GNANGARA MOUND GROUNDWATER RESOURCES

WATER AUTHORITY OF WESTERN AUSTRALIA

Report and Recommendations
of the
Environmental Protection Authority

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Perth, Western Australia
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i SUMMARY AND RECOMMENDATIONS

The Environmental Protection Authority (EPA) has assessed the proposals by the Water Authority of WA to continue to develop the groundwater resource of the Gnangara Mound for public water supply requirements.

As part of this assessment, an Environmental Review and Management Programme (ERMP) was prepared, and released for public review for a total of five months, concluding on 25 March 1987. A total of 86 submissions were received by the EPA.

In addition to the ERMP and submissions, the EPA convened an Advisory Group to obtain specialist advice. As well, further information was sought from the Water Authority.

The EPA considers that the Gnangara Mound Groundwater Resources ERMP provides an excellent basis from which the environmental implications of the proposals can be reviewed. Further, the approach of a continuing environmental assessment beyond this review is appropriate to developments on and management of the Gnangara Mound.

The EPA considers that the approach adopted in the ERMP by the Water Authority using appropriate modelling techniques to predict changes in groundwater levels, is a balanced practical effort based on the best information available now.

The Water Authority sought the EPA's advice on the environmental criteria that should be adopted for wetlands when developing environmentally acceptable groundwater management. For those wetlands within Category 1 (Wetlands of exceptionally high natural and/or human use attributes) and Category 2 (Wetlands with relatively intact natural systems), the EPA has recommended that there should be no change to the existing natural regime of water quality and quantity. The EPA is of the view that there is some limited scope for water level changes in wetlands within their normal range and seasonal variation. The minimum water level is also an important environmental consideration, for reasons of habitat, aesthetics, water quality and fringing vegetation. Therefore the EPA has also recommended minimum summer water levels.

While the environmental impacts of the drawdown predicted in the ERMP are seen as being acceptable for some wetlands, others would be significantly affected. These wetlands, including Loch McNess, Lake Joondalup, Lake Yonderup, Lake Jandabup, Yeal Swamp, Lake Mariginiup, Lake Bindiar, Lake Nowergup and Coogee Springs would be altered to varying degrees but, in each case, the predicted decline is considered by the EPA to be unacceptable.

The EPA considers that, on the basis of research into the relationship between vegetation and the superficial aquifer on the Gnangara Mound, the impact of the proposals on upland vegetation is expected to be minimal.

In view of its recommendations on acceptable water level changes in wetlands on the Gnangara Mound, and recognising the influence of the pine plantations within State Forest 65 on the groundwater resource, the EPA considers that management of the pine plantations needs to be consistent with groundwater resource and environmental objectives.

The EPA considers that the Wanneroo Groundwater Advisory Committee has been an effective means of providing advice on water allocations to the Water Authority.

There is clearly a need for the community to embrace the need for water resource management, not only for public and private purposes but also for environmental and social reasons. Water is a finite resource that is essential for life and is vital in maintaining our quality of life. The EPA considers that the control of water demand and conservation of water as extemely important to the development of Perth.

The EPA is concerned about private groundwater abstraction proposals, given that such proposals are closer to the environmentally sensitive wetlands than the proposed Pinjar wellfield, and abstraction would be more concentrated than from the Scheme. The potential consequences of these proposals can be more significant at the local level than those of the Water Authority, and the need for modelling of these abstractions is as important.

The EPA is of the opinion that acceptance of the whole of the proposed Pinjar Groundwater Scheme would be premature in view of the detailed modelling being prepared, recent groundwater use proposals within the adjacent Wanneroo Groundwater Area and recognising the possible implications of recommendations in this report. However, the environmental implications of the 1st Stage of the Pinjar Scheme, along Perry Road, are considered to be environmentally acceptable. The further stages of the Pinjar Scheme are environmentally acceptable in principle, and details can be considered in the light of further information.

Management of the Gnangara Mound needs to be interactive and iterative, being modified as additional information is obtained. This iterative management process must apply to the whole of the groundwater resource and all of its users, public and private. As a consequence, the quotas for public water supply schemes as well as the proclaimed Groundwater Areas need to be reviewed and reassessed over time and with changing circumstances, including climatic change.

Development, control and management of the Gnangara Mound requires significant commitment and clear direction. The EPA does not consider that any single agency or body can or should provide all of this. Policy direction needs to be provided by the Government. Such policies should recognise the limits of the resources of the Mound and provide the means of making societal decisions. With these policies in place, the coordination and planning roles can then be carried out.

The EPA believes that a hierarchy of policy making, advisory and technical groups needs to be etablished for the Gnangara Mound, involving the Government, key Government agencies and local interests. There would be three levels to such a structure, comprising a Policy Coordinating Group, a Technical Advisory Group, and a Managing Group.

The EPA concluded that:

- the Gnangara Mound groundwater resource is able to be developed for public water supply whilst maintaining the high environmental and social values of the Mound;

- Stage 1 of the Pinjar Groundwater Scheme is environmentally acceptable;

. Stages 2 and 3 of the Pinjar Groundwater Scheme are, in principle, environmentally acceptable but will need to be revised in the light of recommendations in this report and considered again by the EPA; and

RECOMMENDATION 1

The EPA has concluded that, subject to the EPA's recommendations in this report, the plans and policies for land uses on the Gnangara Mound resulting from mechanisms proposed in the ERMP would be environmentally acceptable and recommends that these proceed accordingly.

RECOMMENDATION 2

The EPA recommends that the concepts of sustainable yield of resources and maintenance of ecological systems should be central to decisions affecting management of groundwater resources of the Gnangara Mound, in accordance with the State Conservation Strategy.

RECOMMENDATION 3

The EPA recommends that the Water Authority manage public and private groundwater abstraction from the Gnangara Mound such that the drawdown does not have an impact greater than that specified by the EPA in this report. Furthermore, the EPA recommends that some defined wetlands should experience no change in their existing regime of water quality and quantity, within normal climatic variations and that these and other wetlands should have minimum summer water levels specified which the EPA considers would be environmentally acceptable. (These are given in Table 6.1.)

RECOMMENDATION 4

The EPA recommends that management plans for the land managed by the Department of Conservation and Land Management (existing and proposed) on the Gnangara Mound should include protection of native vegetation and wetlands as principle objectives for management. These management plans, as far as they relate to State Forest 65, should clearly reflect the priority purpose for State Forest 65, water production. Management objectives for the wetlands should be consistent with the water level targets recommended by the EPA in this report.

RECOMMENDATION 5

The EPA recommends that the pine plantations in State Forest 65 be managed with the objective of achieving and maintaining their water use at a level that is no more than that of pre-existing native vegetation. The EPA understands that this represents an average basal area within the pine plantation of approximately 11 square metres per ha.

RECOMMENDATION 6

The EPA recommends that the State Planning Commission and Department of Conservation and Land Management initiate the consolidation into managed conservation reserves those wetlands and upland native vegetation areas on the Gnangara Mound identified by the EPA as having conservation value. For wetlands within the public estate, priority should be for those which fall into:

. Category 1 (Wetlands of exceptionally high natural and/or human use attributes);

. Category 2 (Wetlands with relatively intact natural systems); and

. Category 3 (Wetlands which have been highly modified but which are considered to play important roles in their urban and/or rural settings),

of the EPA's Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area.

RECOMMENDATION 7

The EPA recommends that, where areas of high conservation occur on private property, means for protecting and ensuring their management should be initiated by the Department of Conservation and Land Management and State Planning Commission.

RECOMMENDATION 8

The EPA recommends that the private water allocation quotas proposed in the ERMP be reviewed and revised, if necessary, to ensure that they meet the water level targets for wetlands recommended by the EPA in this report.

RECOMMENDATION 9

The EPA endorses the current approach of the Water Authority in widely publishing the limits on groundwater availability for the Gnangara Mound. The EPA recommends that these figures should be updated and published annually with emphasis on those areas of high conflict for the use of the resource so that limits to growth and development can be clearly seen by all interested parties.

RECOMMENDATION 10

The EPA recommends that the Water Authority actively encourage further reduction in public water demand through its Water Conservation Strategy.

RECOMMENDATION 11

The EPA recommends that the Water Authority continue to review and develop methods to improve monitoring and control of all public and private bores, for the purpose of managing the water resource.

RECOMMENDATION 12

The EPA recognises that there are costs associated with management of the groundwater resource and recommends that the State Government initiate a scheme whereby these environmental management costs are borne by the users of the water resources.

RECOMMENDATION 13

The EPA recommends that Environmental and Planning policies be developed that minimise the impact of land use activities (especially those that have a high water use or are likely to cause pollution to groundwaters) on the groundwater and wetlands and provide protection of the water resource and conservation of wetlands and upland vegetation.

RECOMMENDATION 14

The EPA recommends that the local authorities located on the Gnangara Mound incorporate in their statutory Town Planning Schemes, policies, zones and such other mechanisms as appropriate, the objectives of:

. protection of the groundwater resource of the Gnangara Mound; and

. conservation of wetlands, including their buffer zones.

RECOMMENDATION 15

The EPA recommends that Stage 1 of the Pinjar Scheme, along Perry Road, is environmentally acceptable.

RECOMMENDATION 16

The EPA accepts, in principle, Stages 2 and 3 of the Pinjar Scheme as being environmentally acceptable but recommends that the Water Authority revise them in the light of this Report and Recommendations and refers them to the EPA for further consideration.

RECOMMENDATION 17

The EPA concludes that the staged development of groundwater schemes, which permits the matching of growth in demand with supply and the tailoring of schemes to minimise environmental impact, is an environmentally acceptable approach and recommends that it be applied to future groundwater schemes.

RECOMMENDATION 18

The EPA recommends that the commitments given by the Water Authority in the ERMP and reproduced in Appendix D of this report should form the basis for management of the Gnangara Mound groundwater resource.

RECOMMENDATION 19

The EPA recommends that the basis for decision-making and the criteria established for conservation of the environment and of the groundwater resource be subject to regular review and updated as further information becomes available.

RECOMMENDATION 20

The EPA recommends that the following specific areas of research and monitoring, additional to the existing monitoring programme and commitments in the ERMP, be undertaken:

. clarify the relationship between groundwater level and wetland water quality; and

. improve understanding of the conservation value of wetlands on the Gnangara Mound, especially those for which information on their value is limited.

RECOMMENDATION 21

The EPA recommends that the Water Authority should submit brief annual and more detailed triennial reports on environmental monitoring and management of the Gnangara Mound to the EPA.

RECOMMENDATION 22

The EPA considers that many issues in relation to the Gnangara Mound cannot be considered by any single agency and recommends that policy direction, broad planning and management on the Gnangara Mound should be undertaken by the Government. The EPA suggests the following structure and representation for the Government's consideration:

a. A Policy Coordinating Group, with responsibility to Cabinet for formulation policy directions, comprising -

   Department of the Premier and Cabinet (Chairman)
   Water Authority of WA
   State Planning Commission
   Environmental Protection Authority.

b. A Technical Advisory Group, to provide specific planning and management advice to the Policy Coordinating Group, comprising -

   Water Authority of WA
   Western Australian Water Resource Council
   State Planning Commission
   Department of Conservation and Land Management
   Department of the Premier and Cabinet
   Environmental Protection Authority
   Department of Agriculture
   City of Wanneroo
   Shire of Gingin.

c. The Wanneroo Groundwater Advisory Committee continue, and other such Committees as appropriate be established, to provide advice on applications for private groundwater establishment to the Water Authority.

1. INTRODUCTION

The continued growth in population and per capita water demand in the North-West Corridor has lead the Water Authority of Western Australia to propose the expansion of its capability to supply water to this area.

Following a review of alternative sources, the Water Authority proposed that the groundwater resource of the Gnangara Mound should be further developed, with a series of four wellfields being constructed as further growth in urban land takes place.

The Metropolitan Water Authority (now Water Authority of WA) approached the Environmental Protection Authority (EPA) in April 1985 with separate proposals to develop the Pinjar and Lexia Groundwater Schemes. The EPA indicated that an Environmental Review and Management Programme (ERMP) should be prepared, and that the document should consider future water resource development for the whole of the Mound and the management requirements of that resource.

Recognising the existing private abstraction from the Mound, the Water Authority has proposed that the available groundwater resource be allocated between public and private requirements. As an additional major user of the resource, consideration has also been given to the requirements of the natural environment. In order to achieve a balance between demands for the finite resource, a water and land use management strategy has been proposed.

The ERMP was released for public review for 4 months, closing on 25 February 1987. Following an approach from the City of Wanneroo and with the support of the Water Authority, the EPA extended the review period by a further month.

A total of 86 submissions were received by the EPA. Issues raised in them were provided to the Water Authority for comment.

Aware of the significant environmental and related social implications of the proposals, the EPA appointed an Advisory Group to provide advice on a range of aspects contained in the ERMP.

The Environmental Protection Authority has reviewed the environmental implications of the proposals through the evaluation of the ERMP, public and Government agency submissions, the report of the Advisory Group and additional advice provided to the EPA.

2. ASSESSMENT APPROACH AND PHILOSOPHY

The Gnangara Mound constitutes a very significant water resource, and it is easily accessible over most of its 2 100 square kilometres. This resource is already accessed for public and private water supplies. The superficial aquifer also supports a wide range of flora, fauna and wetlands. These environmental qualities represent a substantial part of the environmental and social values of the region. Additional abstraction of groundwater from the Mound has the potential to significantly threaten these values.

When the separate Notices of Intent for the proposed Pinjar and Lexia Groundwater Schemes were submitted, the EPA considered that it was more appropriate to address the Gnangara Mound water resources as a whole and then assess the individual groundwater schemes on the Mound. This approach

essentially means that the utilization and management of the groundwater is seen in the context of the entire groundwater resource and its full development possibilities and thereby provides a basis for overall assessment and strategic planning, prior to the assessment of individual groundwater schemes.

The EPA regards water resources development of the Gnangara Mound as a continuing and iterative process, within a context that is provided by the Gnangara Mound ERMP. Ongoing environmental assessment would be carried out through future environmental reviews prepared on specific water resource developments as well as the reporting procedures that are in place for existing and future developments. The interrelationships that exist and the cumulative impacts that might arise would therefore be examined in a complete rather than disjointed manner. The Gnangara Mound lends itself to this approach because of the staged and sequential development proposals. Further, with a single authority responsible for water resources, management and planning can take place through an iterative processes, in the context of the whole of the Mound.

The Pinjar Groundwater Scheme is the first specific development proposed within this context. Future groundwater schemes would be Lexia, Yeal and Barragoon. Each of these will be subject to environmental assessment closer to the proposed implementation date.

In order to handle such an approach the EPA has formulated a co-ordination and implementation strategy to address the issues that future developments are likely to raise. Many of these issues, while being restricted in some way by environmental conditions, relate to community expectations of the quality of life in the area, land use changes, and growth and development of the population. These issues are not in the ambit of the Water Authority's role but are community and Government decisions. The EPA sees it as essential that these questions are addressed early in the development of the Gnangara Mound, so as to reduce future conflicts over land and water resources of the area, and so manage the resources to provide the maximum sustainable benefit for the whole community.

The EPA's assessment strategy includes the provision of mechanisms for orderly, equitable and environmentally acceptable development and planning on the Gnangara Mound. The EPA emphasises that this represents a basis on which future developments can be effectively managed: it does not attempt to provide all the detailed answers for the proposal, nor give absolute criteria for environmental protection. It is envisaged that the proposed monitoring programmes will enable firm control measures for all aspects of water utilization as data becomes available and management and planning to be altered to take account of results.

RECOMMENDATION 1

The EPA has concluded that subject to the EPA's recommendations in this report, the plans and policies for land uses on the Gnangara Mound resulting from mechanisms proposed in the ERMP would be environmentally acceptable and recommends that these proceed accordingly.

Further discussion on policy implications is presented in Section 8.

3. DESCRIPTION OF PROPOSAL

The Gnangara Mound water resource is already used for public (Gwelup, Mirrabooka and Wanneroo Groundwater Schemes) and private (suburban gardens, household, market gardens and other land uses) abstraction and the natural environment. That portion of the annual recharge not abstracted as used by the environment is lost to surrounding watercourses and the ocean. The set of proposals are outlined in the ERMP with a view to the extension and expansion of both public and private abstraction over the Gnangara Mound while maintaining significant wetlands and areas of native vegetation. The regional effects of this abstraction are considered and a strategy for development of the water resource is given in the ERMP.

Specifically, the ERMP aims to:

- "provide an overview of the demand and supply of water to the North-West Corridor and identify the need for new public water supply developments;
- review alternatives for the supply of that water and select a preferred alternative;
- provide an overview of public, private and environmental demands associated with the preferred alternative - the shallow groundwater resource of the Gnangara Mound;
- identify the potential regional environmental and social effects as well as any conflicts associated with public and private development of the Gnangara Mound;
- identify the preferred next development for the Gnangara Mound - the Pinjar Groundwater Scheme; and
- define a management strategy for the Pinjar area with due regard for environmental and social effects." (ERMP, p 15)

3.1 PROPOSED PUBLIC WATER SUPPLY SCHEMES

Four additional groundwater schemes have been proposed for public water supply; Pinjar, Yeal and Barragoon to the north and Lexia to the east of the Wanneroo Scheme. As the North-West Corridor expands, Pinjar is the first scheme proposed, followed by Lexia, Yeal and Barragoon. The development and timing of each scheme would be dependent on population increase and consequential public water requirements. These proposed schemes are located within the Gnangara Water Reserve, with the exception of the northern part of the Barragoon Scheme. The distribution of the proposed public water supply schemes is shown in Figure 1 and the proposed timing and quotas from the superficial formations for each scheme is given in Table 3.1.

3.2 PROPOSED PINJAR GROUNDWATER SCHEME

The Pinjar Groundwater Scheme is planned to extend north from the existing Wanneroo Groundwater Scheme, through vacant Crown land and State Forest No 65 (Figure 1).

Groundwater abstraction from three formations (shown in Figure 17 of the ERMP) is proposed:

- the lower third of the superficial formations aquifer;

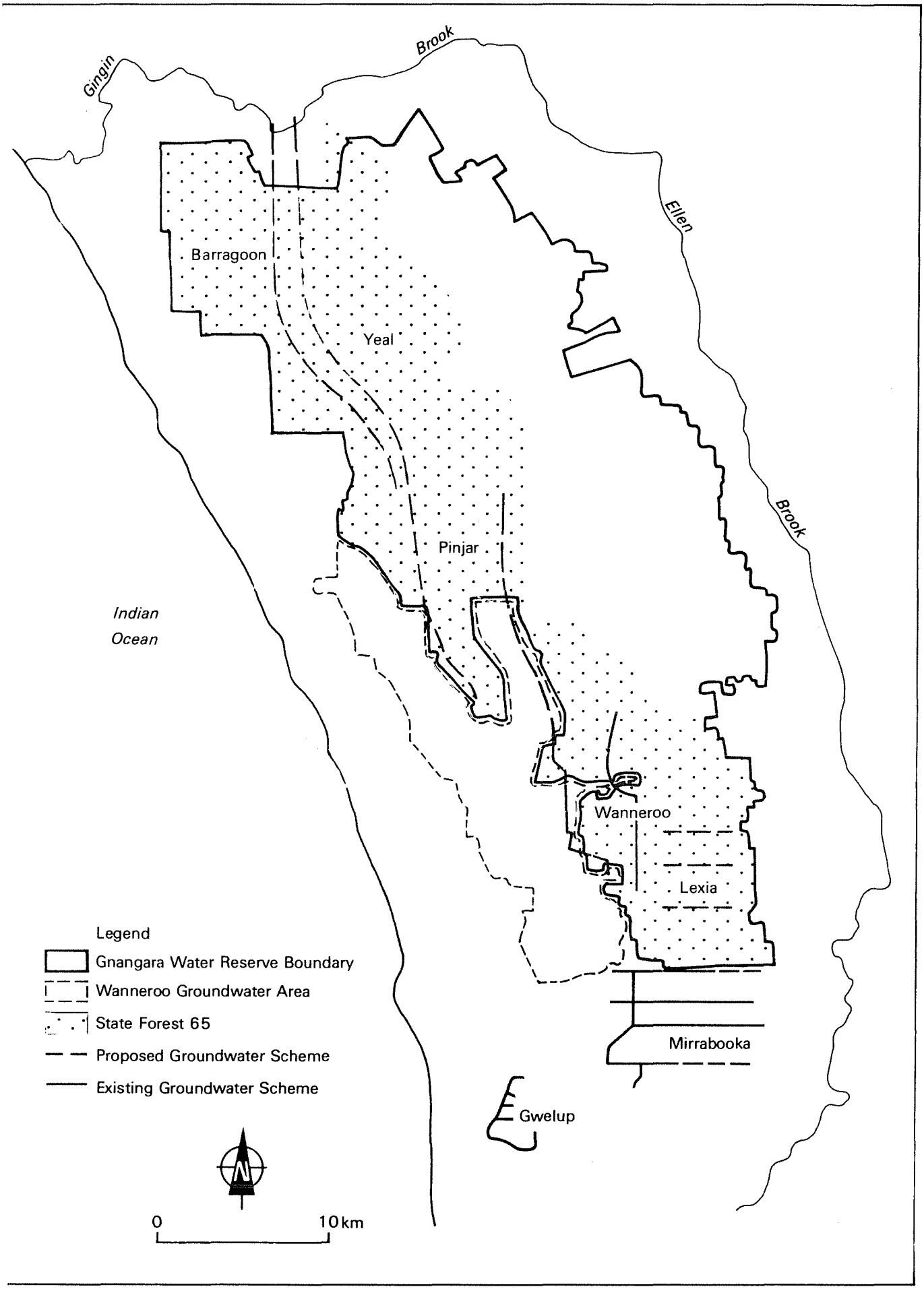

Figure 1. Location of proposed groundwater schemes.

. the Leederville Formation aquifer; and

. the Yarragadee Formation aquifer.

Table 3.1. Proposed Public Water Supply Schemes - Superficial Formations.

PROPOSED GROUNDWATER SCHEME	PROPOSED COMMISSIONING DATE	NUMBER OF WELLS	PLANNED QUOTA (Million cubic metres/yr)
Pinjar	Stage 1 - 1989/90 Stage 2 - 1994/95 Stage 3 - 1997/98	28	14.0
Lexia	2000/2001	15	6.5
Yeal	Stage 1 - 2002/03 Stage 2 - 2003/04	24	9.6
Barragoon	Stage 1 - 2009/10		

(Source: ERMP)

The proposed scheme comprises two lines of wells located approximately 4 km apart, running north-south and straddling Lake Pinjar. Each well would be connected to a collection main and where necessary, the water delivered to a treatment plant.

The ERMP indicates the following staging of the Pinjar Groundwater Scheme:

Table 3.2. Pinjar Groundwater Scheme Development Schedule.

STAGE	COMMISSIONING DATE	NUMBER OF WELLS			ANNUAL QUOTA (Million cubic metres/yr)
		SUPERFICIAL (70 m)	LEEDERVILLE (150 m)	YARRAGADEE (400 m)	
1st	1989/90	-	-	8	10.0
2nd	1994/95	14	4	-	11.0
3rd	1997/98	14	4	-	11.0
TOTAL		28	8	8	32.0

(Source: ERMP)

3.3 POTENTIAL DEVELOPMENT OF PRIVATE GROUNDWATER SUPPLIES

Within the City of Wanneroo there is considerable potential for the expansion of horticultural activities, especially for export vegetables. Markets for other irrigated crops, such as flowers, are also increasing. The

ERMP (p 89) indicates that the combined potential for irrigated horticulture on the Swan Coastal Plain may reach an upper limit of 4 000 to 5 000 ha over 10 years of which perhaps 2 000 ha might be located in the Gnangara Mound area.

At an irrigation rate of 15 000 cubic metres/ha/yr, the 2 000 ha would require an allocation of 30 million cubic metres per year of groundwater over the next 30 years. This would represent a 65% increase over the present estimated usage in the Wanneroo Groundwater Area, producing a combined public and private demand in excess of the calculated safe yield.

This volume can be compared with the currently unallocated portion of the groundwater resource, which amounts to 12 million cubic metres/yr. If this was used solely for market gardening, an additional 800 ha could be irrigated.

The bulk of private demand will be controlled through licences issued under the Rights in Water and Irrigation Act (1914). The proclaimed groundwater areas on the Gnangara Mound are shown in Figure 1.

3.4 PROPOSED MANAGEMENT STRATEGY

The management of the groundwater resource of the Gnangara Mound by the Water Authority will need to balance the competing demands for the resource. Four major aspects of management are proposed in the ERMP.

Public and private groundwater allocations would relate to the available resource and would recognise the significant water needs of the local environment. In order to make management and allocation decisions, the Water Authority has defined a decline of less than 0.5 m in water level within selected lakes and wetlands as being acceptable and has identified quotas for various areas within the Mound.

Within that defined environmental constraint, the Water Authority has planned its borefield and abstraction rates. It has also designated 36 million cubic metres per year as the private abstraction quota within the Wanneroo Groundwater Area.

To assist in providing that quota, the density of the pine plantations located within State Forest 65 would need to be reduced and maintained at a level that approximates native woodland. This is estimated to represent a basal area of about 11 square metres per ha within the pine plantation (ERMP, p 73).

4. ADVISORY GROUP TO THE EPA

Significant environmental and community issues are raised by the Water Authority's proposals. As a consequence, the EPA convened an Advisory Group to provide technical and specialised advice on the complex of issues affecting the Gnangara Mound, with a view to developing a general policy of management.

The Terms of Reference for the Advisory Group were to advise on:

(i) the nature, extent and utilisation of the Gnangara Groundwater Mound;

(ii) the relationships between land uses, the conservation of wetlands and native vegetation, and the groundwater resource;

(iii) the options and trade-offs between alternative land use strategies;

(iv) other issues and strategies which may contribute to the determination of the most appropriate balance between competing demands on the Gnangara Mound groundwater resource;

(v) the adequacy and accuracy of the information contained in the ERMP report;

(vi) the adequacy of the environmental management commitments contained in the ERMP report; and

(vii) the environmental acceptability of the proposed Pinjar Scheme.

The Advisory Group, comprising Mr C W Burton (Chairman), Dr A D Allen, Mrs P A Clay, Mr W R Stevens and Mr J F Thomas, presented its report to the EPA in March 1987. A copy of this report is presented as Appendix A.

The ERMP generated considerable public interest and the EPA decided that the Advisory Group's report should be released for public information. Copies of the report were circulated on 26 March 1987.

The EPA is most appreciative of the contribution made by the members of the Advisory Group to the understanding of the Gnangara Mound. The review of the ERMP by the Advisory Group was very thorough and its advice valuable. Their report has greatly assisted the EPA in dealing with the assessment of the Gnangara Mound issues and proposals.

5. PUBLIC REVIEW

The ERMP was released for public review for a total of 20 weeks. During this period, 86 submissions were received by the EPA; 78 from the public and 8 from Government agencies and local authorities.

A consistent theme expressed in every submission was that the wetlands in the Wanneroo area should not be affected by groundwater abstraction, irrespective of who is pumping. Related to this, another view frequently expressed was that the Water Authority should use water from alternative sources outside of the Wanneroo area because of the impact of the proposed Pinjar scheme on the Wanneroo wetlands.

A summary of the main comments and issues raised in public submissions is provided below.

