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

Task 2: Determination of Ecological Water Requirements

Prepared for:

The Water and Rivers Commission

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INTRODUCTION

In this phase of the project water regimes (EWRs) considered necessary to support the values identified in Tasks 1a and 1b were determined. In contrast to current EWRs, the team has developed EWRs that encompass the true complexity of eco-hydrological interactions but maintain adaptability to management frameworks. Current EWRs have been most often set as minimum and/or maximum water levels based on the requirements of key species. These levels do not address other components of the water regime considered of equal importance in maintaining ecosystem values. In establishing EWRs the team has also considered the duration of required water levels and the rate of water level rise and/or decline, where possible. In all cases, limitations to scientific information and assumptions have been identified to ensure transparency in the scientific basis for EWRs.

During field visits undertaken in Task 1 a small number of wetlands and terrestrial bore sites, identified in the 1991/92, 1995 and 1997 reports were considered to have lost all or most of their ecological value related to groundwater dependence. These GDEs are listed in Table 1 with a brief description of the reason for the loss of values.

This phase of the project has been divided into three sections. The first section presents a summary of existing information on GDEs and their water requirements followed by a review of the existing WA approach and an outline of the process applied in this study.

In Section 2 general EWRs are first described for all GDEs identified in Task 1. Due to the paucity of information on the majority of ‘new’ GDEs, it is not possible to describe EWRs for a large number of ecosystems. Lack of quantitative data for some components of many previously described GDEs also limits EWRs to qualitative assessments. However, where the required level of information is available detailed/quantitative EWRs are described.

In Section 3 comment is made on the likely response to water level changes predicted over 2, 5 and 10 year intervals (2003-05, 2003-08 and 2003-13) modelled under PRAMS 3.0. To achieve this, a GDE’s susceptibility to groundwater decline is determined using a matrix of conservation values, current ecological condition, historic water level decline and current depth to groundwater. Groundwater dependence and drawdown impacts are largely based on vegetation. Limits of acceptable change are described for each type of GDE (wetland, terrestrial vegetation etc.) and comment made on the current standing of each GDE.

Table 1: GDEs identified in the 1991/2, 1995 and 1997 reports not considered in the EWR review due to severe decline or complete loss of ecological values related to groundwater dependence.

Group	GDE	Reason for loss of values related to groundwater dependence
Wetlands		
Gnangara	Coogee Springs	Due to changes in water quality, drying and the associated declines in ecological condition, the ecological values of the wetland have been severely degraded. The wetland no longer supports diverse aquatic macroinvertebrates nor has the potential to support waterbirds and other aquatic vertebrates. Only one species of wetland vegetation persists with little opportunity for recruitment.
Terrestrial ecosystems		
Gnangara	JB5	The bore is within 50m of an operation market garden, which has increased in size in recent years. The majority of native vegetation in the vicinity is also heavily modified.
	PM6	Recent investigations into soil moisture retention suggests there are 3 perched lenses in the soil profile above the water table, which is currently 12m below the ground surface. It is therefore unlikely that vegetation at this site is accessing groundwater and is relying instead on moisture in the perched layers. May be relocated or replaced.
	PM7	Recent investigations into soil moisture retention suggests there are 2 perched lenses in the soil profile above the water table, which is currently 9.5m below the ground surface. It is therefore unlikely that vegetation at this site is accessing groundwater and is relying instead on moisture in the perched layers.
	WM6	The bore is located between Neaves Rd and a semi-rural homesite. Although intact *Banksia* woodland occurs opposite, it is approximately 2m upslope of the bore and as a result the groundwater levels measured in the bore are unlikely to be representative of that underlying the vegetation. May be relocated or replaced.
	MM49B	Vegetation highly degraded and not representative of high priority conservation area within Whiteman Park. May be replaced by GD10.
	PM25	The woodland in the vicinity has been cleared for rural use.
Jandakot		
	JM24	The *Banksia* woodland in the vicinity has been significantly reduced through clearing with further clearing indicated in the near future.
	JM29	The *Banksia* woodland in the vicinity has been significantly reduced through clearing with further clearing indicated in the near future. May be relocated to Bush Forever Site 263.
	JE12C	Water levels are greater than 12m and the area is marked for future urban development.
	JM33	The area is marked for future urban development.
	JE20C	*Banksia* woodland in the vicinity has been impacted by semi-rural use and is marked for future urban development.
	JE23C	The area is marked for future urban development.
	J310	The woodland in the area has been cleared for industrial development.
	JM18	The woodland in the area has been cleared for industrial development.
	JE1B	The woodland in the area has been impacted by clearing for sand-mining and semi-rural use.
	JE18C	The woodland in the area has been cleared for semi-rural use and recreation.
	JM15	The woodland in the area has been cleared for semi-rural use.
	JM27	The woodland in the area has been cleared for rural use. May be relocated to Bush Forever Site 342.
	JM5	The area has been cleared for urban development.

SECTION 1 - ENVIRONMENTAL WATER REQUIREMENTS OF GROUNDWATER DEPENDENT ECOSYSTEMS

1.1 BACKGROUND ON ECOLOGICAL WATER REQUIREMENTS

GROUNDWATER DEPENDENT ECOSYSTEMS

Throughout Australia, the future of groundwater resources are being reviewed due to increasing pressure from consumptive uses for agriculture, mining, urban and commercial developments. The role which groundwater plays in controlling the health of major ecosystems across Australia is also being increasingly recognised. To ensure the continued health of these ecosystems, the respective needs of the principal users of groundwater, that is groundwater–dependent land uses and ecosystems, need to be formally recognised and provided for. Recognition of groundwater dependent ecosystems as a distinct group is relatively recent and may largely be attributed to work by Hatton and Evans (1998), although management of Groundwater Resources in Western Australia has recognised the importance of provision of water to the environment since 1986 (Water Authority of Western Australia, 1986). Groundwater dependent ecosystems can be defined as a complex community of organisms where groundwater is a key element required for consumptive use, biophysical processes or as habitat (Sinclair Knight Merz, 2001). At present, the importance of the role groundwater plays in controlling these ecosystems is poorly understood. If policy and management systems are to consider groundwater dependent ecosystems they require quantitative estimates of their water needs. Consideration of water requirements of groundwater dependent ecosystems has been a recent addition to water allocations decisions and therefore the allocation process is faced with little knowledge regarding the water needs of these ecosystems and the methodologies available for determining these.

ECOLOGICAL WATER REQUIREMENTS

All ecosystems require water to maintain their ecological processes and associated communities of plants and animals. Ecological water requirements (EWR) describe water regimes needed to sustain the ecological values of water dependent ecosystems at a low level of risk (ARMCANZ / ANZECC, 1996). A water regime can be defined as the prevailing pattern of water behaviour over a given time, components of which are groundwater depth, rate of groundwater level rise and duration. Estimations of the water regimes required by an ecosystem are developed through strategic scientific research or through the application of local knowledge based on many years of observation. Determining ecological water requirements for an ecosystem involves identifying those aspects of the natural water regime that are most important for maintaining key ecosystem features and processes. EWRs include elements of quantity and duration and apply both spatially and temporally and are used to inform water resource management and decision makers in the determination of environmental water provisions (EWP). The EWP is the water regime that should be met after consideration of social, economic and ecological water requirements and may involve trade-offs between these requirements. Clearly, it is desirable that the EWR and EWP are the same, however, they may not be equal due to conflicts over the use of water. In such cases the issue of whether the EWP should be equal to or less than the EWR will largely depend on the relative importance placed upon the protection of ecological values by the community concerned.

Until the early 1970's, the management of water resources in Australia was predominantly concerned with the assessment, development and harnessing of new water resources for irrigation, urban and industrial, stock and domestic water supply. However, there is now considerable and increasingly effective public and political pressure for authorities to manage water resources to meet both the traditional needs as well as providing water for the environment.

The Council of Australian Governments endorsed reforms in 1994 to achieve a sustainable water industry that included allocations for the environment and greater environmental accountability of water resource developments. The *National Principles for the Provision of Water for Ecosystems* (1996) produced by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Australia and New Zealand Environment and Conservation Council (ANZECC) provide the basis for considering EWRs as part of water allocation decisions by water resource managers. In Western Australia, the Water and Rivers Commission is the lead agency in water resource management. In 2000, after considerable consultation with the community, the Commission released its Environmental Water Provisions Policy. The Policy sets out the principles and processes for determining EWPs in WA.

The goal for providing water for the environment is to sustain and where necessary restore ecological processes and biodiversity of water dependent ecosystems. Therefore, before EWRs for an ecosystem can be stated, and water provisions set, identification of environmental values need to be considered and criteria developed to protect these values if necessary. Issues considered in identifying environmental values of groundwater dependent ecosystems include the abundance and diversity of flora and fauna, the degree of disturbance and the uniqueness of these characteristics.

The groundwater dependency of many ecosystems within Australia is directly linked to the large areas that experience low surface water inputs due to a semi-arid to arid climate or to seasonal droughts experienced across much of the continent. In a report prepared for LWRRDC, Hatton and Evans (1998) identified a number of GDEs in Australia. As a starting point in the identification process they suggested it was unlikely for any ecosystem to evolve in the presence of groundwater without having some reliance on it. They further suggested that if the availability of groundwater was reduced or its quality altered, these ecosystems would respond in a negative manner regardless of their degree of dependence. The magnitude of dependence was in turn, used to assess and rank the significance of different GDEs.

IDENTIFICATION OF GDES

The GDE identification process can be as straightforward as simple association. For example, an ecosystem associated with a groundwater fed wetland or fauna found in permanent cave-streams. However, the reliance of other ecosystems on groundwater may be much less obvious. For example, the groundwater dependence of terrestrial vegetation ecosystems can be demonstrated using the stable isotope technique. This method is based on the naturally occurring stable isotopes concentrations, which demonstrate differences in hydrogen isotope ratios between potential plant water sources, for example, soil water and groundwater (Ehrlinger & Dawson, 1992; Hatton & Evans, 1998; Walker & Richardson, 1991). Due to the complexities of surface and groundwater interactions, it is often difficult to determine the extent to which an ecosystem depends on one water source or the other. Stable isotope techniques can also be useful in stream and river flow systems in which groundwater often maintains surface water levels long after rainfall has stopped (Roberts, Young, & Marston, 2000).

Leaf area index (LAI) or the biomass of vegetation in a given area, is generally regarded as a simpler yet effective means to identify GDEs (Roberts et al., 2000). LAI works on the assumption that vegetation which has access to groundwater in dry regions would be expected to have greater leaf area than vegetation that was entirely rain dependent. Hatton and Evans (1998) also described the strong relationship between water availability and ‘greenness’ and concluded that LAI is therefore a good indicator of GDEs in semi-arid to arid environments.

Another method relates to observed or measured changes in the composition and/or structure of vegetation and animal communities in response to changes in groundwater availability or quality (Froend, Farrell, Wilkins, Wilson, & McComb, 1993; Research Group on Groundwater Management, 1989; Roberts et al., 2000). Measurable changes in the vigour of wetland 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 wetland) population (altered wetland composition). Any such changes provide an indication that the ecosystem under consideration is potentially groundwater dependent.

Following the methodologies outlined above and an extensive literature review, Hatton and Evans (1998p.1) identified four major types of GDEs covering up to 6% of the Australian land-surface:

- Terrestrial vegetation – vegetation communities with seasonal or occasional dependence on groundwater (phreatophytic)
- Wetlands – aquatic communities and fringing vegetation dependent on groundwater fed lakes and wetlands

- Aquifer and cave ecosystems – aquatic ecosystems that exist in karstic, cave, porous and fissured aquifers.
- River base flow systems – riparian or aquatic ecosystems found along rivers or streams in which groundwater flow is a component of the base flow or mean annual flow (These systems are, strictly speaking, a hydrogeological concept not a class of ecosystem).

Further work by Evans and Hatton (Sinclair Knight Merz, 2001) resulted in two new categories of GDEs being added:

- Terrestrial fauna – native species that use groundwater directly for purposes other than habitat.
- Estuarine and near-shore marine ecosystems – plant and animal communities reliant to some degree on the discharge of groundwater.

GROUNDWATER ATTRIBUTES RELATED TO DEPENDENCY

Environmental Water Requirements can be described in terms of basic groundwater features. Evans and Hatton (Sinclair Knight Merz, 2001) identified four groundwater attributes on which the dependency of GDEs is based:

- Flow or flux – the rate and volume of groundwater required to sustain an ecosystem.
- Level – for unconfined aquifers, the depth below the ground surface of the water table.
- Pressure – for confined aquifers, the potentiometric head of the aquifer and its expression in groundwater discharge areas.
- Quality – the chemical quality of groundwater.

Determination of EWRs requires an understanding of the relationship between these attributes and the dependent elements of an ecosystem and of the nature of any temporal variations. While GDEs will respond to changes in any of these attributes, the degree of change will vary. Some GDEs may show a threshold response, whereby exceeding an attribute value will result in ecosystem collapse. Others may only show a gradual change in structure, composition or health (Sinclair Knight Merz, 2001).

LEVELS OF ECOSYSTEM DEPENDENCY ON GROUNDWATER

Part of the GDE identification process is the determination of the degree of dependence of an ecosystem on groundwater sources. This is an important step in describing the potential impacts of altered water levels on dependent ecosystems. In their assessment, Hatton and Evans (1998 p.1) considered that the "...degree of dependence on groundwater was proportional to the fraction of the annual water budget that the ecosystem derived from groundwater." They described five levels of groundwater dependence:

- Ecosystems entirely dependent on groundwater – ecosystems that would be lost in response to any change in groundwater. Examples of these ecosystems in Western Australia include karstic groundwater systems in Yanchep and Cape Range.

- Ecosystems highly dependent on groundwater – ecosystems that would demonstrate substantial decreases in health or changes in structure or composition in response to moderate changes in groundwater discharge or water tables. Near shore stromatolite systems of coastal Western Australia have been identified as having this level of dependence.

- Ecosystems with proportional dependence on groundwater – ecosystems that would show a less than proportional change in health, composition or structure in response to a change in groundwater. Examples from Western Australia include damplands and sumplands of the Swan Coastal Plain and base-flow dependent systems of the south-west.

- Ecosystems which may only use groundwater opportunistically or to a very limited extent – long-term changes in groundwater may have a negative impact on ecosystems which rely on groundwater only during drought periods or at the end of a dry season. Short-term reductions in water levels may show little impact. The jarrah forest and *Banksia* woodlands of south-west Western Australia provide an example of this level of dependence.

- Ecosystems with no apparent dependency on groundwater – wetland ecosystems which seem to rely solely on surface water. Ecosystems thought to belong to this category include episodic and intermittent arid zone wetlands.

It follows that the greater the level of dependence on groundwater the greater the potential impacts that may arise from altered water levels or changes in water quality.

Evans and Hatton (Sinclair Knight Merz, 2001) identified that an understanding of four key factors was required prior to the establishment of policy and management systems for GDEs

- The nature of the groundwater dependency of an ecosystem.
- The water requirements of the ecosystem.
- The groundwater regime required to meet the water requirements.
- The impacts of an altered water regime on the ecosystem.

1.2 ECOLOGICAL WATER REQUIREMENTS OF DIFFERENT FORMS OF GROUNDWATER DEPENDENT ECOSYSTEMS

TERRESTRIAL VEGETATION

The largest body of literature on phreatophytic terrestrial vegetation water requirements comes from western North America from research carried out on native riparian vegetation (Friedman, Scott, & Auble, 1997; Scott, Shatfroth, & Auble, 1999; Stromberg & Patten, 1990; Stromberg, Tress, Wilkins, & Clark, 1992). These systems have been massively altered over the last century by water development and land use practices. Because of its close dependence on streamflow, riparian vegetation is very sensitive to changes associated with water development and near channel groundwater alterations.

The rapid decline of these valuable ecosystems has made riparian conservation a focal issue for many federal, state and private organisations. Most of the research directed in this area is focused at understanding the context of natural variation in plant response to aid in understanding the effects of past and current water management. Research has been conducted from species to a regional level using interdisciplinary approaches to evaluating natural and human-induced changes in the native vegetation. Scott & Eggleston (1999) and Shafroth, Stromberg & Pattern (2000) quantified the relationship between the patterns of response and mortality in dominant riparian species to groundwater depletion due to in-channel sand mining and other anthropogenic mechanisms. Information on the extent and timing of vegetation response (changes in morphology, growth and mortality) was matched with quantitative data on the rate, depth and duration of water table declines and enabled identification of stress or mortality thresholds.

These studies have aided efforts to promote survival of desirable riparian species and management of activities likely to stress this vegetation. Although the outcomes of this research provide means by which terrestrial vegetation water requirements can be conceptualised, the quantitative information is very specific to shallow depth to groundwater systems in mild, temperate climates.

In South Africa recently adopted water policy and legislation (National Water Act) has major implications for a more integrated sustainable management of both ground and surface waters (DWAF, 1997). In the past, excessive utilisation of groundwater has impacted the baseflow and impacted on the vegetation of numerous perennial rivers and springs (Bate & Walker, 1993; Le Maitre & Scott, 1999). The requirements of vegetation that depend on groundwater in these ecosystems are poorly understood and is an issue that will have to be addressed to meet the obligations of the new South African Water Act. These requirements will place new demands on water resource managers to ensure that utilisation does not lead to damage to the environment, including ecosystems which depend on groundwater. Therefore a greater understanding of the groundwater requirements of plants will be required to enable the determination of water reserves for ecological purposes before water-use licenses may be granted or renewed.

Traditionally, in South Africa, research on the interaction of plants and water sources has been in the domain of the hydrological sciences and divided between disciplines of surface and groundwater hydrology. This division has been addressed during the water law review process recognising that surface and groundwater system are indivisible (DWAF, 1995, 1996). As a result, vegetation-groundwater interactions are the focus of renewed interest towards a holistic approach and integrated management of natural resources in South Africa. This growing interest is likely to generate new information on determining vegetation water requirements in the near future.

In Australia, riparian vegetation has received the most attention when estimating the quantitative groundwater needs of vegetation. Although consideration of riparian vegetation has been a recent addition to environmental water requirement methodologies, approaches have already been described by Roberts *et al*. (2000) for floodplain vegetation. In addition, research has been conducted in the Murray River basin in South Australia to determine the importance of alluvial groundwater in supplying water to the riparian eucalypt forest. Results indicate that groundwater plays a significant role, with this vegetation drawing a substantial proportion of its water requirements from shallow alluvial aquifers of the Murray River basin (Bacon & Stone, 1993; Thorburn, Walker, & Brunel, 1993).

More recently a descriptive desktop methodology for identifying potential groundwater requirements of native vegetation was developed for the Nature Conservation Council of New South Wales (PPK Environment & Infrastructure Pty Ltd., 2001). The aim of the method is to enable classification of potential groundwater dependency of vegetation without conducting field studies by prompting the user to define and assess characteristics of the vegetation and the study area.

In Western Australia the majority of work undertaken on the water requirements of terrestrial vegetation has focussed on the coastal region of the south-west coast. Of the two large unconfined aquifers that underlie this region, the GDEs of the northern aquifer, the Gnangara Mound, are amongst the most studied and best understood systems in the country.

Large areas of woodland, predominantly *Banksia*, occur across the Gnangara Mound. Many of the tree and deep rooted shrub species associated with these communities are phreatophytic, that is, capable of obtaining groundwater from the zone of saturation either directly or through the overlying capillary fringe (Meizner, 1923). The groundwater dependency (phreatophytic nature) of these ecosystems has been acknowledged since the early 1970s when groundwater abstraction first commenced in the area (Arrowsmith, 1996). However, studies have often merely inferred phreatophytic behaviour from observations of deep root systems, response to groundwater declines and water balance studies.

Root system excavations of Banksia woodland species identified deep rooting patterns and an associated ability to reach depths close to or penetrating the underlying water table (Dodd, Heddle, Pate, & Dixon, 1984; Farrington, Greenwood, Bartle, Beresford, & Watson, 1989; Matizke & and Associates, 1991; Nicoski, Groom, & Froend, 1997). The inference drawn from these observations was that as deep rooted woodland species access groundwater they are also capable of using it.

Vegetation mortalities have occurred across the Gnangara Mound in areas of groundwater abstraction in response to altered groundwater regimes. Results of an investigation into these deaths indicated that trees found growing in areas where the depth to groundwater was shallow, between 3 and 5 metres, were most susceptible to changes in water level where declines had been too rapid to provide adequate time for root systems to respond. (Water Authority of Western Australia, 1992). A subsequent study by Groom, Froend, Mattiske & Koch (2000) demonstrated the differences in responses between deep-rooted phreatophytes and shallow-rooted non-phreatophytes in *Banksia* woodlands. These studies provided further observational evidence of the association between groundwater dependence and terrestrial vegetation (Zencich & Froend, 2001).

Dodd and Bell (1993) were the first to demonstrate an association between plant water relations and proximity to the groundwater table. They measured seasonal and diurnal water relations in two terrestrial *Banksia* species. Their results indicated that both species had high rates of water usage throughout the year including the dry summer months, and must therefore be utilizing groundwater in the absence of soil moisture. Other studies of the same species (Grieve, 1955; Grieve & Hellmuth, 1968, 1970), however, showed low water usage in summer. Dodd and Bell (1993) concluded that these species were probably phreatophytes, relying on groundwater only where it was available.

Dawson and Pate (1996) used stable isotope techniques to demonstrate phreatophytic behaviour in *Banksia* species experimentally. Using stable isotopes as tracers, this study demonstrated seasonal variations in water source usage by illustrating preferences for soil moisture uptake in winter and groundwater uptake in summer. Further studies (Zencich, Froend, Turner, & Gailitis, 2002) supported the finding that temporal variations exist in water source usage and indicated that spatial variations also occur. Intraspecific variations have been demonstrated between individuals from different positions in the landscape, while interspecific variations occur primarily as a function of rooting morphology (S. Zencich, pers. comm).

Zencich *et al*.,(2002) determined seasonal water sources for species growing on a coastal dune system that overlies the Gnangara Mound. The plants studied grew over groundwater that ranged in depth from 2.5 to 30 m. The naturally occurring stable isotope of hydrogen (deuterium, δ^2H) was used to distinguish among potential water sources. Isotopic ratios from vascular water of the dominant species of the study area (*Banksia ilicifolia* and *Banksia attenuata*) were compared with those of potential sources of precipitation, soil moisture and groundwater. A relatively shallow-rooted perennial shrub, *Hibbertia hypericoides*, was also included as an isotopic reference.

Research undertaken by ECU (Zencich et al., 2002) to determine the water requirements of phreatophytic *Banksia* woodland vegetation identified classes of phreatophytic dependency based on the influence of groundwater depth (Froend & Zencich, 2001).

Three phreatophytic categories were identified. The greater the depth to groundwater, the lower the requirement for groundwater and the more tolerant *Banksia* are to groundwater decline due to the corresponding increase in alternative water sources. These alternative sources are primarily the larger volume of unsaturated zone (with increasing soil depth) exploitable by the plant's root system. The categories have been based on research on *Banksia attenuata* and *B. menziesii* only (Froend & Zencich, 2001).

Within the categories of 0-3 m, 3-6 and 6-10 m, *Bansksia* are phreatophytic and derive some of their water from groundwater throughout the dry-wet cycle. Between these categories the degree to which groundwater is utilised by *Banksia* is dependent on the proximity of groundwater, availability of moisture in shallower horizons of the soil profile, root system distribution and maximum root depth. The highest proportion (>50%) of groundwater is used by the 0-3 and 3-6 m depth to groundwater vegetation category. Given the apparent high dependency of *Banksia* in these shallow areas of the landscape on summer access to groundwater, it is suggested that they are particularly susceptible to groundwater drawdown. Vegetation in the 6-10 m category also use groundwater, however, they use proportionately more water from the upper layers of the soil profile as they have a larger volume of subsurface soil moisture store beyond the influence of direct evaporation (Zencich et al., 2002).

The results suggested that both *B. attenuata* and *B. ilicifolia* are phreatophytic as they derived some of their water from groundwater throughout the dry-wet cycle, with the exception of *B. attenuata* at the site of greatest depth to groundwater (30 m) which did not use groundwater (Zencich et al., 2002). A high proportion (>50%) of groundwater use was not maintained throughout all seasons. With the onset of the hot Mediterranean summer, progressive drying of the surface soils resulted in increased use of groundwater and deep soil moisture. During the wet winter plants used proportionately more water from the upper layers of the soil profile. The degree to which groundwater was utilised by the study species was dependent on the proximity of groundwater, availability of moisture in shallower horizons of the soil profile, root system distribution and maximum root depth.

WETLAND ECOSYSTEMS

The relationship between groundwater and wetlands has been the focus of much research world-wide and represents a body of work too extensive to review in this report. This section will therefore focus on one component of wetland ecosystems providing a brief overview of wetland vegetation and groundwater dynamics.

There are a number of components of the water regime that influence wetland vegetation (Roberts et al., 2000). The season of flooding determines the climatic variables, such as day length and temperature that persist during inundation (Roberts et al., 2000). The combination of climatic variables and water availability a species requires will determine when it grows and reproduces (Roberts et al., 2000). The rate at which water rises is important as a rapid increase in depth will not allow emergent species to grow quickly enough to stay above the water (Brock & Casanova, 1997). The frequency of flooding and the interval between flood episodes are also important for growth and reproduction. For example, the seeds of some species may become unviable if dry for too long a period, while other species may require lengthy dry periods to germinate and establish (Roberts et al., 2000).

The most important components of the water regime, however, are the depth of inundation and the duration of the flood event (Roberts et al., 2000). The impact of depth is dependent on the size and growth form of a species. As discussed above large species can grow above the water, however, smaller plants will drown (Roberts et al., 2000). The duration of inundation, or the time that surface water is present, will determine whether some species produce sexually or vegetatively, or whether others, tolerant of short periods of inundation only, will survive at all (Roberts et al., 2000). These two water regime components are also the most significant as they have a greater impact on a wider range of species than other factors. For example, inundation will kill many intolerant species regardless of the season of flooding and rate of rise (Mountford & Chapman, 1993).

A strong relationship therefore exists between the distribution, growth and reproduction of wetland vegetation and the depth and duration of seasonal flooding (Brownlow, Sparrow, & Ganf, 1994; Froend & McComb, 1994; Mountford & Chapman, 1993; Neilsen & Chick, 1997). This relationship is especially obvious where vegetation forms bands around a wetland and each successive band is less tolerant of inundation (Wheeler, 1999).

Altered water regimes also demonstrate the importance of water levels to wetland vegetation (Wheeler, 1999). As each species is adapted to a specific water level range, or hydrological envelope, any change in water levels can ultimately affect its distribution. Long-term persistent changes can cause a shift in community composition and structure as species better adapted to the new conditions become established (Harding, 1993). Lowering water tables can result in the loss of species intolerant of drying and their gradual replacement by terrestrial species with drier hydrological (Keddy & Reznicek, 1986; Moore & Keddy, 1988). Changed climatic patterns and human activities such as groundwater abstraction are the main causes of declining water levels in Australia (Balla, 1994; Froend et al., 1993).

Due to their larger size, longer life-span and more expansive root systems, wetland trees are often more tolerant and respond more slowly to changes in water levels than other wetland species (Balla, 1994; Jenik, 1990). Muir (1983) found evidence of this in a study of vegetation of sandplain wetlands, in which a young band of trees was found growing inside a band of an older species known to be more tolerant of inundation. This suggests that, although conditions had dried enough to allow the new species to establish, the other wetland trees persisted.

Emergent macrophytes, that is sedges and rushes with vegetative parts emerging from seasonal fresh water (Semeniuk, 1987), respond much quicker to altered water regimes than trees and many other perennial wetland species (Froend et al., 1993). Not only are they lost to declining water tables, like many species they are also affected by rising (McComb & Lake, 1990; ter Heerdt & Drost, 1994). Increased groundwater levels can result from climatic changes as well as increased runoff from urban areas and the removal of native vegetation (Balla, 1994).

Emergent macrophytes generally respond to increasing water depths in two ways (van der Valk, 1994). Firstly, if levels rise quickly, they may be lost due to drowning if they do not have enough leaf area above the water surface to allow respiration (van der Valk, 1994). Secondly, if the water rises more gradually they may respond by migrating upslope to more suitable (Froend & McComb, 1994; van der Valk, 1994). Migration downslope will occur in response to lower water levels (Froend & McComb, 1994; ter Heerdt & Drost, 1994).

The distribution and composition of perennial wetland shrubs, herbs and ferns are also influenced by water level gradients (Harding, 1993). These species generally tolerate lower depths of inundation for shorter periods than trees and emergent macrophytes and are often more prominent as fringing species (Keddy & Reznicek, 1986). However, changed water regimes will affect these species in a similar fashion to the emergent macrophytes as they are either lost or migrate to more suitable water levels (Keddy & Reznicek, 1986).

The groundwater dependence of many wetland ecosystems has been largely inferred from their position in the landscape, their response to altered water regimes and the occurrence of vegetation species associated with shallow groundwater. Hatton and Evans (1998) described the groundwater dependence of wetlands as ranging from entirely dependent through to highly dependent and proportionally dependent, according to the permanence of the water body. For example permanent lakes were classified as entirely dependent, while seasonally wet or waterlogged wetlands supporting fringing vegetation communities were described as only proportionally dependent.

Groundwater dependency of wetlands has also been inferred through the impact of altered water regimes on the distribution and composition of wetland ecosystems (Carbon, 1976; Havel, 1975; McComb & McComb, 1967). Unlike terrestrial vegetation, wetland species are often shallow rooted having adapted to shallower water tables (Groom et al., 2000; Muir, 1983). Therefore, in response to declining groundwater levels species are either lost from a wetland or have migrated towards more suitable water levels, to be replaced by more xeric species (Froend et al., 1993; Groom et al., 2000; Muir, 1983; Research Group on Groundwater Management, 1989).

Wetlands also support a diverse range of fauna including invertebrates, fish and birds. Many invertebrate species have no requirement for permanent surface water due to a desiccation resistant life-stage or to a long-lived, non-aquatic adult stage (Balla & Davis, 1993; Davis, Harrington, & Friend, 1991; Davis & Rolls, 1987; Water Authority of Western Australia, 1986). They do, however, require water to complete their life-cycles with many also dependent on emergent wetland vegetation for habitat and food (Arrowsmith, 1996), while other invertebrates and fish species depend on permanent water for all life-stages (Water and Rivers Commission, 1997). Waterbirds rely on wetlands as breeding sites, feeding grounds and drought refuges (Arrowsmith, 1996; Storey, Vervest, Pearson, & Halse, 1993). The groundwater dependency of the faunal component of wetland ecosystems can be initially inferred as they occur in groundwater-fed systems and a fundamental tenet of ecology is that ecosystems will generally use resources in proportion to their availabilty. Secondary inferences arise from their potential loss from a wetland as a result of declining water tables and the associated reduction in surface water and/or wetland vegetation.

The presence at a site of a suite of known wetland vegetation species can also identify an ecosystem as groundwater dependent. Froend & McComb, (1994) identified 10 key species common across the Gnangara Mound of which one or more were likely to occur at any wetland. Muir (1983), Smith and Ladd (1994) and Groom *et al*. (2000) discussed a group of shallow-rooted, myrtaceous shrub species commonly associated with winter-wet depressions concluding that these species were generally reliant on shallow groundwater tables.

Loomes (2000) described the water depth ranges of 60 wetland vegetation species found across the Swan Coastal Plain in Western Australia. The distributions of these species across 27 annually monitored permanent transects were compared to monthly surface water data to determine the mean minimum and maximum water depths experienced by each species at each wetland (see section 3.1: Review of existing methodologies for further detail). Data for all wetlands were combined to provide absolute and mean water depth ranges. Loomes and Froend (2001a; 2001b; 2001c) used these ranges to review the water level criteria set under the ‘East Gnangara Environment Water Provisions Plan’ (Water and Rivers Commission, 1997) and the ‘Review of Proposed Changed to Environmental Conditions – Gnangara Mound Groundwater Resources’ (Water Authority of Western Australia, 1995) and also to assess the potential impacts of altered water regimes on the vegetation of six wetlands in the Muir-Byenup peat swamp system (Froend & Loomes, 2001).

The methodology discussed above involved the use of hydrological ranges, including depth and duration, to describe the water requirements of individual species. To establish EWRs for a wetland vegetation community at a specific site the ranges of the most susceptible species were considered. To determine which species was the most susceptible, comparisons between changes in the cover and abundance, health and distribution were made with trends in the current water regime. For example, declining water levels may coincide with a decline in health, cover and abundance of an emergent macrophyte which requires inundation to a depth not reached in recent seasons. As this species required a greater depth of inundation for longer periods of time than all other species at the particular wetland, it was deemed the most susceptible and a community EWR set to protect it. In comparison, the same emergent macrophyte may have increased in cover and abundance in response to increasing water levels, while at the same time, a fringing tree species in the overstorey showed signs of declining health. The tree species was regarded as the most susceptible and EWRs set accordingly.

CAVE AND AQUIFER (HYPOGEAN) ECOSYSTEMS

The ecosystems that exist in cave streams and in aquifers themselves have been identified as entirely groundwater dependent (Hatton & Evans, 1998). This level of dependence relates to the evolution of these ecosystems in a stable, confined environment and is best illustrated by the potential of any changes in water depth or quality to have an impact on faunal assemblages (Gillieson, Hamilton-Smith, & Watson, 1995; Sinclair Knight Merz, 2001).

Although there is a paucity of literature related to the water requirements of these communities, in Europe and the US, hypogean invertebrates are increasingly being recognised for their potential as bio-indicators of groundwater quality, especially in relation to heavy metals and other pollutants (Notenboom, Plenet, & Turquin, 1994; Plenet, 1999; Plenet & Gilbert, 1994; Plenet *et al.*, 1992).

A large body of work has been undertaken on the fauna of cave and aquifers systems in north-west Western Australia (Bradbury & Williams, 1996; Humphreys, 1993a, 1993b; Humphreys, Poole, Eberhard, & Warren, 1999; Poore & Humphreys, 1992) with karst ecosystems of the Cape Range recognised as amongst the most diverse in the world (Spate & Thurgate, 1998). Studies have shown that the invertebrate species living in these ecosystems are grazers and predators dependent on the biofilm that forms in freshwater habitats. These ancient species also provide insights into the interconnectedness of groundwater systems, past climate and evolutionary changes.

Yanchep National Park on the Gnangara Mound contains 273 documented caves (Water Authority of Western Australia, 1995). Groundwater streams or pools in five of these systems are known to support between 30 and 40 invertebrate species, which is up to nine times higher than the number of species recorded elsewhere in the world (Jasinska & Knott, 1991). The ability of these species to survive drying is unknown, but it is thought that permanent or temporary drying of cave streams represents the greatest threat to cave fauna (Jasinska & Knott, 1991).

TERRESTRIAL FAUNA

Groundwater dependent terrestrial and wetland vegetation provides habitat and food for fauna which by extension must also be groundwater dependent (Sinclair Knight Merz, 2001). However, there are other groups of fauna that also depend on groundwater as a source of drinking water. Evans and Hatton (Sinclair Knight Merz, 2001) do not describe the level of dependence of faunal ecosystems, however, it can be assumed they are opportunistically dependent as they would use surface water were available.

This group is dominated by birds and larger mammals, as respiration supplies many small mammals with their water requirements (Sinclair Knight Merz, 2001). Some species of kangaroo are known to dig to shallow groundwater while numbers of both native and exotic species have increased as a result of the extensive use of groundwater for livestock watering. As a recent addition to the list of groundwater dependent ecosystems, little or no research has been undertaken specifically on the groundwater dependency of terrestrial fauna.

RIVER-BASE FLOW SYSTEMS

Base flow is the part of river or stream flow derived from the discharge of groundwater and bank storage (Sinclair Knight Merz, 2001). River base flow systems support both aquatic and riparian vegetation as well as dependent fauna (Hatton & Evans, 1998). The majority of research undertaken on these systems internationally relates to the requirements of riparian vegetation in North America and South Africa as discussed in a previous section on terrestrial vegetation.

The river ecosystems of the south-west of Western Australia were classified as proportionally dependent by Hatton and Evans (1998) as base-flow contributes to surface water flow throughout the year. Coastal rivers of northern Australia are also proportionally dependent, however, this is due to the seasonal nature of surface water availability and the subsequent dependence on groundwater during the dry season.

The dependency of river base flow systems has been experimentally illustrated through the use of the stable isotope technique in the study of water relations of river red gums (*Eucalyptus camaldulensis)* on floodplains in Eastern Australia (Cramer, Thorburn, & Fraser, 1999; Mensforth, Thorburn, Tyerman, & Walker, 1994; Thorburn & Walker, 1994; Thorburn et al., 1993; Thorburn, Walker, & Hatton, 1992). The findings of these studies generally suggested that the dependency of river red gums on groundwater varied with the availability of surface water, but that the uptake of groundwater continued throughout the year.

Despite the body of work by Thorburn and others on the river red gum, there remains a need for further research into the interaction between groundwater and surface water and the extent to which riparian vegetation depends on groundwater (Arthington & Zalucki, 1998).

World-wide more than 100 different approaches over 30 countries have been developed to determine the environmental flows required to maintain riverine and stream ecosystems and ecological processes (Arthington, 2001). A large proportion of this work has been undertaken to identify the water requirements of freshwater fish species (Koehn, 1988; Pusey, 1998; Shields, Knight, & Cooper, 1994; Tenant, 1976) with numerous studies also aimed at the in-stream needs of invertebrates (Davis & Humphries, 1995; Gowns, 1998; Halse, 2000). Although base-flows are identified as essential to the maintenance of habitat in the form of summer pools (Davis, Harrington, & Friend, 1993; Storey, 2001), there is little research that addresses the degree of reliance of fauna on groundwater with the literature generally focussed on overall water requirements with little distinction made between surface and groundwater sources.

ESTUARINE AND NEAR-SHORE MARINE ECOSYSTEMS

It is known that mixing at the interface of freshwater and seawater produce a large number of food sources and habitat for a diverse range of species. Tidal freshwater marshes provide nursery grounds for many anadromous and semianadromous fish species, while organic materials including plants and microbes sustain bivalves and crustaceans (Howes, Weiskel, Goehringer, & Teal, 1996).

The majority of work on these ecosystems has been undertaken in the US and has focussed on surface sources of freshwater, however, the importance of groundwater has been increasingly recognised. Early studies generated conflicting results with estimates of the volume of submarine groundwater discharge ranging from an amount equal to 1% of river discharge to the ocean to 10% of surface water runoff (Simmons, 1992). The focus of later work seemingly shifted from quantitative to qualitative, with research in the Gulf of Mexico describing the composition of water from offshore springs through the analysis of samples for traces of chemicals and nutrients that originated in freshwater (Stuller, 1994). More recently, research in Florida has identified a number of negative impacts resulting largely from altered groundwater quality, however, the magnitude of these impacts to marine species is still largely unknown (Bacchus, 2001a). Changes in volumes of groundwater discharge and a subsequent increase in salinity have been identified as detrimental to seagrass and turtle-grass beds in Florida Bay (Bacchus, 2001a, 2001b; Duarte, 1995; Durako & Kuss, 1994).

Hatton and Evans (1998) described the majority of estuarine and near-shore marine habitats as using groundwater opportunistically or to a very limited extent. The exception to this was the stromatolite systems of southern Western Australia which have developed in groundwater fed coastal lakes (McNamara, 1992) and were therefore classified as entirely groundwater dependent. Lake Thetis south of Cervantes in the Jurien-Arrowsmith area supports stromatolites and should also be classified as a GDE.

The potential of seagrass systems and near shore fisheries to be groundwater dependent has become a recent area of focus for marine ecologists (J. Griffith, ECU, pers. comm. 2001). Studies have shown that seagrass composition can be altered following groundwater abstraction and the resultant reduction in freshwater input (Hemminga & Duarte, 2000). Groundwater may also provide seagrass in some coastal areas with nutrients (Hatton & Evans, 1998).

Mangroves and salt marshes, although strongly associated with salt water, are also known to occur in areas where fresh groundwater discharge into the sea (Adam, 1994). The groundwater dependence of these systems is unknown, however, Tack and Polk (1999) described a large-scale decline in mangroves following groundwater abstraction.

The groundwater dependence of marine animals is also largely undetermined. However, fauna including fish, turtles, crocodiles and macro-invertebrates may feed on other groundwater dependent species or rely on them for habitat (Haywood, Vance, & Loneragan, 1995; Hyndes, Potter, & Lenanton, 1996; Sinclair Knight Merz, 2001).

Despite increasing interest in the importance of groundwater discharge to near-shore marine and estuarine ecosystems a great number of questions regarding the nature and degree of dependence remain unanswered.

1.3 REVIEW OF EXISTING APPROACHES TO DETERMINING ECOLOGICAL WATER REQUIREMENTS

A number of approaches have been developed to determine the water requirements of water dependent ecosystems. The majority of these, however, focus on the requirements of systems dominated by surface water flows with fewer approaches directed entirely towards groundwater dependent ecosystems. The approaches that do exist for GDEs generally focus on one type of ecosystem (eg. wetlands) or on one component of that ecosystem (eg. wetland vegetation). Surface water system approaches are more holistic in nature, considering the requirements of the many interacting components of river systems. Further differences exist in terms of the spatial scale of approaches, for example the water requirements of an individual wetland or an entire catchment. The greatest variation, however relates to available time and resources. These factors in turn influence the extent of fieldwork, intensity of data analysis and the level of involvement by experts.

In this section, the existing WA approach for GDEs will be summarised and general strengths and limitations assessed. For a full review and comparison of other approaches used for groundwater and surface water systems, refer to Froend and Loomes (2004). Particular emphasis will be placed on identifying the recognised weaknesses of past WA approaches and improvements in a revised approach to determining EWRs for GDEs.

CURRENT WA APPROACH

The current WA approach is defined here by the Review of Proposed Changes to Environmental Conditions, Gnangara Mound Groundwater Resource (Section 46) – Western Australian Water Authority (1995).

In response to further proposed increases in groundwater abstraction, changes in private groundwater usage and an improved understanding of groundwater dependent ecosystems, a review of environmental conditions of the Gnangara Mound was undertaken (Section 46) (Water Authority of Western Australia, 1995). The requirements of three types of GDEs were determined, wetland ecosystems, terrestrial vegetation and cave streams.

The specific approach to defining EWR was;

- Identification of GDE components (wetlands, terrestrial vegetation, cave streams and pools).
- Selection of representative parts for which EWRs were set to ensure appropriate protection for the region.
- Identification of values of those parts, including social and environmental aspects.
- Determination of management objectives based on the values.
- Establishing water levels for each ecosystem component that satisfy the identified management objectives and which define the EWR.

Determination of EWRs for wetland ecosystems involved the following steps;

1. Identifying characteristics of the wetland.
2. Identifying values of the wetland, both environmental and social.
3. Determining management objectives that reflect wetland values, in particular those achievable through management of water levels.
4. Developing a water regime consistent with the management objectives, with water levels to describe that regime.

Wetlands were identified as groundwater dependent ecosystems and wetland vegetation was selected as the representative component for protection due to the interdependent nature of wetland biota. Management objectives included conserving the existing distribution and composition of fringing and emergent vegetation. EWRs were set as minimum and maximum water levels. Absolute minimum water levels for each wetland were set to ensure populations of the sedge *Baumea articulata* were sufficiently inundated and that surface water was present long enough for aquatic invertebrates to complete their life-cycles. The water requirements of *B. articulata* were considered as this species is known to be the most susceptible to declining water levels. Maximum water levels were based on ensuring wetland trees were dry for a minimum period per year.

The approach to setting EWRs for terrestrial vegetation was identified separately to that for wetlands, with the aim of determining water levels required for survival and a level of drawdown that could be tolerated by the vegetation. The approach involved;

1. Identification of areas of susceptible native vegetation.
2. Selection of monitoring bores within the areas that best represent water table levels and which can be used to monitor compliance with water levels.
3. Defining rates of change and minimum groundwater levels to minimise the potential for vegetation deaths due to water stress.

This involved the setting of absolute and preferred minimum groundwater levels that did not represent a static volumetric amount. Instead, these were expressed as dynamic water level regimes that could be changed in response to differing needs and situations. In areas where extraction had already been occurring and had resulted in a stabilised drop in the watertable, the philosophy of no further impact on groundwater levels was adopted.

Minimum water level requirements were selected for susceptible terrestrial vegetation, those existing at shallow depths to groundwater (0-8 m), on the basis of previously observed water levels and resulting impacts on the vegetation. Minimum groundwater level requirements were determined using historical monitoring records from groundwater monitoring wells located within areas of susceptible vegetation. The hydrographs from the monitoring well data were analysed to ascertain a 'normal' minimum groundwater level defined as the average minimum groundwater level occurring at the end of summer periods in the early 1970's prior to abstraction and the continuing drought period. The absolute minimum groundwater level was determined by subtracting 1.5 m from what was considered to be the 'normal' groundwater level.

In areas where abstraction had not been occurring for long enough to result in a stabilised watertable, a vegetation water stress study was used to derive the maximum rate of watertable drop that could still support the extant vegetation. The study indicated that the overstorey component of the vegetation could tolerate a water table drawdown of 1.5 m in total (this is where the figure of 1.5 m was derived to arrive at absolute groundwater levels), and that this drawdown could be tolerated at no more than an average rate of 0.2 m per year.

Due to the limited information on groundwater levels in cave streams and pools at the time of the Section 46 review, EWRs were not set. However management objectives were developed to maintain the existing hydrological regimes and permanent water in streams supporting fauna.

EWPs were established following comparisons of groundwater modelling of preferred abstraction and land use scenarios and EWRs. Finally, management and monitoring programs were implemented to minimize the impact of land use activities on groundwater resources and GDEs.

Strengths and limitations

The setting of EWRs for a wetland based on the pre-determined requirements of a single vegetation species (*Baumea articulata*) represents a relatively quick and inexpensive approach. The use of a species identified as most susceptible to water levels changes also ensures that the requirements of other, less susceptible species are met. However, this species generally occurs only in wetlands that hold surface water for some part of the year, making the approach inapplicable to many systems.

The use of pre-determined requirements in the approach for terrestrial vegetation is also quick and inexpensive. However, setting the same water levels for susceptible vegetation (0-8m groundwater depth) does not recognize the variation in dependence of vegetation at different depths to groundwater. For example, vegetation at 0-3m is more susceptible to drawdown than that at 6-8m. Setting a maximum allowable drawdown of 1.5m also does not consider the greater susceptibility of vegetation at shallower depths to groundwater.

This approach was, however the first attempt at setting preferred and absolute minimum groundwater levels that did not represent a static volumetric amount and reflected the dynamic nature of water level regimes.

Since 1995 there have been numerous interim assessments and research conducted on GDEs on the SCP and elsewhere [refer to (Froend & Loomes, 2004) for review] that has led to an improved understanding of the ecology of these systems and the identification of their EWRs. Incremental changes to the approach described above have been made in recognition of observed limitations and increased knowledge. A summary of these limitations is presented below.

Limitations relevant to identification of EWRs:

- Insufficient consideration of all recognised groundwater dependent ecosystems. The original approach assessed wetlands, terrestrial vegetation and cave streams only with little acknowledgement in the variability within each type of GDE.
- Consideration of the water requirements of only one component of a GDE; e.g. determining EWRs of a whole wetland based on wetland vegetation water requirements alone.
- No acknowledgement of the variability in groundwater dependency within a GDE and/or an ecological component; e.g. variability in groundwater dependency of phreatophytic vegetation relative to depth the water table and hydrological ranges (tolerances) of wetland vegetation. Leads to insufficient awareness of biological/ecological variability and incorrect interpretation of EWRs as absolute ‘thresholds’ of tolerance.
- Simplification of water requirements into minimum water table depths without recognition of other hydrological variables important to the ecology of the system; e.g. duration, timing and rate of seasonal flooding/drying and the episodicity of extreme flooding/drying events.
- No consideration of cumulative effects of reduced groundwater availability or a lag-response in the ecology.
- No consideration of the resilience of GDEs to drawdown impacts.
- Consideration of GDEs as single units only without a system/catchment approach towards identifying water requirements and possible impacts.

These limitations have often led to the identification of EWRs that do not accurately reflect the requirements of the ecology, often resulting in technical breaches of environmental conditions (without obvious ecological impact) or understated water requirements leading to unexpected environmental impacts.

Other limitations reflect how EWRs are used in the determination of environmental water provisions (EWPs) or determining likely impacts. Limitations relevant to identification of EWPs:

- Absence of a risk (of impact) assessment incorporating variability in current vulnerabilities (water requirements and drought stress) and potential degree of change/impact.
- Management (environmental compliance) criteria based on simplified minimum ‘threshold’ water table levels without consideration of acceptable changes to ecological values.
- Direct translation of EWRs to EWPs or management criteria without sufficient consideration of social and economic water requirements.
- Inaccurate assessment of groundwater levels/wetland surface water level relative to GDE ecology; e.g. no groundwater monitoring at vegetation monitoring sites.

REVISED APPROACH

Revision of the current WA approach to identification of GDE EWRs should involve the adoption of frameworks described in SKM (2001) and Froend and Loomes (2004). Specifically, a revised approach should:

- Recognise all identifiable GDEs within the study region and set about collecting sufficient information to identify their EWRs. In the case of the SCP, this would see the expansion of wetlands assessed to include damplands, assessment of phreatophytic vegetation over a variety of depths to groundwater, assessment of baseflow-dominated systems, the inclusion of near-shore marine and estuarine systems and increased assessment of cave and mound spring systems.

- Consider the EWRs of as many components of the GDE ecology for which necessary data are available. For example, this would require the determination of wetland EWRs to be an integration of vegetation, vertebrate, macroinvertebrate and physicochemical water requirements. Single components may dominate the EWR assessment of particular GDEs if insufficient data exist to incorporate the other components of the ecology, or if the requirements of one component (e.g. ‘umbrella’ species) can be demonstrated to cater for all other key components.
- Acknowledge variability in EWRs within ecological components (e.g. vegetation) of a GDE. Not all phreatophytic vegetation has the same degree of dependency on groundwater and therefore the same response to drawdown. This variability in dependency has a significant effect on the risk of impact from groundwater drawdown. The expression of EWRs should therefore incorporate the range in water requirements (not absolute ‘threshold’ values only) and or categories of differing requirements/dependency.
- Recognise other hydrological variables important to the ecology of the system; e.g. duration, timing and rate of seasonal flooding/drying and the episodicity of extreme flooding/drying events.
- Consider the cumulative effects of reduced groundwater availability by assessing historical changes in water tables/surface water levels and determine the net change in groundwater availability over key periods of time. This historical change should then be considered in addition to any impacts from proposed developments. A lag-response in a GDE may occur after EWRs have been compromised for some time without obvious ecological response. Identification of EWRs should consider the rate at which GDEs are likely to response to changes in groundwater availability.
- Acknowledge the resilience of GDEs to altered groundwater availability. Ecological values are able to be restored/maintained if remedial/mitigation practices are put in place. Therefore a longer-term perspective in water requirements necessary to maintain ecological values should be adopted.
- Consider system/catchment level water requirements as well as single GDE requirements. Important landscape level ecological processes should be considered, e.g. acid sulphate soils.

SECTION 2 –EWRS

2.1 GENERAL EWRS

In this section EWRs are described for all GDEs identified in Task 1 (Table 2). As previous studies have not been undertaken on the majority of these systems, their ecological values, condition and general structure are widely unknown. At the time of writing, site visits to 'new' wetlands and terrestrial vegetation GDEs identified in Task 1a.2 were being undertaken. However, assessments of values were restricted to vegetation and/or general wetland condition. Assessment of values related to macroinvertebrates, waterbirds, other vertebrates and water quality were beyond the scope of these assessments, as were assessments of 'new' cave pool and near-shore marine systems. EWRs therefore could not be described for a vast number of GDEs while the EWRs for many others remain qualitative and based on what little information is available. However, where the required level of information is available detailed/quantitative EWRs are described.

Vegetation

Where the dominant vegetation species of 'new' and 'previously identified' wetlands have been determined, basic water requirements were described (Table 4). These were based on a previous study of minimum and maximum water depths and duration of inundation experienced by common tree, shrub and emergent macrophyte species of monitored Gnangara and Jandakot wetlands (Loomes, 2000). Comments on the likely magnitude (m) and rate (m/year) of water level decline a wetland can tolerate were also noted (Tables 2 and 3).

Due to the vast number of 'new' wetlands, dominant species are merely listed. The following represents the water depth ranges of the most common/dominant species at 'new' wetlands;

- *M. rhaphiophylla* – mean 0.006 to -2.14 m, absolute 1.03 to -4.49 m.
- *M. preissiana* – mean -0.54 to -2.62 m; absolute 1.03 to -5.04 m.
- *E. rudis* – mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m.
- *B. littoralis* – mean -0.39 to -1.92 m, absolute 0.43 to -3.09 m.
- *B. articulata* – mean 0.28 to -1.22 m, absolute 0.81 to -2.59 m.
- *T. orientalis* – mean 0.74 to -0.95 m, absolute 1.49 to -1.9 m.
- *A. fascicularis* **–** mean -0.35 to -2.26 m, absolute 1.03 to -4.6 m.

Duration of inundation (mean months/year) for the same set of species is as follows;

- *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year).
- *M. preissiana*– mean 0.6, absolute 4.4 (months/year).
- *E. rudis* – mean 1.55, absolute 12 (months/year).
- *B. littoralis* – mean 0.3, absolute 2.8 (months/year).
- *B. articulata* – mean 3.26, absolute 12 (months/year).
- *T. orientalis* – mean 7.7, absolute 12 (months/year).
- *A. fascicularis* – mean 0.66, absolute 2.6 (months/year).

EWRs for terrestrial vegetation were based on previous investigations into the tolerance and dependence of selected *Banksia* sp. to various groundwater regimes (Froend, Loomes, & Zencich, 2002; Froend & Zencich, 2001). In these studies the potential risk of groundwater declines to phreatophytic vegetation were qualitatively assessed. The risk assessment involved categorising areas according to the depth to groundwater as follows;

- 0-3m
- 3-6m
- 6-10m
- >10m.

Within each of these depth categories, an individual plant is thought to respond to the magnitude of drawdown according to a species response curve (Tables 2 and 3). The threshold curve has so far only been developed for two *Banksia* species on the Swan Coastal Plain, *B. ilicifolia* and *B. attenutata*. For these species it is suggested that for each depth category, increasing the magnitude of groundwater decline will lead to a differing level of response. Those populations in areas of highest water tables (0-3m) are most highly dependent on groundwater and are therefore at greater risk of impact from the same degree of drawdown than populations at 3-6m and 6-10m. Where *M. preissiana, E. rudis* and/or *B. littoralis* occurred within an area of 0-3m, the site was regarded as a wetland.

For each terrestrial vegetation site (or 0-3m site with wetland species) EWRs are described as the risk of impact (low, moderate or high) that phreatophytic vegetation of the appropriate depth to groundwater category is at for a range of groundwater level declines. Groundwater level declines are expressed as magnitude (m) and rate (m/year). For example, phreatophytic vegetation in the 0-3m category is at low risk of impact from a decline of 0.75m at a rate of 0.1m/year.

Table 2: Risk of impact level and magnitude of permissible change (m) for phreatophtyic vegetation.

Phreatophytic category	Low	Moderate	High	Severe
0-3m (wetland)	0-0.25	0.25-0.5	0.5-0.75	>0.75
0-3m (terrestrial)	0-0.75	0.75-1.25	1.25-1.75	>1.75
3-6m	0-1.0	1.0-1.5	1.5-2.25	>2.25
6-10m	0-1.25	1.25-2.0	2.0-2.75	>2.75

Table 3: Risk of impact level and rate of permissible change (m/year) for phreatophytic vegetation.

Phreatophytic category	Low	Moderate	High	Severe
0-3m (wetland)	0-0.1	0.1-0.2	0.2-0.3	>0.3
0-3m (terrestrial)	0-0.1	0.1-0.25	0.25-0.5	>0.5
3-6m	0-0.1	0.1-0.25	0.25-0.5	>0.5
6-10m	0-0.1	0.1-0.25	0.25-0.5	>0.5

Vertebrates

The water requirements needed to maintain the fauna can only be discussed in a general sense. For some species of fauna, such as frogs, the species present may be determined by the lowest water levels experienced in the recent past. These would have acted as a bottleneck through which only the more tolerant species could pass. For other faunal groups, however, water levels over successive years will have influenced the abundance and presence of species. All that can be confidently stated is that the faunal assemblage present now has been influenced by the recent history of water levels and the current levels in the area. This faunal assemblage is also dynamic, with rapid changes in some groups but gradual changes in others. This means that maintaining current water levels could still lead to changes in the faunal assemblage, as it is very likely that the assemblage is still influenced by high water levels probably experienced in the 1950s and 1960s.

Macroinvertebrates

Although many of the wetlands of the Gnangara and Jandakot mounds support significant macroinvertebrate assemblages the water requirements needed to maintain macroinvertebrates can only be discussed in a general sense.

Where macroinvertebrate richness is significant for a wetland the known temporal and spatial habitat heterogeneity needs to be maintained by ensuring the mix of vegetation assemblages can persist. Vegetation assemblages may include the following;

- Metaphyton - where known to occur it must remain permanently inundated, all year, every year.
- Submergent - requires inundation according to the specifications of the dominant taxa.
- Emergent - requires inundation according to the specifications of the dominant taxa.
- Littoral assemblages - requires inundation according to the specifications of the dominant taxa.

Rationale: habitat heterogeneity in SCP wetlands is dictated by water regimes as they interact with

- Depression/ landscape geomorphology.
- Vegetation assemblages.

- Sediment processes.
- Water quality.
- Other biotic/abiotic interactions.

These factors are all inter-related and the degree to which any or all of these interact or influence habitat heterogeneity is wetland dependent. Assigning water requirements to one of these as a surrogate for all may, if comprehensively achieved, be adequate to maintain macroinvertebrate richness. Choosing vegetation assemblages as the surrogate has the advantages of contributing to structural heterogeneity, being likely to reflect and contribute to all other influences anyway, and being more likely to be mapped than sediments and water quality.

Where macroinvertebrate proportional endemism is significant for a wetland then the endemic features need to be identified. This is beyond the scope of this work and no EWRs can be set as it requires specific understanding of EWR's of endemic species or assemblages. This type of analysis is begging to be done for plants, invertebrates and microbes. To what degree will endemism be important in wetlands of the SCP? Probably relatively low for macroinvertebrates (>0.5 mm), higher for microinvertebrates (<0.5 mm).

Where macroinvertebrate proportional rarity is significant for a wetland then the rare features need to be identified. This is usually beyond the scope of this work and no EWRs can be set. However, wetland/landscape geomorphology may be a sufficient surrogate for this significant feature, particularly since most proportional rarity is encountered in geomorphologically distinct wetlands like springs, caves, etc. EWRs can therefore be deferred to those set for these wetlands. This type of analysis gives an indication of relative uniqueness and representativeness of any wetland on the SCP.

Waterbirds/waders

Although many of the wetlands of the Gnangara and Jandakot mounds support significant waterbird assemblages water requirements can only be discussed in a general sense. Comments are made on requirements in terms of surface water permeance and depth where possible.

Water quality/sediments

Although wetland water quality is often impacted by inflow of nutrients and pollutants from external sources, in-situ sediment processes also have a major influence. Drying and wetting of sediments containing significant amounts of nutrients can result in the remobilisation of nutrients into the water column. Drying of sediments can also reduce habitat and expose peats and other types of organic matter to fire. The sediment type is generally the determining factor in these processes and may require different water regimes.

Where wetlands have peat or sandy peat, water regime contributions to sedimentary processes leading to the formation of peat need to be maintained. To achieve this, sediments must remain saturated/moist throughout summer, each year. This means that the water table must not drop below the stratigraphic level/layer that is capable of providing water to surface organics through capillary rise during summer.

Where *Baumea articulata* dominates the system this species needs to be inundated each year. The rationale behind this is that sediments that receive predominantly allochthonous organic matter, usually faster than it can be broken down or metabolized or washed away, will accrue layers of peat. This process requires a moisture regime to keep sediments anaerobic (to slow the metabolism) and prevent them from burning (since burning is very rapid metabolism). EWR's for this objective will need to ensure that sediments remain saturated/moist throughout summer, each year, and that vegetation communities that contribute the bulk of this material continue to do so. *Baumea articulata* dominated assemblages are identified as such here, but there are others. Sediments need to be mapped across the SCP.

Where wetlands are known to have, or are likely to have potentially acid sulphate soils (PASS) in their sediments, anaerobic sediments need to be prevented from drying, cracking and aerating. Exposure of anaerobic sediments by lowering water table during periods of high temperatures, exacerbated if associated with removing covering vegetation, will produce the undesired effect. To prevent this, sediments must remain saturated during late summer and early autumn every year.

Sediments need to be mapped across the SCP to identify where PASS occur and where local vulnerabilities exist. Management becomes awkward because two management paradigms currently operating contradict the water regimes required to prevent PASS. One of the management options for eutrophic systems is to dry the sediments out so that phosphorus can be more effectively bound in the sediment the other is that most wetlands on the SCP need to dry out seasonally.

Cave fauna

Root mat communities of the Yanchep Caves persist in permanent pools or streams. As excessive declines in levels are known to expose the suspended root mats and cause them to die-off, stable water levels are required. Water quality is also an important issue for cave fauna which require stable pH, DO and temperature, with minimal diel, seasonal or annual variation.

Table 4: General EWRs for all GDEs identified in Task 1. EWRs for wetland vegetation are described in terms of species water depth ranges and duration of inundation. EWRs for wetland vertebrates and macroinvertebrates are based on permeance and where possible depth of water required for breeding. EWRs for sediment processes and water quality are described in terms of permeance of surface water required to maintain processes. EWRs for terrestrial vegetation are based on previous investigations into the tolerance and dependence of selected *Banksia* sp. to various groundwater regimes. * denotes a 'new' GDE.

Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
WETLANDS **Gnangara**					
Herdsman Complex					
Loch McNess (37411651052)	**Vegetation** 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** Permanent with seasonal fluctuation to provide seasonal variaton in depths and shoreline. **Vertebrates** Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. Permanent with seasonal fluctuation for Rakali and frogs. Permanent of near-permanent surface water required for long-necked tortoises. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. littoralis* – mean 0.3, absolute 2.8 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Current period of inundation (permanent) required for current suite of waterbirds. **Vertebrates** Permanently inundated for fish, frogs and Rakali. Near-permanent for long-necked tortoises. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Metaphyton – where known to occur must remain permanently inundated. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines, particularly in basins with even bathymetry.		• No permanent vegetation monitoring transect at Loch McNess. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Yonderup (37524650756)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *B. littoralis* – mean 0.3, absolute 2.8 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Some drying of organic rich sediments. • Fringing *M. rhaphiophylla* declining health since 1997. • Exotic flora invading wetland basin and surrounds.	• Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	assemblages persist; Metaphyton – where known to occur must remain permanently inundated. **Water quality/sediment processes** Sediments to be permanently saturated/moist.			
Lake Wilgarup (37577650595)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Sediment processes** Sediments to be saturated from late winter to early autumn.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Drying of organic rich sediments. • Widespread loss of *M. rhaphiophylla*. • Thinning of *B. articulata* & *L. longitudinale*. • Exotics encroaching into the basin. • Low macroinvertebrate richness.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater.
Pipidinny Swamp (37504650521)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** Extensive winter/spring flooding required. **Vertebrates** Permanent of near-permanent surface water required for long-necked tortoises. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year) **Waterbirds** At least current periods of inundation.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Increasing conductivity in ponds near dunes. • Exotic flora invading wetland. • Some suggestion that period of inundation has declined to detriment of waterbirds.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Nowergup (37958649929)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year).	**Vegetation** Rate - 0.1m/year; magnitude – 0.25m. Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines,	• Declining health of *M. rhaphiophylla* & *E. rudis*. • Thinning of *B. articulata.* • Encroachment of *Typha orientalis* into wetland.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to

Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
	B. articulata – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** Retention of water in summer and autumn an important feature of this wetland. Winter/spring peak levels flooding fringing vegetation important. **Vertebrates** Permanent water and high peak levels for Rakali and frogs Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	*B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Permanent. **Vertebrates** Permanently inundated for fish and frogs. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Metaphyton – where known to occur must remain permanently inundated. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	particularly in basins with even bathymetry.	• Change in water quality; increase in pH, decreased conductivity, nutrients & chlorophyll-a. • Slight decline in summer invertebrate richness however, species of Cladocera (*Leydigia ciliata*) now known.	groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Joondalup (3857664875)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. *B. juncea* – mean -0.52 to -2.65m, absolute 1.03 to -4.64m. **Waterbirds** Retention of water in summer and autumn an important feature of this wetland. Winter/spring peak levels flooding fringing vegetation important **Vertebrates** Permanent water and high peak levels for Rakali and frogs Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. Permanent of near-permanent surface water required for long-necked tortoises. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. littoralis* – mean 0.3, absolute 2.8 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). *B. juncea* – mean 0.71, absolute 3.6 (months/year). **Waterbirds** Permanent. **Vertebrates** Permanently inundated for fish, frogs and Rakali. Near-permanent fro long-necked tortoises. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Metaphyton – where known to occur must remain permanently inundated. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines, particularly in basins with even bathymetry.	• Poor water quality. • Fringing vegetation & *E. rudis* impacted by frequent fires and wind throw due to drying sediments. • *Typha orientalis* encroaching in southern section of lake.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.				
Lake Goollelal (38769647968)	**Vegetation -** 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** Retention of water in summer and autumn an important feature of this wetland. Winter/spring peak levels flooding fringing vegetation important **Vertebrates** Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. Permanent water and high peak levels for Rakali and frogs. Lake appears to have a large population of the Rakali, probably reflecting relatively stable water levels with flooded fringing vegetation all year round. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation -** 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Permanent. **Vertebrates** Permanently inundated for fish, frogs and Rakali. Fringing vegetation remaining flooded to some degree in summer and autumn. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines, particularly in basins with even bathymetry.	• Increasing chlorophyll-a levels leading to eutrophication. • Low macroinvertebrate family richness however, a high abundance of *Gambusia* sp. • Decline in health of *M. rhaphiophylla* & *E. rudis.* • Contraction of *B. articulata* bands. • Invasion by exotic flora.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Carrabooda Lake* (37849650146)	**Vegetation** . *M. rhaphiophylla*, *E .rudis* and *T. orientalis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Surrounded by market gardens & pasture, extensive clearing of terrestrial vegetation & some infilling. • Annual & perennial weeds encroaching margins of lake.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Neerabup* (38205649442)	**Vegetation** *M. rhaphiophylla, E. rudis, B. articulata* and *T. orientalis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Encroachment of *Typha.* • Eutrophication from surrounding land-use. • Market gardens / semi-rural development intruding into wetland. • Remnant bushland disturbed by grazing. • Road intersects wetland. • Some areas of severe weed infestation.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Gwelup* (38561647226)	**Vegetation** *M. rhaphiophylla* and *E. rudis*. **Waterbirds** Retention of water in summer and autumn an important feature of this wetland. Winter/spring peak levels flooding fringing vegetation important.	**Waterbirds** Permanent in most years, but seasonal variation important. **Vertebrates** Permanent in most years beneficial to frogs. Not known if Rakali present. **Water quality/sediment processes**	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Previously disturbed by rural practices now by urban development. • Several drains feed into wetland. • Annual weed species present. • Surrounded by parkland with some remnant bushland to the north.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	Vertebrates High peak levels in winter/spring for frogs. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	Sediments to be permanently saturated/moist.		• *Typha* encroaching further into wetland. • Terrestrial & wetland trees effected by fire.	
Beenyup Swamp* (38625648247)	**Vegetation** *M. rhaphiophylla* and *E. rudis*.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Surrounded by cleared parkland. • Annual & perennial weed invasion at perimeter of swamp.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Big Carine Swamp* (38506647515)	**Vegetation** *M. rhaphiophylla, E. rudis, B. articulata* and *T. orientalis.* **Waterbirds** Retention of water in summer and autumn an important feature of this wetland. Winter/spring peak levels flooding fringing vegetation important. **Vertebrates** High peak levels in winter/spring for frogs. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Waterbirds** Permanent in most years, but seasonal variation important. **Vertebrates** Permanent in most years beneficial to frogs. Not known if Rakali present. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Situated in large recreation reserve. • Predominantly turf with small section of remnant vegetation. • Fringing *M. rhaphiophylla* on west & southern side generally in higher section of littoral zone are showing signs of drought stress.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Careniup Swamp* (38595647369)	**Vegetation** *M. rhaphiophylla, E. rudis, B. articulata* and *T. orientalis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Highly modified with infilling and urban development on all sides. • Receives road runoff & is highly eutrophic. • Vegetation degraded through physical disturbance & invasion of weeds.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Wallubuenup Swamp* (38696648190)	**Vegetation** *M. rhaphiophylla, E. rudis, B. articulata* and *T. orientalis.* **Waterbirds** Extensive winter/spring flooding of *Melaleuca* important for waterbird breeding.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.		• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Badgerup Lake* (39028648351)	**Vegetation** *Melaleuca preissiana, E. rudis* and *T. orientalis*. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• East side cleared for semi-rural use. • Littoral vegetation cleared around perimeter • Recent fire scorched wetland trees	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Little Badgerup Lake* (39037648274)	**Vegetation** *Melaleuca preissiana, E. rudis* and *T. orientalis*. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the	**Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m.	• Wide buffer of vegetation, some semi-rural use encroaching. • Removal of wetland trees in areas of semi-rural use.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.		High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Some littoral vegetation lost to clearing. • Disturbed areas of littoral zone are heavily weed infested.	
Sumpland* (38348649057)	**Vegetation** *M. rhaphiophylla* and *E. rudis*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Substantial vegetation buffer where joins Neerabup National Park rest private property. • Wetland perimeter degraded from grazing by horses.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Pinjar Complex Lake Mariginiup (38773648936)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. T. orientalis – mean 0.74 to -0.95, absolute 1.49 to -1.9m. **Vertebrates** Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. **Wading birds** Persistence of shallow water into summer/autumn. High levels in winter may be needed to provide vegetation from choking open shallows. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Vertebrates** Permanently inundated for fish. **Wading birds** Shallow water should persist into autumn some years. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines, particularly in basins with even bathymetry.	• Declining surface and groundwater levels since 1995 (dries most summers), leading to drying of organic rich sediments. • Becoming increasingly acidic; critical macroinvertebrate species not yet showing signs of stress. • Decline in flora species richness in plots. • Decline in condition of fringing vegetation dur to drying, fire, physical disturbance and exotic species.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Jandabup (39020648649)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). ***P. ellipticum*** – mean 0.2, absolute 0.6 (months/year).	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Increasing surface water levels since 1995 following artificial maintenance. • Water quality was deteriorating however, since maintenance quality is increasing. • Changed water quality lead to shifts in macroinvertebrates. There were local	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence

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	P. ellipticum – mean -0.61 to -2.22 m, absolute 0 to -3.53m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -3.53m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds/waders** Flooded rushes known to be important for waterbird breeding in winter/spring. Shallows in summer/autumn used by waders so high peak levels may be required to prevent spread of vegetation. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	*H. angustifolium* – mean 0.1, absolute 0.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds/waders** Persistence of shallows into autumn. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Metaphyton – where known to occur must remain permanently inundated. **Water quality/sediment processes** Sediments to be permanently saturated/moist.		extinctions & a decrease in sensitive species and then an increase in acid-tolerant species and finally the return of some significant species found prior to acidification. • Decline in health of fringing *E. rudis* & *M. rhaphiophylla.* • Encroachment of emergent macrophytes. • Decline in flora species richness in plots since 1997.	groundwater dependence are not considered (eg. stratigraphy).
Lake Pinjar* (38766649788)	**Vegetation** *M. rhaphiophylla, E. rudis, M. preissiana* and *B. articulata.* **Terrestrial vertebrates** Unknown but depth to groundwater affects terrestrial vegetation.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Vegetation heavily modified by agriculture. • Little undisturbed vegetation remains. • *E. rudis* shows signs of stress with many dead trees.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Little Mariginiup* (38830649035)	**Vegetation** *E. rudis.* **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• On private property and predominantly cleared. • Entire area appears to be grazed. • Some scattered *Eucalypts* remain around fringe.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Hawkins Rd Swamp* (39120648926)	**Vegetation** *M. preissiana, A. fascicularis* and *B. articulata.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Lies within pine plantation and adjacent to cleared land. • Degraded by tracks, dumping of rubbish and regular fires. • Some invasion of exotics grasses. • Some terrestrialising occurring.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Lake Adams* (38844649190)	**Vegetation** *E. rudis, M. preissiana* and *A. fascicularis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Over half is privately owned & used as paddock. • Some wetland trees remain, with a weedy understorey. • Crown reserve section not cleared but has a walkway constructed through it with planting's of exotic tree species.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Little Adams Swamp* (38955649226)	**Vegetation** *E. rudis* and *M. preissiana.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Extensively on cleared private property with grazing access to lake bed.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Dampland* (39012349008)	**Vegetation** *E. rudis* and *M. preissiana.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Surrounded by cleared farmland with scattered remnant *Eucalyptus* and *Banksia* sp. • Pines invading from east • Some die-back of E. rudis on west side.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean Central & South Complex					
Lake Gnangara (39278648240)	**Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Water quality**	• Low macroinvertebrate family richness. • Low pH & evidence of eutrophication. • Reduced inundation of littoral & fringing vegetation & therefore lower habitat complexity.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean North Complex – Lexia					
Lexia 86 (40136648637)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *P. ellipticum* – mean -0.61 to -2.22 m, absolute 0 to -3.53m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -3.53m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Vertebrates** Higher winter/spring water levels needed for frogs. Depth of surface water in spring 2003 was sufficient to induce breeding of moaning frog, which had not recruited the previous year. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist;	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *P. ellipticum* – mean 0.2, absolute 0.6 (months/year). *H. angustifolium* – mean 0.1, absolute 0.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Vertebrates** 4 months inundation for frogs to breed? Long-necked Tortoises have been found in this wetland but were in very poor condition; these probably require inundation of at least 9 months? **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Drying of organic rich sediment. • Decline in health & patch deaths of fringing *M. preissiana & B. ilicifolia.* • Encroachment of fringing vegetation into wetland basin as *B. articulata* contracts. • Reduction in recruitment of moaning frog.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

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	Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.				
Lexia 186 (40164648730)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *P. ellipticum* – mean -0.61 to -2.22 m, absolute 0 to -3.53m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -3.53m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Vertebrates** Frogs are present but appear to be unable to breed, so higher spring levels required. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). ***P. ellipticum*** – mean 0.2, absolute 0.6 (months/year). *H. angustifolium* – mean 0.1, absolute 0.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Vertebrates** Frogs require 4 months inundation. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Drying of organic rich sediment. • Low macroinvertebrate family richness. • Decline in health of fringing tree species. • Encroachment of fringing trees species into basin as *B. articulata* contracts.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lexia 94 (39830648856)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *P. ellipticum* – mean -0.61 to -2.22 m, absolute 0 to -3.53m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -3.53m. **Vertebrates** Frogs are present but appear to be unable to breed, so higher spring levels required.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *P. ellipticum* – mean 0.2, absolute 0.6 (months/year). *H. angustifolium* – mean 0.1, absolute 0.6 (months/year). **Vertebrates** Frogs require 4 months inundation.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Drying of organic rich sediments. • Decline in health of fringing *M.preissiana.* • Drying & thinning of wetland shrubs & emergent macrophytes across basin.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
4 sumplands* (40141648670, 40132648626,	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				

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40149648594, 40163648635) & 1 dampland* (40135648601)					
Sumpland* (40148648729)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Sumpland* (40156648685, 40238648707)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Dampland* (40203648567)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
1 sumpland* (40256648635)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Sumpland* (40292643721)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
2 damplands* (40297648639, 40346648631)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Sumpland* (40140648683)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Dampland* (40272648506)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
KINGS Spring (near The Maze)* (40077649797)	**Vegetation** *M. preissiana* and *E. rudis.* **Macroinvertebrates** Require perennial flow from spring. Volume of flow not known – but probably not large (matter of several litres per second at a maximum). **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Macroinvertebrates** Perennial flows. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Macroinvertebrates** Not known - assume there could be a seasonal reduction in flows in summer/autumn from winter/spring highs, but still maintain perennial flows.	• Sediments have dried and shrunk away from tree bases. • Blackberry and bracken have invaded basin.	
Bassendean North Complex – Melaleuca Park					
EPP Wetland 173 (40146649172)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *P. ellipticum* – mean -0.61 to -2.22 m, absolute 0 to -3.53m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *P. ellipticum* – mean 0.2, absolute 0.6 (months/year). *H. angustifolium* – mean 0.1, absolute 0.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year).	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Fish - natural rates of drawdown from hydrographs	• Drying of organic rich sediments. • Decline in condition of fringing *M. preissiana.* • Possible decline in Black-stripe minnow.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	3.53m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Vertebrates** Seasonal fluctuation for frog breeding with high spring peak. Depth of surface water in spring 2003 was sufficient to induce breeding of moaning frog, which had not recruited the previous year. Fish - Black-stripe Minnow requires a high degree of soil moisture during summer to survive aestivation. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Vertebrates** Fish - based on hydrographs using period before declines really set; 5 – 6 months from July – December, with converse period of drying (December to June). Current period of inundation is supporting breeding by a broad suite of frogs. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	from period before declines started.		stratigraphy).
Dampland 78 (38959649551)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. Vertebrates Frogs are present but appear to be unable to breed, so higher spring levels required.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Vertebrates** Frogs require 4 months inundation. Long-necked Tortoises have been found in this wetland these probably require inundation of at least 9 months?	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Drying of wetland basin. • Death of wetland vegetation due to water stress. • Decline in number healthy *M. preissiana*, *B. ilicifolia* & *B. attenuata* on transect since 1996. • Decline in density of *P. reticulata* & *B. elegans* since 1996 however, terrestrial species increased. • Frogs have been monitored here and numbers appear to have declined in recent years, probably due to low water levels. There was a single, very large Long-necked Tortoise in the deepest section of his wetland in 2002.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Melaleuca Park Wetlands 40 damplands* 39496649584, 39455649394, 39464649585, 39478648638, 39498649636, 39507649695, 39513649527, 39514649463, 39527649600,	**Vegetation** 39496649584 – *M. preissiana, B. articulata* and *P. ellipticum*. 39455649394, 39464649585, 39498649636, 39513649527, 39906649362, 39510659739 – *M. preissiana*. 39478648638, 39565649347, 39616649454, 39712649551, 39592649232 – *M. preissiana* and *E. rudis.* 39507649695, 39550649619 - *B. ilicifolia*.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Declining water levels leading to drying to organic rich sediments in some wetlands. • 39496649584 – 50-70% *M. preissiana* dead or stressed. Car bodies and rubbish dumped in basin. • 39455649394 – Wetland vegetation condition generally excellent. • 39464649585 – Some *M. preissiana* died recently. • 39478648638 – 80% *M. preissiana* dead or very stressed, some stress in *E. rudis.*	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
39547649649, 39541649417, 39565649347, 39550649619, 39559649393, 39572649792, 39616649454, 39627649484, 39647649353, 39712649551, 39876649518, 39906649362, 39592649232, 39685649249, 39660649160, 39813649148, 39881649161, 39183649754, 39421649304, 39442649618, 39443649445, 39433649770, 39510659739, 39575649169, 39554649527	39513649527 – *M. preissiana* and *A. fascicularis*. 39527649600, 39547649649, 39572649792, 39685649249, 39660649160, 39554649527 – *Banksia* spp. and myrtaceous understorey. 39541649417 – *M. preissiana, H. angustifolium* and *P. ellipticum.* 39627649484, 39813649148, 39443649445, 39433649770 - *M. preissiana, H. angustifolium* and *A. fascicularis* 39647649353, 39881649161 – *M. preissiana, B. littoralis, A. fascicularis* and *H. angustifolium.* 39876649518 - *M. preissiana* and *H. angustifolium.* 39183649754 - *M. preissiana, B. littoralis* and *E. rudis.* 39421649304 - *M. preissiana, B. littoralis, A. fascicularis, P. ellipticum* and *H. angustifolium.* 39442649618 - *M. preissiana, E. rudis* and *M. rhaphiophylla.* 39575649169 - *A. fascicularis* and *H. angustifolium.*			• 39498649636 – Number of stressed *M. preissiana.* • 39507649695 – Wetland has terrestrilaised. • 39513649527 – Wetland terrestrialising. All *M. preissiana* dead or very stressed. • 39513649527 – All *M. preissiana* dead or stressed. Car bodies and rubbish dumped in area • 39527649600 – All *M. preissiana* dead. • 39547649649 – Myrtaceous understorey drought stressed. • 39541649417 – 50% *M. preissiana* dead, myrtaceous shrubs stressed. • 39565649347 – 50-60% *M. preissiana* dead or stressed. *E. rudis* in good condition. • 39550649619 – *M. preissiana* stags across basin. Large areas of drought stressed understorey. • 39572649792 – Wetland has terrestrialised. • 39616649454 – Only one *M. preissiana* living, *E. rudis* stressed. Terrestrialising. • 39627649484 – Some stressed *E. rudis.* • 39647649353 – Most *M. preissiana* dead. • 39712649551 - Most *M. preissiana* dead. • 39876649518 – Area used as market garden. Most *M. preissiana* dead. • 39906649362 – *M. preissiana* drought stressed. • 39592649232 - *M. preissiana* and *E. rudis* drought stressed. • 39685649249 – Wetland is in poor condition. • 39660649160 - Wetland is terrestrialising. • 39813649148 – 50% *M. preissiana* are dead. Wetland is terrestrialising. • 39881649161 – Impacted by fire. • 39183649754 – Wetland impacted by tracks and clearing however vegetation is in good condition. • 39421649304 – Half of wetland cleared however remaining vegetation is in good condition. • 39442649618 – Wetland has been disturbed by mining, weed invasion and vehicular traffic. • 39443649445 – Wetland divided by road. 90% of *M. preissiana* dead. • 39433649770 – Wetland is terrestrialising. • 39510659739 – Wetland impacted by roads and fire. • 39575649169 – Small remnant wetland in pines. • 39554649527 – Vegetation impacted by fire.	
7 sumplands*	**Vegetation**		**Vegetation**	• 39969949158 – Wetland vegetation in excellent	

Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
(39969949158, 39556649708, 39582649556, 39576649679, 39610649565, 39653649561, 39920649456)	39969949158 - *M. preissiana* and *H. angustifolium.* 39556649708 – *M. preissiana, A. fascicularis, B. articulata, H. angustifolium* and *P. ellipticum.* 39582649556, 39920649456 – *M. preissiana, E. rudis* and *H. angustifolium.* 39582649556 – *Banksia spp.* 39610649565 – *M. preissiana, A. fascicularis* and *P. ellipticum.* 39653649561 - *M. preissiana* and *E. rudis.*		Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	condition however *Banksia* seedlings are encroaching into basin. • 39556649708 – Some stress in mature *M. preissiana.* • 39582649556 -50% of *E. rudis* and *M. preissiana* dead. • 39582649556 – *M. preissiana* stags across basin. Wetland terrestrialising. • 39610649565 – 50% of *M. preissiana* chlorotic. Wetland terrestrialising. • 39653649561 – Number of stressed *M. preissiana* and *E. rudis.* Rubbish dumped in wetland. • 39920649456 – Part of wetland is on private property and grazed.	
Bassendean North Complex – East Pinjar					
Bombing Range Wetlands 31 damplands				• No record of changes in ecological values.	
Edgecombe Seepage and Lake Yakine (40506648187)	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Macroinvertebrates** Permanently flowing – therefore sufficient hydrostatic head to ensure perennial flow from spring. Volume of flow not known – but probably not large (matter of several litres per second at a maximum).	**Macroinvertebrates** Perennial flows.	**Macroinvertebrates** Not known - assume there could be a seasonal reduction in flows in summer/autumn from winter/spring highs, but still maintain perennial flows.	• Faunal diversity declined from 11 species in April 1999 to 2 of the original species in December 1999 and November 2000 following drying. • Firebreak graded along fence line and spring was cleared and heavily disturbed. By 2002 flows were returning and the spring was recovering however fauna essentially absent. • Area immediately around spring continues to repair original semblance however, habitat not improving to original conditions.	
Egerton Seepage (40361648418)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. **Macroinvertebrates** Permanently flowing – therefore sufficient hydrostatic head to ensure perennial flow from spring. Volume of flow not known – but probably not large (matter of several litres per second at a maximum). **Water quality**	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *B. littoralis* – mean 0.3, absolute 2.8 (months/year). **Macroinvertebrates** Perennial flows. **Water quality**	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Macroinvertebrates** Not known - assume there could be a seasonal reduction in flows in summer/autumn from winter/spring highs, but still maintain perennial flows. **Water quality**	• No evidence of degradation following clearing of vegetation to west and north of spring.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Karrakatta Central and South Complex					
Little Emu Swamp*	**Vegetation** *E. rudis, M. preissiana, A. fascicularis* and B. *articulata.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m.	• Wetland basin severely disturbed by tracks & fire.	• Specific site conditions that may influence groundwater dependence are not considered (eg.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
(39360647560)			Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Run-off from stormwater has lead to massive weed invasion. • Remnant vegetation surrounds the lake although it has been degraded by fire and weeds.	stratigraphy).
Cottesloe Central and South Complex					
Ridges*	**Vegetation** *E. rudis* and *M. preissiana,* **Terrestrial vertebrates** Unknown relationship between groundwater, upland vegetation and terrestrial vertebrates.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Some clearing in north section of wetland. • Degraded by tracks & dumping of rubbish & car bodies. • Not monitored since 1996 due to fire. • Mortalities of *B. ilicifolia* since 2001. • Weeds generally restricted to NW area • Mature *E. rudis* show high degree of stress • *K. ericifolia* appear drought stressed	• Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean North Transition Complex – North					
11 damplands* (38613651757, 38368651780, 38636651749, 38669651758, 38731651919, 38798652311, 38825652147, 38875652172, 38861652407, 38919652275, 38933652030)	**Vegetation** 38613651757, 38731651919, 38798652311, 38861652407, 38919652275 and 38933652030- *M. preissiana.* 38636651749, 38368651780 and 38669651758 - *M. preissiana* and *E. rudis.* 38875652172 and 38825652147 – *B. ilicifolia*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• System of generally connected damplands situated within a large area of high quality bushland. • (38613651757): Dominated by terrestrial species in understorey. • (38638651780): Some evidence of stress in *E. rudis* occupying the lowest areas. • (38636651749): Vegetation variable across dampland. Some chlorosis in *E. rudis* appears recent. • (38669651758): Number of very stressed *M. preissiana* & occasional dead *B. ilicifolia*. • (38731651919): Approximately 50% of *mature M. preissiana* are dead. Patches of *Kunzea sp*. are severely drought affected. • (38798652311): Dieback occurs in adjacent blocks of the nature reserve. • (38825652147 & 38875652172): *M. preissiana* are dead. Majority of *B. ilicifolia* are resprouting. • (38861652407): Only small patches of dead vegetation. Some death of mature *M. preissiana*. • (38919652275): Road through wetland, has had a detrimental impact. • (38933652030): Adjacent land appears to be severely dieback affected. 60% *of M. preissiana* very stressed or dead. Most of tall *Kunzea* scrubland dead.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean North Complex - Yeal Swamp					
Yeal Swamp* (38267651751)	**Vegetation** . *M. preissiana* and *E. rudis.*	**Terrestrial vertebrates** Unknown.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m.	• Declining health of overstorey species. • Vegetation changes from open woodland to	• Specific site conditions that may influence groundwater dependence are not considered (eg.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	Terrestrial vertebrates Unknown relationship between groundwater, upland vegetation and terrestrial vertebrates.		Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	closed heath – tall scrub with small changes in topography. • Mining of diatomaceous earth in recent years. • Disturbance from vehicle tracks & invasion of annual weeds. • Some *E. rudis* death in southern section. • *Kunzea sp*. show signs of drought stress.	stratigraphy).
Bindiar Lake* (38181651941)	**Vegetation** . *M. preissiana, E. rudis* and *B. littoralis* **Terrestrial vertebrates** Unknown relationship between groundwater, upland vegetation and terrestrial vertebrates.	**Terrestrial vertebrates** Unknown.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Declining health of *E. rudis*. • Excellent vegetation buffer around wetland • Pines 100m from west side • Vehicles access claypan in NW – some localised damage to vegetation. • Dry April 2004.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Dampland* (38488651846)	**Vegetation** . *M. preissiana* and *E. rudis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Undisturbed with intact vegetation. • Large vegetation buffer separates damplands from vehicle tracks • Some *E. rudis* show signs of stress.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
2 damplands* (38340651762 & 38337651800)	**Vegetation** 38340651762 - *M. preissiana, E. rudis* and *B. littoralis* 38337651800 - *M. preissiana, E. rudis, B. littoralis* and *A. fascicularis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• (38340651762): Wetland in excellent condition. Evidence of fire approximately 2 years ago in terrestrial vegetation. • (38337651800): 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.	
Bassendean North Complex – Yeal West					
2 damplands* (38144652776, 38174652305)	**Vegetation** 38144652776 – *M. preissiana* and *B. littoralis.* 38174652305 - *M. preissiana, E. rudis* and *H. angustifolium.*		Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• (38144652776): some dead *M. preissiana.* • (38174652305): Numerous dead and stressed *M. preissiana* and *E. rudis*.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Sumpland* (38551652525)	**Vegetation** *M. preissiana* and *H. angustifolium.*		Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Indications of previous fire in northern area of wetland.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Tangletoe Swamp* (37607652972)	**Vegetation** *M. preissiana, E. rudis* and *A. fascicularis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Although terrestrialisation is occurring vegetation is in excellent condition.	• Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
63 damplands* (37917652461, 37948652434, 37987652796, 37981652582,	**Vegetation** 37917652461, 37948652434, 37987652446, 38009652550, 38309652440 - *M. preissiana E. rudis* and *B. littoralis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	*DoE (2004)* • 37917652461, 37948652434 &37987652446: 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.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

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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, 38317652442, 38336652318, 38342652392, 38394652578, 38386652685, 38361652523, 38381652418, 38416652349, 38455652718, 38415652188, 38456652444, 38480652351, 38532652185, 38533652305, 38560652228, 38580652413, 38587652096, 38585652194,	38732652377, 38533652305 - *M. preissiana* and *E. rudis* . 38386652685 - *M. preissiana, E. rudis, B. littoralis* and *M. rhaphiophylla.* 38058652554, 38310652767, 38394652578, 38416652349, 38415652188, 38480652351, 38580652413 - *M. preissiana, B. littoralis.* 38317652442, 38336652318 – A. *fascicularis* 37987652796, 37981652582, 38030652677, 38024652295, 38026652641, 38039652524, 38033652611, 38036652738, 38046652635, 38083652724, 38078652433, 38090652633, 38082652192, 38088652250, 38097652471, 38139652681, 38122652574, 38147652733, 38151652708, 38168652666, 38162652573, 38167652757, 38182652512, 38225652757, 38220652466, 38230652721, 38245652664, 38252652683, 38266652435, 38280652700, 38285652373, 38289652487, 38287652725, 38342652392, 38361652523, 38381652418, 38455652718, 38456652444, 38532652185, 38560652228, 38587652096, 38585652194, 38589652128, 38642652041, 38651652093, 38420652687, 38389652800, 38334652752, 38764652463 - *M. preissiana* 38997652088 – *Banksia sp*.			Much of the *M. preissiana* dead or dying in the centre & eastern sections. Dead *Banksia* can be seen in the lower section. • 37987652796: Wetland in pristine condition. • 37981652582: Some *M. preissiana* are in poor condition. • 38030652677: Some dead & stressed *B. ilicifolia* to the south. 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. • 38009652550: *M. preissiana* & *E. rudis* on higher ground in excellent condition however, those on lower ground are very stressed. • 38024652295: Majority of the *E. rudis* appear stressed with numerous dead stems in the basin. • 38026652641: Vegetation in excellent condition, with some *M. preissiana* saplings present. • 38039652524: Occasional *Banksia* & *M. Preissiana* stags & stressed individuals • 38033652611: Wetland terrestrialing *M. preissiana* population is senescent but living. • 38036652738: The occasional dead *Banksia sp*. • 38046652635: Vegetation is in excellent condition. • 38058652554: Some scattered dead *B. attenuata* & senescent *M. preissiana*. • 38083652724: Some localized patches of dead scrub & occasional dead or stressed *M. preissiana* & *Banksia sp*. • 38078652433: Some dead *Banksia sp*. & *M. preissiana* & localized areas of dead Myrtaceous scrub. • 38090652633: Significant deaths of Myrtaceous shrubs and a general decrease in both over & understorey species. • 38082652192: Previous fire had a large impact on vegetation however as regeneration progress vegetation in generally in excellent condition. • 38088652250: Vegetation in excellent condition. • 38097652471: Minor localised drought stress in the *Kunzea* & *M. preissiana*. • 38139652681: Large areas of dead *M. preissiana* & *B. littoralis*. • 38122652574: *Melaleuca* is all but gone. Some	

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38589652128, 38642652041, 38651652093, 38732652377, 38420652687, 38389652800, 38334652752, 38764652463, 38997652088)				dead *Banksia spp*. are present in & around the wetland. Wetland appears to be terrestrialising. • 38147652733: 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: Most Myratceous species showing signs of drought stress. Wetland terrestrialising. 90% of *M. preissiana* dead or very stressed. Occasional dead or stressed *Banksia sp*. • 38168652666: Some senescent *M. preissiana* & scattered dead *Banksia sp*. • 38162652573: Approximately 70% of *M. preissiana* is stressed to very stressed. Some dead *Banksia* occurs around the wetland perimeter. • 38167652757: Most *M. preissiana* are dead & being replaced by *Banksia sp*. Large patches of dead Myrtaceous heath across the dampland. • 38182652512: Occasional dead *Banksia* & scattered patches of dead Myrtaceous scrub. • 38225652757: A few isolated stressed *Melaleuca* individuals. Some localized areas of dead Myrtaceous scrub. • 38220652466: Occasional *dead Banksia spp*.. The wetland trees are predominantly very stressed. • 38230652721: Evidence of *M. preissiana* in center of wetland although these individuals are long dead. Scattered dead *Banksia sp*. around perimeter. • 38245652664: All *M. preissiana* in lower basin are dead. Approximately half the remaining *Melaleuca* around the perimeter are stressed. Considerable *Banksia sp*. death in surrounding terrestrial vegetation. • 38252652683: No live *M. preissiana* left but stags suggest the wetland was once Melaleuca woodland. 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. Some localized dead patches of *Kunzea sp* & *Beaufortia.* • 38280652700: Majority of *M. preissiana* dead or stressed (may be old deaths). • 38285652373: Regular patches of dead trees in both the wetland & terrestrial vegetation. Many dead ***Banksia spp.*** in the wetland centre. • 38289652487: Some localised plant deaths.	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
				Most *M. preissiana* are stressed or dead & extensive shrub & *Kunzea spp*. death. • 38287652725: Majority of *M. preissiana* dead or very stressed. • 38310652767: Signs of dieback & stress in the dampland with 25% of *Banksias* & 30% of *M. preissiana* effected. • 38309652440: Some of the larger trees are dead. • 38317652442: 60% of the shrubland in the basin is dead. • 38336652318: Possible *Phytophthora cinnamomi* & drought stress particularly of *Banksia spp*., some *Beaufortia sp*. & myrtaceous heath. • 38342652392: Some localised areas of dead *Kunzea sp*., stressed & dead *B. ilicifolia* & *B. attenuata* & scattered dead *M. preissiana*. • 38394652578: Occasional *M. preissiana* stag. • 38386652685: Occasional stressed *M. preissiana* & *Banksia spp*.. Substantial death of *E. rudis* on south-west side with most trees appearing stressed. • 38361652523: *M. preissiana* virtually all gone & the shrublands appear drought stressed with some localised dead patches. • 38381652418: Some *M. preissiana* stags. • 38416652349: *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: Many *M. preissiana* occurring in dense stands have been killed by fire. 38456652444: No longer any live *M. preissiana* in the basin. • 38480652351: *M. preissiana* population is stressed with some recently dead individuals. • 38532652185: Numerous *M. preissiana* stags. Some *Banksia sp*. deaths upslope. • 38533652305: Scattered dead *B. ilicifolia* occur in the centre of the dampland. Occasional senescent *Melaleuca* & dead patches of *Kunzea* within the wetland. • 38560652228: Numerous senescent *M. preissiana* & many, very stressed trees. • 38580652413: Some localised disturbance. • 38587652096: A few stags & stressed *M. preissiana*. • 38585652194: Some senescent *M. preissiana*.	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
				• 38589652128: Wetland trees restricted to a band on the east side. • 38642652041: A few senescent *M. preissiana*. • 38651652093: Dampland in excellent condition. • 38732652377: Some dying off in *E. rudis* & *M. preissiana*. Recently dead *M. preissiana* & dead or stressed *B. ilicifolia* & some shrub death and chlorosis. • 38420652687: Occasional *Banksia sp.* & *M. preissiana* deaths & scattered stressed *M. preissiana*. • 38389652800: Vegetation surrounding wetland is die-back affected. • 38334652752: *M. preissiana* stags in centre of wetland with scattered dead *Banksia spp*. • 38764652463: Some senescent *M. preissiana*. • 38997652088: *Melaleucas* have been dead for some time, terrestrial plants species are encroaching.	
Deepwater Lagoon* (38881652828)	**Vegetation** *M. preissiana* **Waterbirds** Persistence of shallow water into summer/autumn. High levels in winter may be needed to provide vegetation from choking open shallows.			• Wetland has degraded to a pastoral paddock.	• No permanent monitoring. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
1 dampland* (37797652988)	**Vegetation** *M. preissiana*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Some stress in mature *M. preissiana* and evidence of fire.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
2 sumplands* (37852653007, 37879652973)	**Vegetation** 37852653007 – *M. preissiana, M. rhaphiophylla, E. rudis, B. littoralis* and *B. articulata.* 37879652973 – *M. preissiana, B. littoralis* and *A. fascicularis.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• 3782653007 – Recent deaths of *B. articulata* in open water area. • 37879652973 – Sedge species drought stressed.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean North Complex – Tick Flat					
Tick Flat* (37632652620)	**Vegetation** *E. rudis* and *M. preissiana*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Wetland becoming terrrestrialised. • Consists of remnant bushland to cleared pasture. • Declining condition & health of understorey and overstorey vegetation. • Recently burnt (patchy – some unburnt). • Vehicle track have lead to localised weed invasion • Some pines trees invading near wetland. • Documented changes in vegetation have almost certainly affected fauna	• Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
4 damplands*	**Vegetation**		**Vegetation**	• (37668652593): 100m from main Tick Flat	• No permanent vegetation monitoring transect.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
(37668652593, 37577652591, 37588652556, 37593652546)	*M. preissiana*		Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	wetland, evidence of recent fire. • Majority *M. preissiana* dead / very stressed. • Localised dead areas in understorey • (37577652591); Small wetland in central section of Tick Flat complex. Unburnt in the recent fires. • Occasional dead *Banksia*. • (37593652546; 37588652556); Wetlands lie to the west of the main Tick Flat wetland in a *Banksia* and *Melaleuca* woodland with a variable understorey consisting of terrestrial and dampland species. • Unburnt areas in good condition. • Fires have killed some areas of shrubland.	• Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bassendean North Complex – Yeal East					
Lake Mukenburra* (38405653196)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.		• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
17 damplands* (38821652464, 38829652308, 38831651988, 38898652368, 38861652005, 38913652246, 38913652012, 38919652275, 38933652030, 38951652330, 38973652008, 39008652386, 39008652298 39026652224, 39045652254, 39058652235, 38685652685)	**Vegetation** 38821652464, 38831651988, 38861652005, 39008652386, 39026652224, 39045652254, 39058652235 – *M. preissiana* 38898652368 – *M. preissiana, B. littoralis* and *E. rudis*. 38951652330, 39008652298, 38685652685, 38829652308, 38913652246 - *M. preissiana* and *B. littoralis.* 38913652012, 38973652008 – *M. preissiana* and *H. angustifolium.*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• 388 21652464 – Wetland in good condition. • 38829652308 – *M. preissiana* stressed. • 38831651988 – Wetland terrestrialising, most *M. preissiana* dead. • 38898652368 – 50% *M. preissiana* very stressed or dead. • 38864652005 – Some drought stress in understorey. • 38913652246 – Some *M. preissiana* stressed. • 38913652012 – Some death in understorey. • 38951652330 – Vegetation in excellent condition. • 38973652008 – Most *M. preissiana* dead or stressed. • 39008652386 – Wetland vegetation in good condition, but wetland terrestrialising. • 39008652298 – Vegetation in excellent condition. • 39026652224 – Some *M. preissiana* stags. • 39045652254 - Some *M. preissiana* stags and stressed individuals. • 39058652235 – Most *M. preissiana* dead due to drought stress. • 38685652685 - 50% *M. preissiana* very stressed or dead.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
2 sumplands* (38570652790	**Vegetation** 38570652790 - *M. preissiana, B. littoralis* and *E. rudis*.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m.	• 38570652790 - Recent fire in wetland, but regeneration appears healthy.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
38606652771)	3806652771 - *M. preissiana, M. rhaphiophylla* and *B. littoralis*		Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• 38606652771 - Recent fire in wetland, but regeneration appears healthy.	groundwater dependence are not considered (eg. stratigraphy).
1 sumpland* (38773652686)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
1 floodplain* (39108652522)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
1 sumpland* (38828652623)	**Vegetation** *M. preissiana*		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Wetland is on private property and has been severely degraded by grazing.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Yanga Complex Bambun Lake* (39435652283)	**Vegetation** *M. rhaphiophylla, E. rudis* and *B. articulata* **Vertebrates** Unknown.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Permanent wetland. • Narrow fringe of littoral vegetation. • Some buffer remains although majority surrounding land is cleared farmland. • Very weedy understorey around lake.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Nambung* (39421652168)	**Vegetation** *M. rhaphiophylla* and *E. rudis* **Vertebrates** Unknown.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• 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.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Lake Mungala* (39482652119)	**Vegetation** *M. rhaphiophylla* and *E. rudis* **Waterbirds** Unknown. **Vertebrates** Unknown.		**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Wetland completely surrounded by private property. Owners refused access. • Wetland appears to be dry. • Trees appear to be in good health.	• No permanent vegetation monitoring transect. Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Springs on Lot 11 Archibald St., Muchea	**Macroinvertebrates** Permanently flowing – therefore sufficient hydrostatic head to ensure perennial flow from spring. Volume of flow not known – but probably not large (matter of several litres per second at a maximum).	**Macroinvertebrates** Perennial flows.	**Macroinvertebrates** Not known - assume there could be a seasonal reduction in flows in summer/autumn from winter/spring highs, but still maintain perennial flows.		
Spring sites 3s, 3b, 3r, 4, 5ps, 5pd, 5d, 6, and 7	**Macroinvertebrates** Permanently flowing – therefore sufficient hydrostatic head to ensure perennial flow from spring. Volume of flow not known – but probably not large (matter of several litres per second at a maximum).	**Macroinvertebrates** Perennial flows.	**Macroinvertebrates** Not known - assume there could be a seasonal reduction in flows in summer/autumn from winter/spring highs, but still maintain perennial flows.		
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Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
Herdsman Complex					
Thomsons Lake (38942644227)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** Declining peak water levels and lake drying out in early summer had coincided with much lower waterbird numbers than previously recorded. High levels may be required to prevent spread of vegetation into open water. **Vertebrates** Frogs require extensive flooding of fringing vegetation. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Persistence of water into late summer and autumn important for migratory species. **Vertebrates** Frogs require at least 4 months. Long-necked Tortoises are present may require periods of 9 months or more.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Poor water quality (saline, eutrophic and high pH). • Declines in health of some mature *E. rudis.* • Decline in density of *B. articulata* since 1996 & prolific sapling growth near lake possibly due to lower water levels. • Increased weed invasion due to lack of inundation. • Values influenced by GW abstraction & water quality issues associated with increasing urban development.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
North Lake (38891645024)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** High winter/spring peaks and retention of deep water in summer/autumn for deep-water species. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Permanent.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Encroachment of native vegetation into basin (where previously inundated). • Decline in condition & health of mature *E. rudis* around basin in response to water level decline & insect attack. • Exotic threatening to become dominant in some areas.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Banganup Swamp (38927644051)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) .	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m.	• Drying lead to encroachment of *Typha*. • Cultural eutrophication has occurred.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	5.04m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	*E. rudis* – mean 1.55, absolute 12 (months/year). *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Terrestrial vertebrates** Unknown.	Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.		across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Bibra Lake (38945644839)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds/waders** High winter/spring peaks and retention of deep water in summer/autumn for deep-water species. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds/waders** Permanent.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Exotics are threatening to become dominant in some area. • Decline in wetland tree condition due to water level decline & insect attack.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Yangebup Lake (38969644509)	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Waterbirds** High winter/spring peaks and retention of deep water in summer/autumn for deep-water species. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Waterbirds** Permanent. **Water quality/sediment processes** Sediments to be permanently saturated/moist.		• Cultural eutrophication has occurred. • Reduction in macroinvertebrates species richness since monitoring began.	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.				
Kogolup Lake (38989644422)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. **Waterbirds** High winter/spring peaks and extensive shallows in summer/autumn. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated during late summer and early autumn.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *E. rudis* – mean 1.55, absolute 12 (months/year). *M. preissiana*– mean 0.6, absolute 4.4 (months/year). **Waterbirds** Water should persist into early autumn. **Water quality/sediment processes** Sediments to be permanently saturated/moist.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Cultural eutrophication has occurred. • Loss of fringing vegetation due to water-logging. • Decline in *E. rudis* health since 1998. • Increased weed invasion however, weediness still low.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Little Rush Lake* (38906655657)					
Spectacles North* (39041643485)	**Vegetation** As there is not a vegetation monitoring transect at Spectacles North and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species. **Waterbirds** Breeding by waterbirds affected by flooding around *Melaleuca.* **Vertebrates** Needs to be permanently inundated for fish – critical minimum threshold depth for survival not known. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important. **Sediments/water quality** Organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** Unknown **Vertebrates** Permanently inundated for fish. North Spectacles is currently permanent. South Spectacles is seasonal and water should persist into summer.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m. **Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines, particularly in basins with even bathymetry.		
East Swamp* (38996644985)	**Vegetation** No vegetation monitoring transect and vegetation not	**Terrestrial vertebrates** Unknown.			

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	assessed. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important.				
Hope Rd* (38892644967)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Bassendean Central & South Complex					
Shirley Balla Swamp (39419644203)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03 to -4.6m. *H. angustifolium* – mean -0.16 to -3.53m, absolute -0.16 to -3.53m. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *A. fascicularis* – mean 0.66, absolute 2.6 (months/year). ***H. angustifolium* –** mean 0.1, absolute 0.6 (months/year). **Terrestrial vertebrates** Unknown.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Contaminated with hydrocarbons. • Least used by waterbirds. • Decline in macroinvertebrates since 1996. • Vegetation impacted by fire & physical disturbance.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Twin Bartram (39174644318)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m. **Waterbirds** High winter/spring water levels for breeding. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *B. littoralis* - mean 0.3, absolute 2.8 (months/year). **Waterbirds** Persistence of shallows into summer of value.	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• High level of exotic species. • Disturbed by fire & weed invasion.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Beenyup Rd Swamp (39361644097)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year).	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-	• Decline in health of *M. rhaphiophylla.* • Decreased density of *B. articulata*. • Decline in density of wetland shrubs.	• Wetland species depth ranges based on extrapolation of surface and groundwater levels across the length of the monitoring transects

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	M. rhaphiophylla – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important.	*M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). **Terrestrial vertebrates** Unknown.	0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Exotics dominant in understorey.	rather than actual measured depths to groundwater. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Mather Reserve* (39361644253)	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Waterbirds** High winter/spring water levels for breeding. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important.	**Waterbirds** Breeding may require 6 months inundation. **Terrestrial vertebrates** Unknown.			
Copolup Lake* (39075644156)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Branch St Swamp* (39094644246)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Forest-Tapper Swamp* (39297644396)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Solomon Rd Swamp* (39232644307)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Mandogalup (Wattelup) Lake* (38930643850)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
Karrakatta Central & South Complex					
Forrestdale Lake (39960644134)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m. *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m. **Waterbirds** High winter/spring peaks important, especially for drowning vegetation that threatens to choke the open shallows on which migratory waders depend in summer and autumn. **Vertebrates** High spring peaks for frogs and persistence into autumn. **Water quality/sediment processes** Sediments must remain saturated/moist throughout the summer each year. The water table therefore must not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. rhaphiophylla* – mean 2.15, absolute 9.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year). *B. articulata* – mean 3.26, absolute 12 (months/year). **Waterbirds** Shallows should persist into summer and early autumn for migratory waders. **Vertebrates** Long-necked Tortoises were present in the 1970s and may still be there; require at least 9 months?	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.	• Increased weed invasion due to lack of inundation. • Drying, fire and physical disturbance has disturbed *Melaleuca* sp. • Declining watertable affected vegetation including *M. rhaphiophylla* & *E. rudis*.	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).

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Southern River Complex					
Harrisdale Swamp* (39867644655)	**Vegetation**. As there is not a vegetation monitoring transect and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species. **Terrestrial vertebrates** Relationship between groundwater, upland vegetation and terrestrial fauna may be important. **Sediment processes/water quality** Organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer.				
Lake Balanup* (40011644610)	**Vegetation** No vegetation monitoring transect and vegetation not assessed.				
TERRESTRIAL ECOSYSTEMS					
Gnangara					
Herdsman Complex PM24 (Bush Forever Site 382)	**Vegetation** - 5 year mean and absolute water depth ranges . *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m.	**Vegetation -** 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year).	**Vegetation** Low ROI - rate 0.1m/year; magnitude 0.25m. Moderate ROI – rate 0.1-0.2m/year, magnitude 0.25-0.5m. High ROI – rate 0.2-0.3m/year, magnitude 0.5-0.7m.		• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Badgerup Lake Bushland* (Bush Forever Site 327)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Yellagonga Regional Park* (Bush Forever Site 299)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Pinjar Complex MT3S (Bush Forever Site 324)			**Vegetation** Phreatophytic *Banksia* woodland at 6-10m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.25m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.25-2.0m. High ROI – rate 0.25-0.5m/year, magnitude 2.0-2.75m.	• Decreased abundance of healthy *E. rudis*, *M. preissiana* & *B. ilicifolia* since 1993. • Decreased abundance of *A. fascicularis*, *P. ellipticum* & *H. angustifolium* since 1993. • Increased abundance of healthy *B. attenuata* & *B. menziesii* since 1993.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
					groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
Numbat Rd Bushland* (Bush Forever Site 141/146)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Little Coogee Flat* (Bush Forever Site 443)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Bassendean Central & South Complex					
MM18 (Bush Forever Site 304)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decline in number of healthy *M. preissiana* & *B. ilicifolia* since 1999. • Decline in abundance of *P. ellipticum* since 1999.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
MM53 (Bush Forever Site 304)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Number of small dead *Banksias* in area. • Vegetation density decreased.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
MM55B (Bush Forever Site 304)	**Vegetation** - 5 year mean and absolute water depth ranges . *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m.	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year).		• Generally modified by grazing (fenced are recovering).	
MM59B (Bush Forever Site 304)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-	• Number of small dead *Banksias* in area. • Vegetation density increased.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
			2.25m.		variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
MM16 (Bush Forever Site 304)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.		• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
GD10* (Bush Forever Site 304)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Gnangara Lake and adjacent Bushland* (Bush Forever Site 193)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Bassendean North Complex					
PM9 (Bush Forever Site 380)			**Vegetation** Phreatophytic *Banksia* woodland at 6-10m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.25m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.25-2.0m. High ROI – rate 0.25-0.5m/year, magnitude 2.0-2.75m.	• Vegetation density increased.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
WM1 (Bush Forever Site 398)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decrease in vegetation density. • Recent *B. attenuata* deaths	• See above
WM2 (Bush Forever Site			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to	• Decrease in vegetation density.	• See above

Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
399)			groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.		
WM6			**Vegetation** Phreatophytic *Banksia* woodland at 6-10m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.25m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.25-2.0m. High ROI – rate 0.25-0.5m/year, magnitude 2.0-2.75m.	• Decrease abundance of *A. fascicularis*, *P. ellipticum* since 1999. • Decreased number of healthy *B. ilicifolia* since 1999. • Signs of stress in *Banksia* sp. north of bore & *M. preissiana* to south.	• See above
WM8 (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.		• See above
NR6C (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decreased vegetation density.	• See above
NR11C (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• No change in vegetation density between 1988 – 2000.	• See above
L30C (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decreased vegetation density.	• See above
L110C (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 6-10m depth to groundwater;	• Decreased vegetation density.	• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
			Low ROI – rate <0.1m/year, magnitude <1.25m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.25-2.0m. High ROI – rate 0.25-0.5m/year, magnitude 2.0-2.75m.		
L220C (Bush Forever Site 399)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decrease in vegetation density north & west of bore	• See above
Ellenbrook Bushland (Bush Forever Site 300)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed			• Decrease in abundance of *P. ellipticum*. • Vegetation density grades from a decrease in east to a increase in west. • Decrease in healthy *M. preissiana, B. ilicifolia, B. attenuata* & *B. menziesii* on Maralla site.	• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
MM12 (Bush Forever Site 192)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.		• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
Rosella Rd Bushland (Bush Forever Site 380)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
State Forest 65 – Gnangara Plantation Bushland* (Multiple Bush Forever Sites)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Della Road South Bushland* (Bush Forever Site 298)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Wabling Management Priority Area*	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Yeal Nature					• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Reserve*					
Tangletoe*					
Kirby Rd Bushland* (Bush Forever Site 97)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Muchea Air Weapons Range Bushland*	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above.
Cottesloe Central and south Complex					
Wilbinga-Caraban Bushland* (Bush Forever Site 406)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Yanchep National Park* (Bush Forever Site 288)					• See above
Cottesloe North/Cottesloe Central & South Complex					
Ridges & adjacent Bushland* (Bush Forever Site 381)	**Vegetation** - 5 year mean and absolute water depth ranges . *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m. *M. preissiana* – mean -0.54 to -2.62m; absolute 1.03 to -5.04m. **Vertebrates** Unknown relationship between groundwater, upland vegetation and terrestrial vertebrates.	**Vegetation -** 5 year mean and absolute maximum period of inundation (months/year) . *M. preissiana*– mean 0.6, absolute 4.4 (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year) **Terrestrial vertebrates** Unknown			
State Forest 65 – Pinjar Plantation South Bushland* (Multiple Bush Forever Sites)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Neerabup National Park, Lake Nowergup Nature* (Bush Forever Site 383)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Garden Park Bushland* (Bush Forever Site 470)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
High Road Bushland* (Bush Forever Site 471)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Errina Road	**Vegetation**				• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Bushland* (Bush Forever Site 493)	No terrestrial vegetation monitoring transect and vegetation not assessed				
Lake Gwelup Reserve* (Bush Forever Site 212)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Decourcey Way Bushland* (Bush Forever Site 328)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Landsdale Road Bushland* (Bush Forever Site 199)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Koondoola Regional Bushland* (Bush Forever Site 201)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Bassendean North Transition Complex					
Hawkins Rd Bushland* (Bush Forever Site 326)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Southern River Complex					
Cardinal Drive Bushland* (Bush Forever Site 23)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Caversham Airbase Bushland* (Bush Forever Site 200)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Yanga Complex					
Bullsbrook Nature Reserve* (Bush Forever Site 292)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Sawpit Road Bushland* (Bush Forever Site 13)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Twin Swamps	**Vertebrates**				• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Nature Reserve* (Bush Forever Site 400)	Western Swamp Tortoise may require a high degree of soil moisture during summer to survive aestivation and inundation during winter/spring.				
Ellenbrook Nature Reserve* (Bush Forever Site 301)	**Vertebrates** Western Swamp Tortoise may require a high degree of soil moisture during summer to survive aestivation and inundation during winter/spring.				• See above
Jandakot					
Herdsman Complex					
JE17C (Bush Forever Site 391)	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year). *E. rudis* – mean 1.55, absolute 12 (months/year) *M. preissiana*– mean 0.6, absolute 4.4 (months/year).			• Decline in health of *B. littoralis* & *B. ilicifolia*. • Decline in number healthy *E. rudis* (also impacted by insects). • Decline in number healthy *M. preissiana* and *M. rhaphiophylla* • Increase in number stressed *B. attenuata* & *B. menziesii*. • Decline in abundance of wetland shrub species. • Decline in soil moisture • Exotics dominate understorey.	
Harry Waring Marsupial Reserve* (Bush Forever Site 392)	**Vertebrates**				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Bassendean Central & South Complex					
JE10C			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decline in health of *Banksia* woodland on private property.	• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
JM31			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Private property vegetation heavily modified.	• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
JM19 (Bush Forever Site 390)			**Vegetation**	•	•
JM35 (Bush Forever Site 344)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decline in health of remnant *Banksia* woodland.	• See above
JE4C (Bush Forever Site 344)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Decline in number of healthy *M. preissiana* and *B. ilicifolia.* • Loss of *B. littoralis* from vegetation transect • Decline in number of healthy *B. attenuata* and *B. menziesii*. • Decline in number of healthy *M. rhaphiophylla* stems since 1997.	• See above
JM7 (Bush Forever Site 388)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• *E. rudis* and *M. preissiana* impacted by groundwater level decline and insect attack. • Recent deaths and varied condition of *B. ilicifolia* and *B. attenuata*.	• See above
JM8 (Bush Forever Site 388)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Stress noted in overstorey of large *E. rudis* and *M. preissiana* in vicinity.	• See above
JM45 (Bush Forever Site 388)	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *E. rudis* – mean 1.55, absolute 12 (months/year) *M. preissiana*– mean 0.6, absolute 4.4 (months/year).		**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• *B. ilicifolia, M. preissiana, E. rudis* and *B. attenuata* show symptoms of drought stress.	• See above
8284	**Vegetation** - 5 year mean and absolute maximum period of inundation (months/year) . *E. rudis* – mean 1.55, absolute 12 (months/year) *M. preissiana*– mean 0.6, absolute 4.4 (months/year).		**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-		• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
			2.25m.		
JM49			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• *B. littoralis/ M. preissiana* woodland, weedy understorey on private property opposite private land 100m west of intact *Banksia* woodland.	• See above
JM39			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• In vicinity of intact *Melaleuca* woodland.	• See above
North Lake* (Bush Forever Site 244)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed.				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
Bibra Lake* (Bush Forever Site 244)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
South Lake* (Bush Forever Site 254)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed.				• See above
Mandogalup Rd Bushland* (Bush Forever Site 268)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.
The Spectacles* (Bush Forever Site 269)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Sandy Lake* (Bush Forever Site 270)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Sicklemore Rd Bushland* (Bush Forever Site 272)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Casuarina Prison Bushland* (Bush Forever Site 273)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above

Sub-group / GDE	**Water regime component** **Depth of groundwater (negative value) or surface water (positive value) (m)**	**Duration of inundation or waterlogging (months/year)**	**Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)**	**Impacts associated with water regime change and/or other disturbances.**	**Reliability of information**
Wandi Nature Reserve* (Bush Forever Site 347)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				See above
Banjup Bushland* (Bush Forever Site 263)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Modong Nature Reserve* (Bush Forever Site 348)					• See above
Cottesloe Central & South Complex					
JM16 (Bush Forever Site 253)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.		• Water requirements are approximate as further validation is required. • Habitat type and species present are largely undescribed. • The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site. • The spatial area of vegetation represented by each bore is not defined.
Southern River Complex					
JM14 (Bush Forever Site 389)			**Vegetation** Phreatophytic *Banksia* woodland at 3-6m depth to groundwater; Low ROI – rate <0.1m/year, magnitude <1.0m. Moderate ROI – rate 0.1-0.25m/year, magnitude 1.0-1.5m. High ROI – rate 0.25-0.5m/yeat, magnitude 1.5-2.25m.	• Evidence of impact, recent deaths of *B. attenuata*, older deaths of *B. ilicifolia*, *B. attenuata* and *B. menziesii*, drying of *B. elegans* in understorey. • Decline in number healthy *M. preissiana*.	• See above
Fraser Rd Bushland* (Bush Forever Site 390)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• Habitat type and species present are largely undescribed. • EWRs cannot be determined for ‘new’ terrestrial ecosystems due to the absence of hydrological data.
Piarra Nature Reserve* (Bush Forever Site 262)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Anstey/Keane dampland* (Bush Forever Site 342)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Balannup* (Bush Forever Site 413)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Karrakatta Central & South Complex					
Yangebup & Little Rush Lakes* (Bush Forever Site 256)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
Forrestdale Lake* (Bush Forever Site 345)	**Vegetation** No terrestrial vegetation monitoring transect and vegetation not assessed				• See above
BASE-FLOW SYSTEMS					
Gingin Brook*	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Vertebrates** Fish - needs to be permanently inundated for fish – critical minimum threshold depth for survival not known.	**Vertebrates** Fish – permanently inundated.	**Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines.	• If allowed to recede to isolated pools in summer there is increased risk of fish species losses if accidental drying occurs or poor water quality causes fish deaths (i.e. catchment-related issues such as eutrophication, clearing, sedimentation etc).	
Bennett Brook* (39975647634, 39928647650)	**Vegetation** *M. rhaphiophylla* and *E. rudis* **Vertebrates** Needs to be permanently inundated for fish – however, could recede to isolated permanent pools over summer. Western Minnows migrate upstream to breed in winter. Winter flooding creates extensive swamps for frogs. **Macroinvertebrates** The known spatial and temporal habitat heterogeneity will be maintained by ensuring the following mix of vegetation assemblages persist; Submergent – requires inundation according to specifications of dominant taxa. Emergent - requires inundation according to specifications of dominant taxa. Littoral – requires inundation according to specifications of dominant taxa.	**Vertebrates** Permanently inundated for fish – however, could recede to isolated permanent pools over summer.	**Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines.	• If allowed to recede to isolated pools in summer there is increased risk of species losses if accidental drying occurs or poor water quality causes fish deaths (i.e. catchment-related issues such as eutrophication, clearing, sedimentation etc).	• No permanent vegetation monitoring transect. • Specific site conditions that may influence groundwater dependence are not considered (eg. stratigraphy).
Quin Brook* (38749652539, 38385652763, 38454652772, 38231652928)	**Vegetation** 38749652539 - *M. preissiana, M. rhaphiophylla* and *E. rudis.* 38385652763 - *M. preissiana, M. rhaphiophylla* and *B. littoralis.* *38454652772 - M. preissiana, M. rhaphiophylla, B. littoralis, E. rudis* and *A. fascicularis.* 38231652928 - *M. preissiana, M. rhaphiophylla* and *A. fascicularis.* **Vertebrates** Fish - needs to be permanently inundated for fish – critical	**Vertebrates** Fish – permanently inundated.	**Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines.	• If allowed to recede to isolated pools in summer there is increased risk of fish species losses if accidental drying occurs or poor water quality causes fish deaths (i.e. catchment-related issues such as eutrophication, clearing, sedimentation etc). • Vegetation in excellent to pristine condition despite recent fire and some weed invasion.	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	minimum threshold depth for survival not known.				
Lennards Brook* (on boundary of study area)	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Vertebrates** Fish - needs to be permanently inundated for fish – critical minimum threshold depth for survival not known.	**Vertebrates** Fish – permanently inundated.	**Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines.	• If allowed to recede to isolated pools in summer there is increased risk of fish species losses if accidental drying occurs or poor water quality causes fish deaths (i.e. catchment-related issues such as eutrophication, clearing, sedimentation etc).	
Ellen Brook creek system*	**Vegetation** No vegetation monitoring transect and vegetation not assessed. **Vertebrates** Fish - needs to be permanently inundated for fish – critical minimum threshold depth for survival not known.	**Vertebrates** Fish – permanently inundated.	**Vertebrates** Rate of decline not known – fish are mobile and can probably withstand reasonably rapid natural declines.	• If allowed to recede to isolated pools in summer there is increased risk of fish species losses if accidental drying occurs or poor water quality causes fish deaths (i.e. catchment-related issues such as eutrophication, clearing, sedimentation etc).	
AQUIFER AND CAVE ECOSYSTEMS					
Crystal Cave (YN1)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Known to have permanent stream since discovery, now dry.	• Level of cave floor or nearby bores not known.
Water Cave (YN11)	**Macroinvertebrates** Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptable flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	• Permanent deep water steadily shallowing since mid 1990's. • No invertebrate species recorded in 2001 and 4 in 2002. • Planned recharge scheme is an issue particularly for DO and temperature, however, groundwaters in general are well buffered and therefore if EWRs are provided from natural groundwater flows – water quality should not be a problem (except when contaminants enter the groundwater upstream of the caves).	
Carpark Cave (YN18)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Permanent stream in January 2001 now dry most of the year.	

