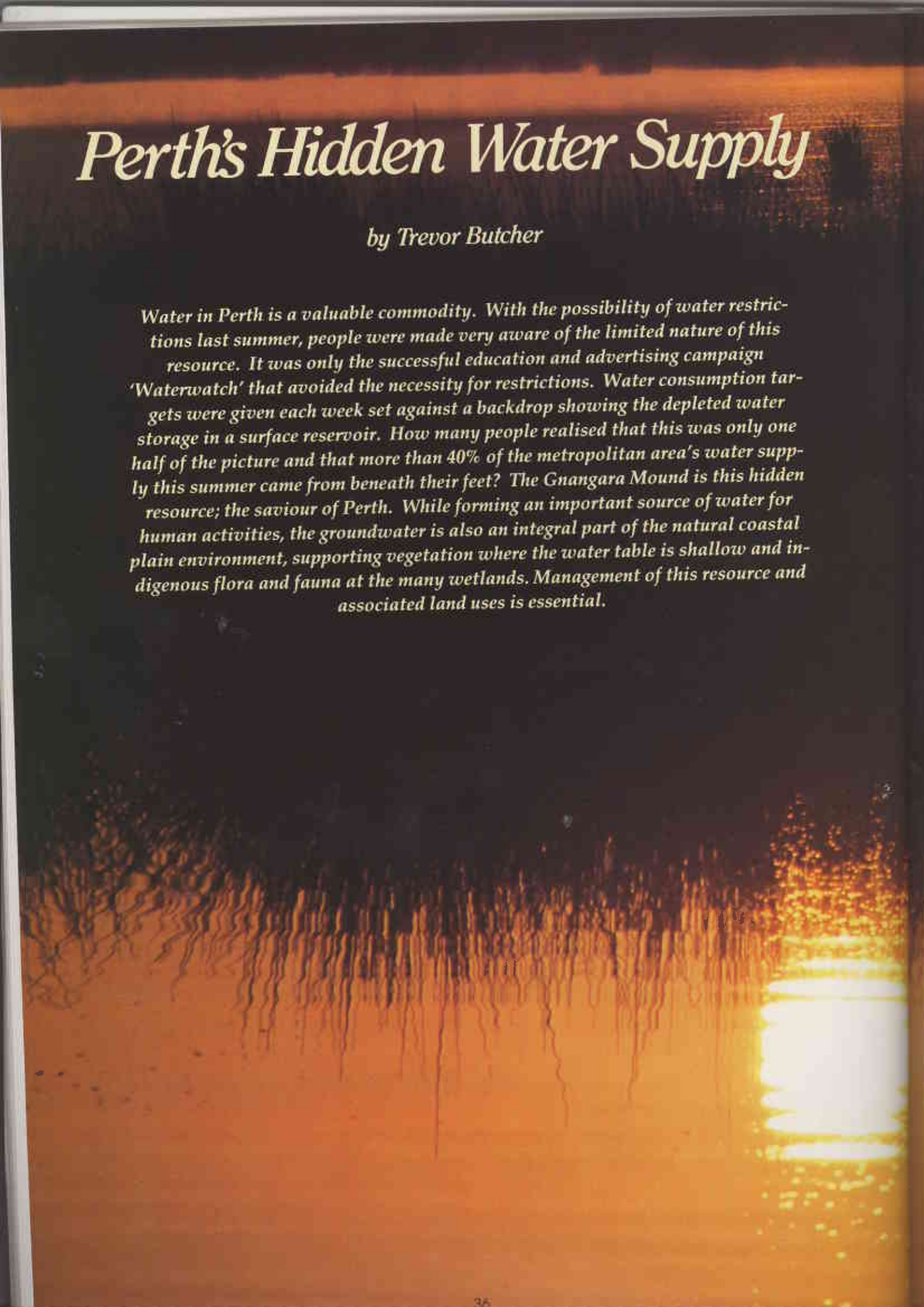
Perth's Hidden Water Supply

by Trevor Butcher

Water in Perth is a valuable commodity. With the possibility of water restrictions last summer, people were made very aware of the limited nature of this resource. It was only the successful education and advertising campaign 'Waterwatch' that avoided the necessity for restrictions. Water consumption targets were given each week set against a backdrop showing the depleted water storage in a surface reservoir. How many people realised that this was only one half of the picture and that more than 40% of the metropolitan area's water supply this summer came from beneath their feet? The Gnangara Mound is this hidden resource; the saviour of Perth. While forming an important source of water for human activities, the groundwater is also an integral part of the natural coastal plain