(a) Alternative Sources of Supply:

- although initial costs are high, desalination would ensure the survival and preservation of the natural local environment;

- alternative sources of water are all rejected through cost/benefit analysis which only considers economic to the exclusion of other legitimate values of landscape and nature;

- the Water Authority and Government should recognise that water supply to Perth will eventually need to be brought down from the State's north sometime in the future, and it should start to budget for this over the next few years;

- treated wastewater should be used to recharge the Gnangara Mound;

- linking of the hills storages to the north-west corridor services, to reduce its dependancy on groundwater and provide supply flexibility, should be considered;

- the urban areas should be supplied from small bores located parallel and close (0.5-2 km) to the coast and drawing from the superficial and confined aquifers;

- large volumes of groundwater are lost from the Gnangara Mound during winter and, if drawn during this period to allow for reduced supply from the hills storages, could allow the dams to exclusively supply summer demands;

- the Water Authority should consider supplying the farms through a reticulated treated wastewater, which would reduce groundwater requirements;

- consideration should be given to augmenting recharge of the Mound aquifers by the diversion of surface flows from the Ellen Brook, Avon River and tributaries, and other Swan River tributaries onto the Mound;

- water should be brought from a source that has large long-term supply capabilities, such as desalination or the Ord River, as this would not lead to unnecessary increases in environmental impacts for the sake of short-term expediency;

- to reduce impacts on the eastern margin of Lake Pinjar, the Water Authority should consider locating the eastern line of bores along the road reserve that runs through the middle of the Lake;

- as commercial and institutional users are major consumers of potable water, could they not be required to treat brackish, saline or seawater (piped to the site by the Water Authority) to provide their requirements;

- consideration should be given to waterless toilets, especially in Groundwater Areas;

- an alternative not reviewed is the redirection of the existing Goldfields water supply from Mundaring to the metropolitan area and the establishment of local desalination plants in the Eastern Districts to replace the source;

- the economic, social and environmental costs and benefits of desalination have not been addressed or adequately discussed;

(b) Demand Management:

- the Water Authority attitude of encouragement to private domestic bores, through a lack of controls and high domestic water charges, needs to be examined;

- all water users, whether supplied through the public mains or by private bore, should be required to 'pay for use';

- the development of private bores in areas serviced by the mains water supplies should be prevented, as should bores for private gardening purposes;

- all bores in rural and urban areas not used for horticultural purposes should be metered to give accurate consumption figures;

- the recently initiated demand management programme should be promoted vigorously, with incentives included and penalties possibly applied to wasteful activities or practices;

- restrictions on the reticulation of gardens and recreational areas during daylight hours should apply irrespective of rainfall considerations;

- overhead reticulation of horticultural and other crops should be discouraged and trickle systems promoted as a water conservation measure;

(c) Impact of Proposed Developments;

- the mathematical basis, assumptions and statistical errors of the predictive model are not provided in the ERMP;

- the value of specific wetlands to waterbirds have not been considered;

- the ERMP does not provide any biological criteria in relation to management of qualities or levels of water in wetlands;

- there is the possibility that the potential impact on the environment could be considerably lessened by complementing the extraction scheme with another bore field at Karakin Lakes;

- scientific evidence suggests that groundwater fluctuations in excess of 0.5 metre modify aquatic and terrestrial ecologies, and therefore should not be accepted;

- an independant assessment of the adequacy and accuracy of the computer model used is essential;

- the effects of drawdown on the small, seasonal wetlands in State Forest 65 and other wetlands outside of reserves should be examined;

- the impact on water levels and resident fauna in the Yanchep caves and other caves in and adjacent to Neerabup National Park need to be further considered, as any drawdown of water levels within them would be detrimental;

- the future intentions of the WAWA concerning management, review, research and control of the impacts of the proposals on natural ecosystems are vague, non-committal and non-specific;

- management plans for the Wanneroo area should include contingency plans for alleviating stress in wetlands during drought periods;

- will increased groundwater abstraction lead to reduced water quality within wetlands, and thus to botulism etc?;

- no details are given as to which wetlands will be affected by the proposed 0.5 metre drawdown or, reflecting on the additional 0.5 metre confidence limit, by a 1 metre drawdown;

- no criteria or objective rationale is provided to indicate how or on what basis the environmental acceptability of a 0.5 metre drawdown of wetlands was determined;

- the likely permanent loss of native woodland on upland sites is of concern;

- the reduction of water levels on the eastern margin of Lake Pinjar could cause spring flows to decline or cease, thus reducing its conservation value as well;

- the implications regarding summer and autumn stress imposed by groundwater abstraction on the flora and fauna using the Mound have not been clearly recognised nor addressed;

- the aesthetic impact of additional abstraction, resulting in changes to vegetation types and dead trees, is not considered in the ERMP;

- it is understood that the Water Authority has commissioned a study of coastal plain wetlands by Mr V Semeniuk, and that the results as they relate to Wanneroo wetlands have not been used in the ERMP;

- the short term and long term impacts of abstraction from the Mound on the Gingin Brook are not presented or are dismissed summarily;

- the drawdown of groundwater levels may prevent saturation of the top soils, thus reducing denitrification and leading to higher nitrate concentrations in the groundwater and impacts on wetlands;

(d) Management of Public Water Supplies:

- the impacts of the proposed abstractions from the Leederville and the Yarragadee Formations are not discussed in the ERMP, including impacts on the superficial formation, salt water intrusion and water quality;

- no alternative long term wetland management plan is offered to the preferred concept presented in the ERMP, including one which increases water abstraction from the Mound;

- the ERMP only addresses a narrow range of abstraction rates for public and private uses;

- the ERMP does not discuss the underlying Water Authority assumption, that the public water supply system is designed on the basis of restrictions only one year in ten, which has significant adverse environmental consequence;

- there is little discussion concerning the 'safe yield' of the aquifers;

- the management plan is inconsistent with sustainable yield, given that drawdowns would be as much as 3 metres;

- there should be a clearer outline of what contingency provisions are to be implemented in the event of unexpected responses by the water-table and coastal plain biology to pumping;

- the Water Authority is transferring water out of the Mound area (and it is therefore lost to the Mound) whereas horticulture and similar uses return most of the water to the groundwater;

- will it be practical for the Water Authority to reduce or cease abstraction when water-tables are declining due to periods of poor rainfall;

- the Water Authority does not set a good example when the Wanneroo Treatment Plant regularly discharges water, which could be used by local landowners, to waste onto the ground;

- details of groundwater quality from the range of aquifers beneath the Mound have not been provided;

(e) Management of Private Supplies:

- the Wanneroo area is being discriminated against compared with the metropolitan area with licencing of bores;

- do land owners have to notify the Water Authority if they change their crops, watering times, etc?;

- existing privately owned reticulated areas should be allowed to be subdivided and new bores allowed within that subdivision, as this would not lead to expanded irrigation areas;

- given increased recharge from land clearing for horticulture, why is horticulture being restricted and given a low priority in planning?;

- horticultural water use estimates, including seasonal and rotational crops, have been grossly exaggerated in an attempt to justify the 'preferred option';

- the agreement to permit piggeries and high water uses (eg turf farms and lucerne growing) in the Wanneroo area is incomprehensible on environmental and water supply grounds;

- licences should only apply to new developments or users, and should not be issued where a new development would affect existing users;

- groundwater abstraction licences should be transferable with the land title;

- the whole State should be proclaimed and managed for groundwater and surface water protection;

- Appendix D indicates that the impression given in the ERMP, that agriculture is the highest private groundwater user, is incorrect as it follows urban garden bores, public parks and institutions, and commerical and industrial users;

- the comparative economics of allowing full development of the Wanneroo horticulture industry with adequate water access and bringing water from

north of the Moore River to compensate for this amount, versus relocating the Wanneroo horticulture industry to the north of the Moore River, has not been considered;

. landowners who impede the flow of surface water from springs, etc should be prevented from doing so;

. would the implementation of the Pinjar scheme require changes to existing land uses and land use practices and controls in the Wanneroo area, and particularly around Lake Pinjar?;

(f) Coordination of Groundwater Management:

. the Water Authority's dual roles of water resource manager and water supplier could be seen as representing a conflict of interest and they should therefore be divorced;

. the Water Authority and other relevant agencies need to more actively point out the environmental and social implications of continued population growth in Perth, and perhaps strongly support decentralisation as one option;

(g) Groundwater Pollution:

. what is the capacity of the contaminant plume from the Pinjar rubbish dump, the Gnangara septage disposal site and the several piggeries in the area to pollute the unconfined aquifer, the possibility of contamination of the confined aquifer, and the worst case scenario that would result?;

. could the abstraction from the Pinjar scheme cause sufficient lowering of the groundwater hydraulic head to cause contamination of Lake Joondalup and other adjacent wetlands from the eastward flow of leachate from the Mindarie rubbish site?;

. do the discharges from urban areas (eg stormwater, septic tanks, etc) cause detrimental impacts on the superficial formations and nearby wetlands?;

. monitoring of the fertiliser and herbicide/pesticide practices of horticulturalists and their effect on groundwater quality should be undertaken;

(h) Compensation:

. will the Water Authority compensate for costs incurred in deepening existing bores where its bores cause reduced water-table levels;

. compensation to landowners not able to develop their land at all or fully because of restricted access to the groundwater should be paid by the Government;

. reduced spring flows on the eastern margin of Lake Pinjar would reduce fodder growth, leading to increased stock feeding costs which need to be compensated;

(i) Aboriginal Heritage:

- the impact on aboriginal heritage sites in the area should be reassessed;

- the preparation of the ERMP did not involve consultation with Aboriginal people and recognition of the implications of the proposals to Aboriginal sites, such as Lakes Gnangara, Goollelal and Joondalup and Emu Swamp and in Yanchep National Park;

(j) Miscellaneous:

- information on wetlands referring to geological history, age, permanence, recent changes, unique aspects and comparisons with other South West wetlands should have been included;

- the discussion does not present the important economic advantages of the Mound;

- any major plans for urban expansion and other high water users should take into account water availability and the affect of obtaining it;

- State Forest 65 should be cleared of pines and returned to native vegetation or replaced with seasonal flora culture or horticulture;

- all landfills, freeways and subdivisions of wetlands should be prevented;

- the presence of numerous mining leases/tenements over the Mound area may cause the management of the Mound to be jeopardised;

- a public information centre, perhaps located in Reserve 21176 at Wanneroo, should be established by the Water Authority, Department of Conservation and Land Management and EPA to provide information on the environment, changes caused by water abstraction and management procedures being implemented for the Mound;

- the public should have access to all information within government concerning the availability of water (surface and groundwater) to Perth;

A list of people and organisations who made a submission to the EPA is attached as Appendix B.

The Water Authority was requested to provide comment on the issues raised in the submissions. A copy of the response of the Water Authority is provided as Appendix C.

6. ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS

The ERMP discusses groundwater use and management issues for the whole of the Gnangara Mound and the next groundwater scheme (Pinjar) in specific detail. The description of likely environmental impacts of the next proposal and the future schemes are based on currently available data. The EPA considers that one of the strengths of a continuing environmental review

process for the Mound is that the likely environmental impacts of future developments can be estimated well in advance and this allows for a responsible and conservative approach to be taken to environmental management.

This process allows monitoring and management programmes to be put in place that will enable the environmental impacts to be fed back into the planning, design and operation of future schemes with more certainty about impacts. In order to achieve this there must be some overall guiding principles.

RECOMMENDATION 2

The EPA recommends that the concepts of sustainable yield of resources and maintenance of ecological systems should be central to decisions affecting management of groundwater resources of the Gnangara Mound, in accordance with the State Conservation Strategy.

The EPA's assessment of the Gnangara Mound proposals is based on these concepts.

Many specific aspects of the proposals have been considered by the Advisory Group, and the EPA has taken full benefit of this. Indeed, the approach used in the remainder of this report is to deal with broader issues within which the proposals need to be seen, and to refer to the appropriate portions of the Advisory Group's Report for many detailed aspects. In addition, the Water Authority's response on issues raised in submissions has been used to expand or elaborate on specific matters.

6.1 PREDICTIVE CAPABILITY

A critical part of the ERMP and its presentation of potential environmental impacts is the mathematical model that has been used by the Water Authority to derive alternate groundwater development and management strategies.

The Perth Urban Water Balance Model has forecast likely changes in groundwater levels in the superficial formation, from which predictions of environmental and social consequences of a range of land use and abstraction strategies have been derived.

Because of its importance, the Advisory Group closely evaluated the basis of the model. In its report (p 22), the Group pointed to the model being the best available tool for assessing regional groundwater level changes under varying climatic, land use and groundwater demand situations.

Use of a computer model allows existing information to be used to predict outcomes, and for data derived from monitoring to be used to refine the initial predictions.

The EPA considers that the approach adopted in the ERMP by the Water Authority using appropriate modelling techniques to predict changes in groundwater levels, is a balanced practical effort to plan and manage within known deficiences in knowledge and should be judged accepting these limitations.

6.2 BIOPHYSICAL IMPACTS

The biological impacts of the proposals fall into three components: wetlands, upland vegetation and pine plantations. Each of these is considered in turn.

6.2.1 WETLANDS

The wetlands associated with the Gnangara Mound are an essential component of the environmental integrity of the region as well as being major uses of the groundwater resource. They also play a significant part in the water balance of the Gnangara Mound. Areas of open water and relatively dense fringing vegetation contribute to the loss of an estimated 70 per cent of the annual water balance through evapotranspiration (ERMP, p 55). They also contribute directly to recharge of the superficial aquifers.

While many of the wetlands on the Mound have already been substantially modified, significant effort has been expended by the Water Authority to reduce the impact of drawdown on those wetlands that have retained much of their conservation value.

The EPA, in December 1986, released for public comment 'Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area' (EPA, 1986). These draft guidelines form a basis for the Authority's comments and recommendations with respect to wetlands.

The approach to wetlands adopted in the ERMP largely revolves around two components: the selection of a level of drawdown of the groundwater that is considered to be environmentally acceptable and the identification of those wetlands to which this level would be applied. The ERMP adopted a maximum 0.5 m drawdown in the most environmentally sensitive areas as being appropriate.

Recent research in the Metropolitan Area has confirmed that wetlands are not uniform in their response to changing water levels and other factors (Davis & Rolls, 1987). This study has shown that:

- increasing urbanisation has resulted in increased nutrient enrichment in some urban lakes while other wetlands have improved water quality;

- lowered water levels alone may not adversely affect water quality in urban wetlands but the effects of evaporation and low water levels may lead to unacceptable increases in salinity and nutrient levels;

- seasonal drying of wetlands may be beneficial, by reducing nutrient cycling and habitat to fauna at the time of poorest water quality; and

- physical and chemical water quality parameters, and the macro-invertebrate fauna of urban wetlands are significantly variable between wetlands.

The Authority concurs with the view of the Advisory Group (p 10) that the impacts of declining water levels in specific wetlands needs to be evaluated on an individual basis. Using Table 24 of the ERMP as a basis, the Authority has assessed the likely impact of the predicted drawdown on the nominated wetlands. This review is presented in Table 6.1. The location of the wetlands is indicated in Figure 2.

Table 6.1 Recommendations on Specific Wetlands on the Gnangara Mound

Wetland name	✱ Category	▼ Land status	■ System six	Predicted water level change of aquifer under preferred land use scenario of ERMP	Recommendation	Comments	Agreement of recommendation with ERMP	▲ Minimum summer water level to maintain current values (in AHD)
Loch McNess	1	NPNCA	M3	< - 0.5	no change to existing regime of water quality and quantity, within normal climatic variation.	for hydrol/geol reasons actual change expected to be close to 0 m	disagrees	7.0
Joondalup	1	NPNCA	M7	< - 0.5	" " "	for hydrol/geol reasons actual level expected to be close to 0 m	disagrees	16.7
Twin Swamps	2	NPNCA	M17	0	" " "	outside predicted area of influence	agrees	n/a
Ellen Brook	2	NPNCA	M17	0	" " "	outside predicted area of influence	agrees	n/a
Yonderup	2	NPNCA	M3	< - 0.5	" " "	for hydrol/geol reasons actual change expected to be close to 0 m	disagrees	5.3
Melaleuca Pk wetlands	2	NPNCA	M9	0 to + 0.5	" " "	-	agrees	n/a
Jandabup	2	NPNCA/ freehold	M8	< - 0.5	" " "	management strategy in place (see footnote 1)	disagrees	44.3
Yeal Swamp	2	CALM	C13	< - 0.5	" " "	not affected by Pinjar Scheme; later schemes impinge	disagrees	n/a
Bindiar	2	CALM	C13	< - 0.5	" " "	not affected by Pinjar Scheme; later schemes impinge	disagrees	n/a
Nowergup	2	NPNCA	M6	< - 0.5	no change to existing regime of water quality and quantity, within normal climatic variation.	for hydrol/geol reasons actual change expected to be close to 0 m	disagrees	16.5
Pipidinny	3	freehold	M3	< - 0.5	predicted change is acceptable	-	agrees	n/a
Goollelal	3	SPC	M7	0	predicted change is acceptable	outside predicted area of influence	agrees	26.4
Gnangara	3	LGA	M8	+ 0.5	predicted change is acceptable	predicted rise would reflect changed forest management	agrees	41.4
Wilgarup	3	NPNCA	M3	< - 0.5	acceptable subject to advice from NPNCA	subject to needs of Yanchep National Park	agrees	n/a
Beonaddy	4	freehold	M3	< - 0.5	predicted change is acceptable	-	agrees	n/a
Coogee Springs	4	freehold	M3	< - 0.5	Water permanency should be maintained	intent is to maintain landscape and historical values	disagrees	n/a
Neerabup	4	freehold		< - 0.5	predicted change is acceptable	affected by historical landuse, landscape (see footnote 2)	agrees	n/a
Lake Adams	4	freehold &LGA	M8	-0.5 to -1.0	predicted drawdown is acceptable	wetland could be further modified (see footnote 3)	agrees	n/a
Mariginiup	4	vCl, freehold	M8	-0.5 to -1.0	a smaller drawdown is may be tolerable	current level reflects WGAC strategy (see footnotes 1 & 4)	disagrees	41.2
Badgerup	4	freehold	M8	+ 0.5	predicted change is acceptable	-	agrees	n/a
Little Badgerup	4	freehold	M8	+ 0.5	predicted change is acceptable	-	agrees	n/a
Pinjar	4	freehold	M8	> - 1.5	predicted change is acceptable	(see footnote 5)	agrees	n/a
Lenzo Rd wetlands	5	freehold -recreation	M8	0	predicted change is acceptable	-	agrees	n/a
Dundarbar	5	freehold		0	no change predicted	is a result of current forest management & WGAC policy	agrees	n/a
Unnamed S.E. of Adams	5	freehold	M8	0	no change predicted	-	agrees	n/a
Snake Swamp	5	freehold	M8	0	no change predicted	-	agrees	n/a
Mindarie	5	freehold	M3	< - 0.5	predicted change is acceptable	wetland value reduced by land use	agrees	n/a
Carabooda	5	freehold		< - 0.5	seek to retain reduced wetland area	(see footnote 6)	agrees	n/a
Little Mariginiup	5	freehold	M8	-0.5 to -1.0	predicted change is acceptable	wetland values lost to land uses	agrees	n/a

KEY TO HEADINGS AND ABBREVIATIONS

★Categories as defined in: Draft Guidelines for Wetland Conservation in the Perth Metropolitan Region. EPA 1986

1. Wetlands of exceptionally high natural and/or human use attributes;
2. Wetlands with relatively intact natural systems;
3. Wetlands which have been highly modified but which are considered to play important roles in their urban and/or rural settings;
4. Wetlands which have been significantly modified and/or which do not have clearly recognized roles in their urban or rural settings;
5. Wetlands with few remaining attributes and limited human use attributes

▼ NPNCA= National Parks and Nature Conservation Authority (vesting agency for reserves for conservation of flora and fauna; CALM = Department of Conservation and Land Management; SPC = State Planning Authority; vCl = vacant Crown land; LGA = Local Government Authority.

■ Code refers to area-specific recommendations in:
Conservation Reservesfor Western Australia as recommended by the Environmental Protection Authority - 1983: The Darling System - System 6. Part II. EPA, 1983.

WGAC = Wanneroo Groundwater Advisory Committee. This committee advises the Water Authority on management of the shallow groundwater resource in the Wanneroo Groundwater Area proclaimed under the Rights in Water and Irrigation Act,

▲ n/a = no level recommended because of limited information.

FOOTNOTES

(1) Water levels in LAKE JANDABUP, and LAKE MARIGINIUP, reflect management of the shallow groundwater exerted by the Water Authority on the Wanneroo Public Water Supply Area and the Wanneroo Groundwater Area. According to the policy followed by the Wanneroo Groundwater Advisory Committee (WGAC), the water requirements of the lakes are taken into account in allocating groundwater from the shallow aquifer to licensed users in the Wanneroo Groundwater Area.
The Environmental Protection Authority is represented on the WGAC.

(2) NEERABUP LAKE: Little pristine wetland remains; landscape value lies in the valley terrain and historical land uses rather than the wetland.

(3) LAKE ADAMS: The landscape and habitat functions of the lake arise in part from channels excavated in the lake bed. Maintenance of functions rests partly on local water use. These functions could be maintained in the face of drawdown by deepening the channels.

(4) LAKE MARIGINIUP: 0.5m drawdown could effectively result in reduction of the lake to a sedge bed, with increased agriculture on the wetland margins which are freehold. This would result in substantial loss of wetland. The biological role of the lake should be investigated. Appropriate vesting of the vCl and either reservation of wetland in freehold ownership or stabilisation of land use by establishment of land-use controls, together with imposition of suitable management regime, could improve the condition of the wetland to a level where some drawdown could be tolerated.

(5) LAKE PINJAR: The lake should be regarded as a flood plain which may be inundated in periods of high rainfall. Effects of drawdown would be to restrict areas of wetland vegetation towards the southern end of the lake where least drawdown in expected. Consideration should be given to reserving an area on the south of the lake, contiguous with the now disused waste disposal site, as an amenity related to the Wanneroo golf course and motor-racing circuit. There should also be modifications to management with intensive land uses such as piggeries being limited to the capacity to treat effluent on-site - requiring limits to growth of existing activities.

As a means of achieving rational land use of Lake Pinjar, the State Planning Commission should investigate imposition of an Improvement Plan to rationalise lot boundaries and modify the subdivsion pattern, with the area of the existing north-south road reserve consolidated into a reserve on the southern end.

(6) LAKE CARABOODA: Portion of the lake warrants investigation as a wetland habitat. Efforts should be made to maintain a reduced wetland area at the southern end, adjacent to karst valley and to Lake Nowergup. Such an area would protect the wetland function and could be considered for addition to the Nowergup Conservation Reserve and Neerabup Regional Park. Expansion of agriculture could be tolerated on the remainder of the wetland.

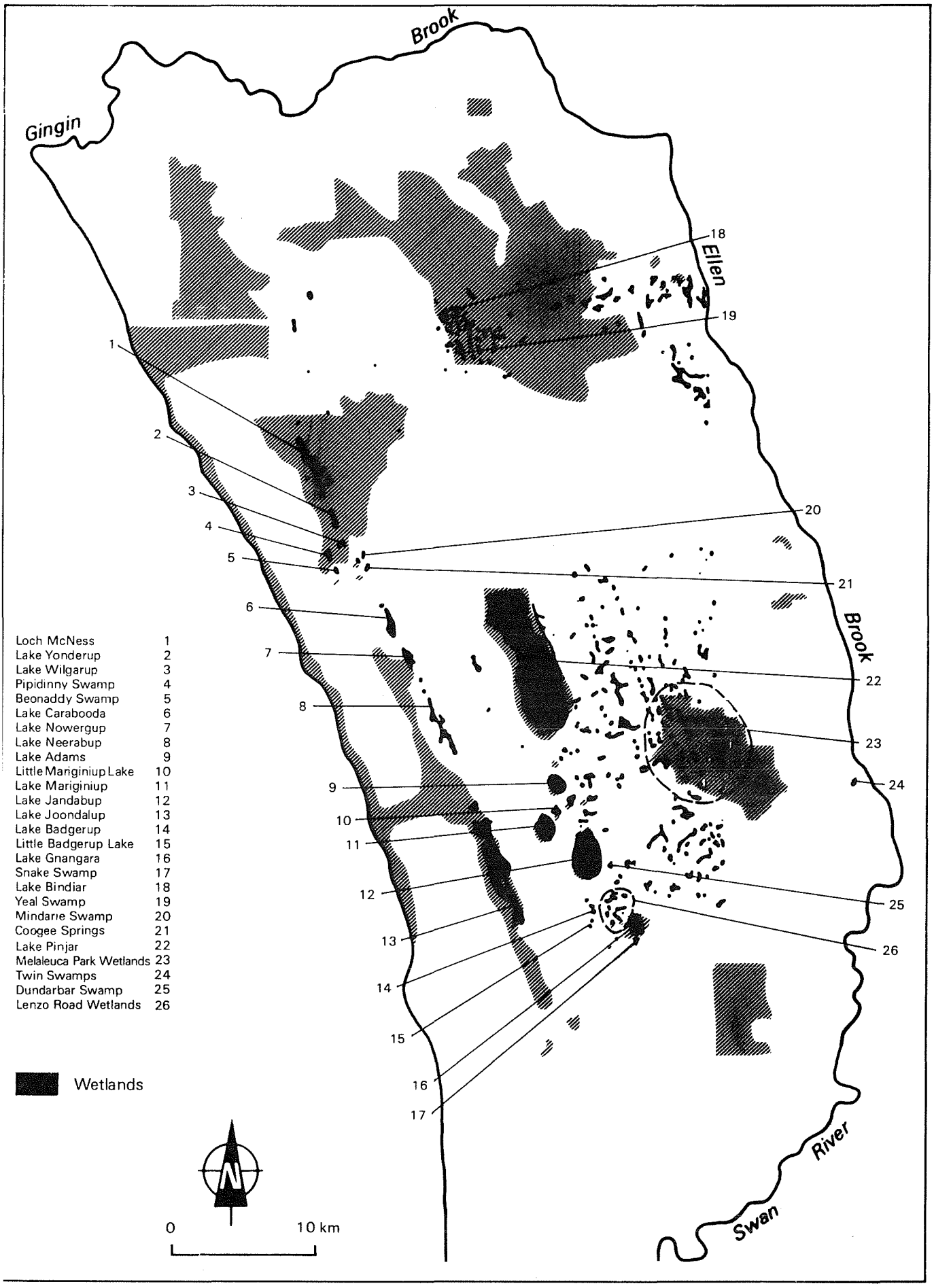

Figure 2. Wetlands of the Gnangara Mound.

The EPA has largely determined the acceptability or otherwise of the water level change on the basis of the consistency of the drawdown with the wetland's management priority indicated in the Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area (EPA, 1986).

For those wetlands within Category 1 (Wetlands of exceptionally high natural and/or human use attributes) and Category 2 (Wetlands with relatively intact natural systems), the EPA has recommended that there should be no change to the existing regime of water quality and quantity, and normal climatic variations. The EPA is of the view that there is some limited scope for water level changes in wetlands within their normal range and seasonal variation. The minimum water level is also an important environmental consideration, for reasons of habitat aesthetics, water quality and fringing vegetation. Therefore, the EPA has also recommended minimum summer water levels.

Another important consideration was the likely change in the character of the wetland and its fringing vegetation resulting from a long term decline in water level. In some lakes, a small permanent reduction in water level would encourage the invasion of vegetation such as Typha sp, leading to significantly diminished open water areas.

While the environmental impacts of a predicted drawdown are seen as being acceptable for some wetlands, others would be significantly affected. These wetlands, including Loch McNess, Lake Joondalup, Lake Yonderup, Lake Jandabup, Yeal Swamp, Lake Mariginiup, Lake Bindiar, Lake Nowergup and Coogee Springs would be altered to varying degrees but, in each case, the predicted decline is considered by the EPA to be unacceptable.

The EPA recognises that two factors may affect the final water levels in the lakes. Firstly, the model from which the predicted changes were derived is based on a regional grid of up to several square kilometres and is considered to be "conservative" (Water Authority, 1987b). Therefore, as the Advisory Group pointed out (p 22), the model predictions would usually represent "worst case" situations. Until the Water Authority has prepared and run the detailed Pinjar model, the extent to which this is a factor cannot be determined. Secondly, the wetlands water levels may not be a direct reflection of the groundwater level. As pointed out in the ERMP and also the Advisory Group's report, a decline or rise in the superficial aquifer may not be reflected entirely in the lake level. There may be a lag in time or some moderated change. However, this relationship for individual wetlands has not been quantified.

