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Groundwater resource allocation, East Gnangara

Water and Rivers Commission

**Report and recommendations
of the Environmental Protection Authority**

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Summary

This report is to provide the advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment, about the establishment of environmental water provisions proposed for East Gngangara. The report is based on the environmental factors relevant to the proposal.

Water and Rivers Commission propose to allow groundwater abstraction for public water supply and private water uses from the eastern side of the Gngangara Mound, while allowing for provision of groundwater to the environment. Abstraction for public use will provide for urban development in the north-east corridor in addition to supplementing the Perth metropolitan water supply.

Relevant Environmental Factors

Although a number of environmental factors were considered by the EPA in the assessment, it is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in the report:

- (a) Terrestrial vegetation - impacts on regionally significant and phreatophytic vegetation from groundwater drawdown; and
- (b) Wetlands and seepages - impacts from groundwater drawdown.

Conclusions

The EPA has considered the proposal by the Water and Rivers Commission for environmental water provisions on the eastern side of Gngangara Mound. The EPA has concluded that the proposal can be managed to meet the EPA's objectives, provided that the conditions in Section 4 and set out in detail in Appendix 3 are imposed.

The EPA considers that the key environmental factors associated with this proposal are the impacts of groundwater drawdown on phreatophytic vegetation and wetlands. The EPA considers the effects of groundwater drawdown can be managed to acceptable levels, particularly by ensuring the rate of drawdown is progressively implemented to minimise impacts.

Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on the relevant environmental factors of terrestrial vegetation, wetlands and seepages set out in Section 3.
2. That the Minister notes that the EPA has concluded that the proposal can be managed in an environmentally acceptable manner, provided there is satisfactory implementation by the proponent of the recommended conditions set out in Section 4.
3. That the Minister imposes the conditions recommended in Appendix 3 of this report.

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1. Introduction

This report provides the advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment on the environmental factors relevant to the proposal by the Water and Rivers Commission (WRC) to establish and implement environmental water provisions (EWPs) at East Gngangara. Establishment of EWPs will allow the Water and Rivers Commission to allocate groundwater for abstraction from the eastern side of the Gngangara Mound.

The proposal for environmental water provisions was referred to the EPA in January 1995, and the level of assessment was set at Public Environmental Review.

The East Gngangara Environmental Water Provisions Plan, referred to here as the PER (WRC 1997), was made available for public review between 27 October 1997 and 22 December 1997. It can be viewed at the Department of Environmental Protection (DEP) library.

In compiling this report, the EPA has considered the environmental factors associated with the development, issues raised by the public, specialist advice from government agencies, the proponent's response to issues raised, the EPA's own research and, in some cases, research provided by other expert agencies.

The report sets out the environmental factors that the EPA considers are relevant to the proposal and the conditions and procedures which should be applied if it is implemented.

2. The Proposal

The scope and objectives of the East Gngangara Environmental Water Provisions Plan encompassed a number of factors, including:

- identification of ecosystem components with high environmental and social values,
- determination of environmental water requirements (EWRs) and EWPs for each ecosystem component,
- determination of quantity of water available for public and private groundwater abstraction,
- computer modelling of differing abstraction scenarios to model likely impact of groundwater abstraction,
- prediction of the changes in water levels induced by groundwater abstraction, to determine if conflicts are likely,
- proposed longterm management and monitoring of groundwater in the study area.

The PER document discussed how the groundwater, after provisions were made to the environment, was to be allocated between public and private users (PER, section 15). The WRC included this in the PER as it believed that private water allocation is of considerable interest to the community. As the EPA's interest is to ensure protection of the environment, the WRC has advised that EPA need not consider the allocation of groundwater between public and private users in this assessment (PER, p 1-2).

The concept of EWRs and EWPs as applied by the WRC has previously been accepted by the EPA when assessing the changes to environmental conditions for the Gngangara Mound groundwater resources (Bulletin 817, May 1996). The EWR is the water requirement of a particular component of the environment required to maintain its ecological values and functions in their current state. The EWP is that portion of the EWR that will be provided. In instances where the full EWR will not be met, some adverse change to that component of the environment

can be expected. The key issue for this assessment is whether the proposed EWPs meet the EPA's environmental objectives.

In the development of the PER, the WRC considered the environmental characteristics of the study area, and made an assessment of the ecological value of different components of the environment dependent on groundwater. The groundwater-dependent components of the environment in the study area include phreatophytic (groundwater-dependent) vegetation, wetlands and seepages. EWRs were established for each environmental component, based on the assessment of their ecological value. EWPs were assigned on the basis of the competing demands for the water resource relevant to that environmental component.

Groundwater-dependent components of the environment for which EWRs and EWPs were determined in the study area include terrestrial vegetation (Banksia woodlands), wetlands and seepages.

EWRs for vegetation were established for the majority of monitoring wells in Whiteman and Melaleuca Parks in the Gngangara Mound Section 46 Report (Water Authority of Western Australia 1995) and reported on in EPA Bulletin 817. EWRs for other monitoring wells in the East Gngangara study area were determined in a similar manner, ie subtracting 1.5m from the average minimum groundwater level at each monitoring well in the early 1970's (prior to the current drought period). Banksia species are believed to be able to tolerate a progressive water table drawdown of 1.5m, at a rate of 0.2m per year. Trees on sites with less than 6m to groundwater are most susceptible to drawdown (WAWA 1992).

Interim EWRs for wetlands have been determined as the basin water requirements of the wetland vegetation until the degree of perching, and consequent reliance on groundwater, has been established for each wetland. Interim EWRs were derived from analysis of historical data on natural water regime and vegetation present at each wetland, and were set as minimum, maximum and absolute minimum water levels for each wetland. It is proposed that water levels are not to fall below the set minimum water levels more than two years in six, and absolute minimums are not breached at all.

Two seepages of significant conservation and environmental value remain intact in the study area, the Edgecombe and Egerton seepages (Figure 1) (Jasinka and Knott 1994). There has been limited data collection on natural water regimes feeding springs or seepages on the east Gngangara Mound. Consequently EWRs proposed for the two seepages are interim, pending the collection of further data.

Details of proposed EWRs and EWPs for terrestrial vegetation, wetlands and seepages are provided in Table 1.

An EWP for the Edgecombe seepage has not been established as factors affecting the groundwater level at this site are beyond the control of WRC, but it is recommended that the groundwater table upstream of the Edgecombe seepage be maintained at 14.35m AHD to sustain the 2m seepage area. The EWP for the Egerton seepage has been set to equal the EWR, to maintain the permanent flow of water believed to feed the seepage.

Locations of monitoring wells in the study area for terrestrial vegetation with established EWRs and EWPs and wetlands and seepages with interim EWRs are provided in Figure 1.

Abstraction will allow the development the Lexia groundwater scheme by the Water Corporation, which will provide for urban development in the north-east corridor, in addition to supplementing the Perth metropolitan water supply and providing groundwater for private users. The Lexia groundwater scheme comprises 11 superficial wells centred in the Gngangara pine plantations of State Forest 65 (SF65), and one semi-confined (Mirrabooka sands) well east

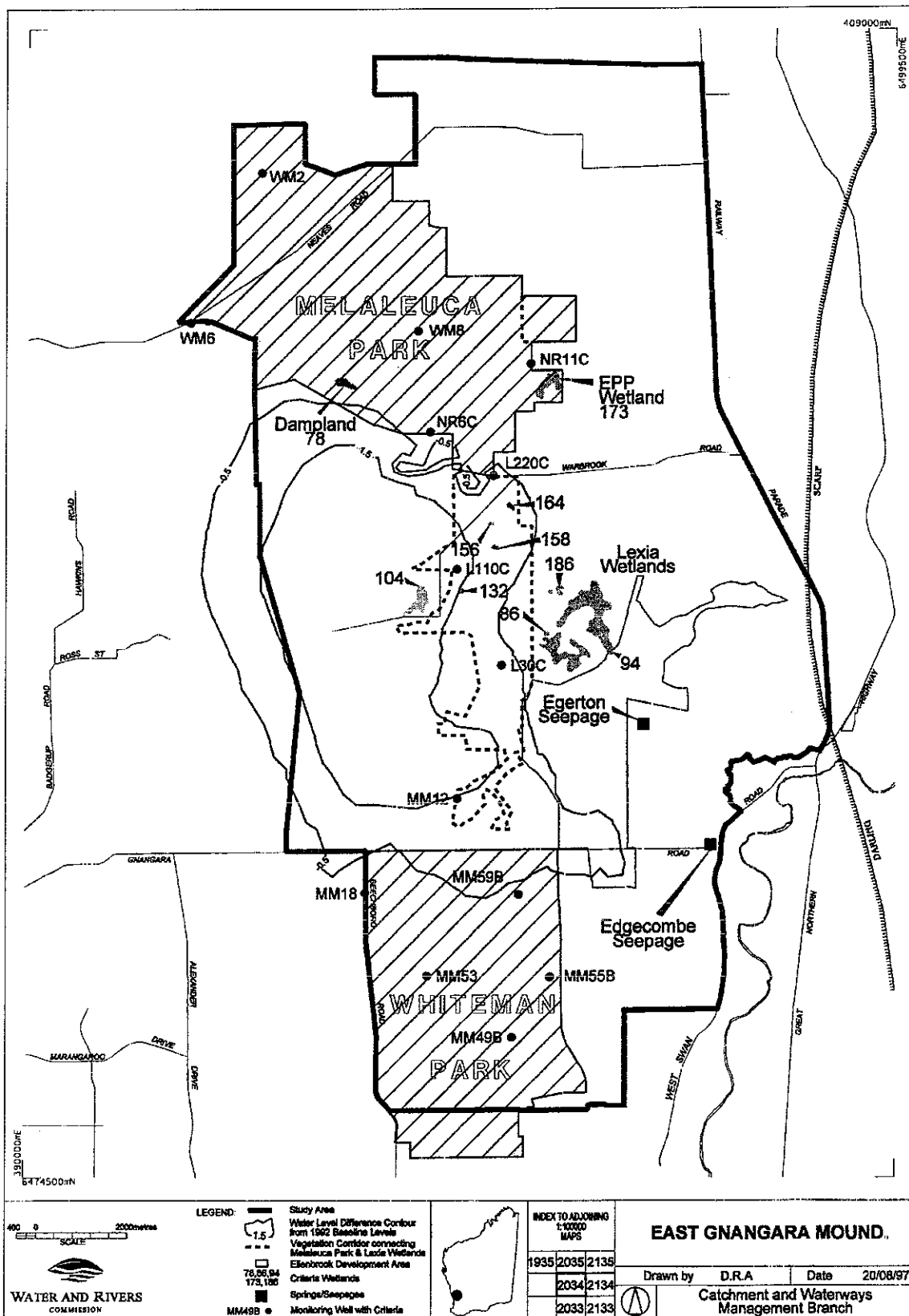


Figure 1. Location of monitoring wells, wetlands and seepages in the East Gungahara study area (source: WRC 1998).

Table 1. Summary of proposed environmental criteria for terrestrial vegetation, wetlands and seepages in East Gngangara study area.

Location	Monitoring Well	EWR (min water level mAHD)	EWP (min water level mAHD)	EWP < EWR (m)
Vegetation				
Melaleuca Park	WM6	58.8	58.3	0.5
Melaleuca Park	WM8	65	64.8	0.2
Melaleuca Park	NR6C	58.5	58.5	-
Melaleuca Park	WM2	67	66.5	0.5
Melaleuca Park	NR11C	55	55	-
Whiteman Park	MM49B	24.7	24.7	-
Whiteman Park	MM53	33.3	33.3	-
Whiteman Park	MM55B	29.5	29.5	-
Whiteman Park	MM18	38.6	38.6	-
Whiteman Park	MM59B	36.3	36.3	-
Vegetation Corridor	MM12	43	42	1.0
Vegetation Corridor	L30C	47.5	47.2	0.3
Vegetation Corridor	L110C	57	55.7	1.3
Vegetation Corridor	L220C	52.5	52.2	0.3
Wetlands		EWR^a		
		Minimum	Absolute minimum	
Melaleuca Park 78	GNM13	5.5m below ground	5.8m below ground	
Melaleuca Park 173	GNM14	0.1m above ground	0.1m above ground	
Lexia 186	GNM15	0.8m below ground	1.1m below ground	
Lexia 86	GNM16	1.0m below ground	1.3m below ground	
Lexia 94	GNM17A	1.5m below ground	1.8m below ground	
Seepages		EWR	EWP	
Edgecombe	B10	14.35 ^b	^b	
Egerton	B25	39.29 ^c	39.29 ^c	

a: Interim EWRs and absolute minimum water levels have been determined for these wetlands. EWPs will be provided following investigation of stratigraphy and water regimes, and reported in the triennial review.

b: Recommendation for management only. The seepage is outside the zone of influence of the proposal; final water levels are expected to be affected by factors unrelated to groundwater abstraction for public water supply.

c: Access to land required before monitoring can be conducted.

of SF65 (Figure 2) A further two superficial wells for the East Mirrabooka Stage 3 scheme are proposed. Total yield will be 11×10^6 kL/yr. The infrastructure for the Lexia wellfield has been previously assessed by the EPA, and is proposed to be operational by late 1999.

The model used by the WRC to allow prediction of water levels in the future incorporated a number of variables, including private groundwater abstraction, urbanisation, climatic variation, pine basal area and well layout. The declines predicted are the result of maximum utilisation of groundwater by each component of the model. The final water level attained on the Mound will be dependent on the interaction between any of the above variables and may not stabilise while drawdown rates are fluctuating. Climatic variability was the single most unpredictable variable in modelling future groundwater levels.

