
Cabaret Cave	11.175
Boomerang Cave	11.316

Groundwater monitoring bores have also been installed in these caves, however, these data were not yet available, and when available, they will be only of a short record length only, and so of little immediate value in determining trends.

There are a large number of groundwater monitoring bores in the Yanchep area, ranging from YN1 in the east to YN2, YN3, YN4 and YN5 moving progressively west towards Loch McNess, and YN6, YN7 and YN8 moving south from Loch McNess towards Lake Wilgarup.

The proximity of these bores to each of the caves is not currently available and therefore the relationship between bore water levels and the AHD of the caves is unknown. Until the location of the bores is known relative to the caves, it is not possible to determine the point at which water levels in the bores will fall below the floor of the specific caves. From Table 8 it may be seen that the AHD of the caves vary from 11.316 (Boomerang Cave) to 6.186 (Water Cave). Bores YN3, YN4 and YN5 are in the vicinity of the caves listed in Table 7, and water levels in these bores vary from 12.0 to 8.0mAHD. However, hydrographs of these bores (Appendix 2) show that groundwater levels are declining, and minimum summer levels would be below the floor level of some of the caves but not others – depending upon which bore was used against which cave.

It is already known that streams in some caves now run dry in summer. For example, Cabaret, Boomerang and Carpark Caves all cease flowing in summer, and have done so for the last few years. In fact, groundwater levels have declined to such an extent that streams in Cabaret and Boomerang no longer flow in winter either. This suggests that groundwater levels have fallen below the floor of these caves for the whole year.

In general terms, if the current trends of declining maximum winter and minimum summer groundwater levels continue, then flows to these caves will not return. Also, caves which contain pools of water which currently are present throughout the year (i.e. Water Cave, Orpheus Cave, cave YN555 on Lot 51) may start to dry. For example, water levels in Water Cave drop by several cms each summer, although the pool is still permanent. However, this seasonal decline in Water Cave either reflects a reduced hydrostatic head

in summer, or else that minimum summer groundwater level is starting to drop below the floor of this cave. A further decline in groundwater level of 50 – 70 cm would see Water Cave dry in summer.

Before the effects of these continuing trends may be more accurately determined, the relationship of water levels in monitoring bores to the AHD of the caves must be established by determining the exact proximity of each bore to each cave.

1c. Propose management objectives for the values identified in Tasks 1a. and 1b.

In this section of the report draft ecological management objectives (EMOs) are described for GDEs included in the 1995, 1997 and 1991/92 reports and those ecosystems in the wider study area for which it may now be appropriate to determine EWRs. Final management objectives will be developed following the completion of Task 3 to incorporate information on biological and ecological parameters.

The proposed EMOs are based on the ecological values identified in Tables 6 and 7 and do not consider social or economic values. 'Holistic' management objectives are beyond the scope of this brief and EMOs need to remain general as quantified management criteria will only follow once EWRs for each key GDE are identified.

In recognition of historic groundwater use impacts and impacts of climatic and land-use changes on GDEs, each EMO is prefaced with the following;
“Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values...".