The relationship between groundwater and wetland water levels should be an area of future study in the region.

RECOMMENDATION 3

The EPA recommends that the Water Authority manage public and private groundwater abstraction from the Gnangara Mound such that the drawdown does not have an impact greater than that specified by the EPA in this report. Furthermore, the EPA recommends that some defined wetlands should experience no change in their existing regime of water quality and quantity, within normal climatic variations and that these and other wetlands should have minimum summer water levels specified which the EPA considers would be environmentally acceptable. (These are given in Table 6.1.)

The Environmental Protection Authority recognises other wetlands on the Gnangara Mound which have not been included in Table 6.1 because of limited information. These include: Beenyup and Walluburnup Swamps, (between Lake Goollelal and Lake Joondalup), the unnamed wetland north of Burns Beach Road, and wetlands on the north and east of the Mound such as Lake Barragoon, Lake Muckenburra, Lake Bambun, Lake Nambung, the lake in Reserve 31241, Quinn's Brook, and seasonal wetlands north of Yeal Swamp, east of Lake Pinjar and on the western side of Ellen Brook. Improved understanding of these wetland systems should precede any specific recommendations. Many of these are located within State Forest 65 and proposed additions to the CALM Estate. Recommendation 4 applies to these sites.

6.2.2 UPLANDS

The ERMP describes eleven vegetation types contributing to a diverse flora and fauna on the Mound. Some of the largest remnants of native vegetation in the Perth region are located on the Mound.

In the past areas with outstanding natural attributes (such as Yanchep National Park) or areas unsuitable for agriculture and pine-growing have been set aside for preservation. More recently the System Six Report identified a number of areas of high conservation and recreation value and recommended that they be preserved as national parks or have a conservation priority. Areas such as Caraban MPA (Recommendation C 12), Wabling MPA (Recommendation C 13) and Yeal MPA (Recommendation M 5) represent upland sites (EPA, 1983).

Much of this upland flora obtains its water from the unsaturated upper soil zone and lowering of the water table is expected to have little effect on this vegetation (ERMP, Appendix A). It is expected that there may be tree deaths of upland vegetation or pines within a few tens of metres of bores, resulting from local groundwater declines.

The EPA considers that, on the basis of research into the relationship between vegetation and the superficial aquifer on the Gnangara Mound, the impact of the proposals on upland vegetation is expected to be minimal.

Much of this upland vegetation is contained within State Forest 65, part of the estate managed by the Department of Conservation and Land Management, and vacant Crown land. The recently released Northern Forest Region Draft Management Plan includes proposals for most of this land (CALM, 1987).

This Plan proposes that the area subject to System 6 Recommendations C 12, C 13 and M 5 should become nature reserves, while M 4 (Ridges Management Priority Area) would be added to Yanchep National Park. The area of vacant Crown land identified as 'Y' in Figure 20 of the ERMP is proposed to be included within State Forest 65. As State forest the purpose for this area would be for the production of water and timber and protection of water catchments (CALM, p 36).

Having proposed that specific portions of the upland area have a conservation purpose, it is important that detailed management plans for these areas be prepared to ensure the protection of their values. It should also be recognised that there are other large areas of upland vegetation within State Forest 65. In most cases, it is unlikely that they would be cleared for pine establishment, although this would need to be confirmed by CALM.

RECOMMENDATION 4

The EPA recommends that management plans for the land managed by the Department of Conservation and Land Management (existing and proposed) on the Gnangara Mound should include protection of native vegetation and wetlands as principle objectives for management. These management plans, as far as they relate to State Forest 65, should clearly reflect the priority purpose for State Forest 65, water production. Management objectives for the wetlands should be consistent with the water level targets recommended by the EPA in this Report.

6.2.3 PINE PLANTATIONS

There are approximately 23 000 ha of pine plantations in State Forest 65. Very little of this forest is expected to be affected by proposed groundwater level reductions. However, pine plantation density has a significant effect on recharge of groundwater, and hence on water levels and the quantity of groundwater available for public and private use. Their influence on groundwater levels, and hence on wetlands, is important if they are to be maintained at environmentally acceptable levels. As the EPA has already (Section 6.2.1) made recommendations on wetlands that effectively set those limits, it follows that the management of the pine plantations needs to be consistent with these objectives.

In its submission on the ERMP, the Department of Conservation and Land Management (CALM) pointed out much of the Gnangara and Pinjar A (west of Lake Pinjar) plantations have been thinned since the 1980 data used in the ERMP were prepared. A comparison of the ERMP estimates (1980) and CALM's current estimates is presented in Table 6.2.

Table 6.2. Proportion of Pine Plantation at Various Stand Densities as Mapped in the ERMP and by CALM.

BASAL AREA CLASS (square metres/ha)	ERMP (Percentage Area in Each Class)	CALM (Percentage Area in Each Class)
0 - 7	32	32
7 - 15	32	56
15 - 20	15	4
> 20	21	7

(Source: CALM)

CALM estimates the proportion of pine plantation with a basal area exceeding 20 m^2/ha at Gnangara to have fallen from 36 to 11 percent between 1980 and 1986 and at Pinjar A from 46 to 17 percent.

The Perth Urban Water Balance Model, which was used to predict groundwater levels and changes, adopted a range of pine plantation densities when the modelling simulations outlined in Table 22 of the ERMP were run. The preferred management strategy in the ERMP is based on pine plantation basal

densities in the range of 7-15 square metres per ha which optimises recharge of the Mound (Carbon et al, 1982). This range coincidently maximises annual pine tree growth increments.

The Advisory Group (p 10) has pointed out that some portions of the existing pine plantation are located on poor quality sites. These areas of plantation may be thinned below this basal area, thus increasing aquifer recharge.

RECOMMENDATION 5

The EPA recommends that the pine plantations in State Forest 65 be managed with the objective of achieving and maintaining their water use at a level that is no more than that of pre-existing nature vegetation. The EPA understands that this represents an average basal area within the pine plantation of approximately 11 square metres per ha.

6.2.4 GENERAL

As a consequence of the foregoing recommendations relating to wetlands, uplands and pines it is essential that broad co-ordination of these matters is undertaken. This is addressed futher in Section 8, however, the EPA considers it appropriate that an opportunity to plan ahead and consolidate much of the conservation areas in this region should be initiated. Two key agencies that would be involved in this are State Planning Commission and CALM.

RECOMMENDATION 6

The EPA recommends that the State Planning Commission and Department of Conservation and Land Management initiate the consolidation into managed conservation reserves those wetlands and upland native vegetation areas on the Gnangara Mound identified by the EPA as having conservation value. For wetlands within the public estate, priority should be for those which fall into:

- **Category 1 (Wetlands of exceptionally high natural and/or human use attributes);**
- **Category 2 (Wetlands with relatively intact natural systems); and**
- **Category 3 (Wetlands which have been highly modified but which are considered to play important roles in their urban and/or rural settings),**

of the EPA's Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area.

RECOMMENDATION 7

The EPA recommends that, where areas of high conservation occur on private property means for protecting and ensuring their management should be initiated by the Department of Conservation and Land Management and State Planning Commission.

6.3 SOCIAL IMPACTS

The Water Authority's proposals have ramifications with respect to human use of the area, ranging from those features of the environment that add to the quality of life in the area to the availability of water for private use

(including rural/commercial) on freehold land. Therefore there are two fundamental aspects to social impacts of the proposal: the need for and consequences of partitioning of the resource and the subsequent benefits and costs to the community.

6.3.1 PARTITIONING OF THE RESOURCE

The Water Authority is responsible, under the Water Authority Act 1984, for "administering the right and interests of the Crown in and in relation to water in the State, of assessing, developing, utilizing and conserving water resources ...". According to the Water Authority's Corporate Plan, this is to be achieved through the provision of services at minimum long term cost and to an acceptable community standard whilst also assessing, planning and managing the use and conservation of the State's water resources for the continuing benefit of the community (Water Authority, 1986a).

The ERMP outlines the Water Authority's proposals to achieve their objectives. The ERMP proposes to allow the orderly development of the water resource while protecting the resource and community assets and values. The proposal is to provide for the maintenance of the quota for private groundwater abstraction south of Flynn Drive Wanneroo at 21 millon cubic metres per year and to allocate 15 million cubic metres per year to that area of the Wanneroo Groundwater Area north of Flynn Drive. These quotas, in conjunction with that proposed to be drawn from the Pinjar scheme for public water supply, have been derived from the projections developed by the model. The Authority accepts that this is an environmentally acceptable approach to the partitioning of the water resource of the Gnangara Mound.

The water allocation quotas were formulated partly on the basis of drawdowns of 0.5 m in some sensitive wetlands. As the EPA has made recommendations (Recommendation 3) on water levels in these wetlands which do not coincide with those used by the Water Authority in the model, the proposed quotas will need to be reviewed to ensure that the EPA's recommendations are met.

RECOMMENDATION 8

The EPA recommends that the private water allocation quotas proposed in the ERMP be reviewed and revised, if necessary, to ensure that they meet the water level targets for wetlands recommended by the EPA in this report.

The method of allocation of the available quota, through the Wanneroo Groundwater Advisory Committee, was considered by the Advisory Group. They found the existing allocation and control arrangements to be the most appropriate at this time (Appendix A, p iii).

The EPA concludes that the Wanneroo Groundwater Advisory Committee has been an effective means of providing advice on water allocation to the Water Authority.

6.3.2 CONSERVATION OF THE RESOURCE

The level of information on the groundwater resource available to the Water Authority through the monitoring bore network is substantial. This data was used as a basis for the predictions presented in the ERMP. Over time, the model will be run to take account of new data, which will also include the amount of the remaining quota in each area.

It is important that the community in general, and existing and potential users in particular, are aware of changes in groundwater levels. In this way, understanding of the need for management would increase, and future proposals could be consistent with increased understanding of the groundwater systems and improved acceptance of constraints on water use. To date, management initiatives have applied to the Wanneroo area, but they should be applied across the whole of the Gnangara Mound.

RECOMMENDATION 9

The EPA endorses the current approach of the Water Authority in widely publishing the limits on groundwater availability for the Gnangara Mound. The EPA recommends that these figures should be updated and published annually with emphasis on those areas of high conflict for the use of the resource so that limits to growth and development can be clearly seen by all interested parties.

Those parties with licenced bores should be furnished with these data to encourage better understanding and cooperation in management of the water resource.

The Water Authority is currently preparing a water conservation strategy for Perth. Such a strategy is important for a number of reasons.

The present growth in Perth's water demand requires a heavy financial commitment to capital infrastructure. By reducing current per capita consumption by about 2 per cent, the future water resource development programme would be substantially reduced, leading to the deferral of the development of new sources, less environmental impacts from water resources developments, and improved opportunities in the future for the community (Water Authority, 1987a). An additional factor is that the environmental implications of a future period of low rainfall may be more severe, especially due to the increased reliance by the public water supply and domestic and commercial users on the groundwater resource.

RECOMMENDATION 10

The EPA recommends that the Water Authority actively encourage further reduction in public water demand through its Water Conservation Strategy.

The abstraction of groundwater by private users within the Wanneroo Groundwater Area is controlled through licences issued under the Rights in Water and Irrigation Act.

At this time, the Water Authority does not require meters to be fitted to bores, instead relying on the area and type of crop irrigated to determine compliance with licence conditions. While this system has been acceptable when there is little competition for the groundwater resource the proposals in the ERMP by the Water Authority, combined with applications for licences, would find the quotas fully allocated in some areas. Some users can effectively sterilise many hectares of other owners land through their applications for large volumes of groundwater.

It appears to the EPA that, as competition increases for the resource, there may be a requirement to accurately monitor and/or control individual licences and uses. The Advisory Group similarly recognised that as the total

resource of the Mound is developed and allocated, further careful thought needs to be given to water pricing and allocation mechanisms (Appendix A, p 22.)

This issue does not just relate to the Wanneroo Groundwater Area. Within the Perth Metropolitan Area, there are estimated to be more than 77 000 private domestic bores. They mostly abstract from the superficial formation. In some districts, the competition for water has lead to saline intrusion into the aquifer or declining water tables. These consequences have been investigated during the Perth Urban Water Balance Study (Water Authority, in press).

The objectives of the Study were:

(i) to identify areas where the groundwater resource may be at risk due to over-utilisation and/or degradation of water quality;

(ii) to investigate the areas of greatest risk; and

(iii) to identify groundwater management options for risk areas.

As a consequence of this Study, the understanding of the superficial aquifer and its relationship to climatic and land use influences has substantially increased. This has permitted a management strategy to be developed which would recognise the significance of the groundwater to the environment while retaining its broad social benefits.

There is clearly a need to recognise the management requirements of this resource, not only for public water supply purposes but for environmental and social reasons. It may be appropriate that more rigid control on the density and abstraction rates of private bores should be applied.

The community (both urban and rural) needs to realise that water is a finite resource that is essential for life and recognise that its role in maintaining our quality of life is paramount. The EPA considers such issues as control of water demand and water conservation as extremely important to the development of Perth.

RECOMMENDATION 11

The EPA recommends that the Water Authority continue to review and develop methods to improve monitoring and control of all public and private bores, for the purpose of managing the water resource.

Current management and monitoring programmes of the Water Authority for the Gnangara Mound, which relate to private and public abstraction, require significant ongoing funding to ensure that management objectives are being achieved. Included within this management is the licencing of private bores.

Over 1 000 licences have been issued in the Wanneroo Groundwater Area and more will be with its recent extension north of Flynn Drive. While the bores in the Wanneroo Groundwater Area are subject to annual licences, no fee is levied by the Water Authority for their administration nor is there any charge for water abstracted. However, the costs to the Water Authority for managing the groundwater resource of the Mound is approximately $200 000.

This is currently funded through revenue received from Water Authority charges and Consolidated Revenue. The cost is not being borne by the licencees, unless they are also serviced by the reticulated public water supply.

RECOMMENDATION 12

The EPA recognises that these are costs associated with management of the groundwater resource and recommends that the State Government initiate a scheme whereby these environmental management costs are borne by the users of the water resources.

In this report, the EPA has recommended against water quantity or quality changes for wetlands within Category 1 and Category 2 of the Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area. With regard to wetlands within Categories 3, 4 and 5, there may be scope for ameliorative measures to be taken to reduce the impact of declining water levels. These measures could include engineering solutions such as deepening, lining, artificial water level maintenance or the establishment of substitute wetlands. Each of these measures will have a cost component, and the Water Authority would need to make provision for them as part of its budget allocation for groundwater management.

6.4 LAND USE PLANNING

The Gnangara Mound covers an area of approximately 2 100 square kilometres and includes fifteen local Government Authorities. The most significant areas of drawdown effects are restricted to the Shire of Gingin and the City of Wanneroo. The latter also contains the main consumers of the groundwater resource. Not only are rural activities within the City of Wanneroo significant users of the groundwater, but the portion of the North-West Corridor north of Hepburn Avenue receives its potable water supplies exclusively from the Gnangara Mound (ERMP, p 9). Future urban development in this Corridor will require further development of the groundwater reserves of the Mound.

The population growth in Wanneroo has been substantial and is expected to continue. Table 6.3 illustrates this trend. The bulk of this increase is accommodated in the North-West Corridor. The State Planning Commission is currently reviewing the existing corridor plan for the Metropolitan Area and this may result in an amended development strategy. The Report of the Advisory Group mentions a number of issues that might arise as a consequence of this review (Appendix A, p 15).

Table 6.3. Projected Population Growth - City of Wanneroo.

DATE	POPULATION
1966	2 240
1984	114 300
2001	260 000
2021	470 000

(Source: State Planning Commission, pers comm)

In view of the existing range and density of land use in the region (including urban, market gardening, viticulture, horticulture, rural activities, special rural zones, parks and recreation, conservation reserves, and pine plantations), the likelihood that they will increase in the future, and their potential to adversely effect groundwater quality and availability, the EPA regards it as essential that planning bodies have regard for this limited groundwater resource. Planning bodies can also assist in the protection of wetlands.

RECOMMENDATION 13

The EPA recommends that Environmental and Planning policies be developed that minimise the impact of land use activities (especially those that have a high water use or are likely to cause pollution to groundwaters) on the groundwater and wetlands and provide protection of the water resource and conservation of wetlands and upland vegetation.

RECOMMENDATION 14

The EPA recommends that the local authorities located on the Gnangara Mound incorporate in their statutory Town Planning Scheme(s), policies, zones and such other mechanisms as appropriate, the objectives of:

- **protection of the ground water resource of the Gnangara Mound; and**
- **conservation of wetlands including their buffer zones.**

6.5 PROPOSED PINJAR SCHEME

The Water Authority has proposed that the Pinjar Groundwater Scheme would be the next public water supply development. This is essentially an extension of the existing Wanneroo Scheme.

As discussed in Section 3, the Pinjar Scheme would be a staged development. Since the release of the ERMP, the programme for the Pinjar Scheme (Table 3.2) has been revised. The current schedule is presented in Table 6.4. and the distribution of the wells is shown in Figure 3.

Table 6.4. Revised Pinjar Groundwater Scheme Development Schedule.

STAGE	COMMISSIONING DATE	NUMBER OF WELLS			ANNUAL QUOTA (Million cubic metres/yr)
		SUPERFICIAL	LEEDERVILLE	YARRAGADEE	
1st	1989/91	9	3	2	10.0
2nd	1994/95	9	3	2	11.0
3rd	1997/98	10	2	4	11.0
TOTAL		28	8	8	32.0

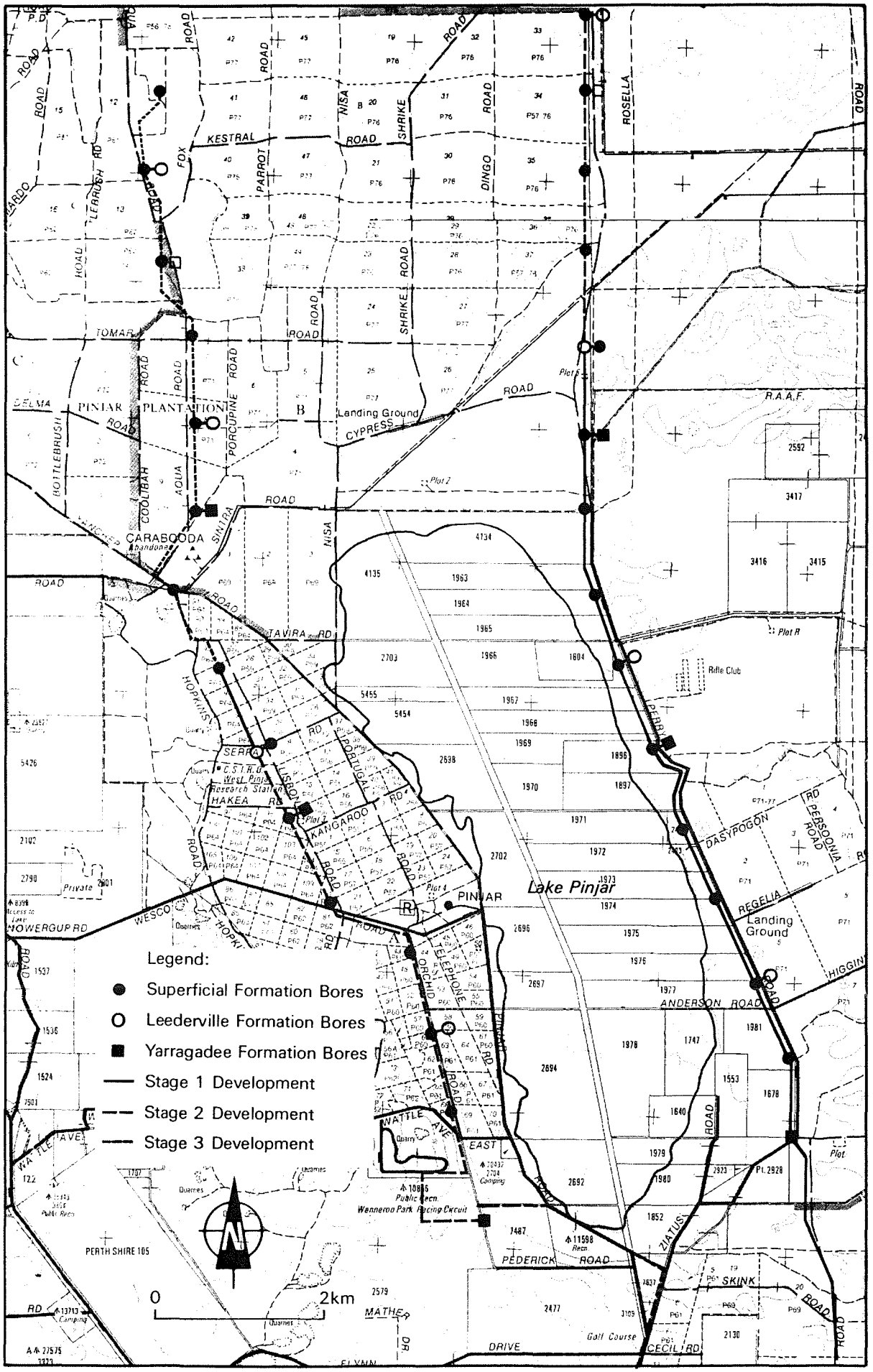

Figure 3. Proposed Pinjar Groundwater Scheme.

The 1st Stage development would comprise 14 wells established along Perry Road, east of Lake Pinjar. A supply main linking the wells with the Wanneroo Treatment Plant would also be constructed.

Later stages would extend the eastern leg to the north of Lake Pinjar and establish the western leg.

As the timing of the Pinjar scheme has been amended, so also has the development timetable for the other schemes. The new timetable is outlined in Table 6.5 and should be compared with Table 3.1.

Table 6.5. Proposed Public Water Supply Schemes - Superficial Formations.

PROPOSED SCHEME	PROPOSED COMMISSIONING DATE	NUMBER OF WELLS	PLANNED QUOTA (million cubic metres per year
Pinjar	Stage 1 - 1989/91) Stage 2 - 1994/95) Stage 3 - 1997/98)	28	14.0
Lexia	1999/2000	15	6.5
Yeal	Stage 1 - 2004/05) Stage 2 - 2007/08)	24	9.6
Barragoon	Stage 1 - 2009/10		

The environmental effects of the two legs of the Pinjar Scheme can be considered separately, although they are inter-related. The eastern leg's potential impacts relate mainly to Lake Pinjar and the vegetation and wetlands east of Perry Road, while the western leg affects private property and wetlands towards Wanneroo Road.

In its System 6 Report, the EPA noted that almost all of Lake Pinjar is privately owned and major modifications have been made to the shoreline and littoral zone (EPA, 1983). In spite of this, the Lake still retained limited conservation value. The more recent Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area has listed Lake Pinjar as a wetland which has been significantly modified and/or which does not have clearly recognised roles in its urban or rural setting (Category 4). The management priority for wetlands in this Category is that the emphasis should be on maintaining the existing functions and, where development is essential, for the important functions of the wetland to be restored in an equivalent area (EPA, 1986). For this reason, the relevant footnote in Table 6.1 suggests that a reserve be created at the southern end of Lake Pinjar.

Table 6.1 notes that there are many wetlands to the east of Perry Road, but the level of understanding of their conservation value is limited. With reduced water table, the Advisory Group (p 28) suggested that the impact on these ephemeral wetlands would be a change towards vegetation that is better adapted to more water constrained conditions.

In considering the Pinjar Groundwater Scheme, the Advisory Group advised the EPA that the proposed scheme should be approved subject to the management

commitments given in the ERMP, comments made in its report and, in particular, on condition that:

"(i) the Water Authority develops, within 12 months, a model to allow the local effects of the Pinjar Scheme to be better defined, monitored and managed;

(ii) the Department of Conservation and Land Management formally agrees to thin the pines in the vicinity of Lake Pinjar to average basal areas with recharge equivalent to natural vegetation, as required by the Water Authority;

(iii) private abstraction in the Wanneroo Groundwater Area north of Flynn Drive does not exceed 15 million cubic metres per year unless further monitoring and modelling shows the impact on water table levels to be acceptable;

(iv) the Water Authority and the Department of Conservation and Land Management, in conjunction with the Environmental Protection Authority, prepare a long term programme for assessing and monitoring environmental impacts in the area; and

(v) the unconfined and confined aquifers are developed concurrently to provide some capacity for managing water table declines under severe drought conditions" (Appendix A, p V).

The Water Authority has responded to this advice by indicating acceptance of each of these points, and has already initiated the model preparation (Appendix C). Not only would this model greatly enhance the Water Authority's predictive capability of environmental impacts, but would also assist management of the resource between various users. As competition for the resource intensifies at local and regional levels, so the management response needs to become more sophisticated. In particular, the implications of specific landuse development proposals dependant on groundwater need to be carefully considered and, if licenced, closely monitored.

The EPA is aware of the current concern about private groundwater use in areas to the west of Lake Pinjar, especially development proposals that would require large proportions of the available quota. Given that such proposals are closer to the environmentally sensitive wetlands than the proposed Pinjar wellfield, and abstraction would be more concentrated than from the Scheme, the EPA also is concerned. Indeed, the potential consequences of these proposals can be more significant at the local level than those of the Water Authority, and the need for modelling of these abstractions is as important.

The EPA is of the opinion that acceptance of the whole of the proposed Pinjar Groundwater Scheme would be premature in view of the detailed modelling being prepared, recent ground-water use proposals within the adjacent Wanneroo Groundwater Area and recognising the possible implications of recommendations in this report. However, the environmental implications of the 1st Stage of the Pinjar Scheme, along Perry Road, are considered to be environmentally acceptable. The further stages of the Pinjar Scheme are environmentally acceptable in principle, and details can be considered in the light of further information.

RECOMMENDATION 15

The EPA recommends that Stage 1 of the Pinjar Scheme, along Perry Road, is environmentally acceptable.

RECOMMENDATION 16

The EPA accepts, in principle, Stages 2 and 3 of the Pinjar Scheme as being environmentally acceptable but recommends that the Water Authority revise them in the light of this Report and Recommendations and refers them to the EPA for further consideration.

RECOMMENDATION 17

The EPA concludes that the staged development of groundwater schemes, which permits the matching of growth in demand with supply and the tailoring of schemes to minimise environmental impact, is an environmentally acceptable approach and recommends that it be applied to future groundwater schemes.

7. ENVIRONMENTAL MANAGEMENT AND MONITORING

The Perth Urban Water Balance Model has been applied in detail to the Wanneroo area (MWA Wanneroo Groundwater Scheme Review 1985) and has enabled the setting of interim limits for private abstraction as well as public abstraction. The Model allows the investigation of the effects of rainfall and landuse changes on wetland water levels. This Model is currently being extended to cover the areas recently incorporated into the Wanneroo Groundwater Area.

The Model can be used to show the predicted drawdown effects of a given land use scenario under average rainfall conditions. This would represent the designed response. After monitoring groundwater levels and rainfall and any changes in land use, the model can be re-run periodically to check if the originally predicted response is occurring or if excessive drawdown is occurring. Once this has been done and any disparity is found, then the need to change abstraction rates and/or land use can be signalled and the Model can be recalibrated to improve its predictive capability.

This then provides one tool for interactive management of the groundwater. It should be emphasised that land use is a major factor to be controlled and so the importance of Government planning, policy and controls cannot be underestimated.

The Water Authority is currently participating in a significant programme related to the monitoring and management of the groundwater of the Gnangara Mound. Groundwater management of the Water Authority is based on the following objectives:

. avoiding long-term depletion of the groundwater resource; and

. maintaining the community assets that rely on groundwater (ERMP, p 129).