3. Relevant environmental factors

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit. It is the EPA's opinion the following are the environmental factors relevant to the proposal, which require detailed evaluation in this report:

- (a) Terrestrial vegetation - impacts on regionally significant and phreatophytic vegetation from groundwater drawdown; and (Section 3.1)
- (b) Wetlands and seepages - impacts from groundwater drawdown. (Section 3.2)

The above relevant factors were identified from the EPA's consideration and review of all environmental factors (preliminary factors) generated from the PER document and the submissions received, in conjunction with the proposal characteristics (including significance of the potential impacts), the adequacy of the proponent's response and commitments, the effectiveness of current management and alternative approval processes which are designed to ensure that the factors will be appropriately managed.

Table 2 summarises the environmental factors considered by the EPA from which the relevant factors were determined. On this basis, the EPA considers that the groundwater quantity and aboriginal heritage factors and other issues raised in the submissions do not require further evaluation by the EPA. These factors either have manageable impacts, are addressed by the proponent's commitments, or are covered by other environmental control processes.

Detail on the relevant environmental factors and their assessment is contained in Sections 3.1 to 3.2 below, and a summary is given in Table 3.

3.1 Terrestrial vegetation - impacts on regionally significant and phreatophytic vegetation from groundwater drawdown

Description

The study area contains extensive phreatophytic vegetation in Melaleuca and Whiteman Parks, the Ellenbrook bushland, and in the tract of native vegetation between Melaleuca Park and Ellenbrook bushland (referred to as the vegetation corridor) (Figure 3). These areas have all been identified by the DEP as regionally significant. Melaleuca Park consists wholly of the management priority area of the System 6 Reserve M9 and Whiteman Park comprises System 6 Reserve M13.

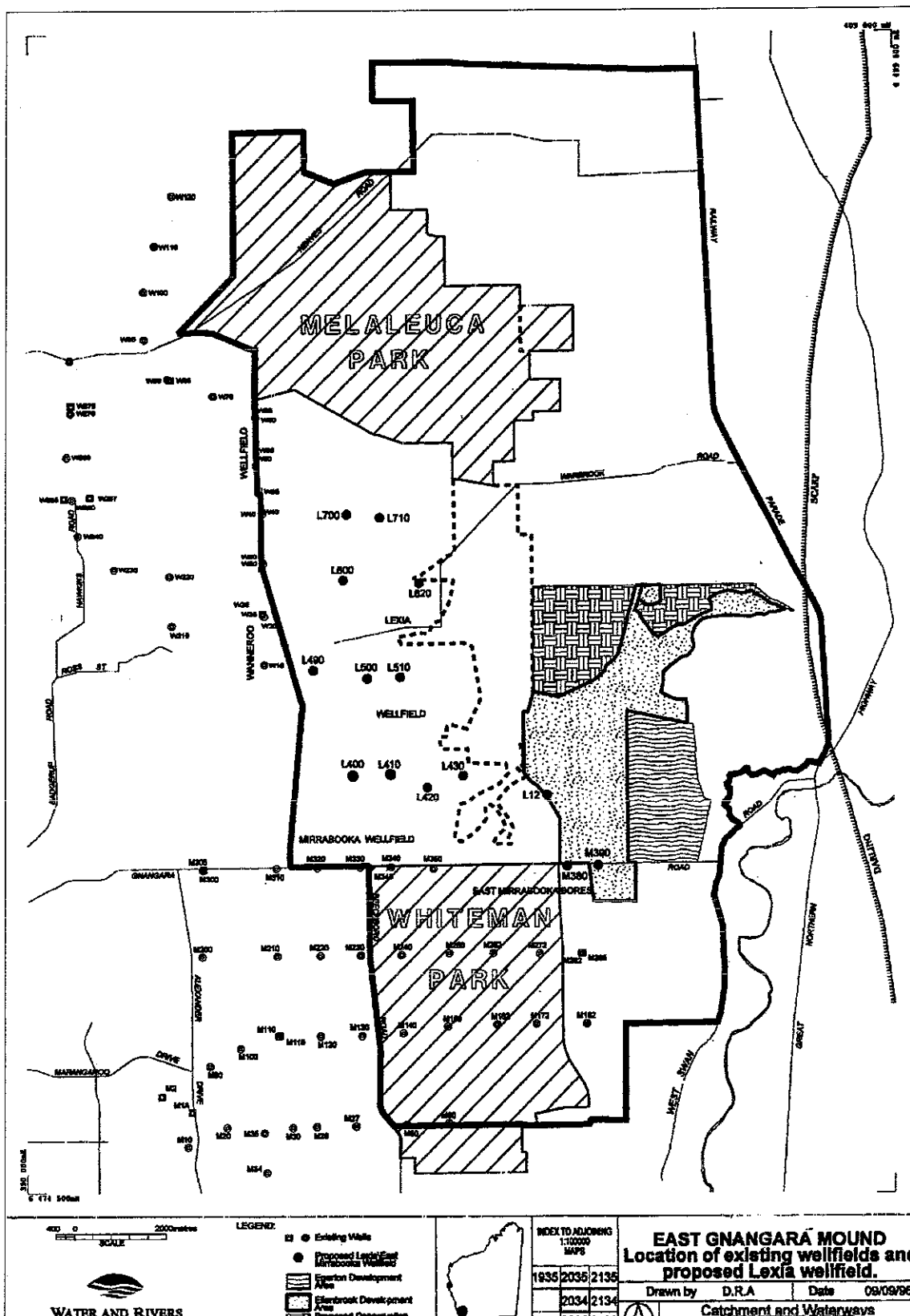


Figure 2. Location of production wells for the proposed Lexia wellfield (Source: WRC 1997).

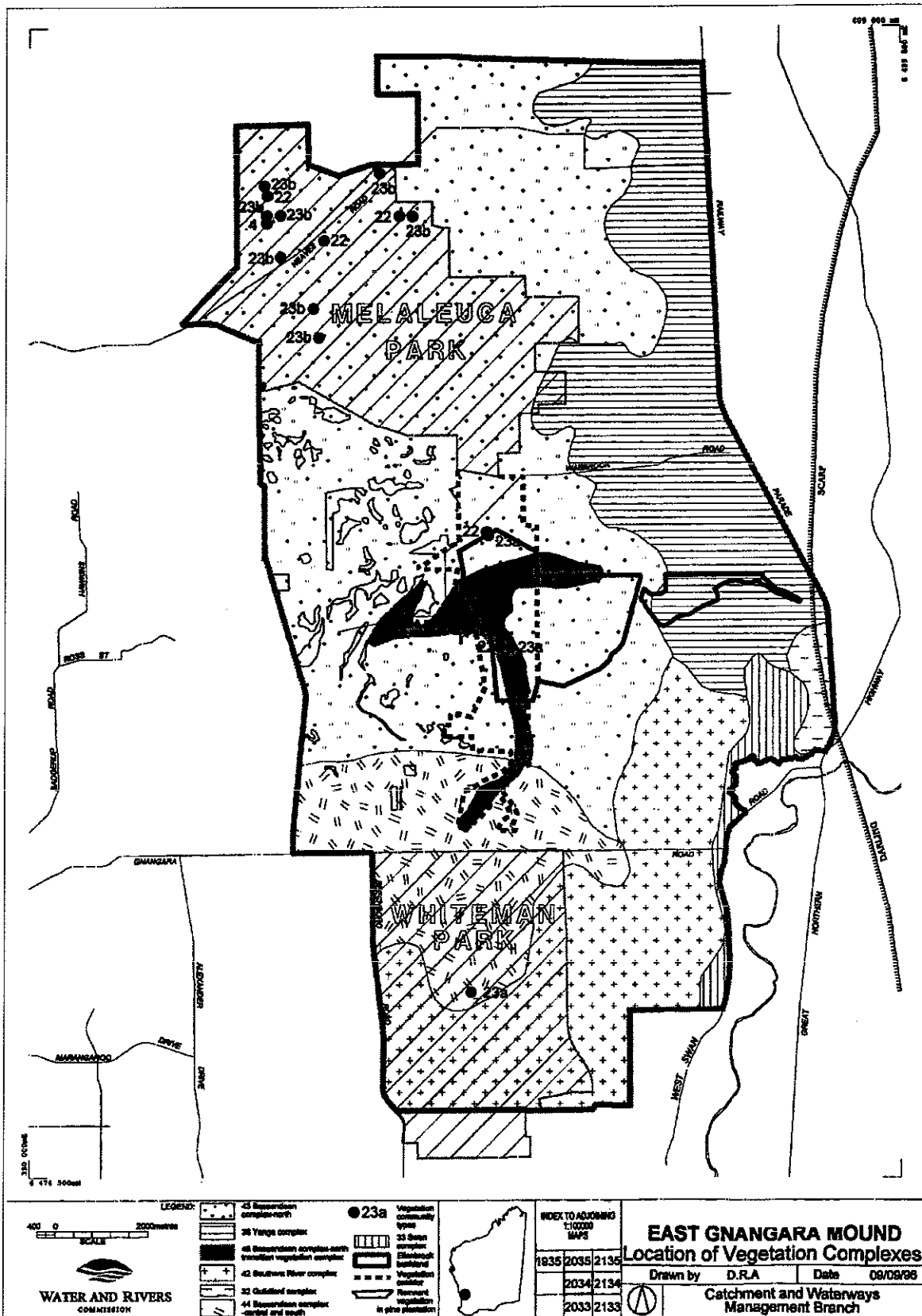


Figure 3. Vegetation complexes in the East Gungahra study area (Source: WRC 1997).

Melaleuca Park contains the Bassendean Complex-North and the Yanga Complex (Heddle *et al* 1980) plant communities. The Yanga Complex is confined to the Pinjarra Plain and comprises closed *Melaleuca* scrub, with low open forest of *Casuarina obesa* favoured by low-lying water-gaining areas. This complex is poorly reserved, and has been extensively cleared for agriculture in the past, with less than 10% of the estimated original coverage remaining. Melaleuca Park also contains the most important remaining example of the Bassendean Complex-North within State forest.

The floristic community types developed by Gibson *et al.* (1994) represented in Melaleuca Park include community types 4 (*Melaleuca priessiana* damplands), 21c (*Banksia attenuata* low lying woodland), 22 (*B. ilicifolia* woodland) and 23a and 23b (Central and Northern *B. attenuata* and *B. menziesii* woodland).

The Ellenbrook bushland is a continuation of the vegetation contained in Melaleuca Park, with the Bassendean Complex-North, limited occurrences of Bassendean Complex-North Transition and the Yanga Complex represented. Communities 4, 5 (mixed shrub damplands), 18 (shrublands on calcareous silts), 21a, 21c, 22, and 23b are represented, while types 5 and 18 are not represented in Melaleuca Park. The Ellenbrook bushland is a particularly species rich remnant of the vegetation of the Swan Coastal Plain, and contains a number of rare or priority flora taxa.

Whiteman Park contains the Bassendean Complex-Central and South, and the only reserved occurrence of the Southern River complex. Additionally, community types 4, 21c and 22 are represented in Whiteman Park.

The vegetation corridor contains the Bassendean Complex-North, Bassendean Complex-North Transition and floristic community types 22 and 23a. The Bassendean Complex-North Transition comprises low open forest or woodland of *Banksia* spp and *Eucalyptus todtiana*. It is geographically restricted, being originally limited to six small patches between Gngangara Road and Gingin and one larger patch which straddles the Moore River. Parts of some of the areas have been cleared. In the study area, this complex is restricted mainly to the vegetation corridor, with small occurrences in the Ellenbrook bushland.

Vegetation complexes and floristic community types, including their reservation and conservation status are summarised in Tables 4 and 5.

Changes in community structure over the Gngangara Mound due to groundwater abstraction may be confounded by climatic events. A trend of decreasing soil moisture in response to below average rainfall over the past 20 years has been observed at sites remote from groundwater abstraction, with consequent changes in the vegetation from phreatophytic to more xeric communities.

Assessment

The area considered for assessment of this environmental factor is the East Gngangara Groundwater Mound study area (Figure 1).

The EPA's environmental objective in regard to this factor is to maintain abundance, species diversity, geographic distribution and productivity of vegetation communities.