Table 9: Management objectives for GDEs as described in the 1995, 1997 and 1991/92 and revised ecological management objectives for previously identified GDEs.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
WETLAND ECOSYSTEMS		
Gnangara		
Herdsman Complex		
Loch McNess	MO • To maintain the environmental quality of the lake. • To maintain North Loch McNess' pristine state. • To continue to use south Loch McNess for low key recreation. • To maintain east Loch McNess in a natural state, to restore, where possible natural flow. WRMO • To maintain the existing hydrological regime.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed wetland with largely intact vegetation. • Good populations of water birds and acts as drought refuge. • Excellent water quality. • Very high macroinvertebrate species richness. • Supports diverse fish species. • Wide diversity of habitat types. • Large body of permanent water.
Lake Yonderup	MO • To maintain the environmental quality of Lake Yonderup. WRMO • To maintain the existing hydrological regime.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Largely undisturbed wetland. • High macroinvertebrate species richness. • Excellent water quality. • Vegetation provides range of habitat types.
Lake Wilgarup	MO • To maintain the environmental quality of Lake Wilgarup. WRMO • To maintain the existing extent and variety of wetland vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Rich and unusual vegetation – dense stands of monospecific sedges.
Pipidinny Swamp	MO • To maintain the existing qualities of Pipidinny Swamp. WRMO • To maintain and enhance wetland vegetation. • To protect and enhance waterbird habitat.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Waterbird habitat. • Supports unique macroinvertebrates. • Vegetation provides range of habiatat types.
Coogee Springs	MO • To maintain and enhance the existing ecological values. WRMO • Maintenance of invertebrate fauna richness. • Maintenance and if possible enhancement of wetland vegetation. • Maintenance of water necessary for bird breeding.	Ecological values of Coogee Springs have been lost due to disturbance and drying.
Lake Nowergup	MO • Wildlife and conservation, scientific study and preservation of features of archaeological, historic or scientific interest. WRMO • To maintain the existing areas of fringing sedge vegetation. • To maintain deep, permanent water as a bird habitat and drought refuge and to protect aquatic invertebrates and fish dependent on permanent water. • To maintain the existing extent of *Baumea* fringe between Typha stands and the fringing woodland. • To provide some area of wading bird habitat at the end of summer, although it is recognised that this is limited by the shape of the wetland.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Permanent deep-water wetland acting as a drought refuge for waterbirds. • Supports fish and other vertebrate species. • Regionally significant for macroinvertebrate species and family richness. • Areas of sedgeland on eastern shore minimize impact of nutrient enrichment on aquatic fauna. • Fringing vegetation provides range of habitat types.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
	• To maintain the areas of fringing woodland on the western shore.	
Lake Joondalup	MO • Conservation and public enjoyment of natural and modified landscape. WRMO • To conserve existing wetland vegetation, including sedge beds, fringing woodland and aquatic macrophytes. • To maintain and if possible enhance the aquatic fauna of the lake. • In conjunction with Lake Goollelal, to support the full range of habitats for avian fauna. • To ensure the landscape and amenity values of the lake are maintained, except under very low rainfall climatic conditions.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Waterbird habitat. • Diverse range of macrophytes. • Supports aquatic vertebrates and macroinvertebrates. • Largely intact fringing vegetation provides range of habitat types.
Lake Goollelal	MO • Conservation and public enjoyment of natural and modified landscapes. WRMO • To protect and if possible enhance, fringing wetland vegetation including woodland and sedge vegetation. • To maintain permanent, deep water for water bird purposes and as a drought refuge. • To maintain permanent water for fish and species dependent on water. • To maintain the landscape amenity values of the wetland.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Permanent water providing waterbird habitat and drought refuge. • Supports good populations of native fish species. • Fringing vegetation provides a range of habitat types.
Pinjar Complex		
Lake Jandabup	MO • Conservation of flora and fauna. WRMO • Maintenance of the current extent of wading bird habitat. • No expansion in the areas of sedge vegetation, but maintenance of existing areas. • Removal of mosquito fish from the lake. • Maintenance of high species richness of aquatic macroinvertebrates, macrophytes and sedge vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse sedge and macrophyte vegetation. • Supports a wide range of waterbirds, especially waders. • Supports diverse range of macroinvertebrates. • Supports significant macroinvertebrate species. • Improving water quality following 1997 acidification event.
Lake Mariginiup	MO • Conservation of flora and fauna. WRMO • To maintain the current area of wading bird habitat. • To maintain the current area of sedge vegetation. • To maintain invertebrate richness. • To maintain, and if possible enhance, fringing woodland vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Wading bird habitat. • Supports rich aquatic macroinvertebrates. • Maintain water quality.
Bassendean Central & South Complex		
Lake Gnangara	MO • To maintain and enhance the natural attributes and functions of the lake. • To manage Lake Gnangara for the dual purposes of conservation and recreation. WRMO • To improve water quality through increased water levels as a means of enhancing both environmental and social values of the lake.	Ecological values lost.
Bassendean North Complex -Lexia		
Lexia 86	MO	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values;