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
	above EWR for macroinvertebrates is achieved.				
Gilgie Cave (YN27)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Unique fauna of caves lost due to drying of cave streams in 1996. • Planned recharge scheme is an issue particularly for DO and temperature, however, groundwaters in general are well buffered and therefore if EWRs are provided from natural groundwater flows – water quality should not be a problem (except when contaminants enter the groundwater upstream of the caves).	• Level of cave floor or nearby bores not known.
Cabaret Cave (YN30)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Strong permanent stream until mid 1990's now dry. • 4 species of invertebrate recorded in 2001, in 2002. • Water table 5-10cm below surface in January 2002. • Planned recharge scheme is an issue particularly for DO and temperature, however, groundwaters in general are well buffered and therefore if EWRs are provided from natural groundwater flows – water quality should not be a problem (except when contaminants enter the groundwater upstream of the caves).	• Level of cave floor or nearby bores not known.
Boomerang Cave (YN99)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Permanent stream now dry most of year. • Planned recharge scheme is an issue particularly for DO and temperature, however, groundwaters in general are well buffered and therefore if EWRs are provided from natural groundwater flows – water quality should not be a problem (except when contaminants enter the groundwater upstream of the caves).	
Twilight Cave (YN194)	**Macroinvertebrates** Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Perennial flows with no seasonal declines in water levels. **Water quality** Perennial flows with no seasonal declines in water levels.	**Macroinvertebrates** Stable flows with no seasonal declines. Drying has been shown to result in loss of fauna. **Water quality** Stable flows with no seasonal declines.	• Permanent stream that flowed strongly until mid 1990's has diminished. • Planned recharge scheme is an issue particularly for DO and temperature, however, groundwaters in general are well buffered and therefore if EWRs are provided from natural groundwater flows – water quality should not be a problem (except when contaminants enter the groundwater upstream of the caves).	• Level of cave floor or nearby bores not known.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
Un-named cave* (YN61)	**Macroinvertebrates** Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	• In 1990 had water up to 1m deep with thick sludge, now drying with mud cracking in summer.	• Level of cave floor or nearby bores not known.
Cave on Lot 51* (YN555)	**Macroinvertebrates** Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	• Solution carving shows cave had been completely filled with water, now shallow. • Elevated nitrogen concentration possibly indicating anthropogenic influence on groundwater.	• Level of cave floor or nearby bores not known.
Orpheus Cave* (YN256)	**Macroinvertebrates** Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	• Laket in bottom of cave now much shallower at winter peak.	• Level of cave floor or nearby bores not known.
Jackhammer Cave* (YN438)	**Macroinvertebrates** Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptable flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this. **Water quality** Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	**Macroinvertebrates** Permanent water with no seasonal declines. **Water quality** Permanent water with no seasonal declines.	• Contained deep water overlaying deep silt and detritus however, levels now 10-20cm below historic water narks on walls.	• Level of cave floor or nearby bores not known.

Sub-group / GDE	Water regime component Depth of groundwater (negative value) or surface water (positive value) (m)	Duration of inundation or waterlogging (months/year)	Rate (m/year) and magnitude (m) of decline and risk of impact level (ROI)	Impacts associated with water regime change and/or other disturbances.	Reliability of information
ESTUARINE AND NEAR-SHORE MARINE ECOSYSTEMS					
Marmion Marine Park*					
Limestone reefs*					
Seagrass Meadows*					
Wrack (Detached Macrophytes)*					
Un-vegetated Sand*					

2.2 DETAILED EWRS

In this section quantitative EWRs are described for a subset of GDEs for which the required level of information is available. These GDEs include all wetlands, mound springs, terrestrial vegetation sites and caves identified in the 1991/92, 1995 and 1997 reports and 'new' GDEs for which it is now considered appropriate to describe EWRs. Where possible water requirements are described to meet the management objectives described in Task 1. For example, two of the management objectives for Loch McNess; '…minimise the contribution of groundwater decline to… support good populations of waterbirds…' and '…minimise the contribution of groundwater decline to ….support diverse fish species', will be addressed through the determination of water requirements for macroinvertebrates and fish.

The information presented in this section not only describes the water requirements of individual components of GDEs (vegetation, macroinvertebrates etc), but provides comments on the likely degree of dependence of each system. Hatton and Evans (1998) recognised five classes of groundwater dependency on groundwater as follows;

- Ecosystems entirely dependent on groundwater – communities where only slight changes in key groundwater attributes below or above a threshold would result in their demise.
- Ecosystems highly dependent on groundwater – communities where moderate changes in groundwater discharge or water tables would result in a substantial change in their distribution.
- Ecosystems with proportional dependence on groundwater – these ecosystems exhibit a proportional response to changes in groundwater attributes rather than the threshold responses of the more highly dependent ecosystems.
- Ecosystems with limited or opportunistic dependence on groundwater – groundwater appears only to play a significant role in the water balance at the end of the dry season or during extreme drought.
- Ecosystems with no dependence on groundwater – these ecosystems may appear to be groundwater dependent, but are either entirely rainfall fed or dependent only on surface water flows.

To adequately describe the water requirements of an ecosystem the water regime in which it operates should be understood (Evan & Clifton, 2001). To access the current water regime information is also presented on the following;

- Processes for which water is required – consumptive uses, habitat or biophysical processes.
- Source of water used by the ecosystem – groundwater, surface water, soil water or rainfall.

The water requirements of all groundwater dependent ecosystems are described based on the best available information.

WETLANDS

EWRs for wetland vegetation are based on the mean water depths of common wetland species as presented in Table 2. For each species listed at each wetland, the mean minimum water depth (m) is subtracted from the minimum elevation (mAHD) at which that species occurs at the wetland. For example, the mean minimum water depth of *M. rhaphiophylla* is -2.14 m and at Lake Joondalup it occurs from 16.8-19.0 mAHD. Following the appropriate calculation (16.8 – 2.14) the minimum water level required to maintain *M. rhaphiophylla* at Lake Joondalup is 14.66 mAHD. If required, a maximum water level can be determined by adding the mean maximum water (m) of a species to its maximum elevation (mAHD) at a wetland.

Minimum elevations have been physically measured across the permanent vegetation transects at the 13 monitored Gnangara wetlands. However, elevations at the monitored Jandakot wetlands have not been measured and can therefore only be based on the presence of species within transects of know elevation. This approach cannot be applied to wetlands at which there are no vegetation transects; Loch McNess, Pipidinny Swamp, Lake Gnangara, Egerton Springs, Edgecombe Seepage, Lake Forrestdale and Lake Yangebup. There is also insufficient information to describe EWRs for 'new' wetlands (those not previously identified in the 1995, 1997 or 1991/92 reports).

There are a number of limitations and assumptions to this approach:

- Wetland species depth ranges are based on extrapolation of surface and groundwater levels across the length of the monitoring transects rather than actual measured depths to groundwater.
- Vegetation has established under a different water regime to that which currently exists. Without information on age class structure at individual sites it is not possible to determine under which regime tree root zones were set. Older trees may have established 20 years ago, younger individuals 3-5 years ago. Although older trees may have been lost, populations may persist due to recruitment of new plants under new conditions.
- Depth to groundwater contouring for 2003 as provided by WRC was significantly different to that provided by Water Corporation for 2000 and did not appear fully representative of groundwater depths measured at some bores and staff gauges. Discrepancies were also noted between the location of known areas of very shallow groundwater and surface water (eg Gingin Brook) and the levels represented by the contouring. These limitations were also identified by the WRC.
- Assessments of level of groundwater dependence of 'new' wetlands are only as accurate as the groundwater contouring provided.
- A number of wetlands previously considered to be groundwater dependent (Froend et al., 2002) now appear to occur at depths >10m to groundwater which may indicate perched systems or significant drawdown.
- Predicted responses to drawdown do not consider specific site conditions (eg. stratigraphy) or influences of other impacts (eg. fire, dieback).

Description of EWRs for waterbirds and aquatic invertebrates and vertebrates are based chiefly on the permeance, and, depth of surface water required by species either known to or expected to occur at a specific wetland. Depths are often based on those required to inundate emergent macrophytes known to provide habitat or food for various fauna species.

Consideration is also given to the likely degree of groundwater dependence of fauna known to occur at a wetland. With the exception of primarily aquatic species that occur in groundwater dependent wetlands (fish, frogs, turtles), the dependence of fauna upon groundwater is largely indirect. EWRs required to meet faunal needs are therefore difficult to quantify as fauna dependent upon vegetation that itself may or may not be groundwater dependent. These varying levels of groundwater dependence of fauna can be reflected by assigning species to one of four categories as below. The use of categories in this manner applies unnatural constraints across a continuum of dependence, but helps to recognise patterns and identify species of particular significance. This process was carried out for the vertebrate fauna of the study area in what must be recognised as an interpretive and to some extent subjective exercise, based upon available information and personal knowledge of the habitat requirements of each species. The categories were as follows:

1. Low dependence upon groundwater. This was applied to species that occur primarily in upland habitats throughout the year or which show no special preference for groundwater dependent vegetation. Changes to groundwater levels are unlikely to affect such species.
2. Moderate dependence upon groundwater. This was applied to species that make some use of habitats that are themselves moderately dependent upon groundwater, such as vegetation not closely associated with wetlands but in which major components are groundwater dependent. This was also applied to species that make seasonal use of vegetation that is moderately or highly dependent upon groundwater. Changes to groundwater levels would affect these fauna species, at least insofar as the vegetation assemblages upon which they dependent wholly or seasonally are affected. The effect may be for both the vegetation and the fauna to move lower in the landscape.
3. High dependence upon groundwater. This was applied to species that are dependent upon phreatophytic vegetation. Because this vegetation occurs low in the landscape, a lowering of groundwater could cause a reduction in habitat area rather than shift in its position in the landscape. Associated fauna species would therefore decline in abundance or disappear.
4. Very high dependence upon groundwater. This was applied to species that rely on aquatic habitats in wetlands and that are therefore likely to become locally extinct if a fall in the groundwater level leads to the disappearance of surface water in wetlands.

Description of EWRs to maintain sediment processes follow comments made for general EWRs. For those wetlands for which basin bathymetry is available, minimum water levels have been determined. These are based on an assumption that organic sediments will remain saturated/moist if the groundwater level does not drop more than 0.5 m below the ground surface.

Gnangara Mound

Loch McNess

1. Revised ecological management objectives.

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 with very low seasonal variation in water levels.

2. Groundwater dependency analysis.

Although Loch McNess receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum - 6.95

   b) Water requirements for ecological components of GDE.

   - Vegetation.

As there is not a vegetation monitoring transect at Loch McNess, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m; duration of inundation - mean 2.15, absolute 9.4.
- *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m; duration of inundation - mean 1.55, absolute 12.
- *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m; duration of inundation - mean 0.3, absolute 2.8.
- *B. articulata* – mean 0.28 to -1.22m, absolute 0.81 to -2.59m; duration of inundation - – mean 3.26, absolute 12.

Further to this, as the wetland vegetation is in excellent condition, the current water regime may be adequate to maintain vegetation values. Current EWRs are therefore likely to be appropriate.

   - Waterbirds.

Loch McNess supports a number of waterbird and wader species known to be highly groundwater dependent. These species generally require permanent surface water with some fluctuation to provide seasonal variation in depth and shoreline. However, as there is little seasonal variation in water depth at Loch McNess, surface water permanence is likely to be of greater importance than shoreline areas to species found at this wetland. Therefore maintenance of the current (2003) water regime should be sufficient to maintain waterbird values at Loch McNess. Current EWRs are therefore likely to be appropriate.

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Submergent species, emergent species and littoral vegetation are likely to be important for habitat at Loch McNess. As discussed under vegetation, there is no vegetation at Loch McNess and it is therefore not possible to describe a maximum water level. However, as the vegetation surrounding the basin is in excellent condition, the current (2003) water regime may be adequate to maintain vegetation and therefore macroinvertebrate values. Current EWRs are therefore likely to be appropriate.

- Vertebrates.

Loch McNess supports fish and frog species and Rakali (water rat). All species require permanent water with seasonal fluctuations also important for frogs and Rakali. As there is little seasonal variation in water depth at Loch McNess, surface water permanence is likely to be most important to species found at this wetland. Therefore maintenance of the current (2003) water regime should be sufficient to maintain vertebrate species values at Loch McNess. Current EWRs are therefore likely to be appropriate.

- Sediment processes.

To maintain sediment processes and prevent related changes in water quality, sediments at Loch McNess must remain saturated throughout the summer each year. Therefore maintenance of the current (2003) water regime should be sufficient to maintain sediment processes at Loch McNess. Current EWRs are therefore likely to be appropriate.

Lake Yonderup

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Lake Yonderup receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.
   a) Superceded EWRs (mAHD).

Summer absolute minimum -5.9.

   b) Water requirements for ecological components of GDE.

- Vegetation.

Although there is a vegetation monitoring transect at Lake Yonderup it is located 750m south of the staff gauge and is not influenced by surface water. The minimum water requirements of wetland vegetation at this site are therefore unlikely to be representative of the requirements of vegetation in closer proximity to the wetland basin. However, as the wetland vegetation surrounding the basin is in excellent condition, the current (2003) water regime may be adequate to maintain vegetation values. Current EWRs are therefore likely to be appropriate.

- Macroinvertebrates.

Lake Yonderup supports high macroinvertebrate species richness. Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Lake Yonderup. As discussed under vegetation, there is no vegetation transect near the wetland basin and it is therefore not possible to describe a maximum water level. However, as the vegetation surrounding the basin is in excellent condition, the current (2003) water regime may be adequate to maintain vegetation and therefore macroinvertebrate values. Current EWRs are therefore likely to be appropriate.

- Vertebrates.

Although there are no ecological values described specifically for vertebrates at Lake Yonderup, it is highly likely that the wetlands supports a similar suite of species to that found at Loch McNess, as the wetlands are in close proximity and of similar geomorphology. Vegetation is noted as providing important habitat, the current (2003) water regime may therefore be adequate to maintain vegetation and therefore vertebrate values. Current EWRs are therefore likely to be appropriate.

- Sediment processes.

To maintain sediment processes and prevent related changes in water quality, sediments at Loch McNess must remain saturated throughout the summer each year. The current (2003) water regime may therefore be adequate to maintain sediment processes. Current EWRs are therefore likely to be appropriate.

Lake Wilgarup

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Lake Wilgarup receives rainfall inputs, the demise of much of the wetland vegetation in response to groundwater decline indicates that the wetland is entirely dependent on groundwater (Evan & Clifton, 2001) for biophysical processes and consumptive use.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Preferred minimum peak - 6.1

Absolute minimum peak -5.65

   b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lake Wilgarup are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 4.81 mAHD, followed by *B. juncea* at 3.90 mAHD and *M. rhaphiophylla* at 3.89 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lake Wilgarup an autumn minimum of 4.81 mAHD is required. As the bore is situated on the monitoring transect it is representative of the required groundwater levels.

- Sediment processes.

To maintain sediment processes and reduce the likelihood of fire, sediments at Lake Wilgarup must remain saturated throughout the summer each year. The watertable must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. It is likley that this level is 0.5 m below the ground surface or 5.5 mAHD near the monitoring bore.

Pipidinny Swamp

1. Revised ecological management objectives.

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 habitat types.

2. Groundwater dependency analysis.

Although Pipidinny Swamp receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Preferred minimum peak - 2.7

Absolute minimum peak - 2.4

Summer absolute minimum - 1.6

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across transects during a one-off assessment at Pipidinny Swamp are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 1.38 mAHD, followed by *T. orientalis* at 0.94 mAHD and *M. rhaphiophylla* at 0.65 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on transects at Pipidinny Swamp an autumn minimum of 1.38 mAHD is required. Current EWRs are therefore likely to be appropriate.

- Waterbirds.

Pipidinny Swamp supports a number of waterbird species known to be highly groundwater dependent. These species require extensive flooding of the wetland in winter/spring. Elevations measured at three of the ponds at Pipidinny Swamp suggest a surface water level of 3.0 mAHD may be required for 2 months of the year in at least 4 out of 6 years to meet the requirements of waterbird species.

- Macroinvertebrates.

Pipidinny Swamp supports unique macroinvertebrates. Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Pipidinny Swamp. To inundate some areas of these vegetation assemblages for 2 months a year, a maximum water level of 3.0 mAHD is required.

- Vertebrates.

Although there are no ecological values described specifically for vertebrates at Pipidinny Swamp, the wetland supports long-necked turtles, which are highly dependent and require near-permanent surface water. A winter/spring maximum of 3.0 mAHD should be adequate to ensure surface water is retained through the summer months.

Lake Nowergup

1. Revised ecological management objectives.

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 minimise impact of nutrient enrichment on aquatic fauna.
- Fringing vegetation provides range of habitat types.

2. Groundwater dependency analysis.

Although Lake Nowergup has been artificial maintained since 1989, receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. Sudden health declines and deaths of fringing wetland trees (*M. rhaphiophylla* and *E. rudis*) on the western side of the lake between February and May 2002 coinciding with rapid declines in groundwater levels provides further evidence of total groundwater dependence. Processes of uses for which groundwater is required include consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Preferred minimum peak - 17

Absolute minimum peak - 16.8

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at Lake Nowergup are presented in Table 4. Application of the approach to determine the minimum water requirements of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 15.22 mAHD, followed by *M. rhaphiophylla* at 14.66 mAHD, *E. rudis* at 14.64 mAHD and *T. orientalis* at 14.44 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at Lake Nowergup an autumn minimum of 15.22 mAHD is required. It must be noted that this is a groundwater level and is applicable only to LN2/89 as this bore is in close proximity to the transects. Due to disparities between surface and groundwater levels, the equivalent surface water level at the staff gauge is 16.35 mAHD.

- Waterbirds.

Lake Nowergup supports a number of waterbird and wader species known to be highly groundwater dependent. These species generally require permanent surface water with some fluctuation to provide seasonal variation in depth and shoreline. Winter/spring inundation of fringing vegetation is also important. To inundate an area of *B. articulata* at the southern end of the wetland a surface water level of 16.853 mAHD is required for 2 months of the year in at least 4 out of 6 years. However, to inundate emergent species on the western shore a maximum surface water level of 17.0 mAHD is required. Therefore maintenance of the current (2003) water regime should be sufficient to maintain waterbird values at Lake Nowergup. Current EWRs are therefore likely to be appropriate.

- Macroinvertebrates.

Lake Nowergup supports significant macroinvertebrate assemblages. Requirements are to ensure the maintenance of permanent water in wetland as interannual and seasonal refuge. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate an area of *B. articulata* at the southern end of the wetland a surface water level of 16.853 mAHD is required for 2 months of the year in at least 4 out of 6 years.

- Vertebrates.

Although long-necked tortoises survive in wetlands that dry for up to 6 months of the year, they are highly dependent and prefer permanent or near permanent surface water. Rakali and fish and frog a species found in Lake Nowergup however, require permanent water. Therefore maintenance of the current (2003) water regime should be sufficient to maintain vertebrate values at Lake Nowergup. Current EWRs are therefore likely to be appropriate.

- Sediment processes.

Organic lacustrine ooze in deeper parts of the lake must be prevented from exposure to drying until more is known about the effects of such drying on ecosystem processes. Recommendations have been made for the mapping of sediments within Lake Nowergup in order to characterise the sediments and their drying potential, and subsequently develop a fire management strategy (Benier & Horwitz, 2003). Water requirements will depend on fire management strategy adopted.

Severe drying and subsequent rewetting will result in acidification of surface and subsurface waters (according to the classification of Lake Nowergup as being at high risk of AASS and PASS within 3 metres of the surface; (Western Australian Planning Commission, 2003)). To prevent acidic surface waters and to prevent an acidic groundwater plume, sediment containing AASS and PASS must remain permanently saturated, until evidence is presented that such consequences will not eventuate.

To protect organic soils at Lake Nowergup, summer/autumn minimum groundwater levels must not drop below 16.353 mAHD (0.5 m below ground surface at the surveyed site).

Lake Joondalup

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Lake Joondalup receives rainfall and stormwater inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 16.2

Summer absolute minimum - 15.8

   b) Water requirements for ecological components of GDE.

   - Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at Lake Joondalup are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 15.88 mAHD, followed by *M. rhaphiophylla* at 15.86 mAHD, *B. juncea* at 14.75 mAHD and *E. rudis* at 14.74 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at Lake Joondalup an autumn minimum of 15.88 mAHD is required. It must be noted that this is a groundwater level however, the vegetation transect is approximately 2000m NE of bore 8281. As groundwater levels are known to be 2m higher at this bore than surface water levels, it is unlikely that groundwater levels at 8281 will reflect those required by the vegetation in question.

   - Waterbirds.

Lake Joondalup supports a number of waterbird and wader species known to be highly groundwater dependent. These species generally require permanent surface water with some fluctuation to provide seasonal variation in depth and shoreline. Surface water current persists in areas along the western shore through summer. Winter/spring inundation of fringing vegetation is also important. To inundate vegetation on the monitoring transects (east, south and north) a water level of 17.0 mAHD is required for 2 months a year in at least 4 out of 6 years.

   - Macroinvertebrates.

Lake Joondalup supports macroinvertebrate assemblages. Requirements are to ensure the maintenance of permanent water in the wetland as interannual and seasonal refuge. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of vegetation on the monitoring transects (east, south and north) a water level of 17.0 mAHD is required for 2 months a year in at least 4 out of 6 years.

- Vertebrates.

Although long-necked tortoises survive in wetlands that dry for up to 6 months of the year, they are highly dependent prefer permanent or near permanent surface water. Rakali and fish and frog species found in Lake Joondalup although also highly groundwater dependent, require permanent water. Therefore maintenance of the current (2003) water regime should be sufficient to maintain vertebrate values at Lake Joondalup. Current EWRs are therefore likely to be appropriate.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To protect organic soils at Lake Joondalup, summer/autumn minimum groundwater levels must not drop more than 0.5 m below ground surface. Organic sediments extend to an elevation of approximately 17.0 mAHD. Therefore to maintain sediment processes across the wetland a minimum of 16.5 mAHD is required.

Lake Goollelal

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Lake Goollelal receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. This is further demonstrated by a high degree of correlation between surface and groundwater levels at Lake Goollelal (Rockwater Pty Ltd., 2003). It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 26.2

Summer absolute minimum - 26

   b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lake Goollelal are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 25.38 mAHD, followed by *M. rhaphiophylla* at 24.46 mAHD and *E. rudis* at 23.39 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lake Goollelal an autumn minimum of 25.38 mAHD is required. Although this represents a substantial decrease from the existing summer minimums, Lake Goollelal has experienced increasing water levels since the 1970's.

- Waterbirds.

Lake Goollelal supports a number of waterbird and wader species known to be highly groundwater dependent. These species generally require permanent surface water with some fluctuation to provide seasonal variation in depth and shoreline. Surface water current persists throughout the year. Winter/spring inundation of fringing vegetation is also important. To inundate vegetation on the monitoring transect (west) a water level of 27.1 mAHD is required for 2 months a year in at least 4 out of 6 years. Under the current (2003) water regime this level is exceeded each year however, the extent of shoreline exposed during summer has declined with increased water levels, thereby reducing the area available for use by wader species.

- Vertebrates.

Rakali and fish and frog species found in Lake Goollelal are highly groundwater dependent and require permanent water. Therefore maintenance of the current (2003) water regime should be sufficient to maintain vertebrate values at Lake Goollelal. Current EWRs are therefore likely to be appropriate.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To protect organic soils at Lake Goollelal, summer/autumn minimum groundwater levels must not drop more than 0.5 m below ground surface. As the wetland is inundated throughout the year, the current (2003) water regime is adequate to maintain sediment processes.

Lake Jandabup

1. Revised ecological management objectives.

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 macroinvertebrate species.
- Improving water quality following 1997 acidification event.

2. Groundwater dependency analysis.

Although Lake Jandabup has been artificially maintained episodically since 1989, receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. Further evidence is provided though the fact that augmentation of surface water levels is required at the time of groundwater level decline (Rockwater Pty Ltd., 2003). It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer absolute minimum - 44.2

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lake Jandabup are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *A. fascicularis* requires the highest minimum groundwater level at 43.54 mAHD, followed by *M. preissiana* at 43.48 mAHD, *B. articulata* at 42.84 mAHD and *H. angustifolium* at 42.57 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lake Jandabup an autumn minimum of 43.54 mAHD is required. It must be noted that this is a groundwater level however, there is no groundwater monitoring bore in proximity of the monitoring transect.

- Waterbirds.

Lake Jandabup supports a number of waterbird and wader species known to be highly groundwater dependent. Flooded emergent species in winter/spring are known to be important for waterbird breeding. To inundate a substantial area of sedges/rushes a peak surface water level of 15.0 mAHD is required. This level should also be adequate to prevent the spread of vegetation into the basin and thereby maintain shallows for use by waders in summer/autumn. The current (2003) water regime appears adequate to maintain waterbird values.

- Macroinvertebrates.

Lake Jandabup supports a diverse range of macroinvertebrate species. Requirements are to ensure the maintenance of permanent water in the wetland as interannual and seasonal refuge. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of vegetation near the monitoring transect a water level of 15.0 mAHD is required for 2 months a year in at least 4 out of 6 years.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer. To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. The current absolute summer minimum of 44.3 mAHD was established to address sediment issues and is remains an appropriate level.

Lake Mariginiup

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Water levels at Lake Mariginiup have declined in recent years with increasing differences between surface and groundwater levels suggesting perching of rainfall and surface water. However, trends in ground and surface water levels are well correlated indicating hydraulic connectivity (Rockwater Pty Ltd., 2003). Therefore it is likely that biophysical processes, habitat and consumptive use of Lake Mariginiup are highly groundwater dependent.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Preferred minimum peak - 42.1

Absolute minimum peak - 41.5

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lake Mariginiup are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *T. orientalis* requires the highest minimum groundwater level at 40.55 mAHD, followed by *E. rudis* at 40.34 mAHD, *B. articulata* at 40.28 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lake Mariginiup an autumn minimum of 40.55 mAHD is required. It must be noted that this is a groundwater level, which should be adequately reflected at bore MS10 as it is within close proximity (<100m) of the transect.

- Waterbirds/waders

Wader species found at Lake Mariginiup are thought to be highly groundwater dependent. These species require shallow water in summer and early autumn with high winter levels also required to prevent the spread of vegetation across the basin and reducing the area of open shallows. To inundate a substantial area of sedges/rushes a peak surface water level of 42.1 mAHD is required. This level should also be adequate to prevent the spread of vegetation into the basin and thereby maintain shallows for use by waders in summer/autumn.

- Macroinvertebrates.

Lake Mariginiup supports a diverse range of macroinvertebrate species. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate a substantial area of sedges/rushes a peak surface water level of 42.1 mAHD is required.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. As the staff gauge appears to dry at 41.3 mAHD and the basin of Lake Mariginiup is basically flat, a minimum groundwater level of 40.8 mAHD should be adequate to maintain sediment processes.

Lexia 86

1. Revised ecological management objectives.

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 fringing and wetland vegetation.
- Supports significant invertebrate and vertebrate communities.

2. Groundwater dependency analysis.

Although Lexia 86 receives rainfall inputs, it is thought that surface water levels are an expression of the underlying groundwater (Rockwater Pty Ltd., 2003). Therefore it is likely to be entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 47.3

Summer absolute minimum - 47

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lexia 86 are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 47.09 mAHD, followed by *B. littoralis* at 47.03 mAHD, *P. ellipticum* at 46.66 mAHD, *M. preissiana* at 46.53 mAHD, *A. fascicularis* at 46.07 mAHD and *H. angustifolium* at 45.49 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lexia 86 an autumn minimum of 47.09 mAHD is required. It must be noted that this is a groundwater level, which is adequately reflected at bore GNM16 as it is within close proximity (<100m) of the transect.

- Macroinvertebrates.

Lexia 86 supports a significant macroinvertebrate community. Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Lexia 86. To inundate appropriate areas of vegetation for 2 months a year, a maximum water level of 48.5 mAHD is required.

- Vertebrates.

Three highly groundwater dependent frog species occur at Lexia 86. Recruitment of the Moaning Frog, occurred in spring 2003 but not during previous successive years. There were also breeding populations of the Squelching Frog and Guenther's Toadlet. The 2003 autmun peak may therefore be sufficient to induce breeding in these species. This suggests an autumn peak of 48.64 mAHD. Lexia 86 also supports the long-necked tortoise, which requires inundation for at least 6 months of the year. Attaining a peak level of 48.64 mAHD should allow surface water to persist for an adequate length of time.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. As the staff gauge appears to dry at 48.31 mAHD and the wetland basin is small and basically flat, a minimum groundwater level of 47.8 mAHD should be adequate to maintain sediment processes and water quality.

Lexia 94

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described damplands of the Swan Coastal Plain as highly groundwater dependent for consumptive use and biophysical processes. Rainfall is also a significant water source and it is thought that there may be some perching at Lexia 94.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 45.8

Summer absolute minimum - 45.5

   b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lexia 94 are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *P. ellipticum* requires the highest minimum groundwater level at 44.28 mAHD, followed by *A. fascicularis* at 44.24 mAHD, *M. preissiana* at 43.88 mAHD, and *H. angustifolium* at 43.05 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lexia 94 an autumn minimum of 44.28 mAHD is required. It must be noted that this is a groundwater level, which should be adequately reflected at bore GNM17A, 200m S/W of the transect.

- Vertebrates

Frogs occur at Lexia 94 however, as no surface water has been present for a number of years, breeding has not occurred. As the ground elevation at the bore is 47.28 mAHD, a peak level greater than this would be required for 4 months to allow frogs to breed.

Lexia 186

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described damplands of the Swan Coastal Plain as highly groundwater dependent for consumptive use and biophysical processes. Rainfall is also a significant water source.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 47.5

Summer absolute minimum - 47.2

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Lexia 186 are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *P. ellipticum* requires the highest minimum groundwater level at 47.71 mAHD, followed by *A. fascicularis* at 47.67 mAHD, *M. preissiana* at 47.31 mAHD and *H. angustifolium* at 46.57 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lexia 186 an autumn minimum of 47.71 mAHD is required. It must be noted that this is a groundwater level, which is adequately reflected at bore GNM15 as it is within close proximity (<50m) of the transect.

- Vertebrates.

Lexia 186 supports frogs, which generally require approximately 4 months of inundation to breed. The excavated sump at the wetland contained surface water during the winter/autumn 2003. The 2003 peak groundwater level of 48.02 mAHD may therefore reflect an appropriate surface water level in the sump.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. The lowest point of the wetland is approximately 48.3 mAHD, therefore a minimum groundwater level of 47.8 mAHD should be adequate to maintain sediment processes.

EPP Wetland 173

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

EPP173 is believed to be a perched wetland, with the water regime relying on rainfall inputs as well as flows from the adjacent springs (Rockwater Pty Ltd., 2003). However, it is still likely that EPP173 is highly groundwater dependent for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer absolute minimum - 50.2

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at EPP173 are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *P. ellipticum* requires the highest minimum groundwater level at 49.34 mAHD, followed by *B. articulata* at 48.98 mAHD, *A. fascicularis* at 48.79 mAHD, *M. preissiana* at 48.76 mAHD and *H. angustifolium* at 48.02 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at EPP173 an autumn minimum of 49.34 mAHD is required. It must be noted that this is a groundwater level, which is adequately reflected at bore GNM14 as it is within close proximity (<100m) of the transect.

- Macroinvertebrates.

EPP 173 supports a significant macroinvertebrate community. Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at EPP 173. To inundate appropriate areas of vegetation for 2 months a year, a maximum water level of 51.1 mAHD is required.

- Vertebrates.

EPP 173 supports high vertebrate species richness. Recruitment of the Moaning Frog occurred in spring 2003 but not during previous successive years. The Quacking Frog was also present at this time, suggesting it requires flooding of areas surrounding the lake including the creek and seepages. The 2003 spring peak may therefore be sufficient to induce breeding in these species. This suggests an spring peak of 51.1 mAHD.

Although there are no known specific water requirements for the Blackstripe Minnow the species can survive in a seasonal wetland, yet needs a high degree of soil moisture during summer to survive aestivation. As it resides in cool water it is important to maintain an adequate depth of water to allow stratification to develop and so provide a cooler layer. It is thought that the species may persist at a maximum surface water level of 50.95 mAHD and minimum groundwater level of 49.41 mAHD however, further research is required to substantiate these levels.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. As the staff gauge appears is dry at 50.4 mAHD and the basin of the wetland is small and basically flat, a minimum groundwater level of 49.9 mAHD should be adequate to maintain sediment processes. However, as the wetland may be perched ground and surface water levels are disparate the current minimum surface water level of 50.2 mAHD should be retained.

Dampland 78

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described damplands of the Swan Coastal Plain as highly groundwater dependent for consumptive use and biophysical processes. Rainfall is also a significant water source.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 65.4

Summer absolute minimum - 65.1

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Dampland 78 are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *A. fascicularis* requires the highest minimum groundwater level at 65.44 mAHD, followed by *M. preissiana* at 61.97 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Dampland 78 an autumn minimum of 65.44 mAHD is required. It must be noted that this is a groundwater level, which may not be adequately reflected at bore GNM31 which is located 50m upslope of the transect.

- Vertebrates

Frogs have been recorded at Dampland 78 but appear unable to breed. As the lowest point of the wetland is approximately 67.0 mAHD water levels are required to exceed this level. However, as the monitoring bore is removed from the basin, it is not possible to determine an appropriate level for the basin.

Lake Gwelup*

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Lake Gwelup receives rainfall and stormwater inputs and no longer has a permanent surface water component, it has in the past been a permanent wetland. Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

a) No current EWR.

b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Lake Gwelup, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla:* depth; mean 0.01 to -2.14 m, absolute 1.03 to -4.49 m, duration;; mean 2.15 (months/year), absolute 9.4 (months/year).
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).
- *T. orientalis:* depth; mean 0.74 to -0.95 m, absolute 1.49 to -1.9 m, duration; mean 7.7 (months/year), absolute 12 (months/year).

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Lake Gwelup.

- Waterbirds

Lake Gwelup may support waterbird and wader species. These species require shallow water in summer and early autumn with high winter levels also required to prevent the spread of vegetation across the basin and reducing the area of open shallows. As the elevation of the staff gauge and ranges of fringing and emergent vegetation are not known, it is not possible to determine an EWR to meet waterbird requirements.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Big Carine Swamp*

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Big Carine Swamp receives rainfall inputs, the decline in condtion of the wetland vegetation in response to groundwater decline indicates that the wetland is likely to be entirely dependent on groundwater (Evan & Clifton, 2001) for biophysical processes and consumptive use.

3. Revised EWRs.

   a) No current EWR.

   b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Big Carine Swamp, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla:* depth; mean 0.01 to -2.14 m, absolute 1.03 to -4.49 m, duration;; mean 2.15 (months/year), absolute 9.4 (months/year).
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).
- *T. orientalis:* depth; mean 0.74 to -0.95 m, absolute 1.49 to -1.9 m, duration; mean 7.7 (months/year), absolute 12 (months/year).

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Big Carine Swamp.

- Waterbirds

Big Carine Swamp may support waterbird and wader species. These species require shallow water in summer and early autumn with high winter levels also required to prevent the spread of vegetation across the basin and reducing the area of open shallows. As the elevation of the staff gauge and ranges of fringing and emergent vegetation are not known, it is not possible to determine an EWR to meet waterbird requirements.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Lake Muckenburra*

1. Revised ecological management objectives.

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 (SCP07).

2. Groundwater dependency analysis.

The TEC is a species rich vegetation community that occurs on heavy clay soils and is generally inundated from winter to mid-spring. As the wetland is likely to fill following ponding of rainfall and groundwater level rise and vegetation most likely accesses soil water held in the clay during summer, Lake Muckenburra should be considered to be proportionally groundwater dependent.

3. Revised EWRs.
   a) No current EWR. May require installation of staff gauge.
   b) Water requirements for ecological components of GDE.
      - Vegetation.

As there is not a vegetation monitoring transect at Lake Muckenburra and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species other than the requirement for flooding in winter/spring.

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Lake Muckenburra.

- Waterbirds.

Lake Mukenburra supports waterbird and wader species. These species require shallow water in summer and early autumn with high winter levels also required to prevent the spread of vegetation across the basin and reducing the area of open shallows. As there is no staff gauge and ranges of fringing and emergent vegetation are not known, it is not possible to determine an EWR to meet waterbird requirements.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Bambun Lake*

1. Revised ecological management objectives.

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 (SCP07 and SCP15).

2. Groundwater dependency analysis.

Bambun Lake supports TEC SCP07, described above for Lake Muckenburra. TEC SCP15 also occurs at the site. This community is described as occurring on alluvial sediments that are inundated for long periods. As the wetland is likely to fill following ponding of rainfall and groundwater level rise and vegetation most likely accesses soil water held in the clay during summer, Bambun Lake should be considered to be proportionally groundwater dependent.

3. Revised EWRs.
   a) No current EWR. May require installation of staff gauge.
   b) Water requirements for ecological components of GDE.
      - Vegetation.

As there is not a vegetation monitoring transect at Bambun Lake, a minimum groundwater level cannot be determined following the methodology outlined above. However, the TECs require winter inundation for flooding in winter/spring.

Comment can also be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland. Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;
- *M. rhaphiophylla:* depth; mean 0.01 to -2.14 m, absolute 1.03 to -4.49 m, duration;; mean 2.15 (months/year), absolute 9.4 (months/year).
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).
- *B. articulata*: depth; mean 0.28 to -1.22 m, absolute 0.81 to -2.59 m, duration; mean 3.26 (months/year), absolute 12 (months/year).

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Bambun Lake.

- Vertebrates.

Permanent surface water is required to support fish species at Bambun Lake.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Yeal Swamp, Lake Bindiar and Wetlands of Yeal Nature Reserve*

1. Revised ecological management objectives.

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;

- System of generally connected damplands situated within large area of high quality bushland within Yeal Nature Reserve.
- Vegetation provides fauna habitat.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described SCP damplands and sumplands with *Melaleuca* and *Banksia* woodlands as proportionally groundwater dependent. Although the depth to groundwater underlying the Yeal wetlands is now >10m, vegetation established under a wetter regime and should still be considered groundwater dependent.

3. Revised EWRs.
   a) No current EWR. May require installation of monitoring bore in close proximity of wetlands.

b) Water requirements for ecological components of GDE.

- Vegetation.

Although a terrestrial vegetation transect was established at Yeal Swamp in 1987, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. preissiana* – mean 0.54 to -2.62m, absolute 1.03 to -5.04m; duration of inundation - mean 2.15, absolute 9.4.
- *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m; duration of inundation - mean 0.3, absolute 2.8.
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).

- Vertebrates.

The relationship between groundwater, upland vegetation and terrestrial fauna may be important.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Edgecombe Seepage

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Despite seasonal input from rainfall, Clifton and Evans (2001) described mound springs of the Swan Coastal Plain as entirely groundwater dependent for habitat, biophysical processes and consumptive use.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer absolute minimum - 14.35

b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Edgecombe Seepage, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland. Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla:* depth; mean 0.01 to -2.14 m, absolute 1.03 to -4.49 m, duration;; mean 2.15 (months/year), absolute 9.4 (months/year).
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).
- *B. articulata*: depth; mean 0.28 to -1.22 m, absolute 0.81 to -2.59 m, duration; mean 3.26 (months/year), absolute 12 (months/year).

- Macroinvertebrates.

Macroinvertebrate assemblages at Edgecombe Seepage require permanently flowing surface water. Therefore sufficient hydrostatic head is required to ensure perennial flow from spring. The volume of flow is not known but it is likely to be a matter of several litres per second at a maximum.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Egerton Spring

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Despite seasonal input from rainfall, Clifton and Evans (2001) described mound springs of the Swan Coastal Plain as entirely groundwater dependent for habitat, biophysical processes and consumptive use.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum - 39.29

   b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Egerton Springs, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. preissiana* – mean 0.54 to -2.62m, absolute 1.03 to -5.04m; duration of inundation - mean 2.15, absolute 9.4.
- *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m; duration of inundation - mean 0.3, absolute 2.8.
- *A. fascicularis* – mean -0.35 to -2.26m, absolute 1.03m to -4.6m; duration of inundation – mean 0.66, absolute 2.6.

It is also likely that the club mosses and liverwort species require permanently saturated soil.

- Macroinvertebrates.

Macroinvertebrate assemblages at Egerton Spring require permanently flowing surface water. Therefore sufficient hydrostatic head is required to ensure perennial flow from spring. The volume of flow is not known but it is likely to be a matter of several litres per second at a maximum.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Kings Spring*

1. Revised ecological management objectives.

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).

2. Groundwater dependency analysis.

Despite seasonal input from rainfall, Clifton and Evans (2001) described mound springs of the Swan Coastal Plain as entirely groundwater dependent for habitat, biophysical processes and consumptive use.

3. Revised EWRs.
   a) No current EWR. May require installation of staff gauge or bore in close proximity.
   b) Water requirements for ecological components of GDE.
      - Vegetation.

As there is not a vegetation monitoring transect at Kings Spring, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. preissiana* – mean 0.54 to -2.62m, absolute 1.03 to -5.04m; duration of inundation - mean 2.15, absolute 9.4.
- *E. rudis:* depth; mean -0.7 to -3.26 m, absolute 1.03 to -6.44 m, duration; mean 1.55 (months/year), absolute 12 (months/year).

- Macroinvertebrates.

Macroinvertebrate assemblages of Kings Spring may require permanently flowing surface water. Therefore sufficient hydrostatic head is required to ensure perennial flow from spring. The volume of flow is not known but it is likely to be a matter of several litres per second at a maximum.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Jandakot Mound

Thomsons Lake

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Thomsons Lake receives rainfall inputs and has a permanent surface water component, Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely dependent on groundwater. This is further demonstrated by a high degree of correlation between surface and groundwater levels (Rockwater Pty Ltd., 2003). It is therefore highly likely that the wetland is entirely groundwater dependent for biophysical processes, habitat and consumptive use.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 11.3

Summer absolute minimum - 10.8

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at Thomsons Lake are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* requires the highest minimum groundwater level at 11.71 mAHD, followed by *T. orientalis* at 10.82 mAHD, *E. rudis* at 10.24 mAHD, and *B. juncea* at 9.2 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at Thomsons Lake an autumn minimum of 11.71 mAHD is required. It must be noted that this is a groundwater level which appears to be inadequately reflected at bore TM14A (Rockwater Pty Ltd., 2003), located approximately 500m north of transects 2 and 3.

- Waterbirds.

Thomsons Lake is a RAMSAR wetland. Waterbird and wader species require shallow water in summer and early autumn with high winter levels also required to prevent the spread of vegetation across the basin and reducing the area of open water. To inundate a substantial area of *T. orientalis* and *B. articulata* a peak surface water level of 12.8 mAHD is required. This level should also be adequate to prevent the spread of *T. orientalis* into the basin and thereby maintain open water.

- Macroinvertebrates.

Thomsons Lake supports macroinvertebrates. Requirements are to ensure the maintenance of permanent water in wetland as interannual and seasonal refuge. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate area of *B. articulata* and *T. orientalis* across the wetland a surface water level of 12.8 mAHD is required for 2 months of the year in at least 4 out of 6 years.

- Vertebrates.

Frogs and possibly long-necked tortoises occur at Thomsons Lake. Frogs require 4 months of inundation to breed with tortoises preferring periods of 9 months or more. A peak level of 12.6 mAHD should be adequate to retain surface water for a sufficient period.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address

PASS anaerobic sediments need to remain saturated through late summer and early autumn. As the staff gauge dries at 11.8 mAHD and the wetland basin is relatively flat a minimum groundwater level of 11.3 should be adequate to maintain sediment processes and water quality not related to run-off inputs.

North Lake

1. Revised ecological management objectives.

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 (JAMBA/CAMBA species).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely groundwater dependent. However, North Lake appears to be perched during periods of low groundwater levels, suggesting it may be only highly dependent (Rockwater Pty Ltd., 2003). North Lake also receives inputs from rainfall however, the volume of surface water entering the lake has decreased in recent years as a result of the diversion of 2 stormwater drains. Uses of groundwater include habitat, biophysical processes and consumption.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 13.5

Summer absolute minimum - 12.7

   b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at North Lake are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. littoralis* requires the highest minimum groundwater level at 12.68 mAHD, followed by *M. rhaphiophylla* at 12.06 mAHD, *A. fascicularis* at mAHD, *B. juncea* at 11.35 mAHD and *E. rudis* at 10.94 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at North Lake an autumn minimum of 12.68 mAHD is required. It must be noted that this is a groundwater level, which may not be adequately reflected at the North Lake criteria bore (Rockwater Pty Ltd., 2003), approximately 300m west of transects 1 and 2.

- Waterbirds.

Waterbird species found at North Lake require high winter/spring peaks, retention of deep water in summer/autumn for deep-water species and inundation of fringing vegetation. A peak surface water level of 13.265 mAHD should be sufficient to inundate *Melaleuca* on both side of the wetland. This level should also be adequate to prevent the spread of sedges and exotics into the basin and thereby maintain open water. However, higher peaks up to 14.0 mAHD would be required to maintain deep water throughout summer.

- Macroinvertebrates

The requirements of the freshwater sponge species found at North Lake are unknown. However, it is likely that they require permanent water and a peak of 14.0 mAHD may be sufficient to maintain the population, providing other variables are suitable. This level should also maintain other macroinvertebrate species.

- Vertebrates.

Frogs and possibly long-necked tortoises occur at North Lake. Frogs require 4 months of inundation to breed with tortoises preferring periods of 9 months or more. A peak level of 13.6 mAHD should be adequate to retain surface water for a sufficient period.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. To protect organic soils water levels should not drop below 12.765 mAHD.

Banganup Swamp

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. However, Rockwater P/L (2003) noted a high correlation between surface and groundwater levels indicating inundation of Banganup Swamp is in direct response to groundwater rise. Banganup Swamp should therefore be regarded as entirely groundwater dependent for habitat, biophysical processes and consumption despite significant seasonal rainfall inputs.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum - 11.25

   b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Banganup Swamp are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. articulata* and *B. littoralis* require the highest minimum groundwater level at 11.48 mAHD, followed by *A. fascicularis* at 10.94 mAHD, *M. preissiana* at 10.58 mAHD, and *E. rudis* at 9.94 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Banganup Swamp an autumn minimum of 11.48 mAHD is required. It must be noted that this is a groundwater level, which appears to be adequately reflected at Banganup criteria bore LB14 (Rockwater Pty Ltd., 2003), approximately 100m west of the monitoring transect.

- Vertebrates.

Banganup Swamp supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Therefore meeting the EWRs of the fringing vegetation, as described above, should maintain this species.

- Macroinvertebrates.

Banganup Swamp supports macroinvertebrates. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of *B. articulata* and fringing tree species around the wetland a surface water level of 13.2 mAHD is required for 2 months of the year in at least 4 out of 6 years.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. As the staff gauge dries at approximately 12.7 mAHD and the wetland basin is small and relatively flat a minimum groundwater level of 12.2 mAHD should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Bibra Lake

1. Revised ecological management objectives.

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.
- Permanent wetland provides summer refuge for waterbirds.
- Wetland and fringing vegetation provides a range of habitat types.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely groundwater dependent. This is further supported by a high correlation between surface and groundwater levels indicating inundation of Bibra Lake is in direct response to groundwater rise (Rockwater Pty Ltd., 2003). Bibra Lake should therefore be regarded as entirely groundwater dependent for habitat, biophysical processes and consumption despite significant seasonal rainfall inputs.

3. Revised EWRs.

 a) Superceded EWRs (mAHD).

Summer preferred minimum - 14.2

Summer absolute minimum - 13.6

 b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Bibra Lake are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *M. preissiana* requires the highest minimum groundwater level at 12.18 mAHD, followed by *E. rudis* at 11.64 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Bibra Lake an autumn minimum of 12.18 mAHD is required. It must be noted that this is a groundwater level, which may be adequately reflected at bore BM7C, approximately 200m west of the monitoring transect. However this bore has not been monitored since 1999 (Rockwater Pty Ltd., 2003).

- Waterbirds.

Waterbirds and waders require high winter/spring peaks, with the retention of deep water in summer/autumn important for deep-water species and shallows for waders. High winter levels are also required to prevent the spread of vegetation across the basin and reducing the area of open water. A peak level of 14.9 mAHD should be sufficient to inundate areas of vegetation, prevent encroachment into the basin and enable deep water to persist through summer.

- Macroinvertebrates.

Bibra Lake supports macroinvertebrates. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of fringing tree species around the wetland a surface water level of 14.9 mAHD is required for 2 months of the year in at least 4 out of 6 years.

- Vertebrates.

Bibra Lake supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Therefore meeting the EWRs of the fringing vegetation, as described above, should maintain this species.

- Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address

PASS anaerobic sediments need to remain saturated through late summer and early autumn. The current absolute minimum of 13.6 mAHD (14.1 mAHD – 0.5 m) should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Yangebup Lake

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described permanent wetlands of the Swan Coastal Plain as entirely groundwater dependent. This is further supported by a high correlation between surface and groundwater levels at Yangebup Lake (Rockwater Pty Ltd., 2003). Although Yangebup Lake should be regarded as entirely groundwater dependent there is some input into the system from nearby disposal ponds and seasonal rainfall. Uses of groundwater at Yangebup Lake include biophysical processes, consumptive use and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum - 15.5

Summer absolute minimum - 13.8

   b) Water requirements for ecological components of GDE.

      - Vegetation.

As there is not a vegetation monitoring transect at Yangebup Lake, a minimum groundwater level cannot be determined following the methodology outlined above.

      - Waterbirds.

Waterbirds require high winter/spring peaks with the retention of deep water in summer/autumn required for deep-water species. High winter levels are also required to prevent the spread of vegetation across the basin and reducing the area of open water. A peak level of 16.7 mAHD should be sufficient to inundate areas of vegetation, prevent encroachment into the basin and enable deep water to persist through summer.

      - Macroinvertebrates.

Yangebup Lake supports macroinvertebrates. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges each year. To inundate areas of sedges around the wetland a surface water level of 16.2 mAHD is required for 2 months of the year in at least 4 out of 6 years.

      - Sediment processes.

To maintain sediment processes sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. A minimum of 14.5 mAHD (15.0 mAHD – 0.5 m) should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Lake Kogolup

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. It is believed that Lake Kogolup may be partially perched however, it is not possible to comment on the degree of correlation between ground and surface water levels (Rockwater Pty Ltd., 2003). Groundwater is used for habitat, biophysical processes and consumptive uses.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 14

Summer absolute minimum - 13.1

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at Lake Kogolup are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that at Lake Kogolup North *B. juncea* requires the highest minimum groundwater level at 15.15 mAHD, followed by *M. preissiana* at 14.98 mAHD and *E. rudis* at 14.34 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at Lake Kogolup North an autumn minimum of 15.15 mAHD is required. It must be noted that this is a groundwater level, which is not currently reflected at the Lake Kogolup criteria bore, approximately 1km south of North Kogolup transects 1 and 2.

At Lake Kogolup South *A. fascicularis* has the highest minimum groundwater level requirement of 13.14 mAHD, followed by *E. rudis* at 11.74 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Lake Kogolup South an autumn minimum of 13.14 mAHD is required.

- Waterbirds.

High winter/spring peaks and extensive shallows are required in spring for waterbirds. A peak level of 15.0 mAHD at Lake Kogolup South should be sufficient to inundate areas of vegetation, prevent encroachment into the basin and enable deep water to persist through summer.

- Macroinvertebrates.

South Kogolup Lake supports macroinvertebrates. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of sedges around the wetland a surface water level of 15.0 mAHD is required for 2 months of the year in at least 4 out of 6 years.

- Sediment processes.

To maintain sediment processes at Lake Kogolup South sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). To address PASS anaerobic sediments need to remain saturated through late summer and early autumn. A minimum of 14.0 mAHD (14.5 mAHD – 0.5 m) at Lake Kogolup South should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Shirley Balla Swamp

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Although it is thought that a moderate correlation exists between surface water levels and groundwater levels, Shirley Balla Swamp may be partially perched and therefore influenced by rainfall and surface water (Rockwater Pty Ltd., 2003). Groundwater is used for habitat, biophysical processes and consumptive uses.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 25

   b) Water requirements for ecological components of GDE.

      - Vegetation.

The mean water depth ranges of wetland species found across the monitoring transects at Shirley Balla Swamp are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *A. fascicularis* requires the highest minimum groundwater level of 23.84 mAHD, followed by *M. rhaphiophylla* at 23.66 mAHD, *M. preissiana* at 23.48 mAHD, *H. angustifolium* at 23.17 mAHD and *B. littoralis* at 23.1 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transects at Shirley Balla Swamp an autumn minimum of 23.84 mAHD is required. It must be noted that this is a groundwater level, which may be adequately reflected at the Shirley Balla Swamp criteria bore, approximately 300m north of transect 1 and 100m east of transect 2.

      - Waterbirds.

High winter/spring peaks and extensive shallows are required in spring for waterbirds. A peak surface water level of 25.227 mAHD, reached for 2 months of the year in at least 4 out of 6 years at Shirley Balla Swamp, should be sufficient to inundate an area of sedges in the northern area of the wetland and prevent encroachment into the basin.

      - Macroinvertebrates.

Shirley Balla Swamp supports macroinvertebrates. In order to maintain habitat diversity, spring peak water levels must inundate littoral sedges and fringing vegetation each year. To inundate areas of sedges around the wetland a surface water level of 25.227 mAHD is required for 2 months of the year in at least 4 out of 6 years.

      - Vertebrates.

To maintain habitat diversity for terrestrial fauna the requirements of wetland vegetation, as described above, should be met.

      - Sediment processes.

To maintain sediment processes at Shirley Balla Swamp organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). A minimum of 24.77 mAHD (25.27 mAHD – 0.5 m) at Shirley Balla should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Twin Bartram Swamp

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. However, a high correlation between surface and groundwater levels indicates inundation of Twin Bartram Swamp is in direct response to groundwater rise (Rockwater Pty Ltd., 2003). Twin Bartram Swamp should therefore be regarded as entirely groundwater dependent for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 22.8

Summer absolute minimum - 22.5

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Twin Bartram Swamp are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *B. littoralis* requires the highest minimum groundwater level at 22.68 mAHD, followed by *T. orientalis* at 22.35 mAHD and *M. rhaphiophylla* at 21.16 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Twin Bartram Swamp an autumn minimum of 22.68 mAHD is required. It must be noted that this is a groundwater level, which is adequately reflected at the Twin Bartram criteria bore within 10m of the monitoring transect.

- Waterbirds.

High winter/spring surface water levels are required for waterbirds to breed at Twin Bartram Swamp. A peak water level of 24.0 mAHD should be sufficient to inundate vegetation and allow breeding.

- Sediment processes.

To maintain sediment processes at Twin Bartram Swamp organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). A minimum of 22.5 mAHD (23.0 mAHD – 0.5 m) at Twin Bartram Swamp should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Beenyup Rd Swamp

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. This is further supported by a moderate correlation between surface and groundwater levels

(Rockwater Pty Ltd., 2003). Groundwater, surface water and rainfall are required for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 24

Summer absolute minimum - 23.6

b) Water requirements for ecological components of GDE.

- Vegetation.

The mean water depth ranges of wetland species found across the monitoring transect at Beenyup Rd. Swamp are presented in Table 4. Application of the approach to determine the minimum water requirement of wetland species (as described on p.62), indicates that *M. rhaphiophylla* requires the highest minimum groundwater level at 24.0 mAHD, followed by *M. preissiana* at 22.38 mAHD. Therefore to meet the minimum groundwater requirements of all wetland vegetation on the monitoring transect at Beenyup Rd. Swamp an autumn minimum of 23.46 mAHD is required. It must be noted that this is a groundwater level, which may be adequately reflected at the Beenyup Swamp criteria bore, approximately 100m north of the monitoring transect.

In addition to a minimum water level requirement, a higher peak surface water level is required to inundate the basin, thereby reducing the dominance of exotic annuals and possibly rehabilitating *B. articulata.* A peak level of 25.0 mAHD may be sufficient to address these issues.

- Vertebrates.

The vegetation surrounding Beenyup Rd Swamp supports terrestrial vertebrates. The water requirements described above for wetland vegetation should also be sufficient to maintain terrestrial species.

- Sediment processes.

To maintain sediment processes at Beenyup Rd Swamp organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). A minimum of 25.5 mAHD (25.0 mAHD – 0.5 m) at Shirley Balla Swamp should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Forrestdale Lake

1. Revised ecological management objectives.

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).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. However, there is a poor correlation between ground and surface water levels at Lake Forrestdale and a suggestion has been made that the lake acts as a groundwater sink (Rockwater Pty Ltd., 2003). Groundwater, surface water and rainfall are required for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum - 21.6

Summer absolute minimum - 21.1

b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Forrestdale Lake, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla* – mean 0.006 to -2.14m, absolute 1.03 to -4.49m; duration of inundation - mean 2.15, absolute 9.4.
- *E. rudis* – mean -0.7 to -3.26m, absolute 1.03 to -6.44m; duration of inundation - mean 1.55, absolute 12.
- *B. littoralis* – mean -0.39 to -1.92m, absolute 0.43 to -3.09m; duration of inundation - mean 0.3, absolute 2.8.

- Waterbirds.

Forrestdale Lake supports significant waterbird and wader species. High winter/spring peaks are important at this wetland to prevent the spread of vegetation across the basin and retain open shallows on which migratory waders depend in summer and autumn. A peak water level of 23.0 mAHD for 2 months a year in 4 out of 6 years should be sufficient to address these issues at Lake Forrestdale.

- Vertebrates.

Forrestdale Lake supports frog species and terrestrial vertebrate species and possibly long-necked tortoises. Frogs require 4 months of surface water for breeding and long-necked tortoises prefer up to 9 months of inundation. A peak water level of 22.5 mAHD should be sufficient to retain surface water for an adequate period at Lake Forrestdale.

- Sediment processes.

To maintain sediment processes at Lake Forrestdale organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). A minimum of 22.0 mAHD (22.5 mAHD – 0.5 m) should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Mather Reserve Swamp*

1. Revised ecological management objectives.

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 fauna.
- Supports waterbirds.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater, surface water and rainfall are required for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

a) No current EWR.

b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Mather Reserve and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species.

- Waterbirds.

High winter/spring water levels are required to support waterbirds, which may require up to 6 months of surface water for breeding. A peak level of 26.0 mAHD may be sufficient for 2 months a year in 4 out of 6 years may be sufficient to meet these requirements.

- Vertebrates.

Bushland surrounding Mather Reserve Swamp supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Therefore meeting the EWRs of the fringing vegetation, should maintain this species.

- Sediment processes.

To maintain sediment processes at Mather Reserve Swamp organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface). As the staff gauge appears to dry at 25.03 mAHD, a minimum level of 24.53 mAHD should be adequate to maintain sediment processes and water quality not related to run-off inputs.

Specatcles North*

1. Revised ecological management objectives.

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 habitats.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater, surface water and rainfall are required for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

   a) No current EWR.

   b) Water requirements for ecological components of GDE.

- Vegetation.

As there is not a vegetation monitoring transect at Spectacles North and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species.

- Waterbirds.

The Spectacles North supports waterbirds. Inundation of fringing *Melaleuca* is important for waterbird breeding. As the range of *Melaleuca* at this wetland is unknown, is not possible to determine a peak surface water level.

- Vertebrates.

Bushland surrounding the Spectacles North supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Therefore meeting the EWRs of the fringing vegetation, should maintain this species.

- Sediment processes.

To maintain sediment processes at Spectacles North organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Harrisdale Swamp*

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater, surface water and rainfall are required for consumptive use, habitat and biophysical processes.

3. Revised EWRs.

   a) No current EWR.

   b) Water requirements for ecological components of GDE.

      - Vegetation.

As there is not a vegetation monitoring transect at Harrisdale Swamp and the wetland had not been assessed at the time of writing, no comment can be made on water requirements of wetland species.

- Vertebrates.

Bushland surrounding Harrisdale Swamp supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Therefore meeting the EWRs of the fringing vegetation, should maintain this species.

- Sediment processes.