environment, supporting vegetation where the water table is shallow and indigenous flora and fauna at the many wetlands. Management of this resource and associated land uses is essential.

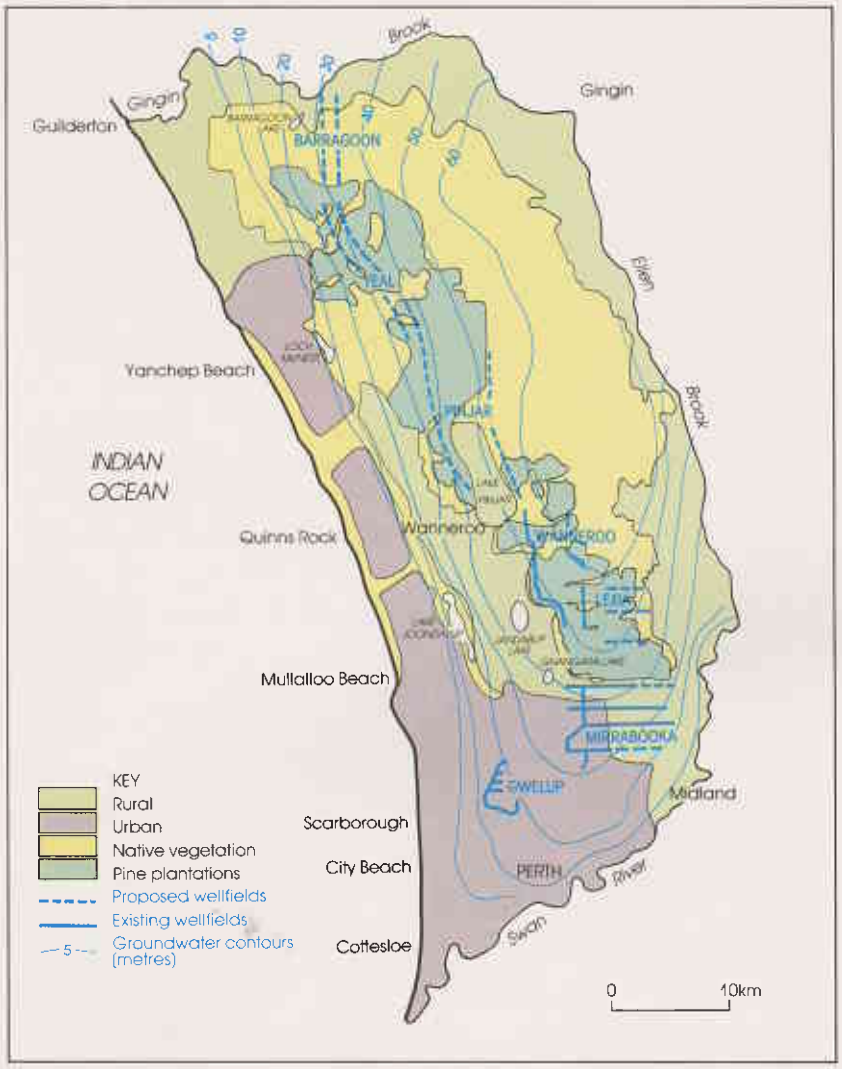


Perth's domestic and industrial requirement for water is expected to double from its present use, to over 350 million cubic metres per year by the year 2 000. The contribution of groundwater to Perth's water supply has risen from 11% in 1971, when the first public groundwater scheme was commissioned, to about 42% in recent years. By the year 2 000, it is estimated that 115 million cubic metres of groundwater will be required. As well as the public water requirement, there are considerable demands on the groundwater by private bores for irrigating domestic, agricultural and horticultural crops; parklands and ovals; and for industrial purposes.