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
	• To conserve ecological values. WRMO • To protect vegetation assemblages in and fringing the wetland. • To protect invertebrate communities dependent in the wetland.	• Supports diverse fringing and wetland vegetation. • Supports signficant invertebrate and vertebrate communities.
Lexia 94	MO • To conserve ecological values. WRMO • Protect current vegetation assemblages in fringing the wetland.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse wetland and fringing vegetation. • Fringing vegetation provides a range of habitat types.
Lexia 186	MO • To conserve ecological values. WRMO • To protect vegetation assemblages in and fringing the wetland. • To protect invertebrate communities dependent in the wetland.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Fringing and wetland vegetation provides a range of habitat types.
Bassendean North Complex – Melaleuca Park		
EPP Wetland 173	MO • To conserve wildlife and landscape values of the wetland. WRMO • To maintain existing areas of wetland and stream and vegetation they support. • To protect the invertebrate communities dependent on the wetland and stream. • To protect the fish species *Galaxiella nigrostriata*.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse wetland and stream vegetation. • High vertebrate and macroinvertebrate species richness. • Supports most northern population of Black-striped minnow (*Galaxiella nigrostriata*). • Wetland, stream and fringing vegetation provides a range of habitat types.
Dampland 78	MO • To conserve wildlife and landscape values of the wetland. WRMO • To maintain existing area of wetland vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports wetland vegetation.
Melaleuca Park Wetlands	MO • To conserve the wildlife and landscape values of the wetlands. WRMO • To maintain the existing areas of wetlands and wetland vegetation	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Wetlands support species of swamp vegetation. • Vegetation provides range of habitat types.
Bassendean North Complex – East Pinjar		
Bombing Range Wetlands	MO • To maintain the environmental qualities of the wetlands. WRMO • To maintain the existing wetland vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Wetlands support species of swamp vegetation. • Vegetation provides range of habitat types.
Egerton Springs	MO • Conservation of flora and fauna. WRMO • Maintain fringing liverwort, bog club moss and other wetland vegetation. • Maintain invertebrate species diversity.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports threatened ecological community (EGO1). • Supports significant club moss and liverwort species. • Supports pristine fringing vegetation. • High conservation as invertebrate habitat.
Edgecombe Springs	MO • Conservation of fauna. WRMO • Maintain invertebrate species diversity.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse fauna populations.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
Jandakot		
Herdsman Complex		
Thomsons Lake	MO • EPA category H - Active management to maintain and enhance the wetland attributes, particularly natural attributes. • To protect the ecological character of the lake in particular its importance as waterbird habitat. WRMO • Maintain links between lake levels and natural course of events (rainfall) associated with environmental attributes of the catchment. • Lake levels to reflect natural seasonal patterns. • Prevent any increases in nutrient input to lake and where possible reduce input.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Important habitat for waterbirds (RAMSAR wetland). • Lake margins support terrestrial bird and other vertebrate species. • Large area of remnant vegetation associated with the wetland.
North Lake	MO • EPA category O – to provide for human uses whilst maintaining and enhancing natural attributes and functions. WRMO • Periodic inundation of *Melaleuca* spp. • Remain within historic water levels range. • Maintain aesthetics.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports freshwater sponge species. • Supports extensive *M. rhaphiophylla* and *B. articulata* stands. • Permanent wetland provides summer waterbird refuge.
Banganup Swamp	MO • Maintain non-aquatic vertebrate habitat. WRMO • Water levels remain above historic minimum.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Non-avian fauna habitat. • High conservation value due to diversity and condition of littoral and fringing vegetation.
Bibra Lake	MO • EPA category C – to maintain and enhance natural attributes and functions. WRMO • Limit spread of *Typha*. • Periodical inundation of *Melaleuca* sp. and mudflats. • Remain within historic water levels range. • Maintain aesthetics. • Maintain access to recreation areas (avoid flooding). • Maintain as a summer refuge for waterbirds.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports a diversity of habitats used by wading birds. • Permanet wetland provides summer refuge for waterbirds. • Wetland and fringing vegetation provides a range of habitat types.
Yangebup Lake	MO • EPA category C – to maintain and enhance natural attributes and functions. WRMO • Limit spread of Typha. • Periodical inundation of *Eucalyptus rudis*. • Remain within historic water levels range. • Maintain aesthetics. • Avoid flooding. • Maintain as a summer refuge for waterbirds.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Permanent wetland provides summer refuge for waterbirds. • Supports high number of macroinvertebrate taxa.
Lake Kogolup	• MO • EPA category C – to maintain and enhance natural attributes and functions. • WRMO • Periodical inundation of *Melaleuca* sp. and mudflats. • Remain within historic water levels range.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Moderate potential for waterbird breeding. • High vegetation diversity. • South Kogolup supports high macroinvertebrate family richness.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
Bassendean Central & South Complex		
Shirley Balla Swamp	MO • Maintain breeding role of wetland. WRMO • Wetland should contain water until end of January.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Diverse array of vegetation, floristically and in terms of habitat for terrestrial fauna. • Supports high number of macroinvertebrates.
Twin Bartram Swamp	MO • Maintain breeding role of wetland. WRMO • Wetland should contain water until end of January.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Potential for waterbird breeding. • Vegetation provides range of habitats.
Beenyup Rd Swamp	MO • Maintain non-aquatic vertebrate habitat. WRMO • Prevent water table drawdown from impacting on wetland vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports *Melaleuca pauciflora* community. • Significant due to wetland size, vegetation assemblages and status. • Non-aquatic vertebrate habitat.
Karrakatta Central & South Complex		
Forrestdale Lake	MO • EPA category C – to maintain and enhance natural attributes and functions. WRMO • Maintain a natural cycle of filling and drying.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Lake margins support terrestrial bird and other vertebrate species. • Waterbird habitat (RAMSAR wetland).
TERRESTRIAL ECOSYSTEMS		
Gnangara		
Herdsman Complex		
PM24 - Lake Pinjar and Adjacent Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Regionally significant bushland/wetland linkage. • Bush Forever Site 382. • Supports one of remaining examples of Pinjar vegetation complex in area. • Area supports non-aquatic fauna. • Supports phreatophytic vegetation at 0-3m to groundwater.
PM25 - Lake Pinjar and Adjacent Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Regionally significant bushland/wetland linkage. • Bush Forever Site 382. • Supports one of remaining examples of Pinjar vegetation complex in area. • Area supports non-aquatic fauna. • Supports phreatophytic vegetation at 3-6m to groundwater.
Pinjar Complex		
MT3S – Jandabup Lake and Adjacent Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
		• Bush Forever Site 324. • *Banksia* woodland 6-10m depth to groundwater.
JB5 – in vicinity of Jandabup Lake and Adjacent Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • *Banksia* woodland 3-6m depth to groundwater.
Bassendean Central & South Complex		
MM49B – Whiteman Park	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • Bush Forever Site 304. • *Banksia* woodland 3-6m depth to groundwater. • Area supports non-aquatic fauna.
MM18 – Whiteman Park	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 304. • *Banksia* woodland 3-6m depth to groundwater. • Area supports non-aquatic fauna.
MM53 – Whiteman Park	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 304. • *Banksia* woodland 3-6m depth to groundwater. • Area supports non-aquatic fauna.
MM55B – Whiteman Park	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • Bush Forever Site 304. • *Melaleuca* woodland 0-3m depth to groundwater. • Area supports non-aquatic fauna.
MM59B – Whiteman Park	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • Bush Forever Site 304. • *Banksia* woodland 3-6m depth to groundwater. • Area supports non-aquatic fauna.
MM16 – Gnangara Rd. Bushland	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 196. • *Banksia* woodland 3-6m depth to groundwater. • Area supports TEC SCP 20a (Telstra01-08). • Area supports non-aquatic fauna.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
Bassendean North Complex		
PM6 – Rosella Rd Bushland.	MO • To protect terrestrial vegetation.	Presence of perched layers suggests site is not groundwater dependent.
PM7 – Rosella Rd Bushland.	MO • To protect terrestrial vegetation.	Presence of perched layers suggests site is not groundwater dependent
PM9 – Rosella Rd Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • Bush Forever Site 380. • *Banksia* woodland 6-10m depth to groundwater. • Area supports non-aquatic fauna. • Regionally significant contiguous bushland linkage.
WM1 – Chitty Rd, Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 398. • *Banksia* woodland 3-6m depth to groundwater.
WM2 – Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
WM8 – Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
NR6C – Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
NR11C – Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
WM6 – Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Disturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 6-10m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
L30C – vegetation corridor Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
L220C – vegetation corridor Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 399. • *Banksia* woodland 3-6m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
L110C - vegetation corridor Melaleuca Park.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • *Banksia* woodland 6-10m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
Ellenbrook Bushland - Maralla Rd Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 300. • *Banksia* woodland <8m depth to groundwater. • Regionally significant area of bushland. • Area supports non-aquatic fauna.
MM12 – Wetherall Rd. Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Undisturbed phreatophytic vegetation. • Bush Forever Site 192. • *Banksia* woodland 3-6m depth to groundwater. • Area supports non-aquatic fauna.
Jandakot		
Herdsman Complex		
JE17C – Thomsons Lake Nature Reserve and Adjacent Bushland.	MO • To protect rare flora habitat.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values;