To maintain sediment processes at Harrisdale Swamp organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

TERRESTRIAL ECOSYSTEMS

The description of EWRs for phreatophytic terrestrial vegetation is based on the depth to groundwater category at each 'criteria' groundwater bore (0-3 m, 3-6 m etc). Recent studies have determined drawdown thresholds for vegetation of each depth category (Froend & Zencich, 2001). Thresholds are described as rate (m/year) and magnitude (m) of drawdown and the associated risk of impact (low, moderate, high, severe) (Tables 4 and 5). Water requirements of terrestrial vegetation in the 0-3m category have been based on drawdown thresholds determined for wetland vegetation. This is acceptable as most terrestrial sites in this depth category support tree species associated with wetlands (eg *M. preissiana, E. rudis*). In the absence of water depths ranges for terrestrial species (as is available for wetland species) this information provides the basis for describing EWRs for terrestrial vegetation. However, as drawdown has already occurred at many sites, it is not appropriate to apply drawdown thresholds to current (2004) groundwater levels. As impacts of drawdown are generally cumulative, consideration must also be given to recent changes in groundwater levels. The Autumn 2001 minimum generally represents the water level at the start of the most recent drying cycle (2000-2004). Use of the 2001 minimum groundwater level as a baseline for setting EWRs, therefore considers the cumulative impacts of recent and future declines in groundwater levels.

To maintain each terrestrial ecosystem at a low level of risk from drawdown, the maximum permissible magnitude of drawdown (m) is subtracted from the 2001 autumn minimum (mAHD). The maximum permissible rate of drawdown is then applied to the 2001 minimum to determine the year at which the minimum groundwater level can be reached. For example, at MT3S *Banksia* woodland occurs at 6-10m depth to groundwater. It is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year. A decrease of 1.25m from the autumn 2001 minimum of 44.137mAHD results in an EWR of 42.887mAHD. However, as the 2004 minimum of 44.067mAHD already represents a decline of 0.07m, levels can only fall a further 1.18m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2016.

There are a number of assumptions and limitations to this approach;

- Water requirements are approximate as further validation is required.
- Phreatophytic classes (0-3m etc) are based on quantitative studies of two *Banksia* species and have not considered requirements of other phreatophytic vegetation.
- Habitat type and species present are largely undescribed.
- Vegetation has established under a different water regime to that which currently exists. Without information on age class structure at individual sites it is not possible to determine under which regime tree root zones were set. Older trees may have established 20 years ago, younger individuals 3-5 years ago. Although older trees may have been lost, populations may persist due to recruitment of new plants under new conditions.
- The hydrology of a terrestrial site is based on water levels as measured at groundwater monitoring bores. This does not represent the variation in topography and its impact on groundwater levels across a site.
- The spatial area of vegetation represented by each bore is not defined.
- Depth to groundwater contouring for 2003 as provided by WRC was significantly different to that provided by Water Corporation for 2000 and did not appear fully representative of groundwater depths measured at some bores. Discrepancies were also noted between the location of known areas of very shallow groundwater and surface water (eg Gingin Brook) and the levels represented by the contouring. These limitations were also identified by the WRC.
- EWRs cannot be determined for 'new' terrestrial ecosystems due to the absence of hydrological data.

Gnangara Mound

PM24

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater and rainfall are required for consumptive use and biophysical processes.

3. Revised EWRs.

 c) Superceded EWRs (mAHD).

Summer absolute minimum – 40.5

 d) Water requirements for ecological components of GDE.

 - Vegetation.

As vegetation at PM24 is in the 0-3m category, occurs in the basin of Lake Pinjar and is dominated by the wetland species *E. rudis* and *M. preissiana*, a minimum groundwater level should not be determined following the methodology outlined above for terrestrial vegetation. However, the approach applied to determine wetland vegetation water requirements is appropriate. Application of this approach indicates that *M. preissiana* requires the highest minimum groundwater level of 40.96 mAHD with *E. rudis* requiring 39.9 mAHD.

 - Vertebrates.

Bushland surrounding Lake Pinjar supports Quenda, a significant mammal species associated with dense vegetation around wetlands. Meeting the water requirements of the fringing vegetation, should maintain this species.

MT3S

1. Revised ecological management objectives.

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 324.
- *Banksia* woodland 6-10m depth to groundwater.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. Zencich (2003) also described Banksia woodland at 6-10m depth to groundwater as opportunistically dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

 a) Superceded EWRs (mAHD).

Summer preferred minimum – 21.6.
Summer absolute minimum – 21.1.

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year. A decrease of 1.25m from the autumn 2001 minimum of 44.137mAHD results in an EWR of 42.887mAHD. However, as the 2004 minimum of 44.067mAHD already represents a decline of 0.07m, levels can only fall a further 1.18m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2016.

MM18

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3) Revised EWRs.

a) Superceded EWRs (mAHD).

Summer absolute minimum – 38.6

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 39.18mAHD results in an EWR of 38.18mAHD. However, as the 2004 minimum of 38.5mAHD already represents a decline of 0.68m, levels can only fall a further 0.32m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2007.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

MM53

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 33.3

   c) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 33.37mAHD results in an EWR of 32.37mAHD. However, as the 2004 minimum of 33.26mAHD already represents a decline of 0.11m, levels can only fall a further 0.89m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

      - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

MM59B

1. Revised ecological management objectives.

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 Foreer Site 304.
- *Banksia* woodland 3-6m depth to groundwater.
- Area supports non-aquatic fauna.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 36.3

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 36.196mAHD results in an EWR of 35.196mAHD. However, as the 2004 minimum of 36.016mAHD already represents a decline of 0.18m, levels can only fall a further 0.82m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

      - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

MM55B

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater and rainfall are required for consumptive use and biophysical processes.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 29.5

   b) Water requirements for ecological components of GDE.

   - Vegetation.

As vegetation at MM55B is in the 0-3m category and is dominated by the wetland species *M. preissiana*, a minimum groundwater level should not be determined following the methodology outlined above for terrestrial vegetation. However, the approach applied to determine wetland vegetation water requirements is appropriate. Application of this approach indicates that *M. preissiana* requires a minimum groundwater level of 29.38 mAHD.

MM16

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 38.8

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 38.8mAHD results in an EWR of 37.8mAHD. However, as the 2004 minimum of

38.8mAHD already represents a decline of 0m, levels can only fall a further 1.0m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2014.

- Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

PM9

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 56.3

   b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year. A decrease of 1.25m from the autumn 2001 minimum of 57.04mAHD results in an EWR of 55.79mAHD. However, as the 2004 minimum of 56.63mAHD already represents a decline of 0.41m, levels can only fall a further 0.84m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

- Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

WM1

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 55.7

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 55.7mAHD results in an EWR of 56.7mAHD. However, as the 2004 minimum of 55.435mAHD already represents a decline of 0.265m, levels can only fall a further 0.735m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

WM2

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 66.5

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 67.495mAHD results in an EWR of 66.495mAHD. However, as the 2004 minimum of 67.325mAHD already represents a decline of 0.17m, levels can only fall a further 0.83m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

      - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

WM8

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 64.8

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 65.517mAHD results in an EWR of 64.517mAHD. However, as the 2004 minimum of 65.567mAHD represents an increase of 0.05m, levels can fall a further 1.05m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2015.

      - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

NR6C

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 58.5

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 59.635mAHD results in an EWR of 58.635mAHD. However, as the 2004 minimum of 59.395mAHD already represents a decline of 0.24m, levels can only fall a further 0.76m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

NR11C

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 55.0

   b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 55.521mAHD results in an EWR of 54.521mAHD. However, as the 2004 minimum of 55.601mAHD represents an increase of 0.08m, levels can fall a further 1.08m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2015.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

L30C

1. Revised ecological management objectives.

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

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 47.2

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 48.594mAHD results in an EWR of 47.594mAHD. However, as the 2004 minimum of 48.474mAHD already represents a decline of 0.12m, levels can only fall a further 0.88m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

   - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

L110C

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 55.7

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year. A decrease of 1.25m from the autumn 2001 minimum of 58.062mAHD results in an EWR of 57.062mAHD. However, as the 2004 minimum of 57.842mAHD already represents a decline of 0.22m, levels can only fall a further 1.03m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2015.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

L220C

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer absolute minimum – 52.2

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 53.041mAHD results in an EWR of 52.041mAHD. However, as the 2004 minimum of 52.881mAHD already represents a decline of 0.16m, levels can only fall a further 0.84m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

MM12

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer absolute minimum – 42.0

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 43.240mAHD results in an EWR of 42.240mAHD. However, as the 2004 minimum of 42.77mAHD already represents a decline of 0.47m, levels can only fall a further 0.53m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2010.

   - Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

Ridges*

1. Revised ecological management objectives.

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 fauna.
- Supports TEC (SCP26a).
- Bush Forever Site 381.
- *Banksia* woodland 6-10m depth to groundwater.
- Representative of terrestrial vegetation with respect to structure and composition.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Groundwater monitoring bore GNM11A may be most representative of the groundwater levels in the area.

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year.

   - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

Rosella Rd Bushland (north)*

1. Revised ecological management objectives.

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;

- Area supports non-aquatic fauna.
- *Banksia* woodland at 3-6m and 6-10m depth to groundwater.
- Bush Forever Site 380.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. *Banksia* woodland at 6-10 m is likely to be opportunistically dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore if any, would be most representative of the area.

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year.

   - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

Muchea Air Weapons Range*

1. Revised ecological management objectives.

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 fauna.
- *Banksia* woodland at 6-10m depth to groundwater..
- Representative of terrestrial vegetation with respect to structure and composition.
- Bush Forever Site 462.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater bore would be most representative of groundwater levels in the area.

   b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year.

- Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

Jandakot

JE17C

1. Revised ecological management objectives.

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;

- *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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater and rainfall are required for consumptive use and biophysical processes.

3. Revised EWRs.

    a) Superceded EWRs (mAHD).

Summer preferred minimum – 16.8
Summer absolute minimum – 16.3

    b) Water requirements for ecological components of GDE.

    - Vegetation.

As vegetation at JE17C is in the 0-3m category and is dominated by the wetland species *E. rudis* and *M. preissiana*, a minimum groundwater level should not be determined following the methodology outlined above for terrestrial vegetation. However, the approach applied to determine wetland vegetation water requirements is appropriate. Application of this approach indicates that *M. preissiana* requires the highest minimum groundwater level of 16.347 mAHD with *E. rudis* requiring 15.707 mAHD.

    - Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JE10C

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

    a) Superceded EWRs (mAHD).

Summer preferred minimum – 21.8
Summer absolute minimum – 21.3

    b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 23.075mAHD results in an EWR of 22.075mAHD. However, as the 2004 minimum of 23.825mAHD represents an increase of 0.75m, levels can fall a further 1.75m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2022.

JM19

1. Revised ecological management objectives.

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 6-10m to groundwater.
- Bush Forever Site 390.
- Representative of terrestrial vegetation with respect to structure, composition and fauna habitat.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater. Zencich (2003) also described *Banksia* woodland at 6-10m depth to groundwater as opportunistically dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum – 25.26
Summer absolute minimum – 24.76

   b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 6-10m depth to groundwater category is at low risk of impact from a total drawdown of 1.25m at a rate of 0.1m/year. A decrease of 1.25m from the autumn 2001 minimum of 25.08mAHD results in an EWR of 23.83mAHD. However, as the 2004 minimum of 24.9mAHD represents a decline of 0.18m, levels can only fall a further 1.07m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2015.

JM31

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

c) Superceded EWRs (mAHD).

Summer preferred minimum - 24.05
Summer absolute minimum – 23.55

d) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 25.01mAHD results in an EWR of 24.01mAHD. However, as the 2004 minimum of 24.9mAHD already represents a decline of 0.11m, levels can only fall a further 0.89m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

- Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JM35

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superseded EWRs (mAHD).

Summer preferred minimum – 21.25
Summer absolute minimum – 20.75

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 23.44mAHD results in an EWR of 22.44mAHD. However, as the 2004 minimum of 23.41mAHD already represents a decline of 0.03m, levels can only fall a further 0.97m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2014.

JE4C

1. Revised ecological management objectives.

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 *Melaleuca sp./Banksia* woodland occurring in area 3-6m to groundwater.
- Bush Forever Site 344.
- Important bird breeding area protected under JAMBA/CAMBA.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Melaleuca*/*Banksia* woodlands of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum – 24.0
Summer absolute minimum – 23.5

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 24.098mAHD results in an EWR of 23.098mAHD. However, as the 2004 minimum of 24.158mAHD already represents a decline of 0.06m, levels can only fall a further 0.94m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2014.

   - Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JM7

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Melaleuca/Banksia* woodlands of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum – 23.17
Summer absolute minimum – 22.67

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 23.061mAHD results in an EWR of 22.061mAHD. However, as the 2004 minimum of 22.791mAHD already represents a decline of 0.27m, levels can only fall a further 0.73m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

   - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JM8

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum – 24.43
Summer absolute minimum – 23.93

   b) Water requirements for ecological components of GDE.

   - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 24.38mAHD results in an EWR of 23.38mAHD. However, as the 2004 minimum of 24.36mAHD already represents a decline of 0.02m, levels can only fall a further 0.98m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2014.

   - Vertebrates.

The area supports significant mammal and reptile species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JM45

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Melaleuca/Banksia* woodlands of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) Superceded EWRs (mAHD).

Summer preferred minimum – 24.02
Summer absolute minimum – 23.52

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that mixed *Banksia/ E. rudis / M. preissiana* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 23.711mAHD results in an EWR of 22.711mAHD. However, as the 2004 minimum of 23.431mAHD already represents a decline of 0.28m, levels can only fall a further 0.72m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

8284

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described *Melaleuca/Banksia* woodlands of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum – 24.82
Summer absolute minimum – 23.32

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 25.345mAHD results in an EWR of 24.345mAHD. However, as the 2004 minimum of 25.125mAHD already represents a decline of 0.22m, levels can only fall a further 0.78m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

JM49

1. Revised ecological management objectives.

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;

- *Melaleuca/Banksia* woodland occurring in area 3-6m to groundwater.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described sumplands of the Swan Coastal Plain as highly groundwater dependent. Groundwater and rainfall are required for consumptive use and biophysical processes.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum – 22.34
Summer absolute minimum – 21.84

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 23.091mAHD results in an EWR of 22.091mAHD. However, as the 2004 minimum of 23.251mAHD already represents a decline of 0.16m, levels can only fall a further 0.84m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

JM39

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum – 21.2
Summer absolute minimum – 20.7

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 21.597mAHD results in an EWR of 20.597mAHD. However, as the 2004 minimum of 21.827mAHD represents an increase of 0.23m, levels can only fall a further 1.23m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2017.

JM16

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum – 23.9
Summer absolute minimum – 23.4

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 24.59mAHD results in an EWR of 23.59mAHD. However, as the 2004 minimum of 24.3mAHD already represents a decline of 0.29m, levels can only fall a further 0.71m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2012.

- Vertebrates.

The area supports significant mammal species. Meeting the water requirements of *Banksia* woodland, should maintain these species.

JM14

1. Revised ecological management objectives.

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.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 3-6m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

a) Superceded EWRs (mAHD).

Summer preferred minimum – 23.39
Summer absolute minimum – 23.89

b) Water requirements for ecological components of GDE.

- Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year. A decrease of 1m from the autumn 2001 minimum of 24.71mAHD results in an EWR of 23.71mAHD. However, as the 2004 minimum of 24.59mAHD already represents a decline of 0.12m, levels can only fall a further 0.88m before a breach occurs. As the rate of decline required to maintain a low of risk of impact is 0.1m/year, it is further stipulated that the EWR cannot be breached prior to 2013.

- Vertebrates.

The area supports fauna. Meeting the water requirements of *Banksia* woodland, should maintain these species.

Anstey/Keane Bushland*

1. Revised ecological management objectives.

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;

- Bush Forever Site 342.
- *Melaleuca/Banksia* woodland 3-6m to groundwater.

2. Groundwater dependency analysis.

Although Clifton and Evans (2001) described *Banksia* woodlands of south-western WA as opportunistically dependent on groundwater, further research by Zencich (2003) determined *Banksia* woodland at 0-3m depth to groundwater was proportionally dependent. This ecosystem would also rely on rainfall and soil water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater bore would be most representative of groundwater levels in the area.

   b) Water requirements for ecological components of GDE.

      - Vegetation.

It is currently thought that *Banksia* woodland in the 3-6m depth to groundwater category is at low risk of impact from a total drawdown of 1.0m at a rate of 0.1m/year.

BASE-FLOW SYSTEMS

There are neither staff gauges nor groundwater monitoring bores in the vicinity of the base-flow systems discussed in this study. There is also insufficient knowledge of vegetation and faunal community structure and their water requirements to allow comment on possible flow requirements of these ecosystems. However, comments can be made on general requirements of vegetation, vertebrates, macroinvertebrates and sediments following the same principles applied to wetlands.

Bennett Brook*

1. Revised ecological management objectives.

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 inverebrates.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described base-flow dependent ecosystems of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and surface water for biophysical processes and habitat.

3. Revised EWRs.
   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.
   b) Water requirements for ecological components of GDE.
      - Vegetation.

As there is not a vegetation monitoring transect at Bennett Brook, a minimum groundwater level cannot be determined following the methodology outlined above. Although wetland and vegetation condition had not been assessed at the time of writing, *M. rhaphiophylla* and *E. rudis* occur at Mussel Pool. Comment can therefore be made on the water depth ranges and period of inundation experienced by these wetland species.

Loomes (Loomes, 2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla*; mean 0.006 to -2.14m, absolute 1.03 to -4.49m; duration of inundation - mean 2.15, absolute 9.4(months/year).
- *E. rudis;* mean -0.7 to -3.26m, absolute 1.03 to -6.44m; duration of inundation - mean 1.55, absolute 12 (months/year).

- Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Bennet Brook.

- Vertebrates.

Bennett Brook supports a diverse assemblage of fish species. Fish require permanent inundation however, can survive in isolated permanent pools over summer. Frogs require 4 months of inundation to breed.

- Sediment processes.

To maintain sediment processes at Lake Forrestdale organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

Quin Brook*

1. Revised ecological management objectives.

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 dependent vertebrates.
- Near pristine vegetation provides fauna habitat.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described base-flow dependent ecosystems of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and surface water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.

   b) Water requirements for ecological components of GDE.

      - Vegetation.

As there is not a vegetation monitoring transect at Quin Brook, a minimum groundwater level cannot be determined following the methodology outlined above. However, comment can be made on the water depth ranges and period of inundation experienced by wetland species know to occur at the wetland.

Loomes (Loomes, 2000) described the 5 year mean and absolute water depth ranges (m) and duration of inundation (months/year) for the following species;

- *M. rhaphiophylla*; mean 0.006 to -2.14m, absolute 1.03 to -4.49m; duration of inundation - mean 2.15, absolute 9.4(months/year).
- *E. rudis;* mean -0.7 to -3.26m, absolute 1.03 to -6.44m; duration of inundation - mean 1.55, absolute 12 (months/year).
- *B. littoralis;* mean -0.39 to -1.92m, absolute 0.43 to -3.09m; duration of inundation - mean 0.3, absolute 2.8 (months/year).
- *M. preissiana*; mean -0.54 to -2.62m, absolute 1.03 to -5.04m; duration of inundation - mean 0.6, absolute 4.4 (months/year).

      - Macroinvertebrates.

Due to the importance of vegetation assemblages as habitat, vegetation EWRs can be considered a surrogate for macroinvertebrate EWRs. Emergent species and littoral vegetation are likely to be of greatest importance for habitat at Quin Brook.

      - Vertebrates.

Quin Brook may support fish species. Fish require permanent inundation however, can survive in isolated permanent pools over summer. It is likely that frogs also occur at Quin Brook. Frog species require 4 months of inundation to breed. The relationship between groundwater and upland vegetation may also be important for terrestrial fauna.

      - Sediment processes.

To maintain sediment processes at Lake Forrestdale organic sediments must remain saturated throughout the summer each year. The water table must therefore not drop below the stratigraphic level/layer capable of providing water to surface organics through capillary rise during summer (0.5 m below ground surface).

AQUIFER AND CAVE ECOSYSTEMS

The proximity of bores to each of the caves is not known and therefore the relationship between bore water levels and the elevation (mAHD) 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. The elevation (mAHD) of the caves vary from 11.316 (Boomerang Cave) to 6.186 (Water Cave). Bores YN3, YN4 and YN5 are in the vicinity and water levels in these bores vary from 12 to 8 mAHD. However, from plots of water levels in these bores it can be seen that groundwater levels in all bores are declining, and minimum summer levels would be below the floor 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 AHD 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. However, as the cave floor level (mAHD) has been measured at Water Cave, Carpark Cave, Boomerang Cave and Cabaret Cave, an interim EWR that allows each cave to be inundated to a minimum dept of 0.2 m can be described.

Crystal Cave (YN1)

1. Revised ecological management objectives.

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 streams and pools support unique aquatic fauna.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.
    a. No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.
    b. Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2 – 3 cms depth in streams on cave floor with deeper pools of up to 10 – 20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Water Cave (YN11)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.

   b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptable flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. A spring minimum water level of 6.386 mAHD (6.186 mAHD + 0.2 m) may be adequate to meet these requirements.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Carpark Cave (YN18)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.

   b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2-3 cms depth in streams on cave floor with deeper pools of up to 10-20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. A spring minimum water level of 7.86 mAHD (7.66 mAHD + 0.2 m) may be adequate to meet these requirements.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Gilgie Cave (YN27)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described base-flow dependent ecosystems of south-western WA as proportionally dependent on groundwater. This ecosystem would also rely on rainfall and surface water for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.

   b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2-3 cms depth in streams on cave floor with deeper pools of up to 10-20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Cabaret Cave (YN30)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

   a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area. May also require installation of a staff gauge.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2-3 cms depth in streams on cave floor with deeper pools of up to 10-20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. A spring minimum water level of 11.375 mAHD (11.175 mAHD + 0.2 m) may be adequate to meet these requirements.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Boomerang Cave (YN99)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2-3 cms depth in streams on cave floor with deeper pools of up to 10-20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. A spring minimum water level of 11.516 mAHD (11.316 mAHD + 0.2 m) may be adequate to meet these requirements.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Twilight Cave (YN194)

1. Revised ecological management objectives.

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 pool and streams support unique fauna (cave root mat TEC).

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Ancient cavernicoles most critical in terms thresholds – require perennial and stable flows to provide approx 2-3 cms depth in streams on cave floor with deeper pools of up to 10-20 cms. Therefore, maintain groundwater depth and hydrostatic head to maintain these flows. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

YN61*

1. Revised ecological management objectives.

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 pool and streams support unique fauna.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

YN555*

1. Revised ecological management objectives.

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 pool and streams support unique fauna.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Orpheus Cave (YN256)*

1. Revised ecological management objectives.

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 pool and streams support unique fauna.

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptible flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

Jackhammer Cave (YN438)*

1. Revised ecological management objectives.

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 pool and stream support unique fauna..

2. Groundwater dependency analysis.

Clifton and Evans (2001) described karstic ecosystems as entirely dependent on groundwater for biophysical processes and habitat.

3. Revised EWRs.

a) No current EWR. Not known which groundwater monitoring bore would be most representative of groundwater levels in the area.

b) Water requirements for ecological components of GDE.

- Macroinvertebrates

Water body is a standing pool of exposed water (presumably extends into floor of cave, with no perceptable flows). Excessive declines in levels are known to expose suspended root mats which then die-off and fauna are lost. Therefore, requires stable water levels. Do not know AHD of bores/levels to achieve this.

- Water quality

Stable water quality in terms of pH, DO and temperature, with minimal diel, seasonal or annual variation, showing buffering influence of groundwater. Will be achieved if above EWR for macroinvertebrates is achieved.

ESTUARINE AND NEAR-SHORE MARINE ECOSYSTEMS

Despite increasing interest in the importance of groundwater discharge to near-shore marine and estuarine ecosystems a great number of questions regarding the nature and degree of dependence remain unanswered. It is therefore not possible to describe EWRs for these ecosystems.

SECTION 3 – SUSCEPTIBILTY, RISK OF IMPACT AND POSSIBLE RESPONSE OF GDES TO DRAWDOWN

In this section comment is made on the likely response to water level changes predicted over 2, 5 and 10 year intervals (2003-05, 2003-08 and 2003-13) modelled under PRAMS 3.0. To achieve this, a GDE's susceptibility to groundwater decline is determined using a matrix of conservation values, current ecological condition, historic water level decline and current depth to groundwater.

SUSCEPTIBILITY

As part of the EWR process there is a need to identify areas of highest susceptibility to impact from water level change, to determine those GDEs that should be afforded the highest level of protection. This can be achieved through consideration of conservation value, current water levels and historic groundwater level change.

The susceptibility of a GDE to future water regime changes is directly influenced by historic water level changes and current depth to groundwater. These factors are considered important as it is unlikely for any ecosystem to evolve in the presence of groundwater without having some reliance on it. It is further suggested that if the availability of groundwater is reduced or its quality altered, these ecosystems would respond in some way regardless of their degree of dependence. If a GDE has experienced historic declines in groundwater levels it may be more susceptible to further declines than other systems. Conversely, historic groundwater rises may buffer future declines.

Conservation values require special consideration when determining the level of protection afforded to GDEs. It is difficult to apply a standard approach to the rating of conservation values for GDEs, especially when trying to differentiate between the importance of international, national and regional conservation classifications. For example, a highly modified wetland may be recognised as an internationally important water-bird habitat under the Ramsar Convention but little regional significance due to its altered nature, whereas a wetlands supporting a vegetation community that is unusual within a specific region, may have regional conservation values, but be of little international importance. Existing impacts may include clearing for urban or agricultural uses, fire, invasion by exotics (flora and/or fauna), dieback, water pollution, climatic changes and vehicular or human traffic.

Rating of susceptibility for use in the matrix should be based on the premise that the most vulnerable GDEs are those in areas of shallow groundwater that are already under pressure (stress, impact etc) from historic drawdown. Current depth to groundwater for wetlands (including base-flow systems) and terrestrial vegetation can be rated based on phreatophytic vegetation categories (0-3m, 3-6m, 6-10m and >10m) (Froend & Zencich, 2001), with the shallowest depths the most susceptible. Depths can be based on modelling or actual water depths from monitoring bores and/or surface water levels.

Long-term hydrological data from groundwater monitoring bores allows assessment of past water regimes. These data can provide comprehensive information on mean groundwater depths, seasonal and long-term changes in groundwater levels (magnitude), duration and rate of water level rise and/or decline and the seasonality of peak and low levels. Of most significance to ecosystem integrity are the mean annual depth to groundwater and magnitude, rate and duration of decline (or rise).

Rapid rates of declines over a short period will generally have had a more noticeable impact than low-rate, longer-term declines (>20 years), as ecosystem components cannot adapt to changes or migrate to more suitable habitats quickly enough. For example, phreatophytic *Banksias* have the capacity to grow new roots and to respond to drawdown by 'following' the water table down. However, this would likely be effective only where water tables changes are gradual (Zencich & Froend, 2001) and of a low magnitude.

In the current project susceptibility was determined for individual wetlands (including base-flow systems), areas of terrestrial vegetation at criteria bore sites, cave systems and a group of associated wetlands (Yeal Swamp) using conservation values, current depths to groundwater (autumn minimum 2003) and the historic water level changes (1992-2003, 1995-2003 or 1997-2003).

Wetlands

The first stage in determining level of susceptibility was to give all wetlands a conservation value. Conservation value is scored between 1-4 (highest value to lowest value), based on categories as described below (Table 5) (Froend & Loomes, 2004).

Table 5: Conservation value scores of wetlands.

Conservation value category	Score
Ecosystem with international, national or regional conservation values (legislated) that has little evidence of alteration from surrounding land-use practices.	1
Ecosystem with international, national or regional conservation values (legislated) that has evidence of low to moderate impacts from surrounding land-use practices.	2
Ecosystem that has not been assessed for conservation values or is poorly understood, and that has evidence of low to moderate impacts from surrounding land-use.	3
Ecosystem with no recognised conservation values that has been moderately to severely degraded by surrounding land-use patterns	4

The second stage in determining level of susceptibility was to consider the current (autumn minimum 2003) depth to groundwater, using hydrodata from the Water and Rivers Commission (Water and Rivers Commission (WIN), 2003). The scores for current depth to groundwater are those outlined by Froend, Loomes & Zencich (2002). Wetlands in areas of >10m to groundwater scored 4, those at 6-10m scored 3, 3-6m scored 2 and 0-3m scored 1 (Table 6).

Table 6: Wetland and terrestrial vegetation depth to groundwater scores.

Depth to groundwater (2003) category	Score
>10m	4
6-10m	3
3-6m	2
0-3m	1

The third stage was to determine the historic groundwater level change from WRC hydrodata (Water and Rivers Commission (WIN), 2003) using the scoring system outlined by Welker Environmental Consultancy (2002). Changes in water levels (surface and/or groundwater) score from 1-5 (high, moderate, low & no change or increase) depending on depth to groundwater category and the degree of water level change (Table 7). Wetlands at <10m depth to groundwater scored a 5. The periods examined for historic groundwater change were 1992-2003 for Jandakot Mound wetlands, 1995-2003 for Gnangara Mound wetlands and 1997-2003 for East Gnangara Mound wetlands. The categories used in Table 7 were based on autumn minimum levels from the earliest year during the period (ie. 1992, 1995 or 1997) (most wetlands did not change category during the period).

Table 7: Historic groundwater level change of wetlands.

Wetland Category	No change or increase (4)	Low (3)	Moderate (2)	High (1)
0-3m	-	<0.25m	0.25 to 0.5m	>0.5m
3-6m	-	<0.75m	0.75-1m	>1m
6-10m	-	<1.25m	1.25-1.5	>1.5m
>10m (5)	-	-	-	-

The final stage was to determine the susceptibility score. This was achieved by adding the scores for conservation value, current depth to groundwater and historic groundwater level change together with lower numbers representing the highest susceptibility.

For example at Loch McNess the conservation value was 1 (high) and the current depth to groundwater was 0-3m, scoring 1. The historic groundwater level change score of 3 (low) was derived by using the 1995 wetland category of 0-3m and the groundwater change between 1995 and 2003 of 0.1m which is less than 0.25m therefore leading to a score of 3. These scores added result in a susceptibility score of 5.

Terrestrial Ecosystems

As with individual wetlands the first stage in determining level of susceptibility was to give all terrestrial vegetation a conservation value. Conservation value is scored between 1-4 (highest value to lowest value) and is based on categories as described below (Table 8) (Froend & Loomes, 2004).

Table 8: Conservation value scores of terrestrial vegetation.

Conservation value category	Score
Ecosystem with international, national or regional conservational values (legislated) that has little evidence of alteration from surrounding land-use practices eg. Bush Forever sites, sites with Threatened Ecological Communities, JAMBA or CAMBA, in good condition.	1
Ecosystem with international, national or regional conservational values (legislated) that has evidence of low to moderate impacts from surrounding land-use practices eg. Bush Forever sites, sites with Threatened Ecological Communities, JAMBA or CAMBA, with low to moderate impacts.	2
Ecosystem that has not been assessed for conservation values or is poorly understood, and that has evidence of low to moderate impacts from surrounding land-use eg. sites that have low to moderate impacts but are not Bush Forever.	3
Ecosystem with no recognised conservation values that has been moderately to severely degraded by surrounding land-use patterns.	4

The second stage was to determine the current depth to groundwater (autumn minimum 2003) using hydrographs from the WRC. The scores for current depth to groundwater are those outlined by Froend *et al.* (2002). Terrestrial vegetation in areas of >10m to groundwater scored 4, those at 6-10m scored 3, 3-6m scored 2 and 0-3m scored 1 (Table 6).

The third stage was to determine the historic groundwater level change from WRC hydrodata using the scoring system outlined by Froend & Zencich (2001). The change in groundwater scored 1-5 (high to low) depending on the depth to groundwater category and the level of change in groundwater (Figure 1). The periods examined for historic groundwater level change were 1992-2003 for Jandakot Mound terrestrial criteria sites, 1995-2003 for Gnangara Mound criteria sites and 1997-2003 for East Gnangara Mound criteria sites. The categories used in Figure 1 were based on autumn minimum levels from the earliest year during the period (ie. 1992, 1995 or 1997).

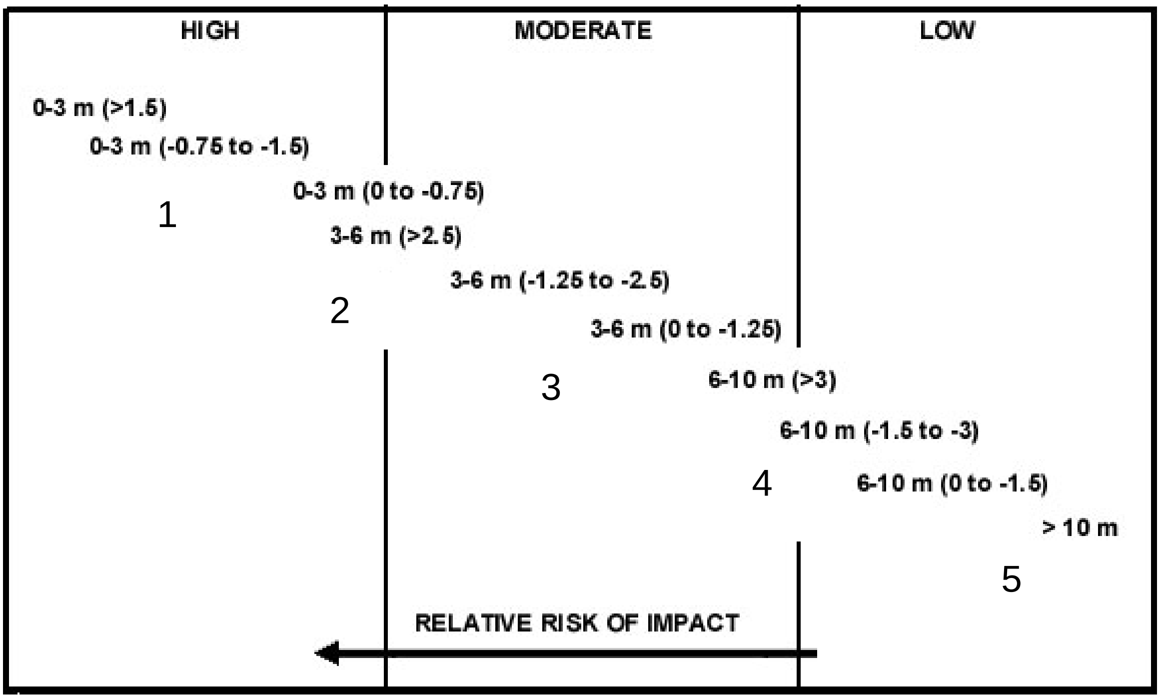

Figure 1: Historic Groundwater Level Change for Terrestrial Vegetation.

The final stage was to determine the susceptibility score. This was achieved by adding the scores for conservation value, current depth to groundwater and historic groundwater level change.

Cave and Aquifer Ecosystems

As with wetlands and terrestrial vegetation the first stage in determining level of susceptibility was to give all cave systems a conservation value. Due to the relictual nature of these ecosystems they were all afforded the highest conservation value of 1. As most caves either currently contain surface water or have only dried in the recent past, all were regarded as falling in the 0-3 m depth to groundwater category. These ecosystems are recognized as totally dependent on groundwater and therefore any drawdown will, at best result in reductions in key elements of ecosystem integrity, at worst, in complete collapse of the entire ecosystem. Therefore any historic groundwater decline (recorded at the nearest monitoring bore) scored a 1. Finally, a susceptibility score was determined by adding the scores for conservation value, current depth to groundwater and historic groundwater level change.

RISK OF IMPACT

In the next step GDE susceptibility was related to proposed (modelled) changes in groundwater levels to describe the risk of impact to GDEs. Risk of impact is expressed as low (4), moderate (3), high (2) or severe (1).

Predicted water regime changes are most often the product of groundwater modelling. This ideally quantifies the spatial and temporal distribution of water level changes across a study area. This project used predicted changes at 2, 5 and 10 year intervals (2003-2005, 2003-2008 and 2003-2013) based on PRAMS 3.0. The scenario used the following components to generate results for April/May minimums (R. Vogwill, DoE, pers. comm., March 2004);

- Climate – rainfall at short-term average.
- Private Abstraction – at 100% of allocation.
- Public Abstraction – Water Corporation pumping at 135GL/yr.
- Landuse – areas from the Future Perth Plan designated for urbanisation, urbanised in 15 years.
- Pines – thinned as per LVL.

The current calibration of PRAMS is such that there are areas of 'intractable error' that are associated with (R. Vogwill, DoE, pers. comm., March 2004);

- Areas in which that the current conceptual model of the Superficial Aquifer is inadequate, often corresponding with areas of heterogeneity and the presence of impeding layers.
- Areas in which there is a large degree of uncertainty in the allocation database regarding either location or quantity of abstraction.

Unfortunately many of these areas are also those with the highest impacts, large amounts of wetlands and distinct ecological values.

Susceptibility value and predicted rates and magnitude values were combined to categorise the risk of impact (ROI). As each GDE type can exhibit a different level of groundwater dependency, different responses to the same changes in water regime may arise.

Wetlands

Future water level changes were determined using predicted modelling scenarios (PRAMS 3.0). These were presented as a series of three maps (2003-2005, 2003-2008 and 2003-2013) depicting predicted changes in groundwater levels (Department of Environment, 2003, 2004). The predicted changes scored 1-5 (severe to no change and/or increase) depending on the rate (m/yr) and magnitude of drawdown (m) (Figure 2). To achieve the final scores for risk of impact the scores for susceptibility and predicted change in groundwater levels were added for each prediction period.

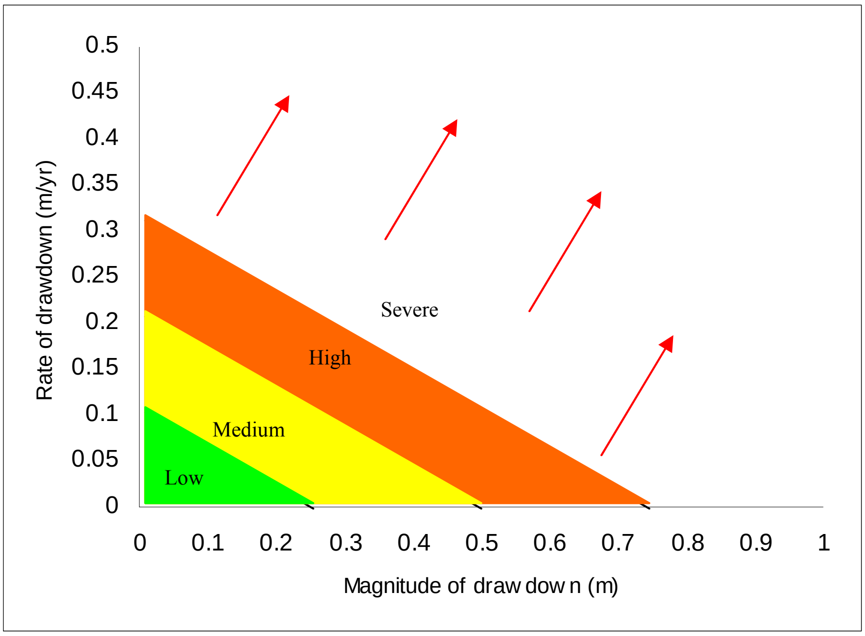

Figure 2: Risk of impact categories for wetland ecosystems based on rate and magnitude of groundwater drawdown.

Continuing with the example for Loch McNess the predicted change in groundwater levels for 2003-2005 was derived by using the predicted change in groundwater between 0.75-1.0m on the west side of the lake and the rate of drawdown (magnitude/year = 0.75/2=0.375), therefore giving Loch McNess a score of 1 (severe). This step was repeated for all prediction periods. To achieve the final scores for risk of impact the scores for susceptibility (5) and predicted change in groundwater levels (2003-2005 = 1) were added for each prediction period. Therefore the final impact score for Loch McNess for the period 2003-2005 was 6.

Terrestrial Vegetation

Future groundwater level changes were determined using predicted modelling scenarios (PRAMS 3.0). Theses were presented as three maps (2003-2005, 2003-2008 and 2003-2013) depicting predicted changes in groundwater levels (Department of Environment, 2003, 2004). The predicted changes scored 1-5 (severe to no change and/or increase) depending on magnitude and rate of drawdown using the appropriate depth to groundwater category (Table 5) according to Figures 3, 4 & 5. To achieve the final scores for risk of impact the scores for susceptibility and predicted change in groundwater levels were added for each prediction period.

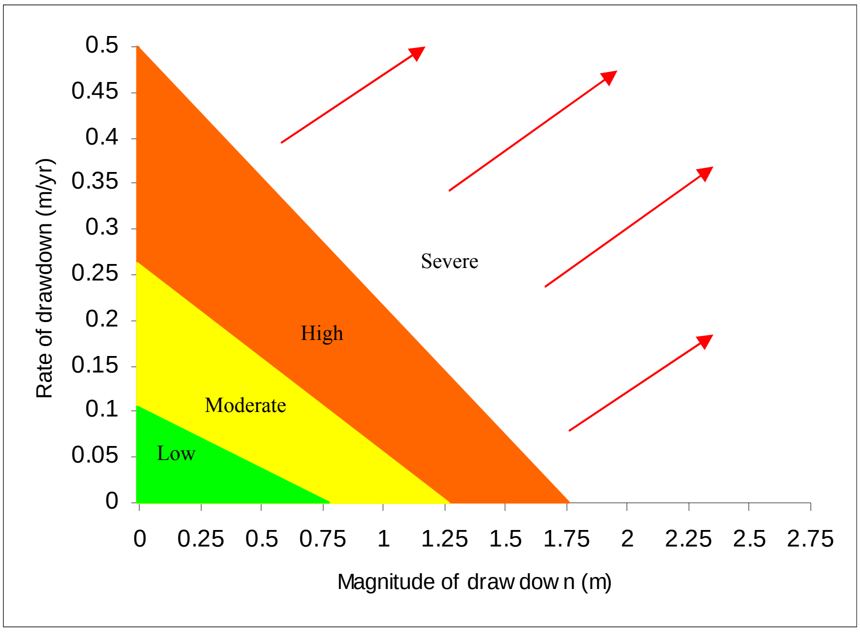

Figure 3: Risk of impact categories for phreatophytic vegetation in the 0-3m depth to groundwater grouping based on rate and magnitude of groundwater drawdown.

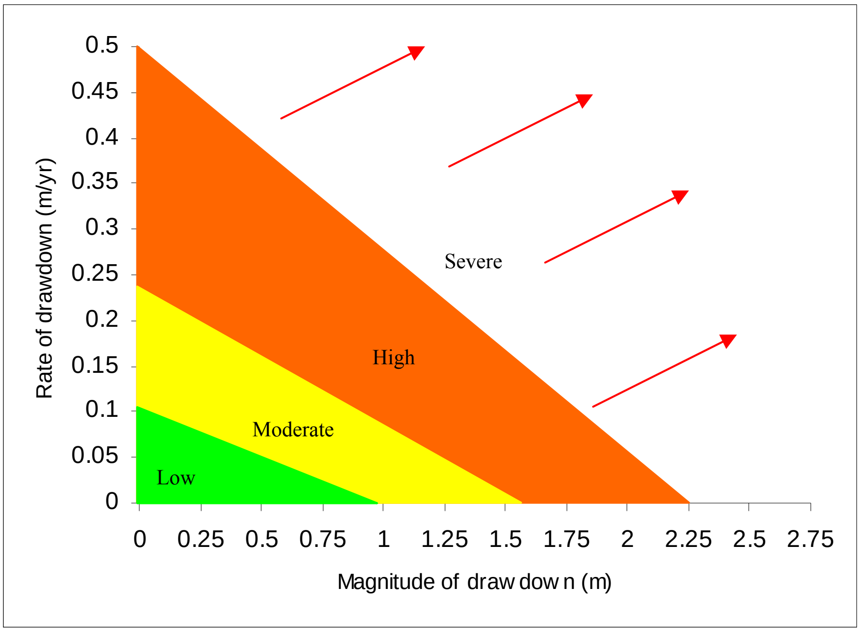

Figure 4: Risk of impact categories for phreatophytic vegetation in the 3-6m depth to groundwater grouping based on rate and magnitude of groundwater drawdown.

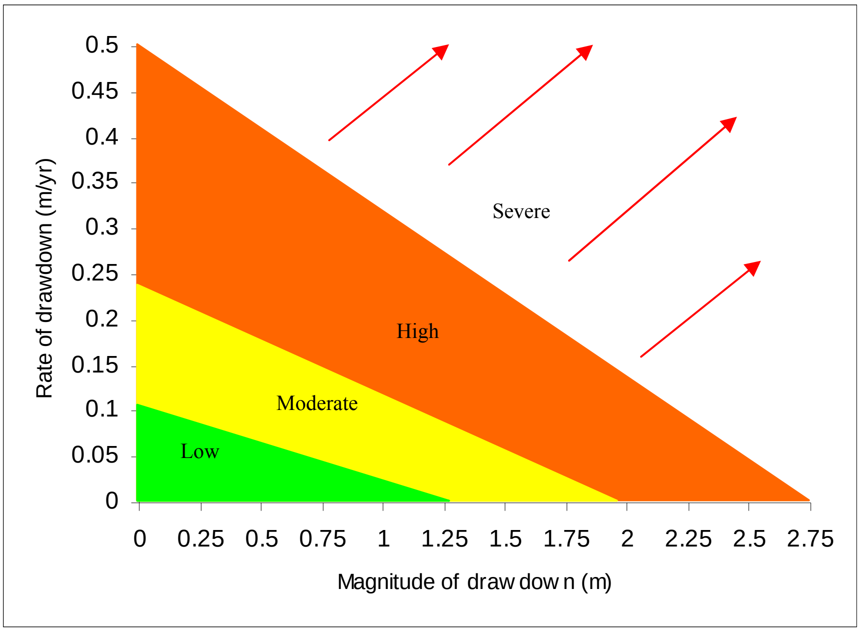

Figure 5: Risk of impact categories for phreatophytic vegetation in the 6-10m depth to groundwater grouping based on rate and magnitude of groundwater drawdown.

Cave and Aquifer Ecosystems

Future groundwater level changes were determined using predicted modelling scenarios (PRAMS 3.0). Theses were presented as three maps (2003-2005, 2003-2008 and 2003-2013) depicting predicted changes in groundwater levels (Department of Environment, 2003, 2004). These ecosystems are recognized as totally dependent on groundwater and therefore any drawdown will, at best result in reductions in key elements of ecosystem integrity, at worst, in complete collapse of the entire ecosystem. Therefore any predicted groundwater decline (recorded at the nearest monitoring bore) scored a 1. To achieve the final scores for risk of impact the scores for susceptibility and predicted change in groundwater levels were added for each prediction period.

LEVEL OF POSSIBLE RESPONSE TO DRAWDOWN

In this step the level of possible response of GDEs to predicted drawdown are rated based on the risk of impact score (Table 9). Scores from 4-6 are rated as a severe response, 7-9 as significant, 10-12 as moderate and 13-15 as not significant.

Tables 10-15 were adapted from Perth's Coastal Waters - Environmental Values and Objectives (Environmental Protection Authority, 2000) and describe the type of response that may occur in key elements of ecosystem integrity for each type of GDE at each level of response. Ecosystem integrity is defined as "… *the ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of natural habitat of the region*" (Karr, 1991).

Table 9: Matrix of conservation values, current depth to groundwater, historic groundwater level change and predicted groundwater level change to determine susceptibility, risk of impact and possible level of response of GDEs to drawdown.

Sub-group / GDE	**Conservation value**	**Current (min 2003) depth to groundwater score**	**Historic water level change score**	**Susceptibility (conservation + current depth + historic)**	**Predicted groundwater level change score**			**Risk of impact**			**Level of possible impact**		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
WETLANDS													
Gnangara													
Herdsman Complex													
Loch McNess	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
Lake Yonderup	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
Lake Wilgarup	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Pipidinny Swamp	1	1	4	6	1	1	1	7	7	7	Significant	Significant	Significant
Coogee Springs	4	1	1	6	1	1	1	7	7	7	Significant	Significant	Significant
Lake Nowergup	1	1	2	4	1	1	1	5	5	5	Severe	Severe	Severe
Lake Joondalup	1	1	2	4	1	1	1	5	5	5	Severe	Severe	Severe
Lake Goollelal	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
Carrabooda Lake * (37849650146)	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Lake Neerabup* (38205649442)	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Lake Gwelup* (38561647226)	2	1	2	5	1	1	1	6	6	6	Severe	Severe	Severe
Beenyup Swamp* (38625648247)	1	1	3	5	1	1	1	6	6	6	Significant	Significant	Significant
Big Carine Swamp* (38506647515)	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Careniup Swamp* (38595647369)	4	1	1	6	1	1	1	7	7	7	Significant	Significant	Significant
Wallubuenup Swamp* (38696648190)	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
Badgerup Lake* (39028648351)	2	3	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Little Badgerup Lake* (39037648274)	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	2003-08	2003-13	2003-05	2003-08	2003-2013	2003-05	2005-08	2005-13
Sumpland (38348649057)*	2	1	3	6	1	1	1	7	7	7	Severe	Severe	Severe
Lake Karrinyup* (38517647354)	3	1	1	5	1	1	1	6	6	6	Severe	Severe	Severe
Pinjar Complex													
Lake Mariginiup	2	2	2	6	1	1	1	7	7	7	Significant	Significant	Significant
Lake Jandabup	1	1	4	6	1	1	1	7	7	7	Significant	Significant	Significant
Lake Pinjar*	2	2	2	6	1	1	1	7	7	7	Significant	Significant	Significant
Little Mariginiup* (38830649035)	4	2	1	7	1	1	1	8	8	8	Significant	Significant	Significant
Hawkins Rd Swamp* (39120648926)	2	3	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Lake Adams* (38844649190)	3	2	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Little Adams Swamp* (38955649226)	3	4	5	12	1	1	1	13	13	13	Not sig.	Not sig.	Not sig.
Dampland (39012649008)*	3	4	5	12	1	1	1	13	13	13	Not sig.	Not sig.	Not sig.
Karrakatta Central & South Complex													
Little Emu Swamp* (39360647560)	2	3	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Bassendean Central & South Complex													
Lake Gnangara	4	1	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Ridges* (sumpland)	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Bassendean North Transition Complex - North													
11 Damplands*													
38613651757	1	4	5	10	2	1	1	12	11	11	Moderate	Moderate	Moderate
38368651780	1	4	5	10	2	1	1	12	11	11	Moderate	Moderate	Moderate
38636651749	1	4	5	10	2	1	1	12	11	11	Moderate	Moderate	Moderate
38669651758	2	4	5	11	2	1	1	13	12	12	Not sig.	Moderate	Moderate
38731651919	2	4	5	11	2	1	1	13	12	12	Not sig.	Moderate	Moderate
38798652311	1	4	5	10	2	1	1	12	11	11	Moderate	Moderate	Moderate
38825652147	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38875652172	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38861652407	1	4	5	10	2	1	1	12	11	11	Moderate	Moderate	Moderate
	2	2	2	6	1	1	1	7	7	7	Significant	Significant	Significant

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
38919652275 38933652030	2	4	5	11	2	1	1	13	12	12	Not sig.	Moderate	Moderate
Bassendean North Complex – Yeal Swamp													
Yeal Swamp* (38267651751)	1	4	1	6	1	1	1	7	7	7	Significant	Significant	Significant
Bindiar Lake* (38181651941)	2	4	1	7	1	1	1	8	8	8	Significant	Significant	Significant
Dampland (38488651846)*	1	4	1	6	1	1	1	7	7	7	Significant	Significant	Significant
2 Damplands* 38340651762 38337651800	1 1	4 4	1 1	6 6	1 1	1 1	1 1	7 7	7 7	7 7	Significant Significant	Significant Significant	Significant Significant
Bassendean North Complex – Yeal West													
Dampland (38821652464)*	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
2 Damplands* 38144652776 38174652305	1 2	3 1	3 1	7 4	1 1	1 1	1 1	8 5	8 5	8 5	Significant Severe	Significant Severe	Significant Severe
Sumpland (38551652525)*	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Tangletoe Swamp* (37607652972)	1	4	5	10	1	1	1	11	11	11	Moderate	Moderate	Moderate
62 damplands* 37917652461 37948652434 37987652796 37981652582 37987652446 38030652677 38009652550 38024652295 38026652641 38039652524 38033652611 38036652738 38046652635	2 2 1 1 2 2 1 2 1 1 2 1 1 1	3 3 4 2 2 2 1 2 2 1 1 4 2 1	3 3 2 5 2 3 1 1 3 2 3 5 3 2	8 8 7 8 6 7 3 5 6 4 6 10 6 5	1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1	9 9 8 9 7 8 4 6 7 5 7 11 7 6	9 9 8 9 7 8 4 6 7 5 7 11 7 6	9 9 8 9 7 8 4 6 7 5 7 11 7 6	Significant Significant Significant Significant Significant Significant Severe Severe Significant Severe Significant Moderate Significant Severe	Significant Significant Significant Significant Significant Significant Severe Severe Significant Severe Significant Moderate Significant Severe	Significant Significant Significant Significant Significant Significant Severe Severe Significant Severe Significant Moderate Significant Severe

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	2003-08	2003-13	2003-05	2003-08	2003-2013	2003-05	2005-08	2005-13
38058652554	2	3	3	8	1	1	1	9	9	9	Significant	Significant	Significant
38083652724	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38078652433	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38090652633	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38082652192	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38088652250	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38097652471	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38139652681	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38122652574	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38147652733	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38151652708	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38168652666	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38162652573	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38167652757	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
38182652512	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38225652757	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38220652466	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38230652721	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38231652411	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38245652664	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38252652683	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38266652435	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38280652700	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38285652373	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38289652487	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38287652725	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38310652767	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38309652440	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38317652442	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38336652318	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38342652392	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
38394652578	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
38386652685	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38361652523	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
38381652418	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38416652349	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
38455652718	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
	2	1	1	4	1	1	1	5	5	5	Severe	Severe	Severe
	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	2003-08	2003-13	2003-05	2003-08	2003-2013	2003-05	2005-08	2005-13
38415652188	2	2	1	5	1	1	1	6	6	6	Severe	Severe	Severe
38456652444	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38480652351	2	3	3	8	1	1	1	9	9	9	Significant	Significant	Significant
38532652185	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38533652305	1	3	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38560652228	1	4	5	10	1	1	1	11	11	11	Moderate	Moderate	Moderate
38580652413	1	4	5	10	1	1	1	11	11	11	Moderate	Moderate	Moderate
38587652096	2	2	1	5	1	1	1	6	6	6	Severe	Severe	Severe
38585652194	2	1	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38589652128	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
38642652041	1	2	3	5	1	1	1	6	6	6	Severe	Severe	Severe
38651652093	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
38732652377	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
38420652687													
38389652800													
38764652463													
38997652088													
38334652752													
Deepwater Lagoon* (38881652828)	3	1	2	6	1	1	1	7	7	7	Significant	Significant	Significant
Dampland (37797652988)*	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
2 sumplands*													
37852653007	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
37879652973	1	4	5	10	1	1	1	11	11	11	Moderate	Moderate	Moderate
Bassendean North Complex – Tick Flat													
Tick Flat* (37632652620)	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
4 Damplands*													
37668652593	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
37577652591	1	4	5	10	1	1	1	11	11	11	Moderate	Moderate	Moderate
37588652556	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
37593652546	2	4	5	11	1	1	1	12	12	12	Moderate	Moderate	Moderate
Bassendean North Complex – Yeal East													
Lake Mukenburra* (38405653196)	1	1	3	5	1	2	1	6	7	6	Severe	Significant	Severe

Sub-group / GDE	**Conservation value**	**Current (min 2003) depth to groundwater score**	**Historic water level change score**	**Susceptibility (conservation + current depth + historic)**	**Predicted groundwater level change score**			**Risk of impact**			**Level of possible impact**		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
17 Damplands*													
38821652464	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38829652308	2	2	2	6	1	1	1	7	7	7	Significant	Significant	Significant
38831651988	1	4	5	10	1	2	1	11	12	11	Moderate	Moderate	Moderate
38898652368	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38861652005	1	4	5	10	1	2	1	11	12	11	Moderate	Moderate	Moderate
38913652246	2	2	2	6	1	1	1	7	7	7	Significant	Significant	Significant
38913652012	1	4	5	10	1	2	1	11	11	11	Moderate	Moderate	Moderate
38919652275	3	2	2	7	1	1	1	8	8	8	Significant	Significant	Significant
38933652030	3	2	2	7	1	1	1	8	8	8	Significant	Significant	Significant
38951652330	1	2	2	5	1	1	1	6	6	6	Severe	Severe	Severe
38973652008	2	4	5	11	1	2	1	12	13	12	Moderate	Not sig.	Moderate
39008652386	1	3	3	7	1	2	1	8	9	8	Significant	Significant	Significant
39008652298	1	3	3	7	1	2	1	8	9	8	Significant	Significant	Significant
39026652224	1	3	3	7	1	2	1	8	9	8	Significant	Significant	Significant
39045652254	1	3	3	7	1	2	1	8	9	8	Significant	Significant	Significant
39058652235	2	3	3	8	1	2	1	9	10	9	Significant	Moderate	Significant
38685652685	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
2 Sumplands*													
38570652790	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
38606652771	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
Sumpland (38773652686)*	3	2	2	8	1	1	1	9	9	9	Significant	Significant	Significant
Floodplain (39108652522)*	3	2	2	8	1	1	1	9	9	9	Significant	Significant	Significant
Sumpland (38828652623)*	3	2	2	7	1	1	1	8	8	8	Significant	Significant	Significant
Bassendean North Complex – Lexia													
Lexia 86	1	1	3	5	4	4	3	9	9	8	Significant	Significant	Significant
Lexia 186	1	1	2	4	4	4	3	8	8	7	Significant	Significant	Significant
Lexia 94	1	1	3	5	4	4	3	9	9	8	Significant	Significant	Significant
4 sumplands*													
40141648670	1	2	3	6	2	3	2	8	9	8	Significant	Significant	Significant
40132648626	1	2	3	6	2	3	2	8	9	8	Significant	Significant	Significant
40149648594	1	2	3	6	2	3	2	8	9	8	Significant	Significant	Significant
40163648635	1	2	3	6	2	3	2	8	9	8	Significant	Significant	Significant
Dampland (40135648601)*	1	3	3	7	3	5	5	10	12	12	Moderate	Moderate	Moderate

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	2003-08	2003-13	2003-05	2003-08	2003-2013	2003-05	2005-08	2005-13
2 Sumplands*													
40156648685	1	3	3	7	3	5	4	10	12	11	Moderate	Moderate	Moderate
40238648707	1	3	3	7	3	5	4	10	12	11	Moderate	Moderate	Moderate
Dampland (40203648567)*	1	3	3	7	3	5	4	10	12	11	Moderate	Moderate	Moderate
Sumpland (40256648635)*	1	4	5	10	5	5	5	15	15	15	Not sig.	Not sig.	Not sig.
2 Sumpland (40292643721,	1	4	5	10	3	5	5	13	15	15			
40148648729)*	2	3	3	8	3	5	4	11	13	12	Moderate	Not sig.	Moderate
2 Damplands*													
40297648639	1	4	5	10	5	5	5	15	15	15	Not sig.	Not sig.	Not sig.
40346648631	1	4	5	10	5	5	5	15	15	15	Not sig.	Not sig.	Not sig.
Sumpland (40140648683)*	1	2	3	6	2	5	3	8	11	9	Significant	Moderate	Significant
Dampland (40272648506)*	1	4	5	10	5	5	5	15	15	15	Not sig.	Not sig.	Not sig.
Kings Spring (The Maze)*	1	2	5	8	2	2	1	10	10	9	Significant	Significant	Significant
Bassendean North Complex – Melaleuca Park													
EPP Wetland 173	1	1	3	5	3	3	2	8	8	7	Significant	Significant	Significant
Dampland 78	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
Dampland (39496649584)*	1	2	3	6	2	2	1	8	8	7	Significant	Significant	Significant
25 damplands*													
39455649394	1	1	3	5	1	1	1	6	6	6	Severe	Severe	Severe
39464649585	2	2	3	7	5	5	1	12	12	8	Moderate	Moderate	Significant
39478649638	2	2	3	7	5	5	5	12	12	12	Moderate	Moderate	Moderate
39498649636	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
39507649695	1	3	3	7	2	3	1	9	10	8	Significant	Moderate	Significant
39513649527	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
39514649463	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
39527649600	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
39547649649	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
39541649417	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
39565649347	2	1	3	6	1	1	1	7	7	7	Significant	Significant	Significant
39550649619	2	2	3	7	1	1	1	8	8	8	Significant	Significant	Significant
	3	1	3	7	1	1	1	8	8	8	Significant	Significant	Significant