The extensive shallow groundwater resources near Perth have several advantages over surface water storage. Engineering costs for development and distribution are lower, the water supply is more reliable and less affected by prolonged periods of drought, and the evaporative loss of water is less. Against this, the poorer quality groundwater requires treatment, and there is the need for careful management to avoid any detrimental environmental effects in wetlands as a result of lowering the water table through pumping.

The water resources of the coastal plain are almost entirely below the surface, ranging from relatively shallow unconfined aquifers to deep artesian aquifers. The shallow unconfined aquifers are of sand overlying clays, in between rivers originating on the Darling Plateau. There is no surface runoff because of the very porous sands. Instead, there is a sub-surface flow from the highest parts of the dune system towards the rivers and the coast. Within the dune system, the underground water forms a mildly sloping mound reaching an elevation of about 70 m above sea level at the centre of the coastal plain. This is referred to as the Gnangara Mound. This shallow water resource north of Perth covers an area of 2 200 sq km.

Lake Goollelal, Wanneroo

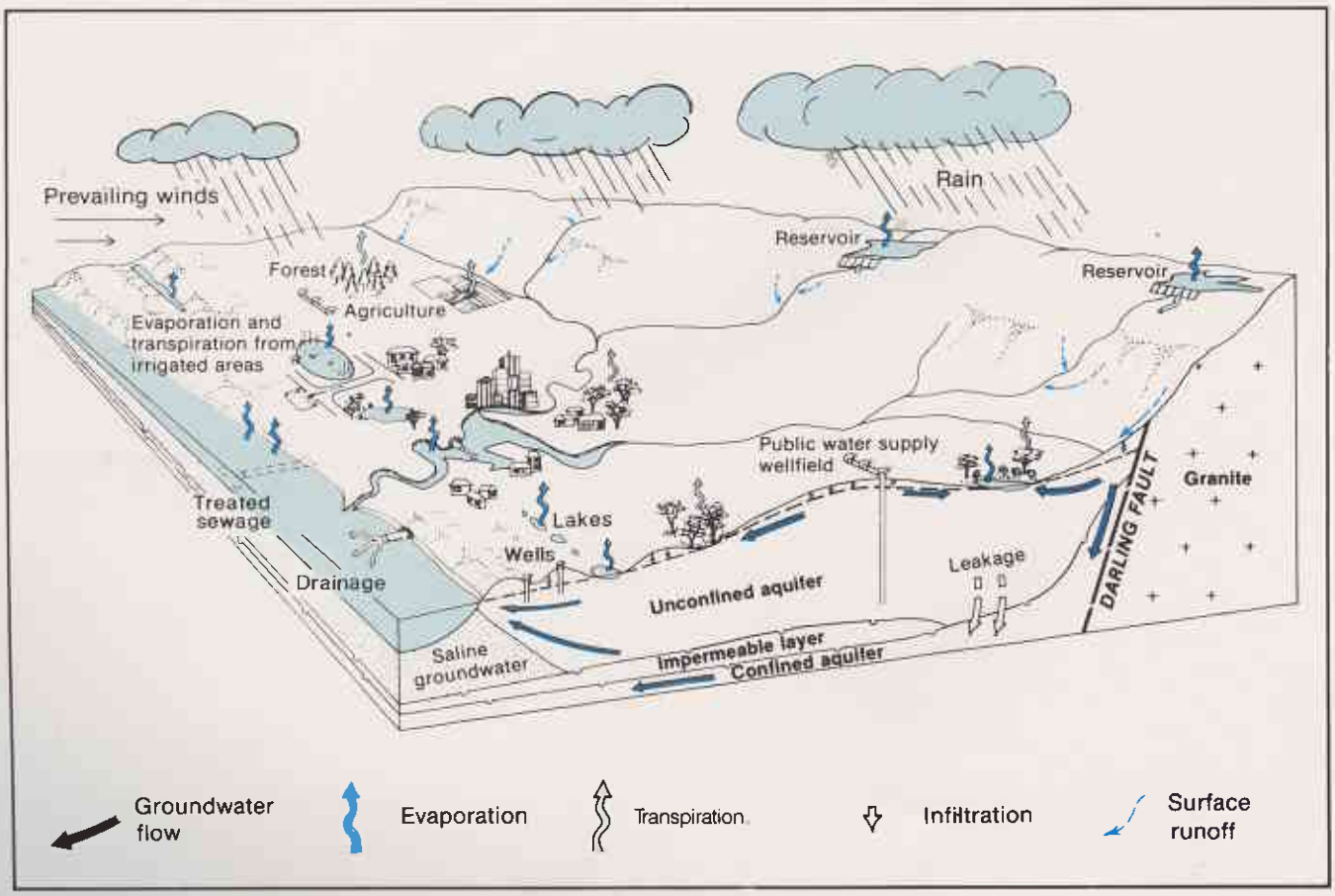


The extent of the shallow water resources within unconfined sandy deposits of the coastal plain north of Perth have been intensively studied since 1961, and this is continuing. Groundwater resources beneath the Swan coastal plain have been well defined and clearly illustrate the magnitude of the hidden supply.

Underground water originates as rainfall. Rain falling on the land

A cross-section of the coastal plain, showing the water cycle (below).

Gnangara Mound water resource and selected land use zones (left).



surface infiltrates the soil and when attractive forces of the soil are exceeded, water moves under gravity through the partially saturated soil to a saturated zone in the formation underlying the soil. This saturated formation is known as an unconfined aquifer and consists mainly of coarse sands which may contain up to 30% by volume of groundwater. The upper surface of the saturated formation is the water table.