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
		• *Eucalyptus rudis/Melaleuca preissiana* woodland occurring in area 0-3m to groundwater. • Bush Forever Site 391. • Reserve supports non-aquatic fauna. • Reserve supports priority flora.
JM24 – in vicinity of Thomsons Lake Reserve.	MO • To protect terrestrial vegetation.	Area marked for urban development.
Bassendean Central & South Complex		
JE10C – Denis de Young Reserve.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 344. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
JM31 - Denis de Young Reserve.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 344. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
JM35 –opposite Denis de Young Reserve.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater.
JE4C - Denis de Young Reserve.	MO • To protect terrestrial vegetation (aquifer evalutation bore).	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia/ Melaleuca/ Casuarina* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 344. • Important bird breeding area protected under JAMBA/CAMBA.
JM29	MO • To protect terrestrial vegetation.	Area marked for urban development.
JM7 – Jandakot Airport.	MO • To protect rare flora habitat.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *M. preissiana/ E.rudis/ Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 388. • Area supports non-aquatic fauna. • No current record of rare orchid species.
JM8 – Jandakot Airport.	MO • To protect rare flora habitat.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 388. • Area supports non-aquatic fauna. • Supports rare orchid species.
JM45	MO • To protect rare flora habitat.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Mixed *Banksia/ E. rudis / M. preissiana* woodland occurring in area 3-6m to groundwater. • No current record of rare orchid species.
8284	MO	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
	• To protect terrestrial vegetation.	contribution of groundwater abstraction to progressive decline in the following ecological values; • Mixed *Banksia/ E. rudis / M. preissiana* woodland occurring in area 3-6m to groundwater.
JM49 – unreserved bushland Rowley Rd, Banjup.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater.
JM39 - unreserved bushland Rowley Rd, Banjup.	MO To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater.
JE12C – unreserved bushland Rowley Rd, Banjup.	MO • To protect terrestrial vegetation (aquifer evaluation bore)	Area marked for future urban development.
JM33 – unreserved bushland Lyon Rd, Banjup.	MO • To protect terrestrial vegetation.	Area marked for future urban development.
JE23C - unreserved bushland Gaebler Rd, Banjup.	MO • To protect terrestrial vegetation.	Area marked for future urban development.
JE20C - unreserved bushland near crn. Beenyup Rd and Sheok Crt, Banjup.	MO • To protect terrestrial vegetation.	Area marked for future urban development.
J310 - unreserved bushland near cnr. Princep Rd and Cutler Rd.	MO • To protect rare flora habitat.	Area cleared for industrial development.
JM18 - unreserved bushland Solomon Rd, Banjup.	MO • To protect terrestrial vegetation.	Area cleared for industrial development.
JE1B - unreserved bushland Solomon Rd, Banjup.	MO • To protect terrestrial vegetation (aquifer evalutation bore)	Area largely cleared for sand mine and semi-rural land use.
JE18C - unreserved bushland Solomon Rd, Banjup.	MO • To protect terrestrial vegetation.	Area cleared for semi-rural land use and public open space.
Cottesloe Central & South Complex		
JM16 – Harrisdale Swamp and Adjacent Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 253. • Area supports non-avian fauna.
Southern River Complex		
JM14 – Acourt Rd Bushland.	MO • To protect terrestrial vegetation.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • *Banksia* woodland occurring in area 3-6m to groundwater. • Bush Forever Site 389. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
JM15 – Acourt Rd Bushland.	MO • To protect terrestrial vegetation.	Area has been cleared for semi-rural land use.
JM19 – Fraser Rd Bushland.	MO • To protect terrestrial vegetation.	Area largely cleared for sand mine operation.
Karrakatta Central & South Complex		