Table 2. Identification of relevant environmental factors

Factors	Proposal Characteristics	Public and Government Agency Comments	Identification of Relevant Factors
Biophysical			
Terrestrial vegetation	<p>EWPs less than EWRs are proposed in the vegetation corridor. Groundwater drawdown in the vegetation corridor may be up to 2m (0.3-1.3m below EWRs), with groundwater levels predicted to fall below EWRs in up to one in three years. This will result in a gradual shift to a more drought tolerant community structure. Some loss of mature banksia trees is anticipated, exacerbating continued dry climatic influence. Production wells near the vegetation corridor will be phased in.</p> <p>EWPs for Whiteman Park and Melaleuca Park will remain the same as those developed for the Gngara S46 (EPA Bulletin 817). Minimal impact in these areas is expected as a result of groundwater allocations associated with this proposal. Groundwater levels are predicted to fall below EWRs due to climatic influences in up to 17% of years in Melaleuca Park.</p>	<p>Government: CALM: Proposed drawdown under the vegetation corridor will result in changes to the vegetation. Drawdown is likely to have an impact on CALM's ability to revegetate the areas after pine removal.</p> <p>Public: Continuing change toward drought tolerant vegetation communities or loss of bush is unacceptable.</p>	<p>This factor warrants further evaluation.</p>
Wetlands and seepages	<p>Wetlands: Interim EWRs have been determined for five wetlands, until degree of perching established. EWPs will be proposed for these wetlands in the next triennial review of groundwater monitoring, following the investigations of the degree of perching.</p> <p>Anticipated drawdowns in the vicinity of wetlands with EWRs</p> <ul style="list-style-type: none"> • 0.25m in dampland 78 • <0.25m in Lexia wetlands 86 and 186 • EPP wetlands 173 and Lexia 94 will not be affected <p>The WRC does not expect that these drawdowns will significantly affect the environmental values of these wetlands.</p> <p>Four conservation category wetlands will experience groundwater drawdown of between 0.7 and 1.5m. The WRC has made a commitment to monitor the impacts on these wetlands and implement mitigation measures and/or replace wetland values if these are lost.</p> <p>A <i>Melaleuca raphiophylla</i> wetland in the centre of the pine plantation is restricted in its geomorphological association. Drawdown in the vicinity of this wetland is expected to be 3m from the current depth of 1.8m. The WRC has made a commitment to monitor this wetland and implement mitigation measures and/or replace or compensate for the loss wetland values if these are lost..</p> <p>Seepages: Two groundwater seepages in the eastern zone of the East Gngara Study area are on the edge of the zone of influence. The EWP for the Egerton seepage has been set to equal the EWR, to maintain the permanent flow of water upstream believed to feed the spring.</p> <p>Proposed urban development at Egerton, upstream of the Edgecombe seepage is considered likely to have a greater effect on this seepage than groundwater abstraction from the Lexia scheme. With urbanisation, irrigation of the Egerton property will cease, resulting in a predicted 0.2m decline in the local groundwater. As a consequence, an EWP for the Edgecombe seepage has not been established, but it is recommended that the groundwater table upstream of the seepage be maintained at 14.35m AHD to sustain the 2m head of seepage area at Edgecombe.</p>	<p>Government: CALM: Commitment of resources may be better directed toward other nature conservation works, instead of wetland mitigation of the <i>Melaleuca raphiophylla</i> wetland in the pine plantation.</p> <p>Public: Current wetland water levels are low, and are a reflection of the low rainfall of the previous 20 years. The effect of allowing pumping to maintain water levels at a predetermined minimum may affect vegetation structure in the long term.</p> <p>Monitoring should be more intense in the first five years. 135 wetlands exist in the study area.</p> <p>Long term integrity of Egerton Seepage has not been guaranteed. Increased abstraction, in addition to inadequate buffers from the proposed urban development close to the seepage will increase pressure on this important wetland.</p> <p>Flow leaving the Mound will be reduced by increased abstraction. This will affect stream systems reliant on groundwater flow. Bennet Brook in particular will be affected, as the headwaters for this stream originate in Whiteman Park and will not receive drainage waters. Bennett Brook has suffered from groundwater abstraction in the past.</p>	<p>This factor warrants further evaluation.</p>

Groundwater quantity	<p>Rural properties in the North-east of the scheme with a high groundwater table may experience a reduction in summer pasture growth. Water levels in small private dams may also be affected.</p> <p>Artificial lakes in Ellenbrook and proposed Egerton estate may not receive the water allocation expected by the developers.</p> <p>Private bores: Water availability to rural properties is not expected to be affected, although watertable may drop 0.25-0.5m in the north eastern area.</p> <p>Pine management: Pines are to be managed to a basal area of 11 m² ha, representative of the original vegetation. The Gngara Conservation Park proposed by CALM for SF65 will involve the progressive clearing of pines over the next 20 years, resulting in significant rises in groundwater levels.</p>	<p>Government: CALM request that a portion of the groundwater made available after harvesting of pines is allocated to the rehabilitation of the Gngara Park.</p> <p>Public: None received</p>	<p>Management of pines by CALM has been the subject of previous EPA consideration and there is no need to further expand in this assessment.</p> <p>This factor does not warrant further evaluation. The EPA has not considered the allocation of groundwater between users in this assessment.</p>
Social Surroundings			
Aboriginal heritage	<p>Large wetlands within the East Gngara study area important to Aborigines include Yakine Swamp, Mussel Brook and Ellen and Bennett Brooks. Many smaller wetlands were also important as sources of food and water.</p>	<p>Government: The Department of Aboriginal Affairs recommends involving the local Aboriginal community directly when developing public involvement and awareness programs.</p> <p>Public: The Swan Valley Nyungah community requests WRC to liaise directly with them regarding the proposal.</p>	<p>Extensive surveys and consultation was undertaken in development of the Plan.</p> <p>The WRC have committed to ongoing liaison with the Swan Valley Nyungah community.</p>

Table 3. Summary of assessment of relevant environmental factors.

Factor	Relevant Area	EPA Objective	Assessment	EPA Advice
Terrestrial vegetation	East Gngalara study area	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.	<p>EWPs are proposed in the vegetation corridor which are below EWRs. Groundwater levels are predicted to fall below EWRs in the vegetation corridor in up to one in three years. This is expected to result in a gradual shift to a more drought tolerant community structure. Some loss of mature banksia trees is anticipated, exacerbating continued dry climatic influences.</p> <p>EWPs are proposed to be equal to EWRs in Whiteman Park and much of Melaleuca Park.</p> <p>Climatic influences are expected to have a greater effect than groundwater abstraction in Melaleuca Park, and EWRs are not expected to be met even with no further groundwater abstraction in up to 17% of years in parts of the Park. Wells will need to be turned off in up to 13% of years in Whiteman Park to ensure EWPs are met.</p>	<p>Having particular regard to:</p> <ul style="list-style-type: none"> • the proponent's commitment for production wells near the vegetation corridor to be phased in, to allow time for tree roots to follow the declining water table; • the proponent's commitment to develop an MOU between CALM and WRC on pine harvesting; • the sand mining proposed for the vegetation corridor for the next 50 years; • the continuation and establishment of vegetation monitoring in Melaleuca Park, Whiteman Park, the vegetation corridor and the Ellenbrook bushland; <p>it is the EPA's opinion that the proposal can be managed to meet its objective for this factor, provided the proponent's commitments are made legally enforceable.</p>
Wetlands and seepages	East Gngalara study area	Maintain the integrity, functions and environmental values of wetlands.	<p>Four conservation category wetlands will be subject to a decline in groundwater levels of greater than 0.7m. Wetland 132 (vegetation corridor) will be the most severely affected, with groundwater levels in the vicinity expected to decline by 1.5. This wetland has an intact <i>M. preussiana</i>, <i>B. littoralis</i> and <i>B. ilicifolia</i> overstorey. Mature trees are expected to be lost as a result of groundwater drawdown.</p> <p>Drawdown in the vicinity of a geomorphologically restricted <i>M. raphiophylla</i> wetland in the pine plantation is expected to be 3m from the current depth of 1.8m.</p> <p>Maintenance of the permanent flow of water upstream of the Egerton seepage should be sufficient to ensure survival of the spring.</p> <p>Proposed urban development at Egerton, upstream of the Edgecombe seepage is considered likely to have a greater effect on this seepage than groundwater abstraction from the Lexia scheme. WRC recommend that the groundwater table upstream of the seepage be maintained at 14.35m to sustain the 2m of seepage at Edgecombe.</p>	<p>Having particular regard to:</p> <ul style="list-style-type: none"> • the monitoring proposed for five wetlands within the study area; • the containment of wetland 132 within the sand mining envelope in the vegetation corridor, and the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of this wetland; • the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of wetlands 156, 158 and 164; • the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of the <i>Melaleuca raphiophylla</i> wetland (104) in the pine plantation; • the degraded nature of the EPP wetland affected by the proposal; and • the monitoring of aquatic invertebrates and vegetation proposed for selected wetlands, <p>it is the EPA's opinion that the proposal can be managed to meet its objective for this factor provided the proponent's commitments are made legally enforceable.</p>

Table 4. Reservation and conservation status of vegetation complexes within the study area potentially impacted by groundwater abstraction.

Complex	Represented in	Reserv'n Status	Conserv'n status	Extant
Bassendean - North	Melaleuca Park, Ellenbrook bushland, vegetation corridor	Extremely good	Extremely good	50% ¹ 63% ³
Bassendean - North Transition	Vegetation corridor, Ellenbrook bushland	Extremely good	Extremely good	60% 86% ³
Yanga	Melaleuca Park, Ellenbrook bushland	Poorly reserved	Extremely poor	<10% ² 9% ³
Bassendean - Central and South	Whiteman Park	Poorly reserved	Extremely poor	15% ¹ 14.5% ³
Southern River	Whiteman Park	Poorly reserved	Extremely poor	8.6% ³ <7% ⁴

1. Trudgeon (1996)

2. Feilman Planning Consultants (1992)

3. Burbridge and Rolfe (1989)

4. Trudgeon and Keighery (1995)

Table 5. Reservation and conservation status of floristic community types (after Gibson *et al.* 1994 and DEP 1996) within the study area potentially impacted by groundwater abstraction.

Comm. no.	Description	Represented in	Reserv'n status ¹	Conserv'n status
4	<i>Melaleuca priessiana</i> damplands	Melaleuca Park, Ellenbrook bushland, Whiteman Park	Well reserved	Low risk
5	Mixed shrub damplands	Ellenbrook bushland	Well reserved	Low risk
18	Shrublands on calcareous silts	Ellenbrook bushland	Poorly reserved	Vulnerable
21a	Central <i>Banksia attenuata</i> - <i>E. marginata</i> woodlands	Ellenbrook bushland	Well reserved	Low risk
21c	Low-lying <i>Banksia attenuata</i> woodlands or shrublands	Melaleuca Park, Whiteman Park	Well reserved	Susceptible
22	<i>Banksia ilicifolia</i> woodlands	Melaleuca Park, Ellenbrook bushland, Whiteman Park, vegetation corridor	Poorly reserved	Susceptible
23a	Central <i>Banksia attenuata</i> - <i>B. menziesii</i> woodland	Melaleuca Park, vegetation corridor	Well reserved	Low risk
23b	Northern <i>B. attenuata</i> - <i>B. menziesii</i> woodland	Melaleuca Park, Ellenbrook bushland	Unreserved	Susceptible

¹Well reserved = found in 2 or more National Parks or Nature Reserves

Poorly reserved = found in 1 National Park or Nature Reserve

Unreserved = not found in either a National Park or Nature Reserve.

Using the preferred well layout and abstraction volumes, and with full urbanisation in Ellenbrook and Egerton, total utilisation of private groundwater allocations, and a pine basal area of 11 m²/ha, the following declines on groundwater levels are predicted;

- 0.25m in the south of Melaleuca Park,
- <0.5m on the western boundary of Ellenbrook bushland,
- 0.25 - 0.5m in the northern third of Whiteman Park, and
- 0.5 - 2.0m in the vegetation corridor.

Vegetation complexes and communities most likely to be affected by the proposal are those in the vegetation corridor. The WRC has proposed EWP's in this area which are up to 1.3m below EWR's. Groundwater levels are predicted to fall below the EWR's in the vegetation corridor in up to one in three years. This is expected to result in a gradual shift to a more drought tolerant community structure, with some loss of mature banksia trees, exacerbating continued dry climatic influences. The proponent is committed to the phasing in of production wells near the vegetation corridor, to allow time for tree roots to follow the declining water table.

The three most common Banksia species in the study area are *Banksia menziesii*, *B. ilicifolia* and *B. attenuata*. Of these, *B. ilicifolia* woodlands (community 22) favour low-lying areas and are highly dependent on near surface groundwater tables. This community type is represented in the vegetation corridor, and will be susceptible to groundwater drawdown. The EWP's have been set to equal the EWR's in Whiteman Park and much of Melaleuca Park. Climatic influences are expected to have a greater effect than groundwater abstraction in Melaleuca Park, and EWR's are not expected to be met even with no further groundwater abstraction in up to 17% of years in parts of Melaleuca Park. The WRC has predicted that wells will need to be turned off in up to 13% of years in Whiteman Park to meet EWP's proposed in this area.

Concerns were expressed in the public submissions on the cumulative effect of groundwater drawdown on vegetation structure and composition in the study area. The EPA notes however, that only the vegetation corridor is likely to be significantly affected by groundwater allocation associated with the proposal. Some loss may be expected but, in general, species diversity in the vegetation corridor is not expected to change. In addition, natural changes in vegetation structure over much of the Gnangara Mound at locations remote from groundwater abstraction have been observed as a result of climatic influences.

Progressive pine removal from plantations in proximity to the vegetation corridor is expected to compensate to some extent for groundwater drawdown in this region. A commitment by the proponent to develop a Memorandum of Understanding with CALM on pine management is expected to address issues associated with the removal of the pine plantation over the next 20 years.

Sand mining is proposed for the lower half of the vegetation corridor, with granted Mining Leases valid for the next 50 years. The sand mines have previously been assessed by the EPA in 1988 and reported in Bulletin 318. Removal of extensive tracts of native vegetation in the central and southern portion of the corridor is likely to occur to allow the mining of the sand resource. Ministerial conditions in relation to rehabilitation and end land use acceptable to the EPA have been imposed.

Having particular regard to:

- (a) the proponent's commitment to manage groundwater abstraction to meet EWRs, and monitor vegetation impacts with a view to revising EWRs if appropriate;
- (b) the proponent's commitment for production wells near the vegetation corridor to be phased in, to allow time for tree roots to follow the declining water table;
- (c) the proponent's commitment to develop an Memorandum of Understanding between the Department of Conservation and Land Management (CALM) and WRC on pine harvesting;
- (d) the proponent's commitment to continue existing, and establish further vegetation monitoring in Melaleuca Park, Whiteman Park, the vegetation corridor and the Ellenbrook bushland; and
- (e) the proponent's commitment to map vegetation on the Gngangara Mound to enable identification of environmental constraints to further groundwater abstraction,

it is the EPA's opinion that the proposal can be managed to meet its objective for this factor, provided the proponent's commitments are made legally binding.

3.2 Wetlands and seepages

Description

Wetlands A total of 135 wetlands are present in the study area, the majority of which will be unaffected by the proposal. A decline in groundwater levels is likely to reduce the size of the affected wetlands and shorten the period over which a wetland contains water each year.

Five wetlands considered representative of wetlands with high conservation value in the study area were identified for investigation and determination of EWRs. These include three from the Lexia suite (86, 94 and 186), one from a group of three EPP listed wetlands in the south-east of Melaleuca Park (173), and a damland in the south-west of Melaleuca Park (78) (Figure 1).