Current management of the Gnangara Mound groundwater resource by the Water Authority is composed of:

. the proclamation of Wanneroo Groundwater Area, Wanneroo Underground Water Pollution Control area, Wanneroo Public Water Supply Area and Gnangara Water Reserve;

- the definition of overall quotas for groundwater abstraction consistent with perceived sustainable yield, based on mathematical model predictions;

- the allocation of groundwater abstraction licences within the overall quota, by the Wanneroo Groundwater Advisory Committee;

- the regular monitoring of groundwater and wetland levels and vegetation transects;

- the joint funding of studies into wetland invertebrate fauna of Lake Joondalup, Lake Jandalup, Lake Goollelal and Loch McNess;

- sponsored studies into evaporation and transporation rates from pine trees and native vegetation;

- the adjustment of abstraction rates from public supply bores if unacceptable impacts are identified;

- the identification and investigation of other mechanisms to manage ground-water availability or use; and

- annual reporting of results from the monitoring programme on existing groundwater schemes to the EPA.

The EPA receives annual reports from the Water Authority on the environmental effects of the operation of the Jandakot, and East Mirrabooka Groundwater schemes. These reports have been provided since 1976. Recently the EPA has agreed that it should receive detailed triennial reports and brief annual reports. The next triennial report is due in 1987.

These reports present information on rainfall variation, annual groundwater production from each scheme, changes in minimal groundwater levels, hydrographs of major lakes (eg Jandabup, Adams, Gnangara and Mariginiup) and selected bores.

7.1 MANAGEMENT PROPOSALS

The Water Authority has presented, in Chapter 11 of the ERMP, its environmental management commitments. They are summarised in Table 27 of the ERMP and are reproduced in Appendix D of this Report.

RECOMMENDATION 18

The EPA recommends that the commitments given by the Water Authority in the ERMP and reproduced in Appendix D of this Report should form the basis for management of the Gnangara Mound groundwater resource.

While these commitments are supported by the EPA, it considers that management responsibility for the environment of the Gnangara Mound should not be solely that of the Water Authority. Other agencies also have a significant part to play, as planners, technical advisers and managers. The main agencies are Western Australian Water Resources Council, State Planning Commission, CALM, EPA, local authorities and Department of Agriculture. They need to participate more actively in management of the Mound. Further discussion on the mechanism for achieving this is presented in Section 8.

Management of the Mound needs to be interactive and iterative, being modified as additional information is obtained. It is therefore essential that the information gained through monitoring and research programmes is relevant to the management of the Mound.

This iterative management process must apply to the whole of the groundwater resource and all of its users, public and private. As a consequence, the quotas for public water supply schemes as well as the proclaimed Groundwater Areas need to be reviewed and reassessed over time and with changing circumstances, including climatic change.

RECOMMENDATION 19

The EPA recommends that the basis for decision-making and the criteria established for conservation of the environment and of the groundwater resource be subject to regular review and updated as further information becomes available.

A number of deficiencies in information were noted in submissions (Section 5) and by the Advisory Group. Consideration needs to be given by Government agencies to addressing them. For example, the relationship between the groundwater level and water level in individual wetlands needs to be better understood. From the hydrographs prepared by the Water Authority, the response of individual wetlands to changing water table levels varies. Another issue is the effect that declining water levels in wetlands have on water quality, and hence on the fauna and flora of that wetland.

There is also clear benefit in developing a simple and reliable monitoring method by which the quality of the wetland can be established and periodically measured. The work of Davies and Rolls (1987) is an attempt to derive such a tool.

RECOMMENDATION 20

The EPA recommends that the following specific areas of research and monitoring, additional to the existing monitoring programme and commitments in the ERMP, be undertaken:

- **clarify the relationship between groundwater level and wetland water quality; and**

- **improve understanding of conservation value of wetlands on the Gnangara Mound, especially those for which information on their value is limited.**

Over time, as more baseline information is obtained, the EPA would expect that the monitoring programme could be simplified.

The current reporting mechanism by the Water Authority to the EPA on existing groundwater schemes (Wanneroo, Gwelup, Mirrabooka, Jandakot) should be the mechanism of reporting to the EPA for monitoring and management of the Gnangara Mound.

RECOMMENDATION 21

The EPA recommends that the Water Authority should submit brief annual and more detailed triennial reports on environmental monitoring and management of the Gnangara Mound to the EPA.

8. FRAMEWORK FOR CO-ORDINATION AND MONITORING

Due to the wide range of issues that this proposal raises and the philosophy adopted for the assessment of the water resource, it is important that co-ordination and the integration of the management of planning, monitoring and development, be achieved. This was an issue raised by the Advisory Group in its report. The Group (p 19) suggested the establishment of a committee to co-ordinate the planning and operation of the various organisations with a strategic interest and influence in the region.

While the ERMP addresses a number of important topics, many issues particularly of a social nature remain to be resolved. The ERMP was not the place nor is it the role of the Water Authority to do so. Issues such as the following need to be considered and decided at the broadest level of Government:

. which land use should have priority of access to groundwater?

. should Wanneroo retain its agricultural base or be urbanised to a greater extent?

. how many people should the area accommodate?

Development, control and management of the Gnangara Mound requires significant commitment and clear direction. The EPA does not consider that any single agency or body can or should provide all of this. Policy direction needs to be provided by the Government. Such policies should recognise the limits of the resources of the Mound and provide the means of making societal decisions. With these policies in place, the coordination and planning roles can then be carried out.

The EPA believes that a hierarchy of policy making, advisory and technical groups needs to be established for the Gnangara Mound, involving the Government, key Government agencies and local interests. There would be three levels to such a structure, comprising a Policy Coordinating Group, a Technical Advisory Group and a Managing Group.

RECOMMENDATION 22

The EPA considers that many issues in relation to the Gnangara Mound cannot be considered by any single agency and recommends that policy direction, broad planning and management on the Gnangara Mound should be undertaken by the Government. The EPA suggests the following structure and representation for the Government's consideration:

a. **A Policy Coordinating Group, with responsibility to Cabinet for formulating policy directions, comprising -**

Department of the Premier and Cabinet (Chairman)
Water Authority of WA
State Planning Commission
Environmental Protection Authority

b. **A Technical Advisory Group, to provide specific planning and management advice to the Policy Coordinating Group comprising -**

Water Authority of WA
Western Australian Water Resource Council
State Planning Commission
Department of Conservation and Land Management
Department of the Premier and Cabinet
Environmental Protection Authority
Department of Agriculture
City of Wanneroo
Shire of Gingin

c. **The Wanneroo Groundwater Advisory Committee continue, and other such Committees as appropriate be established, to provide advice on applications for private groundwater establishment to the Water Authority.**

A prime objective of the Policy Coordination Group should be the preparation of a Government policy on the water resources of the Gnangara Mound, their protection and management, within 6 months.

9. CONCLUSION

The Gnangara Mound Groundwater Resource ERMP provides a comprehensive review of a series of development proposals, with its environmental and other impacts. The approach nominated by the EPA was broad, and the ERMP fulfills the EPA's requirements.

The EPA considers that the approach of a continuing environmental asssessment is appropriate to the development and management of the Gnangara Mound.

The EPA concludes that the Gnangara Mound groundwater resource can be developed for public water supply whilst maintaining the high environmental and social values of the Mound. This requires appropriate policy directions and sound resource and environmental management. The EPA is confident that the recommendations in this report and the commitments by the Water Authority in the ERMP will provide both.

Further, the EPA concludes that the Water Authority's proposals for public water supply schemes, private abstraction control and environmental management for the Gnangara Mound are, broadly, environmentally acceptable, subject to the EPA's Report and Recommendations.

With regard to the proposed Pinjar Groundwater Scheme, the EPA considers that implementation of the Scheme is, in principle, environmentally acceptable and that Stage 1 of the Scheme could be approved. The two later Stages will need to be revised and considered again by the EPA in the light of recommendations in this report.

RECOMMENDATION 1

The EPA has concluded that, subject to the EPA's recommendations in this report, the plans and policies for land uses on the Gnangara Mound resulting from mechanisms proposed in the ERMP would be environmentally acceptable and recommends that these proceed accordingly.

RECOMMENDATION 2

The EPA recommends that the concepts of sustainable yield of resources and maintenance of ecological systems should be central to decisions affecting management of groundwater resources of the Gnangara Mound, in accordance with the State Conservation Strategy.

RECOMMENDATION 3

The EPA recommends that the Water Authority manage public and private groundwater abstraction from the Gnangara Mound such that the drawdown does not have an impact greater than that specified by the EPA in this report. Furthermore, the EPA recommends that some defined wetlands should experience no change in their existing regime of water quality and quantity, within normal climatic variations and that these and other wetlands should have minimum summer water levels specified which the EPA considers would be environmentally acceptable. (These are given in Table 6.1.)

RECOMMENDATION 4

The EPA recommends that management plans for the land managed by the Department of Conservation and Land Management (existing and proposed) on the Gnangara Mound should include protection of native vegetation and wetlands as principle objectives for management. These management plans, as far as they relate to State Forest 65, should clearly reflect the priority purpose for State Forest 65, water production. Management objectives for the wetlands should be consistent with the water level targets recommended by the EPA in this report.

RECOMMENDATION 5

The EPA recommends that the pine plantations in State Forest 65 be managed with the objective of achieving and maintaining their water use at a level that is no more than that of pre-existing native vegetation. The EPA understands that this represents an average basal area within the pine plantation of approximately 11 square metres per ha.

RECOMMENDATION 6

The EPA recommends that the State Planning Commission and Department of Conservation and Land Management initiate the consolidation into managed conservation reserves those wetlands and upland native vegetation areas on the Gnangara Mound identified by the EPA as having conservation value. For wetlands within the public estate, priority should be for those which fall into:

- Category 1 (Wetlands of exceptionally high natural and/or human use attributes);
- Category 2 (Wetlands with relatively intact natural systems); and
- Category 3 (Wetlands which have been highly modified but which are considered to play important roles in their urban and/or rural settings),

of the EPA's Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area.

RECOMMENDATION 7

The EPA recommends that, where areas of high conservation occur on private property, means for protecting and ensuring their management should be initiated by the Department of Conservation and Land Management and State Planning Commission.

RECOMMENDATION 8

The EPA recommends that the private water allocation quotas proposed in the ERMP be reviewed and revised, if necessary, to ensure that they meet the water level targets for wetlands recommended by the EPA in this report.

RECOMMENDATION 9

The EPA endorses the current approach of the Water Authority in widely publishing the limits on groundwater availability for the Gnangara Mound. The EPA recommends that these figures should be updated and published annually with emphasis on those areas of high conflict for the use of the resource so that limits to growth and development can be clearly seen by all interested parties.

RECOMMENDATION 10

The EPA recommends that the Water Authority actively encourage further reduction in public water demand through its Water Conservation Strategy.

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The EPA recommends that the Water Authority continue to review and develop methods to improve monitoring and control of all public and private bores, for the purpose of managing the water resource.

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RECOMMENDATION 14

The EPA recommends that the local authorities located on the Gnangara Mound incorporate in their statutory Town Planning Schemes, policies, zones and such other mechanisms as appropriate, the objectives of:

. protection of the groundwater resource of the Gnangara Mound; and

. conservation of wetlands, including their buffer zones.

RECOMMENDATION 15

The EPA recommends that Stage 1 of the Pinjar Scheme, along Perry Road, is environmentally acceptable.

RECOMMENDATION 16

The EPA accepts, in principle, Stages 2 and 3 of the Pinjar Scheme as being environmentally acceptable but recommends that the Water Authority revise them in the light of this Report and Recommendations and refers them to the EPA for further consideration.

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The EPA concludes that the staged development of groundwater schemes, which permits the matching of growth in demand with supply and the tailoring of schemes to minimise environmental impact, is an environmentally acceptable approach and recommends that it be applied to future groundwater schemes.

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The EPA recommends that the commitments given by the Water Authority in the ERMP and reproduced in Appendix D of this Report should form the basis for management of the Gnangara Mound groundwater resource.

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The EPA recommends that the basis for decision-making and the criteria established for conservation of the environment and of the groundwater resource be subject to regular review and updated as further information becomes available.

RECOMMENDATION 20

The EPA recommends that the following specific areas of research and monitoring, additional to the existing monitoring programme and commitments in the ERMP, be undertaken:

- clarify the relationship between groundwater level and wetland water quality; and

- improve understanding of the conservation value of wetlands on the Gnangara Mound, especially those for which information on their value is limited.

RECOMMENDATION 21

The EPA recommends that the Water Authority should submit brief annual and more detailed triennial reports on environmental monitoring and management of the Gnangara Mound to the EPA.

RECOMMENDATION 22

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   Department of the Premier and Cabinet (Chairman)
   Water Authority of WA
   State Planning Commission
   Environmental Protection Authority.

b. A Technical Advisory Group, to provide specific planning and management advice to the Policy Coordinating Group, comprising -

   Water Authority of WA
   Western Australian Water Resource Council
   State Planning Commission
   Department of Conservation and Land Management
   Department of the Premier and Cabinet
   Environmental Protection Authority
   Department of Agriculture
   City of Wanneroo
   Shire of Gingin.

c. The Wanneroo Groundwater Advisory Committee continue, and other such Committees as appropriate be established, to provide advice on applications for private groundwater establishment to the Water Authority.

10. REFERENCES

Carbon, B A, Roberts, F J, Farrington, P & Beresford, J D (1982), Deep drainage and water use of forests and pastures grown on deep sands in a mediterranean environment. J. Hydrol. 55: 53-64.

Davis J A & Rolls S W (1987), A Baseline Biological Monitoring Programme for the Urban Wetlands of the Swan Coastal Plain, Western Australia. Environmental Protection Authority Bulletin 265.

Department of Conservation and Land Management (1987), Northern Forest Region - Draft Management Plan.

Environmental Protection Authority (1983), Conservation Reserves for Western Australia as Recommended by the Environmental Protection Authority : The Darling System - System 6 (DCE Report 13).

Environmental Protection Authority (1986), Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area (DCE Bulletin 227).

Water Authority of WA (1986a), Corporate Plan 1986-1991.

Water Authority of WA (1986b), Gnangara Mound Groundwater Resources - Environmental Review and Management Programme (Report No WM4).

Water Authority of WA (1987a), Planning Future Sources for Perth's Water Supply (Report No WP 33).

Water Authority of WA (1987b, in press), Perth Urban Water Balance Study (Report No WP 29).

APPENDIX A

Report of the Advisory Committee

APPENDIX A

WATER AUTHORITY OF WESTERN AUSTRALIA
GNANGARA MOUND GROUNDWATER RESOURCES

Report of Advisory Group to the
Environmental Protection Authority

ENVIRONMENTAL PROTECTION AUTHORITY
WESTERN AUSTRALIA

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SUMMARY

LAND AND WATER USE

1 **The Gnangara Groundwater Mound is a major water resource in the Perth Region.** There are complex inter-relationships between the water resource and the major land uses (urban development, rural activities, pine plantations and public water supply) and the natural environment. **Management of this resource and associated land uses is essential if the maximum sustainable benefit is to be derived for the whole community.** A balance must be found between the conflicting demands for water required for development and conservation of the environment. A balance must also be found between the use of water for urban, agricultural and silivicultural purposes.

2 Perth's steady population growth is expected to continue and will result in expansion of the urban area within the North West Corridor. **Continued growth in demand for public water supplies is considered to be inevitable.** However, the Water Authority should continue its efforts to encourage water conservation and thus reduce the rate of growth in demand for water.

3 Urban development will have little direct effect on water table levels except in localised areas. Urbanisation is likely to result in degradation of water quality and will also affect the nature and extent of activities in the rural and forestry areas and the wetlands to the east. **It is highly desirable to restrict urban expansion to the North West Corridor, an area where degradation of quality and any impact on water table levels will not affect other uses.**

4 Changes to groundwater quality are particularly important in relation to public water supplies and the wetlands. The main defense of the groundwater system against degradation is its ability to disperse and dilute contaminants. **Careful planning and management of land use and waste disposal will be required to minimise groundwater quality degradation.**

5 Extractive industries quarry sand, limestone and other materials from the Mound. These activities are usually limited in extent and no direct impact on the groundwater is known. Legislation requiring environmental review and management programmes should provide the protection necessary.

6 The main land uses in the rural area are irrigated horticulture, pastoral activities and hobby farms. **Of these, market gardening is the major water using activity.** Expansion of market gardening in the area, due primarily to increased export demand, is predicted but the rate and extent of growth is uncertain. **The proposed allocation of 36 million cubic metres per year in the Wanneroo Groundwater Area should be adequate to meet growth in demand for water for agricultural activities for at least the next ten years and possibly much longer.**

7 Many market gardens are located near wetlands and their impact on both water levels and quality is potentially significant. Accordingly, water use is regulated where necessary, with the aim of preventing problems rather than having to cure them. This has resulted in concern among some landowners about restrictions on land use and the effect on property values.

8 In the longer term, growth of irrigated horticulture in the Wanneroo area is likely to ease or cease in response to rising land values due to adjacent urban expansion, and to relocate elsewhere. Most other agricultural activities have much lower water requirements and thus have more limited

implications for the water resource. Fertilisers, pesticides and herbicides used in rural activities all have adverse implications for water quality, particularly for wetlands.

9 **State Forest 65 has a strategic role in protecting the quality, and ensuring the availability, of groundwater in the region.** Pine plantations occupy one half of State Forest 65 with much of the balance reserved for conservation of flora and fauna. **Variations in the density of pines have a significant effect on rainfall interception and transpiration and thus on net recharge of the Mound.** Silviculture has little or no detrimental effect on water quality.

10 **The priority purposes of State Forest 65 are conservation and water production.** Fortuitously timber returns are maximised at or near the pine density that equates to native woodland. Reduction of high density plantation areas would significantly increase net recharge with only a marginal impact on timber returns. Approximately one third of the area under pines will, in any case, produce low volumes of timber and these areas, in particular, should be thinned to low densities to increase recharge. **A comprehensive detailed long-term management plan for both the plantation and conservation areas of State Forest 65 should be developed within 12 months.**

11 Management of State Forest 65 for the priority purpose of water, while it will have some impact on timber returns, is supported by the Department of Conservation and Land Management. The major need is to plan and fund a plantation thinning and management programme to produce maximum benefits at least cost.

12 Because there has been no market for some types of forest thinnings, considerable areas of plantation currently have excessive densities. If a market could be established, this work could be undertaken at no net cost to the State. There is a possiblity that such a market may be established, however, delays in thinning will increase the cost of this work if it eventually has to be done non-commercially. **If a market for pine thinnings cannot be established in the near future annual funding should be allocated for this work, as required for water resource management.**

NATURAL ENVIRONMENT

13 **The large remnants of native vegetation including the extensive wetland system on the Mound are environmentally important.** Much of the native vegetation remaining on the Mound occurs in State Forest 65 and on Crown land to the north and east. This native vegetation can be broadly categorised as uplands and wetlands. The uplands are areas of net recharge and the wetlands areas of net loss of water. **The water table declines described in the Gnangara Mound Groundwater Resources Environmental Review and Management Programme (ERMP) will have little effect on the extensive areas of upland native vegetation (and pine plantations) on the Mound.**

14 Wetlands are a surface expression of the water table. They comprise dynamic and inter-dependent systems subject to seasonal and longer term climatic variations, geological and other natural processes and the effects of Man's activities. **Wetlands are constantly changing and have, in the past been both more and less extensive than at present.** It is possible that a warming of the Earth's climate in the decades ahead may result in a significant contraction of wetlands.

15 **Retention of wetlands is the major constraint in managing the groundwater resources of the Mound.** Without this constraint much more water could be abstracted for both public and private supplies.

16 Urban wetlands are primarily valued for aesthetic reasons; less modified wetlands are more important for ecological reasons. The wetlands of the Swan Coastal Plain are important for a number of reasons including their value as refuges for wildlife in dry periods and as habitats for transequatorial migratory waders. Preservation of a range of natural habitats on the Mound is important ecologically and socially. The System Six Study recommended reservation of extensive areas for the protection of flora and fauna. **Consolidation and formalisation of the most important conservation areas should be finalised as a matter of priority.** Other major areas of native vegetation in State Forest 65 and on adjoining Crown Land could form extensions to these areas and compensate for environmental impacts which may occur elsewhere.

17 **Modification of wetlands is inevitable as land and water resource development proceeds; ephemeral wetlands are especially difficult to deal with because of their dispersed nature.** The aim of co-ordinated land use and water resource management should be to contain impacts within acceptable limits. **There is a need to develop criteria for wetland changes.**

FUTURE DEVELOPMENTS

18 Within the constraint on total withdrawals imposed by wetlands conservation, there is a need to plan and manage use of the groundwater for agriculture, silviculture and public supply. The approach proposed by the Water Authority provides for a 50% increase in the water available for agricultural purposes within the Wanneroo Groundwater Area, reduction in the use for pine production and sufficient abstraction to meet growth in urban demand for the next 25 years.

19 The issue of agricultural water demand is complicated by the uncertainty of demand projections and the question of allocation is influenced by the local impact of intensive users on the environment. **Overall, the proposed allocation of 36 million cubic metres per year in the Wanneroo Groundwater Areas should be adequate to meet growth in demand over the next ten years and possibly for much longer.** However, in some areas, environmental considerations mean that some demands will not be able to be met and conflicts will have to be resolved.

20 The scope for increasing the allocation of unconfined groundwater to agriculture by reducing abstraction for urban supply or further thinning of pines is limited. This is because the distance between the "problem" and the "solutions" is considerable.

21 **Participative management of the Wanneroo Groundwater Area, where demand approaches availability, has proved successful in finding solutions to most of the problems and conflicts associated with allocation of water among private users in this sensitive area.** While there is scope for assessing alternative water allocation mechanisms, continuation of the Wanneroo Groundwater Advisory Committee and existing allocation and control arrangements is considered to be the most appropriate at this time.

22 Many of the possible problems and conflicts which may be associated with development of the Mound will not occur for decades and will arise progressively. Accordingly, it is important not to make decisions or take

actions earlier than is necessary for operations to proceed. To do so would forego the benefits of increased knowledge that will be available as the result of further research and investigation.

23 Some decisions and actions associated with groundwater development and management are reversible. This is particularly true of private and public abstraction. **Where unforeseen consequences arise or impacts are greater than predicted, there is scope, at a cost, to take remedial action with the expectation that wetlands will recover.**

24 **The ERMP is a comprehensive and sound document bringing together for the first time much of the information required to plan and manage this important resource and its associated land uses.** The model used to evaluate alternative development strategies is the most powerful tool available. **The model predictions are considered to be a sound basis for decision making.**

25 Additional information is required in some areas and will improve future decision-making. This will require the planning and execution of a research and assessment programme. However, decisions which need to be made now can be made on a far more informed and balanced basis than was the case before the ERMP was prepared.

26 The long term strategy proposed in the ERMP is considered to provide a reasonable balance between the needs associated with development, and conservation of the environment. It provides a sound basis for strategic planning and policy formulation by the many individuals and organisations with an interest in Mound land use and water resources. **The long term strategy proposed by the Water Authority in the ERMP should be the basis for planning and management.**

27 Development of the Gnangara groundwater resources is the least cost alternative for satisfying growth in demand for public water supplies, particularly in the North West Corridor. The proposal is to construct groundwater schemes in stages to match the growth in demand while at the same time minimising the impact on the environment. It is planned to locate future wellfields within State Forest 65 where water quality is protected and water table changes have generally less impact on the natural environment, particularly the wetlands. **The proposed programme of staged development of public water supply schemes in State Forest 65 is a sound and conservative approach.**

PLANNING AND MANAGEMENT

28 **To minimise the impact on the natural environment it is essential that an integrated approach to management should be progressively implemented.** To achieve this it will be necessary to co-ordinate the planning and operations of the various organisations with a strategic interest and influence. **This process could be initiated by establishing a Gnangara Mound Planning and Management Committee under the auspices of the Western Australian Water Resources Council.** The Committee should comprise senior representatives of the:

City of Wanneroo;
Department of Agriculture;
Department of Conservation and Land Management;
Environmental Protection Authority;
Mines Department;
State Planning Commission; and
Water Authority of Western Australia

The role of the Committee would be to ensure that, for the Gnangara Mound region, each organisation develops and implements policies and plans for its area of responsibility within a co-ordinated framework.

29 The objectives of the Committee should be to:

(i) develop and co-ordinate integrated planning and management by the various agencies involved;

(ii) monitor and report on the implementation of both individual agency and overall plans;

(iii) advise on research and investigation priorities; and

(iv) promote community participation in planning and management.

30 **The commitments given by the Water Authority in the ERMP provide a sound basis for managing the complex issues arising from water resource and land use development.** There is a need to formalise commitments, and to develop more specific programmes and plans to put some commitments into effect. Successful management along the lines described in the report also requires formal commitments from other organisations, particularly CALM.

31 **Consideration needs to be given to overall funding arrangements for Gnangara Mound environmental research and management.** While it is reasonable for the Water Authority to bear some of the cost, particularly for work directly related to water supply and water resource management, it should not be required to fund all investigation work, much of which arises out of the land and water use activities of others.

THE PINJAR SCHEME

32 The Pinjar Scheme is the next public water supply development planned for the Mound. Various options have been examined within the context of the longer term strategies described in the ERMP. **There is no clearly superior alternative to the proposed scheme, the first stage of which must be commissioned in 1989 to satisfy growing demand for urban water.** The Water Authority has sought approval to proceed with detailed planning, design and construction.

33 Predicted changes in water table levels beneath the Lake Pinjar plain due to pumping from the proposed scheme will be quite substantial. However, this land is in private ownership, largely cleared and heavily degraded from an ecological point of view. **Water level changes in environmentally sensitive areas to the west and east are generally expected to be small and to have limited effect on the environment.**

34 **The proposed Pinjar Scheme should be approved subject to the management commitments given in the ERMP, comments made in this report and, in particular, on condition that:**

(i) **the Water Authority develops, within 12 months, a model to allow the local effects of the Pinjar Scheme to be better defined, monitored and managed;**

(ii) **the Department of Conservation and Land Management formally agrees to thin the pines in the vicinity of Lake Pinjar to average basal areas with recharge equivalent to natural vegetation, as required by the Water Authority;**

(iii) private abstraction in the Wanneroo Groundwater Area north of Flynn Drive does not exceed 15 million cubic metres per year unless further monitoring and modelling shows the impact on water table levels to be acceptable;

(iv) the Water Authority and the Department of Conservation and Land Management, in conjunction with the Environmental Protection Authority, prepare a long term programme for assessing and monitoring environmental impacts in the area; and

(v) the unconfined and confined aquifers are developed concurrently to provide some capacity for managing water table declines under severe drought conditions.

1. INTRODUCTION

ADVISORY GROUP

1.1 The Water Authority of Western Australia has prepared an Environmental Review and Management Programme (ERMP) for proposed water supply developments on the Gnangara Mound (Mound). The ERMP presents a general strategy for managing the unconfined groundwater resource and also more detailed plans for the proposed Pinjar Scheme.

1.2 The Mound is a major water resource in the Perth Region. The complex and dynamic relationships between land use and groundwater give rise to important environmental, economic and social issues. To assist in its consideration of these issues, the Environmental Protection Authority convened an advisory group to provide an overview of issues affecting the Mound so that a general policy for management could be developed.

TERMS OF REFERENCE

1.3 The terms of reference for the Advisory Group were to advise on:

(i) the nature, extent and utilisation of the Gnangara Groundwater Mound;

(ii) the relationships between land uses, the conservation of wetlands and native vegetation, and the groundwater resource;

(iii) the options and trade-offs between alternative land use strategies;

(iv) other issues and strategies which may contribute to the determination of the most appropriate balance between competing demands on the Gnangara Mound groundwater resource;

(v) the adequacy and accuracy of the information contained in the ERMP report;

(vi) the adequacy of the environmental management commitments contained in the ERMP report; and

(vii) the environmental acceptability of the proposed Pinjar Scheme.