GDE	Existing Management Objectives (MO) & Water Regime Management Objectives (WRMO)	Revised Ecological Management Objectives (EMOs)
JM27 – unreserved bushland cnr. Armadale and Taylor Rd, Forrestdale.	MO • To protect terrestrial vegetation.	Area cleared for rural land use
JM5 – Built-up area Waratah Blvd.	MO • To protect terrestrial vegetation.	Terrestrial vegetation cleared for urban development.
AQUIFER AND CAVE ECOSYSTEMS		
Yanchep Caves		
Crystal Cave, Water Cave, Carpark Cave, Gilgie Cave, Cabaret Cave, Boomerang Cave, Twilight Cave	MO • To conserve the aquatic fauna within the cave pools and streams WRMO • To maintain the existing hydrological regime within the caves, and in particular to maintain permanent water in those caves containing aquatic fauna.	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Cave pools and streams support unique aquatic fauna (cave root mat TEC).

Table 10: Management objectives for GDEs beyond the original study areas for which it may now be appropriate to described EWRs

Region/GDE	Ecological Management Objective
Gnangara Wetlands	
Lake Gwelup	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports waterbird species and other dependent vertebrates.
Little Emu Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates.
Big Carine Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports waterbird species and other dependent vertebrates.
Neaves	
S 39496649584	Values undescribed
Spring at the Maze	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports TEC (Organic Mound Springs)
Pinjar	
Lake Pinjar	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Supports one of remaining occurrences of Pinjar vegetation complex.
Ridges	
Ridges	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Yeal Nature Reserve	
Yeal Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values;

Region/GDE	Ecological Management Objective
	• Supports non-aquatic vertebrates. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Bindiar Lake	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates.
D 38340651762	Values undescribed
D 38337651800	Values undescribed
D 38488651846	Values undescribed
Tangeltoe	
Tangletoe Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports high macroinvertebrate species richness. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.
Lake Mukenburra	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports waterbird species and other dependent vertebrates. • Supports TEC (SCP 07).
Wallingup Plain	
S 38551652525	Values undescribed
D 388216552464	Values undescribed
Bambanup	
Bambun Lake	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse fish species and other dependent vertebrates. • Vegetation provides fauna habitat. • Supports TEC (SCP 15 and SCP 07)
Lake Nambung	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports aquatic vertebrates.

Region/GDE	Ecological Management Objective
Lake Mungala	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports waterbirds and other dependent vertebrates.
Jandakot Wetlands	
Mather Reserve	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Supports waterbirds.
Little Rush Lake	Values undescribed
Spectacles North	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports aquatic and non-aquatic vertebrates. • Vegetation provides range of habitat types.
East Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates.
Harrisdale Swamp	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates.
Gnangara Terrestrial Ecosystems	
Wilbinga-Caraban Bushland	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Supports TEC (SCP 26a). • Supports large area of intact vegetation.
Ridges and adjacent bushland	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Supports TEC (SCP 26a)