Sub-group / GDE	**Conservation value**	**Current (min 2003) depth to groundwater score**	**Historic water level change score**	**Susceptibility (conservation + current depth + historic)**	**Predicted groundwater level change score**			**Risk of impact**			**Level of possible impact**		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
39559649393 39572649792 39616649454 39627649484 39647649353 39712649551 39876649518 39906649362 39592649232 39685649249 39660649160 39813649148 39881649161	2 2 1 2 2 2 2 2 2 2 2 1	3 1 1 1 1 2 1 1 1 1 1 1	3 3 3 3 3 3 3 3 3 3 3 3	8 6 5 6 6 7 6 6 6 6 6 5	1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1	9 7 6 7 7 8 7 7 7 7 7 6	9 7 6 7 7 8 7 7 7 7 7 6	9 7 6 7 7 8 7 7 7 7 7 6	Significant Significant Severe Significant Significant Significant Significant Significant Significant Significant Significant Severe	Significant Significant Severe Significant Significant Significant Significant Significant Significant Significant Significant Severe	Significant Significant Severe Significant Significant Significant Significant Significant Significant Significant Significant Severe
Dampland (39183649754)*	2	4	1	7	5	5	4	12	12	11	Moderate	Moderate	Moderate
6 damplands* 39421649304 39442649618 39443649445 39433649770 39510659739 39575649169	2 2 2 2 2 3	1 2 1 4 3 1	3 3 3 5 3 3	6 7 6 11 8 7	1 5 5 3 3 1	1 2 1 3 3 1	1 1 1 1 1 1	7 12 11 14 11 8	7 9 7 14 11 8	7 8 7 12 9 8	Significant Moderate Moderate Not sig. Moderate Significant	Significant Significant Significant Not sig. Moderate Significant	Significant Significant Significant Moderate Significant Significant
Sumpland (39969949158)*	1	4	3	8	1	1	1	9	9	9	Significant	Significant	Significant
6 sumplands* 39556649708 39554649527 39582649556 39576649679 39610649565 39653649561	1 2 2 2 1 2	3 1 1 2 1 1	3 3 2 3 3 3	7 6 5 7 5 7	2 2 2 1 1 1	1 2 2 1 1 1	1 1 1 1 1 1	9 8 7 8 6 8	8 8 7 8 6 8	8 8 6 8 6 8	Significant Significant Significant Significant Severe Significant	Significant Significant Significant Significant Severe Significant	Significant Severe Severe Significant Severe Significant
Sumpland (39920649456)*	1	4	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Bassendean North Complex – East Pinjar													
Edgecombe Seepage and Lake Yakine	1	1	2	4	5	5	5	9	9	9	Significant	Significant	Significant

Sub-group / GDE	**Conservation value**	**Current (min 2003) depth to groundwater score**	**Historic water level change score**	**Susceptibility (conservation + current depth + historic)**	**Predicted groundwater level change score**			**Risk of impact**			**Level of possible impact**		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Egerton Seepage	1	1	3	5	5	5	5	10	10	10	Moderate	Moderate	Moderate
Yanga Complex													
Bambun Lake* (39435652283)	1	3	2	6	2	4	3	8	10	9	Significant	Moderate	Significant
Lake Nambung* (39421652168)	2	1	3	6	1	3	1	7	9	7	Significant	Significant	Significant
Lake Mungala* (39482652119)	2	1	3	6	1	3	1	7	10	7	Significant	Moderate	Significant
Springs on Lot11 Archibald St., Muchea			3										
Spring sites 3s, 3b, 3r, 4 5ps, 5pd, 5d, 6 & 7.			3										
Jandakot													
Herdsman Complex													
Thomsons Lake	1	1	1	3	1/3	½	1	4/6	4/5	4	Severe	Severe	Severe
North Lake	1	1	1	3	1/3	½	1	4/6	4/5	4	Severe	Severe	Severe
Banganup Swamp	1	1	1	3	1	½	½	4	4/5	4/5	Severe	Severe	Severe
Bibra Lake	1	1	1	3	1	2/3	1	4	5/6	4	Severe	Severe	Severe
Yangebup Lake	2	1	1	4	1	¾	½	5	7/8	5/6	Severe	Significant	Severe
Kogolup Lake	2	1	1	4	1	2/3	½	5	6/7	5/6	Severe	Sig./severe	Severe
Little Rush Lake*													
Spectacles North* (39041643485)	1	1	1	3	2	1	2	5	4	5	Severe	Severe	Severe
East Swamp*													
Hope Rd Lake*													
Bassendean Central & South Complex													
Shirley Balla Swamp	1	1	1	3	3	1	1	6	4	4	Severe	Severe	Severe
Twin Bartram	2	1	4	7	3	2	2	10	9	9	Moderate	Significant	Significant
Beenyup Rd Swamp	2	1	1	4	3	1	1	7	5	5	Significant	Severe	Severe
Mather Reserve* (39361644253)	1	1	2	4	3	1	3	7	5	7	Significant	Severe	Significant
Copolup Lake*													
Branch St Swamp*													
Forest-Tapper Swamp*													

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	2003-08	2003-13	2003-05	2003-08	2003-2013	2003-05	2005-08	2005-13
Solomon Rd Swamp*													
Mandogalup (Wattelup) Lake*													
Karrakatta Central & South Complex													
Forrestdale Lake	1	1	2	4	1	3/5	5/2	5	7/9	9/6	Severe	Significant	Sig./severe
Southern River Complex													
Harrisdale Swamp* (39867644655)	1	1	2	4	3	3	3	7	7	7	Significant	Significant	Significant
Lake Balanup*													
TERRESTRIAL ECOSYSTEMS													
Gnangara													
Herdsman Complex													
PM24	1	1	2	4	3	3	3	7	7	7	Significant	Significant	Significant
Badgerup Lake & Adjacent Bushland, Wanneroo*													
Yellagonga Regional Park, Wanneroo / Woodvale*													
Pinjar Complex													
MT3S	1	3	5	9	2	1	1	11	10	10	Moderate	Moderate	Moderate
JB5	3	2	3	8	1	1	1	9	9	9	Significant	Significant	Significant
Numbat Road Bushland, Mariginiup*													
Little Coogee Flat, Pinjar													
Bassendean Central & South Complex													
MM18	1	2	3	6	5	5	5	11	11	11	Moderate	Moderate	Moderate
MM53	1	2	5	8	5	5	5	13	13	13	Not sig.	Not sig.	Not sig.
MM59B	1	2	3	6	3	4	4	9	10	10	Significant	Moderate	Moderate
MM55B	2	1	5	8	2	4	4	10	12	12	Moderate	Moderate	Moderate
MM49B	2	2	5	9	2	4	5	11	13	14	Moderate	Not sig.	Not sig.
MM16	1	2	5	8	1	1	1	9	9	9	Significant	Significant	Significant

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					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Gnangara Lake & adjacent Bushland, Gnangara*													
Bassendean North													
PM9	2	3	4	9	2	3	2	11	12	11	Moderate	Moderate	Moderate
WM1	1	2	3	6	5	5	4	11	11	10	Moderate	Moderate	Moderate
WM2	1	2	3	6	3	2	1	9	8	7	Significant	Significant	Significant
WM6	2	3	5	10	5	4	3	15	14	13	Not sig.	Not sig.	Not sig.
WM8	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
NR6C	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
NR11C	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant
L30	1	2	3	6	2	4	3	8	10	9	Significant	Moderate	Moderate
L110C	2	3	5	10	5	4	3	15	14	13	Not sig.	Not sig.	Not sig.
L220C	1	2	3	6	4	3	3	10	9	9	Moderate	Significant	Significant
MM12	1	2	3	6	2	2	3	8	8	9	Significant	Significant	Significant
State Forest 65 – Gnangara Plantation Bushland*													
Rosella Rd Bushland* 3-6m 6-10m	1 1	2 3	3 4	6 8	3 4	2 3	2 3	9 12	8 11	8 11	Significant Moderate	Significant Moderate	Significant Moderate
Della Road South Bushland, Bullsbrook*													
Wabling Management Priority Area*													
Yeal Nature Reserve*													
Tangletoe*													
Kirby Road Bushland, Bullsbrook*													
Muchea Air Weapons Range Bushland*	1	3	4	8	4	3	4	12	11	12	Moderate	Moderate	Moderate
Bassendean North Transition Complex													
Hawkins Road Bushland, Jandabup*													
Cottesloe Central & South Complex													

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					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Wilbinga-Caraban Bushland*													
Yanchep National Park *													
Cottesloe North / Cottesloe Central & South Complex													
Ridges & adjacent Bushland – Yanchep*	1	2	1	4	1	1	1	5	5	5	Severe	Severe	Severe
State Forest 65 – Pinjar Plantation South Bushland, Nowergup / Yanchep / Neerabup*													
Neerabup National Park, Lake Nowergup Nature Reserve *													
Garden Park Bushland, Wanneroo*													
High Road Bushland, Wanneroo*													
Errina Road Bushland*													
Lake Gwelup Reserve*													
Decourcey Way Bushland, Marangaroo*													
Landsdale Road Bushland, Landsdale*													
Koondoola Regional Bushland*													
Southern River Complex													
Cardinal Drive Bushland, Ellenbrook*													
Caversham Airbase Bushland, West Swan*													

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					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Yanga Complex													
Ellenbrook, Upper Swan*													
Bullsbrook Nature Reserve*													
Sawpit Road Bushland*													
Twin Swamps Nature Reserve*													
Ellenbrook Nature Reserve*													
Jandakot													
Herdsman Complex													
JE17C	1	1	5	7	2	4	4	9	11	11	Significant	Moderate	Moderate
Harry Waring Marsupial Reserve*													
Bassendean Central & South Complex													
JE10C	3	2	5	10	3	3	3	13	13	13	Not sig.	Not sig.	Not sig.
JM31	3	2	2	7	3	3	4	10	10	11	Moderate	Moderate	Moderate
JM19	2	3	1	6	4	4	4	10	10	10	Moderate	Moderate	Moderate
JM35	1	2	5	8	2	3	3	10	11	11	Moderate	Moderate	Moderate
JE4C	1	2	3	6	2	3	3	8	9	9	Significant	Significant	Significant
JM7	2	2	3	7	1	3	4	8	10	11	Significant	Moderate	Moderate
JM8	1	2	3	6	1	4	4	7	10	10	Significant	Moderate	Moderate
JM45	1	2	3	6	2	4	4	8	10	10	Significant	Moderate	Moderate
8284	3	2	1	6	2	4	4	8	10	10	Significant	Moderate	Moderate
JM49	3	2	3	8	1	2	3	9	10	11	Significant	Moderate	Moderate
JM39	3	2	3	8	1	3	3	9	11	11	Significant	Moderate	Moderate
North Lake, North Lake*													
Bibra Lake, Bibra Lake*													
South Lake*													
Mandogalup Road Bushland*													

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					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
The Spectacles*													
Sandy Lake*													
Sicklemore Road Bushland*													
Casuarina Prison Bushland*													
Wandi Nature Reserve*													
Banjup Bushland*													
Modong Nature Reserve*													
Cottesloe Central & South Complex													
JM16	1	2	2	5	4	5	5	9	10	10	Significant	Moderate	Moderate
JM14	1	2	3	6	2	4	4	8	10	10	Significant	Moderate	Moderate
Southern River Complex													
Piarra Nature Reserve*													
Anstey/Keane dampland & adjacent Bushland*	2	1	1	4	2	3	3	6	7	7	Severe	Significant	Significant
Balannup & adjacent Bushland*													
Karrakatta Central & South Complex													
Yangebup & Little Rush Lakes, Yangebup*													
Forrestdale Lake & adjacent Bushland*													
BASE-FLOW SYSTEM													
Ellen Brook creek system (on boundary of study area)	1												
Quin Brook Lake 181 (38749652539)*	1	2	3	6	1	1	1	7	7	7	Significant	Significant	Significant

Sub-group / GDE	**Conservation value**	**Current (min 2003) depth to groundwater score**	**Historic water level change score**	**Susceptibility (conservation + current depth + historic)**	**Predicted groundwater level change score**			**Risk of impact**			**Level of possible impact**		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Sumpland 61 (38385652763)* Floodplain 48 (38231652928)* Floodplain 88 (38454652772)*	1 1 1	1 2 1	2 2 3	4 5 5	1 1 1	1 1 1	1 1 1	5 6 6	5 6 6	5 6 6	Severe Severe Severe	Severe Severe Severe	Severe Severe Severe
Bennett Brook	1												
Lennards Brook (on boundary of study area)*	1												
CAVE AND AQUIFER ECOSYSTEMS													
Crystal Cave (YN1)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Water Cave (YN11)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Carpark Cave (YN18)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Gilgie Cave (YN27)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Cabaret Cave (YN30)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Boomerang Cave (YN99)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Twilight Cave (YN194)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Un-named cave (YN61)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Cave on Lot 51 (YN555)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Orpheus Cave (YN256) 1	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
Jackhammer Cave (YN438)	1	1	1	3	1	1	1	4	4	4	Severe	Severe	Severe
ESTUARINE AND NEAR-SHORE MARINE ECOSYSTEMS													
Marmion Marine Park													
Limestone reefs													
Seagrass Meadows													
Wrack (Detached Macrophytes)													
Un-vegetated Sand													

Sub-group / GDE	Conservation value	Current (min 2003) depth to groundwater score	Historic water level change score	Susceptibility (conservation + current depth + historic)	Predicted groundwater level change score			Risk of impact			Level of possible impact		
					2003-05	**2003-08**	**2003-13**	**2003-05**	**2003-08**	**2003-2013**	**2003-05**	**2005-08**	**2005-13**
Water Column													

Table 10: Possible response to drawdown in the key elements of wetland ecosystems for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p.20).

Wetlands	**Risk of impact and possible response to drawdown**			
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Primary production	Rates of primary production are maintained within the limits of natural variation.	Some evidence of reduction in rates of primary production in response to drying.	Measurable reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.
- Nutrient recycling	Rates of nutrient recycling are maintained within the limits of natural variation.	Some evidence of reduction in rates of nutrient recycling in response to drying.	Measurable reductions in rates of nutrient recycling in response to drying.	Severe reductions in rates of nutrient recycling in response to drying.
- Foodchains	No detectable change in foodchains.	Some evidence of disruption to foodchains.	Measurable disruptions to foodchains.	Severe disruptions to foodchains.
- Sediment stabilisation	No detectable change in sediment stabilisation.	No detectable change in sediment stabilisation.	Some evidence of sediment destabilisation.	Measurable destabilisation of wetland sediments.
- Pollutant filtration	No detectable change in rates of pollutant filtration	No detectable change in rates of pollutant filtration	Some evidence of change in rates of pollutant filtration.	Measurable reductions in rates of pollutant filtration.
Biodiversity (vegetation)				
- Species composition	No detectable change in species composition.	Some evidence of establishment of exotic species as result of disturbance and/or drying.	Measurable encroachment of xeric species into wetland.	Significant change in dominant populations with terrestrialisation through encroachment of xeric species.
- Species distribution	No detectable change in distribution of species.	Some evidence of changing distribution with disturbance and/or drying allowing establishment of exotic species.	Measurable contraction of wetland through changing demographics of more than one species, with encroachment of xeric species into the wetland.	Greater than 50% reduction in abundance of dominant species and /or significance change in dominant populations, with terrestrialisation through encroachment of xeric species.
- Species mortality	No detectable mortality.	Some mortality of individuals.	Greater than 15% reduction in abundance of dominant species.	Greater than 50% reduction in abundance of dominant species.
- Species richness	No detectable change in species richness.	Some evidence of decline in richness of wetland species.	Measurable decline in richness of wetland species and/or increase xeric species richness.	Significant change in richness of wetland species and replacement by xeric species.
- Community structure	No detectable change in community structure.	Some evidence of change in community structure.	Notable change in community structure.	Significant change in community structure.
Abundances and biomass of biota				
- Vegetation density, cover and frequency	No detectable change in density, cover and abundance.	Some evidence of reduced growth in overstorey and/or understorey species.	Measurable crown dieback in overstorey species and/or reduction in cover of understorey.	Substantial crown dieback in overstorey species and loss of density and cover in understorey.
- Vegetation height and diameter	No detectable change in vegetation height and diameter.	Some evidence of change in height due to loss of vigour and/or thinning of canopy.	Measurable reductions in height due to loss of canopy and/or reduced diameter of adult stems.	Significant reductions in height due to loss of canopy and reduced diameter of adult stems.
- Vertebrate abundance	No detectable change in vertebrate abundance.	Some evidence of reduced vertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
-Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Some evidence of reduced macroinvertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
Quality of water and sediment				
- Physical and biochemical properties of sediments and groundwater	Levels of contaminants & other measures of quality remain within limits of natural variation.	Small detectable changes beyond limits of natural variation but no resultant effect on biota.	Moderate changes beyond limits of natural variation but not to exceed specified criteria.	Substantial changes beyond limits of natural variation.

- Wetlands
    - Ecosystem processes

Wetland water levels fluctuate both seasonally and inter-annually in response to rainfall, with groundwater and wetland water levels generally higher in years of high rainfall and lower during poor rainfall years. Prolonged periods of drying induced or exacerbated by drawdown may reduce primary production and nutrient recycling as well as disrupting foodchains. In extreme cases of drying the loss of wetland vegetation may result in sediment destabilization and reduction of pollutant filtration.

- Biodiversity

Progressive drying results in alteration of vegetation habitat type that often leads to colonisation of more xerophytic species (more tolerant of drier conditions). The process of terrestrialisation is the gradual process of dryland plant species colonisation, encroachment and dominance of a site. This is usually a response to a gradual drying of a wetland to the point where water requirements of wetland species can no longer be met. The consequent death of mesophytic wetland species and decline of their populations is followed by gradual colonisation and replacement by xerophytic dryland species with lower water requirements. The process is not irreversible and is commonly interrupted by changes in rainfall patterns and hydrological support mechanisms.

The potential for colonisation by exotic plant species is increased if the impact of drawdown has resulted in canopy decline and suitable habitat for weeds becoming available. The potential for weed invasion depends on the proximity of propagule sources (e.g. from nearby agricultural land uses) and site conditions. Rapid and extensive weed growth has significant ramifications for native species recruitment success, preventing seedling establishment and increasing the risk of disturbance by fire. Invasive species (ruderals) may come to dominate wetland vegetation (e.g. *Typha*) in rare cases.

Reduced or lost structural diversity and populations of aquatic fauna may occur in response to reduced habitat. For example, reduced open water in permanent wetlands during later months of dry season will reduce available habitat for water birds. Lifecycles of invertebrates are often timed to enable completion while seasonal wetlands contain water. Groundwater decline may disrupt these cycles preventing reproduction and/or maturation of aquatic invertebrate species and their ultimate loss from the wetland.

- Abundances and biomass of biota

Alteration of vegetation habitat as a result of groundwater decline will also impact on the abundance of individual plant and fauna species. Vegetation abundance refers to quantity and is measured by number, size or extent. It includes density, cover and frequency as well as measures of size such as biomass, height or diameter. As described in relation to biodiversity, groundwater declines may lead to terrestrialisation of a wetland ecosystem. This will lead to reduction in abundances of wetland vegetation species and an increase in terrestrial species.

Abundances of vertebrate and invertebrate fauna reliant on wetlands and/or wetland vegetation for habitat, breeding grounds, feeding or as a direct source of water, will generally also be negatively impacted by declining water levels.

- Quality of water and sediment

Groundwater declines and the subsequent drying of wetlands will result in changes in physical and bio-chemical characteristics in wetland sediments and altered physicochemical properties of the water column. Eutrophication may occur due to changes in sediment absorption capacities, internal loading and nutrients derived from the death of aquatic organisms and terrestrial plants growing on the wetland bed (Sommer, 2001). Acidification may also occur in susceptible wetlands along with emissions of CO_2 and CH_4. Shrinking, cracking and compaction of drying sediments may lead to the formation of a hard, impenetrable crust beneath which anoxic condition will prevail (Sommer, 2001).

Table 11: Possible response to drawdown in the key elements of terrestrial ecosystems for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p. 20).

Terrestrial phreatophytic vegetation		**Risk of impact and possible response to drawdown**		
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Primary production	Rates of primary production are maintained within the limits of natural variation.	Some evidence of reduction in rates of primary production in response to drying.	Measurable reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.
- Nutrient recycling	Rates of nutrient recycling are maintained within the limits of natural variation.	Some evidence of reduction in rates of nutrient recycling in response to drying.	Measurable reductions in rates of nutrient recycling in response to drying.	Severe reductions in rates of nutrient recycling in response to drying.
- Foodchains	No detectable change in foodchains.	Some evidence of disruption to foodchains.	Measurable disruptions to foodchains.	Severe disruptions to foodchains.
- Sediment /soil stabilization	No detectable change in soil stabilisation.	No detectable change in soil stabilisation.	Some evidence of soil destabilisation/erosion.	Measurable destabilisation/erosion of soil.
Biodiversity				
- Species composition	No detectable change in species composition.	Some evidence of encroachment of more drought tolerant species.	Measurable signs of encroachment of more drought tolerant species.	Loss of less drought tolerant species from ecosystem, with establishment of exotic species and gradual dominance by more drought tolerant species.
- Species distribution	No detectable change in distribution of terrestrial phreatophtyic species (not measurable in past 20 years).	Some evidence of changing distribution and encroachment of more drought tolerant species into areas previously dominated by less drought tolerant species.	Measurable change in demographics of some species with encroachment of more drought tolerant species into areas previously dominated by less drought tolerant species.	Overstorey and understorey decline and/or loss of species from ecosystem. > 50% reduction in abundance of dominant populations and/or disturbance allowing establishment of exotic species.
- Species mortality	No detectable mortality.	Some mortality of individuals.	Greater than 15% reduction in abundance of dominant species.	Greater than 50% reduction in abundance of dominant species.
- Species richness	No detectable changes in species richness.	Some evidence of decline in richness of less drought tolerant species.	Measurable decline in richness of less drought tolerant species and/or increase xeric species richness.	Significant change in richness of less drought tolerant species and replacement by more xeric species.
- Community structure	No detectable change in community structure.	Some evidence of change in community structure.	Notable change in community structure.	Significant change in community structure.
Abundances and biomass of biota				
- Vegetation density, cover and frequency	No detectable change in density, cover and abundance.	Some evidence of reduced growth in overstorey and/or understorey species.	Measurable crown dieback in overstorey species and/or reduction in cover of understorey.	Substantial crown dieback in overstorey species and loss of density and cover in understorey.
- Vegetation height and diameter	No detectable change in vegetation height and diameter.	Some evidence of change in height due to loss of vigour and/or thinning of canopy.	Measurable reductions in height due to loss of canopy and/or reduced diameter of adult stems.	Significant reductions in height due to loss of canopy and reduced diameter of adult stems.
- Vertebrate abundance	No detectable change in vertebrate abundance.	Some evidence of reduced vertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
-Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Some evidence of reduced macroinvertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
Quality of water and sediment				
- Physicochemical properties of sediment and groundwater	Levels of contaminants & other measures of quality remain within limits of natural variation	Small detectable changes beyond limits of natural variation but no resultant effect on biota	Moderate changes beyond limits of natural variation but not to exceed specified criteria	Substantial changes beyond limits of natural variation

- Terrestrial phreatophytic vegetation

    - Ecosystem processes

Primary production in groundwater dependent terrestrial vegetation is disrupted by groundwater drawdown as individual plants become water stressed leading to reduced vigour and growth rates. Loss of vigour may in turn lead to reduced nutrient uptake from soils and therefore disrupt nutrient cycles. Foodchains may also be disrupted as vegetation structure changes.

    - Biodiversity

As species more vulnerable to prolonged dry periods become locally extinct, the diversity and composition of a phreatophytic terrestrial vegetation community changes. In severe cases, diversity may be significantly reduced, and comprise drought tolerant xerophytic species only. Under conditions of moderate drawdown, replacement of mesophytic species with xerophytes (compositional dynamics) will offset any potential reductions in diversity. Upon death of drought intolerant species, spatial niches may become available to weed species colonisation. Such weed species would possess drought tolerance/avoidance mechanisms that facilitate establishment, reproduction and persistence within the community.

    - Abundances and biomass of biota

Phreatophytic vegetation may respond to groundwater drawdown at three different levels; individual, population or community. At the population level changes in abundance can be described in terms of reduction in canopy cover, loss of mature plants, increase in mortality rates, reduced seedlings establishment and shift in distribution towards a shallower depth to groundwater (Froend et al., 2002).

    - Quality of water and sediment

Although manipulation of the groundwater table during mining operations may lead to re-injection of water of differing qualities into an aquifer, there is little evidence to suggest that groundwater drawdown will lead to changes in the quality of groundwater available to terrestrial vegetation. However, excessive drying of the soil profile may result in changes in organic content and lead to hydrophobic conditions, reducing the water holding capacity of soils.

- Cave and aquifer communities

Subsurface aquifer ecosystems support subterranean fauna and organisms such as invertebrates, crustacea, stygophile and stygobite (PPK Environment & Infrastructure Pty Ltd., 2001). Groundwater dependent cave ecosystems support a variety of flora such as mosses and subterranean fauna including blind fish and crustaceae. These ecosystems are recognized as totally dependent on groundwater and therefore any drawdown will, at best result in reductions in key elements of ecosystem integrity, at worst, in complete collapse of the entire ecosystem. Due to the relictual nature of many of these ecosystems and their subsequent high conservation values, there is no level of change that could be considered acceptable (Table 12).

- Base-flow systems

As riverine and wetland ecosystems support similar processes and biota they can be considered to respond to groundwater drawdown in a similar fashion. However, as it is generally assumed that base-flow systems are only proportionality dependent on groundwater, the level of change in key elements of ecosystem integrity may also be only proportional (Table 13).

Response differences may however occur in relation to water and sediment quality. During dry periods, the baseflow contribution to streamflow is highest. Groundwater drawdown will not only reduce the overall volume of baseflow, but may cause increased concentrations of nutrients, pollutants and salts in both water and sediments.

Table 12: Possible response to drawdown in the key elements of cave and aquifer ecosystems for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p. 20).

Cave and aquifer ecosystems		**Risk of impact and possible response to drawdown**		
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Primary production	Rates of primary production are maintained within limits of natural variation.	Severe reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.
- Foodchains	No detectable change in foodchains.	Severe disruptions to foodchains.	Severe disruptions to foodchains.	Severe disruptions to foodchains.
Biodiversity				
- Species composition	No detectable change in species composition.	Measurable loss of water dependent cave and aquifer fauna.	Measurable loss of water dependent cave and aquifer fauna.	Measurable loss of water dependent cave and aquifer fauna.
- Species distribution	No detectable change in species distribution.	Measurable contraction of species distribution.	Measurable contraction of species distribution.	Measurable contraction of species distribution.
- Species richness	No detectable change in species richness	Measurable decline in species richness due to drying.	Measurable decline in species richness due to drying.	Measurable decline in species richness due to drying.
- Community structure	No detectable change in community structure.	Measurable change in community structure.	Measurable change in community structure.	Measurable change in community structure.
Abundances and biomass of biota				
- Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
Quality of water and sediment				
- Physical and biochemical properties of sediments and water	Levels of contaminants & other measures of quality remain within limits of natural variation	Substantial changes beyond limits of natural variation.	Substantial changes beyond limits of natural variation.	Substantial changes beyond limits of natural variation.

- Estuarine and near-shore marine systems

Some near-shore environments receive freshwater input via aquifers extending off-shore or freshwater seepages above fresh/sea water interface. The occurrence of potentially groundwater dependent seagrass systems and near shore fisheries has become a recent area of focus for marine ecologists (PPK Environment & Infrastructure Pty Ltd., 2001). Studies have suggested that seagrass composition can be altered following groundwater abstraction and the resultant reduction in freshwater input (Hemminga & Duarte, 2000). Groundwater may also provide seagrass in some coastal areas with nutrients (Hatton & Evans, 1998). Fauna, includinh fish, turtles, crocodiles and macroinvertebrates may feed on other groundwater dependent species or rely on them for habitat.

Although it is likely that these ecosystems are only dependent on groundwater to a limited extent, reductions in groundwater inputs may lead to some small changes in the key elements of ecosystem integrity (Table 14).

- Fauna

Groundwater dependent terrestrial and wetland vegetation provides habitat, breeding sites and food for fauna which by extension must also be groundwater dependent. However, there is another group of fauna that depend on groundwater not only as habitat but as a source of drinking water. This group is dominated by birds and larger mammals, as respiration provides many small mammals with their water requirements. Although described as opportunistically dependent, groundwater drawdown will also impact on the key elements of ecosystem integrity as they relate to this group of organisms (Table 15).

The categorisation of faunal dependence upon groundwater indicates that species most dependent upon groundwater and therefore generally at the lowest point in the landscape are likely to be affected to the greatest extent by falls in groundwater level. This is because the ecosystems on which they depend are likely to disappear or alter drastically; the ecosystems will have no-where to go if groundwater levels fall. Other species are likely to shift down in the landscape in response to catenary changes. They will change in landscape position but probably not in area occupied. It is also possible, however, that there may be large impacts at the top of the landscape. This is because with respect to groundwater, there are very large areas of upland habitats that have low dependence upon groundwater. If such upland habitats are affected, such as through slight changes in soil moisture levels above the groundwater, the effect would occur over large areas. All upland habitats would become slightly more xeric. Therefore, the equivalent upland habitat to what occurs over large areas now would be reduced to a narrow zone on the upper slopes. The significance of this impact cannot be assessed but this sort of effect needs to be recognised.

Table 13: Possible response to drawdown in the key elements of base-flow systems ecosystems for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p. 20).

Base-flow systems		**Risk of impact and possible response to drawdown**		
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Primary production	Rates of primary production are maintained within limits of natural variation.	Some evidence of reduction in rates of primary production in response to drying.	Measurable reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.
- Nutrient recycling	Rates of nutrient recycling are maintained within the limits of natural variation.	Some evidence of reduction in rates of nutrient recycling in response to drying.	Measurable reductions in rates of nutrient recycling in response to drying.	Severe reductions in rates of nutrient recycling in response to drying.
- Foodchains	No detectable change in foodchains.	Some evidence of disruption to foodchains.	Measurable disruptions to foodchains.	Severe disruptions to foodchains.
- Sediment stabilization	No detectable change in sediment stabilisation.	No detectable change in sediment stabilisation.	Some evidence of sediment destabilisation/erosion.	Measurable destabilisation/erosion of sediments.
Biodiversity (vegetation)				
- Species composition	No detectable change in species composition.	Some evidence of establishment of exotic species as result of disturbance and/or drying.	Measurable encroachment of terrestrial species	Significant change in dominant populations with terrestrialisation through encroachment of xeric species.
- Species distribution	No detectable change in distribution of species.	Some evidence of changing distribution with disturbance and/or drying allowing establishment of exotic species.	Measurable contraction of riparian vegetation through changing demographics of more than one species, with encroachment of xeric species.	Greater than 50% reduction in abundance of dominant species and /or significance change in dominant populations, with terrestrialisation through encroachment of xeric species.
- Species mortality	No detectable mortality.	Some mortality of individuals.	Greater than 15% reduction in abundance of dominant species.	Greater than 50% reduction in abundance of dominant species.
- Species richness	No detectable change in species richness.	Some evidence of decline in richness of riparian species.	Measurable decline in richness of riparian species and/or increase xeric species richness.	Significant change in richness of riparian species and replacement by xeric species.
- Community structure	No detectable change in community structure.	Some evidence of change in community structure.	Notable change in community structure.	Significant change in community structure.
Abundances and biomass of biota				
- Vegetation density, cover and frequency	No detectable change in density, cover and abundance.	Some evidence of reduced growth in overstorey and/or understorey species.	Measurable crown dieback in overstorey species and/or reduction in cover of understorey.	Substantial crown dieback in overstorey species and loss of density and cover in understorey.
- Vegetation height and diameter	No detectable change in vegetation height and diameter.	Some evidence of change in height due to loss of vigour and/or thinning of canopy.	Measurable reductions in height due to loss of canopy and/or reduced diameter of adult stems.	Significant reductions in height due to loss of canopy and reduced diameter of adult stems.
- Vertebrate abundance	No detectable change in vertebrate abundance.	Some evidence of reduced vertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
- Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Some evidence of reduced macroinvertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.	Greater than 50% reduction in vertebrate abundance due to reduction in food and/or habitat availability as result of drying.
Quality of water and sediment				
- Physicochemical properties of water column and sediments.	Levels of contaminants & other measures of quality remain within limits of natural variation	Small detectable changes beyond limits of natural variation but no resultant effect on biota	Moderate changes beyond limits of natural variation but not to exceed specified criteria	Substantial changes beyond limits of natural variation

Table 14: Possible response to drawdown in the key elements of estuarine and near-shore marine ecosystems for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p. 20).

Estuarine and near-shore marine ecosystem		**Risk of impact and possible response to drawdown**		
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Primary production	Rates of primary production are maintained within limits of natural variation.	Some evidence of reduction in rates of primary production in response to drying.	Measurable reductions in rates of primary production in response to drying.	Severe reductions in rates of primary production in response to drying.
- Nutrient recycling	Rates of nutrient recycling are maintained within the limits of natural variation.	Some evidence of reduction in rates of nutrient recycling in response to drying.	Measurable reductions in rates of nutrient recycling in response to drying.	Severe reductions in rates of nutrient recycling in response to drying.
- Foodchains	No detectable change in foodchains.	Some evidence of disruption to foodchains.	Measurable disruptions to foodchains.	Severe disruptions to foodchains.
- Sediment stabilization	No detectable change in sediment stabilisation.	No detectable change in sediment stabilisation.	Some evidence of sediment destabilisation/	Measurable destabilisation of sediments.
- Pollutant filtration	No detectable change in rates of pollutant filtration	No detectable change in rates of pollutant filtration	Some evidence of change in rates of pollutant filtration.	Measurable reductions in rates of pollutant filtration.
Biodiversity				
- Species composition	No detectable change in species composition.	No detectable change in species composition.	Some evidence of change in species composition	Measurable signs of change in species composition.
- Species distribution	No detectable change in distribution of species.	No detectable change in distribution of species.	Some evidence of changing distribution	Measurable change in demographics of some species.
- Species richness	No detectable changes in species richness.	No detectable changes in species richness.	Some evidence of decline in richness.	Measurable decline in species richness.
- Community structure	No detectable change in community structure.	No detectable change in community structure.	Some evidence of change in community structure.	Notable change in community structure.
Abundances and biomass of biota				
- Vegetation density, cover and frequency	No detectable change in density, cover and abundance.	Some evidence of reduced growth.	Measurable reduction in density, cover and/or abundance.	Substantial loss of density, cover and abundance.
- Vertebrate abundance	No detectable change in vertebrate abundance.	Some evidence of reduced vertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability.
- Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Some evidence of reduced macroinvertebrate abundance.	Measurable changes in vertebrate abundance.	Measurable changes in vertebrate abundance
Quality of water and sediment				
- Physicochemical properties of water column and sediments.	Levels of contaminants & other measures of quality remain within limits of natural variation	Small detectable changes beyond limits of natural variation but no resultant effect on biota	Moderate changes beyond limits of natural variation but not to exceed specified criteria	Substantial changes beyond limits of natural variation

Table 15: Possible response to drawdown in the key elements of groundwater dependent fauna for 4 degrees of risk of impact (adapted from Environmental Protection Authority, 2000, p. 20).

Groundwater dependent fauna		**Risk of impact and possible response to drawdown**		
Key elements	Not significant (no detectable change)	Moderate (small change)	Significant (moderate change)	Severe (large change)
Ecosystem processes				
- Foodchains	No detectable change in foodchains.	Some evidence of disruption to foodchains.	Measurable disruptions to foodchains.	Severe disruptions to foodchains.
Biodiversity				
- Species composition	No detectable change in species composition.	No detectable change in species composition.	Some evidence of change in species composition	Measurable signs of change in species composition.
- Species distribution	No detectable change in distribution of species.	No detectable change in distribution of species.	Some evidence of changing distribution	Measurable change in demographics of some species.
- Species richness	No detectable changes in species richness.	No detectable changes in species richness.	Some evidence of decline in richness.	Measurable decline in species richness.
- Community structure	No detectable change in community structure.	No detectable change in community structure.	Some evidence of change in community structure.	Notable change in community structure.
Abundances and biomass of biota				
- Vertebrate abundance	No detectable change in vertebrate abundance.	Some evidence of reduced vertebrate abundance.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability.	Measurable changes in vertebrate abundance due to reduction in food and/or habitat availability.
- Macroinvertebrate abundance	No detectable change in macroinvertebrate abundance.	Some evidence of reduced macroinvertebrate abundance.	Measurable changes in vertebrate abundance.	Measurable changes in vertebrate abundance
Quality of water and sediment	N/A			

In this section detailed information on the factors considered in the risk of impact matrix are presented for those GDEs for which EWRs have been described in Section 2. Possible responses of vegetation to modelled drawdown are provided at the community and/or species level where appropriate. Comment is also provided on possible response of other ecosystem components where possible.

Wetlands

Gnangara Mound

Loch McNess

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the staff gauge at Loch McNess indicates that minimum surface water levels declined 0.1 m from 1995 to 2003. There is no evidence of changes in ecological condition associated with this decline.

2. Current hydrology, ecological condition and conservation values.

Loch McNess is a permanent wetland that exhibits very small seasonal fluctuations in surface water levels. Although the water dependent biota of the Lake appear to be in excellent condition there has been some evidence of declining water quality in the past. Loch McNess maintains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Loch McNess indicates the western side of the lake may experience drawdown of 0.75-1.0 m by 2005, increasing to 1.0–2.0 m by 2008 and 2013. On the eastern side drawdown of 1.0-2.0 m is predicted by 2005 and 2008 increasing to 2.0-3.0m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a severe level of possible impact. Groundwater level decline may impact on surface water levels and result in Loch McNess becoming a seasonally inundated sumpland or at worst, a seasonally waterlogged dampland. This may result in the loss of habitat for aquatic fauna. Groundwater decline of this magnitude is also likely to lead to significant losses of *M. rhaphiophylla, B. littoralis* and *B. articulata*.

Lake Yonderup

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the staff gauge at Lake Yonderup indicates that minimum surface water levels declined 0.06 m from 1995 to 2003. There is no evidence of changes in ecological condition associated with this decline.

2. Current hydrology, ecological condition and conservation values.

Lake Yonderup is a permanent wetland that exhibits very small seasonal fluctuations in surface water levels. The water dependent biota of the Lake appears to be in excellent condition and it maintains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Lake Yonderup indicates the lake may experience drawdown of 0.75-1.0 m by 2005, increasing to 1.0–2.0 m by 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. Groundwater level decline may impact on surface water levels and result in Lake Yonderup becoming a seasonally inundated sumpland or at worst, a seasonally waterlogged dampland. This may result in the loss of habitat for aquatic fauna. Fringing and emergent vegetation may be lost, in particularly *B. littoralis*, which responds quickly to water level decline and *M. rhaphiophylla*. *B. articulata* and *T. orientalis* may encroach into the basin, reducing the area of open water and impacted on habitat and feeding grounds of vertebrates and waterbirds.

Lake Wilgarup

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the monitoring bore at Lake Wilgarup indicates that minimum groundwater levels declined 0.55 m from 1995 to 2003. This has coincided with severe declines in the ecological condition of the wetland, including the widespread loss of *M. rhaphiophylla* saplings and some mature trees, deaths of mature *B. littoralis*, thinning of *B. articulata* and the invasion of exotic species. No surface water has been recorded at Lake Wilgarup since 1998 resulting in the loss of macroinvertebrates and drying of organic rich sediments.

2. Current hydrology, ecological condition and conservation values.

Lake Wilgaup was regarded as a seasonally inundated wetland, but is now dry throughout the year. The ecological condition of the wetland has declines significantly in recent years however, Lake Wilgarup still retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Lake Wilgarup indicates the western side of the lake may experience drawdown of 0.5-0.75 m by 2005, increasing to 0.75-1.0 m by 2008 and 1.0-2.0 m by 2013. On the eastern side drawdown of 0.75-1.0 m is predicted by 2005 and 2008 increasing to 10.0-2.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. Drawdown will further exacerbate the declining condition of this wetland. Total loss of tree seedlings and emergent macrophytes should be expected along with continued decline in the vigour of mature trees. However, terrestrialisation is unlikely to occur for some time due to the dense nature of litter across the wetland basin. Excessive drying of the peat layer also makes Lake Wilgarup highly susceptible to fire.

Pipidinny Swamp

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the staff gauge at Pipidinny indicates that minimum surface water levels remained relatively constant from 1995 to 2003 however, there has been a decline in peak levels over that time. There has been an increase in the conductibility of the ponds in recent years suggesting the possibility of salt water intrusion associated with surrounding groundwater decline.

2. Current hydrology, ecological condition and conservation values.

Pipidinny Swamp appears to be permanently inundated and continues to support water birds and other groundwater dependent vertebrates and macroinvertebrates. The conservation values of the wetland remain high.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Pipidinny Swamp indicates wetland may experience drawdown of 0.5-0.75 m by 2005, increasing to 0.75-1.0 m by 2008 and 1.0-2.0 m by 2013 in the east and 0.75-1.0 m in the west. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a significant level of possible impact. Groundwater level decline may impact on surface water levels and result in Pipidinny Swamp becoming a seasonally inundated sumpland or at worst, a seasonally waterlogged dampland. This may result in the loss of habitat for aquatic fauna. The sedge species that constitute the TEC at this site may decline in density and condition along with fringing *M. rhaphiophylla*.

Lake Nowergup

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the staff gauge and monitoring bore at Lake Nowergup indicates that minimum surface water levels declined >0.33 m from 1995 to 2003, drying at the staff gauge since 2000, while peak surface water and minimum and peak groundwater levels have increased. These increases are the result of artificial maintenance of surface water levels. Despite artificial maintenance the health of *E. rudis* and *M. rhaphiophylla* has declined significantly in recent years, *B. articulata* has been thinning and *T. orientalis* and other exotics have been encroaching into the basin.

2. Current hydrology, ecological condition and conservation values.
Lake Nowergup is a permanent, deep wetland that has been artificially maintained in recent years. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Nowergup indicates the western side of the lake may experience drawdown of 1.0-2.0 m by 2005, 2008 and 2013. On the eastern side drawdown of 1.0-2.0 m is predicted by 2005 and 2.0-3.0 m by 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a severe level of possible impact. Unless artificial maintenance is successful is retaining adequate surface water level the predicted declines are likely to result in further encroachment of *T. orientalis* across the basin, loss of *B. articulata* from the wetland fringes and continued decline in the condition of *M. rhaphiophylla* and *E. rudis*. Recruitment of exotics and tree species across the basin is also possible.

Lake Joondalup

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge and monitoring bore at Lake Joondalup indicates that minimum surface water and groundwater levels declined 0.12 and 0.4 m respectively from 1995 to 2003. This has coincided with some decline in the condition of fringing vegetation and encroachment of *T. orientalis* into the southern reaches of the basin. Sediments have dried and contributed to wind-throw of some mature *M. rhaphiophylla*. Water quality has also been impacted, with high nutrients, high chlorophyll *a* and low DO recorded during summer.

2. Current hydrology, ecological condition and conservation values.
Lake Joondalup retains small pools of surface water throughout most summers. It provides some drought refuge for waterbirds during summer and supports other vertebrate and invertebrate species. Fires and invasion of exotic plant species have impacted on the ecological condition of the wetland along with water level decline however, the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Joondalup indicates the western side of the lake may experience drawdown of 0.75-1.0 m by 2005 and 1.0-2.0 m by 2008 and 2013. On the eastern side drawdown of 1.0-2.0 m is predicted by 2005 and 2008, to 2.0-3.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There is also likely to be further encroachment of *T. orientalis* and *B. articulata*, increased wind throw of trees, loss of fringing vegetation condition and possible recruitment of exotics and native species across the basin, along with declines in water quality.

Lake Goollelal

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge and monitoring bore at Lake Goollelal indicates that minimum surface water level declined 0.06 m from 1995 to 2003 following a long-term trend of increasing water levels. This has lead to increased inundation of fringing trees and some decline in the condition of *E. rudis* and contraction of *B. articulata* bands away from the wetland basin.

2. Current hydrology, ecological condition and conservation values.

Lake Goollelal is a permanent wetland that has shown an increasing trend in water levels since the 1970's. The wetland provides habitat and feeding grounds for waterbirds and other vertebrate species. Water quality has, however declined in recent years and exotic vegetation dominates the understorey. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Goollelal indicates the western side of the lake may experience drawdown of 0.5-0.75 m by 2005, to 0.75-1.0 m by 2008 and 2.0-3.0 m by 2013. On the eastern side drawdown of 0.75-1.0 m is predicted by 2005, to 1.0-2.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Although Lake Goollelal has experienced increasing water levels in the past, the magnitude and rate of drawdown predicted on both sides of the lake over each time period in combination with conservation values represent a significant level of possible impact. However, other than increased invasion of exotics, it is likely that the condition of wetland vegetation may improve. In contrast, water quality is likely to decline significantly.

Lake Jandabup

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the staff gauge at Lake Jandabup indicates that minimum surface water levels increased 0.03 m from 1995 to 2003. This rise is due to artificial maintenance implemented to address acidification. The decline in pH had previously lead to local extinctions of highly sensitive macroinvertebrate taxa. Prior to augmentation sedge species had encroached into the wetland basin. Despite higher surface water levels the condition of fringing vegetation has continued to decline.

2. Current hydrology, ecological condition and conservation values.
Lake Jandabup is a permanent, shallow wetland that supports macroinvertebrates, waterbirds and other vertebrates. The majority of declines in ecological condition have been arrested through artificial maintenance and the wetand retains very high conservation values however, there remains some concern for fringing vegetation.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Jandabup indicates the north-eastern corner of the lake may experience drawdown of 2.0-3.0 m by 2005 and to >3.0 m by 2013. The remainder of the lake may experience drawdown of 1.0-2.0 m by 2005 to 2.0-3.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a significant level of possible impact. Unless artificial maintenance is continued and retains adequate surface water level the predicted declines are likely to result in further encroachment of sedges across the basin, and continued decline in the condition of fringing. Recruitment of exotics across the basin is also possible. Water quality issues are also likely to resurface under a drier regime.

Lake Mariginiup

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the monitoring bore at Lake Mariginiup shows that minimum groundwater levels declined 0.38 m from 1995 to 2003. This coincided with declines in the condition of fringing *E. rudis* and encroachment of *T. orientalis* into the basin Sediments have also dried and water quality impacted through increasing acidification.

2. Current hydrology, ecological condition and conservation values.
Lake Mariginiup has dried completely in most summers since 1997 with maximum depths and periods of inundation generally declining over time. Fires and other disturbances have also resulted in the loss of much of the fringing vegetation and exacerbated sediment drying. Although there has been decline in the ecological condition of the wetland it retains moderate conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Mariginiup indicates the north-eastern corner of the lake may experience drawdown of 0.75-1.0 m by 2005, increasing to 2.0-3.0 m by 2008 and >3.0 m by 2013. The rest of the wetland is predicted to experience drawdown of 1.0-2.0 m is by 2005 increasing to 2.0-3.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted for the lake over each time period combined with historic changes and conservation values represent a significant level of possible impact. This may lead to the encroachment of *T. orientalis* and *B. articulata* across the entire wetland basin and contraction of *E. rudis* and *M. rhaphiophylla*. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat.

Lexia 86

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the monitoring bore at Lexia 86 indicates that groundwater levels declined 0.18 from 1995 to 2003. This has coincided with decline in health, patch deaths and encroachment of fringing vegetation into the basin and the contraction of *B. articulata*. Sediments have also dried and vertebrate species become less prevalent.

2. Current hydrology, ecological condition and conservation values.
Lexia 86 dries in summer with maximum depths and periods of inundation generally declining over time. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lexia 86 indicates the wetland may experience an increase in groundwater levels of 0-0.25 m by 2005 and 2008, with levels then decreasing 0.25-0.5 m by 2013. The magnitude and rate of drawdown may exceed that required to maintain a low risk of impact.

The predicted water level increases over the first two time periods, are negated by the decrease predicted by 2013. However, the combination of historic changes and conservation values still represent a significant level of possible impact. *B. articulata* may continue to contract with *A. fascicularis* and other fringing vegetation establishing in the basin.

Lexia 94

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the monitoring bore at Lexia 94 indicates that minimum groundwater levels declined 0.19 m from 1995 to 2003. This has coincided with some decline in the condition of fringing vegetation and the drying and thinning of wetland shrubs and emergent macrophytes across the wetland basin.

2. Current hydrology, ecological condition and conservation values.
Lexia 94 is a seasonally waterlogged wetland and it has been suggested that it is perched. Although there has been decline in the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lexia 94 indicates the wetland may experience an increase in groundwater levels of 0-0.25 m by 2005 and 2008, with levels then decreasing 0.25-0.5 m by 2013. The magnitude and rate of drawdown may exceed that required to maintain a low risk of impact.

The predicted water level increases over the first two time periods, are negated by the decrease predicted by 2013. However, the combination of historic changes and conservation values still represent a significant level of possible impact. Drying and thinning of vegetation may continue across the basin with further decline in fringing tree and shrub species.

Lexia 186

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the monitoring bore at Lexia 186 indicates that minimum groundwater levels declined 0.28 m from 1995 to 2003. This has coincided with some decline in the condition of fringing vegetation and the encroachment of fringing tree species into the basin as *B. articulata* dries and thins.

2. Current hydrology, ecological condition and conservation values.
Lexia 186 is a seasonally waterlogged basin with a small man-made sump that contains water in winter. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lexia 186 indicates the wetland may experience an increase in groundwater levels of 0-0.25 m by 2005 and 2008, with levels then decreasing 0.25-0.5 m by 2013. The magnitude and rate of drawdown may exceed that required to maintain a low risk of impact.

The predicted water level increases over the first two time periods, are negated by the decrease predicted by 2013. However, the combination of historic changes and conservation values still represent a significant level of possible impact. There may be further decline in vegetation condition.

EPP Wetland 173

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the monitoring bore at EPP 173 indicates that minimum groundwater levels declined 0.06 m from 1995 to 2003. This has coincided with some decline in the condition of fringing vegetation, reduced water quality and drying of organic sediments.

2. Current hydrology, ecological condition and conservation values.
EPP 173 is spring fed yet dries at the staff gauge in most summers. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for EPP indicates the wetland may experience drawdown of 0.25-0.5 m by 2005 and 2008 and to 0.5-0.75 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted at the wetland over each time period combined with historic changes and conservation values represent a significant level of possible impact. Reduction in flows from the springs due to groundwater drawdown will also likely influence the hydrologic regime of EPP173. If the springs stopped flowing, then the depth and duration of inundation in winter and the soil moisture profile in summer all could be affected. It is likely that lower surface water levels will impact on the breeding capabilities of the Black-striped Minnow and other vertebrate species. Emergent vegetation may also contract into the basin with further decline in the condition of fringing species.

Dampland 78

1. Historic water level change and associated changes in ecological condition.
The hydrograph for the monitoring bore at Dampland 78 indicates that minimum groundwater levels declined 0.37 m from 1995 to 2003. This has coincided with drying of the wetland basin and loss of *B. articulata* along with water stress in fringing *M. preissiana* and declines in density of wetland shrubs.

2. Current hydrology, ecological condition and conservation values.
Dampland 78 is a seasonally waterlogged wetland that is becoming drier over time. Although there has been decline in the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Dampland 78 indicates the wetland may experience drawdown of >3.0 m by 2005 continuing to 2008 and 2013. The magnitude and rate of drawdown far exceeds that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a significant level of possible impact. However, in light of previous changes in ecological condition, the impact is likely to be more severe, with loss of some mature *M. preissiana* and increased thinning in the understorey.

Lake Gwelup*

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate that water levels declined 1.25-1.5 m at Lake Gwelup between 1995 and 2003. This has coincided with encroachment of *T. orientalis* into the wetland basin and a decline in the condition of fringing *E. rudis* and *M. rhaphiophylla*.

2. Current hydrology, ecological condition and conservation values.

Lake Gwelup is a seasonally inundated wetland that is becoming drier over time. Although it is impacted by fires, weed invasion and other urban disturbance and there has been decline in the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Lake Gwelup indicates the wetland may experience drawdown 1.0-2.0 by 2005 and 2.0-3.0m 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There is also likely to be further encroachment of vegetation across the basin and declines in the condition of fringing tree species.

Big Carine Swamp*

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate that water levels declined 1.0 m at Big Carine Swamp between 1995 and 2003. This has coincided with drying of the wetland basin and encroachment of herbs and grasses. Water stress in fringing *M. rhaphiophylla* is prevalent with up to 50% of trees dead or very stressed on the western shore and 25% in the south.

2. Current hydrology, ecological condition and conservation values.

Big Carine Swamp is a seasonally waterlogged wetland that is becoming drier over time. Although there has been decline in the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Big Carine Swamp indicates the wetland may experience drawdown of 0.75-1.0 m by 2005 and 2008 to 1.0-2.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. As much of the vegetation at Big Carine Swamp is already severely impacted, further declines are likely to result in the loss of many *M. rhaphiophylla* and domination of the basin by exotics.

Lake Muckenburra*

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate that water levels increased 0.75 m at Lake Muckenburra between 1995 and 2003. As the condition of this wetland has not been assessed, it is not possible to comment on changes in ecological condition.

2. Current hydrology, ecological condition and conservation values.

Lake Muckenburra is a seasonally waterlogged wetland that is becoming wetter over time. Although it is not known if there has been a decline in the ecological condition of the wetland it retains very high conservation values as it supports a TEC.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Muckenburra indicates the wetland may experience drawdown of 0.5-0.75 m by 2005, 0.75-1.0 m by 2008 and 1.0-2.0 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted over each time period combined with historic changes and conservation values represent a significant to severe level of possible impact. If ponding of surface water is not adequate to meet the requirements of vegetation and fauna, there is likely to be a decline in the condition of fringing vegetation and loss of habitat.

Bambun Lake*

1. Historic water level change and associated changes in ecological condition.
Groundwater contours indicate that water levels increased 0.75 m at Bambun Lake between 1995 and 2003. There appears to have been little change on the condition of the wetland over this time.

2. Current hydrology, ecological condition and conservation values.
Bambun Lake is a permanent wetland. Although much of the surrounding area has been cleared for agriculture and exotics dominant the wetland understorey, intact vegetation appears healthy and the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Bambun Lake indicates the wetland may experience drawdown of 0.5-0.75 m by 2005, 0.25-0.5 by 2008 and 0.5-0.75 by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted over each time period combined with historic changes and conservation values represent a moderate to significant level of possible impact. There may be some decline in the condition of fringing *M. rhaphiophylla* and *E. rudis* and contraction of *B. articulata* into the basin.

Yeal Swamp, Lake Bindiar and Wetlands of Yeal Nature Reserve*

1. Historic water level change and associated changes in ecological condition.
Groundwater contours indicate that water levels decreased 1.75-2.0 m between 1995 and 2003 across the Yeal wetlands. Despite this decline, much of the wetland vegetation appears to be in good condition with the exception of *E. rudis*, which is showing signs of water stress and some myrtaceous wetland shrubs which have dried and thinned across the area.

2. Current hydrology, ecological condition and conservation values.
It is probable that Yeal Swamp, Lake Bindiar and some associated wetlands once held surface water for at least some part of the year. These wetlands now appear to be seasonally waterlogged damplands. Although there has been decline in the ecological condition of the Yeal wetland they retain high conservation values as an interconnected suite of relatively undisturbed wetlands.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for the Yeal wetlands indicates the wetlands may experience drawdown of 0.75-1.0 m in the west (including Yeal Swamp and Lake Bindiar) and 1.0-2.0 m in the east by 2005, increasing to 2.0-3.0 across the area by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

The magnitude and rate of drawdown predicted over each time period combined with historic changes and conservation values represent a significant level of possible impact. It is likely that there will be further declines in the condition and spot deaths of *E. rudis* along with encroachment of more xeric species into the wetlands as wetland shrubs continue to thin.

Edgecombe Seepage

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the monitoring bore at Edgecombe Seepage indicates that minimum groundwater levels declined 0.83 m from 1995 to 2003. This has coincided with a decline in faunal diversity.

2. Current hydrology, ecological condition and conservation values.

Edgecombe Seepage is a permanent mound spring. Due to average rainfall in 2003 water levels increased following declines in previous years. The spring was cleared and heavily disturbed however, by 2002 flows were returning and by 2003 the area was recovering. Although there has been decline in the ecological condition of the wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Edgecombe Seepage indicates groundwater levels may rise 0.25-0.5 m by 2005, increasing to 0.75-1.0 m by 2008 and 1.0-2.0 m 2013. Although water levels are predicted to rise the wetland remains at significant risk of impact due to historic changes and conservation values. However, it is likely that vegetation will continue to re-establish and increased surface water levels by 2008 and 2013 may restore faunal diversity.

Egerton Spring

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the monitoring bore at Egerton Spring indicates that minimum groundwater levels declined 0.2 m from 1995 to 2003. There has been no recorded change in the ecological condition of the site over this time period.

2. Current hydrology, ecological condition and conservation values.

Edgecombe Seepage is a permanent mound spring. Due to average rainfall in 2003 water levels increased following declines in previous years. The spring discharges good quality fresh water that supports diverse macroinvertebrate fauna and pristine fringing vegetation. The wetland it retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Egerton Spring indicates groundwater levels may rise 0-0.25 m by 2005, increasing to 0.25-0.5 m by 2008 and to 0.5-0.75 m 2013. Although water levels are predicted to rise the wetland remains at moderate risk of impact due to historic changes and conservation values. However, it is unlikely that there will be a negative impact on the vegetation of the spring.

Kings Spring*

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate that water levels decreased 0.5 m between 1995 and 2003 near King Spring. This has coincided with drying and shrinkage of wetlands sediments, declines in condition of *M. rhaphiophylla* and invasion of the area by exotics.

2. Current hydrology, ecological condition and conservation values.

It is likely that King Spring once held surface water for the majority of the year, if not permanently. However, the system now appears to dry in summer and is unlikely to flood to previous depths in winter. The conservation values of this mound spring may therefore have been largely lost, but further research is required.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for King Spring indicates the wetland may experience drawdown of 0.25-0.5 m by 2005, increasing to 0.5-0.75 m 2008 and 1.0-2.0 m by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a significant level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. Due to the already stressed nature of the vegetation it is likely that there will be deaths of mature *M. rhaphiophylla* and further encroachment of exotics.

Jandakot Mound

Thomsons Lake

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the staff gauge and monitoring bore at Thomsons Lake indicates that minimum surface water and groundwater levels declined 0.94 and 1.16 m respectively from 1992 to 2003. This has coincided with some decline in the condition of fringing vegetation and encroachment of *T. orientalis.*

2. Current hydrology, ecological condition and conservation values.

Thomsons Lake is a RAMSAR wetland and supports other vertebrate and invertebrate species. Altered hydrology and invasion of exotic plant species have impacted on the ecological condition of the wetland along with water level decline however, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Thomsons Lake indicates the northern side of the lake may experience drawdown of 0.25-0.5 m by 2005, increasing to 0.5-0.75 m by 2008 and to 0.75-1.0 m by 2013. On the southern side drawdown of 0.5-0.75 m is predicted by 2005, increasing to 1.0-2.0 m by 2008 and 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. *T. orientalis, B. articulata* and exotic species are likely to encroach onto the basin wetland, with further decline in the condition of fringing *M. rhaphiophylla* and *E. rudis* and recruitment of both species across the basin.

North Lake

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the staff gauge and monitoring bore at North Lake indicates that minimum surface water and groundwater levels declined 1.57 and 0.74 m respectively from 1992 to 2003. This has coincided with some decline in the condition of fringing vegetation and the encroachment of native species into areas that were previously inundated.

2. Current hydrology, ecological condition and conservation values.

North Lake appears to retain small pools of surface water throughout most summers. It provides some drought refuge for waterbirds during summer and supports other vertebrate and invertebrate species. The invasion of exotic plant species have impacted on the ecological condition of the wetland along with water level decline however, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for North Lake indicates the south-eastern side of the lake may experience drawdown of 0.75-1.0 m by 2005, decreasing to 0.5-0.75 m by 2008 and 2013. The remainder of the wetland may undergo drawdown of 0.75-1.0 m by 2005, 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There may also be further decline in the condition of fringing vegetation, invasion of exotics and encroachment of vegetation across the basin.

Banganup Swamp

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the monitoring bore at Banganup Swamp indicates that minimum groundwater levels declined 1.234 m from 1997 to 2003 with the wetland drying for longer periods each year over time. This has coincided with encroachment of *T. orientalis* into the basin and decline in water quality

2. Current hydrology, ecological condition and conservation values.

Banganup Swamp is now dry for up to 9 months of the year. Although water level decline has impacted on the ecological condition of the wetland, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Banganup Swamp indicates the wetland may experience drawdown of 0.75-1.0 m by 2005, increasing to 1.0-2.0 m by 2008 and 2013, with declines of 2.0-3.0 m possible in the south. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. This may result in the loss of surface water form the system, further contraction of vegetation across the basin and decline in the condition of fringing *M. rhaphiophylla.*

Bibra Lake

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the staff gauge and monitoring bore at Bibra Lake indicates that minimum surface water levels declined 1.002 m from 1992 to 2003. This has coincided with increase in exotics and contributed to insect attack on *E. rudis*. Previously, prolonged periods of inundation on the west side of the lake caused severe deterioration in tree health.

2. Current hydrology, ecological condition and conservation values.

Bibra Lake retains surface water throughout most summers. It provides some drought refuge for waterbirds during summer and supports other vertebrate and invertebrate species. Insect attack, tree health decline and invasion of exotic plant species have impacted on the ecological condition of the wetland along with water level decline however, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Bibra Lake indicates the half of the lake may experience drawdown of 0.75-1.0 m by 2005, decreasing to 0.25-0.5 m by 2008 and back to 0.75-1.0 m by 2013. In other areas drawdown of 0.5-0.75 m is predicted by 2005, 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There may also be further decline in the condition of fringing vegetation, invasion of exotics and encroachment of vegetation across the basin.

Yangebup Lake

1. Historic water level change and associated changes in ecological condition.

The hydrographs for the staff gauge and monitoring bore at Yangebup Lake indicates that minimum surface water and groundwater levels declined 1.335 and 1.52 m respectively from 1992 to 2003. Vegetation is not monitored at this wetland however, water quality has been impacted, with high nutrients recorded during summer.

2. Current hydrology, ecological condition and conservation values.

Yangebup Lake retains surface water throughout the year. It provides drought refuge for waterbirds during summer and supports other vertebrate and invertebrate species. Despite impacts on the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Yangebup Lake indicates the wetland may experience drawdown of 0.75-1.0 m by 2005, 0.25-0.5 m by 2008 and 0.5-0.75 m by 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. This may lead to further decline in water quality and possible drying in summer months.