Most of the annual rainfall is received in the five months from May to September. This is important hydrologically, as evaporation is low and most of the rainfall is potentially available for recharging the aquifers. Groundwater tables rise rapidly after the start of the winter rains, attaining a maximum level in September-October. The water table falls over the summer due to evaporation and seepage, and reaches its lowest level in March-April. Seasonal changes of 0.5 to 1.5 m are common. The amount of recharge is dependent on the amount of rainfall, interception by vegetation and depth to the water table.

Although dominated by climate, groundwater levels have also been affected by human activity. There are few areas on the coastal plain which will not ultimately experience some land use change. Planning and management of groundwater resources is desirable to minimise these conflicts. The major forms of land use on the Mound are the natural environment, urban development, rural activities, water supply and forestry.

The wetlands of the coastal plain are simply intersections of the ground surface and regional water table. Many of the coastal lakes are shallow, a depth of more than 3 m being exceptional. Their levels fluctuate with the seasonal rise and fall of the water table and it has been estimated that more than two-thirds of the winter wetlands are lost by the end of summer due to evaporation. The flora and fauna associated with wetlands are adapted to seasonal flooding and drying. The wetlands are probably more resilient to water level changes than is generally known. Present levels are somewhat artificial in that clearing of bushland for urban development has reduced evapotranspiration, with a consequent rise in water tables. Fence lines across some lakes indicate that water tables in these areas were lower in earlier times. Retention of wetlands is the major restraint in managing the groundwater resources of the Mound. Defining the acceptable change remains somewhat arbitrary; a 0.5 m decline in water level has been adopted by the Water Authority as the criterion for the most environmentally sensitive areas.

Much of the native vegetation remaining on the Mound occurs in State Forest 65 and on Crown land to the north and east. The wetland vegetation is sensitive to changes in water table levels, while upland vegetation is largely independent of this. The recent extended series of below average rainfall years has created extreme drought stress conditions and has led to the decline of the larger overstory and its replacement with seedling and smaller vegetation. The water table declines, forecast for the expanded use of groundwater for public water supply, should have little effect on the extensive areas of upland vegetation on the Mound.