Region/GDE	Ecological Management Objective
	• Large area of intact *Banksia* woodland.
Rosella Rd Bushland (north)	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Large area of intact *Banksia* woodland.
Yeal Nature Reserve	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Large area of intact *Banksia* woodland.
Muchea Air Weapons Range	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports non-aquatic vertebrates. • Representative of terrestrial vegetation with respect to structure, composition and fauna habitat. • Large area of intact *Banksia* woodland.
Gnangara Base-flow Systems	
Quin Brook (Wanneroo branch of Gingin Brook) F 38454652772, F 38231652928, S 38385652763, L 38749652539	Values undescribed
Bennet Brook	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports diverse fish species and other dependent aquatic vertebrates and invertebrates.
Yanchep Caves	
Un-named cave (YN61) – within Yanchep National Park	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports unique cave pool fauna but does not constitute a new occurrence of Cave Root Mat TEC.
Cave on Lot 51 (YN555)	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports unique cave pool fauna but does not constitute a new occurrence of Cave Root Mat TEC.
Orpheus Cave (YN256)	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values;

Region/GDE	Ecological Management Objective
	• Supports unique cave pool fauna but does not constitute a new occurrence of Cave Root Mat TEC.
Jackhammer Cave (YN438)	Recognising the cumulative impacts of abstraction history and long-term climatic and land use change, minimise the contribution of groundwater abstraction to progressive decline in the following ecological values; • Supports unique cave pool fauna but does not constitute a new occurrence of Cave Root Mat TEC.

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APPENDICES

Appendix 1: Listing of Yanchep caves of the Yeal study area (Supplied by Lex Bastian)

Current hydrological condition of caves in the Yanchep area, detailing status when first discovered and current status. Caves highlighted are known to contain root mat communities.

Cave #	Cave Name	Location	Easting	Northing	Earliest known record of water noted by earliest explorer	Earliest known record of water noted by Lex Bastian	Condition of cave streams compared with earlier times, plus date of discovery (if known) shown in brackets; otherwise earliest observation	Current Hydrological condition
YN1	Crystal Cave	Yanchep NP	7581	0883	1903	1942	Crystal Cave, known to have had permanent stream since discovery, now dry	Dry
YN2	Yonderup Cave, first explored 1903*	Yanchep NP	7560	0880	no mention	1942	Yonderup Cave, had a small pond in main trend, has been dry for a long time	Dry
YN6	cave in Boomerang Gorge, first explored 1841*	Yanchep NP	7557	0942	no mention	1989	cave in Boomerang Gorge, still had small wet spot in pool area in1989	Diminished
YN7	cave in Boomerang Gorge, first explored 1841*	Yanchep NP	7556	0940	no mention	1992	cave in Boomerang Gorge, small pool with tree roots at deepest level in cave, now dry	Dry
YN8	Catacombs Cave ("Road Cave"), first explored 1905*	Yanchep NP	7590	0867	1960's	1991	Catacombs Cave (1905: no mention of water) had shallow puddles as late as 1994, now dry	Dry
YN11	Water Cave	Yanchep NP	7483	0850	1960's	1991	Water Cave, has permanent deep water, but has been steadily shallowing since mid 1990's	Diminished
YN12	Mambibby Cave, first explored 1904	Yanchep NP	7482	0837	1904	1959	Mambibby Cave, lakes plus good stream permanent until 1990's, now only lakes in winter	Seasonal
YN13	Loch Overflow Cave, extensive water in winter	Yanchep NP	7466	0858	1960's	1991	Loch Overflow Cave, had very extensive seasonal water, now reduced to isolated ponds	Diminished
YN14	Whites Grotto, Henry White's water supply source	Yanchep NP	7485	0819	pre-1903	1949	Whites Grotto, considered the most reliable stream, now dries in summer	Seasonal
YN15	Hot House Cave, pond at bottom	Yanchep NP	7517	0885	1968	1990	Hot House Cave, streamway had pool in deepest level Jan 1992, (probably now dry?)	Dry
YN18	Carpark Cave, same stream as Whites Grotto	Yanchep NP	7511	0830	1960's	1990	Carpark Cave, permanent stream as recent as January 1991, now dry most of year	Seasonal
YN19	Pophole Cave, short portion of streamway	Yanchep NP	7475	0833	1960's	1990	Pophole Cave, short portion of streamway, dry in recent years	Dry
YN20	Surprise Cave, first explored 1903*	Yanchep NP	7484	0759	no mention	1991	Surprise Cave, wet peat in deepest level seen in Jan 1991, dry in recent years	Dry
YN26	Census Cave, portion of streamway	Yanchep NP	7566	0654	1954	1954	Census Cave, reliable stream until 1990's then winter flow only, finally permanently dry	Dry