MEMBERSHIP

1.4 The Advisory Group members were:

Mr C W Burton (Chairman)
Dr A D Allen
Mrs P A Clay
Mr W R Stevens
Mr J F Thomas

1.5 The members of the Advisory Group were chosen by the Environmental Protection Authority for their personal expertise and experience. This report reflects the views of the individuals and not the policies of the organisations with which they are affiliated.

ACKNOWLEDGEMENTS

1.6 The Group was greatly assisted in its work by briefings given by officers from the following Government and other organisations:

Department of Agriculture	Mr J Gallagher Dr B Stynes Mr G Luke
City of Wanneroo	Mr O Drescher Mr P Thompson
Department of Conservation and Land Management	Mr T Butcher Dr E Hopkins
Environmental Protection Authority	Dr J Arnold
State Planning Commission	Mr R Bulstrode Mr J Jenkins Mr J Singleton
Wanneroo Groundwater Advisory Committee	Mr R Green
Water Authority of Western Australia	Mr G Cargeeg Mr R Harvey Mr D Hopkins Mr B Sadler
Wetlands Conservation Society	Prof P Jennings

1.7 Special assistance was provided to the Advisory Group by the following:

Department of Conservation and Land Management	Dr E Hopkins
Environmental Protection Authority	Mrs C McDavitt Mr C Murray Mr B Stewart Miss C Craster
Mines Department Geological Survey	Mr T Bestow
Water Authority of Western Australia	Mr G Cargeeg

METHODOLOGY

1.8 This report is the outcome of two weeks intensive consideration and discussion of information obtained from published documentation, expert briefings and a field inspection. It assumes a knowledge of the contents of the Gnangara Mound Groundwater Resources ERMP. Other publications containing useful background information are listed in the bibliography.

2. THE GNANGARA GROUNDWATER MOUND

GENERAL DESCRIPTION

2.1 The Gnangara Mound is a shallow body of groundwater occurring between the Swan River and Gingin Brook. It originates from rainfall and occurs in sediments forming the Swan Coastal Plain. The upper surface of the Mound is the water table and its base is formed by older sedimentary rocks (Figure 1). The groundwater in the unconfined aquifer flows slowly outwards from the crest of the Mound to discharge into the ocean and the bounding rivers.

2.2 The sandy sediments of the coastal plain favour rapid infiltration of rainfall. The water table rises as it is recharged during winter and falls during summer as some of the stored groundwater is depleted. The natural factors affecting net recharge of the unconfined aquifer are the amount of rainfall, usage by vegetation, loss of water by direct evaporation from intercepting surfaces and wetlands, and leakage to underlying aquifers.

2.3 The Mound is a major water resource in the Perth region and extends over an area of 2091 square kilometres. The unconfined aquifer ranges in thickness from 10 to 100 metres and is estimated to contain about 19 500 million cubic metres of groundwater in storage.

2.4 The current water balance of the Mound, expressed in millions of cubic metres per year (assuming no change in storage), is:

IN		OUT	
Rainfall	1675	Evapotranspiration	1165
Water Imported from Surface Sources	80	Leakage to Underlying Aquifers	107
		Outflow to Ocean and Rivers	372
		Abstraction from Wells	111
	1755		1755

A relatively modest reduction of the evapotranspiration consumption would significantly increase the quantity of water available for public and private abstraction.

2.5 The groundwater of the Mound is readily accessible and large quantities can be abstracted for public and private use at relatively low cost. As Perth expands northward, the groundwater resources of the Mound are proposed to be further developed for public water supply in stages, as required. The amount of groundwater which can be obtained from the Mound is determined primarily by the desire to limit the impact on the environment, particularly the wetlands.

2.6 In addition to the unconfined groundwater resources of the Mound, artesian and sub-artesian groundwater resources occur at depth below the coastal plain. These resources are more saline and, while large quantities of groundwater are in storage, their annual recharge is approximately one third of that of the Mound. Depth, salinity and legislative control restrict the development of these resources for private use but they are important supplementary resources mainly for public supply. Abstraction from the confined aquifers provides some scope to minimise the effects of pumping from the unconfined aquifer in times of drought.

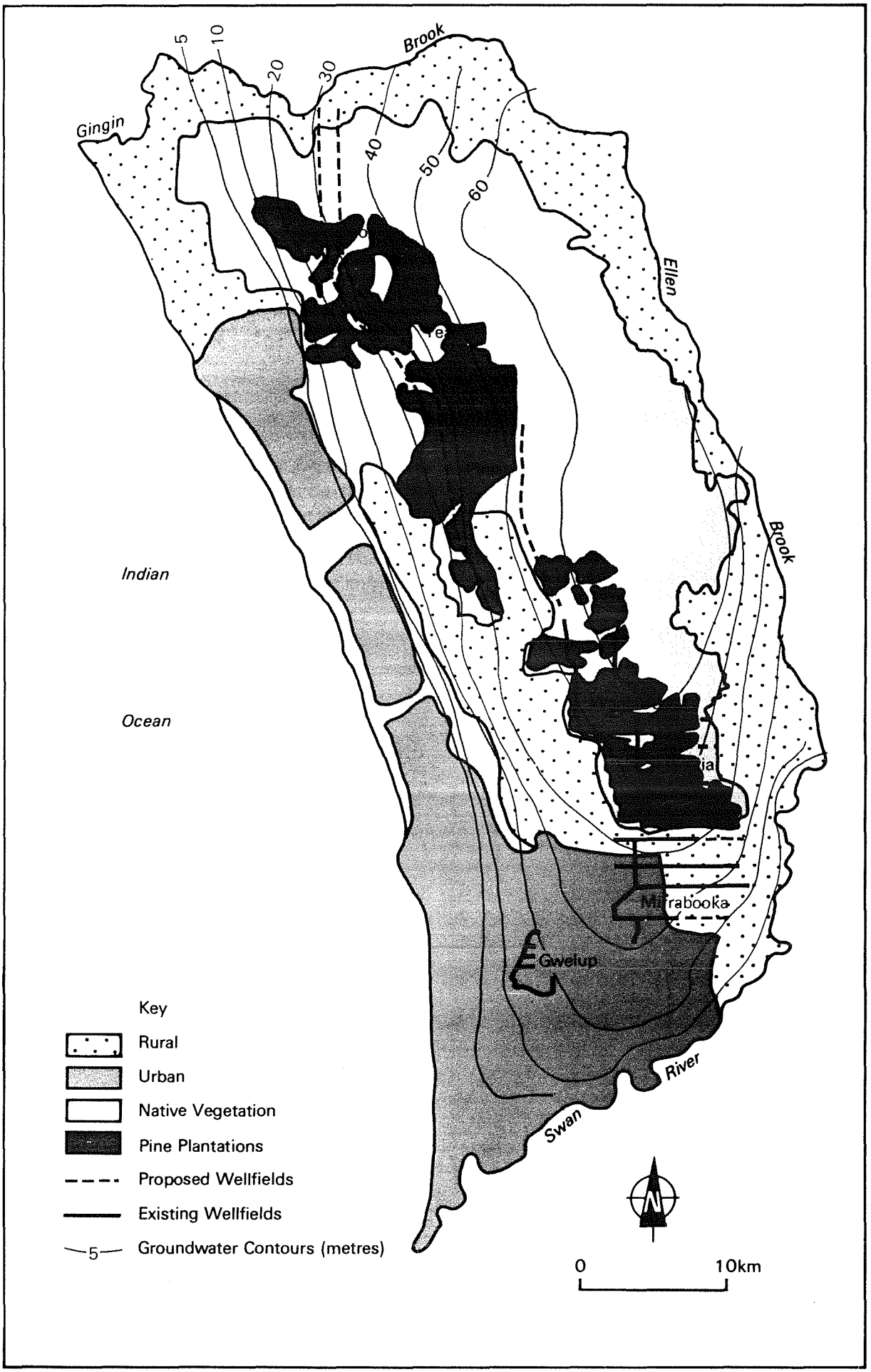

Figure 1. Gnangara Mound Water Resource and Selected Land Use Zones

LAND USE

2.7 There are four major land uses on the Mound (Figure 1). These are:

. urban development;
. rural activities;
. forestry; and
. the natural environment

2.8 Urban development has grown outwards from the original settlement of Perth and has been based on access to commercial centres, proximity to the Swan River and the coast, and areas of prominent topography. With the rapid growth in the post-war period, it was recognized that Perth should not grow without planning. The Corridor Plan and Metropolitan Region Scheme provide the basis for present day development. The first major review for some 15 years is in progress and will set the framework for development of the Perth region into the next century.

2.9 Rural land has generally been located on the fringes of urban development and in favourable areas in the hinterland. Market gardening was first developed on peaty soils near wetlands and later on favourable soil types on higher ground. Over the years market gardeners have moved outwards to the north and south as the urban area expanded. Pastoral activities have been developed depending on the availability and price of freehold land.

2.10 State Forest 65 is located on land that was considered to be useless for agriculture. Numerous problems have had to be overcome since planting of pines commenced in 1918 and it was not until the early 1940s, and particularly since the 1960s, that extensive plantations have been established.

2.11 Some of the largest remnants of native vegetation in the Perth Region are located on the Mound. In the past areas with outstanding natural attributes (eg Yanchep National Park) or areas unsuited for agriculture or pine-growing have been set aside for preservation. Recently, as part of the System Six Study, further areas have been recommended for reservation to preserve habitats and viable examples of coastal plain bushland (Figure 2).

GROUNDWATER USE

2.12 The groundwater resources of the Mound provided the main source of Perth's water for the first half of its history. This included supplies for market gardens which were developed around lakes and swamps. The moist margins of those areas were cultivated in a shifting pattern as groundwater levels rose and fell. More recently, growers have adopted new techniques including overhead sprinkler irrigation using groundwater pumped from wells. Many new market gardens are on higher ground where larger lots are available.

2.13 Most of the market gardens on the Mound are located within the City of Wanneroo and many of these lie within the Wanneroo Groundwater Area. In the Wanneroo Groundwater Area some 1 000 hectares is currently being used for vegetable growing and floriculture. Estimated water use for these and other rural activities in the area is some 24 million cubic metres per year. The rate and extent of growth of agriculture is uncertain but it seems likely that total demand will rise to about 36 million cubic metres per year over the next ten years. Water use may continue to increase in the following

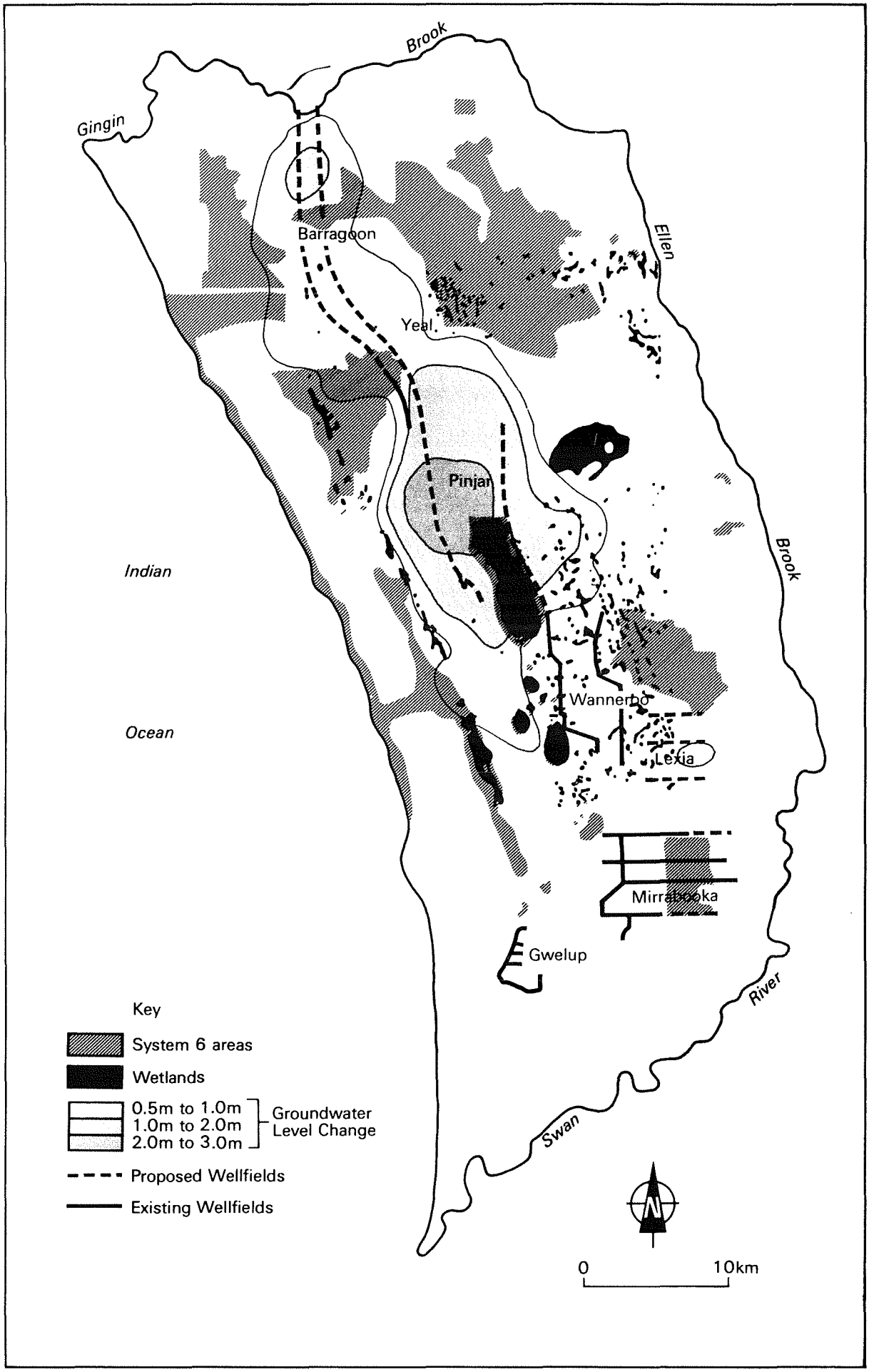

Figure 2. Long Term Groundwater Level Change for Preferred Public Water Supply, Private Use and Pine Management Strategies.

following decade but could stabilise at or about that level as a result of urban development pressures and improved water use efficiency.

2.14 Development of public water supply schemes on the Mound commenced in 1971 when the Mirrabooka Groundwater Scheme began production. This was followed by the Gwelup Scheme in 1974, and the Wanneroo Scheme in 1976. Production quotas from the unconfined aquifer are:

Mirrabooka	12.2	
Gwelup	5.5	
Wanneroo	12.2	
Total	29.9	million cubic metres per year.

The Mirrabooka and Wanneroo Schemes are the only sources of water supply for the North West Corridor.

2.15 Planned quotas for public abstraction of unconfined groundwater from schemes, which are proposed to be developed in stages over the next 25 years to match growth in demand as the North West Corridor expands, are:

Pinjar	14.0	
Lexia	6.5	
Yeal	9.6	
Barragoon Stage 1	3.5	
Total	33.6	million cubic metres per year.

In addition there will be increasing abstraction from artesian aquifers.

3. LAND USE AND GROUNDWATER

GENERAL RELATIONSHIPS

3.1 The groundwater resources of the Mound are derived from rainfall. The amount of rainfall that becomes groundwater is determined by factors such as the intensity of storms, the nature of the soil, the depth to the water table, the vegetation cover and other land use parameters.

3.2 The level of the water table fluctuates in response to seasonal, annual and longer term variations in rainfall. The main factor contributing to the general decline in water levels of the region over recent years has been the extended period of below average rainfall. Only two of the last twelve years have been above average.

3.3 Changes in land use such as clearing of native vegetation, water abstraction, drainage and urban development also affect the water table. When these changes occur equilibrium is eventually re-established with water levels at a new position. In some situations water levels rise while in others they decline. Thus the water resource and land use form a dynamic system, changes in one affecting the other.

3.4 Land use and water resource development have both regional and local implications. While changes have regional consequences, the greater the distance between land use or water supply developments and sensitive areas

such as wetlands, the less the impact is likely to be. What may be an unacceptable development in close proximity to a sensitive area may be satisfactory in a more remote location. Thus there is generally limited scope to increase water availability in one area by reducing demand in another. For example, reducing proposed public abstraction or water use by pines in State Forest 65 would tend to have local effects and would not greatly affect the availability of groundwater for private abstraction to the west.

3.5 By far the greatest consumption component of the water balance is evapotranspiration which accounts for almost 70% of rainfall. This consists of two principal components: a diffuse and widespread loss from plants in the relatively extensive upland areas (57%), and intensive direct evaporation from open water and transpiration from the fringing vegetation of the relatively small areas of wetlands (13%).

3.6 Retention of wetlands is the major constraint in managing the groundwater resources of the Mound. Without this constraint, much more water could be developed for both public and private supplies.

URBAN DEVELOPMENT

3.7 The removal of native vegetation and the construction of roads, roofs and paths causes a significant increase in the proportion of rainfall recharging the groundwater resource and results in a rise in water table levels (eg Lake Claremont). In some cases this has led to a need for a drainage scheme to be constructed to reduce local groundwater levels to prevent flooding of private property. Elsewhere, land previously subject to periodic wetting has become a permanent water body. Conversely, as urban areas become established, water table levels may decline as the number of wells for irrigating private gardens and public open space increases.

3.8 In the longer term, as development stabilises, a new equilibrium is established. With the compensating changes associated with urban development, the net effect on the water table will generally not be significant. However, there may be some local exceptions: for example, within the urban zone, recreation areas are often associated with wetlands and there may be competing demands for groundwater for public open space irrigation and for the wetlands. High densities of private well ownership adjacent to wetland areas may also contribute to lower water levels in urban lakes (eg Perry Lakes).

3.9 Some forms of urban development such as Special Residential developments on 2 000 square metre lots may result in high groundwater demands. The tendency to locate these prestige developments close to aesthetic attractions such as wetlands increases the likelihood of adverse effects.

RURAL ACTIVITIES

3.10 Horticultural developments utilize large quantities of groundwater and can significantly affect the water balance of an area because the irrigation requirements for each hectare cultivated exceed the local recharge by a factor of up to ten. The close proximity of many existing and proposed horticultural developments to the wetlands increases the likelihood of adverse environmental effects.

3.11 Vegetable production in the Perth Region, about half of which occurs on the Mound, is part of the supply chain from Carnarvon in the north to

Albany in the south, a distance of some 1250 kilometres with different climatic conditions. Its value to the central market of Perth and overseas export markets is well known to the industry.

3.12 The first spring crops from Perth come into the market after Carnarvon and Geraldton have finished their season. These spring crops include tomatoes, beans, pumpkin, capsicum and cucumbers; with other crops (lettuce, cauliflowers, carrots, cabbage and, celery) grown year-round. The metropolitan area produces the first of the new season's potato crop supplying a portion of the State's requirements for October and November. There is also high production of strawberries.

3.13 Western Australia is self-sufficient for most fresh produce and expansion of production to satisfy growth in local demand can be expected. Export production is becoming increasingly important and floriculture has expanded rapidly in recent years. While continued growth in these two areas is expected, predictions of the rate of growth vary considerably and the outcome is uncertain.

3.14 Other intensive rural activities such as turf farms and piggeries also have the potential to significantly affect the groundwater. Conversely, the clearing of native vegetation for pastoral activities causes water levels to rise.

3.15 Special Rural Zones generally consist of lots with a land area of one to two hectares. The current groundwater allocation of 1500 cubic metres per year for each lot is sufficient for the domestic needs of a rural lifestyle but is not sufficient for commercial development or irrigation of a significant portion of the land. Conflicts have arisen when unsuitable land has been released or where purchasers have water use expectations that cannot be supported by groundwater availability. Nevertheless, with careful selection of sites, appropriate Town Planning Scheme texts and effective management, Special Rural Zones can be preferable to some other rural land uses.

FORESTRY

3.16 State Forest 65 covers some 50 000 hectares, or nearly one quarter of the Mound. Pine plantations occupy some 23 000 hectares, or about half of State Forest 65, and the remainder is native vegetation. To establish pines the native vegetation is cleared and the land cultivated prior to planting. For the first ten years the recharge beneath the pines exceeds recharge under natural conditions.

3.17 Modern silvicultural practice involves thinning at ages 15, 20 and 30 years, when basal areas (the cross-sectional area of stems, measured 1.3 metres above the ground, per unit land area) are about 16 square metres per hectare, to basal areas of about 7 square metres per hectare. Under this management strategy, the average stand density over the 40 year cropping period is 11 square metres per hectare.

3.18 The net groundwater recharge of pines with a basal area of 11 square metres per hectare approximates the recharge occurring under native vegetation. Pines managed to higher densities can significantly affect the region's water resources. This occurs through reduction in recharge by interception of rainfall and transpiration of water from both the saturated and unsaturated zones of the soil profile. Pines managed to less than 11 square metres per hectare increase recharge.

3.19 About one third of the area of pines in State Forest 65 is located on sites that are now known to be poor for timber production. The pines on these sites can be thinned to low basal areas and maintained as open forest to increase recharge without significantly reducing the return from timber production.

NATURAL ENVIRONMENT

3.20 The ERMP describes eleven vegetation types, contributing to a diverse flora and fauna on the Mound. Several factors determine the vegetation complexes and these include the range of soil types, climatic conditions, depth to groundwater and the activities of Man. Deep-rooted species rely on the water table but shallow rooted species do not.

3.21 Upland flora obtain most of their water from the unsaturated soil zone and lowering of the water table has little or no effect on either the vegetation or net recharge. (Sudden tree deaths within a few tens of metres of a Water Authority well were recorded in 1977-78. This was a period of drought and tree deaths in areas remote from wells and in the pine plantations were also recorded at this time). Periodic controlled burning in managed areas of upland may result in increased recharge for a limited period due to reduction of interception loss.

3.22 Wetlands are areas of seasonally, intermittently or permanently waterlogged soil or inundated land. On the coastal plain they are generally surface expressions of the water table and their size and extent varies depending on the level of the water table. Wetlands are temporary geological features tending, in the long term, to fill with peat and sediment.

3.23 A network of wetlands with varying morphology and resources is required to serve the fauna throughout the year. Birds move from one wetland to another depending on availability of food and habitat. Three distinct morphological types of wetland occur within the Mound area. These are the linear lakes, circular lakes and swamps.

3.24 The linear lakes are steep-sided and relatively permanent. These lakes, which include Joondalup, Goollelal, Neerabup and Loch McNess are deeper and their free water areas are less susceptible to reductions in groundwater levels than other wetland types. The circular lakes such as Jandabup, Mariginiup and Gnangara are shallow with gentle slopes. Because of their shallowness and sloping floors these lakes are more susceptible to both rises and falls in the water table. Swamps occur where the water table lies close to the ground surface. In winter they are occasionally flooded. They support plants at the wet end of the vegetation continuum and are susceptible to water table changes.

3.25 While wetlands can be grouped, the groundwater regime of each wetland is affected by water depth, area, presence of lake sediments, and inflow and outflow mechanisms. Thus no two wetlands are exactly alike and they may react differently to changing groundwater conditions. As a consequence of the variation in salinity, and in extent and duration of water levels, the aquatic biota and the fringing vegetation may vary considerably between apparently similar wetlands.

3.26 The fringing vegetation around lakes and swamps is important as well as the free water surface. While small amounts of nutrients can sometimes be beneficial in increasing biological productivity fringing vegetation can

intercept nutrients that may cause pollution to wetlands. It also acts as a buffer preventing midges and mosquitoes from being blown from the free water surface into residential areas.

3.27 The System Six Report identified sixteen areas on the Mound for their high conservation and recreation value and recommended that they should be reserved as national parks and conservation areas. Many of these areas are large and/or include extensive wetlands (Figure 2). The Government has made a commitment to implement the recommendations of the System Six Report as opportunities arise and subject to financial constraints. Implementation of these recommendations would facilitate planning and management of the Mound land and water resources, and ensure preservation of areas with high conservation value.

WETLAND CHANGES

3.28 Study of the sediments in some lakes shows that in the last few thousand years wetlands have been both more and less extensive than at present. Descriptions of some of the lakes at time of first settlement indicate that they were less extensive than at present and this is confirmed by fencelines across some lakes. The flora and fauna associated with wetlands are adapted to seasonal flooding and drying. Elements of flora and fauna will vary from one wetland to another, particularly fauna which moves in response to seasons and availability of food and habitat.

3.29 The wetlands are probably more resilient to water level change than is generally accepted. However, changes in water quality, particularly nutrients, may have a more profound effect. There are a number of examples (Lake Joondalup and Lake Monger) where algal blooms, eutrophication, odours and botulism death of birds, can be attributed to changed water quality.

3.30 The Water Authority has data on water levels and water quality from some wetlands. It has also commissioned specific studies of the biota of wetlands to identify invertebrate fauna that can be used to monitor changes in wetland regimes. The object of this work is to obtain some scientific reference against which changes in wetlands can be measured. No generally accepted level or indice has yet been determined. Furthermore available data does not sway public opinion which is largely based on selective memory of wetlands as they were and the expectation that wetlands should always be full of water. The latter situation may in fact lead to degradation of some wetlands.

3.31 Recognising that the wetlands are a system requiring both geographical spread and diversity for sustained viability, more general guidelines for the wetlands as a whole are required. The Environmental Protection Authority has recently published draft guidelines for wetland conservation in the Perth metropolitan area.

3.32 Because of the complexity of wetlands and the factors affecting them, defining acceptable change remains somewhat arbitrary and non-scientific. Water level and quality criteria need to be developed. As they are not yet available, a 0.5 metre change in water level has been adopted by the Water Authority as an interim criterion for the most environmentally sensitive areas. This raises two issues:

. the level from which the decline is to be measured; and

. the variable impact of a 0.5 metre decline on different wetlands.

3.33 The ultimate resolution of these issues may be the determination for individual wetlands of a minimum water level that is tolerable. In established urban and rural areas and in undeveloped areas, recent historic low water levels may be the most appropriate datum. In areas undergoing development, criteria may have to be established after a period of investigation and monitoring. In the meantime, determination of what is acceptable remains an ill-defined and subjective matter with 0.5 metre decline from "current" levels as the framework for assessment.

3.34 There is mounting, but not universally accepted evidence, that the burning of fossil fuels and the release of carbon dioxide into the atmosphere will produce a warming of the Earth's climate in the decades ahead. The effects predicted for south-western Australia are for an increase in temperature, lower rainfall (particularly in the winter) and increased storm frequency.

3.35 If these predictions are correct then the water balance will be changed due to reduced groundwater recharge. This may result in contraction of wetlands both in areas unaffected by pumping and in urban and rural areas where there will be increased groundwater usage to maintain horticulture and urban life-styles. Decreased rainfall and higher temperatures may place additional stresses on the region's water resources. To enable Perth's public water supply requirements to be met, demand may have to be reduced or additional sources developed.

PUBLIC WATER SUPPLIES

3.36 Public water supply developments reduce groundwater levels around areas of abstraction with a decrease in evapotranspiration and groundwater outflow, and a consequent increase in recharge. Some existing and all proposed groundwater schemes are located primarily within areas of land under Government control. The location of many wellfields within State Forest 65 provides an opportunity to develop joint management strategies for the public water supply schemes and pine plantations. Any land use change for State Forest 65 and adjoining areas must be carefully considered to ensure that neither the quality nor the quantity of the groundwater resource is diminished.

MINING

3.37 The sediments of the coastal plain contain deposits of silica sand, limestone, clay, peat, diatomite, phosphate and heavy mineral sands. Extractive industries already quarry sand, limestone, clay and peat. These activities are usually located in relatively small areas and no direct impact of them on the groundwater is known. However, some of the disused quarries are convenient sites for landfill and if these are not regulated some undesirable point-source contamination of groundwater may occur.

3.38 Peat and diatomite deposits are located in wetlands. For example, large diatomite deposits are known in Lake Gnangara. Depending on the circumstances mining of these may be beneficial by deepening a wetland and providing permanent open water or they may be ecologically undesirable. Legislation requiring environmental review and management programmes should provide the necessary protection.