Seepages. The Egerton and Edgecombe seepages are downstream of the proposed Lexia wellfield on the eastern edge of the zone of influence.

Proposed urban development at Egerton, upstream of the Edgecombe seepage is considered likely to have a greater effect on this seepage than groundwater abstraction from the Lexia wellfield. With urbanisation, irrigation of the Egerton property with water sourced from the confined aquifer will cease, resulting in a predicted 0.2m decline in the local groundwater levels.

The Egerton seepage will also be affected by the urban development proposed for Egerton, with the seepage being incorporated into public open space within the estate. This seepage contains pristine vegetation, and supports a club moss and liverworts considered to be extreme geographical outliers. Additionally, a previously unrecorded amphipod was collected from Egerton seepage in a survey in 1994. This amphipod was found to be an undescribed genus (Jasinska and Knott 1994). Invertebrates found in the Edgecombe and Egerton seepages are likely to be dependent on permanent water, with little resistance to drying.

Assessment

The relevant area for this factor is the East Gngangara Study Area (Figure 1).

The EPA's objective in relation to this relevant environmental factor is to maintain the integrity, functions and environmental values of wetlands.

Anticipated drawdowns for the five wetlands where interim EWRs have been determined are:

- 0.25m in dampland 78
- <0.25 in Lexia wetlands 86 and 186
- EPP wetland 173 and Lexia wetland 94 will be unaffected

The WRC considers that drawdowns of less than 0.25m will not result in any loss of environmental values for these wetlands. The WRC will carry out further investigations of these wetlands to determine the degree of perching of groundwater and propose EWPs for them to protect their environmental values.

The wetlands in the study area that will be subject to greater groundwater drawdown will be affected to varying degrees (Table 6) Four conservation category wetlands will be subject to a decline in groundwater levels greater than 0.7m, in addition to one (169) protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP). A number of smaller wetlands contained in the pine plantations will also suffer from a groundwater decline, however these have previously been degraded and impacted by drawdown from the pines.

Table 6. Predicted drawdown and management of impacts of wetlands affected by groundwater drawdown.

Wetland	Tenure	Mgt categ.	Predicted drawdown (m)	Management proposed
132	State forest, vegetation corridor	C	1.5	Monitoring and mitigation or replacement if significant loss of values. Wetland is within sand mining envelope.
156	State forest, vegetation corridor	C	1.0	Monitoring and mitigation or replacement if significant loss of values.
158	State forest, vegetation corridor	C	1.0	Monitoring and mitigation or replacement if significant loss of values.
164	State forest, vegetation corridor	C	0.7	Monitoring and mitigation or replacement if significant loss of values.
104	State forest, pine plantation	RE	3.0	Monitoring and mitigation or replacement if significant loss of values.
125	State forest, Melaleuca Park	RE	0.5	No management proposed as impacts are likely to be negligible.
159	State forest, vegetation corridor	RE	0.5	No management proposed as impacts are likely to be negligible.
169 (EPP)	Private property	MU	0.5	No management proposed as impacts are likely to be negligible.
68	State forest, vegetation corridor	MU	2.0	Impacts are likely to be negligible as few natural attributes remain.

The four conservation category wetlands will be affected as follows:

- Wetland 132 (vegetation corridor) will be the most severely affected, with groundwater levels in the vicinity expected to decline by 1.5m. This wetland has an intact *Melaleuca preissiana*, *B. littoralis* and *B. ilicifolia* overstorey. Some tree and shrub species are expected to be lost, however replacement is expected to occur from recruitment. The effect of groundwater drawdown on water levels and vegetation health will be monitored as part of the monitoring program. This wetland is contained within the sand mining envelope in the vegetation corridor.
- Wetlands 156, 158 and 164 are to the north of the sand mining envelope, in the vegetation corridor. These wetlands will be subject to a predicted groundwater drawdown of between 0.7m and 1.0m. This is considered by WRC to be the maximum drawdown that these wetlands will be able to sustain, and it is expected that some mature trees will be lost. WRC recommend that the rate of groundwater drawdown not be greater than 0.2m per year.

In addition:

- A *M. raphiophylla* wetland (104) in the centre of the pine plantation which has a management category of Resource Enhancement is restricted in its geomorphological association. Drawdown in the vicinity of this wetland is expected to be 3m. Artificial maintenance will be considered once the degree of perching has been established, with replacement of the wetland in the event of significant loss of ecological values of the wetland.
- The EPP wetland 169 on private property has a predicted drawdown of 0.5m. The wetland has been heavily grazed and few natural attributes remain. Therefore it is not expected that groundwater allocations associated with this proposal will significantly affect the environmental values of this wetland.

Requirements of the life cycles of aquatic invertebrates have been included in the establishment of EWRs for wetlands. However the WRC admit that limited information is available on invertebrate species in half the selected wetlands. EWRs have been established to protect wetland vegetation, on the expectation that protection of the vegetation water requirements will in turn afford protection of the other values of the wetland. Results of spring 1996 and 1997 invertebrate sampling in the Lexia wetlands will be incorporated into the EWRs for these wetlands when available, with adjustments made if necessary.

The EPA considers that wetlands and seepages chosen for the determination of EWRs are representative of pristine systems remaining in the study area. The wetland monitoring proposed for wetlands is adequate to effectively monitor the health of the wetlands on an on-going basis, and ensure the early detection of any adverse effects of groundwater drawdown. The inclusion of wetland 132 (with a predicted drawdown of 1.5m) in the monitoring program will provide the proponent with information on species most susceptible to drawdown (indicator species), which can be used for early detection of disturbance in protected wetlands.

A decline of 1.5 m in the vicinity of wetland 132 will have a significant effect on the water cycle of this wetland. A change to a drier community structure is anticipated. Wetland 132 will also be indirectly affected by sand mining in the future, as the hydrology of the area will be changed after the excavation of the sand.

One EPP wetland will be impacted by the proposal, however a factor mitigating the impacts of groundwater drawdown on the wetland is its degraded nature. Summer pasture growth adjacent to the wetland will be limited. No public submissions regarding the effect of the proposal on water levels in private wetlands or dams were received.

The EPA notes the commitment by the proponent to develop a wetland mitigation strategy to minimise impacts in the remaining conservation category wetlands to be affected by the proposal, and to artificially maintain or compensate for the loss of the *M raphiophylla* wetland in the pine plantation. This strategy is to be developed in consultation with CALM, the DEP and the Water Corporation. The Water Corporation will be responsible for implementing the strategy as part of the license conditions imposed by the WRC

Having particular regard to:

- (a) the proponent's commitment to manage groundwater abstraction to meet EWRs, and monitor wetland impacts with a view to revising EWRs if appropriate;
- (b) the monitoring proposed for five wetlands within the study area where interim EWRs have been determined;
- (c) the containment of the conservation category wetland 132 within the sand mining envelope in the vegetation corridor, and the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of this wetland;
- (d) the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of conservation category wetlands 156, 158 and 164;
- (e) the proponent's commitment to develop a wetland mitigation strategy to minimise or manage impacts, or compensate for the loss of the *Melaleuca raphiophylla* wetland (104) in the pine plantation;
- (f) the degraded nature of the EPP wetland affected by the proposal; and
- (g) the monitoring of aquatic invertebrates and vegetation proposed for selected wetlands,

it is the EPA's opinion that the proposal can be managed to meet its objective for this factor provided that the proponents commitments are made legally enforceable.

4. Conditions

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

In developing recommended conditions for each project, the EPA's preferred course of action is to have the proponent provide an array of commitments to ameliorate the impacts of the proposal on the environment. The commitments are considered by the EPA as part of its assessment of the proposal, and following discussion with the proponent the EPA may seek additional commitments.

The EPA recognises that not all of the commitments are written in a form which makes them readily enforceable, but they do provide a clear statement of the action to be taken as

part of the proponent's responsibility for and commitment to continuous improvement in environmental performance. The commitments then form part of the conditions to which the proposal should be subject if it is to be implemented.

The EPA may of course, also recommend conditions additional to that relating to the proponent's commitments

Having considered the proponent's commitments and the information provided in this report, the EPA has developed a set of conditions which the EPA recommends be imposed if the proposal by WRC to allocate groundwater from the east Gngangara Mound, is approved for implementation. These conditions are presented in Appendix 3. Matters addressed in the conditions include:

- the proponent shall fulfil the commitments in the Consolidated Commitments statement set out as an attachment to the recommended conditions in Appendix 3.

5. Conclusions

The EPA has considered the proposal by the Water and Rivers Commission for environmental water provisions on the eastern side of Gngangara Mound. The EPA has concluded that the proposal can be managed to meet the EPA's objectives, provided that the conditions in Section 4 and set out in detail in Appendix 3 are imposed.

The EPA considers that the key environmental factors associated with this proposal are the impacts of groundwater drawdown on phreatophytic vegetation and wetlands. The EPA considers the effects of groundwater drawdown can be managed to acceptable levels, particularly by ensuring the rate of drawdown is progressively implemented to minimise impacts.

6. Recommendations

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the conditions and procedures to which the proposal should be implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on terrestrial vegetation, wetlands and seepages set out in Section 3.
2. That the Minister notes that the EPA has concluded that the proposal can be managed in an environmentally acceptable manner, provided there is satisfactory implementation by the proponent of the recommended conditions set out in Section 4.
3. That the Minister imposes the conditions recommended in Appendix 3 of this report.

Appendix 1

List of submitters

State and local government agencies:

Aboriginal Affairs Department
Department of Minerals and Energy
Shire of Swan

Organisations:

Aboriginal Corporation
Amber Oak Developments
The Bennett Brook Catchment Group
Canoble Park
Conservation Council of Western Australia Inc.
Edgecombe Bros Pty Ltd
JDA Consultants Hydrologists
North Ellenbrook Landowner's Group
Rocla Quarry Products
Sanwa Property Group
Swan Valley Nyungah Community
Wesley College Endowment Fund
Brajkovich Holdings Pty Ltd & Stefanelli Nominees Pty Ltd

Members of the Public:

W. Bestry
C. Dods
R. Gray
W. Kimba
M. Kailis & A. Kourtesis
K. Kirkby
J. & A. Kourtesis, L. Stambelos, J. Chaplin
W. Kuhn
G. & V. Meakins
Mr. K. Titelius
Vincent Nominees Pty Ltd
J. West

Appendix 2

References

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- Dames and Moore (1986) *Environmental Review and Management Programme Gnangara Mound Groundwater Resources* Water Authority of Western Australia.
- ecologia (1998) *Evaluation of Gnangara wetlands* Water and Rivers Commission
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- Gibson N, Keighery BJ, Keighery GJ, Burbidge AH and Lyons MN (1994) *A floristic survey of the southern Swan Coastal Plain* Western Australian Dept of Conservation and Land Management and the Western Australian Conservation Council, unpublished.
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- Jasinska EJ and Knott B (1994) *Aquatic fauna in the Gnangara Mound discharge areas of the Ellenbrook catchment*, WA Dept Zoology, University of Western Australia, Perth.
- Trudgeon ME (1996) *An assessment of the conservation values of the remnant vegetation in the City of Wanneroo with recommendations for appropriate reserves in the City* City of Wanneroo, unpublished.
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- Water Authority of Western Australia (1995) *Review of proposed changes to environmental conditions - Gnangara Mound Groundwater Resources* (Section 46).
- Water and Rivers Commission (1997) *Public Environmental Review East Gnangara Environmental Water Provisions Plan*.

Appendix 3

List of recommended Ministerial Conditions and Proponent's consolidated commitments

ERRATA - THIS PAGE IS TO BE SUBSTITUTED FOR PAGE 1 APPENDIX 3.

**STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED
(PURSUANT TO THE PROVISIONS OF THE
ENVIRONMENTAL PROTECTION ACT 1986)**

EAST GNANGARA ENVIRONMENTAL WATER PROVISIONS PLAN

Proposal: The abstraction of groundwater for public and private water supply from the East Gnangara Mound, with provision for environmental water requirements, as documented in schedule 1 of this statement.

Proponent: Water and Rivers Commission

Proponent Address: 3 Plain Street, EAST PERTH WA 6004

Assessment Number: 932

Report of the Environmental Protection Authority: Bulletin 904

The proposal to which the above report of the Environmental Protection Authority relates may be implemented subject to the following conditions and procedures:

1 Implementation

- 1-1 Subject to these conditions and procedures, the proponent shall implement the proposal as documented in schedule 1 of this statement.
- 1-2 Where the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is substantial, the proponent shall refer the matter to the Environmental Protection Authority.
- 1-3 Where the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

2 Proponent Commitments

- 2-1 The proponent shall implement the consolidated environmental management commitments documented in schedule 2 of this statement.
- 2-2 The proponent shall implement subsequent environmental management commitments which the proponent makes as part of the fulfilment of conditions and procedures in this statement.

3 Proponent

- 3-1 The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person in respect of the proposal.
- 3-2 Any request for the exercise of that power of the Minister referred to in condition 3-1 shall be accompanied by a copy of this statement endorsed with an

**STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED
(PURSUANT TO THE PROVISIONS OF THE
ENVIRONMENTAL PROTECTION ACT 1986)**

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- 1-3 Where the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

2 Proponent Commitments

- 2-1 The proponent shall implement the consolidated environmental management commitments documented in schedule 2 of this statement.
- 2-2 The proponent shall implement subsequent environmental management commitments which the proponent makes as part of the fulfilment of conditions and procedures in this statement.

3 Proponent

- 3-1 The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person in respect of the proposal.
- 3-2 Any request for the exercise of that power of the Minister referred to in condition 3-1 shall be accompanied by a copy of this statement endorsed with an

undertaking by the proposed replacement proponent to carry out the proposal in accordance with the conditions and procedures set out in the statement.