YN27	Gilgi Cave, was a reliable stream	Yanchep NP	7555	0657	no report	1949	Gilgi Cave, had strong permanent stream until 1990's, dried out and never come back	Dry
YN30	stream cave adjacent to Cabaret Cave	Yanchep NP	7551	0946	1841	1992	Cabaret Cave stream, was a strong permanent stream until mid 1990's, now dry.	Dry
YN31	cave on same stream as YN30	Yanchep NP	7546	0944	no report	1951	cave on same stream as YN30, same history	Dry
YN37	Loch overflow point, north end	Yanchep NP	7322	1230	1964	1991	Loch north-end overflow point; was very strong until 1991, still flows in winter but reduced	Seasonal
YN59	collapse & small cave N of YN61	Yanchep NP	7411	1129	no report	1991	collapse & small cave, in 1991 had sludge pools similar to YN61; no recent visit	Unknown
YN61	stream cave with thick Fe oxide sludge	Yanchep NP	7411	1124	ca1983	1990	stream cave, in 1990 had water up to 1 metre deep with thick sludge, now drying in summer	Seasonal
YN80	small cave ENE of YN81 - same stream*	Yanchep NP	7373	1159	ca1983	1990	cave with stream, which was running in 1990 - would have same history as YN81	Seasonal
YN81	Fridge Grotto (chilly), stream with Fe oxide sludge	Yanchep NP	7371	1158	ca1983	1990	Fridge Grotto, stream reduced to a trickle in winter only.	Seasonal
YN86	small cave & stream	Yanchep NP	7360	1190	no report	1990	small cave & stream, no recent info.	Unknown
YN99	stream cave, Boomerang Gorge	Yanchep NP	7552	0938	1977	1992	stream cave, Boomerang Gorge, was permanent, now dry most of year	Dry
YN102	Onychophora Cave	Yanchep NP	7524	0815	no report	1989	Onychophora Cave, in 1989 had two broad shallow pools in winter, now dry all year round	Dry
YN110	stream hole, filled over with rubbish	Yanchep NP	7553	0872	1841	n.a.	stream hole, originally permanent strong stream, was filled with rubbish ca twenty years ago	Unknown
YN143	Cherax Cave, stream	Yanchep NP	7574	0646	1982	1988	Cherax Cave, small stream which ran until the 1990's, not seen water in recent years	Dry
YN151	decorated cave first explored in 1995*	Yanchep NP	7490	0844	n.a.	2000	pool of deep clear water in fissure found in July 2000 (no root material); not checked since.	Unknown
YN162	Gnamarup Cave, ponds and tunnelling at base level	Yanchep NP	7534	0674	ca1970	1988	Gnamarup Cave (1970's), main pond had 1m.+ water early 1990's (no roots), almost gone	Diminished
YN165	Concinna Cave, solution labyrinths	Yanchep NP	7524	0606	1988	= 1st explor.	Concinna Cave, labyrinths had extensive seasonal water, now dry	Dry
YN166	second entrance of Concinna Cave*	Yanchep NP	7522	0602	1988	= 1st explor.	additional section of water table tunnels, water history as for Concinna Cave	Dry
YN168	stream cave up-slope from YN41	Yanchep NP	7529	0688	no report	1988	stream cave up-slope from YN41, dry when last visited (July 2003)	Dry
YN192	cave beside Wanneroo Road	Yanchep NP	7555	0620	no report	1949	cave beside Wanneroo Road (date?), shallow peat-floored pool, now dry	Dry
YN193	cave with tree root entrance beside Wanneroo Road	Yanchep NP	7555	0618	no report	1990	cave has spongy sand/peat floor, had shallow water sheet in winter 1990, now dried out	Dry
YN194	Twilight Cave = good stream cave	Yanchep NP	7564	0665	no report	1989	Twilight Cave, stream ran strongly all-year-round until 1990's.	Diminished
YN197	rubbly cave with stream S of YN194	Yanchep NP	7564	0663	no report	2001	cave S of YN194, streamway had good rootmats and was moist in July 2001	Unknown
YN203	stream cave S of YN134	Yanchep NP	7566	0644	1990	= 1st explor.	stream cave S of YN134, had winter stream in 1990, not visited in recent years	Unknown
YN217	Keyhole Cave	Yanchep NP	7567	0685	1990	= 1st explor.	Keyhole Cave, in Nov 1990 had stretch of wet streamway (not checked since)	Unknown
YN233	small cave N of Crystal Cave exit road	Yanchep NP	7556	0890	no report	1991	small cave, had standing water in streamway May 1991 (not checked since)	Unknown
YN238	small cave with same stream as YN81	Yanchep NP	7369	1156	no report	1990	small cave with same stream as YN81	Seasonal