WATER QUALITY

3.39 Under changed land use conditions, chemicals can be added to the groundwater from point sources such as landfill and industrial disposal sites, and from non-point sources such as septic tanks, road run-off, and agricultural chemicals and fertilisers. The low rates and infrequency of fertiliser applied to pine plantations present no potential groundwater quality problems. However, the drift of aerially-spread fertiliser may cause elevated nutrient levels within adjacent wetlands.

3.40 Changes to water quality are particularly important considerations on the coastal plain where the water table is generally shallow and where the sands have a low ability to adsorb or exchange contaminants. The main defence of the groundwater system is its ability to disperse and dilute contaminants. While the size of the resource means that any massive degradation is unlikely, groundwater contamination which does occur may be very expensive or impossible to remove. The contamination may take many years to flush out of the system and, in the meantime, the use of the resource may be severely restricted.

3.41 There are various examples of groundwater contamination or degradation on the Mound. Increased nitrate levels from septic tanks and garden fertilising are the most pervasive of these and have the greatest implications for wetlands. The possible effect of some long-lived insecticides and herbicides may also be important.

3.42 Some chemicals, such as phenols, heavy metals and organic compounds, even in minute concentrations, may introduce unacceptable odour or taste or be detrimental to public health. Consequently the location of public water supplies in areas not subject to urban, industrial or intensive rural use is desirable if the long-term quality of water supplies is to be preserved. Where the groundwater is being used for urban or agricultural irrigation, the same degree of constraint does not apply.

3.43 Existing waste and effluent disposal sites on the Mound are generally small, are monitored where required and do not pose a major threat to public water supplies or regional wetlands. Imminent development of a new major facility located near the coast at Mindarie will meet the waste disposal needs of the region for at least the next 50 years and limit any contamination to an acceptable area.

4 PLANNING AND MANAGEMENT

4.1 Increasing demands for groundwater, environmental conservation, and urban and other land development are making water resource management progressively more complex. It has become clear that decisions and activities in such matters as urban planning, forestry, main roads, horticultural development, industrial, commercial or extractive land use and wetlands conservation can have significant impacts on, or be materially influenced by, water resource management. However, these linkages have not yet been adequately reflected in institutional arrangements for planning and management of the land and water resources of the Mound.

WATER AUTHORITY

4.2 The Water Authority of Western Australia has a two-fold responsibility in planning and management of water resources:

. as the public water utility, it is charged with providing adequate volumes of high quality water to consumers at the lowest cost; and

. as the manager of the overall resource, it must ensure that development is compatible with protection of the productivity and quality of the resource, that allocation between users is in the best interests of the State and that environmental impacts are minimised.

4.3 The Water Authority has a commitment to long term forward planning at several levels including a State Water Plan, Corporate Development Plan and Sources Development Plan as well as plans such as the Gnangara Mound Groundwater Resources ERMP.

4.4 Groundwater Areas are established where management of the resource is required. Committees with local representation have been established to advise the Authority on water allocation and management within these areas (eg Wanneroo Groundwater Advisory Committee).

WATER RESOURCES COUNCIL

4.5 The Western Australian Water Resources Council provides advice to the Minister for Water Resources on general questions relating to water resources. Its objectives include:

. to co-ordinate water resource matters which influence other planning initiatives, particularly those relating to land use; and

. to prepare long-term strategies for co-ordinating the allocation and utilisation of water resources most effectively for all uses that have a benefit for the community, including public and private water supplies, conservation of the environment and recreation.

4.6 The Council has a number of Committees including:

. Planning and Management;
. Groundwater Management; and
. Conservation and Education.

The Council and its Committees have wide representation to ensure informed advice on diverse and complex water resource and land use issues. It has vigorously pursued its purpose and has undertaken a number of important initiatives. These include commissioning a study of groundwater management strategies and a study of water allocation and water use strategy options for the Perth to Bunbury Region. The latter includes a sub-project on horticultural demand for water and land.

STATE PLANNING COMMISSION

4.7 Land use is controlled by the State Planning Commission primarily through the Metropolitan Region Scheme and local Town Planning Schemes. Provision is made for input from other bodies, including the Water Authority, in the planning process. The Commission, through its influence on land use, has the potential for major impacts on the groundwater resources of the Mound.

4.8 The Commission is currently undertaking a major review of the Corridor Plan and Metropolitan Region Scheme which have guided development since 1971. A document describing the main options for metropolitan development is expected to be released for public comment by mid-1987. A range of scenarios is being considered to accommodate an expected population of around 1.6 million by the year 2021. It seems likely that more concentrated forms of development will be favoured with thickening of the existing corridors and some urban infill at the base of the rural wedges. Despite efforts to reverse the decline in population in the inner metropolitan areas the best that can be hoped from planning initiatives is that population of inner areas can be maintained at existing levels.

4.9 Key issues considered in developing alternative scenarios have included the need to provide affordable housing for all sections of the community, protection of water resources, preservation of vegetation and heritage values, provision of adequate regional open space, waste disposal, forestry and agricultural activities, energy conservation, the role of rural wedges and the possibility of significant climatic change.

4.10 The main implications of these issues for land use on the Mound are:

- there will be continuing rapid growth of population in urban areas on the southern and western flanks of the Mound;

- the Mirrabooka wellfield area may become urbanised, like that of Gwelup;

- the wetlands, natural bushland and pine plantations will become even more important as recreational areas for urban residents;

- agriculture will become a "dominated" use, giving way to urban development as markets for land evolve at the metropolitan fringes. In the long term, some water may become free for re-allocation as market gardens leave fringing areas and are replaced by urbanisation;

- no major industrial development appears to be likely on the Mound, but some mining claims are expected to be developed;

- the status of State Forest 65 as a strategic regional feature, is not expected to change;

- large remnants of native vegetation on Crown Land may be consolidated into a continuous system of regional parks and vegetation complexes; and

- protection of wetlands, especially ephemeral swamps, will become increasingly difficult but regulation, land planning and management of development can assist.

4.11 In the current review the Mound had been assigned a low level of land use constraint against urban development and this had been applied to only the area above the 30 metre groundwater contour. This contrasted with the highest level constraint against urban development designated for surface catchment areas. Overseas experience has shown that, despite introduction of controls, urbanisation over groundwater catchment areas would inevitably threaten the resource as, over a period of time, nutrients, and toxic discharges enter the unconfined aquifer. A higher level and more appropriately defined land use constraint has now been assigned to the Mound water resources.

4.12 The emphasis of the review has been on urban development. In future, there will be a need for more regular review of regional plans from a wider perspective, particularly in view of the expected pace of development and the complex relationships between land uses and the major groundwater resources of the coastal plain.

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

4.13 Over much of the Mound, the principal land planning and management agency is the Department of Conservation and Land Management (CALM). This Department operates State Forest 65 within the guidelines set out in the General Working Plan of 1982 and a Timber Strategy which is currently in preparation.

4.14 CALM has three main areas of responsibility on the Mound:

. planning and management of State Forest 65;

. management of wildlife; and

. management of conservation reserves.

4.15 The State's timber supply strategy relies heavily on pine production over the next 25 years. However, though the existing stock of maturing trees contains valuable logs, the Pinus pinaster plantations of State Forest 65 are stated not to be strategically critical to long term timber production plans.

4.16 Pinaster pines were first planted at Gnangara in 1918 to provide import substitution and to find a profitable use for the Bassendean Sands system. Research addressed and overcame problems of nutrient supply, genetic selection and land preparation. Plantings rose from around 500 hectares per year in the 1945-60 period to about 1 000 hectares per year in the 1960s. Pines now cover about 50% of State Forest 65. Clearing of native vegetation and planting of new areas of pines has almost ceased.

4.17 Successful pine growth in State Forest 65 depends on soil-water-plant relationships. A substantial proportion of earlier plantings produced poor trees due to inadequate site selection and poorly controlled seed stock. Land within the Bassendean system that would be suitable for pine planting was later identified by site-vegetation mapping which essentially differentiated zones of different soil moisture conditions. The early trial and error plantings can be seen today as areas of poor-quality trees, particularly in upland areas and areas prone to water logging. Until the 1970s there was no concept of large scale groundwater abstraction, and no account was taken of this possibility in planning.

4.18 As a result of this history of State Forest 65, a 40-year pine cropping cycle with sustained yield has yet to be achieved. A viable sawn timber industry requires at least 55 000 cubic metres per year of logs covering the full range of saw log sizes. At present only 34 000 cubic metres per year of small to medium sized saw logs are available. The higher level of production will be attained within five to ten years. Because considerable areas of pine have only recently been planted, the first cropping cycle will continue for another 40 years.

4.19 Following changes in policy and priorities, and also in silvicultural practices, State Forest 65 is now managed with conservation and water

production as principal objectives. The strategy for timber production can generally fit in with this, but some silvicultural requirements still have to be met: for example, all plantations need the competition of densely planted trees in the first 15 years in order to produce straight stems. Heavily thinned, closely managed pines seem to be the best form of catchment management for the area. Broadscale heavy thinning or even clear felling the pines over a few years is plainly uneconomic and not needed. It would be expensive not to do this and some viable alternative land use would have to be found.

4.20 At present the main obstacle to economic operation of State Forest 65 for the primary purpose of water production is the lack of a local market for some types of pine thinnings. While the cost of non-commercial thinning may only be in the order of $150 000 per year for several years this expenditure would be offset by receipts if a market could be established. If this is not possible in the near future it will be necessary to plan and implement a programme of non-commercial thinning where benefits to sensitive environmental areas would result. One example of this is the plantation immediately east of Lake Jandabup where stand densities are high and the Water Authority has virtually ceased pumping from three production wells to ease pressure on the adjacent wetlands.

4.21 It appears that the next decade will be a period of much greater harvesting activity. Also, many younger stands will be thinned, hopefully with some commercial return. This increase in forestry activity will coincide reasonably well with increasing abstractions of groundwater by the Water Authority and market gardeners. The evolving management of State Forest 65 will then seek to yield a level of recharge at least as high as that of native vegetation.

4.22 CALM planning and management recognises other multiple-use benefits of State Forest 65, including recreation (eg walking, trail bikes, horse riding, gun clubs), and isolated sites for various public utility installations. This approach is endorsed by the City of Wanneroo. Conflicts between forest management and recreational use via fire risks can be overcome. State Forest 65 also contains large areas of native vegetation where prescribed burning and other management activity occurs as part of forestry operations.

4.23 Approval of the ERMP would clear the way for CALM planning to proceed. It is currently developing an economic model which, for given assumptions about tree growth, management regime, recharge, recreational use, market parameters and forestry costs, will optimise social return. Finalisation of an economic model should be given a high priority, as it will determine the possibilities for strategic change within future plantation management. There is a need to produce detailed land use management plans for State Forest 65 as a matter of priority.

4.24 In view of the strategic importance of the large remnants of natural vegetation on the Mound, and the possible impacts of water resource development on wetlands, there is a need to produce detailed management plans for conservation reserves and adjoining areas outside State Forest 65. It is understood that the management plan for the northern forest recommends that Management Priority Areas within State Forest 65 should be changed to A Class Reserves. Other major areas of native vegetation in State Forest 65 could form extensions to these areas and possibly compensate for environmental impact which may occur elsewhere. A Class status may reduce the freedom of the Water Authority to undertake some activities in these areas.

ENVIRONMENTAL PROTECTION AUTHORITY

4.25 The Environmental Protection Authority (EPA) is responsible for assessing all developments that have environmental implications. The Gnangara Mound ERMP has been submitted as a part of this process. In the past, not all developments with an environmental impact have been referred to, or considered by, the Authority. Broad scale planning policy and continued clearing of native vegetation in State Forest 65 are just two significant examples. Under new environmental legislation all proposals with a significant impact on the environment are required to be referred to the EPA. This legislation also brings control of all pollution of land or water, including groundwater, under the Environmental Protection Authority. In view of its requirement for water protection, the EPA has delegated its pollution control licencing provisions to the Water Authority.

4.26 In 1977, as part of its environmental protection role, the Department of Conservation and Environment (now EPA) published guidelines for protection and management of wetlands, based on general principles. The objective was to inform planners, local authorities and land owners about desirable approaches to land use if surviving wetlands were to be conserved. In December 1986 the EPA produced draft guidelines specifically for wetlands in the Perth region. Key objectives are to assist in identifying the attributes and ecological functions of particular wetlands and to provide directions as to management priorities. However, there is currently no ongoing, formal framework within which the EPA can offer advice about emerging issues of wetlands planning and management.

LOCAL GOVERNMENT AUTHORITIES

4.27 Local government authorities, through their town planning schemes and other activities, have the capacity for considerable direct and indirect impact on groundwater resources. Much of the area of the Mound in which horticultural and public supply schemes are located falls within a single local authority: the City of Wanneroo (ERMP Figure 10). The City, through its Town Planning Scheme, is working towards the development of a rural land use policy. Other influences on land planning include local authority by-laws and other powers under the Local Government Act. Water Authority restrictions on groundwater use, and policies on main drainage and sewerage, also influence land use decisions by the City of Wanneroo.

DEPARTMENT OF AGRICULTURE

4.28 Agricultural production is a highly fragmented activity and there is not the same level of integrated planning and management as for other land use activities on the Mound. While the Department of Agriculture does play a part, its role has been primarily one of undertaking technical research and providing advice to individual farmers. However, in recent years the Department, through its Marketing and Economics Branch, has paid increasing attention to the questions of future demand, value, and transfer of irrigation water for horticulture.

MINES DEPARTMENT

4.29 The Mines Department is involved in exploration of the resources of the region including groundwater resources. It also has an administrative and regulatory role in relation to commercial mining proposals and operations.

INTEGRATION

4.30 As outlined, planning and managing the land and water resources of the Mound involves various Government agencies with State-wide responsibilities, and other local agencies. The timing of major policy reviews, detail of policy assessment, and technical approaches differ between agencies. For example, water resource development has been assessed largely on the basis of cost effectiveness within the framework of the Water Authority Sources Development Plan. Conservation planning has proceeded mainly through a growing inventory of characteristics of areas with conservation significance, as in the System Six Study. Urban planning has tended to follow the principle of fitting projected needs into the landscape by sieve mapping within the general framework of the Corridor Plan.

4.31 To date, metropolitan planning has tended to accommodate the requirements of water resources planning and wetlands conservation by rough and ready inclusion of the implied constraints without detailed evaluation of the trade-offs involved nor with a specific objective of protecting potable water resource. As the urban area expands into the Mound area, such evaluation will be harder to avoid in future, regardless of whether the trade-offs are to be considered in physical, biological, economic or social terms.

4.32 Consideration must be given to appropriate organisational arrangements to achieve integration of planning and management within the Mound area. These will be needed on a long term basis. At least the following agencies should be involved:

. City of Wanneroo;
. Department of Agriculture;
. Department of Conservation and Land Management;
. Environmental Protection Authority;
. Mines Department
. State Planning Commission; and
. Water Authority.

Representation of other selected local authorities may also be desirable in future.

4.33 An initial integrating mechanism, with little or no additional direct expenditure implications, would be to establish a Gnangara Mound Planning and Management Committee of senior representatives from each of these organisations under the auspices of the Western Australian Water Resources Council and drawing on the various agencies for resources as required. The role of the Committee would be to provide a framework within which each organisation can develop and implement policies, plans and programmes for its area of responsibility, and to facilitate more effective working relationships.

4.34 Responsibilities of the Committee could be:

(i) develop and co-ordinate integrated planning and management by the various agencies involved;

(ii) monitor and report on the implementation of both individual agency and overall plans;

(iii) advise on research and investigation priorities; and

(iv) promote community participation in planning and management.

4.35 The proposed Committee could operate under the auspices of several existing organisations, including the State Planning Commission and the Environmental Protection Authority, and there is no clearly preferable option. The Water Resources Council is proposed, initially at least, because of its effective and vigorous efforts to identify and resolve inter-related water resource and land use issues.

5. WATER ALLOCATION

EXISTING MECHANISM

5.1 In allocating water, three separate purposes (economic efficiency, social equity, and environmental protection) are often confused but need to be distinguished. Social equity considerations dominate the existing allocation mechanism, which is administrated by the Water Authority within the legislative framework of the Rights in Water and Irrigation Act and the Metropolitan Water Supply Sewerage and Drainage Act.

5.2 Perhaps the most important aspect of groundwater law in Western Australia is that rights to water are vested in the State. Water rights do not form part of any title to land. However, until recently, the State has seldom practised its water allocation policies in a manner that would emphasise this legal situation. Thus, for example, expansion of horticulture on the Mound was initially based on what amounted to common property access to groundwater.

5.3 Exploratory drilling in the 1960s and the declaration of the Gnangara Water Reserve in the early 1970s signalled the State's long term interest in the resource. The water reserve covers the whole of State Forest 65 and large areas of Crown and Commonwealth Land to the north and east. It forms a statutory basis for long term co-ordination of developments so as to protect the water resource.

5.4 The Swan and Gingin Groundwater Areas on the south eastern and north eastern margins of the Gnangara Water Reserve have been established to deal with allocation between private users. There is no significant public abstraction within these areas.

5.5 Development of the Mirrabooka, Gwelup and Wanneroo Groundwater Schemes during the 1970s involved proclamation of Public Water Supply, Underground Water Pollution Control and/or Groundwater Areas. These give the Water Authority powers to:

- abstract groundwater found in the area;
- licence private use;
- place conditions on licences and issue instructions to licencees;
- suspend, amend or revoke licences;
- install meters on private wells;
- control polluting activities through by-laws; and
- prosecute offenders.

5.6 Gwelup and Mirrabooka Schemes have not led to major conflict and there has been no need to invoke most of these powers. Proclamation of the Wanneroo Groundwater Area in 1982, and its extension in 1986, has led to concern on the part of the rural community that its access to groundwater would be restricted. In fact, overall, restriction has not occured. Indeed a 50% expansion of the total allocation for private use is proposed.

5.7 Environmental factors have been included as part of the determination of quotas. Within the Wanneroo Groundwater Area, the principal quota has been subdivided and these specific quotas have taken account of proximity to wetlands and the relationship of the groundwater flow and wetland. In one part of the Wanneroo Groundwater Area (the eastern margin of Lake Jandabup) the full quota has now been allocated so some people are unable to obtain groundwater, other than for domestic purposes, or to increase their use. In some other parts of the Area, allocations are approaching the quota.

5.8 The Wanneroo Groundwater Advisory Committee provides advice to the Water Authority on water allocations to private users in the Wanneroo Groundwater Area. The Wanneroo Committee includes local community representation. Decisions of the Water Authority based on the advice of the Committee are subject to appeal to the Minister for Water Resources: this has occurred on three occasions. In time, other advisory committees may need to be set up within the Mound area.

ECONOMIC AND ENVIRONMENTAL CONSIDERATIONS

5.9 For economic efficiency, water should be allocated according to its value to users. According to this principle, the uses with the least economic value would be the first to be reduced in conditions of local or regional water scarcity. Also, water abstraction would never take place unless somebody was prepared to pay the costs. Willingness of each user to pay the cost of supply would be the criterion for water allocation.

5.10 Where the level of water abstraction resulting from free market forces exceeds some safe environmental level, possible courses of action include:

. setting a quota limiting abstraction to the safe level; and

. imposing a resource rental tax which yields a level of water use which is consistent with environmental protection.

5.11 Currently, allocation of Gnangara Mound water is based on quotas. While this provides an effective mechanism for controlling the spatial distribution of abstraction, it assumes that the overall allocation between major user groups is "correct". Within the private sector, concerns include defining the criteria of allocation both overall and to individual applicants, reallocation where area quotas are fully allocated, and insecurity regarding future water availability.

5.12 Mechanisms for water transfer between private rural users pose problems in groundwater management. Uncontrolled transfers may lead to spatially concentrated withdrawals with effects on other users, quotas may still be needed in drought periods, and hoarding of water "rights" may occur in conjunction with land speculation. On balance, at this time, there appears to be limited potential benefits from a transferable water right system between private rural users on the Mound.

5.13 The ERMP assumes that abstraction will continue to be determined by quotas. Within this system there is little economic justification for additional imposition of environmental charges on private water users located on the Mound since the charges would redistribute income rather than changing pumping rates or environmental effects. While environmental monitoring and forestry operations should be taken into account in public water supply costing and pricing, the argument for environmental charges on private users turns solely on equity issues as long as the quota system applies.

5.14 As the total resource of the Mound is developed and allocated, further careful thought needs to be given to water pricing and allocation mechanisms.

6. ADEQUACY OF ERMP REPORT

STRENGTHS

6.1 The Gnangara Mound Groundwater Resources ERMP prepared by the Water Authority is a most comprehensive and effective document. For the first time it provides baseline data and a starting point for expanding or establishing management principles for a natural region comprising an important part of the Swan Coastal Plain.

6.2 The ERMP is a significant compilation of existing information as well as containing results of some new work. Nevertheless, there are some large deficiencies in information mainly concerning ecosystems and their importance and inter-relationships.

6.3 The ERMP does not seek to maximise groundwater abstraction for public water supply but to allocate the groundwater between all users consistent with constraints imposed by the size of the resource and the environment. It is a balanced, practical effort to plan and manage within known deficiences in knowledge, and should be judged accepting these limitations.

6.4 The model used to predict the likely impacts is very sophisticated and is the best available tool for assessing regional groundwater level changes under varying climatic, land use and groundwater demand situations. Model development and data uptake took about ten person years. The model outputs should be regarded as a reliable guide to likely effects except that in most cases they represent "worst case" situations. In judging the environmental acceptability of predicted water level declines, the estimated model error of up to 0.5 metre should not be added to the model predictions. This would be excessively conservative and may result in distorted decision making.

6.5 The management philosophy and four-stage management strategy described in the ERMP embody the Water Authority's experience in groundwater management. The approach proposed is based on the premise that management should be introduced to avoid problems, rather than to manage problems once they have arisen. It is conservative and if followed should ensure safeguards for water users and the environment.

6.6 The management programme proposes to continue monitoring groundwater levels in some 900 existing observation wells and also continuing or initiating monitoring at a number of selected wetlands. On-going water level monitoring is considered to be essential.

6.7 The brief annual reports, complemented by more comprehensive triennial reports, on the operation and impact of the existing groundwater schemes are considered an appropriate way of accounting to the Environmental Protection Authority and of disseminating information. The frequency of the reports will enable any changes to operations, monitoring or management as required. In addition there is a need for broad overviews of the Mound to be made about once every five years, and when new groundwater schemes are planned or other major land use changes are proposed.

SHORTCOMINGS

6.8 While the Water Authority has funded considerable research, and other work has been done by CALM, the Environmental Protection Authority and others, knowledge of the biological environment is deficient. There has been inadequate mapping of flora; identification and listing of vertebrate and invertebrate species is incomplete; and relationships between and within ecosystems are inadequately understood. A comprehensive long term programme of biological study should be developed and priorities set so that research is co-ordinated and directed to the most important issues first.

6.9 This work, which will require the effort of both botanists and specialist biologists, should have an initial focus on the area affected by the Pinjar Scheme. The work could be supported in part by the Water Authority, co-ordinated by CALM and carried out using private consultants or by supporting appropriate university research. It will require a research programme of at least five years.

6.10 Lowering of the water table and its consequent effect on water levels in the wetlands has an effect on water quality within the wetlands. There is little information in the ERMP concerning this aspect, yet its implications for wetland fauna may be substantial. Specific water quality data for monitoring vegetation and fauna should be discussed with experts. The main need appears to be for a wider geographical spread of sampling rather than a more extensive range of chemical analyses.

6.11 Consideration needs to be given to overall funding arrangements for Gnangara Mound environmental research and management. While it is reasonable for the Water Authority to bear some of the cost, particularly for work directly related to water supply and water resource management, it should not be required to fund all investigation work, much of which arises out of the land and water use activities of others.

6.12 Discussion of the groundwater model is too brief. Reports in preparation should largely alleviate this problem.

6.13 Adequate management of the groundwater resources is dependent on modelling capability but the ERMP contains no commitment to maintain and improve modelling. A commitment is required from the Water Authority that the model will be maintained and appropriate personnel will be available for its operation and refinement. As part of the detailed planning of each future scheme, a model should be developed to allow the local effects to be better defined, monitored and managed. This information will complement the regional perspective obtained from the Gnangara Mound model.

6.14 The relationship between the unconfined groundwater of the Mound and the confined aquifers needs more assessment to confirm the extent to which lowering of the water table will reduce recharge to the confined aquifers and pumping from the confined aquifers will affect the water table. Because

the intake areas of the confined aquifers occur mainly beneath the upper part of the Mound, where only small lowering of the water table is predicted, there is unlikely to be any significant reduction in recharge. Also, because the confined aquifers are thick and composed of interbedded sandstone and siltstone, drawdown effects will be largely taken up by leakage and slight compression of the aquifer. Any effects on water table levels of pumping from the confined aquifers will be propagated over most of the intake area and will be very small and probably not detectable. These expectations need to be confirmed by further study.

6.15 ERMP Figure 22, which shows the basal area of pines in State Forest 65, is out of date and has been superceded by information gathered by CALM since the report was prepared. However, the ERMP information was not used directly as input to the predictive model and thus its results are not affected. Basal areas of pine plantations need to be regularly and systematically monitored by CALM.

6.16 Information about the location of the various rural activities, and statistics about crops and their water use are a deficiency in the report. There is scope for the Department of Agriculture to have a stronger role in this area. A report being, prepared by consultants for the Water Resources Council may help clarify and focus on factors affecting rural activities.

6.17 The report does not provide an overall map or statistical summary of land use on the Mound. The Metropolitan Region Scheme map is too broad-scale to identify all land uses, particularly horticulture, and covers only part of the area. The City of Wanneroo carries out a detailed annual survey which would provide much of the data required.

6.18 Numerous reports and papers on aspects of monitoring and management will be generated. A computerised data base of these and of previous work needs to be established. Whenever possible, this information should be available to the public.

6.19 Undertaking all the work required to overcome present information deficiencies, will take years. In the meantime the practical reality is the need to meet demand for water supplies with minimum environmental impact.

7. FUTURE DEVELOPMENT OF THE MOUND

GENERAL

7.1 Assuming that population increases as predicted, urban expansion occurs along the North West Corridor and all the proposed groundwater schemes are developed, then the groundwater resources of the Mound will be largely committed within 25 years.

7.2 A likely and most desirable scenario is that most of the Mound will continue to be protected by State Forest 65 and adjoining native vegetation. This will depend on planning decisions affecting State Forest 65 and large areas of Crown land on the eastern side of the Mound which together comprise the Gnangara Water Reserve.

7.3 Every water development project has environmental impacts and a balance must be found between:

- maintaining ecological processes, preserving genetic diversity and ensuring sustainable utilisation of species; and

- the need to provide for the essential economic and social needs of individuals and society.

Forcing the development of surface water resources or more remote groundwater resources merely transfers the environmental impact to possibly more sensitive areas.

7.4 Many of the possible problems and conflicts which may be associated with development of the Mound will not occur for many years and will arise progressively. Accordingly, it is important not to make decisions or take actions earlier than is necessary for operations to proceed. To do so would forego the benefits of reduced uncertainty, and increased knowledge that will be available as the result of further research and investigation.

7.5 Furthermore, some decisions and actions associated with groundwater development and management are reversible. This is particularly true of private and public abstraction. Where unforeseen consequences arise or impacts are greater than predicted, there is scope, at a cost, to take remedial action with the expectation that wetlands will recover. An example of this is the decision to virtually cease pumping from three Water Authority wells on the eastern margin of Lake Jandabup.

7.6 Significant climatic change has been predicted over the decades ahead and if this occurs it may have important implications for land and groundwater use on the Mound. No specific action in anticipation of this possibility is considered appropriate at this time.

7.7 The model predictions are for a situation occurring more than 30 years from now. Lowering of the water table is likely to be less than predicted. Furthermore, the only scheme proposed to be constructed in the next ten years is the Pinjar Scheme. By the time it is operating, more complete information will be available about the performance of the aquifer and about the ecosystems. This will permit refinement and modification of development proposals and management strategies.