- 3-3 The proponent shall notify the Department of Environmental Protection of any change of proponent contact name and address within 30 days of such change.

4 Commencement

- 4-1 The proponent shall provide evidence to the Minister for the Environment within five years of the date of this statement that the proposal has been substantially commenced.
- 4-2 Where the proposal has not been substantially commenced within five years of the date of this statement, the approval to implement the proposal as granted in this statement shall lapse and be void. The Minister for the Environment will determine any question as to whether the proposal has been substantially commenced.
- 4-3 The proponent shall make application to the Minister for the Environment for any extension of approval for the substantial commencement of the proposal beyond five years from the date of this statement at least six months prior to the expiration of the five year period referred to in Conditions 4-1 and 4-2.
- 4-4 Where the proponent demonstrates to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority that the environmental parameters of the proposal have not changed significantly, then the Minister may grant an extension not exceeding five years for the substantial commencement of the proposal.

5 Compliance Auditing

- 5-1 The proponent shall submit periodic Performance and Compliance Reports, in accordance with an audit program prepared in consultation between the proponent and the Department of Environmental Protection.
- 5-2 Unless otherwise specified, Chief Executive Officer of the the Department of Environmental Protection is responsible for assessing compliance with the conditions, procedures and commitments contained in this statement and for issuing formal clearance.
- 5-3 Where compliance with any condition, procedure or commitment is in dispute, the matter will be determined by the Minister for the Environment.

Schedule 1

The Proposal

The WRC propose to allocate groundwater for abstraction from the eastern side of the Gnangara Mound to the Water Corporation and other uses, while allowing for provision of groundwater to the environment. Abstraction will provide for urban development in the north-east corridor in addition to supplementing the Perth metropolitan water supply, and groundwater for private users.

Table 1. Key environmental criteria for terrestrial vegetation, wetlands and seepages in East Gnangara study area.

Location	Monitoring Well	EWR (min water level mAHD)	EWP (min water level mAHD)	EWP < EWR (m)
Vegetation				
Melaleuca Park	WM6	58.8	58.3	0.5
Melaleuca Park	WM8	65	64.8	0.2
Melaleuca Park	NR6C	58.5	58.5	-
Melaleuca Park	WM2	67	66.5	0.5
Melaleuca Park	NR11C	55	55	-
Whiteman Park	MM49B	24.7	24.7	-
Whiteman Park	MM53	33.3	33.3	-
Whiteman Park	MM55B	29.5	29.5	-
Whiteman Park	MM18	38.6	38.6	-
Whiteman Park	MM59B	36.3	36.3	-
Vegetation Corridor	MM12	43	42	1.0
Vegetation Corridor	L30C	47.5	47.2	0.3
Vegetation Corridor	L110C	57	55.7	1.3
Vegetation Corridor	L220C	52.5	52.2	0.3
Wetlands		EWR^a		
		Minimum	Absolute minimum	
Melaleuca Park 78	GNM13	5.5m below ground	5.8m below ground	
Melaleuca Park 173	GNM14	0.1m above ground	0.1m above ground	
Lexia 186	GNM15	0.8m below ground	1.1m below ground	
Lexia 86	GNM16	1.0m below ground	1.3m below ground	
Lexia 94	GNM17A	1.5m below ground	1.8m below ground	
Seepages		EWR	EWP	
Edgecombe	B10	14.35 ^b	b	
Egerton	B25	39.29 ^c	39.29 ^c	

a: Interim EWRs and absolute minimum water levels have been determined for these wetlands. EWPs will be provided following investigation of stratigraphy and water regimes, and reported in the triennial review.

b: Recommendation for management only. The seepage is outside the zone of influence of the proposal; final water levels are expected to be affected by factors unrelated to groundwater abstraction for public water supply.

c: Access to land required before monitoring can be conducted.

Locations of vegetation, wetlands and wells are provided in Figures 1, 2 and 3.

Schedule 2

**Proponent's Consolidated Environmental
Management Commitments**

September 1998

**EAST GNANGARA ENVIRONMENTAL WATER
PROVISIONS PLAN(932)**

Water and Rivers Commission

Commitments

1. The Water and Rivers Commission will manage public and private groundwater abstraction to meet the water regime management objectives and Environmental Water Provisions (EWPs) summarised in Table A. The Water and Rivers Commission will also manage abstraction to meet the interim EWRs in Table B. As these EWRs are interim, they will be reviewed in the first triennial report to the EPA and updated as appropriate.

2. The Water and Rivers Commission will report on the management and monitoring of the Eastern Gngangara Mound to the EPA as part of existing reporting for the Gngangara Mound. Triennial reports will include information on the operation of groundwater schemes by the Water Corporation and private groundwater use, compliance with EWPs and environmental conditions and outline any environmental impacts. Annual reports will provide information on compliance with environmental conditions.

3. The Water and Rivers Commission will investigate stratigraphy and water regimes in the Lexia wetlands, EPP wetland 173 in Melaleuca Park and Melaleuca Park dampland 78. For wetlands displaying characteristics of perching the importance of groundwater to wetland water levels will be established and EWRs updated for the first triennial report to the EPA. EWPs will also be determined at this time.

4. The Water and Rivers Commission will support further research and investigations into the EWRs of wetlands, vegetation and seepage areas as defined in Section 16.5 of the PER document.

5. EWPs will be reviewed every six years in triennial reports or more frequently if necessary. Feedback, through the monitoring programme, of any unexpected impacts of groundwater abstraction will be used to update EWPs and water allocations if necessary. Any update will involve consultation with the EPA and incorporate public involvement.

6. The Water and Rivers Commission will, after receiving environmental approvals, implement and undertake the following monitoring programme to the satisfaction of the EPA and report results in annual and triennial reports to the EPA:
 - 6.1 Continue monitoring the network of wells on the East Gngangara Mound, at the frequency of 1 - 3 monthly depending on the well.

 - 6.2 Monitor water levels in terrestrial vegetation monitoring wells with EWPs monthly.

6.3 Develop three new terrestrial vegetation transects on the East Gngalara Mound: one in Melaleuca Park and two in the Ellenbrook bushland near the Lexia wetlands, and monitor every three years

6.4 On a shared cost basis with the Whiteman Park Board of Management, recommence monitoring the terrestrial vegetation transect established in 1991 by WAWA in Whiteman Park.

6.5 Continue monitoring the terrestrial vegetation transect established in 1966 in Melaleuca Park, at a 3 - 6 year frequency.

6.6 At each of the terrestrial vegetation transects, select a range of species which provide an indication of vegetation composition. The indicator species will be monitored in Spring every three years to assess any change towards a drier community. Parameters that will be assessed include; age (size), class distribution, vigour and recruitment.

6.7 Calculate a similarity index for each transect at each monitoring period with the aim of summarising spatial and temporal changes in vegetation composition.

6.8 For each terrestrial vegetation transect on the Eastern Gngalara Mound determine an 'acceptable' rate of change in vegetation composition. Rates of change will be measured using indicator species and similarity indices.

6.9 Monitor water levels monthly in wetlands and/or in nearby monitoring wells for the following wetlands:

Lexia wetland 94;

Lexia wetland 186;

Lexia wetland 86;

Melaleuca Park Dampland 78;

EPP wetland 173; and

Lake Yakine (located east of Edgecombe seepage).

6.10 Develop vegetation transects in each of the wetlands listed in Commitment 6.9 (with the exception of Lake Yakine). Monitoring will be undertaken in Spring of the first three years and reviewed in the first triennial report

6.11 Conduct baseline monitoring on aquatic invertebrates and water quality in the Lexia wetlands. Findings will be published in the first annual report

6.12 Monitor aquatic invertebrate fauna and water quality in the wetlands listed in Commitment 6.9 which contain open water, in Spring each year.

6.13 Map wetland habitats along a regional transect in Melaleuca Park in Spring using large scale aerial photography annually for the first three years, then every three years.

6.14 Monitor water levels in the Egerton and Edgecombe seepages and upstream of the seepages on a monthly basis (once access is granted).

6.15 Provided access is granted, conduct baseline monitoring of aquatic invertebrate fauna and water quality in the Egerton seepage. Results will be given in the first triennial report.

6.16 Monitor aquatic invertebrate fauna and water quality in the Egerton and Edgecombe seepages annually in Spring (once access is granted)

6.17 Monitor water levels in wells with EWPs more frequently than once a month where necessary to determine compliance with provisions.

7. The Water and Rivers Commission will consult with CALM to endeavour to develop a Memorandum of Understanding (MOU) on pine management regimes in State Forest 65 which recognises the dual use of forests and optimises water and timber production, while minimising environmental impacts. The MOU will include agreements associated with the removal of the pine plantation over the next 20 years and the proposed establishment of Gngangara Park. In the process of developing the MOU, further modelling studies will investigate the impact of the various scenarios of pine removal on water tables. This will include consideration of how the 'extra water' could be 'allocated' between consumptive and ecosystem protection uses.

8. The Water and Rivers Commission will provide advice on the impact of land-uses on groundwater resources of the Gngangara Mound to relevant agencies.

9. The Water and Rivers Commission will determine EWPs for new wells in the native vegetation corridor which have been installed at more appropriate places to replace wells MM12, L30C, L110C and L220C once sufficient monitoring data is available from the new wells.

10. The Water and Rivers Commission will continue to chair and provide support for a Consultative Committee as a forum of information exchange and to provide advice to the Water and Rivers Commission in relation to management of water on the Gngangara Mound. A reduced number of members representing each of the East Gngangara and Gngangara Committees will be combined to form one Consultative Committee for the Gngangara Mound.

11. The Water and Rivers Commission will require the Water Corporation, through licence conditions, to phase in the production wells closest to phreatophytic vegetation to allow the

vegetation to adapt slowly to the drawdown and minimise the overall impacts of drawdown.

12. The Water and Rivers Commission will require the Water Corporation to develop and implement a mitigation strategy to:

- identify actions to minimise loss of values, prior to development,
- monitor wetlands to determine whether loss of values has occurred, on an ongoing basis, and
- compensate for any loss of values in the event of adverse impacts becoming apparent

for the conservation category wetlands 132, 156, 158 and 164 and the *Melaleuca raphiophylla* wetland (104) in the pine plantation, on the advice of the WRC and the DEP.

13. The Water and Rivers Commission will within six months of receiving environmental approval, require that the Water Corporation, through licence conditions, update their operations plan to include the Lexia and East Mirtabooka groundwater schemes. This will include environmental management of the schemes and details of how abstraction will be managed to meet EWPs. As part of the operating strategy the Water Corporation will be required to submit annual production plans.

14. To assist with future groundwater management and water supply planning the Water and Rivers Commission will map vegetation communities on the Gnangara Mound. This will be done through the following process in consultation with the Department of Environmental Protection

1. Determine the procedures required to undertake mapping of vegetation communities on the Mound;
2. Use the procedures to develop a programme for mapping communities; and
3. Undertake mapping to the satisfaction of the Department of Environmental Protection.

15. The Water and Rivers Commission will monitor water levels monthly and establish a vegetation transect in wetland 132 in the vegetation corridor. The vegetation transect will be monitored in Spring of the first three years to gain information on the impacts of drawdown on the vegetation. The monitoring will then be reviewed in the first triennial report. The monitoring will be undertaken to gain information on early indicators of drawdown impacts

16. The Water and Rivers Commission will liaise directly with the Swan Valley Nyungah Community regarding the proposal.

TABLE A. Environmental Criteria

WELL	LOCATION	Environmental Water Provisions (EWPs)		
		Management Objective	Minimum water level (mAHD)	Absolute minimum water level (mAHD)
WM6	Melaleuca Park	Protect native vegetation from any further groundwater abstraction impacts	58.3	*
WM8	Melaleuca Park	Protect native vegetation from any further groundwater abstraction impacts	64.8	*
NR6C	Melaleuca Park	Protect native vegetation from any further groundwater abstraction impacts	58.5	*
WM2	Melaleuca Park	Protect native vegetation from any further groundwater abstraction impacts	66.5	*
NR11C	Melaleuca Park	Protect native vegetation from any further groundwater abstraction impacts	55	*
MM49B	Whiteman Park	Protect native vegetation from any further groundwater abstraction impacts	24.7	*
MM53	Whiteman Park	Protect native vegetation from any further groundwater abstraction impacts	33.3	*
MM55B	Whiteman Park	Protect native vegetation from any further groundwater abstraction impacts	29.5	*
MM18	Whiteman Park	Protect native vegetation from any further groundwater abstraction impacts	38.6	*
MM59B	Whiteman Park	Protect native vegetation from any significant groundwater abstraction impacts	36.3	*
MM12	Native vegetation corridor	Protect native vegetation but allow a slow change to a drier community structure	42	*
L30C	Native vegetation corridor	Protect native vegetation but allow a slow change to a drier community structure	47.2	*
L110C	Native vegetation corridor	Protect native vegetation but allow a slow change to a drier community structure	55.7	*
L220C	Native vegetation corridor	Protect native vegetation but allow a slow change to a drier community structure	52.2	*
GNM13	Dampland 78 ¹ - Melaleuca Park	Maintain existing areas of wetland vegetation	**	**
GNM14	EPP 173 - Melaleuca Park	<ul style="list-style-type: none"> • Maintain existing areas of wetland and stream • Maintain existing areas of wetland 	**	**

		vegetation •Protect invertebrate communities dependent on the wetland and stream • Protect the fish, <i>Galaxiella nigrostrata</i>		
GNM15	Lexia wetland 186	•Protect current vegetation assemblages in and fringing the wetland • Protect any aquatic invertebrate fauna dependent on the wetland	**	**
GNM16	Lexia wetland 86	•Protect current vegetation assemblages in and fringing the wetland • Protect any aquatic invertebrate fauna dependent on the wetland	**	**
GNM17A	Lexia wetland 94	Protect current vegetation assemblages in the wetland	**	**
B25	Egerton seepage	Maintain a permanent flow of water in the seepage	39.29 ***	*

* *not applicable*

** *interim EWRs have been determined for these wetlands . EWRs will be determined following investigation of stratigraphy and water regimes, and reported in the triennial review*

*** *Cannot be monitored until access to the land granted*

¹ wetland reference numbers from WRC PER document.