YN241	Rabbit Warren (solution tunnel maze)	Yanchep NP	7523	0692	1990	1990	Rabbit Warren, labyrinths had continuous water sheet in winter 1990, now dry	Dry
YN247	Burnup Cave, W of Ghost House Trail	Yanchep NP	7442	1097	no report	1993	Burnup Cave, short portion of small streamway, no longer flows but mud gets moist	Diminished
YN254	small cave S of Orpheus C, to water table	Yanchep NP	7360	1184	no report	1991	cave to water table, red mud streamway was wet in Feb1991, not checked since	Unknown
YN256	Orpheus Cave, pond in bottom chamber	Yanchep NP	7353	1222	1991	= 1st explor.	Orpheus Cave, lakelet in bottom chamber now much shallower at winter peak	Diminished
YN270	cave joins Mambibby system via crawls	Yanchep NP	7471	0841	no report	1993	cave is part of Mambibby labyrinth complex, same history	Seasonal
YN289	small cave S of Cauliflower Cave	Yanchep NP	7582	0844	no report	1992	small cave S of Cauliflower Cave, streamway had wet mud Jan 1992, not checked recently	Unknown
YN296	cave with streamway SW of Mambibby C	Yanchep NP	7471	0831	1992	= 1st explor.	cave WSW of YN19, mudcracked streamway (moist) in Dec1992, drier in 2000	Diminished
YN298	cave with shallow ponding	Yanchep NP	7418	1121	1991	= 1st explor.	cave with shallow ponding, was continuous sheet of water in Aug 1991, no recent visit	Unknown
YN306	Suspended Column Cave, first explored 1903	Yanchep NP	7403	0828	no report	1991	Suspended Column Cave had 7-8m pool in late 1991, now dry	Dry
YN354	cave between YN30 & YN31 (on same stream)	Yanchep NP	7547	0945	1992	= 1st explor.	in Aug 1992 had same strong flow as YN30 (Cabaret Cave stream), now permanently dry	Dry
YN360	cave 150m ESE of Cauliflower Cave (YN9)*	Yanchep NP	7593	0845	no report	2002	extension with shallow water found 2002, solution features indicate was originally water filled	Diminished
YN362	shallow cave with water	Yanchep NP	7428	1108	no report	1992	shallow cave with water in north chamber, streambed was soggy in Dec 1992	Unknown
YN371	cave on hillside above YN110	Yanchep NP	7555	0873	no report	1993	cave above YN110, streambed was wet in May1993, no recent visit	Unknown
YN397	cave 200m NW of Cauliflower Cave	Yanchep NP	7568	0864	no report	1994	cave NW of Cauliflower Cave, in Feb 1994 had damp sandy floor, no recent visit	Unknown
YN403	Goalpost Cave (near East Oval)	Yanchep NP	7552	0923	no report	1994	Goalpost Cave, in March 1994 very moist, peat in lowest corner saturated, no recent info.	Unknown
YN416	Chingah Cave, fairly large muddy pond area	Yanchep NP	7568	0704	no report	1994	Chingah Cave, winter-wet mud in 1994 (many root mats), now fully dried out	Dry
YN436	cave near Census Cave YN26*	Yanchep NP	7567	0657	1995	1997	cave has streamway with rootmats, but was already dry when first seen	Dry
YN438	Jackhammer Cave, deep water but v.peaty	Yanchep NP	7484	0844	1996	= 1st explor.	Jackhammer Cave, deep peat-sludge lakes are shallower, some ponds dry with fresh cracks	Diminished
YN439	Stanley Steamer, pools in several spots	Yanchep NP	7479	0842	no report	1995	Stanley Steamer, in1995 winter had pools in several spots, now much reduced	Diminished
YN534	Bike Cave - decoration/stream	Yanchep NP	7310	1244	2000	2000	Bike Cave - streambed was mudcracked in March 2000	Dry
YN544	cave S of Twilight Cave with streamway*	Yanchep NP	7563	0664	2001	2001	Small pocket of streamway, sandy bed was wet in July 2001	Diminished
YN121	cave with dried lakelet	Outside NP	7778	0316	no report	1971	cave with lakelet, had 30cm water Dec1971, now permanently dry	Dry
YN428	Doogarch Cave, first seen by George Grey 1838	Outside NP	7728	0421	no mention	1995	Doogarch Cave, in Dec1838 had strong stream running north, but dry in Feb1995	Dry
YN465	filled-in water cave, now under fig tree	Outside NP	7759	0446	no access	n.a.	filled-in water cave, now buried under fig tree (local description)	Unknown
YN470	pit-entrance cave NE of YN121	Outside NP	7782	0324	1998	= 1st explor.	pit-entrance cave NE of YN121 (now dry)	Dry

YN474	Tuart Cave, pool in one corner	Outside NP	7761	0331	1998	= 1st explor.	Tuart Cave, old crystal-lined pool in one corner (now dry)	Dry
YN476	good cave E of Wilgarup Lake, streamway	Outside NP	7647	0592	no record	1998	cave E of Wilgarup Lake, streamway with extensive solution carving, dry when first seen	Dry
YN479	Tartarus Cave, broad streamway	Outside NP	7758	0330	1998	= 1st explor.	Tartarus Cave, broad streamway, ripple marks show it once had strong flow (dry)	Dry
YN485	Carabooda Cave, pool in south chamber	Outside NP	7785	0368	no record	1998	Carabooda Cave, old crystal-lined pool with calcite rafts in south chamber (dry)	Dry
YN505	cave with stream, now bulldozed over	Outside NP	7773	0393	1999	= 1st explor.	cave with streamway, covered over during Emerald Valley development (dry)	Dry
YN555	phreatic water cave in Lot51	Outside NP	7675	0576	no record	2001	phreatic cave: solution carving shows it had been completely water-filled, now shallow	Diminished