State Forest 65 covers some 500 sq km or nearly one-quarter of the

C. Sandiford

Fence lines across some lakes indicate that water tables in these areas were lower in earlier times.

C. Sanders

Pine management is critical for the Mound (left).

All vegetation competes for water with pumps. Pines, however, can be thinned to maintain water yield (below left).

Wetland wildlife: Oblong Tortoise (below).

Flower farming in Wanneroo (bottom).

C. Sanders

M. Lochman

M. Lochman

J Lochman

Joondalup Lake, Wanneroo

Mound area. About half of State Forest 65 is native woodland. The remainder has been converted to pine forest. *Pinus pinaster* trees were first planted at Gnangara in 1926 to provide a softwood timber supply close to the Perth market. Planting increased from around 500 ha per year in the 1950s to about 1 000 ha per year in the 1960s. The final planting of first rotation forests on the Gnangara Mound was completed in 1987. It was not until the 1970s that the potential of the Mound for water supply was realised. Land use objectives have now changed from total wood production to yield maximisation of both pine sawlogs and potable water. This has required changes in management strategies. To reconcile pine silviculture with water catchment, it is necessary to grow pine stands at a relatively low density to ensure replenishment of groundwater. Both forms of land use are compatible, as wood growth on individual trees is maximised in low density stands.

Manipulation of tree numbers by thinning increases throughfall of rainfall and the recharge of the soil moisture system. In an open pine forest, 10% of rainfall is intercepted by tree crowns and this increases to 26% in a dense forest. Rainfall interception in the *Banksia* woodland averages 15%.

Managed pine forests are critical to the development of the Mound. In young pine forests, recharge exceeds the native woodland for the first ten years, and maturing pine trees can be thinned to maintain regional water levels. Thinning can be used as a tool to provide groundwater for extraction and to maintain wetlands and lakes in the immediate proximity.

CALM's management aim is to maintain pine forests at a low density. It is paramount to reduce the interception potential of the pines and allow for the rapid movement of wetting fronts through the sand profile, beyond the concentration of pine roots in the surface soil horizons. Tree diameter growth is largely dependent on the moisture stored in the unsaturated soil zone. Water use by pine trees in summer is greatly reduced even where water tables are close to the surface. Forestry is a preferred form of alternative land use because the quantity of fertilisers used is markedly below that for agriculture, and there is much less danger of biological pollution.

The Gnangara Mound is a major water resource ideally located to serve the irrigation needs of horticulturists close to markets in Perth. The market garden areas of Wanneroo and the viticulture area of the Swan Valley are two main areas that have been recommended in a Corridor study to be preserved for intensive agriculture. Groundwater has been allocated to meet the projected growth in demand for water for agriculture for the next ten years.

Urbanisation of the North West Corridor will occur gradually in the

coastal strip north of Wanneroo. Much of the Gnangara Mound north of Lake Pinjar is sparsely populated and likely to stay so under the present Corridor plan for metropolitan development. The area of State Forest 65 will make an important contribution to regional open space for recreation, conservation, water and timber production.

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. The Mirrabooka and Wanneroo schemes are the only sources of water supply for the Metropolitan North West Corridor. The Pinjar Scheme, north of Wanneroo, is currently being developed. Water could be flowing from this Scheme by 1989. It is planned to construct future schemes in stages to match the growth in demand while at the same time minimising the impact on the environment. Future wellfields will be located within State Forest 65 where water quality is protected and water table changes have generally less impact on the natural environment, particularly the wetlands.

For further information:

Gnangara Mound Groundwater Resources Environmental Review and Management Programme

Published by: Water Authority of Western Australia.

What is the Gnangara Mound?