Table B. Interim Environmental Water Requirements

Wetland	Interim Environmental Water Requirement¹	
	Minimum	Absolute minimum
Lexia wetland 1 (94)	1.5m below ground (45.8 mAHD - well GNM 17A)	1.8m below ground (45.5 mAHD - well GNM 17A)
Lexia wetland 2 (86)	1m below ground (47.3 mAHD - well GNM 16)	1.3m below ground (47 mAHD - well GNM 16)
Lexia wetland 3 (186)	0.8m below ground (47.5 mAHD - well GNM 15)	1.1m below ground (47.2 mAHD - well GNM 15)
EPP wetland 173	0.1m above ground (in western sector)	
Dampland 78	5.5m below ground (65.4 mAHD - well GNM 13)	5.8m below ground (65.1 mAHD - well GNM 13)

1. Note that these EWRs are by necessity, interim, due to a range of difficulties in establishing appropriate criteria taking into account “perching” of water levels and accurate survey information. Final criteria monitoring points are still to be established in some wetlands

**EAST GNANGARA ENVIRONMENTAL WATER PROVISIONS PLAN ENVIRONMENTAL MANAGEMENT
COMMITMENTS**

Commitment number	Commitment (What)	Objective (Why)	Action (How/ Where)	Timing (When)	Whose advice (to Whom)	Measurement/ Compliance criteria
1.	Manage public & private groundwater abstraction to meet objectives and EWPs	As per column 3 of table A	As per column 4 in table A (& columns 3&4 in table B)	Ongoing particularly summer/ autumn	DEP	Annual/ Triennial reports & as necessary
2.	Prepare annual & triennial reports	Report on compliance, impacts, review abstraction & criteria etc	Review abstraction, monitoring etc	annually, triennially	DEP	Annual/ Triennial reports
3.	Investigate water regimes and stratigraphy in Lexia wetlands, and wetland 173 and dampland 78 in Melaleuca Park	To identify if perched, degree of dependence on groundwater, and to confirm EWRs	By a drilling and monitoring programme	In first 3 years following project approval	DEP	First triennial report
4.	Conduct research on EWRs	Improve knowledge	provide support to research projects, conduct investigations	ongoing major vegetation project will finish end 1999	DEP	Triennial reports
5.	Review EWPs	Adaptive management - incorporate new knowledge.	By monitoring / research	Six yearly or more frequently as necessary	DEP	Triennial reports & as necessary
6.	Implement monitoring programme	Feedback to EWPs	water level, vegetation, and invertebrate monitoring as outlined 6.1-6.17 in document.	monthly, yearly, triennially & ongoing.	DEP	Annual & Triennial reports & as necessary.
7.	Determine pine management	Optimise water and timber production/	Develop an MOU with CALM which include	June 1998	DEP	MOU and monitoring

	regime for SF65	development of Gngangara Park while minimising environmental impacts	pine harvesting over 20 years and Gngangara park establishment			results in annual reports
8.	Provide advise on impacts of landuse on groundwater resources	Assist protection/management groundwater resources	Provide advice as required	Ongoing	Relevant agencies, especially Shire of Swan and MFP.	-
9.	Determine EWPs for new, appropriately located, wells in the vegetation corridor	To assist groundwater resource management and to be in compliance with EWPs for new wells	Collect and review monitoring data	In first 3 years following project approval	DEP	annual report
10.	Chair Consultative Committee for the Gngangara Mound	To exchange information/advice with stakeholders	Conduct meetings at local shire	Annually	local government, relevant government agencies, conservation and community groups	Meeting minutes and brief documentation in triennial reports.
11.	Production wells close to phreatophytic vegetation to be appropriately <u>phased in</u> by Water Corporation	To allow vegetation to adapt to groundwater drawdown	Include requirement in licence conditions	When groundwater licence for Lexia wells provided.	Water Corporation DEP	Licence conditions. Annual reports by Water Corporation.
12.	Require the Water Corporation to develop and implement a wetland mitigation strategy for the <i>M. rhapsiophylla</i> wetland in the	To mitigate for large drawdowns and predicted significant impact on this	Assist with determining an appropriate wetland mitigation strategy and include requirement in	Develop strategy prior to commissioning of Lexia wellfield and implement actions	Water Corporation CALM	Licence conditions

	pine plantation.	wetland.	licence conditions	as necessary to avoid or compensate loss of values as impacts become apparent	DEP	
13.	Require the Water Corporation to prepare operations plans (with environmental commitments to meet EWPs) for the Lexia and East Mirrabooka groundwater schemes	To ensure WC's operation of groundwater schemes complies with WRC's environmental conditions/commitments on EWPs	Include requirement for operations plan in licence conditions.	In 6 months following project approval and prior to commissioning of the Lexia wellfield	DEP	Licence conditions Operations Plan
14.	Map vegetation community types on the Gngangara Mound.	To assist future groundwater management and water supply planning	Develop and undertake a vegetation mapping programme	To be determined in development of mapping programme which will be submitted 3 months after approvals of the East Gngangara Plan obtained	DEP	Mapping programme and maps
15	Monitor water levels and vegetation in wetland 132	To obtain information on drawdown impacts	Monitor water levels monthly & vegetation transect in Spring	Establish monitoring prior to commissioning of wellfeild and conduct for 3 years then review	DEP	<i>Licence conditions</i> Annual / Triennial reports.
16	Liase with Aboriginal community	Provide an understanding of the proposal and how it relates to Aboriginal issues	WRC will consult directly with Swan Valley Nyungah Community	In 6 months following project approval and prior to commissioning of Lexia wellfeild	DEP	Meeting minutes & brief documentation in annual report.

RESPONSE TO SUBMISSIONS

1. Environmental

1.1 Effects of abstraction on vegetation.

Cumulative effects of groundwater drawdown on native bush in the vicinity of bore fields are unknown. Continuing change toward drought tolerant vegetation communities or loss of bush is unacceptable.

A precautionary approach to abstraction should be adopted to minimise the risk of over-abstraction resulting in tree deaths such as those that occurred in 1991 and 1993. It is environmentally unacceptable that groundwater abstraction will result in the deaths of mature banksias in the vegetation corridor.

The areas of bushland within the study area and near the proposed wellfield include Melaleuca Park, Whiteman Park and the vegetation corridor.

There is predicted to be virtually no drawdown over Melaleuca Park from the scheme. Minimum water level criteria have been set in monitoring wells throughout the park (four of five of these were previously approved by the Minister for the Environment in the assessment of the Gnangara Mound Groundwater Resources Review of Proposed Changes to Environmental Conditions) and vegetation transects will be monitored to ensure there are no significant impacts in this area from abstraction. It should be noted however that there have been gradual natural changes to a drier community over the park mainly due to climate with some impact from the Wanneroo groundwater scheme to the west of the park, as indicated by past vegetation monitoring. There are also likely to be future impacts from climate if the current dry period continues. This has been allowed for in the previously approved criteria by setting the Environmental Water Provision (EWP) less than the Environmental Water Requirement (EWR) in three of the monitoring wells.

There will be no additional groundwater abstraction impacts on vegetation in the conservation zone of Whiteman Park. The current area of native bush is provided protection by minimum water level criteria which are higher than the water levels reached in 1991. These criteria are set to prevent water levels falling to 1991 levels in order to prevent tree deaths in the future. These criteria were previously accepted by the Minister for the Environment in the assessment of the "Gnangara Mound Groundwater Resources Review of Proposed Changes to Environmental Conditions".

Section 7 of the East Gnangara Environmental Water Provisions Plan (EGEWPP) discusses the EWRs for Melaleuca and Whiteman Parks; predicted impacts of the preferred abstraction and landuse scenario and the EWPs are discussed in sections 13.2.6 (and figure 27) and 14.1.

In the vegetation corridor there is proposed to be a change towards a more drought tolerant vegetation. These impacts would occur with a continuing dry climate, however abstraction will cause the effects to occur more rapidly and to an increased extent. It is important to consider the current impacts in this area. The bottom two-thirds of the vegetation corridor is currently subject to a mining lease and mining is occurring and likely to continue. The top third of the corridor suffers from dieback. Therefore the WRC considers a gradual change to drier community with some deaths of mature trees to be an acceptable trade-off to providing a highly valuable water source for Perth. These issues are discussed in section 14.1.3 of the document.

The level of native vegetation remaining in the Caversham airbase has been underestimated, with sedgelands not included in Fig 13.

The aim of figure 13 was to show bushland areas in a 0-8m depth to groundwater. The areas were identified using large scale aerial photography. For this reason sedgeland not surrounded by bushland may not have been identified, however it is likely to have been picked up in the wetland mapping shown in figure 7. An underestimation of vegetation here does not impact on the outcomes of the document. This area is a large distance from the areas of groundwater abstraction and will not be impacted.

Current wetland water levels are low, and are a reflection of the low rainfall of the previous 20 years. The effect of allowing pumping to maintain water levels at a predetermined minimum may affect vegetation structure in the long term.

The rise in groundwater expected after the removal of pines could be used to prioritise wetland regeneration to replace some of the 70% of wetlands lost on the Swan Coastal Plain since 1829.

The purpose of setting environmental criteria in wetlands is to maintain current values which are a reflection of the low rainfall over the previous 20 years and surrounding landuse impacts. Therefore the water regime criteria will also reflect this situation. The WRC feels this is the most sensible and practical approach to protection of the wetlands where alternatives are flawed. For example if an historic situation was to be mimicked the first problem would be identifying what the wetland would have been like at that time. This would be based on certain assumptions which would not necessarily be accurate due to lack of information. The next problem would be to achieve that scenario. It would be socially and economically unacceptable, for example, to change surrounding landuse to achieve a scenario we do not necessarily know is better. Attempting to change the current regime may also have adverse impacts on the wetland. The other complication in reflecting another scenario is the question of what scenario should it be. This is based on value judgements. For these reasons the water level criteria aim to protect current values. Also refer to section 8.4 of the document for the rationale in using current values. This approach has been previously accepted by the Environmental Protection Authority in its assessments of the Gnanagara Mound Groundwater Resources Environmental Review and Management Programme and Section 46 review.

Although the water regime criteria reflect current values they will be reviewed on a six yearly basis (commitment 5, page 79 of document). If rainfall was to increase again in the future, then water levels in wetlands would rise. This could cause gradual changes in the distribution of the vegetation and perhaps other components/ values of the wetland. As the vegetation distribution and other values of the wetland change then the criteria will also be updated in the six yearly reviews in order to reflect the new situation. Abstraction will then need to comply with the new criteria (ie it could not be increased to take up the extra water created by climate).

The wellfield is constructed to abstract a certain capacity of water (ie that determined through the modelling which meets environmental criteria) and that capacity then limits the increases in abstraction that can be made. Also, the WRC licenses the Water Corporation's wells to abstract a certain amount. Therefore the Water Corporation cannot increase abstraction without it first being approved by the WRC. The WRC will not allow increases unless the EWPs can be met and they are achieving the objective of protecting the identified values.

The WRC would like to see some of the additional water made available through the removal of pines allocated to abstraction and some water allocated to conservation (particularly in areas identified to have high values which are currently suffering from low water levels eg cave streams). It would be beneficial to use some of the extra water for abstraction because this is an area with an identified priority for water supply and has the

appropriate groundwater protection mechanisms available to provide high quality drinking water. Using water from State Forest 65 would delay the need to develop alternative supplies and the associated impacts in other areas. Although the WRC supports regeneration of wetlands it does not support this as being the priority allocation for water in State Forest 65. A detailed review will be undertaken by the WRC to determine how the additional water should be allocated. This review will have community input and may be required to be assessed by the EPA.

1.2 Adequacy of monitoring.

Monitoring also needs to be conducted in the damplands of the Lexia wetlands, as these are adapted to a specific water regime.

One submitter would prefer WRC to conduct the monitoring, instead of consultants for Multiplex, in the hope of avoiding the impacts on Lake Yakine and Edgcombe seepage that were observed in 1994/95.

Monitoring should be more intense in the first five years in particular. 135 wetlands exist in the study area, and it is recommended that monitoring be conducted annually in all of these.

How will monitoring information from Egerton seepage be gathered without permission from Multiplex Construction to enter the property?

The WRC feels there is adequate monitoring in the Lexia wetlands and it includes dampland areas. Of all the wetland areas in the study boundary the Lexia wetlands are proposed to have the most monitoring with 3 wetlands with EWP's around the perimeter of the property. Two sites are on the boundary closest to abstraction and one is in a large dampland area. Please refer to section 9.1 and figure 14 for wetlands selected. The monitoring includes monitoring of water levels at each wetland, invertebrate monitoring at the two that contain open water in Spring and vegetation monitoring in each of the three wetlands and 2 bushland transects. Section 16 of the document discusses proposed monitoring. There are also a number of groundwater monitoring wells over the Lexia property as part of the WRC general monitoring network.

All proposed monitoring related to EWPs on the Egerton property (section 16.4) will be conducted by the WRC and/ or consultants for the WRC. This will occur once access is permitted to the WRC. Until permission is granted water level monitoring information will be received through Multiplex's consultants in B10 and B25 (EWP monitoring wells) and from other wells in the WRC general monitoring network. Invertebrate monitoring can not be conducted until permission is granted. Any monitoring to do with the development is the responsibility of Multiplex as part of their development conditions.

In the future areas of bushland are likely to become Crown Land as part of the governments public open space requirements. In the meantime, the WRC will continue to seek access to monitoring sites.