EFFECTS

7.8 The groundwater schemes, private abstraction, forestry, and bushland cover described in the ERMP are expected to result in a regional decline of the water table of 0.5-2.5 metres parallel to the wellfields (Figure 2). The greatest water level decline is expected to occur in an upland area to the north west of Lake Pinjar where there will be little or no impact on vegetation. This effect may be less than indicated if horticultural activities become more dispersed than the ERMP assumed.

7.9 Lake Pinjar is an extensive plain of originally swampy land that has been dry for many years; some wetland areas remain, particularly on the eastern margin. The model results indicate that with the exception of the Pinjar plain most wetlands which may be affected by lowering the level of the water table are within State Forest 65 and have already been considerably affected by clearing for and growth of pine plantations.

7.10 The conceptual wellfield layout proposed in the ERMP seeks to minimise effects on environmentally sensitive areas. Consequently, wetlands within areas recommended for reservation in the System Six Study will generally be

subject to minor water level changes. To some extent any impacts of development may be offset by an area of wetlands in the vicinity of the Wanneroo Scheme where the water table is expected to rise by up to 1.5 metres as a result of thinning the pine plantations (ERMP Figure 50).

7.11 While a range of alternatives has been investigated, more detailed consideration of the Yeal, Barragoon and Lexia Schemes, when they are due for development, may reveal variations that either increase sustainable yield or reduce environmental effects. For example, it may be desirable to modify the lines of wells in the proposed Yeal and Barragoon Schemes to avoid the Ridges and Wabling Management Priority Areas. This could include extending the Barragoon Scheme parallel to Gingin Brook. Some re-alignment of the proposed wells in the Lexia Scheme to intercept throughflow over a wider front may also be desirable.

FINDINGS

7.12 If public water supply development on the Mound proceeds along the lines proposed in the ERMP, and land use and water resource planning and management are integrated, then:

. good quality, low cost water supplies to meet growing urban demands will be assured;

. wetlands, National Parks and nature reserves will be afforded protection;

. State Forest 65 will become a viable source of softwood with the added advantage of providing some public amenities;

. rural water supplies will be secure subject to licencing; and

. groundwater supplies will continue to be available in urban areas.

8. THE PROPOSED PINJAR SCHEME

NEED

8.1 To satisfy demand for water in the rapidly expanding North West Corridor, the Water Authority must commission a new source by 1989. Current demand management initiatives are unlikely to reduce demand for water sufficiently to defer the need for additional supplies.

8.2 The Pinjar Scheme, the next stage of development of the groundwater resources north of Perth, is the Water Authority's least cost alternative for satisfying the projected demand arising from continuing population growth and urban development. Deletion of Pinjar from the sources development plan would cost $13 million at 1985 prices. Alternatives such as constraining growth in the North West Corridor, using treated effluent, pumping groundwater to surface storages in winter and developing other water sources are not considered to be sound on economic, practical and/or environmental grounds.

8.3 In arriving at a preferred option which reflects a balance between cost to the community and impact on the environment, the Water Authority has evaluated a range of variations to the Pinjar Scheme. The proposed scheme comprises a line of wells on each side and extending north of the Pinjar

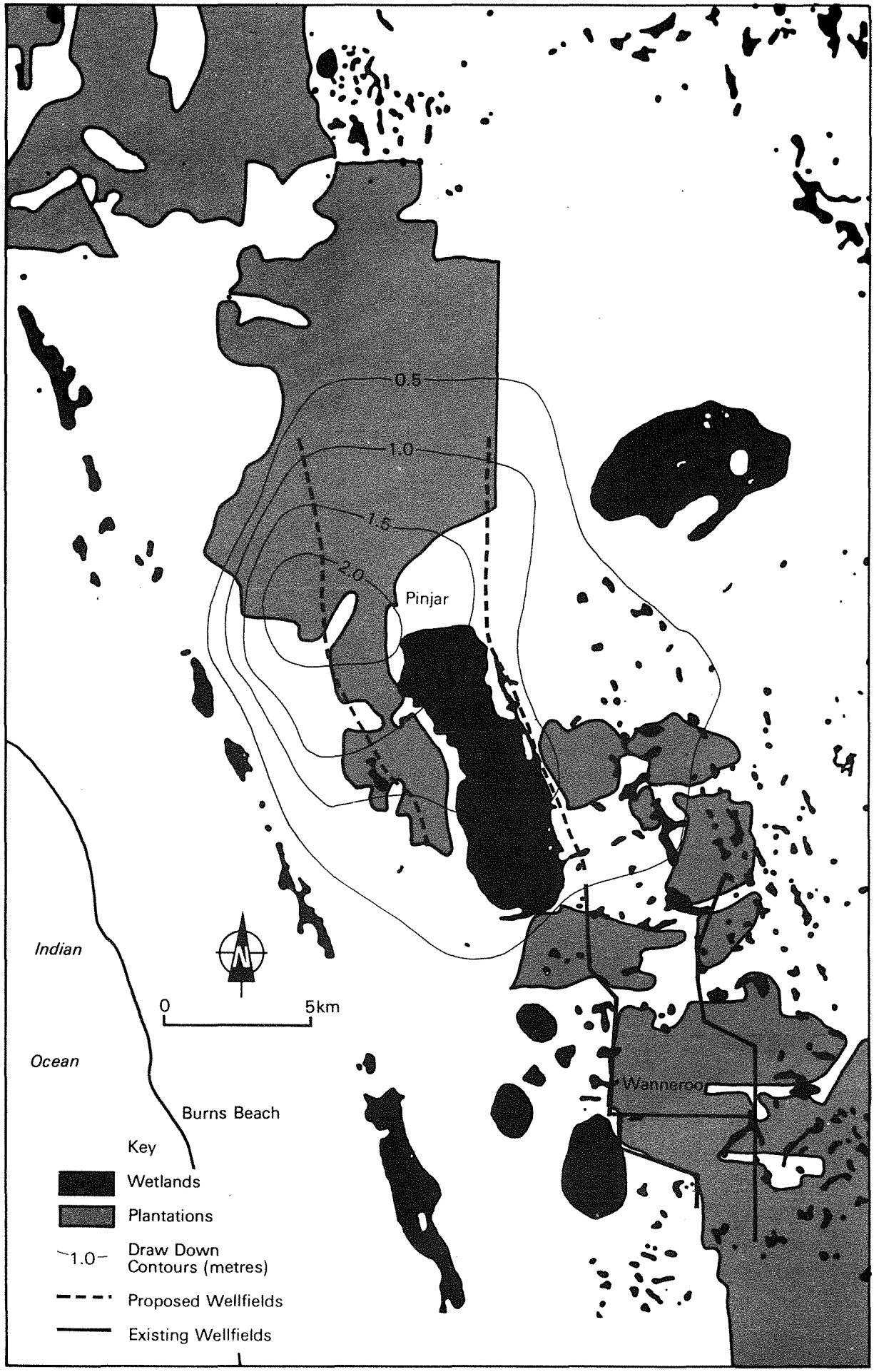

Figure 3. Groundwater Level Change for Preferred Pinjar Scheme, No Increase in Private Use and No Thinning of Pines.

plain. Of the ultimate Scheme yield of 32 million cubic metres per year, the unconfined aquifer will supply 14 million cubic metres per year with the balance coming from the confined aquifers.

8.4 Development will occur progressively with the first stage due for completion in 1989 and the last in 1997. The mix of aquifer development for each stage has not been finalised and is partially dependent on testing of the quality of water from the confined aquifers. However, it currently provides for concurrent development of the unconfined and confined aquifers to allow monitoring of the effects of abstraction from each resource.

EFFECTS

8.5 Pumping of groundwater from the confined aquifers will have negligible effect on water levels in the unconfined aquifer. Pumping of water from the unconfined aquifer will lower water table levels (Figure 3 and ERMP Figure 44). Much of the decline in water levels will occur under areas of pine plantation or upland native vegetation where the environmental impact will be acceptable, and beneath Lake Pinjar itself. Some water level change is also predicted in the vicinity of the linear lakes to the west and some ephemeral wetlands to the east.

8.6 To reduce the potential effect on the linear lakes (Carabooda, Nowergup and Neerabup), the Water Authority proposes to reduce the pumping originally planned from the southern half of the western line of wells by two-thirds and to increase abstraction from the eastern line of wells. This modification, together with management of private abstraction and pine plantation densities in the area, will reduce the water level decline in the vicinity of the linear lakes with little additional impact elsewhere. The characteristics of the linear lakes are such that the predicted decline in the water table level on their eastern margin of 0.5 metres is considered to be environmentally acceptable.

8.7 The Pinjar plain is a large area of freehold land bounded to the west, north and south east by State Forest 65. Most of this land has been cleared for agriculture. The hydrogeology of the area is complex and the depth to the water table varies from zero to some 3 metres from east to west. The reduction in water levels beneath Pinjar as a result of pumping from the scheme are predicted to range from 0.5 metres in the south to 2 metres in the north.

8.8 Pinjar was identified as a conservation area in the System Six Study but was rated lowest in priority for reservation. While the environmental value of Pinjar is difficult to assess, parts of it have value as a wetland ecosystem. Some impact on these areas can be expected. Conversely, the swamp gum woodland developing on the south western side may in fact expand with a slight lowering of the water table. With the limited knowledge available it is not possible to predict the full implications of the predicted water level changes. Because it has been heavily degraded over the years, further modification to the preferred Pinjar Scheme that would increase environmental impacts elsewhere as well as increasing the cost, is not advocated.

8.9 Drawdowns of up to 0.5 metres are predicted for some upper Mound swamps to the east of Pinjar. Many of these are within State Forest 65 and have been affected by plantation development. With the gradual drawdown expected at this distance from the Pinjar wells, the impact on these ephemeral wetlands will be a move towards plants that are more adapted to drought conditions. There will be no detectable effect on the wetlands of Melaleuca Park.

8.10 Plants may adapt to the changing water table if their root systems are given a chance to adjust over a period of time to changed soil moisture levels. Recognizing that there will be some impact in the Pinjar area, and that there is a more significant impact if the water table is suddenly dropped, pumping should be introduced gradually.

FINDINGS

8.11 On balance the proposed Pinjar Scheme should be approved subject to the management commitments given in the ERMP, comments made in this report and, in particular, on condition that:

(i) the Water Authority develops, within 12 months, a model to allow the local effects of the Pinjar Scheme to be better defined, monitored and managed;

(ii) the Department of Conservation and Land Management formally agrees to thin the pines in the vicinity of Lake Pinjar to stand densities with recharge equivalent to native vegetation, as required by the Water Authority;

(iii) private abstraction in the Wanneroo Groundwater Area north of Flynn Drive does not exceed 15 million cubic metres per year unless further monitoring and modelling shows the impact on water table levels to be acceptable;

(iv) the Water Authority and the Department of Conservation and Land Management, in conjunction with the Environmental Protection Authority, prepare a long term programme for assessing and monitoring environmental impacts in the area; and

(v) the unconfined and confined aquifers are developed concurrently to provide some capacity for managing water table declines under severe drought conditions.

9. CONCLUSIONS

9.1 The Gnangara Mound is a major water resource in the Perth region. Management of this resource and associated land uses is essential if the maximum sustainable benefit is to be derived for the whole community. To achieve this, there is an urgent need to establish a body for integrating planning and management on a regional basis. A Committee of the Western Australian Water Resources Council is recommended.

9.2 The ERMP is a most comprehensive and effective document. Nevertheless, there are some large deficiencies in the information available mainly concerning ecosystems and their importance and inter-relationships. These deficiencies can be overcome by a programme of research and investigation.

9.3 The long term strategy proposed in the ERMP provides a reasonable balance between the needs associated with development, and conservation of the environment. If this strategy is implemented within a framework of integrated land use and water resource planning and management, then:

. good quality, low cost water supplies to meet growing urban demands will be assured;

- wetlands, National Parks and conservation areas will be afforded protection;

- State Forest 65 will become a viable source of softwood with the added advantage of providing some public amenities;

- rural water supplies will be secure subject to licensing; and

- groundwater supplies will continue to be available in urban areas.

9.4 The commitments given by the Water Authority are a sound basis for the management of the complex issues arising for water resource and land use developments. However, there is a need to formalise commitments from other organisations and to develop more specific programmes and plans to put various commitments into effect.

9.5 Approval to proceed with the proposed Pinjar Scheme on a staged basis should be given, subject to the commitments in the ERMP and some additional specific conditions. Monitoring developments and impacts, together with on-going research and investigation, will enable corrective action to be taken, if required.

BIBLIOGRAPHY

The following publications contain background information relevant to matters raised in the Gnangara Mound Groundwater Resources Environmental Review and Management Programme.

Chittleborough, R G. Towards a State Conservation Strategy. 1. Planning to meet Climatic Changes. Department of Conservation and Environment, Western Australia. Bulletin 207, July 1985.

Environmental Protection Authority. Conservation Reserves for Western Australia, The Darling System - System 6. Department of Conservation and Environment, Western Australia. Report No 13, October 1983.

Environmental Protection Authority. Draft Guidelines for Wetland Conservation in the Perth Metropolitan Area. Department of Conservation and Environment, Western Australia. Bulletin 227, December 1986.

Gallagher, J., Eckersley, P. and Brennan, D. The Future Demand Value and Transfer Methods of Irrigation Water. Western Australian Department of Agriculture, November 1986.

Land Resource Policy Council. Conservation of Native Vegetation in Farming Areas - A Discussion Paper. Department of the Premier and Cabinet. Western Australia, June 1986.

Mauger, G. Planning Future Sources for Perth's Water Supply. Water Authority of Western Australia. Report No WP33, January 1987.

Research Group on Groundwater Management. Working Paper on Groundwater Management in the Jandakot Area. Western Australian Water Resources Council. Perth, June 1986.

State Conservation Strategy Consultative Committee. A State Conservation Strategy for Western Australia. A Sense of Direction. Department of Conservation and Environment, Western Australia Bulletin 270. January 1987.

Whelan, B.R. (Ed). Groundwater Resources of the Swan Coastal Plain. Proceedings of the Symposium jointly organised by the CSIRO Division of Land Resources Management and the W.A. State Committee of the Water Research Foundation of Australia, May 21 and 22, 1981.

Wronski, E. and Associates. Impact of Proposed Gnangara Mound Groundwater Developments on the City of Wanneroo. February 1987.

APPENDIX B

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APPENDIX C

Response by the Water Authority to Issues Raised in Submissions

APPENDIX C

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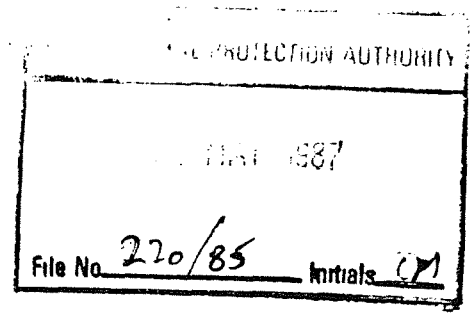

DIRECTOR
EVALUATION DIVISION
ENVIRONMENTAL PROTECTION AUTHORITY

GNANGARA MOUND ERMP PUBLIC SUBMISSIONS

The issues arising from the public and government agency submissions, as identified in your letter of April 2, 1987 have been reviewed by the Water Authority. Discussions have been held between officers of the Water Authority and Mr Colin Murray to identify the major issues. The attached comments have been prepared in response to these issues.

In general, the Authority considers that most of the major issues raised in the submissions have been adequately addressed in the ERMP or will be addressed by the management procedures or further investigation proposed in the document. Therefore, no modification to the Pinjar Scheme is proposed at this stage. However, as stated in the ERMP, further investigation will be conducted and environmental documentation prepared prior to development of the Yeal, Barragoon, and Lexia Schemes.

The recommendations of the EPA's Advisory Group have been considered by the Water Authority and the Western Australian Water Resources Council. The Authority is in agreement with these recommendations and accordingly has initiated detailed modelling of the Pinjar area to enable the predicted effects on the wetlands to be refined and if appropriate, the proposed management strategies modified. The Groundwater Management Committee of the WAWRC has resolved to recommend to the Council that it establish a committee to co-ordinate the planning and management of the Gnangara Mound as recommended by the Advisory Group.

Should you require any additional information or wish to discuss any of these matters further, please contact Mr Graham Cargeeg at the Water Centre on telephone 420 2911.

for MANAGER
WATER RESOURCES MANAGEMENT

May 12, 1987 IW:BC

9371R

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GNANGARA MOUND ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

WATER AUTHORITY RESPONSE TO ISSUES RAISED IN PUBLIC SUBMISSIONS

The public review period for the Gnangara Mound ERMP closed on March 25, 1987. Subsequently, the Environmental Protection Authority identified the major issues raised in the submissions and invited the Water Authority to comment. This report contains the Water Authority's comments on these issues. Discussion has been arranged under the following general headings.

1. Alternative sources
2. Demand management
3. Impact of proposed developments
4. Management of public water supplies
5. Management of private water supplies
6. Co-ordination of groundwater management
7. Groundwater/wetland pollution
8. Compensation
9. Aboriginal heritage
10. Miscellaneous issues

1. ALTERNATIVE SOURCES OF SUPPLY

A number of issues were raised in the public submissions relating to the consideration given in the ERMP to the alternative sources of supply to the North West Corridor (NWC).

As outlined in the ERMP and detailed in the Water Authority publication of January 1987, "Planning Future Sources for Perth's Water Supply", the Water Authority uses a Sources Development Plan (SDP) as the basis for planning the development of Perth's water supply. The SDP ranks potential sources according to their cost effectiveness and, unless constrained by other factors, the most economic sources are scheduled to be developed first. The timing of when sources are developed is a function of the increase in demand for water. However, the SDP is flexible and proposed sources may be modified, re-scheduled or deleted to satisfy environmental, social or technical constraints.

The Gnangara Mound ERMP broadly assesses the environmental issues associated with the development of each of the sources on the SDP. A number of sources not yet listed on the SDP and, based on the current most likely planning timetable, not scheduled for development before 2009/2010 were also considered. From this assessment it was apparent that no source on the SDP clearly had lower environmental impacts than the other sources. The potential impacts associated with the Gnangara Mound were identified as being largely avoidable if the schemes were appropriately designed and managed. As this source is also the most economic on the SDP to supply the NWC, it was selected as the source for detailed investigation.

The submissions suggest that a number of specific sources should be considered as alternatives to the Gnangara Mound. Of the sources suggested, desalination and transferring water from the Northwest of the State are clearly addressed in the ERMP and based on their costs and associated environmental impacts, are discounted as viable sources. For example, desalination of seawater is approximately seven times as expensive as the Gnangara Mound and still has significant environmental impacts such as those associated with the generation of power for the plant, visual intrusion of a large plant near the coast, and disposal of brine. Sources beyond 750 km from Perth have been shown to be even more uneconomic compared to desalination of seawater and therefore sources from the north of the State such as the Ord, are non-viable. These sources will, however, be kept under review to ensure that technological advances are incorporated in the assessment of costs.

The development of groundwater north of Gingin Brook would involve similar environmental issues to the Gnangara Mound but would be more expensive due to the extra costs in transferring water some 100 km. The resource north of Gingin Brook is also largely committed to private developments and the allocation of part of the resource for public water supply would create an additional social issue.

The Water Authority and the Geological Survey of Western Australia, are conducting investigations to enable the size of this resource to be better defined and the potential for its use for public water supplies will be reviewed when these investigations are completed.

Other sources raised in the submissions which were not specifically addressed in the ERMP are briefly discussed below.

Coastal wellfields

The Water Authority has previously investigated the feasibility of a coastal groundwater scheme in the vicinity of the Whitfords area. This investigation identified a number of potential constraints to the operation of such a scheme including:

a) despite the close proximity to the NWC, the low lying topography of the coastal areas makes distribution of the water difficult and expensive due to pumping costs;

b) due to the low elevation of the water table (about 5m), large abstractions in the vicinity of the coast could contribute to saltwater intrusion problems;

c) development of groundwater schemes in urban areas is generally considered less desirable than in undeveloped areas due to the potential for pollution of the resources. There would also be social costs associated with restricting activities in the area to ensure the potential for pollution is minimised.

To further assess these matters, the Water Authority has made provision in its work programme for 1988 to review the feasibility of such a scheme.

Diversion of river flows onto the Gnangara Mound

The Water Authority has investigated the feasibility of diverting flows from nearby rivers onto the Gnangara Mound. This investigation included the development of a pilot recharge study on the Gnangara Mound. The results of this study demonstrated that artificial recharge of groundwater is technically feasible, however, the costs associated with river headworks, pipelines, pump stations, earthworks on the mound and operation costs of such a scheme mean that it is not scheduled for development within the timespan of the current Sources Development Plan.

Recharging treated wastewater to the mound

Pilot studies conducted by the Authority have demonstrated that this option is technically feasible. However, because of the nutrients in the wastewater there is potential for a build up of nitrate and phosphorous to occur in the groundwater, with the potential to cause health problems and pollute wetlands. Also, this option is very expensive,, particularly due to the costs associated with transportation of effluent from the

treatment plant to the recharge area, and would be more so if nutrients were to be removed before recharging. Therefore such a scheme is not scheduled for development within the timespan of the current Sources Development Plan.

Linking Hills sources to the Northwest Corridor

At present the Water Authority has no capacity to transfer water from the Hills sources to the NWC. To do so would involve substantial capital expenditure for additional pipelines and pumping stations. In addition, more expensive surface water developments with associated environmental impacts would need to be advanced to make up for the water diverted to the NWC. The capital and operating costs associated with this option are estimated to be in the order of 700 million dollars, which would result in a five-fold increase in the cost of water supplied to the NWC. There would also be significant social and environmental costs associated with the construction of a main pipeline through the Perth urban area.

Diverting water from Mundaring Weir to the NWC and establishing desalination plants in the Goldfields

Mundaring Weir is already interconnected with the Metropolitan System and in years of surplus capacity it can be used to supplement supply to the metropolitan area. However, the spare capacity amounts to only 12% of the yield from the Pinjar scheme and as discussed above, an expensive new main pipeline would be required to transfer the water to the NWC.

In addition, the water resources (fresh or saline) in the vicinity of the population centres in the eastern goldfields may be insufficient to meet the requirements of the existing population in the area. As well as supplying towns in the eastern goldfields, water from Mundaring Weir is also used to supply towns in the eastern agricultural districts and an alternative source of supply would have to be found.

Maintenance of the existing goldfields supply is consistent with the Authority's State-wide objectives of supplying acceptable quality water to consumers at minimum long-term cost, taking into account environmental and social considerations.

Modification of the Pinjar Scheme

It was suggested that the Pinjar Scheme should be modified by shifting the eastern leg to the centre of Lake Pinjar to minimise the effects on agricultural pursuits on the eastern margin. This modification would increase drawdowns to the west, towards the sensitive Wanneroo wetlands, and may not substantially reduce drawdowns to the east. A well line down the centre of the lake may also, in years of above average rainfall, be subject to flooding. This would result in access problems for routine operation of the scheme. To overcome this problem a causeway could be built and the individual well sites

elevated. However this would be both expensive and visually intrusive. Given the dubious benefits of such a proposal it is not considered appropriate.

The preferred layout of the Pinjar Scheme detailed in the ERMP has been designed with regard to minimising the environmental effects of pumping and achieving optimum availability of water for both public and private use.

2. DEMAND MANAGEMENT

A number of submissions stressed the importance of an effective demand management strategy and suggested a range of components which should be included.

As outlined in the ERMP, the Water Authority is currently preparing a demand management strategy. The strategy includes initiatives in the following areas:

- education regarding the efficient use of water;
- design criteria to ensure the use of water-efficient appliances;
- pricing policies to ensure wasteful activities are discouraged.

The Water Authority's recent 'Make Every Drop Count' water conservation campaign was the first of a number of regular summer campaigns initiated by the preparation of the strategy.

Specific issues raised in the submissions relating to demand management include:

Restrictions should be placed on watering during daylight hours

The Authority's demand management strategy will be aimed at educating consumers of the most efficient times to irrigate their gardens. As a consequence, it is hoped that restrictions will not have to be applied.

Overhead reticulation of horticultural crops should be discouraged and trickle systems promoted

The Authority's policy of allocating water within groundwater management areas encourages horticulturalists to use their allocations effectively. Where appropriate, licences are granted on the condition that efficient means of irrigating are used. The Department of Agriculture provides advice to market gardeners on the most efficient means of irrigating particular crops.

All water users should pay for use

The Authority's demand management strategy will contain a pricing policy which will discourage wastage of water supplied by the Authority. Private users of groundwater already pay for use in so far as it costs money to operate and maintain a well and therefore there is a strong incentive for major commercial users to only use what is required. However, it is known that most domestic well owners use in the order of three times more water than is necessary and the Authority's education programme will address this problem. Another consideration is that the costs involved in metering and charging all water users would be prohibitively expensive.

Water Authority policy of encouraging development of private domestic wells needs to be reviewed

Private domestic wells are an important component of the overall water supply system in Perth. They result in a significant saving in capital expenditure that would be required to provide alternative supplies through the public water supply system. However, the development of this resource must be carefully managed to ensure that unacceptable impacts do not occur. The Perth Urban Water Balance Study being undertaken by the Water Authority in conjunction with the Department of Conservation and Environment, the Centre for Water Research at the University of Western Australia and the Geological Survey of Western Australia is assessing various management strategies for the shallow groundwater resources of the Perth region. The report of this study is scheduled for release later this year.

Wells in rural and urban areas should be metered to give an accurate assessment of consumption

The Perth Urban Water Balance Study has considered the need for greater control on groundwater use within the Perth region. It is considered that an initial step in effective management is the refinement of the estimates and distribution of the number of wells and the amount of groundwater used. The major use of the groundwater resource is for community and industry based activities including public water supply, public open space irrigation and market garden irrigation. Two-thirds of all the groundwater used is for purposes such as these. The most effective approach to management may be through licensing and control of these major users and a complementary public education programme aimed at more efficient use of groundwater drawn from backyard wells. The costs associated with metering the estimated 77 000 private wells would be significant and is considered prohibitive and unnecessary in the first instance.

3. IMPACT OF PROPOSED DEVELOPMENTS

A number of submissions raised issues relating to the predicted impacts of the proposed developments. In particular, the basis for the adoption of the 0.5 m drawdown criteria for sensitive wetlands was questioned.

When considering the predicted impact of the proposed developments, it is important to note that the wetlands of the Gnangara Mound have already been affected to some extent by land use changes within the area. Broadscale changes to vegetation cover associated with the development and management of the pine plantations within State Forest 65 have had a considerable effect on regional water levels. Development of the urban corridors and rural areas has also had an effect on the water level and quality in nearby wetlands.

During the preparation of the ERMP it was recognised that target water levels were required to effectively manage wetlands. Following consultation with CALM and the EPA it was apparent that such criteria were not available. Therefore, following consultation with officers from the EPA and CALM and on advice of the Authority's expert consultants, the 0.5 m drawdown guideline was selected for the most environmentally sensitive areas. Changes of less than 0.5 m are generally within natural fluctuations and are therefore considered unlikely to result in significant effects. However, the Authority recognises that this criterion should be used as an interim guideline only and it should be reviewed as knowledge of specific wetlands increases. As stated in the ERMP, the Authority has undertaken to assist CALM and EPA develop guidelines for environmentally acceptable water level changes. Research being supported by the Water Authority and undertaken by Dr Arnold of the EPA and Dr Davis of Murdoch University, is a component of this work.

Other issues raised in the submissions relating to the predicted impacts of the proposed developments are briefly discussed below:

<u>Accuracy and basis of computer model - need for independent review</u>

The computer model used for the assessment of the effects of abstraction patterns and land use changes on groundwater levels was developed by the Perth Urban Water Balance project team. The model was developed in conjunction with the Centre for Water Research at the University of W.A. Discussions were held with officers of CSIRO, CALM and the EPA in developing the model. The data base used in the modelling studies was developed from the best available information. Liaison will be maintained with the appropriate government agencies and the local authorities to ensure any additional information or need for refinement of the model is included in subsequent modelling studies.