Lake Kogolup

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge at Lake Kogolup South indicates that minimum surface water levels declined 1.35 and 0.4 m from 1992 to 2003. This has coincided with some decline in the condition of fringing vegetation and water quality.

2. Current hydrology, ecological condition and conservation values.
Lake Kogolup South retains some surface water throughout most summers. It provides some drought refuge for waterbirds during summer and supports other vertebrate and invertebrate species. Despite impacts on the ecological condition of the wetland it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Lake Kogolup indicates that North Kogolup may experience drawdown of 0.5-0.75 m by 2005, 0.25-0.5 m by 2008 and 0.5-0.75 m by 2013. At South Kogolup drawdown of 0.5-0.75 m is predicted by 2005, 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted at Lake Kogolup over each time period combined with historic changes and conservation values represent a severe level of possible impact. This may result in contraction of wetland species and further declines in fringing tree health.

Shirley Balla Swamp

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge and monitoring bore at Shirley Balla Swamp indicate that minimum surface water levels have declined since 1993 with groundwater levels declining 0.56 m from 1992 to 2003. This has coincided with some decline in the condition of fringing vegetation along with a reduction in macroinvertebrate species richness and decreasing water quality.

2. Current hydrology, ecological condition and conservation values.
Shirley Balla Swamp has dried for progressively longer periods since 1993 and is now dry for up to 8 months of the year. Fire, physical disturbance and invasion of exotic plant species have impacted on the ecological condition of the wetland along with water level decline however, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Shirley Balla Swamp indicates the wetland may experience drawdown of 0.25-0.5 m by 2005 and 0.75-1.0 m by 2008 and 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There may also be further decline in the condition of fringing vegetation and water quality.

Twin Bartram Swamp

1. Historic water level change and associated changes in ecological condition.

The hydrograph for the monitoring bore at Twin Bartram Swamp indicates that minimum groundwater levels decreased 1996 to 1997, before increasing by 0.22 to 2003. Surface water levels have also increased over that time. There has been little or no change in ecological condition associated with water level change.

2. Current hydrology, ecological condition and conservation values.
Twin Bartram Swamp has retained surface water for progressively longer periods over the past 5 years, possibly due to increased runoff from nearby urban development. Fire and the invasion of exotic plant species have impacted on the ecological condition of the wetland however, the wetland retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Twin Bartram Swamp indicates the wetland may experience drawdown of 0.25-0.5 m by 2005 and 0.5-0.75 m by 2008 and 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a moderate to significant level of possible impact. This may result in the decline in condition of *M. rhaphiophylla* across the wetland basin and further invasion by exotics.

Beenyup Rd Swamp

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge and monitoring bore at Beenyup Rd Swamp indicates that minimum groundwater levels declined 0.54 from 1992 to 2003, with surface water levels also declining over that time period. This has coincided with some decline in the density of *B. articulata*, increased invasion of exotics across the basin and some decline in the condition of fringing trees.

2. Current hydrology, ecological condition and conservation values.
Beenyup Rd Swamp has dried for progressively longer periods since 1993, with no surface water recorded at the staff gauge at all in 2003. Water level decline has impacted on the ecological condition of the wetland however, it retains high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Beenyup Rd Swamp indicates the wetland may experience drawdown of 0.25-0.5 m by 2005, 0.75-1.0 m by 2008 and 1.0-2.0 m by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a significant to severe level of possible impact. The surface water component of the wetland is likely to remain dry unless perching occurs resulting in the loss of habitat. There is also likely to be total loss of *B. articulata* and further decline in the condition of fringing vegetation.

Forrestdale Lake

1. Historic water level change and associated changes in ecological condition.
The hydrographs for the staff gauge and monitoring bore at Forrestdale Lake indicates that surface water levels have declined since 1992, with groundwater levels falling 0.49 m since 1996. This has coincided with some decline in the condition of fringing vegetation and encroachment of exotics across the wetland basin.

2. Current hydrology, ecological condition and conservation values.
Forrestdale Lake now dries completely in most summers remaining dry for longer periods each year. This has reduced the value of the wetland as an important waterbird and wader habitat. Despite this and the impact of water level decline on vegetation, the wetland retains very high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Forrestdale Lake indicates the western side of the lake may experience drawdown of 0.5-0.75 m by 2005, 0.25-0.5 m by 2008 and 0.5-0.75 by 2013. On the eastern

side drawdown of 0.5-0.75 m is predicted by 2005, levels increase 0-0.25 m by 2008, increasing again by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake during the first time period combined with historic changes and conservation values represent a severe level of possible impact. The surface water component of the wetland is likely to dry completely unless perching occurs resulting in the loss of habitat. There is also likely to be further encroachment of vegetation across the basin and declines in the condition of fringing *M. rhaphiophylla* and *E. rudis*.

Mather Reserve Swamp*

1. Historic water level change and associated changes in ecological condition.

The staff gauge at Mather Reserve indicates minimum surface water levels have declined 0.81 m since 1992, while groundwater levels at the bore have decreased 0.39 m since monitoring commenced in 1997. As the condition of this wetland had not been assessed at the time of writing it is not possible to comment on changes in ecological condition.

2. Current hydrology, ecological condition and conservation values.

The Mather Reserve wetland is seasonally inundated however, surface water levels and periods of inundation have declined. Ecological condition is unknown.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Mather Reserve indicates the wetland may experience drawdown of 0.25-0.5 m by 2005, 0.5-0.75 m by 2008 and 0.75-1.0 m 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a significant to severe level of possible impact. Although the current ecological condition of Mather Reserve Swamp is unknown, it is likely that vegetation condition will decline and the surface water component of the wetland is likely to dry completely.

Spectacles Swamp North *

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate water levels at the Spectacles Swamp increased 1.5 m from 1992 to 2003. As the condition of this wetland had not been assessed at the time of writing it is not possible to comment on changes in ecological condition.

2. Current hydrology, ecological condition and conservation values.

Spectacles Swamp North is a seasonally inundated wetland that may support waterbirds. Ecological condition is unknown.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Spectacles Swamp indicates the western side of the lake may experience drawdown of 0.5-0.75 m by 2005, 0.75-1.0 m by 2008 and 0.5-0.75 by 2013. On the eastern side drawdown of 0.25-0.5 m is predicted by 2005 and 0-0.25 by 2008 and 2013. The magnitude and rate of drawdown far exceed that required to maintain a low risk of impact.

Drawdown predicted on both sides of the lake over each time period combined with historic changes and conservation values represent a severe level of possible impact. Although the current ecological condition of Spectacles Swamp North is unknown, it is likely that vegetation condition will decline and the surface water component of the wetland is likely to dry completely.

Harrisdale Swamp*

1. Historic water level change and associated changes in ecological condition.

Groundwater contours indicate Harrisdale Swamp has experienced an increase in water levels of >3.0 m however, the bore suggests levels have declined 0.37 m since 2000. As the condition of this wetland is unknown it is not possible to comment on changes in ecological condition.

2. Current hydrology, ecological condition and conservation values.
It is likely that Harrisdale Swamp is a seasonally inundated wetland. Ecological condition is unknown.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Harrisdale Swamp indicates the wetland may experience drawdown of 0.25-0.5 m by 2005, 0-0.25 m by 2008 and 0-0.25 m by 2013. Although the magnitude and rate of drawdown represents a low risk of impact, when considered with historic changes and conservation values the wetland is at significant level of possible impact. Although the current ecological condition of Harrisdale Swamp is unknown, it is likely that vegetation condition will decline.

Terrestrial Vegetation

<u>Gnangara Mound</u>

PM24

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at PM24 declined 0.02 m from 1995-2003. There appears to have been no associated change in ecological condition, with a large number of *E. rudis* and *M. preissiana* saplings currently establishing.

2. Current hydrology, ecological condition and conservation values.
PM24 is located in the basin of Lake Pinjar in an area of 0-3 m depth to groundwater. Despite clearing of much of the wetland basin for agriculture vegetation in the vicinity of PM24 is relatively intact and supports one of the remaining examples of the Pinjar Vegetation Complex in the area. PM24 therefore retains its high conservation values.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for PM24 indicates the wetland may experience an increase in groundwater levels of 0.25-0.5 m by 2005 and 2008, with levels then decreasing 0.25-0.5 m by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted at PM24 over each time period combined with historic changes and conservation values represent a significant level of possible impact. This may result in the contraction of sedge species and terrestrialisation of the wetland basin. However, the saplings establishing in the area should persist.

MT3S

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at MT3S declined 0.38 m from 1995-2003. There appears to have been no associated change in ecological condition.

2. Current hydrology, ecological condition and conservation values.
MT3S is located in a small area of remnant *Banksia* woodland at 6-10 m depth to groundwater. The site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for MT3S predicts groundwater drawdown of 0.75-1.0 m by 2005 increasing to 2.0-3.0m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown exceed that required to maintain a low risk of impact.

Drawdown predicted over each time period combined with historic changes and conservation values represent a moderate level of possible impact. This may result in the loss of some individual *Banksia* and encroachment of more drought tolerant species.

MM18

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at MM18 declined 0.40 m from 1995 to 2003. This coincided with some decline in condition of individual *Banksia*.

2. Current hydrology, ecological condition and conservation values.
MM18 is located in *Banksia* woodland at 3-6 m to groundwater. Although it is adjacent to a major road, the woodland of Whiteman Park is of high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for MM18 indicates groundwater levels may increase 0.5-0.75 m by 2005 and 2008, and 0.25-0.5 m by 2013. Although an increase in groundwater levels should not impact on vegetation the area remains at moderate risk due to historic changes, high conservation values and current depth to groundwater.

MM53

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at MM53 increased 0.08 m from 1995 to 2003. Although this appeared to have little impact there was some decline in vegetation condition during summer 2003/04.

2. Current hydrology, ecological condition and conservation values.
MM53 is located in *Banksia* woodland at 3-6 m depth to groundwater within Whiteman Park. The woodland remains intact and retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for MM53 indicates the wetland may experience an increase in groundwater levels of 0-0.25 m by 2005, to 0.5-0.75 by 2008, and 0.25-0.5 m by 2013. Due to increases in groundwater levels, historic changes, high conservation values and current depth to groundwater the risk of impact to vegetation at MM53 is not significant.

MM59B

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at MM59B decreased 0.2 m from 1995 to 2003. A number of dead and stressed *Banksias* were noted in the area in 2003.

2. Current hydrology, ecological condition and conservation values.
MM59B is located in *Banksia* woodland at 3-6 m depth to groundwater within Whiteman Park. Despite some decline in condition the woodland remains intact and retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for MM59B predicts groundwater level declines of 0.25-0.5 m by 2005, 2008 and 2013. Although the magnitude and rate of drawdown should maintain a low risk of impact, in combination with historic changes, conservation values and current depth to groundwater they represent a moderate to significant level of possible impact. This may result in changes in the distribution of some species and encroachment of more drought tolerant species.

MM55B

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at MM55B increased 0.18 m from 1995-2003. There has been no change in ecological condition at this site.

2. Current hydrology, ecological condition and conservation values.
MM55B is located in *Melaleuca* woodland at 0-3 m depth to groundwater within Whiteman Park. As much of the surrounding area has been cleared for grazing the conservation value of the site is moderate.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for MM55B predicts groundwater level declines of 0.5-0.75 m by 2005, decreasing to 0-0.25 m by 2008 and 0.25-0.5 m by 2013. Although there has been a historic groundwater level increase, the combination of conservation values, current depth to groundwater and predicted changes places MM55B at moderate risk of impact. This may result in changing distribution of *M. preissiana* and wetland shrubs in the vicinity.

MM16

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at MM16 increased 0.025 m from 1995 to 2003. There appears to have been no associated change in ecological condition at this site.

2. Current hydrology, ecological condition and conservation values.

MM16 is located in *Banksia* woodland at 3-6 m depth to groundwater within a Bush Forever site that supports a TEC. The woodland remains intact and retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for MM16 predicts groundwater level declines of 1.0-2.0 m by 2005, increasing 2.0-3.0 m by 2008 and >3.0 m by 2013. Although there has been a historic groundwater level increase, the combination of conservation values, current depth to groundwater and predicted changes places MM16 at significant risk of impact. This may result in changes in the distribution of some species and encroachment of more drought tolerant species.

PM9

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at PM9 decreased 1.2 m from 1995 to 2003. This coincided with significant declines in understorey density and deaths of individual *Banksias* in the area.

2. Current hydrology, ecological condition and conservation values.

PM9 occurs in a Bush Forever site in *Banksia* woodland at 6-10 m depth to groundwater. Due to the significant decline in vegetation condition, conservation values can only be regarded as moderate.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for PM9 predicts groundwater level declines of 0.75-1.0 m by 2005 and 2008 increasing to 2.0-3.0 m by 2013. Although historic and predicted drawdowns are significant, the greater depth to groundwater and lower conservation value places PM9 at a moderate risk of impact. This could result in further loss of phreatophytic *Banksia* and encroachment of more drought tolerant species in both the overstorey and understorey.

WM1

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at WM1 decreased 0.67 m from 1995 to 2003. This coincided with thinning in the understorey and some *Banksia* deaths.

2. Current hydrology, ecological condition and conservation values.

WM1 is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation condition the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for WM1 predicts a groundwater level increase of 0.25-0.5 m by 2005, and 0-0.25 by 2008, before decreasing 0.25-0.5 m by 2013. Although the drawdown predicted to 2013 is negated by the increases to 2005 and 2008, historic changes in combination with current depth to groundwater and conservation values represent a moderate level of possible impact. This may result in further decline in *Banksia* woodland condition.

WM2

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at WM2 decreased 0.38 m from 1995 to 2003. This coincided with decreased vegetation density.

2. Current hydrology, ecological condition and conservation values.

WM2 is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation density the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for WM2 predicts a groundwater level decline of 0.25-0.5 m by 2005, increasing to 1.0-2.0 m by 2008, and 2.0-3.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. This is likely to result in deaths of mature *Banksia* sp., thinning of the understorey and encroachment of more xeric species.

WM8

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at WM8 decreased 0.25 m from 1995 to 2003. This coincided with decreased vegetation density.

2. Current hydrology, ecological condition and conservation values.

WM8 is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation density the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for WM8 predicts a groundwater level decline of >3.0 m by 2005, continuing to 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. This is likely to result in deaths of mature *Banksia* sp., thinning of the understorey and encroachment of more xeric species.

NR6C

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at NR6C decreased 0.47 m from 1995 to 2003. This coincided with decreased vegetation density.

2. Current hydrology, ecological condition and conservation values.

NR6C is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation density and the site is in close proximity to a pine plantation it retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for NR6C predicts a groundwater level decline of 2.0-3.0 m by 2005, increasing to >3.0 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. This is likely to result in deaths of mature *Banksia* sp., thinning of the understorey and encroachment of more xeric species.

NR11C

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at NR11C decreased 0.26 m from 1995 to 2003. This coincided with decreased vegetation density.

2. Current hydrology, ecological condition and conservation values.

NR11C is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation density the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for NR11C predicts a groundwater level decline of 1.0-2.0 m by 2005, increasing to 2.0-3.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. This is likely to result in deaths of mature *Banksia* sp., thinning of the understorey and encroachment of more xeric species.

L30C

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at L30C decreased 0.09 m from 1995 to 2003. This coincided with decreased vegetation density.

2. Current hydrology, ecological condition and conservation values.

L30C is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Although there has been some decline in vegetation density the site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for L30C predicts a groundwater level decline of 0.75-1.0 m by 2005, 0-0.25 m by 2008 and 0.75-1.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. This is likely to result in further declines in vegetation density due to spot deaths and vegetation condition decline.

L110C

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at L110C decreased 0.25 m from 1995 to 2003. This coincided with decreased vegetation density due to spot deaths in mature *Banksia attenuata*.

2. Current hydrology, ecological condition and conservation values.

L110C is located within a Bush Forever site in *Banksia* woodland at 6-10 m depth to groundwater. Although there has been some decline in vegetation density the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for L110C predicts a groundwater level increase of 0-0.25 m by 2005, levels will then decline 0-0.25 m by 2008 and 1.0-2.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values do not represent a significant level of possible impact. However, there may be some decline in vegetation condition.

L220C

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at L220C decreased 0.08 m from 1995 to 2003. There appears to have been no associated change in ecological condition at this site.

2. Current hydrology, ecological condition and conservation values.

L220C is located within a Bush Forever site in *Banksia* woodland at 6-10 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for L200C predicts a groundwater level decrease of 0-0.25 m by 2005, 0.5-0.75 m by 2008 and 0.75-1.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. This may result in some decline in vegetation condition.

MM12

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at MM12 decreased 0.90 m from 1995 to 2003. There is some evidence declines in condition and density of *Banksia* woodland at this site.

2. Current hydrology, ecological condition and conservation values.

MM12 is located within a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for MM12 predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 1.0-2.0 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. This may result in spot deaths of mature *Banksia* and declines in vegetation density.

Ridges*

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at Ridges decreased from 1995 to 2003, with declines ranging from 0.25 m to 2.0 m across the area. This coincided with declines in condition and deaths of *B. ilicifolia* and *E. rudis* at this site.

2. Current hydrology, ecological condition and conservation values.

Ridges is located within a Bush Forever site and supports a Threatened Ecological Community (SCP14). Although there are a number of *E. rudis* in the basin the majority of the site is *Banksia* woodland at 3-6 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Ridges predicts a groundwater level decrease of 1.0-2.0 m by 2005, 2.0-3.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a severe level of possible impact. This is likely to lead to deaths of *B. ilicifolia* and *E. rudis* and phreatophytic *Banksias* and encroachment of more xeric species.

Rosella Rd Bushland (north)*

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels in the northern region of Rosella Rd Bushland have declined significantly, with drawdown of >2.0 m in areas of 3-6 m and 6-10 m depth to groundwater. It is not known what impact these declines have had on the vegetation. However, there is likely to have been greater impact in areas of lower depth to groundwater.

2. Current hydrology, ecological condition and conservation values.

Rosella Rd. Bushland is a Bush Forever Site. Although there may have been drawdown impact the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Rosella Rd Bushland predicts a groundwater level decrease of 0.5-0.75 m and 0.75-1.0 m by 2005, 1.0-2.0 m by 2008 and >3.0 m by 2013. Vegetation in the 3-6 m depth to groundwater category is at significant risk of impact level with that in the 6-10 m category at moderate risk of impact. This may result in declines in vegetation condition.

Muchea Air Weapons Range*

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels in the Muchea Air Weapons Range have declined up to 2.0 m in areas of 6-10 m depth to groundwater. It is not known what impact these declines have had on the vegetation.

2. Current hydrology, ecological condition and conservation values.
Muchea Air Weapons Range is a Bush Forever Site. Although there may have been drawdown impact the site retains its high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Muchea Air Weapons Range predicts a groundwater level decrease of 0.75-1.0 m by 2005, to 1.0-2.0 m by 2008 and >3.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. This may result in declines in vegetation condition.

<u>Jandakot</u>

JE17C

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JE17C increased 0.03 m from 1993, when records commenced, to 2003. There is some evidence of declines in condition and density of *E. rudis* at this site.

2. Current hydrology, ecological condition and conservation values.
JE17C is located within a Bush Forever site in *E. rudis/M. preissiana* woodland at 0-3 m depth to groundwater. Despite some decline in vegetation condition and invasion of the understorey by exotics, the site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for Ridges predicts a groundwater level decrease of 0.5-0.75 m by 2005, to 0.25-0.5 m by 2008 and 0.5-0.75 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. It is possible that there will be declines in the condition of *M. preissiana* and further declines in *E. rudis.*

JE10C

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JE10C increased 0.88 m from 1992 to 2003. There has been a recent decline in the condition of *Banksia* woodland at this site.

2. Current hydrology, ecological condition and conservation values.
JE10C is located on a road verge adjacent to private property in *Banksia* woodland at 3-6 m depth to groundwater. Due to near-by clearing and some reduction in the condition of the vegetation this site is of moderate conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JE10C predicts a groundwater level decrease of 0.25-0.5 m by 2005 and 0.75-1.0 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values do not represent a significant level of possible impact. There may however, be some further decline in the condition of mature *Banksias*.

JM31

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JM31 decreased 0.79 m from 1992 to 2003. There has been some decline in the condition of *Banksia* woodland at this site.

2. Current hydrology, ecological condition and conservation values.
JM31 is located on a road verge adjacent to private property in *Banksia* woodland at 3-6 m depth to groundwater. Due to near-by clearing and some reduction in the condition of the vegetation this site is of moderate conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM31 predicts a groundwater level decrease of 0.25-0.5 m by 2005, 0.5-0.75 m by 2008 and 0.75-1.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. It is likely that there will be further decline in the condition of mature *Banksias*.

JM19

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JM19 decreased 1.26 m from 1992 to 2003. There has been some decline in the condition of *Banksia* woodland at this site.

2. Current hydrology, ecological condition and conservation values.
JE17C is located on the boundary of a Bush Forever site in *Banksia* woodland at 6-10 m depth to groundwater. Groundwater levels are influenced by abstraction from a nearby sand mine and much of the area has been cleared. The site is however, of high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM19 predicts a groundwater level decrease of 0.25-0.5 m by 2005, 0-0.25 m by 2008 and 0.25-0.5 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. It is possible that there will be further decline in the condition of mature *Banksias*.

JM35

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JM35 increased 1.39 m from 1992 to 2003. There has been some recent decline in the condition of *Banksia* woodland at this site.

2. Current hydrology, ecological condition and conservation values.
JM35 is located on the boundary of a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Despite some decline in vegetation condition and impacts of the adjacent road, the site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM35 predicts a groundwater level decrease of 0.25-0.5 m by 2005, 0-0.25 m by 2008 and 0.25-0.5 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. It is possible that there will be further decline in the condition of mature *Banksias*.

JE4C

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JE4C decreased 0.82 m from 1992 to 2003. This coincided with a general decline in the condition of nearby *Banksia* woodland and *M. preissiana*.

2. Current hydrology, ecological condition and conservation values.
JE4C is located in a Bush Forever site in *Melaleuca* woodland at 3-6 m depth to groundwater. Despite some decline in vegetation condition, the site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JE4C predicts a groundwater level decrease of 0.5-0.75 m by 2005, to 0.75-1.0 m by 2008 and 1.0-2.0 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact. It is likely that there will be further decline in the condition of mature *Banksia* and *M. preissiana* and some encroachment of more xeric species.

JM7

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM7 decreased 1.25 m from 1992 to 2003. This coincided with a significant decline in the condition of *M. preissiana* and *E. rudis* and nearby *Banksia* woodland.

2. Current hydrology, ecological condition and conservation values.

JM7 is located in a Bush Forever site in *M. preissiana/ E. rudis* woodland at 3-6 m depth to groundwater. Due to the decline in vegetation condition, the site has dropped from very high to high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JM7 predicts a groundwater level decrease of 0.75-1.0 m by 2005, and 0.5-0.75 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be further decline in the condition of *M. preissiana* and *E. rudis* and nearby *Banksia* woodland and some encroachment of more xeric species.

JM8

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM8 decreased 1.32 m from 1992 to 2003. Recent signs of water stress have been noted in *Banksia* woodland in the vicinity.

2. Current hydrology, ecological condition and conservation values.

JM8 is located in a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JM8 predicts a groundwater level decrease of 0.75-1.0 m by 2005, 0-0.25 m by 2008 and 0.25-0.5 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be further decline in the condition of mature *Banksias.*

JM45

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM45 decreased 1.32 m from 1992 to 2003. Recent signs of water stress have been noted in mature *E. rudis* and *M. preissiana* and *Banksia* woodland in the vicinity.

2. Current hydrology, ecological condition and conservation values.

JM45 is located in a Bush Forever site in mixed *E. rudis/ M. preissiana*/ *Banksia* woodland at 3-6 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JM45 predicts a groundwater level decrease of 0.25-0.5 m by 2005, 0.25-0.5 m by 2008 and 0.5-0.75 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be further decline in the condition of *M. preissiana* and *E. rudis* and nearby *Banksia* woodland.

8284

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at 8284 decreased 1.26 m from 1992 to 2003. Recent signs of water stress have been noted in mature *E. rudis* and *M. preissiana* in the vicinity.

2. Current hydrology, ecological condition and conservation values.

8284 is located on a road verge adjacent to private property in mixed *M. preissiana/ E. rudis/ Banksia* woodland at 3-6 m depth to groundwater. Due to near-by clearing and some reduction in the condition of the vegetation this site is of moderate conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for 8284 predicts a groundwater level decrease of 0.5-0.75 m by 2005, 0-0.25 m by 2008 and 0.25-0.5 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be further decline in the condition of *M. preissiana* and *E. rudis* and encroachment of more xeric species.

JM49

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM49 decreased 0.39 m from 1992 to 2003. There appears to have been some change in the condition of vegetation in the vicinity.

2. Current hydrology, ecological condition and conservation values.

JM49 is located on a road verge adjacent to private property in mixed *M. preissiana/ B. littoralis* woodland at 3-6 m depth to groundwater. Due to near-by clearing and some reduction in the condition of the vegetation this site is of moderate conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JM49 predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 1.0-2.0 m 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be further decline in the condition of *M. preissiana* and possible spot deaths in *B. littoralis* and encroachment of more xeric species.

JM39

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM39 decreased 1.32 m from 1992 to 2003. There appears to have been little change in the condition of vegetation in the vicinity.

2. Current hydrology, ecological condition and conservation values.

JM39 is located on a road verge adjacent to private property in *Melaleuca/ Banksia* woodland at 3-6 m depth to groundwater. Due to near-by clearing this site is of moderate conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for JM39 predicts a groundwater level decrease of 0.75-1.0 m by 2005, 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be declines in condition of mature *Melaleuca* and *Banksias* and encroachment of more xeric species.

JM16

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at JM16 decreased 0.71 m from 1992 to 2003. There appears to have been little change in the condition of vegetation in the vicinity.

2. Current hydrology, ecological condition and conservation values.
JM16 is located in a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. The site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM16 predicts a groundwater level decrease of 0-0.25 m by 2005 before rising 0-0.25 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is likely that there will be some decline in the condition of mature *Banksias*.

JM14

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JM14 decreased 0.73 m from 1992 to 2003. There has been some recent declines and deaths of mature *Banksias* in the vicinity.

2. Current hydrology, ecological condition and conservation values.
JM16 is located in a Bush Forever site in *Banksia* woodland at 3-6 m depth to groundwater. Despite some decline in condition, the site retains its very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM14 predicts a groundwater level decrease of 0.5-0.75 m by 2005 and to 0-0.25 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate to significant level of possible impact. It is possible that there will be some decline in the condition of mature *Banksias*.

Anstey/Keane Bushland*

1. Historic water level change and associated changes in ecological condition.
Minimum groundwater levels at JM23 decreased 0.73 m from 1992 to 2003. It is not known if there have been associated changes in vegetation condition in the area.

2. Current hydrology, ecological condition and conservation values.
Anstey/Keane Bushland is a Bush Forever Site in *M. preissiana* and *Banksia* sp woodland at 0-3 m depth to groundwater. The site is of high conservation value.

3. Predicted drawdown and possible GDE/community/species response.
PRAMS 3.0 modelled drawdown for JM23 predicts a groundwater level decrease of 0.25-0.5 m by 2005 and to 0-0.25 m by 2008 and 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant to severe level of possible impact. There is likely to be some decline in the condition of phreatophytic vegetation across the area.

Base Flow Systems

Bennett Brook*

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at MM49B in the vicinity of Bennett Brook increased 0.12 m from 1995 to 2003. It is not known if the surface water levels of the Brook have changed during this time. The current condition of vegetation at Bennett Brook is unknown.

2. Current hydrology, ecological condition and conservation values.

Some areas of Bennett Brook, including Mussel Pool appear to be permanently inundated. Despite clearing of much native vegetation in the area for recreation, the wetland supports fauna and maintains a high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Bennett Brook predicts a groundwater level increase of 0.25-0.5 m by 2005, 0.75-1.0 m by 2008 and 0.5-0.75 m by 2013. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a moderate level of possible impact. However, it is likely that increased water levels will negate any previous impacts on vegetation condition.

Quin Brook*

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at GB22 and GB16 in the vicinity of Quin Brook decreased 0.49 m and 0.73 m respectively from 1995 to 2003. There does not appear to have been associated changes in vegetation condition in the area.

2. Current hydrology, ecological condition and conservation values.

Quin Brook comprises of a series of interconnected wetlands in an area of 0-3 m and 3-6 m depth to groundwater dominated. The wetlands are of high conservation value due to the pristine nature of the vegetation (*M. rhaphiophylla, E. rudis* and *M. preissiana*) despite recent fire and some weed invasion.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Quin Brook predicts a groundwater level decrease in the south (lake area) of 0.25-0.5 m by 2005, 0.5-0.75 m by 2008 and 1.0-2.0 m by 2013. The remaining three wetlands may experience drawdown of 0.5-0.75 by 2005, 0.75-1.0 m by 2008 and 2.0-3.0 m by 201. The magnitude and rate of drawdown over each time period combined with historic changes, current depth to groundwater and conservation values represent a significant level of possible impact in the south a sever risk in the north. There is likely to be decline in the condition of *M. rhaphiophylla, E. rudis, M. preissiana* and other groundwater dependent vegetation.

Cave and Aquifer Ecosystems

Crystal Cave (YN1)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN3 in the vicinity of Crystal Cave decreased 0.64 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that once occurred in Crystal Cave is now dry. Cave Fauna now persist only in artificial pools however, the cave maintains a very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Crystal Cave predicts a groundwater level decrease of 1.0-2.0 m by 2005 and 2008 and 2.0-3.0 m by 2013. Cave fauna will be unable to survive unaided in Crystal Cave.

Water Cave (YN11)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN7 in the vicinity of Water Cave decreased 0.47 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The flow of the permanent stream that occurs in Water Cave has decreased. However, root mat communities persist and the cave maintains a very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Water Cave predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 1.0-2.0 m by 2008 and 2013. This is likely to lead to drying of the stream and loss of root mats and associated fauna.

Carpark Cave (YN18)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN7 in the vicinity of Carpark Cave decreased 0.47 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that occurs in Carpark Cave now dries for most of the year. However, root mat communities may persist and the cave maintains a very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Carpark Cave predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 1.0-2.0 m by 2008 and 2013. This is likely to lead to total drying of the stream and loss of root mats and associated fauna.

Gilgie Cave (YN27)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN8 in the vicinity of Gilgie Cave decreased 1.03 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that occurred in Gilgie Cave has dried. Although it is unlikely that root mat communities persist, the cave should be regarded as being of high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Gilgie Cave predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 2008 and 1.0-2.0 m by 2013. This is likely to lead to total loss of root mats and associated fauna.

Cabaret Cave (YN30)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN3 and YN4 in the vicinity of Cabaret Cave decreased 0.39 m and 0.64 m respectively from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that occurred in Cabaret Cave has dried. Although it is unlikely that root mat communities persist, the cave should be regarded as being of high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Cabaret Cave predicts a groundwater level decrease of 1.0-2.0 m by 2005 and 2.0-3.0 m by 2008 and 2013. This is likely to lead to total loss of root mats and associated fauna.

Boomerang Cave (YN99)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN3 in the vicinity of Boomerang Cave decreased 0.64 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that occurs in Boomerang Cave now dries for most of the year. However, root mat communities may persist and the cave maintains a very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Boomerang Cave predicts a groundwater level decrease of 1.0-2.0 m by 2005 and 2008 and 2.0-3.0 m by 2013. This is likely to lead to total loss of root mats and associated fauna.

Twilight Cave (194)

1. Historic water level change and associated changes in ecological condition.

Minimum groundwater levels at YN8 in the vicinity of Twilight Cave decreased 1.03 m from 1995 to 2003.

2. Current hydrology, ecological condition and conservation values.

The permanent stream that occurs in Twilight Cave now dries for most of the year. However, root mat communities may persist and the cave maintains a very high conservation value.

3. Predicted drawdown and possible GDE/community/species response.

PRAMS 3.0 modelled drawdown for Twilight Cave predicts a groundwater level decrease of 0.75-1.0 m by 2005 and 2008 and 1.0-2.0 m by 2013. This is likely to lead to total loss of root mats and associated fauna.

YN61*

Location unknown

YN555*

Location unknown

Orpheus Cave (YN256)*

Location unknown

Jackhammer Cave (YN438)*

Location unknown

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APPENDICES

APPENDIX 1: REVIEW OF THE REPRESENTATIVENESS OF JANDAKOT TERRESTRIAL VEGETATION CRITERIA BORES

All terrestrial criteria bores on the Jandakot Mound were visited during April 2004 to assess vegetation condition and the appropriateness of bores as representative of vegetation in the vicinity. Descriptions of sites were supplemented by photographs. Three bores could not be located, JM8, JM15 and JM39.

During the field visits it was noted that land adjacent to many of the bores had been either totally or partially cleared for urban development or other forms of land-use in recent years rendering a number of sites unrepresentative of terrestrial vegetation and reducing the value of others. Of the 25 bores assessed only 8-10 remain truly representative of phreatophytic terrestrial vegetation as shown in the table below. It is the recommendation of the authors that bores 'not representative of terrestrial vegetation' be decommissioned as criteria bores.

Representative of terrestrial vegetation	Representativeness impacted by other factors (land use)	Not representative of terrestrial vegetation
JE17C	JE20C	JM23C
JE4C	JM24	J310
JM7	JE10C	JE18C
JM8	JM31	JM19
JM45	JM35	JM27
JE12C	JM29	JM5
JM16	JM49	JE19C
JM14	JM33	JM18
8284	JE1B	
JM39	JM15	

JE17C

JE17C is located on Branch Cross within the Thomson Lake Nature Reserve. The vegetation surrounding JE17C is *Eucalyptus rudis* and *Melaleuca preissiana* woodland with a fairly dense overstorey with bracken fern and an exotic understorey containing *Pelargonium capitatum* and *Conyza albida* (fleabane). The opposite side of the road is *M. preissiana* and insect impacted *E. rudis*. This area is representative of terrestrial vegetation however, declared rare flora is no longer recorded for this site on the CALM flora base. The condition of the surrounding vegetation is good.

Looking west towards JE17C and *E. rudis /M. preissiana* woodland of Thomsons Lake Nature Reserve.

Looking east from JE17C towards *E. rudis /M. preissiana* woodland with weed dominated understorey.

<u>JE4C</u>

JE4C is located in the Denis De Young Reserve. The vegetation west of JE4C is *Melaleuca spp.* and dense healthy intact *Casuarina* woodland. Twenty meters east of the bore the vegetation is *M. preissiana* and *B. menziesii* with some *B. ilicifolia* 100m south of the bore. This area is representative of terrestrial vegetation and the condition of the surrounding vegetation is good.

Looking east from JE4C towards dense, intact mixed woodland of Denis de Young Reserve.

Looking west at JE4C.

<u>JM7</u>

JM7 is located on Hope Road leading into Jandakot Airport. The vegetation surrounding JM7 is impacted *E. rudis* and *M. preissiana* woodland above a weedy understorey. Several of the large *M. preissiana* are resprouting and the *E. rudis* have been damaged by insects. This is upslope from *E. rudis* and *Banksia spp.* woodland. On the opposite side of the road the vegetation consists of *Banksia spp.* and *E. todtiana* woodland which is in reasonable condition. This area is representative of terrestrial vegetation however, declared rare flora is no longer recorded for this site on the CALM flora base. The condition of the surrounding vegetation is reasonable.

Looking south towards JM7 and severely impacted mature *M. preissiana*.

Looking north from JM7 into *Banksia* woodland.

Impacted *E. rudis* south-east of JM7.

JM8

JM8 is located within the grounds of the Jandakot Airport. This area is representative of terrestrial vegetation and declared rare flora is recorded for this site on the CALM flora base.

JM45

JM45 is located in remnant vegetation southwest of the Jandakot airport. The vegetation close to JM45 is insect impacted *E. rudis* woodland with some *M. preissiana* which are showing signs of tip drying. Surrounding this is *Banksia* woodland showing signs of seasonal drying but generally in good health. This area is representative of terrestrial vegetation however, declared rare flora is no longer recorded for this site on the CALM flora base. The condition of the surrounding vegetation is good.

Looking west from JM45.

Looking north-west from JM45 towards impacted *E. rudis*.

JE12C

JE12C is located on Rowley Road (private property) opposite developed semi-rural land 500m west of intact *Banksia* woodland. The vegetation surrounding JE12C is intact healthy *Banksia* and *Eucalyptus* woodland. This area is representative of terrestrial vegetation. The depth to groundwater in the vicinity if JE12C is greater than 12m and therefore the vegetation is not considered highly groundwater dependant. The condition of the surrounding vegetation is good.

Looking south towards JE12C and healthy *Banksia* woodland.

Looking north from JE12C towards private property.

JM16

JM16 is located at the Harrisdale Swamp Bushland. The vegetation consists of intact *B. attenuata* and *B. menziesii* woodland (1 dead *B. attenuata* noted) with *Banksia* woodland of Canning Vale Prison Bushland on the opposite side of the road. This area is representative of terrestrial vegetation and the condition of the surrounding vegetation is good.

Looking east towards JM16 and intact *Banksia* woodland of Harrisdale Swamp Bushland.

Looking west from JM16 towards *Banksia* woodland of Canningvale Prison Bushland.

JM14

JM14 is located in the Acourt Road Bushland, Jandakot Regional Park. The vegetation consists of *Banksia* woodland with *M. preissiana*. Although an undisturbed area there is evidence of impact with recent deaths of *B. attenuata* and older deaths of *B. ilicifolia, B. attenuata* and *B. menziesii* and drying of *B. elegans* in understorey. This area is representative of terrestrial vegetation and the condition of the surrounding vegetation is good.

Looking north from JM14 towards *M. preissiana* and wetland vegetation.

Looking east towards JM14 and dead *Banksia*.

Looking south from JM14 towards healthy *Banksia* overstorey above impacted *Beaufortia elegans*.

<u>8284</u>

8284 is located on private property on Solomon Road. The vegetation on the private property side contains some *E. rudis* and *M. preissiana*. Adjacent to this is the sand mine which has an area of bush near by that contains *M. preissiana*. On the opposite side of the road the vegetation is remnant *Banksia* on cleared semi-rural land. This is approximately 100m north from intact, healthy *Banksia* woodland of Fraser Road Reserve. This area is representative of terrestrial vegetation and the condition of the surrounding vegetation is good.

Looking west towards 8284 and private property.

Looking east from 8284 towards largely cleared private property.

JM39

JM39 is located on Rowley Road. Although we have not yet found the site it appears to be in the vicinity of intact *M. preissiana* and *M. rhaphiophylla* woodland surrounded by semi-rural lots. This area is representative of terrestrial vegetation and the condition of the surrounding vegetation is good.

JE20C

JE20C is located on Beenyup Road opposite the cut flower farm that leads through to Beenyup Swamp. The vegetation on the side of the road with the bore is *Banksia* woodland with dense *Melaleuca spp*. which look healthy. This is also private property. This areas representativeness has been impacted by land use changes. The vegetation condition is good.

Looking east towards JE20C and *Melaleuca* woodland on private property.

Looking west from JE20C towards cut flower farm on private property.

JM24

JM24 is located off Hammond Road. The vegetation consists of a small area of healthy mixed *Banksia* woodland (1ha) (*B. attenuata, B. menziesii & B. ilicifolia*). The opposite side of the road has been recently cleared for urban land. There is an area of *E. rudis* approximately 100m to the west. This areas representativeness has been impacted by land use changes. The condition of the remnant vegetation is good.

Looking north from JM24 towards remnant *Banksia* woodland.

Looking south from JM24 towards recently cleared urban land.

JE10C

JE10C is located on Liddelow Road. The land is private property on both sides of the road. The vegetation is impacted *Banksia* (some young *B. ilicifolia* and *B. menziesii* dead) and *Casuarina* woodland with semi-cleared private property opposite. This areas representativeness has been impacted by land use changes. The vegetation condition is reasonable.

Looking east towards JE10C and impacted *Banksia* woodland on private property.

Looking west from JE10C towards disturbed vegetation on private property.

JM31

JM31 is located on Taylor Road (private property). The opposite side has an open area dominated by exotics with some *E. rudis* in the overstorey. An area of *Acacia* shrubs occurs some 100m to the west. This areas representativeness has been impacted by land use changes. The vegetation condition is reasonable.

Looking east from JM31 towards private property.

Looking west from JM31towards partly cleared *E. rudis* woodland.

<u>JM35</u>

JM35 is located on Taylor Road opposite Denis De Young Reserve (part of Jandakot Regional Park). The vegetation consists of impacted *Banksia* and *Casuarina* woodland opposite cleared land. This areas representativeness has been impacted by land use changes. The vegetation condition is reasonable.

Looking east towards JM35 and impacted *Banksia /Casuarina* woodland.

Looking west from JM35 towards Denis de Young Reserve.

<u>JM29</u>

JM29 is located on Beenyup Road (private property). On the opposite side there is an open area and *M. preissiana/E. rudis* woodland approximately 50m southwest of the bore. Urban development has begun approximately 200m northwest of the bore. This areas representativeness has been impacted by land use changes. The condition of remnant vegetation is reasonable.

Looking east towards JM29 and cleared private property.

Looking west from JM29 and newly cleared urban land (left side of photo).

Looking south-west from JM29 towards remnant *M. preissiana / E. rudis* woodland.

JM49

JM49 is located on Rowley Road on private property. The vegetation consists of *B. littoralis* and *M. preissiana* woodland with dense bracken fern and exotics in the understorey. On the opposite side there is private property which is highly disturbed and 100m west is intact *Banksia* woodland. This areas representativeness has been impacted by land use changes. The vegetation condition is reasonable.

Looking south towards JM49 and *Banksia / Melaleuca* woodland on private property.

Looking north from JM49 towards private property,

Looking south-west from JM49 towards intact *Banksia* woodland.

JM33

JM33 is located on Barfield Road. The vegetation consists of a large area of intact *Banksia / Casuarina* woodland. On the opposite side there is newly cleared urban land. This areas representativeness has been impacted by land use changes. The vegetation condition is reasonable.

Looking east towards JM33 and healthy, intact *Banksia* woodland.

Looking west from JM33 towards recently cleared urban land.

JE1B

JE1B is located on Solomon Road. The vegetation consists of *B. attenuata* and *B. menziesii* woodland. Approximately 100m west of the sand mine, on the opposite side, the vegetation is intact *Banksia* woodland on private property. This areas representativeness has been impacted by land use changes. The depth to groundwater is greater than 10m and therefore the vegetation is not considered highly groundwater dependant. The vegetation condition is reasonable.

Looking west towards JE1B and *Banksia* woodland on private property.

Looking east from JE1B towards band of *Banksia* woodland adjacent to sand-mine.

<u>JM15</u>

JM15 is located ??? could not find.

<u>JM23C</u>

JM23C is located on private property on Gaebler Road. On the opposite side the land has been recently cleared for urban development. This area is not representative of terrestrial vegetation.

Looking south from JM23C and cleared rural land.

Looking north from JM23C towards recently cleared urban land.

<u>J310</u>

J310 is located on Princep Road in an industrial area. There is no vegetation native directly adjacent to the bore, the closest vegetation consists of healthy, intact *E. rudis* 50m to the west and the condition of the understorey is not known. This area is not representative of terrestrial vegetation. Declared rare flora is no longer recorded for this site on the CALM flora base.

Looking west towards J310 and a timber yard. *E. rudis* can be seen in the background.

Looking east from J310 towards an industrial area.

<u>JE18C</u>

JE18C is located on private property on Tapper Road. The vegetation has been largely cleared, with only a few *E. rudis* left on the road edge. On the opposite side there is a park with a small wetland surrounded by *M. preissiana*, which is approximately 500m from intact vegetation and an area of *Typha*. This area is not representative of terrestrial vegetation.

Looking east towards JE18C and private property.

Looking west from J310 towards reticulated parkland.

<u>JM19</u>

JM19 is located in the Fraser Road Bushland in close proximity to a sand mine. What little vegetation remains in the vicinity is influenced by groundwater abstraction for the mine. This area is not representative of terrestrial vegetation.

Aerial photo showing location of JM19 in area impacted by sand mining.

JM27

JM27 is located on Armadale Road. The vegetation consists of a 20m wide strip of *Banksia / Casuarina* woodland along the roadside. On the opposite side of the road is a cleared rural area. This area is not representative of terrestrial vegetation.

Looking south towards JM27 and cleared rural land.

Looking north from JM27 across Armadale Rd and towards cleared rural land.

JM5

JM5 is located in the grounds of a primary school on Eucalyptus Boulevard in an urban area. This area is not representative of terrestrial vegetation.

Looking north across school ground towards JM5.

Aerial photo showing location of JM5 in the grounds of an urban school.

JE19C

JE19C is located on Beenyup Rd. (private property). On the opposite side of the road the land has been cleared for urban land development (previously *Melaleuca* woodland). The Jandakot Regional Park is located approximately 100m south and the vegetation there is dense wetland vegetation. The area surrounding JE19C is not representative of terrestrial vegetation. Declared rare flora is no longer recorded for this site on the CALM flora base.

Looking east towards JE19C and private property.

Looking west from JE19C towards recently cleared urban land.

JM18

JM 18 is located in a cleared industrial area 400m north of a managed conservation reserve. Wetland vegetation in reserve (*M. preissiana, B. articulata, A. fascicularis*) intact and healthy and there is evidence of a weed control program. However, the area surrounding JM18 has all been cleared for industrial use.

Looking north towards JM18 and recently cleared industrial land.

Looking south from JM18 and recently cleared industrial land. Wetland reserve can be seen in the background.

APPENDIX 2: ASSESSMENT OF VEGETATION AND WETLAND CONDITION AT 'NEW' STUDY WETLANDS.

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
Out of Map Range	Ridges - Damplands	Category = none given. Some clearing in north section (limestone mining). Track to wetland fringe leading to dumping of car bodies & rubbish.	Terrestrial: Open Woodland of *B. menziesii*, *B. grandis* & *B. ilicifolia*. Understorey dominated by *Adenanthos sp*., *J. furcellata* & *Eremaea sp*. Wetland: Woodland to open woodland of *E. Rudis* & *M. preissiana*. Open heath of *K. ericifolia* around wetland & extending to terrestrial community.	Weeds generally restricted to northern section where pine trees are establishing. Mature E. rudis highly stressed over most of wetland. K. ericifolia heath appears drought stressed
2034 II SW	Lake Gwelup (38561647226)	Category =2 Lake surrounded by parkland & urban development with wide buffer of remnant bushland to the north. Main area of lake fed by drains & supports herbage of annual weeds, suggesting surface water is annually present. Lake dry in April 2004.	Terrestrial: Open woodland *of E. gomphocephala* & *C. calophylla* with *Acacia saligna* Wetland: Open forest of *E. rudis* & *M. rhaphiophylla* with annual & perennial grasses dominating understorey. Sedgeland of *Typha orientalis* in band around lake.	Terrestrial: Recent fire has scorched most of the trees in close proximity to the lake. Wetland: Wetland trees stressed due to recent fire. *Typha sp*. appears to be encroaching further in wetland suggesting reduced surface water depth & duration.
2034 II NW	Beenyup Swamp (38625648247)	Category = 1 Wetland with one large area of probably permanent open water (may be useful refugee for water birds). Surrounded by cleared parkland on all sides. Connected to Wallubuenup Swamp by narrow creek in south-east corner. Creek was flowing slowly in April 2004.	Terrestrial: Scattered *Corymbia calophylla* with grass understorey on west side. Wetland: Low closed forest of *M. rhaphiophylla* with understorey of *Lepidosperma longitudinale* & various weeds. M. rhapiophylla apparent in less dense areas of paperbark forest.	Annual & perennial weeds have invaded the *E. rudis* & *M. rhaphiophylla* around perimeter of swamp, however, a dense canopy over much of the wetland has limited weed invasion into the basin. *M. rhaphiophylla* is generally in good condition.
	Wallubuenup (38696648190)	Category = 1 Wetland in predominantly cleared catchment of mixed urban & semi-rural development. Agricultural land extend to edge of basin on east side with virtually no remnant vegetation left. To west a narrow & patchy band (0-20m) of littoral vegetation remains surrounded by open parkland.	Terrestrial: None Wetland: Woodland of *E. rudis* & *M. rhaphiophylla* to the margins. Open forest *of M. rhaphiophylla* in some central areas with closed to open sedgeland of *T. orientalis* in wetland. Mixed *Typha* & *Baumea sp*. closed sedgeland to the south.	Some die-back of *E. rudis* is apparent on western side however, probably due to recent fire. Substantial weed invasion is occurring from farmland to the east. Typha showing signs of drought stress.
	Big Carine Swamp (38506647515)	Category = 2 Wetland in large recreation reserve, predominantly turf & a small areas of remnant vegetation in north-east corner. A narrow band of wetland tree species remain around perimeter of lake with more extensive stand towards the centre. Dry in April 2004.	Terrestrial: *E. gomphocephala* woodland near NE corner. Wetland: Woodland to open forest of *E. rudis* & *M. rhaphiophylla* becoming low open forest of *M. rhaphiophylla* towards the centre of the lake. Sedgeland of *Typha orientalis* & *Baumea sp*. over much of the lake. Annual & perennial herbs & grasses cover the exposed sediment in the lowest areas.	Scattered *Melaleuca* seedlings occurring in the lake. Vegetation in lake is in excellent condition. Approximately 50% of the *Melaleuca* on the west side is dead or very stressed & 25% is stressed at the southern end. Stressed trees are generally restricted to the higher sections of the littoral zone.
	Careniup Swamp (38595647369)	Category =4 Highly modified from infilling & urban development on all sides. Some deep permanent water occurs at northern end & eastern side. Northern end receives road runoff & is therefore eutrophic.	Terrestrial: None Wetland: Patchy woodland of *E. rudis* & *M. rhaphiophylla* with numerous exotic trees (*Salix sp.*) Sedgeland of *Typha orientalis* & *Baumea sp*.	Vegetation degraded through physical disturbance & presence of invasive weed species. No evidence of drought stress in April 2004.
	Badgerup Lake (39028648351)	Category = 2 Large (>100m) vegetation buffer to north, west & south. Eastern margin predominantly cleared for semi-rural development. Majority of woody littoral species have been cleared from perimeter. Wetland dry in April 2004.	Terrestrial: Low open woodland of *B. attenuata*, *B. menziesii* & *B. ilicifolia*. Understorey includes *J. furcellata*, *Adenanthos sp*., *Hakea prostrata* & *Hibbertia sp*. Wetland: Open woodland of *E. rudis* & *M. preissiana* with an understorey of annual weeds & *Carpobrotus sp*. Closed sedgeland of *T. orientalis* on wetland basin. Open woodland of *E. rudis*, *M. preissiana* & *Viminaria juncea* extends through to Little Badgerup Lake at the southern end with *B. elegans* & *Calytrix fraseri* in the understorey.	Littoral vegetation cleared in a band approx. 20-40m wide around wetland. Annual grasses slashed suggesting zone is intentionally kept clear of vegetation. Recent fire has scorched remaining littoral trees but has not affected the upland vegetation. Typha sedgeland extremely drought stressed.
	Little Badgerup Lake (39037648274)	Category = 2 Wide vegetation buffer surrounds wetland. Semi-rural development encroaching at northern end resulting in the removal of a large area of the wetland tree community that connects this wetland to Badgerup Lake. Some littoral vegetation lost on west side due to clearing. Wetland dry in April 2004	Terrestrial: Low open woodland of *B. attenuata, B. menziesii* & *B. ilicifolia*. Understorey of *J. furcellata*, *Adenanthos sp*. & *Macrozamia riedlei*. Wetland: Open woodland of *E. rudis* & *M. preissiana* with understorey of annual weeds & *Carpobrotus sp*. Closed sedgeland of *T. orientalis* on basin.	Littoral vegetation has areas of localised clearing on west side. Disturbed areas heavily weed infested. Numerous *E. rudis* seedlings & saplings around edge of basin. Some mature *E. rudis* have poor crown condition although some are regenerating vigorously from epicormic growth. Terrestrial vegetation in good condition. *Typha* community very drought stressed.
2034 II NE	Little Emu Swamp (39360647560)	Category =2 Swamp in south-east corner of Koondoola Regional Park with buffer of remnant vegetation. Vehicle tracks surround wetland	Terrestrial: Low open woodland of *B. menziesii*, *B. attenuata* & *N. floribunda* with understorey of *X. preissii* & *J. furcellata*. Wetland: Woodland of *E. rudis* & *M. preissiana*. Open heath of *A. fascicularis* & *Calytrix sp*. over open	Vegetation show signs of stress from recent fire, particularly in centre of wetland. No obvious signs of drought stress. Substantial cover of annual weeds & some

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
		basin & fire occurs regularly. Wetland dry in April 2004.	sedgeland of *B. juncea*.	localised areas of physical disturbance (fire & vehicle tracks).
2034 I SE	Spring near the Maze (40077649797)	Category = 1 Spring fed wetland near area of mixed rural land uses & remnant vegetation. Appeared dry in 2004.	Terrestrial: Open woodland of *C. calophylla* & *E. marginata* with *B. menziesii*, *B. ilicifolia & A. fraseriana* dominating the large gaps. Understorey dominated by *Adenanthos sp.* & *X. preissii*. Wetland: Open forest of *E. rudis* & *M. preissiana* becoming low closed forest of *M. preissiana* across seasonally wet area. Understorey of *K. ericifolia* & *Lepidosperma sp.* with *Leucopogon sp.* Some bracken & blackberry near spring. Blackberry extends through most of the wet area to west of spring.	Remnant terrestrial vegetation & wetland vegetation to west of spring in excellent condition. Vegetation to east in good condition however, blackberry rapidly invading understorey.
	Sumpland (39969649158)	Category = 1 Most of wetland overstorey is at edge of basin not across it. B. attenuata seedlings present on basin suggesting drying of wetland.	Terrestrial: Woodland of *B. attenuata, B. ilicifolia, B. menziesii* & *Nuytsia floribunda* with shrubland of *Adenanthos sp., Bossiaea eriocarpa, Dasypogon sp. Eremaea fimbriata, Grevillea sp., Leucopogon sp., Scholtzia sp. & X. preissii*. Wetland: Basin, woodland of *B. ilicifolia, M. preissiana* & *N. floribunda* with closed heath of *B. elegans* & *Hypocalymma sp*. Perimeter, woodland of *B. ilicifolia, C. calophylla, M. preissiana* & *N. floribunda*, with closed heath of *B. elegans, Dasypogon sp., Grevillea sp.* & *Hypocalymma sp*.	Vegetation in excellent condition.
	Sumpland (39556649708)	Category = 1 Wetland generally in excellent condition although there has been a fire in the north & evidence of diatomaceous earth mining on the basin. There is some establishment of terrestrial plants on the basin. M. preissiana are regenerating well.	Terrestrial: Woodland to open forest dominated by *B. attenuata, B. ilicifolia, B. menziesii, Allocasuarina* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Boronia purdieana, E. fimbriata, Hibbertia sp., Leucopogon sp., Macrozamia sp., Melaleuca scabra, Petrophile sp., Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Basin, low closed forest dominated by *M. preissiana*, with scattered open shrubland dominated by *Astartea sp.* & *Kunzea sp.*, with closed sedgeland of *B. articulata* in the open areas. Perimeter, open heath dominated by *Adenanthos sp., Beaufortia sp., Dasypogon sp., Hypocalymma sp., Kunzea sp.* & *Pericalymma sp.*	Most adult and regenerating *M. preissiana* trees are in excellent condition, however, the mature trees on the northern fringe are generally very stressed or dead. The scrub and shrubland are both generally in excellent condition. The *B. articulata* population appears to have been very stressed, but currently appears to be regenerating. There are also healthy scattered *Kunzea sp.* seedlings on the basin.
	Dampland (39554649527)	Category = 2 Dampland with generally intact heath. Overstorey reduced to few resprouting *B. ilicifolia*. No evidence of *M. preissiana*.	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. fimbriata, R. ciliata, Bossiaea eriocarpa, Scholtzia sp., M. trichophylla, Leucopogon sp., Hibbertia sp., Stirlingia sp.* & *Boronia sp.* Wetland: Open woodland of *B. ilicifolia* over a shrubland to open heath of *Adenanthos sp., B. elegans, H. angustifolium* & *D. bromeliifolius.*	Numerous dead *B. ilicifolia* and some dead *B. attenuata* at the dampland fringe. Fire scars suggest most were killed by a fairly recent, hot fire. Some localised patches of dead scrub, otherwise vegetation is in very good to excellent condition.
	Dampland (39582649556)	Category = 2 Dense areas of annual and perennial weeds along tracks, which pass through the southern end of the wetland.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* and *N. floribunda*, with shrubland dominated by *Adenanthos sp., Allocasuarina humilis, Dasypogon sp., Grevillea ciliata, Hibbertia sp., Leucopogon sp., Macrozamia sp., Melaleuca scabra, Regelia ciliata, R. inops* & *Xanthorrhoea sp.* Wetland: Basin, woodland to closed forest dominated by *B. ilicifolia, E. rudis* & *M. preissiana*, with tall open to closed scrub dominated by *Adenanthos sp., Beaufortia sp., Hypocalymma sp.* & *Kunzea sp.*	Approximately 50% of the *E. rudis* & *M. preissiana* are stressed or very stressed, with some recent death of the *E. rudis.* There are scattered *Banksia sp.* stags; & patches of dead scrub, which appear drought affected.
	Dampland (39576649679)	Category = 2 No Description given.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* and *N. floribunda*, with shrubland dominated by *Adenanthos sp., Allocasuarina humilis, Dasypogon sp., Grevillea ciliata, Hibbertia sp., Leucopogon sp., Macrozamia sp., M. scabra, Regelia ciliata, R. inops* & *Xanthorrhoea sp.* Wetland: Open woodland dominated by *B. ilicifolia* & *N. floribunda*, with tall open to closed scrub dominated by *Adenanthos sp., Dasypogon sp.* & *Kunzea sp.*	Numerous *M. preissiana* stags across the basin, with no visible live specimens; there are areas of dead scrub, possibly due to drought stress; and some dead *Banksia sp.*
	Sumpland (39610649565)	Category = 1 Terrestrial plant species on the edge of the low open forest, indicate that the wetland is becoming drier, & terrestrial plant species are moving into the wetland.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *N. floribunda*, with shrubland dominated by *Adenanthos sp., A. humilis, Dasypogon sp., Grevillea ciliata, Hibbertia sp., Leucopogon sp., Macrozamia sp., M. scabra, Regelia ciliata, R. inops* & *Xanthorrhoea sp.* Wetland: Basin, low open forest dominated by *M. preissiana*, with tall open scrub dominated by *Astartea sp., Adenanthos sp., Kunzea sp.* & *Pericalymma sp.* Perimeter, woodland to open woodland dominated by *E. rudis* & *M. preissiana*, with shrubland dominated by *Astartea sp., Adenanthos sp., Bossiaea sp., Dasypogon sp.,* & *Pericalymma sp.*	There are large areas of dead scrub & shrubland; also approximately 50% of the *M. preissiana* are showing signs of chlorosis.
	Dampland (39653649561)	Category = 2 There are two main degrading sources to the wetland, an adjacent road & numerous mounds of litter, such as, general rubbish, used vehicle tyres, asbestos sheets and weeds.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* & *B. menziesii*, with shrubland dominated by *Adenanthos sp., Bossiaea sp., Eremaea sp., Hibbertia sp., Patersonia sp., Regelia sp., Verticordia nitens* & *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. ilicifolia, E. marginata, E. rudis* & *M. preissiana*, with tall open scrub dominated by *Adenanthos sp., Beaufortia sp., Dasypogon sp.* & *Kunzea sp.*	Numerous *M. preissiana* stags across the basin; the living *M. preissiana* are very stressed; the *E. rudis* is slightly stressed; & the *B. ilicifolia* & *B. attenuata* appear to be extending their range into the wetland. However, the scrub is generally in excellent condition.
	Sumpland (39920649456)	Category = 2 Part of the wetland is in private property, & consequentially that	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* & *B. menziesii*, with shrubland dominated by *Hibbertia sp., Leucopogon sp., Patersonia sp., Macrozamia sp.* & *Xanthorrhoea sp.*	Both the wetland & terrestrial vegetation are generally in excellent condition, with the exception of the vegetation