It would be impractical and unnecessary to conduct monitoring in all of the 135 wetlands in the study area. Although there are approximately 135 wetlands many are degraded from other landuses or will not be impacted by abstraction. In monitoring wetlands close to the Lexia scheme the wetlands further away are also protected. The monitoring also aims to give the greatest level of protection to wetlands with the highest values. This approach was also taken in the 1995 "Gnangara Mound Groundwater Resources - Review of Proposed Changes to Environmental Conditions" and the EPA endorsed the approach. Section 8.1 of the East Gnangara document explains how wetlands were selected and some explanation of why certain wetlands were not selected for monitoring. Section 13.2 explains the predicted impacts on wetlands which will not be monitored.

1.3 Effects of abstraction on Edgecombe and Egerton seepages.

Long term integrity of Egerton Seepage has not been guaranteed. Increased abstraction, in addition to inadequate buffers from the proposed development close to the seepage will increase pressure on this important wetland.

One submitter proposed that the well B10 be artificially maintained with groundwater from well B25 to enable Edgecombe seepage and Lake Yakine to remain viable ecosystems.

Why is vegetation monitoring not being conducted at Edgecombe seepage, as this meets the criteria for having conservation significance?

A minimum EWR of 14.35 mAHD is proposed for Edgecombe seepage, to provide for a sufficient level of head to maintain 2m of seepage area at Edgecombe. One submission asked what was the basis concern that a model for the Egerton Drainage Management Plan stated that before (including irrigation) and after development, groundwater discharge would nearly cease by September.

Although the WRC recommends (see section 10.5) a minimum water level requirement of 14.35 m AHD in well B10 (upstream of the Edgecombe seepage) it must be noted that it is only a recommendation (see section 10.5.2 and 11) and in order to meet it there must be some control on water levels. The water levels can not be controlled through managing groundwater abstraction from the Lexia groundwater scheme as the impacts of the scheme are not predicted to extend that far (section 13.2.6 and figure 27). The water level changes which are predicted to impact on the Edgecombe seepage are mainly from the Egerton development. The Egerton Nutrient and Drainage Management Plan contains modelling which shows that groundwater discharge to the seepage area will reduce as irrigation is removed to allow for urbanisation. The irrigation has caused an artificial mound of water, established through irrigation from the Leederville formation, which will fall as irrigation water no longer replenishes it. As water levels fall so will flow in the seepage. The seepage will not suffer from increased abstraction as the submission states but reduced abstraction.

The issue of inadequate buffers between the development and seepage/wetland is a development issue, not a water allocation issue.

If well B10 was artificially maintained from well B25 (well monitoring groundwater levels upstream and supporting Egerton seepage) then the water required to protect Egerton seepage would be reduced and Egerton seepage is also of high value. However artificial maintenance of Edgecombe seepage could be possible by injecting water into the groundwater upstream of the seepage from an alternative source. However the success of this has not been proven given the complications of artificially maintaining groundwater levels as opposed to lake levels. The WRC does not propose to implement an artificial maintenance scheme as the water balance changes due to urbanisation dominate impacts on water levels in this area. Multiplex has obtained approval for this urbanisation from the Minister for the Environment.

Vegetation monitoring is not proposed to be conducted at the Edgecombe seepage because its high conservation value is due to the high diversity and endemism of the invertebrate fauna it supports. The vegetation in this area is degraded by past clearing and grazing. Most of the native species have been removed (apart from one patch mature banksias and a variety of other banksias amongst introduced vegetation) and there is significant areas of weeds from past planting and grazing. Rehabilitation of the of native flora and preventing access of stock would benefit the area. The Water and Rivers Commission vegetation monitoring is in areas of intact, high value vegetation.

1.4 Wetlands and streams within the study area

The PER does not nominate a desired maximum water level for wetlands, to account for normal seasonal variation.

The PER provides recommended maximum levels which are maximum levels recommended not to be exceeded (refer to section 9 of the document). This is provided for the benefit of other developments which can cause increased water levels such as clearing and urbanisation.

The PER does not provide recommended minimum peak levels because the wetlands in this area are dry most or all of the year and abstraction will impact mainly on minimum levels. The minimum water level reached by the end of summer has the most significance for drier types of wetlands. The maximum levels reached each year are mainly determined by the amount of rainfall and the seasonal variation in the wetlands will be maintained by rainfall. Water level monitoring will provide information on whether "normal" maximum levels are continued to be reached. Vegetation monitoring (and invertebrate/ fish monitoring in the wetlands that do have some water for part of the year) will also provide an indication on whether there are changes to "normal" seasonal variation.

A pristine wetland in Rookwood St, Henley Park may be affected by the proposal.

Wetlands such as Horse Swamp have been severely impacted, and need to be supported by suitable allocations to ensure their structural survival.

Flow leaving the Mound will be reduced by increased abstraction. This will affect stream systems reliant on groundwater flow. Bennet Brook in particular will be affected, as the headwaters for this stream originate in Whiteman Park and will not receive drainage waters. Bennett Brook which has suffered from groundwater abstraction in the past.

The wetland in Rookwood street, Henley Park and Horse Swamp and Bennett Brook in Whiteman Park will not be impacted by the proposal to any significant extent. Flow from the Gngangara Mound will only be reduced by a limited amount in a localised area as a result of the development of the Lexia groundwater scheme. In order to demonstrate the change in throughflow a figure is attached to show the change in the existing levels of the groundwater contours as a result of the predicted drawdown from the scheme. Flow is at right angles to contours and is maintained by the gradient identified by the contour intervals. The change in water levels and reduced throughflow occurs in the pine plantation area with some change over the vegetation corridor. There is predicted to be no reduction in flow to the areas of concern. Beyond the eastern edge of the vegetation corridor and south of Gngangara road there are no changes to contours and therefore throughflow because recharge becomes balanced with discharge again. The potential for any reductions in flow to downstream areas is minimised by the water made available from clearing of the pines to 11m²/ ha. This helps to balance the drawdowns from abstraction.

The current impacts from the Mirrabooka groundwater scheme and any additional drawdown/ reduced flow by the Lexia groundwater scheme will be managed by meeting the EWPs for Whiteman Park. The EWPs will prevent further drops in water levels in the Conservation zone and areas downstream.

1.5 Siting of production bores in pine plantations

The EGEWPP proposes large drawdowns under the pine plantations in State Forest 65. The potential for impact on pine health or productivity is not addressed. The Plan is dependant on the pines being managed to a basal area of 11 m²ha⁻¹ which places a requirement on CALM to develop the Memorandum of Understanding on pine

management. This requirement does not address the external market forces imposed upon CALM in managing the pines.

The proposal by CALM to establish Gngangara Park in the future in the existing pine forest will affect development of the area. CALM recommends that groundwater made available by the removal of pines be allocated to Gngangara Park.

It seems unreasonable to require CALM to agree to an MOU on pine management by June 1998.

The priority use for State Forest 65 has been understood to be public water supply for more than 12 years. The requirement by CALM to meet a basal area of $11\text{m}^2/\text{ha}$ has also been known for many years. The issue was initially considered in the EPA's assessment of the "Gngangara Mound Groundwater Resources Environmental Review and Management Programme" in 1987/ 1988. In the report and recommendations the EPA stated that pine plantations should be managed to achieve an average basal area which is equivalent to native vegetation. This was determined to be between $7\text{-}15\text{m}^2/\text{ha}$ with an average of $11\text{m}^2/\text{ha}$. At that time the former Water Authority made the commitment to 'liaise with CALM to control tree density in State Forest 65' (commitment P19) and the EPA set the condition that 'the pine plantation in State Forest 65 shall be managed by CALM with the objective of achieving water use at a level which is no more than that of pre-existing native vegetation.....'. This was agreed by CALM at the time.

After considerable liaison with CALM it was identified that a Memorandum of Understanding is needed between CALM and the Water Authority (now WRC) on the management of pine plantations in State Forest 65. Therefore commitment P38 ["The WATER AND RIVERS COMMISSION will, by December 1996 (dates have changed) in conjunction with the Department of Conservation and Land Management develop a memorandum of understanding on pine management regimes within State Forest 65 which recognises the dual use of timber and forests, and optimises water and timber production, while minimising environmental impacts"] was made by the Water Authority (now WRC) in the 1995 "Gngangara Mound Groundwater Resources Review of Proposed Changes to Environmental Conditions". The requirement to manage pine density was also reflected in the procedure 5 ("The Department of Conservation and Land Management will manage the pine plantations in State Forest 65 with the objective of achieving and maintaining their water use at a level that is no more than that of pre-existing native vegetation.....) in the EPA's Report and Recommendations.

The same commitment was then included in the East Gngangara Plan because the same issues affect this plan.

In more recent times CALM has proposed to develop Gngangara Park. The WRC still believes there is a need for development of a Memorandum of Understanding identifying priorities for clearing and use of the extra water (above the average basal area of $11\text{m}^2/\text{ha}$ requirement) created by the clearing. The WRC would like to see additional water in some areas used for abstraction in order to avoid / delay developing sources elsewhere. The WRC would also like additional water provided to conservation requirements in some areas currently suffering from low water levels. Due to the announcement of Gngangara Park the WRC now proposes that the MOU to be met by June 1998 be an MOU defining the process by which the issues will be resolved.

2. Social

2.1 Public consultation.

The community consultation committee met too infrequently for all issues to be adequately covered, with one period of 12 months between meetings. The commitment to combine the East Gnangara and Gnangara consultative committees is supported.

In the earlier stages of the project the Water Authority (now WRC) held consultative committee meetings monthly or every second month. Meetings were held after some work had been completed towards each phase of the project and some new information was available for consideration by the committee. Meetings were held to discuss each point listed as part of the scope and objectives in section 1.2 of the document. The point at which a meeting was not held for 12 months (over 1996) was when computer modelling was being conducted. It was a long process of trying to optimise well locations and abstraction rates but minimising impacts. The water requirements of the Swan Valley were also being incorporated at that time. Once the WRC had developed what they believed to be an acceptable proposal it was taken to the consultative committee. There were also other reasons for delays between meetings at that time including a restructuring of the water industry. However the WRC agrees that 12 months was a long period for no meetings to have taken place.

2.2 Demand management

Planners, engineers, farmers and other such agencies do not have a full understanding of the benefits, services and replacement costs of our community's groundwater and wetland assets. Demand management should be hard sold to these bodies.

The Section outlining the Philosophy and Approach to Environmental Water Requirements should include important impacts for major stakeholders if EWR's are ignored.

A moratorium on wetland destruction for housing developments should be imposed pending further research into what it is that is being destroyed.

The WRC has a water use efficiency program aimed at educating users of the importance of conservation and efficient management of water resources. WRC is also developing (or assisting) initiatives to manage levels of demand. Some examples of the initiatives currently being undertaken are as follows:

- Promotion of the use of backyard bores in urban areas where there are high water levels for use on gardens. This should lower the pressures on scheme water. Currently one-third of scheme water is used on gardens. The promotion strategy aims to reduce this so that more of the water would then be available for drinking (and therefore reduce pressure for new developments).
- The WRC has set down efficient water use requirements for the Water Corporation to manage to a water use cap of 180kl/person/yr and that it should reduce to 170kl/person/yr by 2005 through use of water efficiency measures.
- The WRC requires that the Water Corporation manage water use efficiently. This is a requirement on their scheme licenses and must be outlined in their operating strategy to the WRC.
- The WRC works with the Irrigation Association of Australia in developing ways of efficiently using irrigation water.
- The WRC is currently funding a project by the Horticulture Research and Development Corporation which is investigating ways of using water more efficiently.

It is assumed in the report that readers are aware of the implications of ignoring EWRs. It is stated in the report that EWRs are determined with the aim of protecting current values. Therefore it implies that if EWRs are ignored then current values may not be able

to be maintained. Water regimes may change and this could result in impacts such as tree deaths, changes in the distribution of vegetation, reduced availability of water for invertebrates in wetlands etc.

Housing developments are assessed individually by the Environmental Protection Authority (EPA). It is not within the powers of the WRC to set a moratorium on wetland destruction in housing developments. The WRC is provided the opportunity to comment on such proposals and is developing policies relating to development near wetlands to assist with such comments. Through this process, the WRC is a strong advocate on the need to protect wetland areas.

Model runs of various population and human water demand scenarios would assist in the comprehension of the consequences of population growth.

In the absence of a Population Policy, demand for water is increasing as Perth's population increases. WRC should add its voice to those calling for a need to determine the level of water consumption the natural environment can sustain.

The issue of population growth and human water demand is dealt with at an earlier stage than in plans such as the East Gnangara Environmental Water Provisions Plan. The Water Corporation has considered population growth and future demand for water resources through "Perth's Water Future Strategy". This estimates what Perth's demand for water is predicted to be until 2021 and where the supplies for that demand is likely to come from. This assists the Water Corporation to plan future source development. The Commissions assessments of the Strategy ('Allocating Water for Perth's Future') reduced the water demand figures by defining efficient per capita consumption values. The Strategy is also being assessed by the EPA.

The WRC also develops regional plans to identify broadly what water may be diverted from an area, (the level of sustainable abstraction) and what environmental constraints there are within an area. This helps the Water Corporation and other developers in their planning.

At a later stage the development of a single source will be planned in more detail and at this point it will undergo an assessment of the environmental impacts. It is often at this point that an actual allocation limit will be assigned to the scheme. This is the stage that the East Gnangara Plan falls into. Once that allocation is finalised it does not change with increased demand but may change when EWP's are reviewed. The groundwater scheme is constructed to the capacity of that allocation and needs to meet the requirements of the environmental criteria and commitments (eg EWP's). This will limit the amount of water that can be taken from that area. As demand increases other identified sources will undergo assessments and be developed.