The ERMP report was reviewed by Dr Wronski for the City of Wanneroo who examined the processes used in the computer model in detail. In Dr Wronski's address to a public meeting organised by the City of Wanneroo, he stated that he could not fault the technical basis of the report and in previous discussions with the Water Authority he had expressed satisfaction with the computer model.

Which wetlands will be affected by 0.5 drawdown

The ERMP (Fig. 50 and Table 25) clearly identifies which wetlands are predicted by the computer model to be affected by drawdowns. It should be noted when looking at specific areas, that the model predicts regional groundwater level changes and is considered to be conservative, i.e. predict greater than expected drawdowns, particularly in the vicinity of wetlands. Advice from the Geological Survey of W.A. and the Authority's operational experience suggest that the layered nature of the underlying sediments in the wetlands of the Gnangara Mound tends to minimise water level changes induced by pumping from the lower half of the unconfined aquifer. The Authority proposes to conduct additional detailed modelling to enable more accurate predictions of the effect of abstractions on wetlands to be made, prior to the development of the Pinjar Scheme.

Effect of the Pinjar Scheme on the Mindarie waste disposal site and Lake Joondalup

The groundwater level at Mindarie is approximately 4 m AHD. The water level in Lake Joondalup is about 17 m AHD. Therefore the Pinjar scheme would have to reduce the water level in Lake Joondalup to about 3 m AHD, i.e. 9 m below the base of the lake, before leachate from Mindarie will flow towards the lake. As shown in Fig. 50 of the ERMP, the effect on groundwater levels within the vicinity of lake Joondalup will be no more than 0.5 m and in view of the conservative nature of the model and the local hydrogeological complexities, is expected to be significantly less.

The effect on small seasonal wetlands in State Forest 65 and other wetlands outside reserves should be examined

The objective of the ERMP modelling studies was to identify the wellfield layout and abstraction pattern which minimises the impacts on the wetland areas recommended for reservation in the System 6 study or areas identified by CALM, EPA or the Authority's consultants as being of high conservation value. It is acknowledged that some wetlands, such as Pinjar and wetlands in State Forest 65 which have not been recognised as being of high conservation value, will be affected. As shown in Fig. 2 of the EPA's Advisory Group Report the wetlands within State Forest 65 that are likely to be affected are limited to those ephemeral wetlands east of Lake Pinjar. However, it should be noted that State Forest 65 has over its major portion a management priority purpose of water production and accordingly, the Authority has attempted to concentrate the

impacts of the public water supply developments within this area. Wetlands within S.F. 65 have already been affected by plantation development. It is anticipated that these wetlands will become more ephemeral in nature and that the species composition of the vegetation and fauna present will gradually change to a more drought tolerant community.

Impact on water levels and resident fauna in Yanchep and Neerabup caves

The high hydraulic conductivities in the limestone areas in the vicinity of the caves is expected to mitigate against water levels being significantly reduced in the caves. The Authority's water level monitoring programme has demonstrated that levels in these areas generally do not fluctuate greatly. For example, water levels in Loch McNess vary by less than 0.3 m in each year. Further detailed modelling will be used to confirm that the effects on water levels in the caves can be expected to be negligible.

Effect of the development of the Gnangara Mound on Gingin Brook

As shown in Figure 50 of the ERMP, the predicted impact of the proposed developments, including the Yeal and Barragoon schemes, on Gingin Brook is expected to be minimal. Environmental reviews, including further detailed modelling studies, will be conducted prior to development of the Yeal and Barragoon schemes to ensure the effect, if any, on Gingin Brook is acceptable.

Need for more information on wetlands

The need for more information on specific wetlands to assist in management is recognised by the Water Authority, however, at the time of writing the ERMP, only limited information was available. The Authority is currently funding a study aimed at developing a classification and evaluation system for the wetlands of the SW of the State. The Authority is also jointly funding the publication of a wetland inventory of the Perth area by Dr Jenny Arnold of the EPA and publication of Dr Jenny Davis' work on macroinvertebrate fauna of coastal plain wetlands. The Authority has made the commitment in the ERMP to provide ongoing support to Dr Davis' work.

It should be recognised that most wetlands on the Swan Coastal Plain have already been affected by developments and current water levels do not represent long-term natural conditions. Wetland guidelines and criteria are essential if wetlands are to be managed effectively.

4. MANAGEMENT OF PUBLIC WATER SUPPLIES

Issues related to the Authority's proposed management of public water supplies are discussed as follows:

Effects of groundwater abstraction on the Leederville Formation and Yarragadee Formation aquifers

The Leederville Formation and Yarragadee Formation aquifers are thick and sandy and confined within relatively impermeable layers of material (except in recharge and discharge areas). Advice from the Geological Survey of W.A., and experience gained from operation of the Authority's existing schemes suggest that the impermeable layers above and below these aquifers results in effects being contained largely within confined the aquifer. As a consequence, there is not expected to be any significant drawdown reflected in the overlying unconfined aquifer or the associated wetlands. Therefore, the Leederville Formation and Yarragadee Formation aquifers are important sources of groundwater particularly during times of drought. The Authority is currently constructing an investigation well into the Yarragadee Formation at Pinjar to further assess the water quality. During the test pumping of this well the water levels in the unconfined aquifer will be monitored to confirm that drawing water from the Yarragadee Formation will not effect these water levels. Similar testing will be undertaken prior to proceeding with developments associated with the Yeal and Barragoon Groundwater Schemes.

Management response to adverse effects

The monitoring programme proposed in the ERMP will rapidly identify the response of the water-table to groundwater abstraction and the subsequent effect on associated ecosystems. The Authority will document the results of the monitoring programme and report annually to the EPA. Reports submitted to the EPA will be available for perusal by the public in the EPA's reading room. If the monitoring programme identifies that the predicted effects are being exceeded, the management strategies will be modified in consultation with the EPA. Options for modification of the wellfield operation include biasing abstractions away from sensitive wetlands by reducing the quota for specific superficial wells and or increasing the percentage of water obtained from the confined aquifers. The Authority has already taken this initiative in the management of the Wanneroo Groundwater Scheme where abstraction from three wells has been significantly reduced to minimise the effects on Lake Jandabup. (Abstraction from wells remote from the lake has been increased to maintain the scheme quota.) This action, and the slightly above average rainfall in 1986, contributed to the water levels in Lake Jandabup at the end of the 1986 winter being the highest for eight years.

Management response to drought conditions

During periods of prolonged drought, restrictions on water use may be applied to reduce the demand on the Water Authority's supply. The Authority's planning for the development of sources is based on the assumption that restrictions will be applied on average one year in every ten. As detailed in the ERMP, groundwater resources tend to be buffered against drought in the short term. During periods of prolonged drought, greater reliance may be placed on the confined aquifers if the monitoring programme demonstrates that the combined effect of low rainfall and shallow groundwater abstraction is unacceptable.

The Authority's current operating strategy for the artesian resources relies on these higher salinity resources being diluted with lower salinity groundwater from the unconfined aquifer to ensure that the Water Authority's objective for water quality of 500 mg/L TDS is achieved. Greater reliance on artesian groundwater during periods of drought may result in the salinity of water supplied exceeding this objective.

The total quota for the Pinjar scheme will not be exceeded in periods of drought to compensate for shortages in 'Hills' supplies without prior consultations with the EPA.

The Water authority sets a poor example when water is wasted from the Wanneroo Groundwater Scheme

As part of the normal operating proceedures of a groundwater scheme the performance of individual wells is regularly monitored and well maintenance is undertaken to ensure that a maximum operating life is achieved. Part of this proceedure involves measuring the amount of sand infiltrating into the well and where necessary undertaking remedial action. These activities may involve the discharge of some water onto the ground. However, the amount of water involved is significantly less than 1% of the total scheme output and some of this water will return to the water-table. All endeavours are made to ensure that the amount of water discharged to the ground is kept to a minimum.

5. MANAGEMENT OF PRIVATE SUPPLIES

A number of submissions raised issues relating to the Authority's existing and proposed management of private groundwater use.

Groundwater management is required in areas of high groundwater use to ensure the maximum community benefit is achieved whilst avoiding such effects as:

- over exploitation;
- degradation of water quality;
- adverse environmental impacts;
- salt water intrusion.

As outlined in the ERMP, the Authority has adopted a four-staged approach to the management of groundwater resources:

1. Maintain awareness of developments in areas with the potential to adversely affect the environment or established users.

2. Proclaim areas and licence wells within these areas to more closely monitor groundwater use and the response of the aquifer.

3. Actively manage use where it encroaches on the requirements of existing users or the environment.

4. Monitor the effectiveness of the strategy and modify as required.

Groundwater Areas may be proclaimed under the provisions of the Rights in Water and Irrigation Act 1914. Within these areas all wells must be licensed, the conditions of which will relate to the water allocation and permitted use. At the time of proclamation, established users are usually given a licence allocation for their existing requirements. A project that is causing excessive drawdown or using an excessive quantity of water may be restricted to a lower allocation of water. Applications for new developments or increases to existing licence allocations must be referred to the Water Authority. Such applications are assessed in view of the water availability in the area and the proposed use of the water.

To assist in the management of a Groundwater Area, an Advisory Committee may be formed to provide advice to the Water Authority regarding licence applications. Such a committee has been formed for the Wanneroo Groundwater Area (WGA). The Advisory Committee membership includes representatives from the Water Authority and other government agencies and local land owners.

The following specific issues raised in the submissions are briefly discussed.

The whole of the State should be proclaimed for groundwater management

The Authority's approach to groundwater management ensures that those areas requiring management are identified and proclaimed. It would be unnecessary and administratively very expensive to proclaim the whole State. However, it should be recognised that over 50% of the State has been proclaimed and that almost all of the major groundwater resources of the State now fall within proclaimed areas.

The Wanneroo area is being discriminated against by the requirement for licensing of wells

The WGA has been proclaimed and extended in accordance with the Authority's strategy to ensure the resource is conserved, equitably allocated and the environment protected. Most of the Perth Basin outside the urban areas is now proclaimed for groundwater management. The extension of the WGA in September 1986 included one of the last remaining unproclaimed areas of rural land overlying significant groundwater resources.

Horticultural activities are given a low priority in planning procedures

The ERMP recognises horticulture as a major legitimate use of groundwater. However, the close proximity of the rural areas to the sensitive wetlands has necessitated active management. The total allocation for private use in the WGA is 36 x $10^6 m^3/yr$ which at the time of writing the ERMP allowed for a 67% increase in groundwater use north of Flynn Drive and a 40% increase in the area south of Flynn Drive. This total allocation for private use exceeds the allocation for the Wanneroo and Pinjar public water supply schemes using the superficial formations (26 x $10^6 m^3/yr$) by 10 x $10^6 m^3/yr$.

Transfer of licences with land title

Groundwater is vested in the crown and therefore rights to groundwater do not form part of the title to land. So as to ensure that groundwater allocations are used and not merely acquired to enhance property value whilst depriving other landowners of the supply, licences are issued only for the period the licensee occupies the property. However, where there is a licensed established use at the time of the sale, a licence will be issued, on application, to the new owner for that use. An application for increased use will be treated as a new application and the change in land ownership will be disregarded during consideration of the application.

Subdivision of existing irrigated areas

Applications to subdivide an irrigated area of land and its licence allocation must be referred to the Water Authority. The Authority would be unlikely to object to such a proposal providing the overall use of water on the land did not increase beyond the available supply. A planning consideration may be to avoid the lot sizes becoming too small for viable horticultural pursuits to continue.

Licence conditions relating to crop type and watering times

Licence holders are required to advise the Authority if they change their produce type, e.g. from vegetables to lucerne, as such changes have implications for the magnitude of the allocation because different crop types have different water requirements. However, within the WGA there is no need to advise of changes within produce types or of changes to watering times.

6. CO-ORDINATION OF GROUNDWATER MANAGEMENT

Dual role of the Water Authority

The Water Authority has the dual role of supplying water for public use and the responsibility for the management of the State's water resources.

In its role in the management of water resources, the Water Authority is charged with managing the State's water resources for the continuing benefit of the community. The Authority seeks the appropriate balance between the cost of its activities, protection of the environment and the social expectations of the community.

In making decisions regarding water resource matters, the Minister for Water Resources receives independent advice through the Western Australian Water Resources Council (WAWRC), a body which was established specifically to give advice to Government particularly where there may be a conflict of interest in the Water Authority's dual role.

The overall objective of the WAWRC is to ensure, as far as practical, that the State's water resources provide the maximum long-term benefits for the people of Western Australia. To assist in achieving this objective, the WAWRC has established a number of advisory committees including a Planning and Management Committee, a Groundwater Management Committee, a Conservation and Education Committee, and a Rural Water Committee.

In general the ERMP fails to acknowledge the role of the local authorities

The Water Authority recognises the major role that the local authorities play in relation to land planning issues. The potential effect of land use on water resources requires close liaison between the agencies involved. The Authority has been particularly appreciative of the very positive attitude taken by the City of Wanneroo toward the Wanneroo Groundwater Advisory Committee and the extensive assistance provided by its officers to staff of the Authority and its consultants in preparation of the ERMP.

The EPA's Advisory Group recommended that a committee be established under the auspices of the Western Australian Water Resources Council, to integrate planning and management of the groundwater resources of the Gnangara Mound. The suggested membership of the committee includes senior representatives from each of the following organisations:

- City of Wanneroo
- Department of Agriculture
- Department of Conservation and Land Management
- Environmental Protection Authority
- Mines Department
- State Planning Commission
- Water Authority

This committee will ensure that the City of Wanneroo has the opportunity for greater involvement in the planning and management of the groundwater resource.

7. GROUNDWATER - WETLAND POLLUTION

A number of issues were raised regarding groundwater pollution and these are discussed below.

Potential for pollution of groundwater resources

Several point sources of pollution on the Gnangara Mound, such as the Gnangara liquid waste disposal site, the closed Pinjar rubbish dump, and piggeries have the potential to pollute the unconfined groundwater resource. Non-point sources of pollution such as urbanisation and large scale fertiliser and pesticide usage in rural areas also have the potential to degrade the unconfined water resources. The Water Authority monitors water quality on a regional basis and in specific cases monitoring wells have been installed to closely monitor particular pollutant sources.

Because of the location of production wells none of the current landuse activities in the vicinity of the existing or proposed groundwater schemes on the Gnangara Mound are likely to affect the quality of water produced by the schemes.

In accordance with its primary corporate objectives, the Authority will ensure that water supplied by its groundwater schemes meets acceptable community and National Health and Medical Research Council criteria. To assist in achieving this objective, the Authority has proclaimed Underground Water Pollution Control Areas (UWPCAs) around its groundwater schemes. Within these areas the Authority can control potentially polluting activities. The Environmental Protection Authority, under the provisions of the EPA Act, 1986, has prime responsibility for the prevention of pollution of groundwater and surface water.

The Water Authority closely monitors the quality of water produced by its wellfields. If water quality deteriorates, action such as reducing abstraction from or closing the contaminated well will be taken. Owners of private wells from which water is used for human consumption should contact their local Health Surveyor if concerned about water quality.

Requirement for land use changes in the vicinity of the Pinjar Scheme

Existing land use activities in the Pinjar area will not be affected. The Water Authority is aware of and currently licenses the major polluting activities. It is possible that in the future, the Authority may prevent the establishment of additional industries, which have the potential to pollute the groundwater resource in the area.

Effect of water level on water quality

It is possible that a reduction in water level may exacerbate an existing water quality problem in a wetland by resulting in increased water temperatures and concentrating suspended

material. However, the wetlands of the Swan Coastal Plain are adapted to fluctuations in water levels and many dry out on a regular seasonal basis. Work conducted by Dr Davis from Murdoch University has demonstrated that the health of a wetland is not necessarily related to maintenance of water levels (Davis and Rolls, 1987). Dr Davis suggests that the drying out of wetlands may in fact alleviate water quality problems and cites Lake Jandabup as an example.

Effect of mining leases on water resources management

All mining leases within the Gnangara Water Reserve must be referred to the Water Authority for approval before any development can proceed. The Authority therefore has the opportunity to ensure that the proposed development does not adversely affect the quality or quantity of the groundwater resources.

8. COMPENSATION

Several submissions were related to claims for compensation for any loss or hardship resulting from management of private or public groundwater supplies.

Groundwater is vested in the Crown and therefore rights to groundwater do not form part of the title to land. Consequently, there are no legal grounds for payment of compensation to landowners who perceive themselves to be adversely affected by the Water Authority's groundwater management strategies.

Specific cases where compensation has been requested include:

- Compensation to landowners restricted in the development of their property.

- Compensation to landowners for loss of summer pasture.

- Compensation to landowners for reduction in land values resulting from groundwater management.

It was also claimed that landowners who have to deepen their wells as a result of the development of Public Water Supplies should be compensated. The Authority is of the opinion that if wells are adequately constructed, they will not require deepening. Landowners should ensure that wells are constructed with consideration to the potential for drawdowns to be induced by the development of wells on adjacent land. It is more likely that private wells will be affected by neighbouring private wells rather than the more distant Water Authority wellfield.

9. ABORIGINAL HERITAGE

General issues relating to aboriginal heritage sites were raised and are discussed below:

- Preparation of ERMP did not involve consultation with Aboriginal people.

- Impact on Aboriginal heritage needs to be reassessed.

Discussions have been held with officers of the Aboriginal Sites Department of the Museum of Western Australia. Their assistance has been sought in identifying any areas of concern to aboriginal people so that appropriate action can be initiated.

The ERMP involved an assessment of archeological sites within areas of direct disturbance. (Appendix F). The report concluded that due to the highly disturbed nature of the area resulting from planting of the pine forest, there was no known archaeological sites that would be directly affected by the proposal. The report further concluded that the integrity of archaeological sites within the region would not be affected by the predicted changes in water level.

In assessing impacts of the proposed management strategies on the ethnographic aspects of aboriginal heritage sites within the region, it was concluded that the changes in water levels were within recorded historical fluctuations and therefore the ethnographic value of these sites would not be affected. In this assessment it must be recognised that most wetlands on the Swan Coastal Plain have already been affected by developments and current water levels do not represent long term natural conditions.

10. MISCELLANEOUS ISSUES

Planning for urban expansion and water availability

One of the key factors considered in planning for further urban expansion is the availability of public water supplies. The State Planning Commission maintains a close liaison with the Water Authority so that planning for urban development can take into account the availability of public water supplies. The State Planning Commission recently carried out a review of the urban corridor plan and during the development of this planning review, a senior officer from the Authority was seconded to the Commission to ensure that water related issues were taken into account.

Water Authority transfers water out of the Gnangara Mound while horticulture returns most to the Mound

Advice received from the Department of Agriculture indicates that providing an irrigator uses water efficiently, only a minimal amount of water is returned to the water-table. This has been confirmed by research carried out for the Perth Urban Water Balance Study which demonstrated that there was no significant return to the water-table beneath a suburban lawn irrigated from a private well. Much of the water used in sprinkler irrigation is lost to the atmosphere through evaporation and the remainder is consumed by the lawn or crops and returned to the atmosphere through transpiration.

Efficient irrigation application should provide enough water to meet the transpiration requirements of the crop plus a small component to ensure salts are leached from the crop root zone to prevent land salinisation.

The fate of irrigation water has been taken into account in the computer modelling carried out during the preparation of the ERMP.

Public should have access to all information relating to availability of groundwater and surface water supplies

The Water Authority recently released a public document titled "Planning Future Sources for Perth's Water Supply" which provides details of both surface water and groundwater supplies in the Perth region. This report is available from the Authority's Public Affairs Branch.

A report produced by the Western Australian Water Resources Council on "Water Resources and Water Use" details the regional availability of water supplies throughout the State. This report is also available through the Public Affairs Branch.

In addition the Water Authority reports each year to the EPA on the operation and management of its groundwater schemes within the metropolitan region. These reports are placed in the EPA reading room and are available for public information.

Further information on water availability is contained in reports produced by both the Water Authority and the Geological Survey of W.A. These reports are available through the relevant organisation's library.

Effect of lowering saturation of top soils which could lead to reduced denitrification

Nitrification and denitrification occurs naturally in areas where biological activity in or near a water body is present. The significance of this process in relation to nutrient enrichment is not known as little research has been carried out to date.

Due to the large natural fluctuations in water levels that occur naturally on the Gnangara Mound, it is not considered that any additional drawdowns in the summer periods will have any significant effect on the nitrification and denitrification process.

In the particular case of Lake Pinjar any increase in nitrates would potentially effect only those wells downstream of Lake Pinjar. The water drawn from these wells will be diluted with water drawn from the remainder of the scheme. It is not anticipated that any significant effects on water quality will result from lower water levels in Lake Pinjar. Should any effect occur the dilution within the aquifer and with other water produced from the scheme will ensure that water quality standards are maintained.

Issues raised in Dr Ed Wronski's report to the City of Wanneroo

Dr Wronski's report titled "Impact of Proposed Gnangara Mound Groundwater Developments on the City of Wanneroo" was commissioned by the City of Wanneroo to provide an independent assessment of the Gnangara Mound ERMP. Whilst Dr Wronski's report provides a concise summary of the main issues, it places a higher priority on groundwater for agricultural development than for public water supply.

A number of aspects of Dr Wronski's report are considered inaccurate or reflect the bias of the assessment. The main areas are:

i) The report suggests that there will be constraints on groundwater use for irrigated agriculture. This is not so, as the groundwater allocations proposed allow for significant increase in usage.

ii) The report concentrates on analysing the various water balance components but does not recognise that the major constraint to groundwater use is water levels, in particular lake water levels.

iii) The water balance figures used in the report include the abstraction of artesian groundwater for public water supply without including private use of the artesian resources. this, together with the discounting of private irrigation for the "extra recharge" obtained from cleared land presents a biased view and suggests that the private irrigators are disadvantaged.

iv) The suggested priorities for the allocation of groundwater are not in accordance with the Water Authority's philosophy. The Authority's view is that public and private use have equal priority with the pine plantations having a secondary priority.

APPENDIX D

List of Commitments by the Water Authority in the ERMP

APPENDIX D

LIST OF COMMITMENTS BY THE WATER AUTHORITY IN THE ERMP

LAYOUT OF SCHEMES FOR PUBLIC WATER SUPPLY

The layouts of the proposed Lexia, Yeal and Barragoon Schemes will be further assessed as part of detailed investigation prior to selection of the preferred strategies for management of the groundwater resource.

ABSTRACTION STRATEGIES FOR PUBLIC WATER SUPPLY SCHEMES

Groundwater levels will be monitored using the existing network of over 900 monitoring points in conjunction with measurements from the production wells. The abstraction strategy will be reviewed, and if necessary, modified taking into account the results of monitoring and the need to maintain the resource to meet public, private and environmental needs. The Water Authority will not exceed the quota or substantially modify the abstraction strategy from the scheme without prior Environmental Protection Authority approval.

MANAGEMENT OF PRIVATE WATER USE

The Water Authority will manage private abstraction within the Wanneroo Groundwater Area, so as not to exceed the private groundwater abstraction quota. This quota will be reviewed as part of the annual reporting procedure for the Environmental Protection Authority. Provision will be made for the Wanneroo Groundwater Advisory Committee to have appropriate public representation from the entire Wanneroo Groundwater Area.

COOPERATIVE LAND MANAGEMENT

The Water Authority will liaise with the Department of Conservation and Land Management so that plans for thinning, control burning and future management of pine plantations recognise the effect of plantation management on the groundwater resource.

The Water Authority will provide advice during preparation of management plans for conservation areas and recreational activities to ensure protection of water quality.

The Water Authority will continue to liaise with the State Planning Commission to ensure that appropriate consideration is given to water resource management when land planning issues are being considered.

The Water Authority will continue to liaise with the Departments of Conservation and Environment, and Conservation and Land Management to assist them in developing guidelines for water level changes which take into account the need for environmental conservation.

The Water Authority will continue to liaise with the Mines Department and the Department of Conservation and Environment to ensure that consideration is given to water resource management when mining applications are evaluated.

LIST OF COMMITMENTS BY THE WATER AUTHORITY IN THE ERMP (contd)

The Water Authority will take account of future land management in the area of the proposed Yeal Nature Reserve extension when planning future groundwater management in the area, by liaison with the Department of Conservation and Land Management.

DEMAND MANAGEMENT

The Water Authority will prepare a demand management strategy.

ON-GOING REVIEW

Monitoring of water levels will be used to assess the effectiveness of management strategies which will be reviewed as appropriate.

MONITORING

The programme of groundwater investigations and vegetation monitoring will continue, forming the basis for the monitoring to be undertaken in connection with existing and future developments on the Gnangara Mound area generally and the Pinjar Scheme in particular.

PROPOSED WATER MONITORING

Regular monitoring of groundwater levels will be carried out within the Pinjar area. This will include observation bores at the site of proposed production wells to monitor the local drawdown effects and selected lakes and swamps. These lakes will include Lake Carabooda, Nowergup, Neerabup, Pinjar, Adams, Mariginiup, Jandabup and Loch McNess. Water level monitoring from over 900 other existing stations will continue. The existing regional groundwater quality monitoring programme will continue. The quality of water produced by the Pinjar Scheme will be monitored frequently to ensure that the water meets potable standards.

The need for specific water monitoring data in conjunction with vegetation and fauna monitoring, will be evaluated in consultation with the Departments of Conservation and Environment, and Conservation and Land Management.

PROPOSED VEGETATION MONITORING

The Water Authority will prepare an appropriate vegetation monitoring programme in consultation with the Departments of Conservation and Land Management, and Conservation and Environment.

PINE PLANTATION MONITORING

The Water Authority will liaise with the Department of Conservation and Land Management regarding future monitoring of the basal area of pine plantations in State Forest No 65.

LIST OF COMMITMENTS BY THE WATER AUTHORITY IN THE ERMP (contd)

PROPOSED FAUNA MONITORING

The existing wetland invertebrate monitoring programme will continue and be expanded to include Lake Goollelal and Loch McNess. The Water Authority will continue to support this programme.

The Water Authority will consult the Departments of Conservation and Environment, and Conservation and Land Management on the need for essential monitoring of other animals.

PROPOSED SOCIAL MONITORING

The Water Authority will continue to liaise with and provide support to the Western Australian Water Resources Council's Groundwater Management Project study team.

The Water Authority will continue to take into account the advice of the Groundwater Advisory Committees as an important contribution to the management of the resource.

REPORTING AND ASSESSMENT

The results of the management and monitoring programmes will be reported regularly for review by the Environmental Protection Authority and the programmes modified where appropriate. Reporting on the existing Wanneroo and Mirrabooka Schemes will continue in the established format with brief annual reports complemented by comprehensive triennial reviews for submission to the Environmental Protection Authority.

PINJAR DEVELOPMENTS

The existing reporting to the Environmental Protection Authority will be extended to cover the proposed Pinjar Scheme, together with a review of private groundwater usage in the area.

A brief annual report will be submitted to the Environmental Protection Authority. It will contain:

- a review of operations and productions volumes;
- a summary of well, lake level and water quality monitoring;
- brief reviews of the vegetation and fauna monitoring programmes; and
- an overview of any other developments which may be significant to the operation of the scheme, have potential environmental effects or may be of relevance to management of the groundwater resource.

A comprehensive triennial review of the Pinjar Scheme will also be submitted, covering similar topics to the annual reports but in more detail, with the emphasis on any important changes in the resource and the implications for any alterations required to future management. Management strategies will be reviewed and modified as appropriate.

LIST OF COMMITMENTS BY THE WATER AUTHORITY IN THE ERMP (contd)

FUTURE DEVELOPMENTS

The Water Authority will provide appropriate environmental documentation to enable the Environmental Protection Authority to assess future groundwater developments on the Gnangara Mound.