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
		part is invaded with weeds & possibly grazed by livestock.	Wetland: Woodland to open forest dominated by *C. calophylla, E. rudis* & *M. preissiana*, with open to closed heath dominated by *Astartea sp., B. elegans* & *Hypocalymma sp.* Perimeter, an open forest of *E. marginata* & *C. calophylla.*	located on private property, which is in poorer condition.
	Dampland (39496649584)	Category = 2 Large variable dampland with central "wet" area that has been mined for diatomaceous earth. A cleared area around this central section carries vehicle traffic and has been used for dumping car bodies and other rubbish. Surface water was present in July 2004.	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over an open heath of *X. preissii, Adenanthos sp., M. riedlei, R. ciliata, V. nitens, R. inops* & *E. fimbriata.* Wetland: Centre: Sedgeland of *B. articulata* & *Juncus sp.* Upper: Woodland of *M. preissiana* over a tall closed scrub of *K. ericifolia, B. elegans, Astartea sp., P. elipticum* & *Adenanthos sp.*	Approximately 50 – 70% of *M. preissiana* dead or stressed, many recently dead. Saplings occur throughout much of the tall scrub. Tall scrub and remnant sedgeland in excellent condition.
	Dampland (39455649394)	Category = 1 No Description Given	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over an open heath of *M. riedlei, X. preissii, Calothamnus sanguineus, E. fimbriata, Adenanthos sp., Lomandra sp.* & *Leucopogon spp.* Wetland: *B. ilicifolia* open woodland over an open heath of *B. elegans, H. angustifolium, Adenanthos sp., D. bromeliifolius* & *B. eriocarpa.*	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. Condition of vegetation generally excellent.
	Dampland (39464649585)	Category = 2 Some of the *M. preissiana* appear to have died recently.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii, E. todtiana* & *Nuytsia floribunda*, with open heath dominated by *Adenanthos sp., Bossiaea eriocarpa, Dasypogon sp., Leucopogon sp., Regelia ciliata, Verticordia nitens* & *Xanthorrhoea sp.* Wetland: Open woodland dominated by *M. preissiana*, with tall closed scrub dominated by *Kunzea sp.*, & shrubland surrounding the dampland, which is dominated by *Adenanthos sp., Dasypogon sp.* & *Xanthorrhoea sp.*	There are very few living *M. preissiana* with numerous stags across the basin; there are scattered *Banksia sp.* stags in the fringing vegetation; however, the tall scrub is in excellent condition.
	Dampland (39478649638)	Category = 2 No description Given	Terrestrial: Woodland of *B. attenuata* & *B. menziesii*, over an open heath of *Adenanthos sp., V. nitens, M. riedlei, R. ciliata, E. fimbriata, R. inops, Stirlingia sp.* & *Leucopogon sp.* Wetland: Woodland of *E. rudis* & *M. preissiana* over a tall closed scrub of *K. ericifolia, Chorizema sp.* & *D. bromeliifolius.*	Approximately 80% of *Melaleuca* dead or very stressed. Most *E. rudis* in good condition although drought stress is evident in a small proportion. There is evidence of a hot fire (>4 yrs) which has killed many of the *B. ilicifolia* in the surrounding littoral vegetation. Scattered *Banksia sp.* & *X. preissii* establishing in the dampland.
	Dampland (39498649636)	Category = 2 Small dampland connected to Dampland 24 by broad area of *Melaleuca* woodland and tall scrub.	Terrestrial: Woodland of *B. attenuata* & *B. menziesii* over an open heath of *Adenanthos sp., V. nitens, M. riedlei, R. ciliata, E. fimbriata, R. inops, Stirlingia sp.* & *Leucopogon sp.* Wetland: Woodland of *M. preissiana* & *B. ilicifolia* over a tall closed scrub of *K. ericifolia, B. elegans, Chorizema sp.* with *D. bromeliifolius* & *X. preissii* on the fringe.	Healthy *M. preissiana* are generally restricted to the west side of the dampland. Numerous stags & very stressed individuals occur across the rest of the basin. *B. ilicifolia* & *B. attenuata* are establishing within the dampland basin. Tall scrub excellent.
	Dampland (39507649695)	Category = 1 The vegetation is marked by a past fire. The dampland appears to becoming more terrestrial, rather than "true" wetland vegetation.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* & *B. menziesii*, with open heath dominated by *Adenanthos sp., B. purdieana, E. fimbriata, E. purpurea, Hibbertia sp., Jacksonia sp., Leucopogon sp., Macrozamia sp., Patersonia sp., Regelia ciliata, V. nitens* & *Xanthorrhoea sp.* Wetland: Open woodland dominated by *B. attenuata, B. ilicifolia* & *Nuytsia floribunda*, with tall open scrub dominated by *Kunzea* & *R. inops.*	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 basin of the dampland appears to becoming more terrestrial, there are numerous *B. ilicifolia* seedlings across the basin, also *Adenanthos sp.* & *Verticordia nitens* appear to be invading the dampland.
	Dampland (39513649527)	Category = 2 No description given	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over an open heath of *Adenanthos sp., E. fimbriata, X. preissii, R. ciliata, Scholtzia sp., M. trichophylla, Leucopogon spp., Hibbertia sp., B. eriocarpa, M. scabra* & *Stirlingia sp.* Wetland: Open woodland of *M. preissiana.* Understorey a tall closed scrub of *K. ericifolia, B. elegans, R. inops, Astartea sp.*, & *Adenanthos sp.*	All *M. preissiana* very stressed or dead. *B. ilicifolia* colonising much of the wetland although many of these appear to have been killed by fire. Tall scrub in generally excellent condition.
	Dampland (39514649463)	Category =2 Small dampland with vehicle access form the north. Some localised weed invasion and rubbish dumping.	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over an open heath of *M. riedlei, X. preissii, Calothamnus sanguineus, Eremaea fimbriata, Adenanthos sp., Lomandra sp., Leucopogon spp.* & *R. ciliata.* Wetland: Woodland of *M. preissiana* & *B. ilicifolia* over a closed heath of *B. elegans, Astartea sp., P. ellipticum, H. angustifolium, D. bromeliifolius.* Upper littoral zone dominated by *E. todtiana, B. ilicifolia* & *B. attenuata* over an open heath of *R. inops* & *Adenanthos sp.*	All *M. preissiana* dead or stressed. Some drought stress is apparent in the heath vegetation. *B. attenuata* and *B. ilicifolia* spreading into the lower area of the dampland.
	Dampland	Category = 2	Terrestrial: Woodland of *B. menziesii* & *B. attenuata* over an open heath of *X. preissii, M. riedlei, A.*	All *Melaleuca* dead. *Banksia sp.* encroaching onto the

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
	(39527649600)	Small dampland dominated by tall scrub. *Banksia sp.* encroaching onto the dampland.	*cygnorum, E. fimbriata, Boronia sp., Petrophile sp., Leucopogon spp. & Bossiaea eriocarpa.* Wetland: Tall closed scrub of *K. ericifolia, B. elegans & D. bromeliifolius.*	dampland. Tall scrub in excellent condition.
	Dampland (39547649649)	Category = 2 Linear dampland with a *Banksia* overstorey and a mixed terrestrial / wetland understorey.	Terrestrial: Woodland of *B. menziesii &B. attenuata* over an open heath of *X. preissii, M. riedlei, E. fimbriata, Leucopogon sp., R. ciliata & Scholtzia sp.* Wetland: Open woodland of *B. ilicifolia & B. attenuata* over an open heath to tall open scrub of *K. ericifolia, Adenanthos sp., B. elegans, H. angustifolium, D. bromeliifolius, V. nitens & X. preissii.*	Approximately 50% of *Banksia sp.* dead (no evidence of recent fire). Myrtaceous species appear drought stressed in places although a central strip of tall scrub remains healthy. The edges and southern section are dominated by terrestrial species.
	Dampland (39541649417)	Category = 2 Small dampland close to Neaves Rd. A track runs through the east side and has been used for dumping rubbish in and around the wetland. Evidence of frequent fire.	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. pauciflora, R. ciliata, V. nitens, Patersonia occidentalis & Bossiaea eriocarpa.* Wetland: Upper; Woodland of *M. preissiana, N. floribunda & B. ilicifolia* over an open heath of *B. elegans, Adenanthos sp., Hypocalymma angustifolium & Dasypogon bromeliifolius.* Lower; *M. preissiana* woodland with an open heath to tall open scrub of *Astartea sp., Pericalymma ellipticum, K. ericifolia & Lepidosperma sp*	Around 50% of *Melaleuca* dead or very stressed. Evidence of hot fires in some areas of the dampland. Young saplings in wetland centre are in excellent health. Myrtaceous scrub shows localised signs of stress.
	Dampland (39565649347)	Category = 2 Large dampland dominated by tall closed scrub of *Kunzea* with scattered emergent trees. Some vehicle tracks intersect the dampland causing localised disturbance and weed invasion	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. pauciflora, R. ciliata, V. nitens, Patersonia occidentalis, Bossiaea eriocarpa & M. riedlei.* Wetland: Woodland of *M. preissiana, E. rudis & B. ilicifolia* over a tall closed scrub of *K. ericifolia & B. elegans.*	Around 50 – 60% of *Melaleuca* are dead (some recently) or very stressed. Scattered *M. preissiana* saplings can be found in the tall scrub. Majority of *E rudis* in excellent condition. Tall scrub generally excellent
	Dampland (39550649619)	Category = 2 The wetland appears to be in poor condition.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia & B. menziesii*, with shrubland dominated by *Adenanthos sp., Bossiaea sp., Eremaea sp., Hibbertia spp., Patersonia sp., Macrozamia sp., Regelia sp., Verticordia nitens & Xanthorrhoea sp.* Wetland: Open woodland dominated by *B. attenuata & B. ilicifolia*, with tall open to closed scrub dominated by *Beaufortia sp., Dasypogon sp., Hypocalymma sp. & Kunzea sp.*	There are, scattered *M. preissiana* stags across the basin; some recent *Banksia spp.* stags; and large areas of drought-stressed scrub.
	Dampland (39572649792)	Category = 2 No description given	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia & B. menziesii*, with open heath dominated by *Adenanthos sp., Boronia purdieana, Eremaea fimbriata, E. purpurea, Hibbertia sp., Jacksonia sp., Leucopogon sp., Macrozamia sp., Patersonia sp., Regelia ciliata, Verticordia nitens & Xanthorrhoea sp.* Wetland: Open woodland dominated by *B. attenuata, B. ilicifolia & N. floribunda*, with tall open scrub dominated by *Kunzea & Regelia inops.*	There are dead *Banksia spp.* on the fringe of the wetland, which may be due to fire and drought. The tall scrub appears to be retreating, consequentially there is now a wide buffer of mixed wetland and terrestrial vegetation surrounding the basin.
	Dampland (39616649454)	Category = 2 Large basin dampland which has lost majority of overstorey & is being colonised by terrestrial species. Some rubbish dumping around perimeter.	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. pauciflora, R. ciliata, V. nitens, Patersonia occidentalis & Bossiaea eriocarpa.* Wetland: Woodland of *E. rudis, M. preissiana, B. ilicifolia, B. attenuata, B. menziesii & N. floribunda* woodland over an open heath of *B. elegans, K. ericifolia & H. angustifolium.* Upper perimeter dominated by *D. bromeliifolius & X. preissii.*	Dominant overstorey of *M. preissiana* has been lost with only one live individual remaining. *E. rudis* is restricted to south-west corner and is very stressed. *Banksia spp.* are establishing over much of the dampland. Heath in generally very good condition. Some stressed and recently dead *B. ilicifolia* and *B. attenuata* occur on the south and west sides.
	Dampland (39627649484)	Category = 1 Small dampland with indistinct, gradual transition from terrestrial to wetland vegetation type.	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. pauciflora, R. ciliata, V. nitens, Patersonia occidentalis & Bossiaea eriocarpa.* Wetland: Woodland of *E. rudis & B. ilicifolia* over a tall open to closed scrub of *Adenanthos sp., B. elegans, K. ericifolia, H. angustifolium & Astartea sp.*	Occasional stressed *E. rudis* and localised dead patches of scrub. Numerous *E. rudis* saplings occur on the western side. No evidence of *M. preissiana* within the wetland.
	Dampland (39647649353)	Category = 2 Large dampland with virtually all *Melaleuca* dead. *B. ilicifolia* colonising much of the wetland basin.	Terrestrial: Woodland of *B. attenuata & B. menziesii* over a shrubland to open heath of *Eremaea sp., R. ciliata, X. preissii, Acacia sp., Scholtzia sp., P. occidentalis & Leucopogon spp.* Wetland: Woodland of *M. preissiana, B. littoralis &B. ilicifolia* over a tall closed scrub of *K. ericifolia, B. elegans, Astartea sp. & H. angustifolium.*	Majority of *Melaleuca* dead (most long dead). *B. littoralis & B. ilicifolia* in excellent condition. *B. ilicifolia* saplings establishing in basin of dampland. Tall scrub generally excellent with some localised dead patches.
	Dampland (39712649551)	Category = 2 No description given	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *X. preissii, Adenanthos sp., E. pauciflora, R. ciliata, V. nitens, Patersonia occidentalis & Bossiaea eriocarpa.* Wetland: Woodland of *E. rudis, M. preissiana, C. calophylla & B. ilicifolia* over a closed heath of *B. elegans, K. ericifolia, H. angustifolium, V. nitens & Chorizema sp*	Very few live *M. preissiana* remain although some regeneration is apparent on the southern side. Eucalypts are in generally good condition. Evidence of fire in some sections of the heath although this is regenerating vigorously. Terrestrial tree species form the dominant

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
				overstorey of the dampland
	Dampland (39876649518)	Category = 2 Dampland located adjacent to private property currently being used for agricultural purposes (market garden). The dampland appears to be becoming dry & drought stressed, with very few live *M. preissiana* present; & very few *M. preissiana* stags visible, which possibly indicates that the majority of these trees have been dead for quite some time.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* & *B. menziesii*, with shrubland dominated by *Hibbertia sp., Leucopogon sp., Patersonia sp., Macrozamia sp.* & *Xanthorrhoea sp.* Wetland: Basin, open woodland dominated by *B. attenuata, B. ilicifolia* & *M. preissiana*, with shrubland dominated by *B. elegans, Dasypogon sp.* & *Hypocalymma sp.* Fringe, open forest dominated by *C. calophylla*, with shrubland dominated by *Kunzea sp.*	There are almost no live *M. preissiana* trees, scattered *B. ilicifolia* stags & patches of dead shrubland with *B. attenuata* and *Dasypogon sp.* seedlings establishing on the basin. The terrestrial vegetation also appears to have *Phytophthora cinnamomi.*
	Dampland (39906649362)	Category = 2 The vegetation on the wetland appears to be becoming more terrestrial.	Terrestrial: Woodland to open forest dominated by *B. attenuata, B. menziesii* & *N. floribunda*, with shrubland dominated by *Allocasuarina humilis, Bossiaea eriocarpa, Eremaea pauciflora, Hibbertia sp., Jacksonia sp., Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. ilicifolia* & *M. preissiana*, with tall open scrub dominated by *Kunzea sp*	The terrestrial vegetation is in excellent condition; the *Banksia spp.* on and around the basin are all in excellent condition; and the scrub is generally excellent with only scattered dead patches. However, the basin appears to be drying, the *M. preissiana* population is very stressed, with many stags across the basin, and there are *Banksia spp.* invading the basin.
	Dampland (39592649232)	Category = 2 No description given	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland to open heath dominated by *Adenanthos sp., Eremaea fimbriata, Leucopogon sp., Petrophile sp., Regelia ciliata, Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Woodland to low open forest dominated by *E. rudis* & *M. preissiana*, with tall open to closed scrub dominated by *Kunzea sp.*	The terrestrial vegetation is in excellent condition, as is the scrub; and there are large areas of dense *E. rudis* saplings in the basin. However, the *M. preissiana* and *E. rudis* populations are very stressed, with stags across the basin.
	Dampland (39685649249)	Category = 2 The wetland is generally in poor condition.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland to open heath dominated by *Adenanthos sp., Eremaea fimbriata, Leucopogon sp., Petrophile sp., Regelia ciliata, Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Basin, woodland to open woodland dominated by *B. ilicifolia*, with tall open scrub dominated by *Chorizema sp., Hypocalymma sp.* & *Kunzea sp.* Perimeter, woodland dominated by *B. attenuata, B. ilicifolia* & *B. menziesii*, with open heath dominated by *Hypocalymma* & *Regelia inops.*	There are, patches of drought stressed scrub in the basin and in the fringing vegetation; scattered dead *Banksia spp.; B. attenuata* & *B. menziesii* are moving into the wetland; and *M. preissiana* stags are present across the wetland, which appear to have previously constituted a *M. preissiana* woodland, there appears to be no live *M. preissiana* at present.
	Dampland (39660649160)	Category = 2 Small dampland dominated by tall Myrtaceous scrub and *Banksia* species	Terrestrial: Woodland of *B. attenuata, B. ilicifolia* &*B. menziesii* over an open heath of *X. preissii, M. riedlei, M. scabra, R. ciliata, Adenanthos sp.* & *Leucopogon spp.* Wetland: Woodland of *B. ilicifolia* & *B. attenuata* over a closed heath to tall closed scrub of *B. elegans, K. ericifolia* & *H. angustifolium.*	Some evidence of *M. preissiana* stags in the wetland although these are long dead. Overstorey is now dominated by *Banksia* species. Understorey generally in excellent condition.
	Dampland (39813649148)	Category = 2 Large areas of terrestrial vegetation appear to have been burnt approximately three to five years ago.	Terrestrial: Woodland to open forest dominated by *B. attenuata* & *B. menziesii*, with shrubland dominated by *Adenanthos sp., Eremaea fimbriata, Leucopogon sp., Patersonia sp., Macrozamia sp., Melaleuca scabra, Scholtzia sp., Stirlingia sp.* & *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. attenuata, B. ilicifolia* & *M. preissiana*, with tall open to closed scrub dominated by *Astartea sp., Hypocalymma sp., Kunzea sp.* & *Xanthorrhoea sp.* With fringing vegetation dominated by *N. floribunda* & *Banksia spp.*	The scrub is in excellent condition, as are the *Banksia spp.*; the terrestrial vegetation is fire affected but healthy. However, approximately 50% of the *M. preissiana* trees in the wetland are stags; and the *Banksia spp.* appear to be moving into the wetland.
	Dampland (39881649161)	Category = 1 The wetland is generally in excellent condition. However, there are several disturbances, weeds are present in some areas, such as *Pinus sp.*; there are several tracks running through the eastern part of the wetland; and much of the terrestrial and a small area of the western part of the wetland are damaged by fire.	Terrestrial: Woodland to open forest dominated by *B. attenuata* & *B. menziesii*, with shrubland dominated by *Adenanthos sp., Eremaea fimbriata, Leucopogon sp., Patersonia sp., Macrozamia sp., Melaleuca scabra, Scholtzia sp., Stirlingia sp.* & *Xanthorrhoea sp.* Wetland: Western area, low open forest dominated by *M. preissiana*, with closed heath dominated by *Chorizema sp., Kunzea sp.* & *Pteridium esculentum*. Eastern area, woodland to low open forest dominated by *B. littoralis* & *M. preissiana*, with tall closed to open scrub dominated by *Astartea sp., Chorizema sp., Hypocalymma* & *Kunzea sp.*	The vegetation is generally in excellent condition, with the exception of small areas of the wetland severely affected by fire.
	Dampland (39183649754)	Category = 2 A large dampland mostly surrounded by cleared pine plantation. The dampland has highly variable vegetation reflecting elevation, which creates a mosaic of vegetation structure. There are numerous tracks surrounding and passing through the dampland; and much of the surrounding vegetation has been cleared, however, the	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii, E. todtiana* & *N. floribunda*, with open heath dominated by *Adenanthos sp., Bossiaea eriocarpa, Dasypogon sp., Leucopogon sp., Regelia ciliata, Verticordia nitens* & *Xanthorrhoea sp.* Wetland: Lower elevation areas, woodland to low closed forest dominated by *B. grandis, B. littoralis, E. marginata, E. rudis, M. preissiana, M. viminea, M. teretifolia* & *N. floribunda*, with closed tall scrub dominated by *B. elegans, Kunzea sp.* & *L. longitudinale.* Higher elevation areas, woodland to low closed	The vegetation is generally in excellent to pristine condition. There is an occasional *M. preissiana* stag, otherwise the *M. preissiana* population are in near-pristine condition. The understorey is in excellent condition, as is the overstorey. There are *E. rudis* saplings on parts of the basin.

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		dampland and dampland vegetation appear the be in excellent condition, the *M. preissiana* population are in near pristine condition, making this quite a unique dampland for this area.	forest dominated by *M. preissiana*, with shrubland dominated by *Dasypogon sp., Daviesia sp., Dryandra nivea, Pericalymma sp., Restionaceae sp. & Xanthorrhoea sp.*	
	Dampland (39421649304)	Category = 2 Large dampland with variable vegetation complexes ranging from wet areas dominated by *Astartea sp.* through to terrestrial communities. The western area (approx. half the total area) has been cleared for housing and farming and high tension power lines divide the remaining area.	Terrestrial: Woodland of *B. attenuata, B. ilicifolia & B. menziesii* over an open heath of *Eremaea pauciflora, Regelia ciliata, Verticordia nitens, Scholtzia sp., Lyginia barbata, Stirlingia sp., Leucopogon sp. & Hibbertia spp.* Wetland: Woodland of *M. preissiana & B. littoralis* to low open forest over a tall open scrub to closed heath of *Astartea sp.. P. ellipticum. Hypocalymma sp.. B. elegans. L. longitudinale, Chorizema sp., K. ericifolia, X. preissii & Adenanthos sp.*	Remaining vegetation is in generally excellent condition with some areas of severe localised disturbance through clearing. The wetland trees are healthy which is unusual in the regional context. One area of trees in the south-east has been severely affected by a recent fire. Understorey is excellent other than those areas disturbed by clearing.
	Dampland (39442649618)	Category = 2 The surrounding vegetation has been cleared to the edge of the wetland on all sides, bar the east side. The cleared area appears to have been a pine plantation. There are several other disturbances to the wetland; there is a road circling the wetland; there appears to have been diatomaceous earth mining in the eastern part of the wetland; there are numerous species of weeds in and around the wetland, such as *Pinus sp.* and *Carpobrotus edulis*; and there appears to have been a fire in the eastern part of the wetland. The north-western area of the wetland is steep-sided, in this area are very dense stands of *M. preissiana.*	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii, E. todtiana & N. floribunda*, with open heath dominated by *Adenanthos sp., Bossiaea eriocarpa, Dasypogon sp., Leucopogon sp., Regelia ciliata, Verticordia nitens & Xanthorrhoea sp.* Wetland: Areas of woodland with tall closed scrub, to areas of low closed forest with a sparse, open shrubland, understorey. Woodland to low closed forest dominated by *E. rudis, M. preissiana & M. rhaphiophylla*, with a tall closed scrub dominated by *Astartea sp., B. elegans & Kunzea sp.* There is also a woodland of *C. calophylla* on the fringe of the wetland.	The vegetation is generally in excellent condition, with only several *M. preissiana* stags in the far eastern part of the wetland.
	Dampland (39443649445)	Category = 2 Large wetland divided by logging road. North-west section lies within pine plantation, south-east section within remnant vegetation.	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over an open heath of *M. riedlei, X. preissii, Calothamnus sanguineus, E. fimbriata, Adenanthos sp., Lomandra sp. & Leucopogon spp.* Wetland: Woodland of *M. preissiana, B. ilicifolia & B. attenuata* over a closed heath of *B. elegans, Astartea sp., H. angustifolium & D. bromeliifolius.* Northern section an open heath of *B. elegans, Astartea sp., H. angustifolium & D. bromeliifolius* with *N. floribunda* around the perimeter.	Approximately 90% of *Melaleuca* dead, some recently. *Banksia spp.* colonising central section of dampland. Heath excellent. All *Melaleuca* dead in northern section and large patches of heath have recently died.
	Dampland (39433649770)	Category = 2 Terrestrial plant species appear to be invading the wetland.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii, E. todtiana & N. floribunda*, with open heath dominated by *Adenanthos sp., Bossiaea eriocarpa, Dasypogon sp., Leucopogon sp., Regelia ciliata, Verticordia nitens & Xanthorrhoea sp.* Wetland: Open woodland dominated by *B. attenuata, B. ilicifolia, M. preissiana & N. floribunda*, with tall open scrub dominated by *Adenanthos sp., Astartea sp., B. elegans, Dasypogon sp., Hypocalymma sp. & Kunzea sp.*	There are very few *M. preissiana* at this site, there are only several re-sprout individuals on the basin; and there are no visible stags. Terrestrial plants appear to be invading the wetland, there is a large mixed terrestrial and wetland vegetation buffer surrounding a small retreated basin. However, the scrub is in excellent condition.
	Dampland (39510649739)	Category = 2 The dampland is disturbed by several roads in the northern part, one of which, has been recently widened, claiming a small part of the wetland. There is some evidence of a hot fire occurring approximately five to six years ago.	Terrestrial: Woodland dominated by *B. attenuata & B. menziesii*, with open heath dominated by *Adenanthos sp., Eremaea fimbriata, Leucopogon sp., Macrozamia sp., Regelia ciliata, R. inops, Stirlingia sp. & Verticordia nitens.* Wetland: Open woodland dominated by *B. ilicifolia & M. preissiana*, with tall closed scrub dominated by *Adenanthos sp., B. elegans & Kunzea sp.*	The remnant *M. preissiana* are restricted to a small area in the north-west corner of the dampland, however, they are in excellent condition. There are numerous *B. ilicifolia* stags in the dampland that appear to have been killed in a fire, with numerous *B. ilicifolia* seedlings across the basin. The tall scrub is in excellent condition.
	Dampland (39575649169)	Category = 3 Small remnant wetland within cleared pine plantation. Wetland was probably cleared initially and has been re-colonised by wetland shrubs.	Terrestrial: Pine plantation. Wetland: Tall closed scrub of *K. ericifolia, Astartea sp., H. angustifolium, B. elegans & Chorizema sp.*	No wetland trees present. Tall scrub in generally very good condition. Some invasion of annual weeds and pine seedlings is occurring.
2034 I SW	Lake Neerabup (38205649442)	Category = 2 Lake adjoins extensive bushland remnant to the east & market gardens / semi-rural development to the west. The east shows signs of grazing pressure & market gardens are intruding into wetland to north-west. A road intersects wetland at northern end. Lake dry at northern end in April 2004.	Terrestrial: Forest to woodland of *E. gomphocephala & E. marginata*. Understorey not inspected due to limited access. Wetland: Woodland of *E. rudis & M. rhaphiophylla* on lake fringe with patches of low closed forest of *M. rhaphiophylla* further into lake. Sedgeland of *Typha sp., B. articulata & B. juncea* across most of lake. Large areas of *M. rhaphiophylla* saplings & seedlings occur in sedgeland at the northern end.	Some areas with severe weed infestation by perennial shrubs & annual grasses. No indications of drought stress in trees, however, *Typha sp.* appears to be extending range into *B. articulata* sedgeland & *M. rhaphiophylla* is extending into wetter areas currently dominated by *Baumea* community.
	Lake Pinjar (38766649788)	Category = 2 Majority of lake is cleared or otherwise disturbed by agriculture. No surface water apparent in April 2004.	Wetland: In areas with remnant vegetation; Woodland of E. rudis & M. preissiana on higher margins becoming E. rudis & M. rhaphiophylla woodland towards the lower areas. Some stands of pure M. rhaphiophylla in centre of lake with scattered sedgelands of B. articulata. Understorey predominantly annual	E. rudis populations shows signs of stress with many dead individuals on the west & south-west sides. Wetland condition varies from completely degraded to good.

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
			& perennial grasses.	
	Lake Adams (38844649190)	Category = 3 More than half of wetland is private property & currently used as a paddock. Some scattered wetland trees remain with a weedy understorey. The section under crown reserve has not been cleared but a walkway has been constructed & non local tree species planted.	Terrestrial: Scattered Eucalypts with perennial grass understorey that is regularly mown. Wetland: Woodland of *E. rudis* & *M. preissiana*. Open heath of *Kunzea* & *Astartea sp*. mixed with sedgeland of *B. articulata*, *B. juncea* & *Lepidosperma sp*.	In crown reserve around the constructed walkway the planted non-local Eucalypt species & pine trees are rapidly colonising the lake bed & although remnant littoral trees & shrubland show no signs of stress the rapid establishment of non-local trees suggests water levels may be declining.
	Little Mariginiup (38830649035)	Category =4 Wetland lies on private property & is predominantly cleared & grazed. Some scattered Eucalypts remain around the fringe of the seasonally wet area.	Terrestrial: Banksia woodland on surrounding properties to the north & west. Wetland: Open woodland of *E. rudis* in patches. Understorey & wetland basin contains annual grasses/weeds.	Remaining *E. rudis* trees appear healthy.
	Little Adams Swamp (38955649226)	Category =3 Wetland on extensively cleared private property with grazing access to the lake bed.	Terrestrial: None Wetland: Patchy distribution of *E. rudis* & *M. preissiana* woodland.	No sign of drought stress in remaining trees. Understorey, shrubland of *Xanthorrhoea preissii* with annual grasses.
	Hawkins Road Swamp (39120648926)	Category = 2 Swamp within pine plantation adjacent to cleared land on west side. Tracks intersect swamp, forming a cleared circle near centre. Some dumping of rubbish & regular fire is apparent.	Terrestrial: Pine plantation Wetland: Open forest of *M. preissiana* with shrubland of *Beaufortia elegans*, *Kunzea sp*. & *Astartea fascicularis*. *Kunzea sp*. forms tall closed scrub near wetland centre with *B. articulata* & *Cyperaceae sp*. sedgeland surrounding. Numerous *Kunzea sp*. seedlings also present here.	Diverse community with some invasion of introduced grasses. Trees scarred from numerous fires. Trees in excellent condition however, some terrestrial species have established within wetland suggesting reduced surface water in recent years.
	Sumpland (38348649057)	Category = 2 Adjoins Neerabup National Park to west, this provides substantial vegetation buffer. Much of east & south-west side private property. Horse have access to much of the perimeter & this zone is highly degraded by grazing. Soil under tree canopy moist suggesting surface water may be present further into wetland.	Terrestrial: Open woodland of *E. gomphocephala* & *E. todtiana* on higher ground grading to *B. attenuata*, *B. prionotes* & *B. ilicifolia* with understorey of annual grasses & weeds. Wetland: Open forest of *E. rudis* & *M. rhaphiophylla* on wetland perimeter becoming closed forest of *M. rhaphiophylla* on basin. Understorey grazed leaving scattered annual weeds.	Clearing under high tension power lines & grazing has led to a highly disturbed area between wetland & National Park, otherwise terrestrial vegetation is in good condition. Wetland vegetation is similarly affected by constant grazing however, vegetation density on the basin prevents stock access so the vegetation appears to be in excellent condition.
	Dampland (39012649008)	Category = 3 Wetland surrounded by cleared farmland with scattered remnant *Eucalypts* & *Banksia sp*. Remnant littoral trees have understorey of dense annual & perennial grasses.	Terrestrial: Paddock with scattered *Eucalyptus* & *Banksia spp*. Wetland: Woodland to open forest of *E. rudis* & *M. preissiana*.	Some die-back of E. rudis apparent on west side & pines invading from east.
2034 IV NE	Lake Carrabooda (37849650146)	Category = 2 Surrounded by Market gardens & pasture. Terrestrial vegetation cleared to edge of lake with some localised infilling at southern end. Areas accessed were dry in April 2004.	Terrestrial: None Wetland: Open forest of *E. rudis* . Low open forest of *M. rhaphiophylla* changing to low closed forest further into lake. Sedgeland of *Typha* with *Baumea* & *Juncus sp*. in open areas.	Some annual & perennial weeds encroaching margins of the lake.
2035 II SE	Lake Bambun (39435652283)	Category = 1 Permanent Wetland. Narrow fringe of littoral vegetation surrounds the lake. Some buffer remains although the majority of the surrounding land is cleared farmland.	Terrestrial: Predominantly cleared. Wetland: Woodland of *E. rudis* & *M. rhaphiophylla* with occasional *M. viminea*. Understorey a sedgeland of *B. articulata*, *Juncus sp*. & perennial weeds (Kikuyu). Vegetation in winter wet depression joining lake this lake with Nambung (to south) consists of low closed forest of *M. viminea* & *M. teretifolia* with no understorey. Occasional *E. rudis* occur in northern portion. Bracken forms low closed heath in higher zones of transition area. Transition area is private property.	Overstorey in excellent condition. Very weedy understorey around lake. Vegetation of transition zone is generally in very good condition.
	Lake Nambung (39421652168)	Category = 2 Ephemeral lake with narrow strip of littoral vegetation to the south & east separating the wetland from farmland. Some remnant vegetation occurs to the north-west. Dry in April 2004.	Terrestrial: None Wetland: Woodland to open forest of *E. rudis, M. rhaphiophylla* & *C. obesa*. Understorey predominantly annual grasses. Some *Wilsonia* sp. on dry lake bed.	All trees appear in good health. No signs of drought stress.
	Lake Mungala (39482652119)	Category = 2 Wetland completely surrounded by private property. Owners refused access. Following comments are made from distant inspection. Wetland appeared to be dry.	Terrestrial: None Wetland: Woodland to open forest *E. rudis, M. rhaphiophylla* & *C. obesa*. Understorey annual grasses.	Trees appeared to be in good health.
2035 II SW	Yeal Swamp (38267651751)	Category = 1 Large wetland within nature reserve with vegetation changing from	Terrestrial: Woodland of *C. calophylla, B. attenuata, B. menziesii* & *Allocasuarina fraseriana*. Understorey dominated by *Xanthorrhoea sp., M. riedlei, Chorizema sp.* & *Hibbertia sp.*	Some localised areas of disturbance from vehicle tracks and invasion of annual weeds. One relatively small area of

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
		open woodland to closed heath of tall scrub with small changes in topography. Dry April 2004.	Wetland: Open woodland of *E. rudis & M. preissiana* with shrubland of *Kunzea sp.*	*E. rudis* death is apparent in the southern section. *Kunzea sp.* shows signs of drought stress in higher areas in the northern section.
	Dampland (38340651762)	Category = 1 Wetland in excellent condition. Dry April 2004	Terrestrial: Woodland of *C. calophylla, B. attenuata, B. menziesii & B. ilicifolia* with an understorey dominated by *Xanthorrhoea sp.* & *Kunzea sp.* Wetland: Open woodland of *E. rudis, M. preissiana & B. littoralis* with closed tall scrub of *Kunzea sp.*	Vegetation in excellent condition. Evidence of fire (>2 yrs) in terrestrial vegetation.
	Dampland (38337651800)	Category = 1 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.	Terrestrial: Woodland of *C. calophylla, B. attenuata, B. menziesii & B. ilicifolia* with an understorey dominated by *Xanthorrhoea sp.* & *Kunzea sp.* Wetland: Low closed forest of *M. preissiana, E. rudis & B. littoralis* with an open sedgeland of *Lepidosperma sp.* & occasional *Astartea sp.*	Vegetation in excellent to pristine condition.
	Bindiar Lake (38181651941)	Category = 2 Wetland occurs in nature reserve and has excellent vegetation buffer. Pines occur within 100m of western side. Vehicles access the claypan area in the north west leading to some localised areas of damage to the vegetation. Dry in April 2004.	Terrestrial: Woodland of *C. calophylla, B. attenuata, B. menziesii & Allocasuarina fraseriana*. Understorey dominated by *Xanthorrhoea sp., M. riedlei* & *Hibbertia sp.* Wetland: Woodland of *E. rudis, M. preissiana & B. littoralis* with scattered dense stands of *M. preissiana* or *E. rudis.* Tall open scrub to open heath of *Kunzea sp.* & *Beaufortia sp.* with *Lepidosperma sp.* Numerous seedlings of *E. rudis* & *B. littoralis* occur around the perimeter of the lowest (open) areas.	Vegetation in very good to excellent condition. Some localised areas of disturbance from vehicle access. Some non-aggressive weeds near tracks and a few pine trees establishing on lake bed. Mature *E. rudis* showing signs of stress, some very stressed, on the west side and towards the centre of the lake. The majority of the trees to the south are in excellent condition.
	Dampland (38731651919)	Category = 2 A very small dampland with a road running through the middle of it, however, the road does not appear to have serious negative impacts on the condition of the dampland. The dampland and the vegetation are generally in good condition.	Terrestrial: A woodland overstorey of *B. menziesii, B. ilicifolia*, & *B. attenuata.* With an open heath understorey of a *Myrtaceous* shrub, *Hibbertia sp., Patersonia sp. & Kunzea sp.* in the western part of the vegetation, & *Xanthorrhoea sp., Hibbertia sp., Patersonia sp.* & *Kunzea sp.* in the eastern part of the vegetation. Wetland: A *B. attenuata, B. menziesii* & *M. preissiana* woodland overstorey. With a tall open shrubland understorey of *Kunzea sp.* & *Xanthorrhoea sp.* With an open sedgeland of *Lepidosperma sp.* in openings, & a scattering of *Leucopogon sp.* & *Xanthorrhoea sp.*	The vegetation is in very good to excellent condition. Approximately fifty percent of the adult *Melaleuca preissiana* are dead, with some stags. Also patches of the *Kunzea sp.* are severely drought effected, with several generations dead.
	Dampland (38798652311)	Category = 1 A narrow dampland with a mixed terrestrial understorey. The dampland is located in a large nature reserve, which is essentially undisturbed. However, it should be noted that *Phytophthora cinnamomi* does occur in adjacent blocks in the nature reserve.	Terrestrial: A woodland overstorey of *B. menziesii, B. attenuata* & *B. ilicifolia*. With an understorey dominated by *V. nitens* & *Dasypogon sp.* Wetland: A woodland overstorey of *M. preissiana, B. menziesii, B. attenuata* & *B. ilicifolia.* With an open heath understorey of *Myrtaceous shrub sp., Bossiaea sp., Hibbertia sp., Regelia sp., Xanthorrhoea sp., Verticordia nitens, Petrophile sp., Melaleuca trichophylla, Dasypogon sp., Lepidosperma sp.* & *Hypolaena sp.*	Pristine. No obvious signs of fire, disease, land-use impacts or dieback.
	Dampland (38825652147)	Category = 1 Damplands 120 and 125 are a large pair of damplands that are possibly connected; and are both located in a large undisturbed nature reserve. The dampland is generally in a very good condition.	Terrestrial: An overstorey of *E. todtiana, B. menziesii* & *B. ilicifolia* woodland. With an open heath understorey of *V. nitens, Myrtaceous shrub sp., Leucopogon sp., Regelia sp., Xanthorrhoea sp., M. trichophylla* & *M. scabra*. Wetland: A woodland overstorey of *M. preissiana, B. menziesii, B. attenuata* & *N. floribunda.* With a tall scrubland understorey of *Kunzea sp.*, a shrubland of *Beaufortia sp, Xanthorrhoea sp., V. nitens* & *Adenanthos sp.*, and a grassland of *Dasypogon sp.*	The vegetation is in excellent to pristine condition.
	Dampland (38875652172)	Category = 1 One dampland of a pair that are possibly hydrologically connected. Both are located in a large nature reserve.	Terrestrial: An overstorey *of E. todtiana, B. menziesii* & *B. ilicifolia* woodland. With an open heath understorey of *V. nitens, Myrtaceous shrub sp., Leucopogon sp., Regelia sp., Xanthorrhoea sp., M. trichophylla M. scabra.* Wetland: The western part of the dampland has an open woodland overstorey of *B. ilicifolia*, with an open heath understorey of *V. nitens, Beaufortia sp., Dasypogon sp.* & *Xanthorrhoea sp.* Th eastern part of the dampland has a woodland overstorey of *B. menziesii,* with a tall open scrub to tall closed scrub understorey of *Kunzea sp., Beaufortia sp.* & *Adenanthos.*	*M. preissiana* stags are present however, no live specimens are visible. The majority of the *B. ilicifolia* are re-sprouting (though there are no obvious signs of fire), there are various dead *Banksia* tree's, and there is some shrub death. However, it should be noted that the condition of the vegetation improves in the eastern part of the dampland, where vegetation condition is excellent.
	Dampland (38861652407)	Category = 1 A small distinct dampland surrounded by larger damplands. There are roads upland of the dampland; however, the roads do not appear to negatively impact the dampland. The wetland is generally in very good condition, with only small patches of dead vegetation.	Terrestrial: The overstorey is a woodland of *Banksia attenuata, B. menziesii* & *B. ilicifolia.* With a shrubland understorey of *Regelia sp., Beaufortia sp., Macrozamia sp., Myrtaceous shrub sp* & *Dasypogon sp.* Wetland: An overstorey of *M. preissiana* around the perimeter of the wetland. With a closed tall scrubland of *Kunzea sp.*	The condition of the terrestrial vegetation is generally in excellent to pristine condition; however, there is some shrub death and some death of *B. attenuata*. The condition of the wetland vegetation is also in excellent to pristine condition, however, there is some death of mature *M.*

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				preissiana (however, this is restricted to the most mature).
	Dampland (38919652275)	Category = 2 A small dampland in a dieback affected area. There is a road through middle of wetland, which has had a detrimental impact (the wetland is small and the road has been widened).	Terrestrial: Woodland of *B. menziesii, B. ilicifolia* & *Eucalyptus todtiana*. With an understorey of *Dasypogon sp., Xanthorrhoea sp., Melaleuca trichophylla* & patches of *Beaufortia sp.* Wetland: The overstorey was a woodland of *Melaleuca preissiana, Banksia ilicifolia* and *B. attenuata*; however, virtually all trees are dead or dying. The understorey is an open heath of *Beaufortia sp., Verticordia sp., Xanthorrhoea sp.*, with scattered clumps of *Dasypogon sp.*	Virtually all trees either dead or dying. Possible cause is *Phytophthora cinnamomi*, however further investigation is required for a definite conclusion.
	Dampland (38933652030)	Category = 2 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.	Wetland: A *M. preissiana* & *B. ilicifolia* woodland, with a tall scrubland of *Kunzea sp.* and a low shrubland understorey of *Hypocalymma sp.* and sedge species.	Approximately 60% of the *M. preissiana* are very stressed or dead; there are scattered dead *B. ilicifolia* and other *Banksias*. Most of the tall *Kunzea* scrubland is dead. Also the terrestrial vegetation to the east is very dieback effected.
	Dampland (38488651846)	Category = 1 Wetland occurs in large bush block and forms part of a series of damplands with similar vegetation associations. Dampland extends well beyond the boundaries defined in Hill *et al.* Large buffer of vegetation separates the damplands from vehicle tracks. Virtually undisturbed system.	Terrestrial: Woodland of *E. todtiana, B. ilicifolia, B. attenuata & B. menziesii*. Understorey an open heath of *Xanthorrhoea sp., Adenanthos sp., Hibbertia sp., M. scabra* (?) & *Calothamnus sanguineus*. Wetland: Woodland to open forest of *E. rudis & M. preissiana* with a tall shrubland to tall open scrub of *Kunzea sp., Beaufortia elegans & Regelia sp.* Some *C. calophylla* occurs on the upper edge of the wetland.	All the myrtaceous species are in excellent condition. Some evidence of stress can be seen in the *E. rudis* population although the majority are in good condition. Wetland vegetation in pristine condition.
	Dampland (38144652776)	Category = 1 Flat dampland with mixture of terrestrial and wetland species.	Terrestrial: Woodland of *Banksia menziesii, B. attenuata & B. ilicifolia* over a shrubland of *Adenanthos sp., Eremaea pauciflora, Regelia ciliata, Leucopogon spp., Verticordia nitens & Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, B. littoralis, B. ilicifolia & B. menziesii*. Understorey a tall open scrub of *Beaufortia sp., Kunzea ericifolia, Hypocalymma sp., Adenanthos sp & Xanthorrhoea sp.*	Vegetation in excellent condition. Some dead *M. preissiana* in the south-east and occasional patched of dead scrub.
	Dampland (38821652464)	Category = 1 The wetland is generally in a very good condition, the vegetation is generally in excellent health, and there are no signs of recent fire. The wetland is virtually undisturbed; however, this is an old track through the northern part of the wetland.	Terrestrial: A woodland overstorey comprised of *B. ilicifolia, B. menziesii, B. attenuata & E. todtiana*. With an understorey having the following dominant species, *Xanthorrhoea sp., Kunzea sp., Jacksonia sp. Dasypogon sp*., & *Adenanthos sp.* Wetland: A patchy overstorey, ranging from woodland to open forest, consisting of *M. preissiana, B. ilicifolia*, *B. menziesii*, *B. attenuata* & *E. todtiana.* With a tall open shrubland of *Kunzea sp.* & *Beaufortia sp.* and on the southern region a tall closed shrubland of *Kunzea* with *Patersonia sp.*	The wetland and terrestrial vegetation are generally in an excellent condition, however, there was some dead *Banksia sp.*
	Dampland (38174652305)	Category = 2 Dampland extends beyond the boundary defined in Hill *et al.*, to an area of woodland crossing the vehicle track to the south-west. This area is severely die-back affected and extends some way down slope into the wetland basin.	Terrestrial: Woodland of *B. attenuata & B. menziesii* with an understorey dominated by *Myrtaceae sp., V. nitens & Adenanthos sp* Wetland: Woodland of *M. preissiana & E. rudis* on the wetland perimeter with a shrubland to tall shrubland of *Beaufortia sp., Kunzea sp., Adenanthos sp.* & *Hypocalymma sp.* Dampland basin contains a tall shrubland to tall open scrub of *Kunzea* and *Beaufortia* with patches of *M. preissiana* low closed forest.	Numerous dead and very stressed *Melaleuca* and *Eucalyptus* in the south-western section near the track. Most of the vegetation on the dampland is in excellent health although the majority of the *E. rudis* shows signs of stress.
	Dampland (38551652525)	Category = 1 Peaty soil is present in the basin of the dampland.	Terrestrial: Woodland dominated by *B. littoralis, C. calophylla, E. rudis & N. floribunda*. Wetland: A low closed forest of *M. preissiana*, with some terrestrial species, with tall open scrub dominated by *Adenanthos sp., Chorizema sp., Hypocalymma sp. & Kunzea sp.*, and a sedgeland of *Lepidosperma sp.*	There are some dead *Banksia sp.* and *Corymbia sp.* trees, and indications of a previous fire in the northern part of the sumpland.
	Dampland (38829652308)	Category = 2 Wetland dominated by an open heath of wetland and terrestrial species with wetland trees generally restricted to the north-west edge.	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland to open heath of *Adenanthos sp., X. preissii, V. nitens, E. pauciflora, Scholtzia sp. & R. ciliata.* Wetland: Woodland of *M. preissiana, B. littoralis, B. menziesii, B. attenuata & B. ilicifolia* over shrubland to open heath of *B. elegans, Adenanthos sp., D. bromeliifolius & V. nitens.*	*Melaleuca* generally stressed to very stressed. Scattered dead *B. ilicifolia* occur within the open heath, which shows signs of severe drought stress. The species composition and condition of the heath suggests the dampland is becoming a more terrestrial system.
	Dampland (3883165198)	Category = 2 Some terrestrial plant species appear to be invading the wetland.	Terrestrial: Woodland dominated by *Banksia attenuata & B. menziesii*, with open heath dominated by *E. pauciflora, Hibbertia spp., Leucopogon sp., Lyginia barbata, Regelia ciliata, Scholtzia sp., Stirlingia sp.* & *V. nitens.* Wetland: Basin, open woodland dominated by *B. ilicifolia & M. preissiana*, with tall open to closed scrub dominated by *Kunzea sp.* Fringe, woodland dominated by *B. attenuata, B. ilicifolia, M. preissiana & N. floribunda*, with shrubland dominated by *Kunzea sp., Regelia inops & Xanthorrhoea sp.*	There appears to be almost no live *M. preissiana* on the basin, with stags across the basin, however there are some healthy individuals on the fringe. There are large areas of dead scrub; numerous *Kunzea sp.* seedlings on the basin; and *B. ilicifolia* establishing on the basin, and *Banksia spp.* establishing in the fringing vegetation.
	Dampland (38898652368)	Category = 2 A very large wetland. There are several tracks and a group of beehives in the eastern part of the wetland.	Terrestrial: Woodland dominated by *B. attenuata, B. menziesii & E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Hibbertia sp., Leucopogon sp., Regelia sp., Scholtzia sp., V. nitens & Xanthorrhoea sp.* Wetland: Woodland dominated by *B. ilicifolia, B. littoralis, E. rudis* & *M. preissiana*, with tall open to	Approximately 50% of the *M. preissiana* appear to be very stressed or dead, with scattered stags. The other 50% of the *M. preissiana* are in excellent condition. There are numerous immature *B. ilicifolia* in the basin, with the *B.*

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			closed scrub dominated by *Adenanthos sp., Beaufortia sp.* & *Kunzea sp. C. calophylla* dominates the overstorey on the perimeter of the wetland.	*ilicifolia* range extending into the wetland. The *E. rudis* is in notably good condition.
	Dampland (38861652005)	Category = 1 A broad transition zone of mixed terrestrial and wetland vegetation surrounding the dampland.	Terrestrial: Woodland dominated by *B. attenuata* & *B. menziesii*, with open heath dominated by *E. pauciflora, Hibbertia spp., Leucopogon sp., Lyginia barbata, Regelia ciliata, Scholtzia sp., Stirlingia sp.* & *V. nitens.* Wetland: Basin, woodland dominated by *B. ilicifolia* & *M. preissiana*, with shrubland dominated by *Beaufortia sp., Hypocalymma sp., Kunzea sp.* & *Xanthorrhoea sp.* Transition zone, woodland dominated by *B. ilicifolia*, with shrubland dominated by *Kunzea sp., Regelia inops* & *Xanthorrhoea sp.*	The vegetation is generally in very good to excellent condition, however, there is some drought stress in the *Kunzea sp.* shrubland.
	Dampland (38913652246)	Category = 2 Large, linear dampland with wide transition zone of mixed species between terrestrial and wetland vegetation. Evidence of dieback in terrestrial community.	Terrestrial: Woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over a shrubland to open heath of *Adenanthos sp., X. preissii, V. nitens, E. pauciflora, Scholtzia sp.* & *R. ciliata.* Wetland: Woodland of *M. preissiana, B. littoralis, N. floribunda, B. menziesii, B. attenuata* & *B. ilicifolia* over a tall open to closed scrub of *B. elegans, K. ericifolia* & *Adenanthos sp.*	Occasional stressed mature *Melaleuca* and localised areas of dead scrub, otherwise vegetation in excellent condition. Young *Banksia spp.* colonising basin of dampland.
	Dampland (38913652012)	Category = 1 No description given.	Terrestrial: Woodland of *B. menziesii* & *B. attenuata* over an open heath of *E. pauciflora, R. ciliata, Scholtzia sp., V. nitens, Lyginia barbata, Stirlingia sp., Leucopogon spp.* & *Hibbertia sp.* Wetland: Upper: Woodland of *M. preissiana, B. ilicifolia, B. attenuata* & *B. menziesii* over an open heath of *R. inops, K. ericifolia, B. elegans, Leucopogon sp.* & *Scholtzia sp.* Lower: *M. preissiana* open woodland over a tall open scrub of *K. ericifolia* &. *angustifolium*.	*M. preissiana* generally in very good to excellent condition. Occasional dead *B. ilicifolia* around perimeter. Large areas of dead scrub on the basin with some regeneration of *K. ericifolia*.
	Dampland (38951652330)	Category = 1 A healthy and intact dampland, with a mixed of wetland and terrestrial vegetation.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Dasypogon sp., Jacksonia sp., Macrozamia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. attenuata, B. grandis, B. ilicifolia, B. littoralis, B. menziesii, C. calophylla* & *M. preissiana*, with tall open scrub dominated by *Adenanthos sp.* and *Kunzea sp.;* and shrubland dominated by *Beaufortia sp., Dasypogon sp., Leucopogon sp., Jacksonia sp., Regelia inops* & *Xanthorrhoea sp.*	All parts of the vegetation are in excellent condition.
	Dampland (38973652008)	Category = 2 Small dampland dominated by Myrtaceous shrubs. Surrounding vegetation dieback affected.	Terrestrial: Woodland of *B. menziesii* & *B. attenuata* over an open heath of *E. pauciflora, R. ciliata, Scholtzia sp., V. nitens, Lyginia barbata, Stirlingia sp., Leucopogon spp.* & *Hibbertia sp.* Wetland: Open woodland of *M. preissiana* & *B. ilicifolia*. Understorey a tall open scrub of *K. ericifolia, R. inops, H. angustifolium* with *Leucopogon spp.* & *Adenanthos sp.* around the perimeter.	Numerous *Melaleuca* stags occur on and around the wetland basin with the remaining few live stems showing severe stress. The scrub appears very drought stressed although *Kunzea* seedlings have germinated amongst the dead plants. *B. ilicifolia* saplings are establishing in the lower areas of the basin.
	Dampland (39008652386)	Category = 1 A track runs through the wetland. Much of the wetland vegetation is a mix of terrestrial and wetland vegetation, with only small pockets of "true" wetland vegetation.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* and *B. menziesii*, with shrubland dominated by *Dasypogon sp., V. nitens* and *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii, M. preissiana* & *N. floribunda*, with shrubland dominated by *Adenanthos sp., Beaufortia sp., Dasypogon sp., Kunzea sp.* & *V. nitens*; and some low areas with an overstorey dominated by *M. preissiana*, and tall closed scrub dominated by *Kunzea sp.* and *Dasypogon sp.*	There are some senescent *M. preissiana* on the wetland; and some *Banksia sp.* seedlings on the wetland, indicating an invasion of terrestrial species; and some *Banksia sp.* stags in the terrestrial vegetation.
	Dampland (39008652298)	Category = 1 A distinct and sharp transition between terrestrial and wetland vegetation is observed at this site.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Acacia sp., Eremaea sp., Macrozamia sp., Regelia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: Low open forest dominated by *B. littoralis, M. preissiana* & *N. floribunda*; with tall open forest of *C. calophylla* on the western fringe; and low open heath to tall open scrub dominated by *Beaufortia sp., Kunzea sp., Pericalymma sp.* & *Xanthorrhoea sp.*	The vegetation is generally excellent to pristine.
	Dampland (39026652224)	Category = 1 No description given.	Wetland: Woodland dominated by *B. attenuata, B. ilicifolia* & *N. floribunda*, with tall closed scrub dominated by *Beaufortia sp., Dasypogon* & *Kunzea sp.*	There are numerous *M. preissiana* stags on the basin, with very few live individuals observed. *Banksia* species appear to be replacing the *M. preissiana* as the dominant overstorey species. The scrub is in excellent condition.
	Dampland (39045652254)	Category = 2 No description given.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Dasypogon sp., Jacksonia sp., Macrozamia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: Woodland to low open forest dominated by *B. ilicifolia, M. preissiana* & *N. floribunda*, with tall	The vegetation is generally in excellent condition. There is some *M. preissiana* stags and stressed individuals.

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			closed scrub dominated by *Beaufortia sp., Chorizema sp.* & *Kunzea sp.*	
	Dampland (39058652235)	Category = 2 A sharp transition between terrestrial and wetland vegetation. The wetland is significantly altered in structure, with almost all *M. preissiana* trees dead. This outcome is possibly due to drought stress.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Dasypogon sp., Jacksonia sp., Macrozamia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. ilicifolia* & *M. preissiana*, with tall open to closed scrub dominated by *Beaufortia sp.* & *Kunzea sp.*	The vegetation is generally in very good condition. The *M. preissiana* stags present on the wetland indicate that the wetland overstorey was previously a *M. preissiana* woodland, however there are only a few *M. preissiana* individuals at present. There are *B. ilicifolia* seedlings in the lower parts of the wetland, indicating that terrestrial plant species are invading. The shrubland is in excellent condition.
	Dampland (38685652685)	A linear wetland with a sharp transition between terrestrial and wetland vegetation. A clearing, approximately 40 metres wide with high-tension power lines through the middle of the wetland.	Terrestrial: Woodland dominated by *Allocasuarina sp., B. attenuata, B. ilicifolia, B. menziesii,* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Kunzea sp., Leucopogon sp., Jacksonia sp., Macrozamia sp.* & *Verticordia sp.* Wetland: Woodland dominated by *B. littoralis* & *M. preissiana*, with tall closed scrub dominated by *Adenanthos sp., Beaufortia sp.* & *Kunzea sp.*	Approximately 50% of the mature *M. preissiana* are stressed or very stressed. The terrestrial vegetation is in excellent condition.
	Dampland (38570652790)	Category = 1 Visual evidence of a recent fire.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* & *E. todtiana*, with a shrubland dominated by *Adenanthos sp., Hibbertia sp., Leucopogon sp., Petrophile sp., Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Basin, open heath dominated by *M. lateritia, M. teretifolia* & *M. viminea*. Perimeter, woodland to low open forest dominated by *B. littoralis, E. rudis* & *M. preissiana*, with a shrubland dominated by *Astartea sp., Beaufortia sp., Hypocalymma sp., Jacksonia sp.* & *L. longitudinale.*	Vegetation severely fire affected, however regeneration appears healthy.
	Dampland (38606652771)	Category = 1 The area appears to have recently been exposed to a hot bush-fire. Basin currently consists of open to closed heath, which, should regenerate to a closed low forest.	Terrestrial: Woodland dominated by *Allocasuarina sp., B. attenuata, B. ilicifolia, B. menziesii,* & *E. todtiana*, with shrubland dominated by *Adenanthos sp., Eremaea sp., Kunzea sp., Leucopogon sp., Jacksonia sp., Macrozamia sp.* & *V. nitens.* Wetland: Basin, regenerating open to closed heath dominated by *Melaleuca. aff. viminea, M. teretifolia, M. lateritia, Astartea sp.* & *L. longitudinale.* Fringe, woodland dominated by *B. littoralis, M. preissiana* & *M. rhaphiophylla*, with a shrubland dominated by *Astartea sp., Lepidosperma sp., Hypocalymma sp.* & *Jacksonia sp.*	Vegetation is severely affected by recent fire, however regeneration appears healthy.
	Sumpland (38828652623)	Category = 3 Sumpland lies in a cleared paddock with a narrow, patchy fringe of trees and heavily grazed grasses. A block of more intact vegetation lies to the north-west. Entire area is private property. Surface water present in mid July 2004.	Terrestrial: Open woodland of *B. menziesii, B. attenuata* & *B. ilicifolia* over an open shrubland of *Scholtzia sp* & *Hakea spp.* Wetland: Open woodland of *M. preissiana, N. floribunda* & *C. calophylla* over a grassland of annual and perennial species.	Vegetation severely degraded by clearing and grazing.
	Dampland (38613651757)	Category = 1 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.	Terrestrial: Woodland of *E. todtiana, B. menziesii, B. ilicifolia* & *B. attenuata* with an open to closed heath of *Xanthorrhoea sp., Regelia sp., Hakea sp., Myrtaceae sp1., Hibbertia spp.* & *M. trichophylla.* Wetland: Woodland to open woodland of *M. preissiana, B. menziesii, B. attenuata* & *B. ilicifolia.* Understorey a closed heath of *Myrtaceae sp., Leucopogon sp., M. trichophylla, Regelia sp., Patersonia sp.* & *Xanthorrhoea sp.*	Vegetation in excellent to pristine condition.
	Dampland (38636651749)	Category = 1 One small area within a large dampland is identified by Hill *et al.*(see attached photo). No clear boundaries exist although the vegetation is variable across the dampland. The following is a general description of the central and southern section of this dampland.	Terrestrial: Woodland of *E. todtiana, B. menziesii, B. ilicifolia* & *B. attenuata* with an open to closed heath of *Xanthorrhoea sp., Regelia sp., Hakea sp., Myrtaceae sp., Hibbertia spp.* & *M. trichophylla.* Wetland: Vegetation ranges from a woodland of *E. rudis* & *M. preissiana* to a woodland of *B. menziesii, B. attenuata* & *B. ilicifolia.* Understorey is variable and consists of grasslands of *Lomandra sp.* to a closed heath of *Regelia sp.* and shrublands of *Xanthorrhoea sp.* & *Hibbertia sp.*	Excellent condition. Chlorosis is apparent in the *E. rudis* although this appears to be a very recent occurrence.
	Dampland (38638651780)	Category = 1 Northern section of dampland area comprises a low central section consisting of wetland species and broad areas of transition vegetation on the eastern slope.	Terrestrial: Woodland of *E. todtiana, B. menziesii, B. ilicifolia* & *B. attenuata* with an open to closed heath of *Xanthorrhoea sp., Regelia sp., Hakea sp., Myrtaceae sp., Hibbertia spp.* & *M. trichophylla.* Wetland: Woodland to open forest of *M. preissiana, B. menziesii, B. attenuata* & *N. floribunda.* Understorey a shrubland of *Myrtaceae sp., Hibbertia sp., M. riedlei, Regelia sp., Kunzea sp.* & *Xanthorrhoea sp.* Vegetation grades to a woodland of *E. rudis* & *M. preissiana* in the lower section with a tall open scrub of *Kunzea sp.* & *Adenanthos sp.*	Generally in excellent condition. Some evidence of stress in the *E. rudis* occupying the lowest areas.
	Dampland	Category = 2	Terrestrial: Woodland of *E. todtiana, B. menziesii* & *B. attenuata* with a shrubland to open heath of *C.*	Considerable number of very stressed *M. preissiana* and

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
	(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.	*sanguineus, Myrtaceae sp., Regelia sp., Hibbertia sp., M. trichophylla, Xanthorrhoea sp. & Patersonia sp.* Wetland: Open woodland of *M. preissiana, E. rudis, B. ilicifolia & B. attenuata*. Tall shrubland (closed in places) of *Kunzea sp. & Adenanthos sp.*	occasional dead *B. ilicifolia*. *E. rudis* appear healthy.
	Lake (Gingin Brook Lake) (38749652539)	Category = 1 Large semi-permanent lake. Intact vegetation buffer although heavy weed infestation in inflow. Some surface water still present in May 2004.	Terrestrial: Woodland of *B. attenuata, B. menziesii & B. ilicifolia* with a shrubland dominated by *Xanthorrhoea sp., Melaleuca sp., Petrophile sp. & V. nitens.* Wetland: Open forest of *M. preissiana, M. rhaphiophylla & E. rudis* with an open shrubland of *M. teretifolia* and sedgeland of *Lepidosperma sp.* Around the wetland basin, vegetation becomes a low closed forest of *M. rhaphiophylla* with *M. teretifolia* dominating the understorey.	Weed invasion predominantly annual grasses in inflow. Vegetation excellent to pristine.
	Sumpland (38385652763)	Category = 1 Large sumpland joined to, and forming part of the floodplains 88 and 48. Surface water present in June 2004.	Terrestrial: Woodland of *B. attenuata, B. menziesii & B. ilicifolia* with a shrubland dominated by *Xanthorrhoea sp., M. scabra., Petrophile sp. & V. nitens.* Wetland: Upper floodplain : Woodland of *M. preissiana, B. littoralis* with a closed heath of *B. elegans, Calytrix sp., Eremaea sp. & K. ericifolia.* Vegetation becomes closed forest of *E. rudis, M. preissiana & M. rhaphiophylla* in the southern (lower) section. Lower floodplain: Woodland of *M. preissiana & M. rhaphiophylla* with an open heath to tall open scrub of *Astartea sp. & Kunzea ericifolia.* Lower areas adjacent to open water contain *M. lateritia* closed tall shrub with admixtures of *K. ericifolia, Astartea sp. & B. elegans.*	*E. rudis* in the north west section show signs of stress. Some die-back apparent in the terrestrial vegetation.
	Floodplain 88 (38454652772)	Category = 1 Numerous tracks cross the floodplain leading to weed invasion in localised areas. Recent fire is apparent in central region.	Terrestrial: Woodland of *B. attenuata, B. menziesii & B. ilicifolia* with a shrubland dominated by *Xanthorrhoea sp., Melaleuca sp., Petrophile sp. & V. nitens.* Wetland: Upper floodplain : Woodland of *M. preissiana & B. littoralis* with a closed heath of *B. elegans, Calytrix sp., Eremaea sp. & K. ericifolia.* Vegetation becomes closed forest of *E. rudis, M. preissiana & M. rhaphiophylla* in the southern (lower) section. Lower floodplain: woodland of *M. preissiana & M. rhaphiophylla* with an open heath of *Astartea sp & Kunzea ericifolia.* Channel: Tall closed Shrub of *M. lateritia* with admixtures of *K. ericifolia, Astartea sp. & B. elegans.*	Recent fire (< 2yrs) in central section has caused some death of Myrtaceous shrublands. Paperbarks appear to be regenerating well. Some aggressive weeds around vehicle tracks (eg. *Mentha sp.*). Die-back apparent in some sections of terrestrial vegetation.
	Floodplain 48 (38231652928)	Category = 1 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.	Terrestrial: Woodland of *B. attenuata, B. menziesii & B. ilicifolia* with a shrubland dominated by *Xanthorrhoea sp., Melaleuca sp., Petrophile sp. & V. nitens.* Wetland: The upper floodplain consists of a low open to closed forest of *M. preissiana* with *Beaufortia sp., Eremaea sp. & Xanthorrhoea sp.* In the channel, *M. preissiana & M. rhaphiophylla* form a low open to closed forest with a tall open scrub of *M. teretifolia, M. lateritia & K. ericifolia*. *Astartea sp. & Lepidosperma sp.* occur in the gaps.	Weed invasion and die-back is apparent around the vehicle tracks. Some patches of terrestrial vegetation contain numerous dead *Banksia spp*.
	Dampland (38039652524)	Category = 1 The dampland is generally in excellent condition, it is located in a large nature reserve. The dampland is close to a track, however, it seems to be no longer in use and is quite overgrown.	Terrestrial: A woodland of *B. attenuata, B. menziesii* and *B. ilicifolia*. The understorey is dominated by *Xanthorrhoea sp.* and *Eremaea sp.,* with some *V. nitens, M. trichophylla* and *Hibbertia sp*. Wetland: A woodland overstorey of *B. attenuata, B. ilicifolia, N. floribunda* and *M. preissiana*. With a tall open scrub of *Kunzea sp*.; and up from the centre a shrubland of *Xanthorrhoea sp*., *Astartea sp*. and *Dasypogon sp*.	The condition of the vegetation is in excellent, with occasional *Banksia sp.* and *M. preissiana* stags and stressed individuals.
	Dampland (38139652681)	Category = 2 Large variable dampland with a wide transition zone of mixed terrestrial / wetland vegetation. Large areas of dead *M. preissiana* and *B. littoralis.*	Terrestrial: Woodland of *E. marginata, B. menziesii, B. attenuata & B. ilicifolia* over a shrubland of *Adenanthos sp., E. pauciflora, R. ciliata, Leucopogon spp., V. nitens & Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, N. floribunda, B. littoralis, B. ilicifolia, B. attenuata & B. menziesii* over an open to closed scrub of *K. ericifolia, Xanthorrhoea sp. & Dasypogon bromeliifolius. Astartea sp. & Pericalymma sp.* shrubland dominates the lower areas.	Patches of dead and stressed overstorey species although most trees in good health. Understorey in excellent condition. Evidence of recent fire.
	Dampland (38122652574)	Category = 2 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.	Terrestrial: Woodland of *B. menziesii, B. attenuata, B. ilicifolia* with a shrubland of *Xanthorrhoea sp., Regelia sp., Eremaea sp., Leucopogon sp., Hibbertia spp., M. scabra, Bossiaea sp.* and *M. trichophylla*. Wetland: Woodland of *M. preissiana, Banksia menziesii, B. attenuata* and *B. ilicifolia* generally restricted to the perimeter. Understorey a tall open scrub of *Beaufortia sp., Kunzea sp.* with *Dasypogon sp.* in gaps.	Only a few *M. preissiana* remain around the perimeter with numerous stags present on the wetland basin. Large patches of Myrtaceous tall scrub are dead or very stressed. Some dead *Banksia spp.* are present in and around the wetland. Vegetation appears to be changing to a more terrestrial community structure.
	Dampland (38147652733)	Category = 2 Large variable dampland with obvious decline in overstorey health. Open scrub of Myrtaceous species dominates the lower areas on peat soils.	Terrestrial: Woodland of *Banksia menziesii, B. attenuata & B. ilicifolia* over a shrubland of *Adenanthos sp., Eremaea pauciflora, Regelia ciliata, Leucopogon spp., Verticordia nitens & Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, B. littoralis, B. ilicifolia, B. attenuata & B. menziesii* over an open heath to tall open scrub of *Beaufortia elegans, Kunzea ericifolia, Adenanthos sp., Xanthorrhoea preissii & Dasypogon bromeliifolius.*	Approximately 30% of the *M. preissiana* are dead or stressed. Some recently dead *B. attenuata* and *B. ilicifolia* occur along with dead patches of Myrtaceous scrub.