In terms of more general advice to government on population growth and sustainability of development the main agency with a role is the Ministry for Planning. The EPA also advises government through the state of the environment reporting. The WRC provides advice to government on the implications of water use under different growth scenarios. As mentioned above the WRC also sets efficient use limits in order to contain demand.

2.3 Effects of urbanisation in the study area.

Proposed urbanisation will lower the level of groundwater locally. This will impact on the natural recharge as stormwater will be directed to out to sea instead of being trapped on the palusplains.

Proposed urban sites have already been cleared. Groundwater levels beneath these sites will therefore not rise as a result of vegetation clearing. Stormwater is to be directed to sewerage and not be available to recharge the groundwater, possibly leading to a decrease in local groundwater levels.

The creation of artificial lakes is an indulgent use of a precious resource and is unacceptable on the basis of allowing excessive evaporation, and providing a direct link for nutrients to enter the groundwater.

Urbanisation will not result in lower groundwater levels (apart from in some areas at Egerton as a result of reduced irrigation. Refer to section 10.5.2 in the document and submission 1.3 above). There will be rises in groundwater, even in the areas already cleared (which is not the whole development) because of concentration of runoff from roads, roofs and pavements, importation of water through public water supply etc. Stormwater is not directed to sewage or out to sea. As much as possible stormwater will be recharged to groundwater on site via infiltration/retention basins, soakwells, and swale drains. Artificial lakes, such as Woodlake Village lake, are a way of recharging stormwater created by development as well as removing nutrients. Woodlake Village Lake is a detention basin and the major service role is the removal of suspended nutrients (as well as a role for recreation/ aesthetics). There is some capacity in this basin for the removal of dissolved nutrients by fringing vegetation. A major water pollution control pond is planned for construction downstream of Woodlake Village Lake. Nutrients will be removed by absorption by the vegetation that will line the pond and by sedimentation. The retention basins have been constructed to strip nutrients from the water before it recharges the groundwater or discharges to downstream environments.

The issue of artificial lakes creation was dealt with in the environmental assessments for Ellenbrook and is not an issue for the East Gngangara Plan apart from the issue of water allocation to lakes. The WRC does not propose to provide a water allocation to maintain water levels in artificial lakes.

Little consideration has been given to the social issues associated with groundwater abstraction on existing and future urban development within the North Ellenbrook area. Such issues include;

- *effects of groundwater abstraction on proposed artificial lakes,*
- *the availability of water to irrigate future public open space within the proposed North Ellenbrook Project, and*
- *the availability of water from the superficial aquifer for use by domestic bores in the proposed North Ellenbrook Project.*

The effects of groundwater abstraction on artificial lakes has not been considered in any detail in the plan because the plan's objectives were to protect natural high value wetlands. The aim is to minimise impacts and allocate sufficient water to areas with high value ecological attributes. In taking this approach abstraction was concentrated in areas which were degraded and outside natural bushland areas. However impacts on artificial wetlands are limited. The significant areas of drawdown are west of the development areas. There is a small drawdown in water levels near M380 and M390 which may lower water levels a limited extent in the artificial wetland in this area. As outlined above, the WRC does not propose to provide a water allocation to maintain water levels in artificial lakes.

The WRC has not until now received any indication of the need for water by developers of North Ellenbrook. In that area there are still large amounts of water available from the Neaves and Radar sub-areas of which some could potentially be used in the development. It is also understood that at this stage the development is only in the early planning phase and has not undergone environmental impact assessment and will not be developed for a

number of years. At that time the situation may have altered given that CALM is planning to clear the pine plantation. This could increase water availability in this area.

The availability of water in the superficial aquifer for domestic bores in the proposed North Ellenbrook Project has been considered in the East Gngangara document.

Assumptions have been made over the Ellenbrook, Egerton and northern development areas proposed over the next 20 years that 25% of households will consume 500kl/yr (or slightly more in some areas). This allocation has been included in the modelling process.

Groundwater beneath the Caversham airbase and the proposed Albion townsite has recently been downgraded from priority one to priority three groundwater protection areas. It is suggested that the justification for this is the interest the government has in the land for subdivision. Urbanisation will significantly impact upon the quantity and quality of groundwater available.

The boundary of the Gngangara Underground Water Pollution Control Area (UWPCA) is proposed to be changed in order to reflect a scientifically determined boundary rather than a cadastral boundary. This is the result of recommendations made by the Select Committee on Metropolitan Development and Groundwater Supplies. Since the recommendations were made computer modelling has been carried out to determine the actual groundwater capture zones for production wells. These capture zones will be used to determine the new boundaries. The Caversham Airbase will now fall outside the UWPCA because it is not within a capture zone.

The area around the Albion townsite is proposed to be changed from a priority two (not one) to a priority three groundwater protection area. The reason for this is that the area has been previously zoned urban deferred in the Metropolitan region scheme. The current review of priority areas needs to ensure that priority boundaries become consistent with zoning's that have already been made. This was also a recommendation made by the Select Committee on Metropolitan Development and Groundwater Supplies.

2.4 Aboriginal issues

Any proposed development within the study area should include an Aboriginal heritage survey.

Nyungah Elders should be consulted when taking water from the Mound.

In the development of the original 1986 "Gngangara Mound Groundwater Resources Environmental Review and Management Programme" which established a long term water supply strategy for the Gngangara Mound, there was considerable consultation with the Aboriginal community. A document was also produced in 1989 which identifies the aboriginal significance of wetlands in the Perth to Bunbury region. This was used as a reference in the development of the East Gngangara Plan. Other information was also obtained as follows:

• In the earlier stages of planning the Lexia groundwater scheme the WRC had an Aboriginal heritage survey conducted in the area where the groundwater scheme, treatment plant and mining and scheme access road are constructed/ proposed to be constructed. Three archaeological sites were identified within 3km of the survey area, however each has been previously destroyed or disturbed.

• The WRC also wrote to the Aboriginal Affairs Department requesting a map of sites within the East Gngangara study boundary listed on the departments register. Five sites

were identified but are either disturbed/ destroyed or not impacted by construction of the Lexia scheme or proposed abstraction.

- The WRC has not consulted directly with the Nyungah elders on the EGEWPP specifically, however the opportunity to comment has been provided through sending a copy of the document to the Aboriginal Affairs Department at the commencement of the public review period.

Since this time the Water Corporation has proposed to commence construction of the groundwater scheme (ie production wells and pipelines). Approval to do so was obtained from the EPA for the construction (but not the water allocation - this depends on the EGEWPP. Once approval is obtained the WRC will license the Water Corporation). The WRC is also aware that this has raised concern from Aboriginal groups. These groups wish to be consulted before the construction takes place. The Water Corporation has therefore delayed construction until that consultation has occurred. Construction issues are the responsibility of the Water Corporation.

The WRC is happy to consult with Aboriginal groups on issues related to the water allocation if requested.

3. Allocation and abstraction

3.1 Influence of environmental factors on groundwater levels

The PER does not indicate how sensitive the control of abstraction from production bores is at regulating groundwater levels. Is it likely that the minimum water levels will be breached?

The abstraction from production bores should not cause minimum water level criteria to be breached. Monitoring of water levels will be conducted monthly and more frequently when necessary to ensure compliance with the EWPs. In order to avoid breaching the EWPs production wells will be switched off as water levels approach the minimum levels. This is discussed in sections 14.1.4 and 16 and relevant commitments made in section 17.

There is some risk of breaches in extreme years and in sequences of years with low rainfall. Although the WRC has a good level of confidence in model predictions and predictions using historical hydrographs (refer to sections 13 and 14), it is recognised that additional work is required to look at the impacts of long term climate change. This work will commence in the near future as part of a project to review allocation in the mound due to the clearing of pines.

3.2 Consideration of other users of water resource

The Swan Groundwater Area is influenced by the Gnangara Mound. The future of the Swan Valley is reliant on adequate allocations, and those proposed do not address the need to supply water to this area. It is essential that over-provisions are made to the Valley, and these are not compromised by man made lakes, mass domestic bore abstraction, artificial lowering of the water table to satisfy lower cost of urban development etc.

The Egerton property is currently licensed to abstract groundwater from the Leederville aquifer. Abstraction of groundwater from this aquifer has not been addressed.

Water allocations for groundwater sub-areas have not been considered in the PER.

The current unallocated availability is not sufficient to irrigate proposed 84 ha of public open space in the Egerton development.

Multiplex Constructions requests confirmation that future private garden watering in the proposed Egerton development has been provided for by the WRC.

Water allocations to the Swan Valley have been considered in the allocations made to the Swan Groundwater Area. The Swan Valley is located in the South - Swan Sub-Area and the quota to this area was actually increased to that which was in the 1991 Swan Groundwater Area Management Plan to allow for viticulture requirements. The quota proposed is 4.25 million kilolitres per year and 1.6 million kilolitres per year, in the Superficial and Mirrabooka Sands aquifers respectively. Taking away what is already allocated leaves 0.8 million kilolitres per year in total available for allocation. Please refer to section 15 for allocations and figure 10 for sub-area boundaries (also refer to section 4.3.2 for information on private groundwater use and section 13 for information on abstraction impacts which were considered by computer modelling. The modelling process included consideration of how allocations would be made between public and private users).

Abstraction from the Leederville aquifer has not been considered in the East Gngangara Plan as the scope did not include this (It was however included in the model when necessary, because irrigation from the Leederville aquifer was adding water to the superficial aquifer eg Egerton). Because the Lexia groundwater scheme will be drawing water from the Superficial and Mirrabooka Sands aquifers and because drawdown from these aquifers will impact upon water levels under wetlands and vegetation and the flow from seepages, these were the aquifers considered. The WRC is conducting a separate study in the impacts of abstraction from the Leederville aquifer.

Future private garden watering in Egerton has been incorporated in the East Gngangara Plan. It has been assumed that 25% of households abstract 500kl/yr in the model runs (see section 13.2.3). In terms of public open space requirements the WRC is currently looking at options for allocating water to the developments within the North Swan groundwater area in consultation with the developers. The WRC has received copies of the submissions from Egerton, Ellenbrook and North Ellenbrook outlining their requests for water. There is currently 0.3 million kilolitres per year available for allocation in the area but it will not cover all the requirements.

Egerton is currently allocated water from the Leederville aquifer for pasture use. One possibility for providing water to Egerton for public open space is to use some of the Leederville allocation already provided (instead of taking Egerton off the Leederville as planned in the past). The urban area will require less water than the current land use and the remaining water from the Leederville should be provided to viticulture as has been planned for many years.

In Ellenbrook the irrigation requirements in the submission appear to be excessive. The WRC has met with the Ellenbrook developers on this issue and they will reconsider and calculate their exact requirements. It may be possible that the remaining water available in North Swan combined with Ellenbrook's current allocation will be sufficient for their requirements for public open space. Another option discussed with Ellenbrook (which could also be an option for the other developments) is not to allow private backyard bores in some areas and to use allocations of water provided for this purpose. The WRC will work with Ellenbrook Management to determine a solution and develop a water efficiency programme. The North Ellenbrook requirements are discussed above in 2.3. Water is available in the Neaves and Radar sub-areas and using some of the private domestic bore allocations is another option for this area.

The Vines have also indicated that they will need water from the North Swan sub-area. The Vines currently has a large allocation which the WRC believes should meet their requirements.

Any variations in allocations will be made in such a way as not to compromise the EWPs proposed in the East Gngangara document.

4. Technical, model considerations

4.1 Calibration of model

The model has been calibrated using groundwater levels of the western half of the study area, without considering those for the eastern portion of the study area. Model predictions for the east are therefore unlikely to be reliable.

There has been a trend in recent years for average annual rainfall to be lower than the historical data used to calibrate the model. The model is therefore unable to accommodate more frequently occurring dry periods.

The model has not only been calibrated using groundwater levels on the western half of the study area. This impression may have been given because figure 15 shows examples of model calibrations and these examples are of monitoring wells with EWPs which mainly occur on the western side of the study area. Calibration points include a far greater number of monitoring wells covering the entire study area.

It is true that there has been a recent trend for average annual rainfall to be lower than historical data and that the total historical record has been used to calibrate the model. If the dry period alone was used the frequency of breaches of the EWP would be greater and therefore the number of proposed wells may have been less or the number of times wells need to be switched off would be predicted to be increased. It must be noted that actual breaches will be avoided in the real situation even if there are more dry years because an EWP has been set and water levels will be monitored to ensure compliance. If water levels begin to approach the minimum EWP level than production bores in the vicinity will be switched off to avoid breaches. Ultimately it is the criteria and the monitoring that will actually dictate abstraction.

The other issue which should be considered is that CALM is proposing to totally clear the pine plantation for Gngangara Park so water levels are actually likely to be higher in this area in the future than what the model has predicted (The model assumes an average basal area of 11m²/ha). This will provide compensation for effects of a drying climate.

The WRC is considering using a drier period of the rainfall record only in its future groundwater modelling projects. As mentioned in submission 3.1 the WRC will also review allocations to East Gngangara as a result of pine clearing and the implications of long term climate change.

5. Mining and vegetation corridor

Mining Act 1978 tenements have been incorrectly portrayed as being confined to south of Gngangara Rd and east of Beechboro Rd. Tenements actually continue north of Gngangara Rd and into the vegetation corridor. Sand mining (ML 70/238) is proposed for the next 50 years.

The assumption of a long-term vegetation corridor between Melaleuca Park and the Lexia wetlands is incorrect, within the boundary of Mining Lease 70/238.

It would be useful to incorporate both the sand resource area and priority extraction areas in Fig 8 to show all land-uses in East Gngangara.

The current mining lease in the vegetation corridor has been included in the document. The WRC is aware that the vegetation corridor is being mined for sand and considered this in the plan (first outlined in section 4.1.4). Figure 8 shows the mining lease. Refer to the vertical line symbols used in the vegetation corridor.