Gnangara Mound reaches from Gingin Brook in the north to the Swan River in the south, and from the Indian Ocean in the West to Ellens Brook in the east. It covers 2 200 sq kilometres, including the North-West Corridor development of Perth and extensive tracts of rural and semi-rural areas.

State forests and natural ecosystems managed by CALM also comprise a significant proportion of the area, as do intensive market gardening and horticultural plots. With such a variety of habitats, natural and urban, it is sometimes difficult to realise that the Mound is one system, or a set of sub-systems that are very closely linked. The Gnangara Mound is formed from ancient coastal dune systems which have compacted against the impermeable fault line of the Darling Scarp, the permanent scenic backdrop for most Perth residents.

The Bassendean Dune System is the oldest of the three major systems which form the Mound, and is closest to the Darling Scarp. It is the largest in area, covering from Bayswater and Maylands on the Swan River to the perimeter of the Moore River and extending inland from Wanneroo to Bullsbrook. The highest point of the Mound is located in this area and reaches up to 70 m above sea level.

Adjacent to the western border of the Bassendean System is the Spearwood System which runs closer to the coast and encompasses a narrow corridor of land reaching from Swanbourne to Yanchep. The development of Perth's northern suburbs follows this line. The newest and most fragmented dune system is the Quindalup Dune System, which includes some of the more prestigious beach front suburbs from City Beach to Mullaloo.

The compacting of land and the nature of the soils on the Gnangara Mound has led to the formation of an interesting subterranean profile of the coastal plain. On a bedrock layer of older geological formations there is a thin covering of shale. Above that is a variable mantle of sand, limestone, silt and clay, with a predominance of limestone closer to the ocean and more gravelly sand closer to the scarp. This gives the soil of the area a significant water retention capacity, and forms a huge area of groundwater.

Because we are more familiar with surface-level concepts of water storage, we may make the mistake of thinking of groundwater in the shape of an underground river or lake. Most groundwater is actually held in geological formations. Within the compacted sandy soils of the old dunes, usable quantities of water are stored in the tiny spaces between sand, pebbles and in rock fractures. This groundwater-bearing formation is referred to as an aquifer, and there are two types of aquifer.

The first is a confined aquifer where the water is trapped beneath clay, silt or other impervious material and is under pressure. There are two main confined aquifer underlying the area of the Gnangara Mound, the Leederville and the Yarragadee aquifers. Artesian and sub-artesian bores tap this water, relying on storage pressure to force the water to the surface.The water from confined aquifers is used in conjunction with water from unconfined aquifers and other surface water for public water supply. Unconfined aquifers, as the name suggests, don't have an impervious level overlying them.

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EDITORIAL

Anybody who reads tourist brochures in this State will appreciate that the tourist industry is, to a large extent, dependent on natural features and wildlife for its 'product'. Many people who are concerned with the natural environment are antagonistic to tourism, and it is certainly true that in the past there have been some insensitive tourist developments in the State. But, just as the farming community over the past ten years has become one of the greatest allies of conservation, so, increasingly, is the tourist industry. For example, in a recently published tourist industry report on tourism in the Kimberley, the need to preserve this environment was given top priority.

This report is indicative of the growing awareness in that industry of the symbiotic relationship between tourism and the protection and maintainance of our unique flora, fauna and landscapes. Rather than being despoilers, the tourist industry has the potential to become one of the strongest advocates for conservation in the broadest sense.

There is a great potential for synergism between those interested in the science of conservation and the tourist industry. One of the ways by which the tourist potential of any natural area can be enhanced without any cost to the environment is by providing information to the visitors on the natural science that makes that area special.

Landscope is one avenue by which we are attempting to provide an added dimension to the 'look it's lovely' tourist experience. Interestingly, while *Landscope* receives almost universal acclaim from the general public, there is ongoing, often vigorous, internal debate about how technical we should make the magazine. We would appreciate your views.

Cover Photo

'Now, just how do I find my way out of this Renoir landscape?'
Photographer **Richard Woldendorp** captured this lizard taking a sighting.

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