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	Dampland (381516527087)	Category = 2 Small dampland with severely stressed vegetation. Most Myrtaceous species showing signs of drought stress. Terrestrial species colonising dampland basin.	Terrestrial: Woodland of *E. marginata, B. menziesii, B. attenuata, B. ilicifolia* over a shrubland of *Adenanthos sp., E. pauciflora, R. ciliata, Leucopogon spp., V. nitens, Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, N. floribunda, B. ilicifolia, B. attenuata & B. menziesii* over an open shrubland of *Beaufortia sp., Kunzea ericifolia & Dasypogon bromeliifolius.*	90% of *M. preissiana* dead or very stressed. Occasional dead or stressed *Banksia sp.* Most of the shrubland is dead or showing signs of drought stress. *Banksia spp.* seedlings colonising the basin. General shift towards terrestrial species is apparent.
	Dampland (38168652666)	Category = 1 Large variable dampland with a wide transition zone of mixed terrestrial / wetland vegetation.	Terrestrial: Woodland of *E. marginata, B. menziesii, B. attenuata & B. ilicifolia* over a shrubland of *Adenanthos sp., E. pauciflora, R. ciliata, Leucopogon spp., V. nitens & Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, N. floribunda, B. littoralis, B. ilicifolia, B. attenuata & B. menziesii* over an open to closed scrub of *K. ericifolia, Xanthorrhoea sp. & D. bromeliifolius. Astartea sp.* & *Pericalymma sp.* shrubland dominates the lower areas.	Some senescent *M. preissiana* and scattered dead *Banksia spp.*
	Dampland (38162652573)	Category = 2 Small dampland with gradual slope towards a central basin dominated by Myrtaceous shrubs.	Terrestrial: Woodland of *B. menziesii, B. attenuata, B. ilicifolia* with a shrubland of *Xanthorrhoea sp., Regelia sp., Eremaea sp., Leucopogon sp., Hibbertia spp., M. scabra, Bossiaea sp.* and *M. trichophylla*. Wetland: Woodland of *M. preissiana, B. attenuata, B. ilicifolia* and *Nuytsia floribunda*. Understorey a shrubland of *Xanthorrhoea sp., Adenanthos sp., Dasypogon sp., Beaufortia sp., Kunzea sp.* and *Hypocalymma sp.* Centre (lowest) area of wetland supports a tall closed scrub of *Beaufortia sp., Kunzea sp.*	Approximately 70% of *M. preissiana* is stressed to very stressed. Some dead *Banksia* occurs around the wetland perimeter. Tall scrub in excellent condition.
	Dampland (38167652757)	Category = 2 Small dampland showing signs of drought stress. Most *Melaleuca preissiana* are dead and are being replaced by *Banksia spp.*	Terrestrial: Woodland of *B. menziesii, B. attenuata & B. ilicifolia* over a shrubland of *Adenanthos sp., E. pauciflora, R. ciliata, Leucopogon spp., V. nitens & Xanthorrhoea sp.* Wetland: Woodland of *M. preissiana, N. floribunda, B. ilicifolia, B. attenuata & B. menziesii* with an open heath of *Beaufortia sp.* and *Kunzea ericifolia*.	*M. preissiana* are virtually all dead, some recently. Large patches of recently dead myrtaceous heath occur across the dampland. *Banksia spp.* in excellent condition.
	Dampland (38182652512)	Category =1 Small dampland dominated by Banksias with a Myrtaceous shrub understorey.	Terrestrial: Woodland of *B. menziesii, B. ilicifolia & B. attenuata*. Shrubland dominated by *Xanthorrhoea sp., E. pauciflora, Leucopogon sp., Regelia sp., Hibbertia spp., M. riedlei* and *M. trichophylla*. Wetland: Woodland of *B. menziesii* and *B. attenuata* with a tall open scrub of *K. ericifolia, Beaufortia sp.* and *Dasypogon bromeliifolius* in gaps.	Occasional dead *Banksia* and scattered patches of dead Myrtaceous scrub. Otherwise, vegetation in excellent condition.
	Dampland (38225652757)	Category = 1 Large dampland supporting *Melaleuca* trees across much of the wetland basin. Dense Myrtaceous shrubs throughout.	Terrestrial: Woodland of *B. menziesii, B. ilicifolia, B. attenuata* and *N. floribunda*. Understorey an open heath of *E. pauciflora, X. preissii, R. ciliata, V. nitens, Hibbertia spp.* and *M. trichophylla*. Wetland: Upper: Woodland of *M. preissiana, B. littoralis, B. ilicifolia, B. menziesii, B. attenuata & N. floribunda*. Understorey an open scrub of *Beaufortia sp., K. ericifolia, & Adenanthos sp.* Lower: *M. preissiana & B. littoralis* woodland over a tall closed scrub of *Beaufortia sp. & Kunzea ericifolia*.	Majority of *Melaleuca* in excellent condition with some stags to the east and isolated stressed individuals throughout. Some localised areas of dead Myrtaceous scrub. Otherwise excellent.
	Dampland (38220652466)	Category = 2 Dampland has lost the majority of its overstorey and is essentially an open heath to tall open scrub of mixed wetland and terrestrial species.	Terrestrial: Woodland of *B. attenuata, B. menziesii & B. ilicifolia* with a shrubland of *Myrtaceae sp, M. trichophylla, Regelia sp. Leucopogon sp.* and *Dasypogon bromeliifolius.* Wetland: Low open woodland of *M. preissiana & B. ilicifolia* with an open heath to tall open scrub of *Beaufortia sp., Kunzea sp.* and *Adenanthos sp.*	Terrestrial vegetation is in excellent condition with occasional dead *Banksia sp.* The wetland trees are predominantly very stressed *B. ilicifolia* and regenerating *M. preissiana*. Large stags of *M. preissiana* occur across dampland. Understorey is in excellent condition.
	Dampland (38230652721)	Category = 1 The dampland is steep-sided, with a rapid and distinct transition between terrestrial and wetland vegetation; with some very large *M. preissiana* present.	Terrestrial: Woodland dominated by *B. attenuata, B. menziesii* and *E. todtiana*, with a shrubland dominated by *Acacia sp., Beaufortia sp., E. pauciflora, K. ericifolia, Scholtzia sp.* and *Xanthorrhoea sp.* Wetland: Basin, woodland dominated by *E. rudis* and *M. preissiana*, with a tall open scrub dominated by *Astartea sp.* and *Kunzea sp.* Transition vegetation, a woodland dominated by *B. attenuata, B. menziesii, E. rudis* and *M. preissiana*. With an open heath dominated by *Astartea sp., Kunzea sp., Macrozamia sp.* and *Xanthorrhoea sp.*	The majority of the *E. rudis* appear stressed, with numerous dead *E. rudis* stems on the basin, however some *E. rudis* plants are in excellent condition, in particular the more mature individuals. The *M. preissiana* trees are in excellent condition. There is some *E. rudis* and *M. preissiana* saplings around the edge of the basin.
	Dampland (38245652664)	Category = 2 Small dampland in a shallow swale just west of the large Dampland 20. The wetland slopes down to a linear area of wetland vegetation on a loam soil with healthy mature trees and saplings / seedlings.	Terrestrial: Woodland of *E. todtiana, B. menziesii & B. attenuata*. Understorey a shrubland of *E. pauciflora, Adenanthos sp., Regelia ciliata* and *Xanthorrhoea sp.* Wetland: Woodland of *E. rudis, M. preissiana, B. ilicifolia & B. attenuata* over an open scrub of *Beaufortia sp.* and *Adenanthos sp.* Lower zone supports a low open forest of *E. rudis & M. preissiana* with a shrubland of *Astartea sp* and *Pericalymma ellipticum.*	*E. rudis* in excellent condition with numerous saplings in the lowest areas. *M. preissiana* generally good with some scattered stags in the upper perimeter and occasional dead *Banksia spp.* Understorey excellent.
	Dampland (38252652683)	Category = 2 Large dampland joined to northern end of dampland 20. Large flat basin with mixed terrestrial / wetland species.	Terrestrial: Woodland of *E. todtiana, B. menziesii & B. attenuata*. Understorey a shrubland of *E. pauciflora, Adenanthos sp., R. ciliata* and *Xanthorrhoea sp.* Wetland: Woodland of *E. rudis, M. preissiana, N. floribunda, B. ilicifolia, B. attenuata & B. menziesii* over a shrubland to tall open scrub of *Xanthorrhoea sp., Kunzea ericifolia, Beaufortia sp. & Adenanthos sp.*	Some localised patches of dead scrub with occasional dead and stressed *M. preissiana* and *Banksia spp.* A few *E. rudis* and *M. preissiana* seedlings can be found in the central area.
	Dampland (38266652435)	Category = 2 No description given.	Terrestrial: Woodland of *B. menziesii & B. attenuata* with a shrubland of *E. pauciflora, R. ciliata, Hibbertia spp., M. trichophylla* and Restionaceae sp.	*M. preissiana* generally stressed or very stressed with several large stags present. Roughly 30% of the *B.*

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			Wetland: Woodland of *M. preissiana, B. ilicifolia, B. attenuata, B. menziesii & N. floribunda* woodland. Understorey an open scrub of *K. ericifolia* and *Beaufortia sp.*	*ilicifolia* appear stressed. Other trees generally excellent. Some localised dead patches of *Kunzea* and *Beaufortia*.
	Dampland (38280652700)	Category = 2 No description given.	Terrestrial: Woodland of *B. menziesii, B. ilicifolia, B. attenuata* and *N. floribunda.* Understorey an open heath of *E. pauciflora, X. preissii, R. ciliata, V. nitens, Hibbertia spp.* and *M. trichophylla.* Wetland: Open woodland of *M. preissiana & B. ilicifolia* over a tall closed scrub of *K. ericifolia*.	Majority of *M. preissiana* dead or stressed (tree death appears to have occurred many years ago). *B. ilicifolia* and tall scrub all in excellent condition.
	Dampland (38285652373)	Category = 2 Dampland shows a gradual transition of terrestrial vegetation into a basin supporting dense Myrtaceous shrubs and *M. preissiana.* Overstorey condition is variable throughout the area with regular patches of dead trees in both the wetland and terrestrial vegetation.	Terrestrial: Woodland of *B. attenuata & B. ilicifolia* with an understorey dominated by *Xanthorrhoea sp., Regelia sp., Hibbertia sp.* and *Lomandra sp.* Wetland: Woodland of *M. preissiana, B. ilicifolia & B. attenuata* with a tall open to closed scrub of *Beaufortia sp., Kunzea sp. & Adenanthos sp.* Upper wetland edge supports an open heath of *Hypocalymma sp., Xanthorrhoea sp., Beaufortia sp.* and *Dasypogon bromeliifolius.*	Scattered *M. preissiana* stags occur across the dampland with many dead *Banksia spp.* in the wetland centre and fringe. Approximately 60-70% of remaining *M. preissiana* are in good health. Understorey is in excellent condition.
	Dampland (38289652487)	Category = 2 An open dampland located within a nature reserve, but close to a road.	Terrestrial: A woodland overstorey of *B. ilicifolia, B. attenuata* and *B. menziesii.* With a shrubland of *Beaufortia sp., V. nitens, Dasypogon sp.* and *Adenanthos sp.* Wetland: An overstorey of *M. preissiana* open woodland with some *B. ilicifolia*. With a *Kunzea sp.* tall shrubland and a *Beaufortia sp.* shrubland in the basin of the dampland.	There are localised plant deaths. Most of the *M. preissiana* are stressed or dead; and there is extensive shrub and *Kunzea sp.* death. However, the fringing and terrestrial vegetation is in excellent condition.
	Dampland (38287652725)	Category = 2 No description given.	Terrestrial: Woodland of *B. menziesii, B. ilicifolia, B. attenuata* and *N. floribunda.* Understorey an open heath of *E. pauciflora, X. preissii, R.. ciliata, V. nitens, Hibbertia spp.* and *M. trichophylla.* Wetland: Upper: Woodland of *M. preissiana, B. ilicifolia, B. attenuata, B. menziesii* over a shrubland of *X. preissii, K. ericifolia* and *B. elegans.* Lower: Open woodland of *M. preissiana* over a tall closed scrub of *K. ericifolia* and *B. elegans.*	Majority of *M. preissiana* dead or very stressed. Otherwise, vegetation in excellent condition.
	Dampland (38310652767)	Category = 2 The dampland is located in a large nature reserve, and is in excellent condition. However, there are signs of dieback in the terrestrial vegetation and signs of dieback and stress in the dampland. Also, there is a track through the dampland, however, this appears to pose no significant direct threat to the condition of the dampland. However, the track may be a vector route of dieback.	Terrestrial: A woodland overstorey of *B. menziesii, B. ilicifolia* and *B. attenuata*, with a shrubland understorey of *Eremaea sp., Regelia sp., Macrozamia sp.* and *Adenanthos.* Wetland: An open woodland overstorey of *M. preissiana, B. littoralis, B. ilicifolia* and *B. attenuata*. With a closed tall scrub of *Kunzea sp., Beaufortia sp., Adenanthos sp.* and *Xanthorrhoea sp.*	*Phytophthora cinnamomi* appears to have affected approximately 25% of *Banksias*, and approximately 30% of *M. preissiana* (predominantly mature trees) are very stressed. There are also signs of *P. cinnamomi* in the terrestrial vegetation.
	Dampland (38309652440)	Category = 2 The dampland is generally in very good condition. There is a road close to the dampland, however it appears to have little impact on the dampland. There are many *B. littoralis* seedlings.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia, B. littoralis, N. floribunda* and *M. preissiana*, with a shrubland understorey of *Adenanthos sp., Kunzea sp., Beaufortia sp., Dasypogon sp.* and *V. nitens.* Wetland: A woodland of *B. attenuata, B. ilicifolia, B. littoralis, E. rudis* and *M. preissiana*. With a tall closed scrub of *Kunzea sp.* with *Lepidosperma sp*.	The vegetation is in excellent to pristine condition, with some larger trees dead.
	Dampland (38317652422)	Category = 2 The dampland is located in a large nature reserve close to a trafficked track, though the use of the track seems to pose no direct threat to the condition of the wetland.	Wetland: A open woodland of *B. ilicifolia, B. attenuata* and *N. floribunda* around the perimeter of the dampland. With a tall shrubland of *Kunzea sp.* and *Beaufortia sp.* in the basin of the wetland.	The condition of the vegetation is excellent, with approximately 60% of the shrubland in the basin dead.
	Dampland (38336652318)	Category = 2 The dampland is located in a large nature reserve and is virtually undisturbed. Possible *P. cinnamomi* and drought stress.	Terrestrial: A low open forest around the perimeter of the wetland *of B. menziesii, B. attenuata* and *B. ilicifolia*. With an open heath of *Eremaea sp., Beaufortia sp., Kunzea sp.* and *V. nitens.* Wetland: A low open forest around the perimeter of the wetland of *B. menziesii, B. attenuata* and *B. ilicifolia.* With a closed heath of *B. elegans* and *Beaufortia sp.* in the basin of the wetland.	The condition of the wetland is very good. With, substantial death of *Banksia* species; some *Beaufortia sp.* death; signs of drought stress in the *Myrtaceous* heath; and some shrubs with parts dying-off.
	Dampland (38342652392)	Category = 2 The dampland is located in a large nature reserve. It has a track through the middle of it. The dampland is generally in excellent condition, with the exception of stress and death of some plants.	Wetland: A woodland overstorey of *B. ilicifolia, B. attenuata, M. preissiana & N. floribunda.* With a tall shrubland of *Kunzea sp., Beaufortia sp., Adenanthos sp., Hypocalymma sp.* and areas of *Dasypogon.*	Localised areas of dead *Kunzea sp.* in the shrubland; shrub death; stressed and dead *B. ilicifolia* and *B. attenuata;* and scattered dead *M. preissiana*, the majority being in good health.
	Dampland (38394652578)	Category = 1 A medium sized dampland in a large nature reserve. The dampland is in excellent condition, with the vegetation in good health and little disturbance to the area. There is a distinct elevation gradient in the vegetation, with a track dividing the northern and southern parts.	Terrestrial: A woodland overstorey of *B. menziesii, B. attenuata, B. ilicifolia* and *E. todtiana*, with a shrubland understorey of *Eremaea sp., Hibbertia sp.*, *Regelia sp.* and *Adenanthos sp.* Wetland: In the northern part, a *M. preissiana* woodland to open forest overstorey, with a shrubland understorey of *Kunzea sp., Beaufortia sp.* with some *Hypocalymma sp.* and a sedge species. In the southern part, a woodland of *M. preissiana, B. ilicifolia, B. attenuata, B. littoralis* and *N. floribunda.*	Occasional mature *M. preissiana* stag. There are numerous immature *M. preissiana* in the northern part of the dampland.
	Dampland (38386652685)	Category = 2 Large dampland with variable vegetation communities. Steeply	Terrestrial: Woodland of *E. todtiana, B. attenuata B. menziesii.* Understorey a shrubland of *Adenanthos sp., E. pauciflora, Regelia sp., Hibbertia spp.* and *M. riedlei.*	Occasional stressed *M. preissiana* and *Banksia spp.* Substantial death of *E. rudis* on south-west side with most

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
		sloping on the south-west side.	Wetland: Woodland to open forest of *M. preissiana, M. rhaphiophylla & B. littoralis* with *E. rudis* in localised areas. Understorey a tall open to closed scrub of *Kunzea sp.* with occasional *Beaufortia sp.* Upland littoral zone includes *C. calophylla, M. preissiana, B. ilicifolia, B. attenuata, B. menziesii* and *N. floribunda* woodland with a mixed terrestrial / wetland understorey.	remaining trees appearing stressed.
	Dampland (38361652523)	Category = 2 A small dampland in average condition located in a large nature reserve.	Wetland: A woodland of *B. attenuata, B. ilicifolia, M. preissiana & N. floribunda,* with a closed heath of *Beaufortia sp.* and *Xanthorrhoea sp.* with *Dasypogon sp*	The *M. preissiana* are virtually all gone, the shrubland appears to be drought stressed with some localised dead patches. However, the remnant trees appear to be in excellent condition.
	Dampland (38381652418)	Category = 1 No description given.	Terrestrial: Woodland dominated by *B. attenuata* and *B. menziesii*, with a shrubland dominated by *Adenanthos sp., Eremaea sp., Leucopogon sp., Patersonia sp., Macrozamia sp., Scholtzia sp.* and *Stylidium sp.* Wetland: Woodland dominated by *E. rudis & M. preissiana,* with tall open scrub dominated by *Astartea sp., Beaufortia sp., Hypocalymma sp.* and *Kunzea sp.*, to a tall closed scrub dominated by *Astartea sp., Beaufortia sp. & Kunzea sp.*	The vegetation is generally in excellent condition, with the exception of some *M. preissiana* stags.
	Dampland (38416652349)	Category = 2 The dampland is in very good condition.	Terrestrial: Woodland of *B. attenuata, B. menziesii & E. todtiana,* with a shrubland of *Adenanthos sp., Eremaea sp., Leucopogon sp., Macrozamia sp., A. humilis* and *C. sanguineus*, with *Mesomelaena sp.* Wetland: In the basin, a woodland of *B. littoralis,* and *M. preissiana,* with a tall open/closed scrub of *Kunzea sp.* and *Beaufortia sp.* Upland, a woodland of *B. attenuata, B. ilicifolia, B. menziesii, E. rudis, N. floribunda*, with a tall shrubland of *Adenanthos sp., Beaufortia sp., Kunzea sp.* and *Xanthorrhoea sp.*	The majority of the *M. preissiana* are stressed to very stressed, and much of the dying-off of the crown is very recent. There are scattered dead *Banksia spp.*, and localised areas of dead *Myrtaceous* shrub. However, the *E. rudis* and *B. littoralis* are in excellent condition.
	Dampland (38455652718)	Category = 1 No description given.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia* and *B. menziesii*, with a shrubland understorey dominated by *Eremaea sp., hibbertia sp., Jacksonia sp., Regelia sp., Scholtzia sp., V. nitens* and *Xanthorrhoea sp.* Wetland: Fringe, a woodland of *M. preissiana* and *B. littoralis*, with a tall open scrub understorey of *Beaufortia sp., Kunzea sp.* and *Xanthorrhoea sp.* Basin, a tall closed scrub of *Astartea sp, Kunzea sp.* and *Beaufortia sp.* Also, there is *N. floribunda* and *C. calophylla* on the outskirts of the wetland.	The condition of the terrestrial and wetland vegetation is pristine.
	Dampland (38415652188)	Category = 1 Small dampland with moist, organic soils in centre. Evidence of recent, intense fire.	Terrestrial: Woodland of *E. todtiana, B. menziesii, B. attenuata & N. floribunda* over a shrubland to open heath of *Adenanthos sp., E. pauciflora, Regelia sp., Xanthorrhoea sp., Leucopogon sp., & Astroloma sp.* Wetland: Open forest of *M. preissiana & B. littoralis* with scattered *B. attenuata, B. menziesii, B. ilicifolia & N. floribunda*. Understorey a tall open scrub of *Kunzea sp., Beaufortia sp, Calytrix sp., Pericalymma sp., Hypocalymma sp. & Xanthorrhoea sp.* with *Lepidosperma sp.*	Intense fire appears to have caused considerable damage to this "wet" dampland. Many of the *M. preissiana* occurring in dense stands have been killed by fire. Some individuals have re-sprouted and saplings can be seen in localised areas. Terrestrial species are establishing on the wetland suggesting drier conditions.
	Dampland (38456652444)	Category = 2 A dampland located in a large nature reserve. The dampland has large areas of shrubland. The dampland in excellent condition, however, there are no longer any live *M. preissiana* in the basin of the dampland.	Terrestrial: A woodland of *E. todtiana, B. attenuata, B. ilicifolia, & B. menziesii*, with a shrubland of *Xanthorrhoea sp., Regelia sp., Hibbertia sp., Eremaea sp., & M. trichophylla.* Wetland: A woodland of *B. attenuata, B. ilicifolia, B. menziesii* and *M. preissiana*, with a tall open / closed scrub of *Kunzea sp., Beaufortia sp., & Adenanthos sp.*, with a sedge species.	All *M. preissiana* (previously in basin) are now restricted to the edge of the dampland, all *M. preissiana* in basin are now dead. The shrubland is in excellent condition, with localised dead areas.
	Dampland (38480652351)	Category = 2 No description given.	Terrestrial: Woodland of *B. menziesii & B. attenuata*. Understorey a shrubland to open heath of *Adenanthos sp., Regelia sp., E. pauciflora, Scholtzia sp., Calytrix sp., V. nitens & Petrophile sp.* The *B. littoralis* is replaced by *B. ilicifolia* in the upper littoral zone. Wetland: Woodland to open forest of *M .preissiana* and *B. littoralis*. Understorey consists of a tall open to closed scrub of *K. ericifolia* and *Beaufortia sp.* Open areas on the basin carry a sedgeland of *Lepidosperma sp.*	*B. littoralis* and most of the tall scrub is in excellent condition. Typical of the damplands in this area, the majority of the *M. preissiana* population is stressed and contains some recently dead individuals.
	Dampland (38532652185)	Category =1 No description given.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia, B. littoralis, B. menziesii, E. rudis & M. preissiana*, with an open heath dominated by *Acacia sp., Eremaea sp., M. trichophylla, Myrtaceous sp., Scholtzia sp., V. nitens* and *Xanthorrhoea sp.* Wetland: Woodland dominated by *B. attenuata, B. ilicifolia, B. menziesii* and *E. todtiana*, with an open heath dominated by *Adenanthos sp., Beaufortia sp., Hypocalymma sp.* and *Kunzea sp.*	*M. preissiana* is 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 up-slope. The terrestrial vegetation is in excellent condition.
	Dampland (38533652305)	Category = 1 Large dampland supporting healthy stands of *E. rudis.*	Terrestrial: Woodland of *B. attenuata* and *B. menziesii* over a shrubland of A*denanthos sp., V. nitens, E. pauciflora, Regelia sp. & Patersonia sp.* Wetland: Woodland to open forest of *E. rudis, M. preissiana, B. ilicifolia & B. attenuata* with a tall open	All *E. rudis* appear in good condition. Scattered dead *B. ilicifolia* occur in the centre of the dampland. Occasional senescent *Melaleuca* and dead patches of *Kunzea* can be

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			scrub of *K. ericifolia, Beaufortia sp.*, becoming a closed scrub in lower areas.	seen within the wetland.
	Dampland (385606522287)	Category = 2 Dampland in two distinct zones based on elevation gradient. Higher zone supports mixed terrestrial / wetland communities and surrounds a lower area dominated by a tall scrub of myrtaceous species.	Terrestrial: Woodland of *B. menziesii & B. attenuata* with a shrubland dominated by *Xanthorrhoea sp., Regelia sp., V. nitens & E. pauciflora*. Wetland: Upper zone supports a woodland to open woodland of *M. preissiana, B. attenuata, B. ilicifolia, B. menziesii & N. floribunda* over a shrubland to open heath of *Adenanthos sp., Regelia sp., V. nitens, Beaufortia sp., Hibbertia spp., Lomandra sp.,* and *Dasypogon bromeliifolius.* Lower area consists of a tall open to closed scrub of *K. ericifolia* and *Beaufortia sp.*	*M. preissiana* population consists of numerous senescent individuals and many, very stressed trees. Younger trees in generally good condition. Terrestrial species colonising much of the dampland area. Otherwise vegetation in excellent condition.
	Dampland (38580652413)	Category = 1 A large flat basin covered with a tall open scrub and a closed sedgeland, fringed with *M. preissiana*. The dampland is somewhat unique for the area in which it is located. The dampland is generally in excellent condition, however, there is some localised disturbance from vehicles on the eastern side.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia, B. menziesii, E. todtiana,* and *N. floribunda.* With a shrubland of *Eremaea sp., Hibbertia sp., Macrozamia sp., M. scabra, Scholtzia sp., V. nitens & Xanthorrhoea sp.* Wetland: In the basin, a low woodland overstorey of *B. littoralis* and *Hakea sp.*, with a tall open scrub of *Kunzea sp.,* and in the open areas is a closed sedgeland of *Restionaceae sp.* and other sedge species. The perimeter, an open forest overstorey of *B. littoralis & M. preissiana,* with a shrubland understorey dominated by *Kunzea sp.* and *Beaufortia sp.*	The condition of the vegetation is in excellent to pristine condition.
	Dampland (38587652096)	Category = 2 No description given.	Terrestrial: Woodland of *B. menziesii & B. attenuata* with a shrubland dominated by *Xanthorrhoea sp., Regelia sp., V. nitens & E. pauciflora*. Wetland: *M. preissiana, B. attenuata & B. ilicifolia* woodland. Understorey a tall open to closed scrub of *K. ericifolia, Beaufortia sp. & Adenanthos sp.*	*M. preissiana* in generally excellent condition. A few stags and stressed individuals are apparent on the edge of the wetland. Tall scrub in excellent condition with localised dead patches.
	Dampland (38585652194)	Category = 1 The wetland is generally in excellent condition. The dampland is located in a large nature reserve, however, a track passes through the northern tip of the dampland.	Terrestrial: A woodland of *B. attenuata* and *B. menziesii*, with a shrubland dominated by *Regelia sp.* and *Xanthorrhoea sp.*, with *V. nitens* and *Eremaea sp.* Wetland: A woodland of *B. attenuata, B. menziesii, M. preissiana & N. floribunda.* With a shrubland of *Adenanthos sp.* and *Kunzea sp.*, with *Dasypogon sp.* in the northern part of the dampland.	The condition of the vegetation is generally excellent, with some senescent *M. preissiana* trees.
	Dampland (38589652128)	Category = 1 Indistinct dampland with terrestrial species throughout. Wetland trees restricted to a band on the east side.	Terrestrial: Woodland of *B. menziesii & B. attenuata* with a shrubland dominated by *Xanthorrhoea sp., Regelia sp., V. nitens & E. pauciflora*. Wetland: Woodland of *M. preissiana, B. ilicifolia, B. attenuata* and *B. menziesii*. Understorey a tall open scrub of *Beaufortia sp., K. ericifolia* and *Adenanthos sp*	*Melaleuca* in good condition. Terrestrial species appear to be colonising across the dampland.
	Dampland (38642652041)	Category = 1 The dampland is generally in excellent condition; and is located in a large nature reserve.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia, B. menziesii & N. floribunda*, with a shrubland of *Adenanthos sp., Eremaea sp., Macrozamia sp., Regelia sp., V. nitens* and *Xanthorrhoea sp.* Wetland: Transition vegetation consisting of a woodland overstorey of *B. attenuata, B. ilicifolia,* and *B. menziesii,* with a shrubland understorey of *E. purpurea, Adenanthos sp., R. inops, V. nitens, Xanthorrhoea sp.,* and *Lomandra sp.* and *Dasypogon sp.* The "true "dampland vegetation consists of a woodland overstorey of *B. ilicifolia, B. attenuata*, and *M. preissiana.* With a tall closed scrub of *Adenanthos sp., Hypocalymma sp., Kunzea sp.* and *Regelia inops.*	The vegetation is in excellent condition, with only a few senescent *M. preissiana* trees.
	Dampland (38651652093)	Category = 1 The dampland is in excellent condition, one of the best in the area.	Terrestrial: A woodland of *B. attenuata, B. menziesii, M. preissiana* and *N. floribunda*. With a shrubland understorey of *Eremaea sp., Leucopogon sp., Regelia sp., Scabra sp., Scholtzia sp., V. nitens,* and *Xanthorrhoea sp.* Wetland: A basin overstorey of *M. preissiana* woodland to low open forest, with a closed tall scrub of *Kunzea sp.* An upland overstorey of *B. menziesii, M. preissiana,* and *N. floribunda*, with a open shrubland dominated by *Xanthorrhoea sp.*, with *Dasypogon sp.*	The vegetation is in excellent to pristine condition, with a wide range of size classes in the *M. preissiana*, and healthy *Kunzea sp.* seedlings.
	Dampland (38732652377)	Category = 2 There is a road through the middle of the dampland; and some stress is evident, however the wetland is generally in excellent condition. The dampland is located in a nature reserve.	Terrestrial: A woodland of *B. ilicifolia, B. attenuata, B. menziesii* and *E. todtiana*, with a shrubland understorey of Myrtaceous shrub sp., *V. nitens, Kunzea sp., Xanthorrhoea* and *Beaufortia sp.* Wetland: The overstorey is a *E. rudis, M. preissiana, B. ilicifolia, B. attenuata* woodland, with the majority of the overstorey being *E. rudis* and *M. preissiana.*	There is some dying off in numerous *E. rudis* and some *M. preissiana* trees*;* recently dead *M. preissiana* and dead or stressed *B. ilicifolia* in the western part of the dampland; and some shrub death and chlorosis. Also there are scattered saplings of *E. rudis*.
	Dampland (38420652687)	Category = 2 There are signs of a previous fire. *Adenanthos sp.* and *B. ilicifolia* plants appear to be beginning to colonise the wetland.	Terrestrial: A woodland overstorey of *B. attenuata, B. ilicifolia* and *B. menziesii*, with a shrubland understorey dominated by *Adenanthos sp., Hibbertia sp., Jacksonia sp., Macrozamia sp., M. trichophylla, Regelia sp., Scholtzia sp., V. nitens* and *Xanthorrhoea sp.* Wetland: A woodland dominated by *B. ilicifolia, B. littoralis* and *M. preissiana*, with a closed tall scrub dominated by Astartea sp., *Beaufortia sp., Hypocalymma sp., Kunzea sp.* and *Pericalymma sp.*	The vegetation is generally in excellent condition. The are occasional death of *Banksia sp.* and *M. preissiana* trees, and scattered stressed *M. preissiana*. *Adenanthos sp.* and *B. ilicifolia* plants appear to be beginning to colonise the wetland.
	Dampland	Category = 1	Terrestrial: Open forest of *B. attenuata* with occasional *B. menziesii, B. ilicifolia* with a diverse shrubland	Vegetation within the area defined as the dampland is in

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	(38389652800)	Linear feature of dense terrestrial vegetation slightly upslope of large dampland / floodplain.	dominated by *M. scabra, E. pauciflora, Hibbertia sp., Leucopogon sp.* and *Epacridaceae sp.*	excellent to pristine condition. Surrounding vegetation is die-back affected.
	Dampland (38764652463)	Category = 1 No description given.	Terrestrial: A woodland overstorey dominated by *B. attenuata, B. menziesii* and *E. todtiana*, with a shrubland understorey dominated by *Adenanthos sp., Bossiaea sp., Eremaea sp., Hibbertia sp., M. trichophylla, Regelia sp,* and *V. nitens.* Wetland: A *M. preissiana* woodland, with a tall closed scrub understorey dominated by *Astartea sp., Beaufortia sp., Dasypogon sp., Hypocalymma sp.* and *Kunzea sp.*	The condition of the wetland and terrestrial vegetation is excellent, with the minor exception of some senescent *M. preissiana* trees.
	Dampland (38997652088)	Category = 2 There is a track through the middle of the dampland.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia* and *B. menziesii*, with a shrubland dominated by *Adenanthos sp., Eremaea sp., Regelia sp.* and *V. nitens.* Wetland: Was previously a *M. preissiana* woodland, however, the overstorey presently consists of *B. ilicifolia*, with a tall closed scrub dominated by *Kunzea sp.*	*Melaleuca* trees have been dead for some time, some terrestrial plant species are encroaching, and the shrubland is fine but affected by the road. The terrestrial vegetation is in excellent condition.
	Dampland (38334652752)	Category = 1 Small basin dominated by Myrtaceous shrubs within the Quin Brook floodplain.	Terrestrial: Woodland of *E. todtiana, C. calophylla, B. attenuata, B. menziesii* and *B. ilicifolia* with a shrubland of *Xanthorrhoea sp, E. pauciflora, M. scabra, Adenanthos sp., Hibbertia spp* and *Regelia sp.* Wetland: Tall open scrub of *K. ericifolia, Beaufortia sp., Xanthorrhoea sp. and Hypocalymma sp.* Woodland of *M. preissiana, B. attenuata & B. ilicifolia* occurs around the perimeter of the scrub.	*M. preissiana* stags in centre of wetland with scattered dead *Banksia spp.* Otherwise excellent condition.
2035 III SE	Tick Flat (37632652620)	Category = 2 Large dampland extending across remnant bushland through to cleared pasture. Recent fires have affected much of the wetland although large unburnt patches remain, particularly in the northern section. Dry in May 2004.	Terrestrial: Woodland of *E. todtiana, B. attenuata, B. ilicifolia & A. fraseriana* with a shrubland to open shrubland of *M. riedlei, Xanthorrhoea sp., Adenanthos sp & Verticordia nitens*. Wetland: Open woodland of *E. rudis & M. preissiana* with admixtures of *B. attenuata & B. ilicifolia*. Understorey is dominated by *Adenanthos sp., Beaufortia sp., Kunzea sp. & Calytrix sp.*	Fires have caused significant depletion of the understorey in localised areas. Some weed invasion is apparent around the vehicle tracks that cross the wetland. Some pine trees can be found in clusters near the wetland.
	Dampland (37668652593)	Category = 2 Large dampland approximately 100m east of the main Tick Flat wetland. Separated from the Tick Flat group by a low dune. Recent fire is evident in the southern half of the wetland. Dry in May 2004.	Terrestrial: Woodland of *E. todtiana, B. attenuata, B. ilicifolia & A. fraseriana* with a shrubland to open shrubland of *M. riedlei, Xanthorrhoea sp., Adenanthos sp. & V. nitens*. Wetland: Open woodland of *M. preissiana, B. ilicifolia, B. menziesii & B. attenuata.* Understorey a tall open scrub to closed tall scrub of *Adenanthos sp., Beaufortia elegans, Kunzea sp. & Xanthorrhoea sp.*	The majority of the *M. preissiana* are dead or very stressed. Some healthy individuals remain at the western side. Understorey condition is variable with localised dead areas where the understorey is dominated by myrtaceous species. The majority of the shrubland is in very good to excellent condition. The recent fire was generally restricted to the southern section of this wetland.
	Dampland (37577652591)	Category = 1 Small wetland in the central section of the Tick Flat complex. Unburnt in the recent fires. Dry in May 2004.	Terrestrial: Woodland to open forest of *Banksia prionotes* with an understorey dominated by *Verticordia sp., Hakea lissocarpha, Adenanthos sp., Scholtzia sp. & Beaufortia elegans.* Wetland: Open woodland of *B. prionotes, B. ilicifolia & B. attenuata* surrounding a closed to open heath of *B. elegans & Adenanthos sp.*	Occasional dead *Banksia*, otherwise the vegetation is in excellent condition.
	2 Damplands (37593652546, 37588652556)	Category = 2 Wetlands lie to the west of the Main Tick Flat wetland in a *Banksia* and *Melaleuca* woodland with a variable understorey consisting of terrestrial and dampland species. Boundaries defined in Hill *et al*, cannot be distinguished in the field. Area is dominated by *Banksia* with occasional *Melaleuca* stands occurring in depressions or clay soils. Dry in May 2004.	Wetland: Woodland of *B. prionotes & B. attenuata* with a shrubland to open heath of *Kunzea sp., Beaufortia sp. & Adenanthos sp.* Occasional stands of *M. preissiana* in clay soils with a shrubland to tall shrubland of *Beaufortia sp. & Kunzea sp.*	Unburnt areas are in good to very good condition. Myrtaceous shrublands show drought stress in lowest areas. Fire has killed areas of shrubland although affected areas are patchy. Density and structure of understorey suggests recurrent fire and/or drought is impacting on community health.
	3 Damplands (37917652461; 37948652434; 37987652446)	Category = 2 Three damplands are defined by Hill *et al*, (1996) in this seasonally wet area in Yeal West. No distinct boundaries exist between the damplands which essentially form one long dampland running in an east-west direction. Elevations suggest the dampland drains from west to east.	Terrestrial: Woodland of *E. todtiana, B. menziesii, B. attenuata, B. ilicifolia* with an open heath dominated by *M. riedlei, Myrtaceous shrub sp., Xanthorrhoea sp., M. trichophylla, Allocasuarina humilis & Adenanthos sp.* Wetland: Open woodland of *M. preissiana, B. littoralis & E. rudis* in the west and around the perimeter becoming open forest of *E. rudis & M. preissiana* in the lower sections and towards the east. Understorey varies between an open heath of *Adenanthos sp. & Kunzea sp.* and a tall open scrub of *Kunzea sp. & B. elegans* in the lower sections. Occasional terrestrial *Banksia* species are scattered throughout the dampland.	Condition varies across this large dampland with a general decline towards the east. The myrtaceous shrubs show signs of drought stress across the entire area, increasing from west to east with significant areas of the tall open scrub dead or very stressed in the eastern section. Much of the *M. preissiana* population is dead or dying in the centre and eastern sections. Some large stags are present which appear to have died > 5 years ago. The poor health of the paper-barks appears to follow the elevation gradient although healthy individuals do occur across the entire area. Dead *Banksia* can be seen in the lower section. The *E. rudis* are generally in good condition.

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
	Dampland (37987652796)	Category = 1 Small, steep sided wetland supporting very dense stands of wetland trees with a closed tall scrub of myrtaceous species. Locally unique vegetation complex suggests this site is wetter than surrounding damplands. Moist, organic sediment.	Terrestrial: Woodland of *E. todtiana, B. menziesii & B. attenuata* over a shrubland of *Xanthorrhoea sp., Regelia ciliata, M. scabra, Bossiaea sp., E. pauciflora & Hibbertia spp.* Wetland: Open to closed forest of *M. preissiana & B. littoralis*. Understorey a closed tall scrub of *K. ericifolia, Astartea sp. & M. teretifolia.* Upper littoral zone a sedgeland of *Lepidosperma sp.*	Pristine wetland. Density of trees and shrubs and presence of *M. teretifolia* make this a locally unique wetland in an unusually "wet" site.
	Dampland (37981652582)	Category = 1 The dampland is located in a large nature reserve. The dampland has a distinct basin with steep sides, and is in excellent to pristine condition. There are some very large *M. preissiana* trees that are in excellent condition and some *M. preissiana* saplings in the basin. The basin is quite damp. There is also some *Pteridium esculentum* individuals in the basin.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia & B. menziesii*, with a shrubland understorey of *Adenanthos sp., Astartea sp., Eremaea sp., Hibbertia sp. & Xanthorrhoea sp.* Wetland: The perimeter of the dampland is woodland of *M. preissiana, B. attenuata, B. ilicifolia, B. menziesii, & Nuytsia sp.* With a closed tall scrub in the basin, consisting primarily of *Kunzea sp.*, with occasional *Acacia sp.* and sedge species.	Some of the up-slope *M. preissiana* are in poor condition, however, others are in excellent condition, as is the shrubland and the terrestrial vegetation.
	Dampland (38030652677)	Category = 2 Large dampland dominated by terrestrial vegetation over much of its area. Wetland species dominate in the lowest area in the north-east.	Terrestrial: Woodland of *E. todtiana, B. menziesii & B. attenuata*. Understorey a shrubland of *E. pauciflora, Adenanthos sp., R. ciliata & Xanthorrhoea sp.* Wetland: woodland of *M. preissiana, B. ilicifolia & B. attenuata* with a *Beaufortia sp., Adenanthos sp. & Lomandra sp.* shrubland. Lower areas are dominated by a *E. rudis, M. preissiana & B. ilicifolia* woodland with a tall open scrub of *Beaufortia sp.* & *Kunzea ericifolia.*	South: Some dead and stressed *B. ilicifolia*, otherwise vegetation in excellent condition. West: Roughly 50% of *E. rudis* very stressed. Some recently dead. Myrtaceous scrub shows signs of drought stress. North West: Melaleuca stags amongst healthy individuals. Some stressed *E. rudis.* Some recently dead *Banksia spp.* and large patches of dead Myrtaceous scrub. Obvious signs of drought stress in overstorey and understorey along west side.
	Dampland (38009652550)	Category = 1 The dampland is in excellent condition, it is large/medium sized and is in a in a large nature reserve. The dampland has a road through the southern tip, however, the road appears to pose no direct significant threat.	Terrestrial: A woodland *of B. attenuata, B. ilicifolia & B. menziesii*, with a shrubland understorey of *Adenanthos sp., Astartea sp., Eremaea sp., Hibbertia sp. & Xanthorrhoea sp.* Wetland: A woodland to open forest overstorey of *E. rudis, M. preissiana, B. littoralis* & *Nuytsia sp.* With a tall open scrub of *Adenanthos sp., Beaufortia sp., Hypocalymma sp., Kunzea sp.* & *Xanthorrhoea sp.*	The *B. littoralis, M. preissiana & E. rudis* on the higher ground, are all in excellent to pristine condition. However, the *E. rudis* and *M. preissiana* on the lower ground are very stressed, with the occasional *M. preissiana* stag.
	Dampland (38024652295)	Category = 2 The dampland is steep-sided, with a rapid and distinct transition between terrestrial and wetland vegetation; with some very large *M. preissiana* present.	Terrestrial: Woodland dominated by *B attenuata, B. menziesii* & *E. todtiana*, with a shrubland dominated by *Acacia sp., Beaufortia sp., E. pauciflora, K. ericifolia, Scholtzia sp.* & *Xanthorrhoea sp.* Wetland: Basin, woodland dominated by *E. rudis* & *M. preissiana*, with a tall open scrub dominated by *Astartea sp.* and *Kunzea sp.* Transition vegetation, a woodland dominated by *B. attenuata, B. menziesii, E. rudis* & *M. preissiana*. With an open heath dominated by *Astartea sp., Kunzea sp., Macrozamia sp.* & *Xanthorrhoea sp.*	The majority of the *E. rudis* appear stressed, with numerous dead *E. rudis* stems on the basis, however some *E. rudis* plants are in excellent condition, in particular the more mature individuals. The *M. preissiana* trees are in excellent condition. There is some *E. rudis* and *M. preissiana* saplings around the edge of the basin.
	Dampland (38026652641)	Category = 1 No description given.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia* & *B. menziesii*, with a shrubland of *Adenanthos sp., Eremaea sp., Leucopogon sp., Scholtzia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: A woodland of *B. littoralis, M. preissiana* & *N. floribunda*, with a shrubland of *Beaufortia sp., Astartea sp.* & *Pericalymma sp.*, with a closed tall scrub of *Kunzea sp.* and a sedge species in the centre of the dampland.	The vegetation is in excellent condition, with *M. preissiana* saplings.
	Dampland (38033652611)	Category = 2 Some terrestrial plant species appear to be invading the dampland.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia* & *B. menziesii*, with a shrubland understorey of *Adenanthos sp., Eremaea sp., Leucopogon sp., Scholtzia sp., Verticordia sp.,* & *Xanthorrhoea sp.* Wetland: A woodland of *B. ilicifolia* & *M. preissiana*, with a shrubland to tall open scrub of *Adenanthos sp., Beaufortia sp., Hypocalymma sp.* & *Pericalymma sp.*	The condition of the terrestrial vegetation is excellent. The *M. preissiana* population is senescent but living.
	Dampland (38036652738)	Category = 1 Small dampland in a shallow swale just west of the large Dampland 20. The wetland slopes down to a linear area of wetland vegetation on a loam soil with healthy mature trees and saplings / seedlings.	Terrestrial: Woodland of *E. todtiana, B. menziesii* & *B. attenuata*. Understorey a shrubland of *E. pauciflora, Adenanthos sp., R. ciliata* & *Xanthorrhoea sp.* Wetland: Woodland of *E. rudis, M. preissiana, B. ilicifolia* & *B. attenuata* over an open scrub of *Beaufortia sp.* & *Adenanthos sp.* Lower zone supports a low open forest of *E. rudis* & *M. preissiana* with a shrubland of *Astartea sp* & *P. ellipticum.*	*E. rudis* in excellent condition with numerous saplings in the lowest areas. *M. preissiana* generally good with some scattered stags in the upper perimeter and occasional dead *Banksia spp.* Understorey excellent.
	Dampland (38046652635)	Category = 1 No description given.	Terrestrial: A woodland of *B. attenuata, B. ilicifolia* and *B. menziesii*, with a shrubland of *Adenanthos sp., Eremaea sp., Leucopogon sp., Scholtzia sp., Verticordia sp.* & *Xanthorrhoea sp.* Wetland: An open forest of *M. preissiana*, with a tall closed scrub of only *Kunzea sp.*, surrounded by a	The vegetation is in an excellent condition.

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			woodland of *B. attenuata* and *B. ilicifolia*, with a shrubland of *Adenanthos sp., Kunzea sp.* and *Pericalymma sp.*	
	Dampland (38058652554)	Category = 1 The dampland is generally in excellent condition. The dampland is located in a nature reserve close to other damplands. There is a road through part of the dampland.	Wetland: An open woodland overstorey of *N. floribunda, B. ilicifolia, B. littoralis, B. menziesii,* and *E. todtiana.* With a closed tall scrub understorey of *Adenanthos sp., Kunzea sp., Beaufortia sp.* and *Scholtzia sp.*	The condition of the vegetation is generally excellent to pristine, there is scattered dead *B. attenuata* and some *M. preissiana* are senescent but otherwise appear healthy.
	Dampland (38083652724)	Category = 2 Large dampland joined to northern end of dampland 20. Large flat basin with mixed terrestrial / wetland species.	Terrestrial: Woodland of *E. todtiana, B. menziesii & B. attenuata*. Understorey a shrubland of *E. pauciflora, Adenanthos sp., R. ciliata & Xanthorrhoea sp.* Wetland: Woodland of *E. rudis, M. preissiana, N. floribunda, B. ilicifolia, B. attenuata & B. menziesii* over a shrubland to tall open scrub of *Xanthorrhoea sp., Kunzea ericifolia, Beaufortia sp. & Adenanthos sp.*	Some localised patches of dead scrub with occasional dead and stressed *M. preissiana* and *Banksia spp.* A few *E. rudis* and *M. preissiana* seedlings can be found in the central area.
	Dampland (38078652433)	Large areas of transition vegetation, which consists of the terrestrial vegetation plus stands of *Melaleuca preissiana* and shrublands of *Kunzea sp.* Areas of peaty soil in basin, with *Melaleuca preissiana* seedlings and saplings.	Terrestrial: A woodland of *B. attenuata* and *B. menziesii*, with an open heath of *Adenanthos sp., M. trichophylla, Petrophile sp., R.egelia sp., Verticordia sp.* and *Xanthorrhoea sp.* Wetland: Basin, closed forest of *M. preissiana,* with a tall open scrub of *Kunzea sp.*, and a very open sedgeland. An open forest of *E. rudis* and *M. preissiana*, with a open heath of *Kunzea sp.* Shrubland of *Beaufortia sp. & Pericalymma sp.*, with *Lepidosperma sp.*	The condition of the vegetation is excellent, with some *Banksia* and *M. preissiana* deaths, and localised areas of dead Myrtaceous scrub.
	Dampland (38090652633)	Category = 2 The dampland appears to be becoming invaded with terrestrial plant species.	Terrestrial: Woodland dominated by *B. attenuata, B. ilicifolia & B. menziesii*, with a shrubland understorey dominated by *Adenanthos sp., Eremaea sp., Leucopogon sp., Verticordia sp. & Xanthorrhoea sp.* Wetland: Woodland to open woodland dominated by *B. ilicifolia, M. preissiana & N. floribunda*, with a tall open scrub dominated by *Adenanthos sp., Beaufortia sp., Astartea sp. & Pericalymma sp.*, with occasional *Dasypogon sp. & Hypolaena sp.*	Significant death of the *Myrtaceous* shrubs; some tree stags; decreased density in both the overstorey and the understorey, with a general terrestrial trend in area; and a variety of size classes in the *M. preissiana*.
	Dampland (38082652192)	Category = 1 A peaty soil found in the basin of the dampland supports an open forest of *B. littoralis* and *M. preissiana.* There has previously been a fire, which has had a large impact on the vegetation of the dampland, however the vegetation, particularly the *M. preissiana* are regenerating.	Terrestrial: A woodland of *B. attenuata, B. menziesii, E. rudis & E. todtiana*, with an open heath of *Eremaea sp., Regelia sp. Scholtzia sp., Verticordia sp.* and *Xanthorrhoea sp.* Wetland: Basin, an open forest of *M. preissiana* and *B. littoralis*, with a shrubland of *Beaufortia sp., Kunzea sp.* and *Pericalymma sp.* with *Lepidosperma sp.* Transition vegetation, a woodland overstorey of *B. attenuata, B. ilicifolia, B. menziesii, E. rudis, M. preissiana*, and *N. floribunda*, with a shrubland of *Adenanthos sp., Astartea sp., Beaufortia sp., Kunzea sp.* and *Pericalymma sp.* with *Lepidosperma sp.*	The *M. preissiana* open forest is regenerating from a previous fire, but are otherwise in excellent condition; The *E. rudis* is notably in excellent condition; and there are scattered dead *Banksia spp.* up-slope.
	Dampland (38088652250)	Category = 1 The dampland is located in a large nature reserve close to a road. It shows virtually no signs of disturbance from surrounding land uses; and is in an excellent condition	Wetland: A low open forest of *M. preissiana & B. attenuata*, with shrubland understorey of *Regelia sp., Beaufortia sp., Xanthorrhoea sp., V. nitens, Calytrix sp., Acacia sp.* & a diversity of *Myrtaceous* shrubs with clumps of *Dasypogon.*	The condition of the vegetation is excellent to pristine.
	Dampland (38097652471)	Category = 2 The dampland is generally in excellent condition, however there is a road through the middle of it. The dampland is located in a large area of reserve and so has a considerable buffer from most land-uses, except for the road through it and the small pine plantation near by.	Terrestrial: A woodland of *B. attenuata* and *B. menziesii*, with occasional *M. preissiana*. With a shrubland understorey of *Xanthorrhoea sp., Myrtaceous shrub sp., Kunzea sp., M. trichophylla & Adenanthos sp.* Wetland: A woodland of *M. preissiana*, with closed tall scrub of *Kunzea sp. & Beaufortia sp*	The vegetation is generally in excellent condition, with minor localised drought stress in the *Kunzea* and *M. preissiana.*
2035 III NE	Tangletoe Swamp (37607652972)	Category = 1 Pristine wetland in extensive reserve of undisturbed vegetation.	Terrestrial: Woodland to open woodland of *E. todtiana, B. attenuata, B. ilicifolia & B. menziesii.* Understorey is dominated by *Hibbertia sp., Xanthorrhoea sp., Calothamnus sp., Stirlingia latifolia, Astroloma sp. & Cyperaceae spp.* Wetland: Species rich community with a mixture of terrestrial and wetland plants. Overstorey consists of a woodland of *M. preissiana & E. rudis* with *B. attenuata, B. menziesii & B. ilicifolia.* Diverse understorey is a tall shrubland of *Kunzea sp. & Adenanthos sp.* to an open heath of *M. trichophylla, Beaufortia sp., Leucopogon sp., Lepidosperma sp., Astartea sp.*, with *Conostylis sp., Xanthorrhoea sp., Petrophile sp. & Hibbertia spp.* on the fringe.	Some isolated dead *Banksia* occurs on the fringe of the wetland. Otherwise, vegetation is in pristine condition.
	Dampland (37797652988)	Category = 2 No description given.	Terrestrial: Woodland dominated by *B. attenuata, B. menziesii, E. todtiana & N. floribunda*. With a shrubland understorey dominated by *Adenanthos sp., Eremaea sp., Leucopogon sp., Macrozamia sp., C. sanguineus, Regelia sp., V. nitens, & Xanthorrhoea sp.* Wetland: A *M. preissiana* woodland, with a closed heath dominated by *B. elegans, Astartea sp. & Hypocalymma sp.*	There is evidence of a previous fire; some *M. preissiana* trees are stressed, but otherwise the vegetation is in excellent condition.
	Dampland	Category = 2	Terrestrial: Woodland dominated by *B. attenuata, B. menziesii, E. todtiana & N. floribunda*. With a	The vegetation is generally in excellent condition; the

Map Number	Wetland Type & ID Number / Name	Conservation Category & Overall Condition	Vegetation Type / Community	Vegetation Condition
	(37852653007)	*E. rudis* & *M. rhaphiophylla* seedlings and saplings are present on the edge of the basin.	shrubland understorey dominated by *Adenanthos sp., Eremaea sp., Leucopogon sp., Macrozamia sp., C. sanguineus, Regelia sp., V. nitens,* & *Xanthorrhoea sp.* Wetland: On the upper slope of the wetland, there is a perimeter woodland of *B. ilicifolia, B. menziesii, E. rudis & M. preissiana.* With an understorey that is essentially completely cleared, with the exception of some *Astartea sp.* and *Hypocalymma sp.* Between the basin and the upper slope of the wetland, perimeter woodland of *B. littoralis, M. rhaphiophylla & M. viminea;* in the eastern part is a low open forest of *M. teretifolia.* The basin is largely bare due to the seasonal water that is holds, with the exception of clusters of *Baumea articulata.*	overstorey is in excellent condition; however, the *Baumea articulata* has recently died.
	Dampland (37879652973)	Category = 2 The wetland is in excellent condition.	Terrestrial: Woodland dominated by *B. attenuata, B. menziesii, E. todtiana* & *N. floribunda*. With a shrubland understorey dominated by *Adenanthos sp., Eremaea sp., Leucopogon sp., Macrozamia sp., C. sanguineus, Regelia sp., V. nitens,* & *Xanthorrhoea sp.* Wetland: Up-slope: a low open forest of *Allocasuarina sp., B. littoralis, B. menziesii* & *M. preissiana*, with a shrubland understorey dominated by *Astartea sp., Adenanthos sp., Beaufortia sp.* & *Hypocalymma sp.* Basin: a low closed forest of *M. viminea*, with a open shrubland dominated by *Astartea sp., M. teretifolia* & *Baumea sp.*	The condition of the vegetation is excellent; the trees are in pristine condition; however, the *Baumea sp.* appears to be very drought stressed.
2035 II NW	Deepwater Lagoon (38881652828)	Category = 3 This site is extremely degraded, being paddock with some remnant stands of *Melaleuca sp.* on the perimeter of the lake, however surface water is present.	Not applicable as the area is a pastoral paddock.	Not applicable as the area is a pastoral paddock.